Oct. 24, 1933. H. H. SMITH ET AL 1,932,235

TELEPHONE SYSTEM

Filed July 13, 1931 9 Sheets-Sheet 1

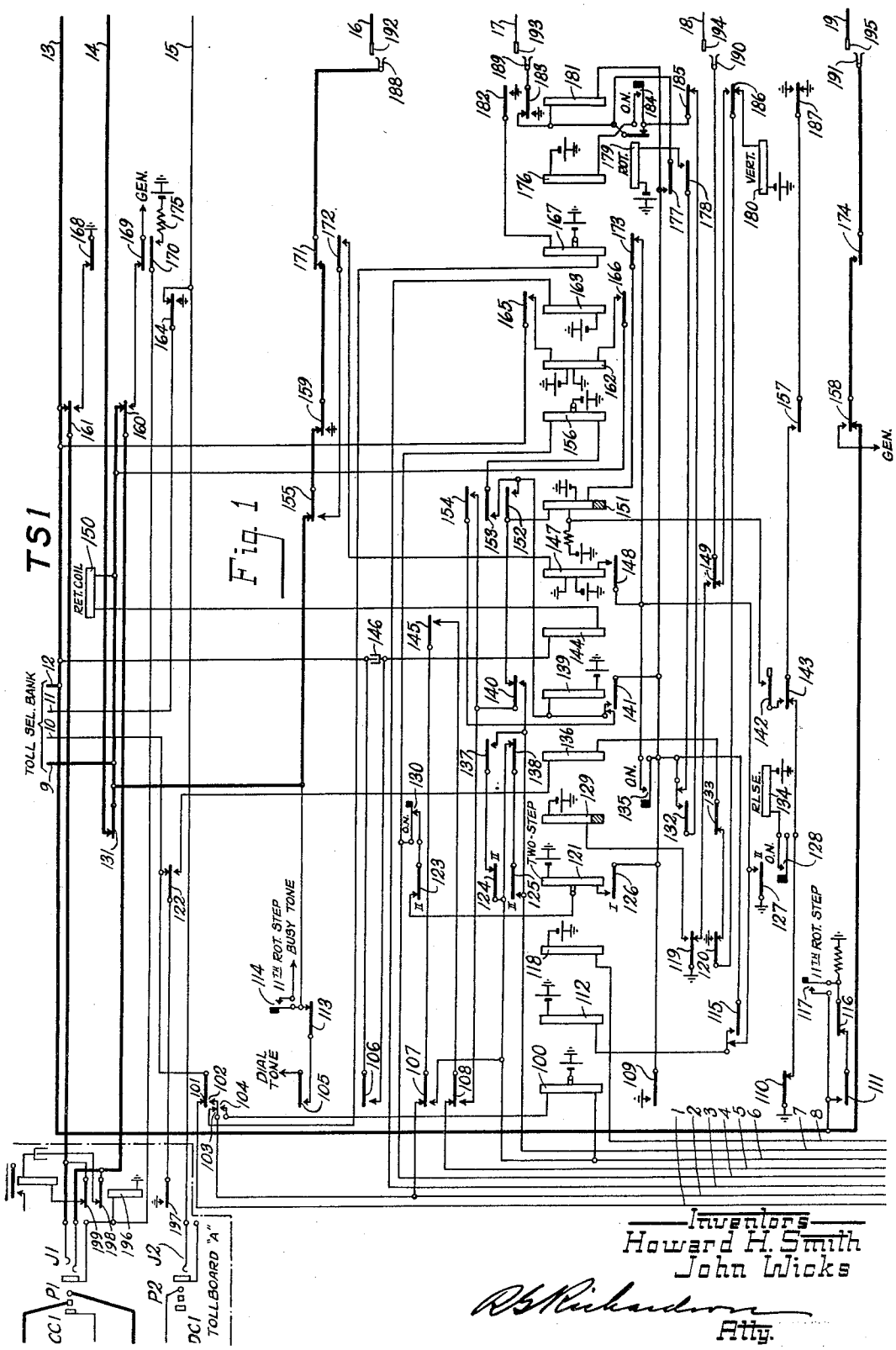

Fig. 1

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TELEPHONE SYSTEM

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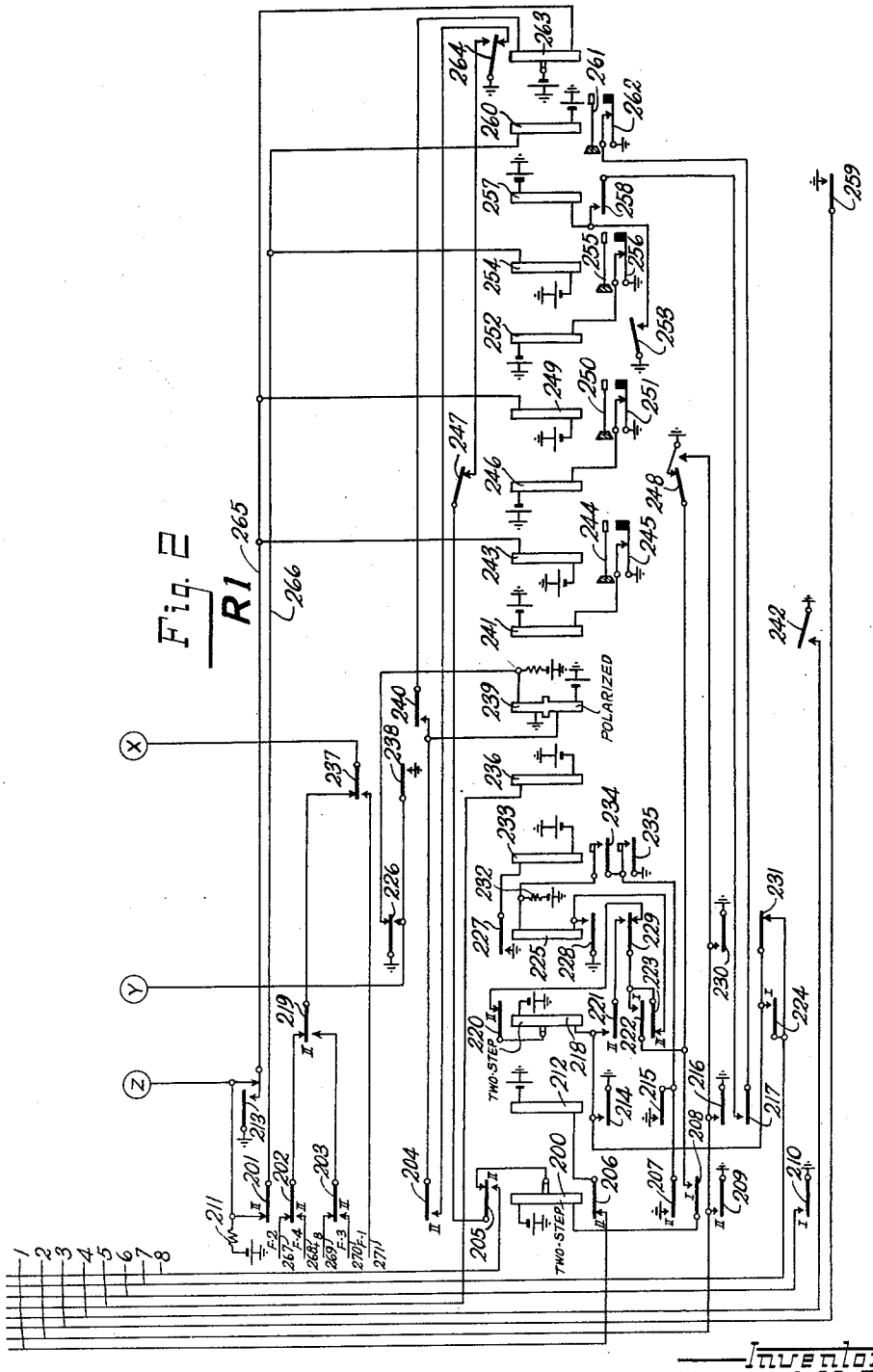
Fig. 2

R1



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TELEPHONE SYSTEM

Filed July 13, 1931 9 Sheets-Sheet 3

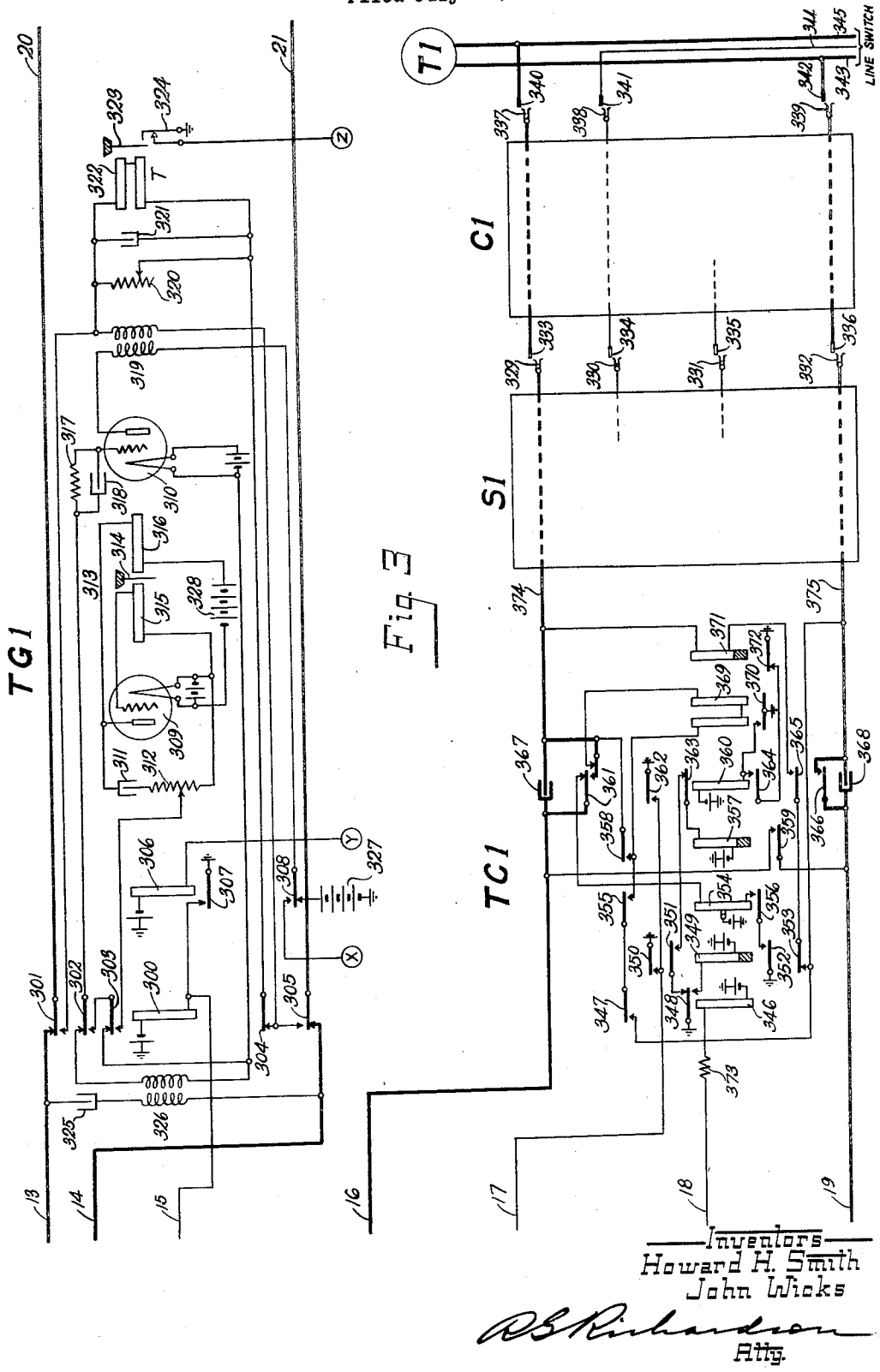

Fig. 3

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TELEPHONE SYSTEM

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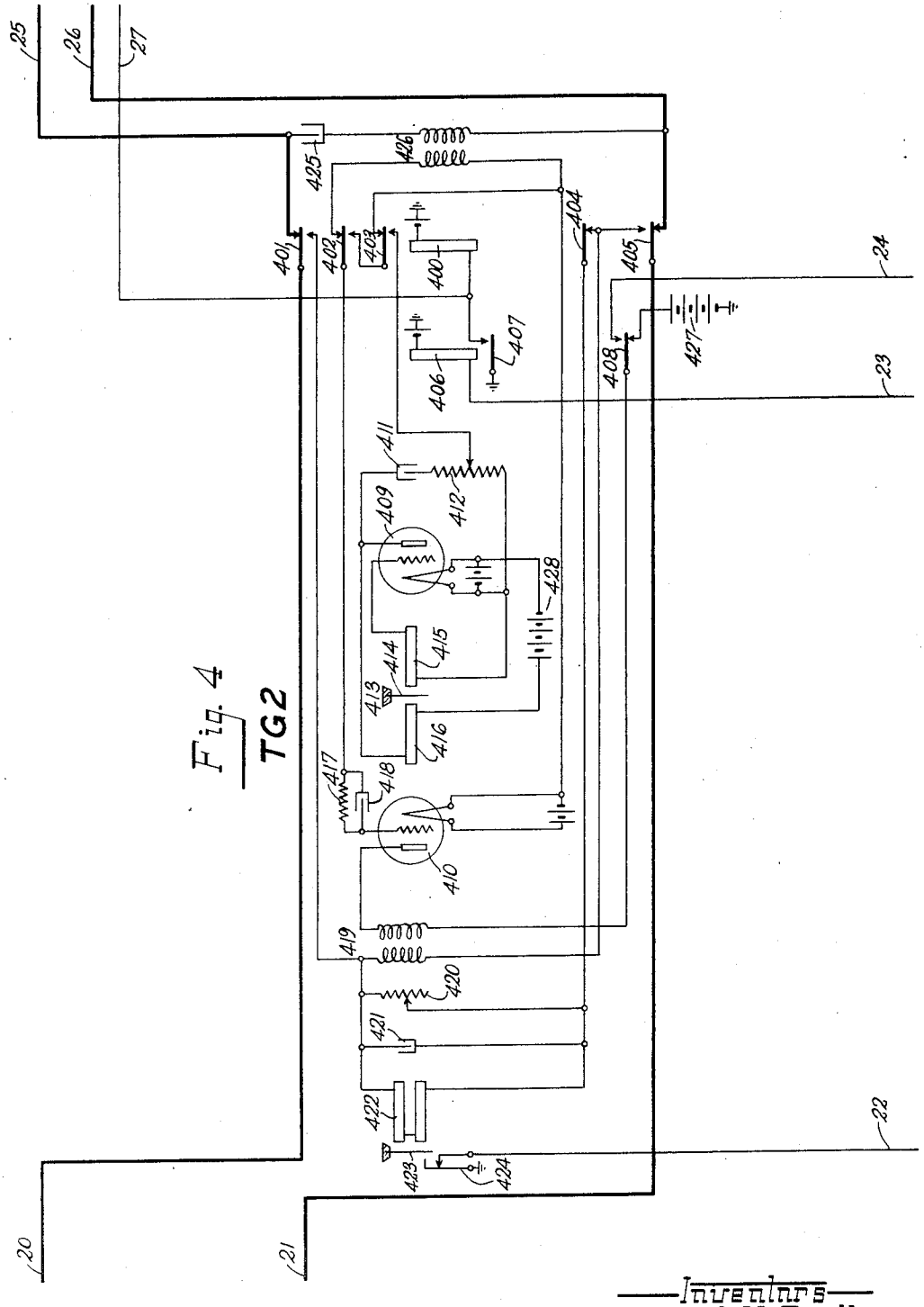

Fig. 4

TG2

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TELEPHONE SYSTEM

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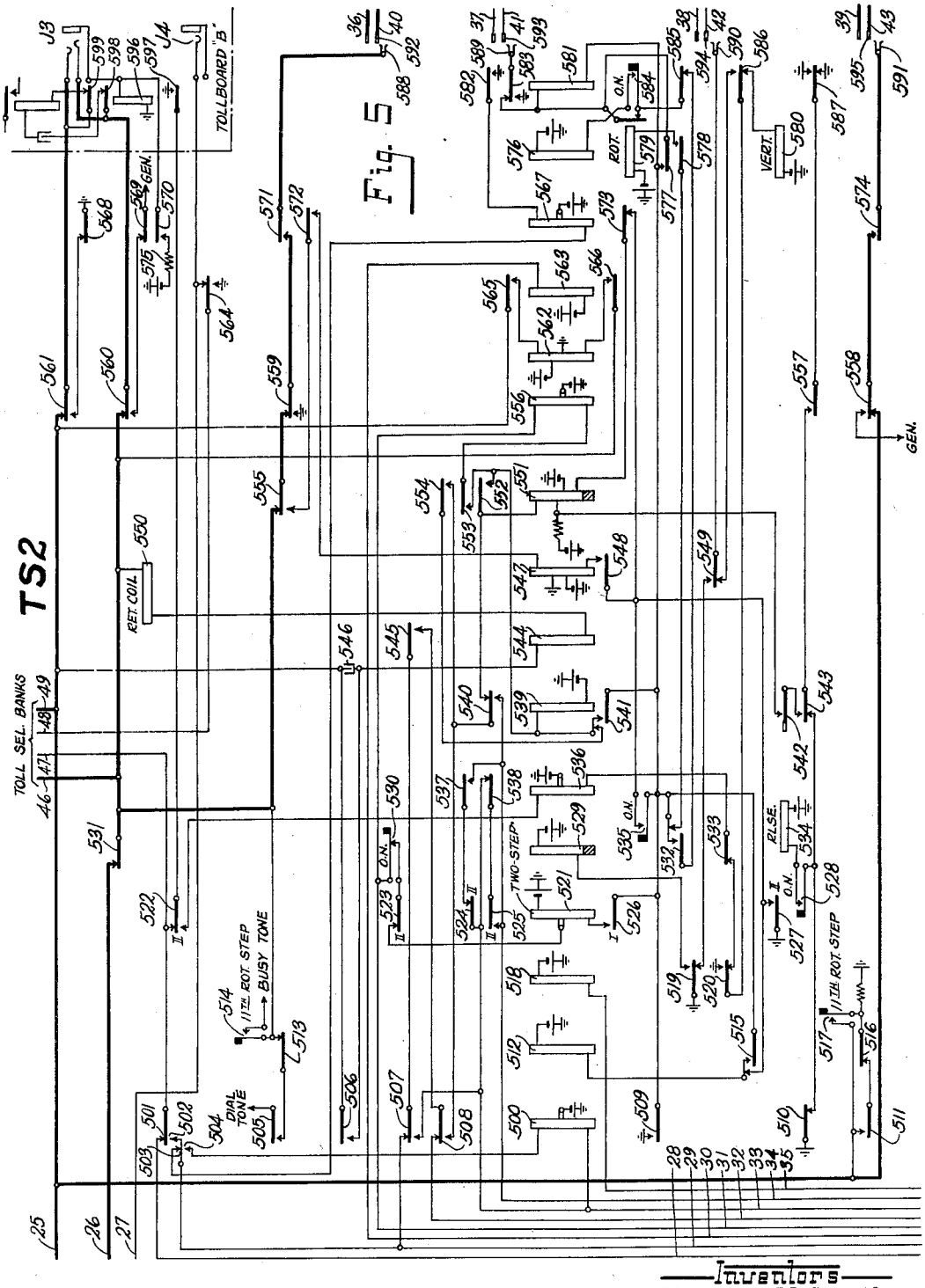

Fig. 5

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TELEPHONE SYSTEM

Filed July 13, 1931 9 Sheets-Sheet 6

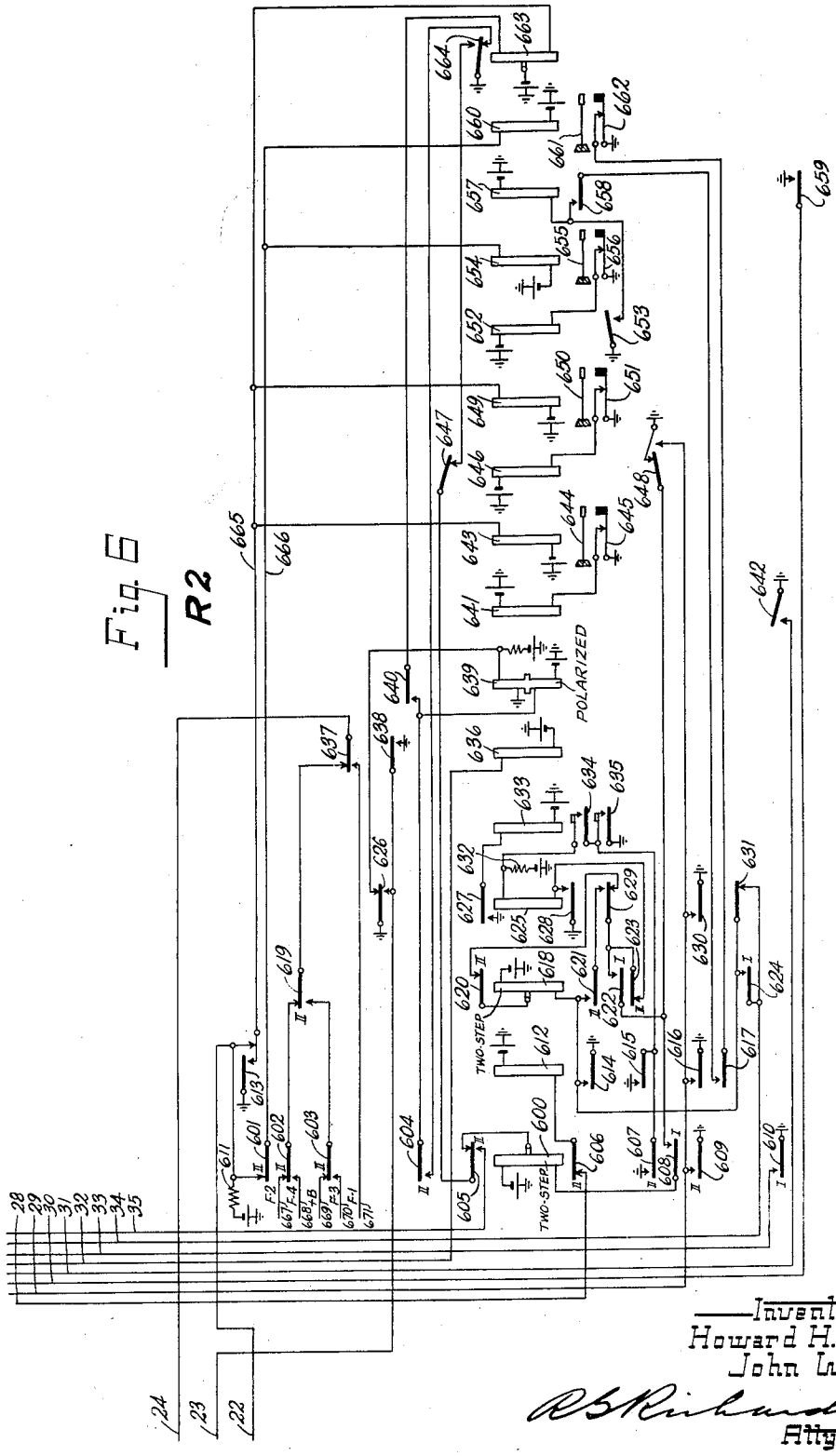

Fig. 5

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TELEPHONE SYSTEM

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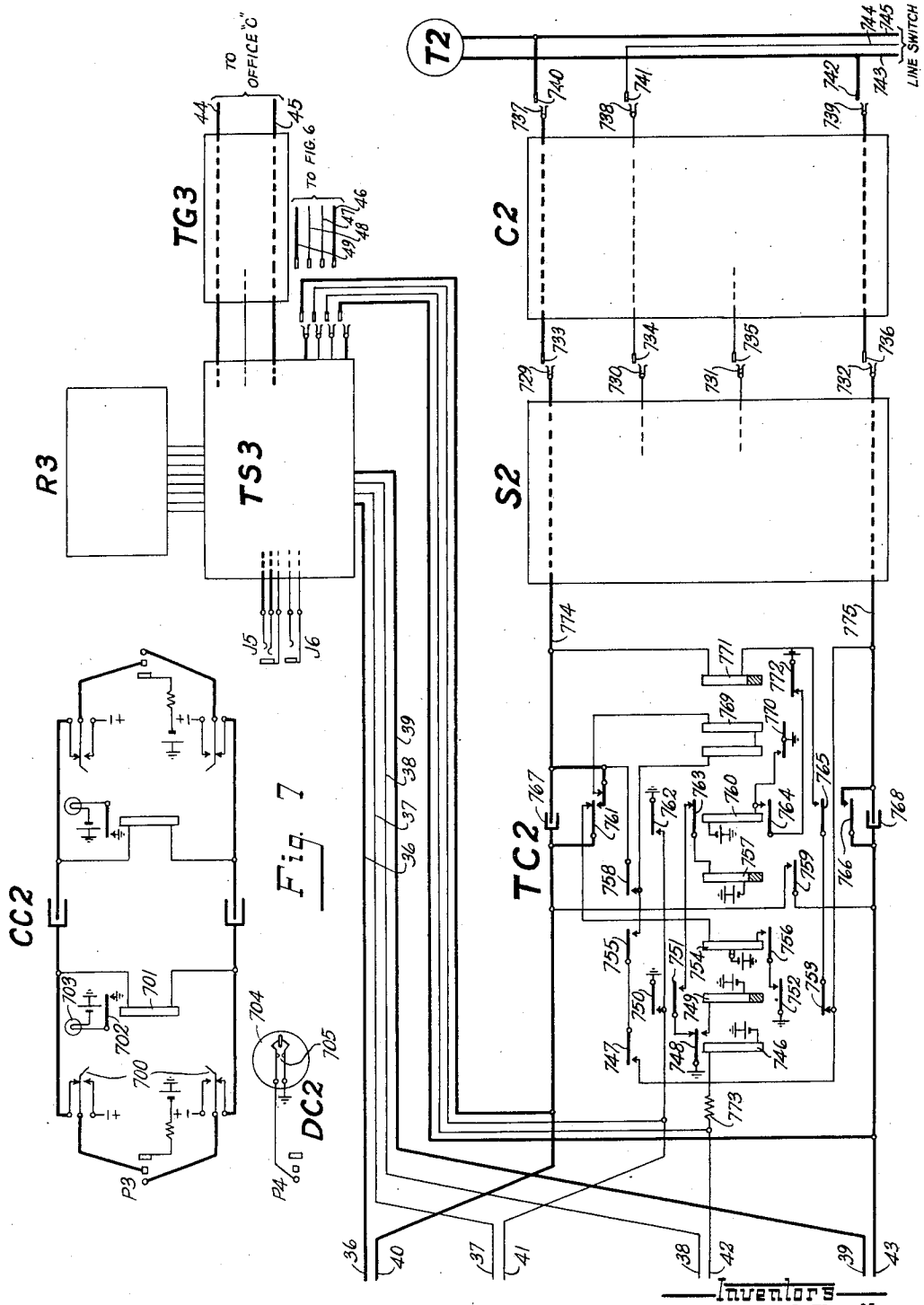

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TELEPHONE SYSTEM

Filed July 13, 1931 9 Sheets-Sheet 8

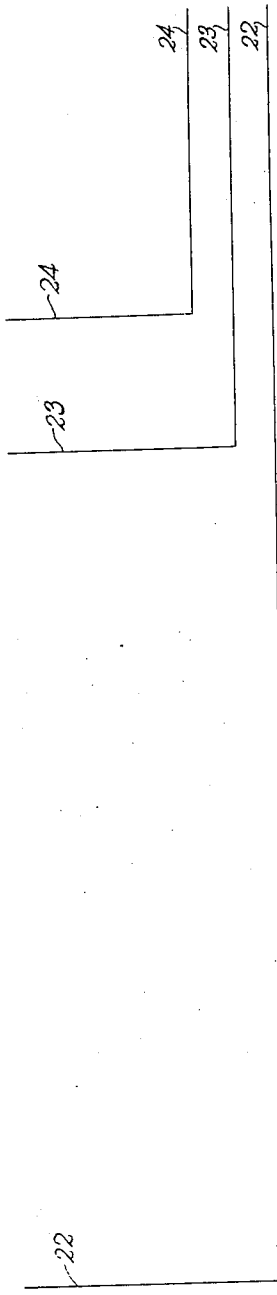


Fig. 9

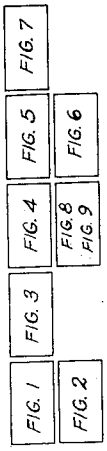
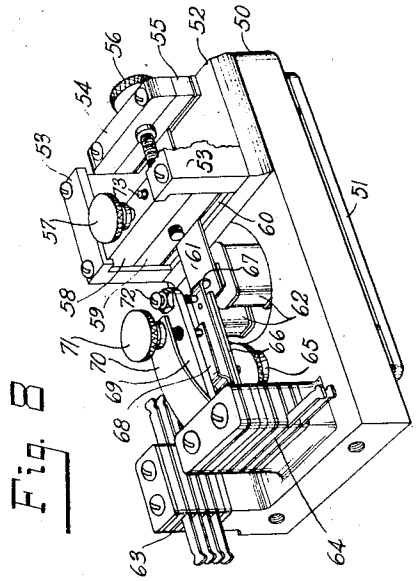


Fig. 8



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TELEPHONE SYSTEM

Filed July 13, 1931 9 Sheets-Sheet 9

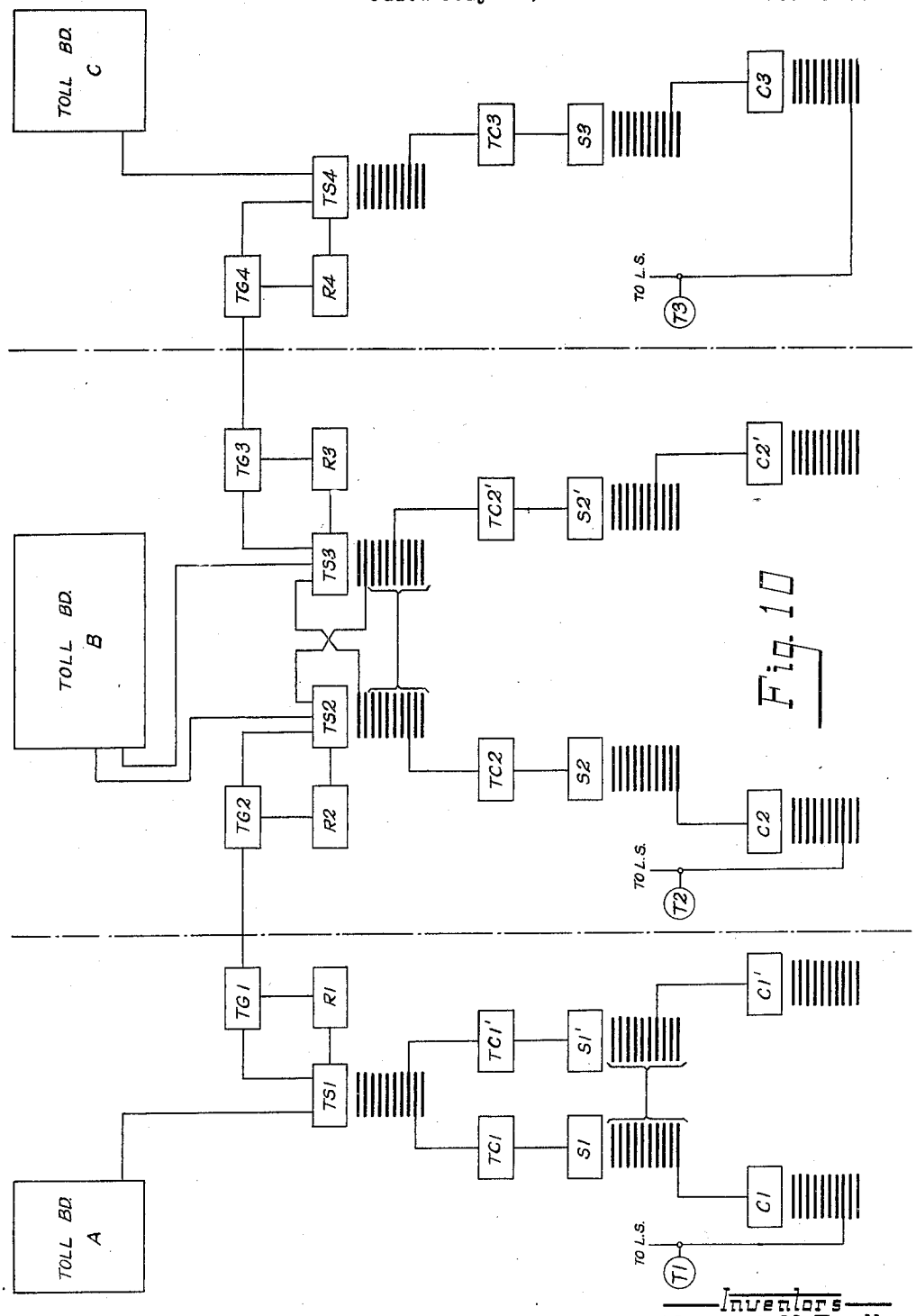

Fig. 10

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Patented Oct. 24, 1933 1,932,235

UNITED STATES PATENT OFFICE

1,932,235

TELEPHONE SYSTEM

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Application July 13, 1931. Serial No. 550,436

29 Claims. (Cl. 179—16)

The present invention relates in general to telephone systems, but more particularly to toll switching apparatus and equipment for automatic telephone systems.

In order to increase the revenue derived from long distance toll lines, it is common practice to phantom the trunks so that three talking circuits are available over four conductors and, in addition, to use the individual line conductors for direct current telegraph circuits. In some instances, additional telegraph facilities are provided by employing low frequency alternating current and carrier current for telegraph signalling. Where any of these telegraph facilities are provided, it is necessary to employ some type of toll dialling and signalling which will not interfere with the various telegraph circuits and which is incapable of being interfered with by the telegraph signalling currents.

A system suitable for use in cases where only direct current telegraph circuits are employed is disclosed in the co-pending application of John Wicks, Serial No. 540,992, filed May 29, 1931, and assigned to the assignee of the present application. In that case, low frequency alternating current impulses of different durations are used for various operating, release, and supervisory signals. However, such a system is not suitable in cases where alternating current telegraph facilities are provided.

The main object of the present invention is to provide a system of toll dialling and signalling which may be used on all types of toll lines irrespective of the telegraph and other facilities employed. This is made possible by the use of signalling current having a frequency lying within the voice frequency range.

In employing currents of voice frequencies for signalling in telephone systems, the greatest difficulty is encountered in preventing the actual voice currents from operating the signaling apparatus. According to one feature of the present invention, this difficulty is overcome by employing a basic frequency current lying within the voice frequency range, and interrupting this basic frequency current at different rates below audible frequency to effect the operation of the proper apparatus.

According to another feature of the invention, a new and improved tuned reed relay is provided which responds only to the basic signalling frequency used and which in turn interrupts the circuit of other tuned reed relays designed to respond to the various low frequencies at which the signalling current of basic frequency is interrupted for the different signals.

Another feature of the invention lies in the arrangement for producing the various signalling currents composed of the basic signalling frequency current interrupted at the proper low frequencies.

The above and other features of the invention not specifically mentioned will be more clearly understood from a perusal of the following specification when read in connection with the accompanying drawings comprising Figs. 1 to 10, inclusive, which shows by means of the usual schematic diagram the application of the present invention to a multi-office telephone system in which toll connections are completed by the originating toll operator.

In the drawings, Fig. 1 discloses the toll dialling selector TS1 in exchange A which terminates one of the inter-office trunk lines connecting this exchange with exchange B. The toll board in exchange A is indicated in the upper left-hand portion of the figure, the operator's cord circuit CC1 and the dialling cord DC1 being merely indicated in this figure.

Fig. 2 of the drawings discloses the voice frequency dialling repeater R1 associated with the toll dialling selector TS1.

Fig. 3 discloses the tone group TG1 associated with the toll dialling selector TS1, and in the lower portion of this figure is indicated the toll train in exchange A, consisting of the trunk circuit TC1, the toll transmission selector S1, and the toll connector C1. The toll transmission selector S1 and the toll connector C1 may be switches of a standard toll train and may be in all respects similar to the selector S and connector C disclosed in the patent to Victor S. Tharp, No. 1,811,444, granted June 23, 1931.

Fig. 4 discloses the tone group TG2 associated with the toll dialling selector TS2 terminating the trunk in exchange B. This tone group is in all respects similar to the tone group TG1 in exchange A.

Fig. 5 discloses the toll dialling selector TS2 located in exchange B and terminating the trunk extending from exchange A. This toll dialling selector is in all respects similar to selector TS1 in exchange A. The toll board located in exchange B is indicated in the upper right-hand corner of this figure.

Fig. 6 discloses the voice frequency dialling repeater R2 associated with the toll dialling selector TS2, and this repeater is in all respects

similar to repeater R1 disclosed in Fig. 2 of the drawings.

An operator's cord circuit CC2 and a dialling cord DC2 are shown in the upper portion of Fig. 7 of the drawings. Only a sufficient portion of these cord circuits have been disclosed to enable the present invention to be understood. Similar cord circuits are used at each of the toll boards in exchanges A and C. The toll train comprising a trunk circuit TC2, a selector S2, and connector C2, is shown in the lower portion of this figure. The trunk circuit TC2 is the same as trunk circuit TC1 in exchange A, while the selector S2 and connector C2 are the same as selector S1 and connector C1 in exchange A, and are preferably of the type disclosed in the above-mentioned patent to Tharp. The toll train shown in the lower portion of this figure is accessible to the toll dialling selector TS2 over conductors 40 to 43, inclusive. In the upper right-hand portion of this drawing, the trunk line extending to exchange C has been indicated and shown as terminating in a toll dialling selector TS3 and associated repeater R3 and tone group TG3, and also at the toll board in exchange B at jacks J5 and J6. The circuits of selector TS3, repeater R3, and tone group TG3 are in all respects similar to the circuits of the corresponding apparatus disclosed in detail in Figs. 1, 2, and 3 of the drawings. The selector TS3 has access to the same toll train as selector TS2, and also has access to selector TS2 and the trunk to exchange A over conductors 46 to 49, inclusive. The selector TS3 and the associated trunk to exchange C is available to the selector TS2 over conductors 36 to 39, inclusive.

Fig. 8 of the drawings discloses a perspective view of the improved tuned reed relay which is used to respond to the basic signaling frequency.

Fig. 9 discloses the manner in which Figs. 1 to 9, inclusive, are to be arranged to present a complete circuit diagram of the system of the present invention.

Fig. 10 is a trunking layout of the telephone system including three automatic exchanges, A, B, and C with a toll board located in each exchange. The two-way inter-office trunk lines connecting exchange A with exchange B terminate in the toll board at each exchange and also in voice frequency toll dialling selectors, such as TS1 in exchange A and TS2 in exchange B. Associated with the toll dialling selector TS1 is the voice frequency dialling repeater R1 and the tone group TG1. Similarly, voice frequency dialling repeater R2 and tone group TG2 are associated with the toll dialling selector TS2 in exchange B. Exchanges B and C are interconnected by two-way trunk lines terminating in similar apparatus at each of these exchanges. This figure also discloses the trunking arrangement of the toll train in each of the three exchanges.

Referring now to the trunking layout shown in Fig. 10 of the drawings, a brief description will first be given of the manner in which the various connections are set up in the system shown. Assuming that the toll operator in exchange A receives a request for a connection to the subscriber T2 in exchange B, the operator inserts the calling end of her cord circuit and also her dialling cord circuit into the jacks terminating one of the trunk lines extending to exchange B. It will be assumed that the trunk terminating in the toll selector TS1 and associated repeater and tone group is the trunk seized. As soon as the trunk is seized, the voice frequency dialling repeater R1 transmits a calling signal consisting of an uninterrupted impulse of the basic frequency current. This calling signal prepares the equipment in exchange B for an incoming call. The toll operator at exchange A then dials the telephone number of the desired subscriber. The first series of impulses operates the toll dialling selector TS2 in exchange B to the proper level and the selector then rotates to select an idle trunk circuit, such as TC2, and associated toll transmission selector S2. The second digit of the called member operates the toll transmission selector S2 to select a toll connector, such as C2, in the proper hundreds group. The final two digits of the called number operate the connector C2 into engagement with the desired called line. It is to be understood that one or more toll selectors may be inserted between the toll transmission selector, such as S1, S2, or S3, and the toll connector, such as C1, C2, or C3, depending upon the sizes of the various exchanges and the number of digits in the telephone numbers. When the connection has been established, the answering and disconnect supervision and the release functions are controlled over the inter-office trunk line by proper signals of the basic frequency current interrupted at different low frequencies as controlled by the voice frequency repeaters R1 and R2.

In case the toll operator at exchange A receives a request for a connection to a subscriber, such as subscriber T3 in exchange C, she inserts her cords in the trunk jacks associated with the trunk line extending to exchange B in the same manner as described above. The first digit dialled in this case would be the digit 0, which would operate the toll dialling selector TS2 to the tenth level and the selector then automatically rotates to select an idle trunk extending to exchange C and the associated toll dialling selector TS3, repeater R3, and tone group TG3. When this trunk is seized, the voice frequency repeater R3 transmits a calling signal consisting of uninterrupted basic frequency current over the trunk line to exchange C in order to prepare the apparatus in this exchange for an incoming call. The succeeding four digits dialled by the toll operator then operate the toll selector TS4, the toll transmission selector S3, and the toll connector C3 to establish the connection to the desired subscriber. The supervisory and release functions in this case are controlled by repeaters R1 and R4 and the signals are repeated through the intermediate exchange B by the voice frequency dialling repeaters R2 and R3 and associated equipment.

Connections from the toll board in exchange B to subscribers in exchange A or exchange C are established in the same manner as connections from toll boards in exchange A to a subscriber in exchange B. The toll operator in exchange C establishes connections to subscribers in exchange B in the same manner as previously described for connections from the toll operator in exchange A to a subscriber in exchange B. In case the toll operator in exchange C wishes to establish a connection to a subscriber, such as T1, in exchange A, she selects a trunk line extending to exchange B and dials the digit 9 which operates the toll selector TS3 to the ninth level, and it then automatically rotates to select an idle trunk extending to exchange A and the associated selector, repeater, and tone group. The supervisory and release signals in this case are repeated through exchange B by means of the voice frequency dialling repeaters R2 and R3.

The circuits are also arranged so that any one of the toll operators may signal any other toll operator. In case the toll operator at exchange A wishes to converse with the operator at exchange B, she selects a trunk extending to exchange B and simply operates her ringing key. The repeater R1 then transmits a signal consisting of the basic frequency interrupted at a particular low frequency and this signal is received by the repeater R2, which in turn operates a calling signal at the toll board in exchange B. Similarly, the toll operator in exchange A may signal the toll operator at exchange C by selecting a trunk extending to exchange B and dialling the digit 0. The toll selector TS2 is thereby operated to select an idle trunk extending to exchange C and the associated selector, repeater, and tone group. The toll operator at exchange A then operates her ringing key, which causes the repeater R1 to transmit a ringing signal in the same manner as previously described. This ringing signal is repeated by repeaters R2 and R3 and is received by repeater R4, which brings in the calling signal at the toll board in exchange C.

Having given a brief description of the manner in which the various connections may be established between the toll operators and subscribers in any one of these exchanges and between any toll operator and any other toll operator, a detailed explanation of the operation of the circuits and apparatus in establishing these various connections will now be given. For this description, reference is had to Figs. 1 to 9, inclusive, arranged in the order shown in Fig. 9 of the drawings.

Call from toll operator in exchange A to substation T2 in exchange B

It will first be assumed that the toll operator in exchange A receives a request for a connection to the subscriber at substation T2 in exchange B. It will be assumed that the telephone number of the wanted subscriber is 3131. The operator at toll board A inserts the plug P1 of cord circuit CC1 into the jack, such as J1, associated with an idle trunk extending to exchange B, and the plug P2 of the dialling cord DC1 into jack J2 associated with this same trunk. The insertion of plug P1 into jack J1 causes the cut-off relay 196 to operate from battery over the sleeve of cord circuit CC1. At armature 197, relay 196 busies the toll selector TS1 in the banks of the other toll selectors having access to the trunk extending to exchange B by placing ground on conductor 10 through armature 122 and its resting contact. This same ground is extended to armature 101 and its resting contact, conductor 1, resting contact of armature 206 and said armature, winding of relay 212, to battery.

Relay 212 operates and at armatures 214 and its working contact it completes a circuit for the two windings of relay 218 in series. At armature 215 and its working contact it short circuits the weighted spring contact 235 of relay 233 for a purpose to be described later. At armature 216 and its working contact, it places ground on conductor 2, which ground is extended over contact 103 of relay 100 of the toll selector TS1, lower winding of relay 167, to battery. Relay 167 operates, and at armatures 168 and 169 and their resting contacts disconnects the generator leads to prevent the possibility of ringing current being connected to the conductors extending to the toll board. The operation of the remaining armatures of this relay is without effect at this time. At armature 217 and its working contact, relay 212 prepares a locking circuit for the supervisory relay 257, and at the normally closed springs controlled by armature 213 it disconnects the impulse conductor Z from the low frequency tuned reed relays 243 and 249.

The upper winding of relay 218 is a weak winding, and when energized alone can operate only armatures 222 and 224. When the circuit of the relay is closed at armature 214 of relay 212, the relay begins to energize over both of its windings in series, but as soon as armature 222 closes its working contact, the upper winding of the relay is shunted from ground at the working contact of armature 248 of the normally energized relay 246, armature 222 and its working contact, armature 229 and its resting contact, resting contact of armature 220 and said armature, to the junction point of the two windings, thereby shunting out the lower winding of the relay. The relay now waits in its half-step position until relay 225 operates to open the shunting circuit at armature 229.

The operating circuit for relay 225 extends from ground, working contact of armature 248 and said armature, armature 222 and its working contact, armature 223 and its resting contact, winding of relay 225, resistance 232, to battery. Relay 225, at armature 229 and its resting contact, opens the shunt circuit for the lower winding of relay 218 so that this relay is now completely operated over both of its windings in series. At armature 220 and its resting contact, relay 218 opens a further point in the shunting circuit for its lower winding, and at armature 223 and its resting contact opens the initial energizing circuit of relay 225. The latter relay, however, is locked energized over armature 228 and its working contact. At armature 219 and its working contact, relay 218 connects a high positive potential over conductor 269 resting contact of armature 203 and said armature, working contact of armature 219 and said armature, resting contact of armature 237 and said armature, to conductor X extending to the tone group TG1 shown in Fig. 3 of the drawings.

Relay 225, in operating, at armature 226 and its resting contact removes the shunting circuit from the upper winding of polarized relay 239 but this relay does not operate when its upper winding is energized. The purpose and operation of this relay will be explained later. At the front contact of armature 226, relay 225 connects ground to conductor Y extending to the tone group TG1, thereby energizing relay 306 in an obvious circuit. Relay 306 operates and at armature 307 and its working contact closes an obvious circuit for relay 300, at armature 308 and its resting contact disconnects the plate circuit of the amplifying tube 310 from battery 327, and at the working contact of this armature it connects the plate circuit to conductor X, which was connected to high positive potential by the operation of relay 218, as just explained. At armature 227 and its working contact, relay 225 completes an obvious circuit for relay 233. At armature 230 and its working contact it connects ground to the busy conductor 2.

Relay 233 is a double armature relay having two sets of weighted timing springs. These springs are so arranged that a definite interval of time is required for armature 234 to close its contact after the relay has been energized. The weighted spring associated with armature 235 is so designed that about three times the

interval of time required for the closure of springs 234 is required for the closure of springs 235. When relay 233 is energized in the above-traced circuit, the weighted springs start to vibrate, and after an interval armature 234 completes its contact with its associated weighted spring. During this interval of time, an impulse of uninterrupted basic frequency signalling current is being transmitted over the trunk line, as will now be explained.

Referring to the tone group TG1 shown in the upper portion of Fig. 3, the vacuum tube 309 and the associated tuned reed device 313 form a tuned reed oscillator such as disclosed and claimed in the application of Laurence J. Lesh, Serial No. 353,283, filed April 8, 1929, and assigned to the assignee of the present application. This oscillator is designed to operate at the basic signalling frequency which is being employed in the system. This may conveniently be 1000 cycles per second. In this case the tuned reed 314 is designed so that its natural period of vibration is 1000 cycles per second. This tuned reed provides the coupling between the two coils 315 and 316 located in the grid and plate circuits of tube 309, respectively. The device is thereby caused to oscillate at a thousand cycles per second in a manner fully described in the above-mentioned Lesh application.

When relay 306 was operated responsive to the operation of relay 225, as previously described, it completed the circuit for relay 300 at armature 307 and its working contact. Relay 300 operates and at armatures 302 and 303 and their working contacts it connects a varying potential taken from potential divider 312 located in the plate circuit of the oscillating tube 309 to the grid circuit of amplifying tube 310. The potential on the grid of this tube is thereby varied at one thousand cycles per second, causing corresponding changes in the plate current through the primary winding of output transformer 319. A thousand-cycle alternating current is thereby induced in the secondary winding of this output transformer and transmitted over the truck line through armatures 301 and 305 and their respective working contacts, to trunk conductors 20 and 21 extending to exchange B. At armature 304 and its resting contact relay 300 disconnects the thousand-cycle tuned reed relay 322 so that this relay will not be operated at this time.

The length of the calling signal which is transmitted in the above manner responsive to the operation of relay 225 of repeater R1 is determined by the time required for the weighted spring contact 234 to close. When these springs close, ground from armature 215 of relay 212 is extended over the contacts 234 to the upper terminal of the winding of relay 225, thereby shunting this winding and causing the relay to release after an interval. Resistance 232 is provided to prevent the short-circuiting of the battery. Relay 225 in releasing opens the circuit of relay 233 at armature 227 and its working contact. At armature 228 and its working contact it opens its own locking circuit, and at armature 226 and its working contact it removes ground from the Y conductor extending to relay 306 and allows this relay to release. Relay 306, in releasing, at armature 307 and its working contact opens the circuit of relay 300 and this relay thereupon releases, opening the grid circuit to the amplifying tube 310 and disconnecting the output transformer from the trunk conductors, thereby terminating the calling signal.

The splash of uninterrupted thousand-cycle current which was transmitted over the trunk line conductors 20 and 21 responsive to the insertion of the plugs P1 and P2 into jacks J1 and J2, respectively, at the toll board in exchange A, is received at the tone group TG2 in exchange B over conductors 20 and 21, armatures 401 and 405 and their resting contacts, and through condenser 425 and the primary winding of input transformer 426. The current induced in the secondary winding of transformer 426 is impressed on the grid of tube 410 through the resting contact of armature 402 and said armature and resistance 417 and condenser 418 in multiple. A one-thousand-cycle pulsating plate current accordingly flows through the primary winding of transformer 419 and the induced current in the secondary winding of this transformer flows through the winding of the thousand-cycle tuned reed relay 422 over armature 404 and its resting contact.

The resistance 417 and condenser 418 connected in multiple in the grid circuit of tube 410 have two functions. First, they are provided in order to increase the impedance of the grid filament circuit which is in effect bridged across the line through transformer 426. This eliminates the low impedance shunt across the line during conversation. Second, the resistance and condenser serve as an automatic volume control and maintain the output to the tuned reed relay 422 at a practically constant value. When a signal is being received through transformer 426, the varying potential is impressed on the grid of tube 410 causing corresponding variations in the plate circuit through the windings of relay 422. As the grid of the tube becomes positive some of the electrons emitted from the filament are attracted to the grid. The amount of electrons so attracted is proportional to the value of the positive potential on the grid. During the negative half cycles of received current these electrons collect on one plate of condenser 418 and tend to leak off through resistance 417. The effect of the charge on condenser 418 is to oppose the positive potential placed on the grid of the tube by the received signal.

In case the received signal is of greater strength, the amount of electrons collected on the grid of the tube is increased and the condenser 418 is charged to a higher degree. This increases the opposition to the positive potential being placed on the grid by the incoming signal. As a result, effective strength of the signal is reduced and the output of the tube to the tuned reed relay is practically the same as it was for the weaker signal. Thus, the stronger the incoming signal, the greater the effect of the grid suppressor circuit comprising resistance 417 and condenser 418, and the resultant output of tube 410 is practically the same irrespective of the strength of the incoming signal. The capacity of condenser 418 is much higher than that used in connection with the ordinary detector circuit. One set of values which has been found to be satisfactory is one megohm for resistance 417 and .01 m. f. for condenser 418.

Relay 422 responds to thousand-cycle current since the tuned reed 423 is adjusted to vibrate at one thousand cycles per second. The condenser 421 and resistance 420 bridged in multiple across the windings of tuned reed relay 422 form a tuned circuit which will resonant at 1000 cycles,

thereby improving the operation of the tuned reed. The vibrations of the reed operate the armature 424, thereby opening the circuit which is normally closed from ground at armature 424 and its resting contact, conductor 22, normally closed springs controlled by armature 613, conductor 665, and through the windings of relays 643, 649, and the lower winding of relay 663 in multiple, to battery. The tuned reeds associated with relays 643 and 649 are designed to be set into vibration only when the current through the windings of these relays is interrupted at a particular low frequency. However, when ground is removed from conductor 665, relay 663 releases and at armature 664 and its resting contact completes the circuit for relay 600 extending from ground, armature 664 and its resting contact, working contact of armature 647 and said armature, armature 605 and its resting contact, upper winding of relay 600, to battery.

Relay 600 operates in its first step, and at armature 608 and its working contact closes a locking circuit for itself from ground at the working contact of normally operated armature 648 of relay 646. At armature 610 and its working contact it connects ground to conductor 33. When relay 663 again operates at the end of the calling signal, ground is removed from the junction point of the two windings of relay 600 and this relay now operates completely over both of its windings in series. At armature 605 and its resting contact it opens the initial energizing circuit, and at the working contact of this armature it prepares the impulsing circuit over conductor 35 to relay 518 of the toll selector TS2. At armature 601 and its resting contact it opens the incoming signalling lead to the tuned reed relays 654 and 660, and at armatures 602 and 603 it changes the connections so that frequencies F3 and F4 are available for signalling on the incoming call, and cuts off the high positive potential and frequency F2 which are used when the repeater is used on an outgoing call. At armature 609 and its working contact, relay 600 connects ground to busy conductor 29.

The ground connected to conductor 33 at armature 610 and its working contact is extended over the lower winding of relay 500 of toll selector TS2. Relay 500 operates and at its upper armature it closes contacts 502 thereby extending the ground from the busy conductor 29 to the test conductor 47 to busy the selector switch TS2 in the banks of other toll dialling selectors which have access thereto. At the same armature it closes contacts 504, thereby completing a locking circuit for the upper winding of relay 500 from ground on the busy conductor 29. At armatures 505 and its working contact it connects dial tone to the lower trunk conductor to inform the toll operator at exchange A that the equipment in exchange B is ready to receive dial impulses. At armature 506 and its working contact it short-circuits the condenser 546 which is normally connected in the circuit of relay 544 so that this relay may be used for supervision. At armatures 507 and 508, relay 500 prepares circuits which will be explained later. At armature 509 and its working contact it supplies ground for various operating and holding circuits, none of which are effective at this time, and at armature 510 and its resting contact it opens a point in the circuit of the release magnet of the switch. The equipment in exchange B is now ready to be operated to establish the desired connection.

Upon hearing the dial tone, the toll operator at the toll board in exchange A proceeds to dial the digits in the called telephone number, which in this case is assumed to be 3131. After the number has been dialled, the dialling cord DC1 may be removed from jack J1 and used in the establishment of other connections. The dialling cord DC1 is the same as the dialling cord DC2 disclosed in Fig. 7 of the drawings. The dial is arranged so that the impulsing contacts are normally open or the standard dial may be used in combination with a relay arrangement so that the operation of the dial will send corresponding ground impulses over the tip of the dialling plug. Responsive to the dialling of the first digit, three ground impulses are transmitted over the tip of plug P2 and jack J2, conductor 15, winding of relay 300, to battery. Relay 300 accordingly energizes and releases three times, and at each operation of the relay it connects a thousand-cycle potential, generated by the oscillator, through armatures 303 and 302 and their working contacts to the grid of tube 310. Accordingly, a thousand-cycle current flows through the primary winding of output transformer 319 and is induced in the secondary winding and transmitted over the trunk line conductors 20 and 21 through the working contacts of armatures 301 and 305 and said armatures. Three impulses at the rate of ten impulses per second are thereby transmitted over the trunk line conductors 20 and 21.

The three impulses of thousand-cycle current are received by the tone group TG2 through the input transformer 426 and connected to the grid of tube 410. Accordingly, three impulses of thousand-cycle current are transmitted through transformer 419 to the thousand-cycle tuned reed relay 422. The tuned reed relay 422 responds to each impulse and opens the circuit of relays 643, 649, and 663. Relay 663 releases each time its circuit is opened and at armature 664 and its resting contact it connects ground through the working contact of armature 647 and said armature, armature 605 and its working contact, conductor 35 winding of relay 518, to battery.

Relay 518 operates at each closure of its circuit and at armature 519 and its working contact closes an obvious circuit for relay 529, which operates at the first impulse and remains operated throughout the impulse train. At armature 520 and its working contact, relay 518 transmits three ground impulses to the vertical magnet 580 through armature 586 and its resting contact. Accordingly, the toll selector TS2 is operated three vertical steps and the wipers come to rest opposite the third level of bank contacts. At armature 533 and its resting contact, relay 529 opens the circuit of relay 536, and at the normally closed springs controlled by armature 532 it opens a point in the circuit of the rotary magnet 579. At armature 532 and its working contact relay 529 connects ground to the upper terminal of the winding of relay 531 to prevent the operation of this relay in series with relay 576 when off-normal springs 584 are closed on the first vertical step of the switch. Off-normal springs 528 which are closed on the first vertical step of the switch prepare a circuit for release magnet 534, off-normal springs 530 open a point in the operating circuit of relay 521, and off-normal springs 535 complete circuits for relays 551 and 512. These circuits extend from ground at the working contact of armature 509 and said armature, off-normal springs 535, and from this point through the normally closed springs controlled by armature 515, through the winding of

relay 512, to battery, and through resting contact of armature 573 and said armature, through the lower winding of relay 551, to battery.

Relay 512 operates in the above-traced circuit and at armature 513 and its resting contact disconnects dial tone from the lower trunk conductor. At armature 515 it opens the initial energizing circuit, and at the working contact of this armature it completes a locking circuit for itself dependent upon the ground through armature 509 of relay 500. At armature 516 and its resting contact it disconnects ground through a resistance from the lower talking conductor. Relay 551, in operating, at armature 555 and its working contact prepares a circuit for the upper winding of relay 547, at armatures 554, 553, and 552 it prepares a locking circuit for itself and an operating circuit for relays 539 and 556.

Relay 576 operates when off-normal springs 584 are closed on the first vertical step of the selector. The operating circuit for this relay extends from ground at the working contact of armature 509 and said armature, working contact of armature 532 and said armature, resting contact of armature 535 and said armature, off-normal springs 584, winding of relay 576, to battery. At armature 578 and its working contact, relay 576 prepares a circuit to the rotary magnet 579 which is open during the first series of impulses at armature 532 of the slow-to-release relay 529. At armature 577 and its working contact, relay 576 short-circuits the winding of relay 581.

When relay 529 drops back a short interval after the cessation of the first series of impulses, a circuit is completed from ground at the working contact of armature 509 and said armature, normally closed springs controlled by armature 532, armature 578 and its working contact, winding of rotary magnet 579, to battery. The rotary magnet energizes and rotates the wipers of the switch into engagement with the first set of bank contacts in the third level. At the rotary interrupter springs of the rotary magnet, the circuit of testing relay 576 is opened and this relay accordingly deenergizes, and, at armature 578, opens the circuit of the rotary magnet, which also releases and again closes a point in the circuit of relay 576. The operation now depends upon whether or not the trunk accessible in the first set of bank contacts is idle.

In case the first trunk is busy, there will be ground potential present on the bank contact engaged by wiper 589 and this ground is extended over armature 583 and its resting contact, interrupter springs of the rotary magnet, off-normal springs 584, winding of relay 576, to battery. This ground is also connected to the upper terminal of the winding of relay 581, thereby keeping this relay shunted to prevent its operation. Relay 576 operates, and at armature 578 and its working contact again completes the circuit for the rotary magnet. The rotary magnet operates to step the wipers of the selector into engagement with the next set of bank contacts, and at the interrupter springs associated with the magnet opens the circuit of stepping relay 576 which thereupon releases. Relay 576, in releasing, at armature 578 and its working contact opens the circuit to the rotary magnet which releases and again closes its interrupter springs to close the test circuit to the stepping relay 576. This interaction between relay 576 and the rotary magnet continues until wiper 589 is stepped into engagement with a bank contact upon which there is no ground potential.

As soon as wiper 589 fails to find ground potential, relay 581 operates in a circuit from ground at the working contact of armature 509 and said armature, winding of relay 581, interrupter springs of the rotary magnet, off-normal springs 584, winding of relay 576, to battery. Relay 576 does not operate in this circuit due to the high resistance of the winding of relay 581. At armature 583 and its working contact, relay 581 connects ground to wiper 589 to busy the seized trunk to other selectors having access thereto. At armature 585 and its resting contact it opens a point in the energizing circuit of relay 576, at armature 586 and its resting contact it opens a point in the circuit of the vertical magnet, and at the working contact of this armature it prepares an impulsing circuit from armature 520 of relay 518 through the control wiper 590, and at armature 582 and its working contact it completes a circuit for the upper winding of relay 567.

Relay 567 energizes and at armature 573 and its resting contact opens the circuit of relay 551, at armature 572 and its working contact it prepares a circuit for the upper winding of relay 547, at armatures 569 and 568 it disconnects the generator leads to prevent the possibility of signalling the operator at the toll board in exchange B, at armature 570 and its working contact it connects battery through a resistance to the sleeve of jack J3 at the toll board in exchange B to operate sleeve relay 596, and at armatures 571 and 574 and their working contacts it completes points in the talking conductors. Relay 596 opens the circuit to the calling relay at the toll board to prevent a false calling signal.

It will be assumed that the first trunk available to selector TS2 is the trunk comprising conductors 40 to 43, inclusive, and terminating in the trunk circuit TC2 shown in Fig. 7 of the drawings. When relay 567 operated and closed its armatures 571 and 572, a circuit was completed from ground, upper winding of relay 547, working contact of armature 572 and said armature, working contact of armature 555 and said armature (relay 551 being slow to release, and, therefore, remaining energized for a short time after its circuit is opened at armature 573 of relay 567), resting contact of armature 559 and said armature, working contact of armature 571 and said armature, wiper 588 and bank contact 592, conductor 40, armature 761 and its resting contact, upper winding of relay 754, to battery.

Relays 754 and 547 operate in series in this circuit. At armature 548 and its working contact relay 547 completes a locking circuit for its lower winding from ground at armature 509 of relay 500 and through off-normal springs 535, and at armature 549 and its working contact it completes the control circuit to wiper 590 of the selector. Relay 746 of the trunk circuit TC2 is operated in a circuit extending from ground, armature 519 and its resting contact, working contact of armature 549 and said armature, wiper 590 and bank contact 594, conductor 42, resistance 773, winding of relay 746, to battery. Relay 746 operates and at armature 748 and its working contact completes an obvious circuit for relay 749. At armature 747 and its working contact it closes the loop extending to the toll transmission selector switch S2, the loop including the polarized relay 769. Relay 749 operates and at

armature 752 and its working contact completes the locking circuit for relay 754 which was prepared at armature 756 and its working contact. At armature 751 and its working contact it prepares an energizing circuit for the series relay 757, at armature 759 and its working contact it connects ground to the release trunk conductor 41 to busy the trunk in the banks of all selector swtches, such as TS2 and TS3, and at armature 753 and its working contact it opens a point in a bridge circuit including relay 771.

The bridging of relay 769 across the outgoing trunk conductors 774 and 775 closes a loop to the toll transmission selector switch S2 and prepares this switch for operation. As previously stated, the toll transmission selector switch S2, and the connector switch C2 may be in all respects similar to the selector S and connector C disclosed in the previously-mentioned patent to Tharp.

When the remaining digits of the desired telephone number are dialled by the toll operator in exchange A, relay 300 responds to the impulses of each digit and at each operation it connects the thousand-cycle current source to the trunk line conductors 20 and 21. These impulses of thousand-cycle current are received by the tone group TG2 and bring about the release of relay 663 in repeater R2 in the manner previously explained. Each time relay 663 releases in accordance with the impulses of the remaining digits it connects ground over the working contact of armature 647 and said armature, armature 605 and its working contact, conductor 35, winding of relay 518, to battery. Relay 518 responds to each impulse, and at armature 519 and its resting contact it opens the circuit of the repeating relay 746 in the trunk circuit TC2. At armature 519 and its working contact it completes the circuit for relay 529 which energizes and remains energized throughout each impulse series. The operation of relay 529 opens the lower trunk conductor at armature 531 and its resting contact, but has no other effect at this time.

Each time relay 746 deenergizes in response to the impulses of the succeeding digits, it connects ground over armature 751 and its working contact, resting contact of armature 763 and said armature, winding of relay 757, to battery. Relay 757 operates and at armature 758 and its working contact shunts the windings of polarized relay 769 in order to improve the impulsing circuit. At armature 747 and its working contact, repeating relay 746 opens the loop circuit extending to the toll transmission selector switch S2, thereby repeating the impulses to this switch. The selector switch is stepped to the first level and automatically rotates over the bank contacts in this level to find an idle trunk extending to an idle connector switch, such as C2. The remaining two digits, 3 and 1, in the called telephone number are received in the same way and repeated by the trunk circuit TC2 to operate the connector switch C2 into engagement with the called line.

When the connector C2 is operated into engagement with an idle subscriber's line, the battery connections to trunk conductors 774 and 775 are reversed in a manner clearly described in the above-mentioned patent to Tharp, and this reversed battery through the polarized relay 769, which is bridged across the trunk conductors, allows it to operate and at armature 770 complete a circuit for relay 760. Relay 760 operates and at armature 764 and its working contact completes a locking circuit for itself to ground at armature 772 of relay 771. At armature 763 and its resting contact it opens the circuit of relay 757, at armature 762 and its working contact it connects an additional ground to the release trunk conductor 41, at armature 765 and its working contact it closes a point in the bridge circuit including relay 771, and at armatures 761 and 766 and their working contacts it short-circuits the condensers 767 and 768, respectively. When these condensers are short-circuited, the battery connections to conductors 774 and 775 at the toll transmission selector S2 are extended over line conductors 40 and 43, bank contacts 592 and 595, wipers 533 and 591, armatures 571 and 574 and their working contacts, armatures 559 and 558 and their resting contacts, armature 555 and its resting contact, armature 506 and its working contact, and through the winding of relay 544 and retard coil 550.

Relay 544 operates in this circuit and at armature 545 and its working contact completes a circuit extending from ground on the hold conductor 33, working contact of armature 507 and said armature, armature 545 and its working contact, armature 508 and its working contact, armature 540 and its resting contact, upper winding of relay 551, through the resistance to battery. Relay 551 operates, and at armature 554 and its working contact extends the ground through the normally closed contacts controlled by armature 541, winding of relay 539, to battery. At armature 552 and its working contact it extends the operating ground for relay 539 to its own upper winding to lock itself energized, and at armature 553 and its working contact it extends this ground to the lower winding of relay 556. Relay 539, in operating, at armature 541 and its working contact completes a locking circuit for itself from ground at armature 509 of relay 500. This ground is also extended over armature 552 and its working contact, through the upper winding of relay 551, and over the working contact of armature 553 and said armature, through the lower winding of relay 556. At armature 540 and its resting contact relay 539 opens the initial energizing circuit of relay 551 and at the working contact of this armature it completes a circuit from ground on the hold conductor 33, working contact of armature 507 and said armature, armature 545 and its working contact, armature 508 and its working contact, armature 540 and its working contact, conductor 34, resting contact of armature 631 and said armature, lower and upper windings of relay 618, to battery. The operation of relay 618 brings about the transmission of a supervisory signal to the toll operator at exchange A, as will be described presently.

Relay 539 is equipped with a weighted spring armature 542 and a short interval of time is required for this armature to come to rest against its working contact after relay 539 has been energized. Relay 556, which operated in the above-traced circuit upon the operation of relay 551, at armature 557 closes one point in the shunt circuit of relay 551, at armatures 560 and 561 it opens the trunk to the toll board in exchange B, and at armatures 558 and 559 it connects ringing generator and ground to the outgoing line conductors. This ringing current is transmitted over wipers 588 and 591 and the associated bank contacts, conductors 40 and 43, conductors 774 and 775, to the toll transmission selector S2 and serves to start the automatic ringing of the called line by the

toll connector switch, as is fully disclosed in the above-mentioned patent to Tharp.

The splash of generator current which is transmitted to the toll transmission selector by the operation of relay 556 is terminated upon the release of relay 551 after the weighted spring armature 542 of relay 539 has come to rest and completed a shunting circuit for the upper winding of relay 551 extending from ground at the working contact of armature 587, armature 557 and its working contact, armature 543 and its working contact, weighted spring armature 542 and its working contact, to the lower terminal of the upper winding of relay 551. The resistance is provided to prevent the short-circuiting of the battery. When relay 551 releases it closes a point in the talking circuit at armature 555 and its resting contact, at armature 554 and its working contact it opens the initial energizing circuit of relay 539, and at armatures 552 and 553 it opens points in the operating circuit of relays 556 and 551.

Returning now to the point where relay 539 operated and at armature 540 completed a circuit from ground on the hold conductor 33 to conductor 34 to operate relay 618 in the repeater R2, the two windings of relay 618 are energized in series and the relay begins to operate. However, as soon as armature 622 closes its working contact, a circuit is completed from ground at the working contact of armature 648 and said armature, armature 622 and its working contact, armature 629 and its resting contact, resting contact of armature 620 and said armature, to the junction point of the two windings of relay 618. Thus the lower winding of relay 618 is shunted and the relay remains in its half operated condition since it cannot fully operate over its upper winding alone. The shunting ground is also extended through armature 623 and its resting contact, winding of relay 625, resistance 632, to battery.

Relay 625 operates in this circuit and at armature 627 and its working contact completes an obvious circuit for relay 633. As soon as relay 625 operates it opens the shunting circuit to the lower winding of relay 618 and allows this relay to operate completely. At armature 623 and its resting contact, the initial energizing circuit of relay 625 is opened but this relay is now locked to ground at armature 628 and its working contact. At armature 619 and its working contact, relay 618 connects the frequency control lead 24 to conductor 670 over which alternating current of frequency F3 is supplied. Relay 625, in operating, at armature 626 and its working contact connects ground to conductor 23, through the winding of relay 406 of tone group TG2, to battery. The operation of relay 406 completes the circuit of relay 400 in an obvious circuit, and at armature 408 and its working contact it connects the plate circuit of the sending tube 410 to the frequency control conductor 24 which is extended over armature 637 and its resting contact, armature 619 and its working contact, armature 603 and its working contact, to lead 670 over which current of frequency F3 is transmitted. The operation of relay 400 connects the secondary winding of output transformer 419 across the outgoing trunk conductors 20 and 21 to transmit the supervisory signal to exchange A to indicate to the operator that the called line has been seized.

As was previously explained, the basic signalling current of one thousand cycles per second is interrupted at several different low frequencies for the transmission of the different supervisory signals. Four frequency leads have been indicated as extending to the voice frequency dialling repeaters, such as R1 and R2. The source of these different frequency currents may be the regular ringing converters which are used for frequency ringing in the automatic telephone exchanges. Thus the frequencies may conveniently be as follows: frequency F1—thirty cycles per second; frequency F2—forty-two cycles per second; frequency F3—fifty-four cycles per second; and frequency F4—sixty-six cycles per second. These frequencies are connected to the plate circuit of the sending tube of the associated tone group, so that the thousand-cycle current generated by the oscillator may be interrupted at the proper low frequency since plate current will flow in the sending tube 410 only during the positive half cycles of the low frequency current connected over the frequency control lead 24.

Returning now to the point where relay 400 operated and connected the secondary winding of transformer 419 across the outgoing trunk conductors 20 and 21, alternating current of one thousand cycles per second, interrupted at a frequency of fifty-four cycles per second, which has been assumed for frequency F3, is transmitted over the trunk line comprising conductors 20 and 21 to the automatic exchange A. The duration of this supervisory signal is determined by the time required for the weighted spring engaged by armature 634 to come to rest and complete a shunting circuit for relay 625. When armature 634 finally maintains its contact closed, relay 625 is shunted in a circuit extending from ground at the working contact of armature 607 and said armature, armature 634 and its working contact, to the upper terminal of the winding of relay 625. Relay 625 accordingly releases and armature 627 and its working contact opens the circuit of relay 633 and allows this relay to release. At armature 626 and its working contact it opens the circuit of relay 406 which accordingly releases, and at armature 407 and its working contact opens the circuit of relay 400. Relay 400 in releasing disconnects the sending apparatus from the outgoing trunk line and at the resting contacts of armatures 401 and 405 it again extends the trunk conductors to the toll selector TS2.

The one thousand cycle signalling current interrupted at frequency F3 or fifty-four cycles per second, is received at the tone group TG1 in exchange A and passes through the primary winding of input transformer 326. The current induced in the secondary winding of this transformer is impressed upon the grid of tube 310 causing a corresponding plate current through the primary winding of transformer 319. The current induced in the secondary winding passes through the thousand cycle tuned reed relay 322 and causes this relay to open contacts 324 at the rate of fifty-four times per second. The opening of contacts 324 at the frequency F3 interrupts the circuit of tuned reed relays 254 and 260 at a corresponding rate. The tuned reed 255 of relay 254 is designed to vibrate at fifty-four cycles per second, and when the circuit of relay 254 is interrupted at this rate the reed begins to vibrate and operates the armatsure spring 256, thereby opening the circuit of relay 252. Relay 252 releases and at armature 253 and its resting contact completes an obvious circuit for relay 257.

Relay 257 operates and at armature 258 and its working contact locks itself operated to ground

at armature 262 of relay 260 through armature 217 and its working contact. At armature 259 and its working contact it connects ground to conductor 3 which is extended over this conductor to the winding of relay 163 of toll selector TS1. Relay 163 operates and at armatures 165 and 166 and their working contacts connects the battery-feed coil 162 across the two line conductors extending to the toll board in exchange A. This battery connection to the line conductors operates the supervisory relay in the cord circuit CC1, which corresponds to relay 701 of the cord circuit CC2, shown in Fig. 7 of the drawings, and the latter relay at its armature and working contact lights the supervisory lamp associated with cord circuit CC1 to inform the operator that the connection has been extended to an idle line.

As was previously explained, when relay 539 of toll selector TS2 in exchange B first operated, it grounded the supervisory conductor 34 to transmit a supervisory signal to the toll board of exchange A and also brought about the release of relays 551 and 556 to end the splash of generator to the toll transmission selector S2 which started the automatic ringing of the connector C2. When the called subscriber answers the call, battery is removed from the conductors 774 and 775 extending to the toll transmission selector and the trunk is cut dry in a manner clearly pointed out in the above-mentioned patent to Tharp. As soon as battery is removed from line conductors 40 and 43, relay 544 in toll selector TS2 releases and at armature 545 and its working contact removes ground from the supervisory lead 34, thereby opening the circuit of relay 618. Relay 618 starts to release and its second-step armatures 619, 620, 621, and 623 close their resting contacts before the first-step armatures 622 and 624 have opened their working contacts. When the relay reaches its first-step position, the following circuit is closed for the upper winding of the relay: from ground at the normally operated contact of relay 646, armature 648, armature 622 and its working contact, armature 629 and its resting contact, resting contact of armature 620 and said armature, upper winding of relay 618, to battery. The energization of the upper winding of relay 618 is sufficient to hold the relay in its first-step position.

A circuit is now closed from ground at armature 648 of relay 646, armature 622 and its working contact, armature 623 and its resting contact, winding of relay 625, to battery. Relay 625 operates and at armature 628 and its working contact completes a locking circuit for itself. At armature 627 and its working contact it completes a circuit for relay 633, at armature 629 and its resting contact it opens the circuit for the upper winding of relay 618 which now completely releases, and at armature 626 and its working contact it connects ground to the sending conductor 23 to operate relay 406 of the tone group TG2. Relay 406 brings about the operation of relay 400 to connect the tone generating circuit to the outgoing trunk conductors 20 and 21 and at armature 408 and its working contact it connects the plate circuit of sending tube 410 to the frequency control conductor 24. Since relay 618 is now completely released, the frequency conductor 24 extends over armature 637 and its resting contact, armature 619 and its resting contact, armature 602 and its working contact, and over conductor 668 to the source of current of frequency F4 which has been assumed to be sixty-six cycles per second. A signal consisting of one thousand cycle current interrupted at sixty-six cycles per second is now being transmitted over trunk line conductors 20 and 21 to exchange A.

Relay 633 energizes when its circuit is closed at armature 627 of relay 625 and, after an interval, armature 634 and its working contact remain closed, thereby short-circuiting the winding of relay 625 in the manner previously described. Relay 625 thereupon releases and at armature 626 and its working contact it removes ground from the sending conductor 23 to terminate the supervisory signal being transmitted over the trunk line. At armature 628 and its working contact it opens its own locking circuit, at armature 629 and its working contact it opens a point in the locking circuit of relay 618, at armature 630 and its working contact it opens one ground connection to the busy conductor 29, and at armature 631 and its resting contact it again prepares the initial energizing circuit of relay 618.

The answering supervisory signal transmitted over trunk line conductors 20 and 21 to exchange A is received at tone group TG1 and operates the thousand cycle tuned reed relay 322. Accordingly, the circuit of tuned reed relays 254 and 256 are interrupted at a rate of sixty-six cycles per second. The reed 261 of relay 260 is tuned to respond to this frequency, and, accordingly, operates its armature 262, thereby opening the locking circuit of relay 257. Relay 257 releases and at armature 258 and its working contact opens a point in its locking circuit, and at armature 259 and its working contact removes ground from the supervisory lead 3, thereby opening the circuit of relay 163 of toll selector TS1. Relay 163 releases and at armatures 165 and 166 and their working contacts removes the battery connections from the trunk line conductor extending to toll board A, thereby allowing the supervisory relay in cord circuit CC1 to release and put out the supervisory lamp. This informs the operator that the called subscriber has answered and she may now cut through the connection through her cord circuit and the calling and called subscribers may converse.

At the end of the conversation when the subscriber at substation T2 replaces his receiver, battery and ground are again connected to conductors 774 and 775 and extended over conductors 40 and 43 and wipers 588 and 591 of toll selector TS2 to again operate relay 544. Relay 544 at armature 545 and its working contact again connects ground to the supervisory lead 34, thereby operating relay 618 in the manner previously described. Relay 618 operates in its first step and brings about the operation of relays 625 and 633 in the manner previously described. Relay 625 starts the transmission of a disconnect signal consisting of thousand-cycle current interrupted at frequency F3 and the operation of armature 634 of relay 633 terminates the disconnect signal. The operation of these relays to send the disconnect signal is the same as previously explained for sending the supervisory signal when the connector C2 was operated into engagement with an idle called line.

At exchange A the disconnect signal operates tuned reed relay 322 which opens the circuit of relays 254 and 260 at a rate of fifty-four times per second. Relay 254 responds and at armature 256 and its working contact opens the circuit of relay 252 which releases and at armature 253 and its resting contact completes the circuit of relay 257. Relay 257 operates and at

armature 258 and its working contact completes a locking circuit for itself and at armature 259 and its working contact grounds the supervisory lead 3, thereby operating relay 163 of the toll selector TS1. Relay 163 again bridges the battery-feed coil 162 across the trunk line conductors extending to the toll board, thereby lighting the supervisory lamp associated with cord circuit CC1 in the manner previously described.

In case the toll operator at exchange A wishes to re-ring the subscriber T2, she operates the ringing key associated with her cord circuit, thereby connecting ringing current over the tip and ring of cord circuit CC1 and jack J1, through condenser 146, winding of relay 144, and the retard coil 150. Relay 144 operates and at armature 145 and its working contact connects ground from the busy conductor 2 over resting contacts of armature 107 and said armature, armature 145 and its working contact, armature 108 and its resting contact, conductor 5, winding of relay 236, to battery. Relay 236 operates and at armature 237 and its working contact connects the frequency control conductor X to conductor 271, over which alternating current of frequency F1 or thirty cycles per second is supplied. At armature 223 and its working contact it connects ground to conductor Y, thereby operating relays 306 and 300 in tone group TG1. The operation of relay 300 brings about the connection of the tone generating equipment to the outgoing line conductors 20 and 21 and a re-ring signal consisting of thousand-cycle alternating current interrupted at thirty cycles per second is transmitted over trunk line conductors 20 and 21 to automatic exchange B.

This re-ring signal is received by tone group TG2, causing the operation of the tuned-reed relay 422, which interrupts its contacts 424 at the rate of thirty times per second. The reed 644 of tuned reed relay 643 is tuned to respond to this frequency and operates its armature 645, thereby opening the circuit of relay 641. Relay 641 releases and at armature 642 and its resting contact connects ground to conductor 31, thereby completing the energizing circuit for the upper winding of relay 556. Relay 556 operates and at armatures 559 and 558 and their working contacts it again connects the generator leads to wipers 583 and 591, thereby transmitting ringing current to the toll transmission selector S2. This brings about the signalling of the subscriber at substation T2 by the toll connector C2 in the manner clearly described in the above-mentioned patent to Tharp.

The re-ring signal is transmitted over the trunk line to exchange B as long as the toll operator at exchange A holds her key depressed. When she releases the key, relay 144 releases and at armature 145 and its working contact opens the circuit of relay 236. Relay 236 releases and at armature 238 and its working contact disconnects ground from conductor Y, thereby terminating the re-ring signal. When the called subscriber answers after being re-rung in the above-described manner, battery is disconnected from the trunk line conductors 774 and 775, thereby bringing about the release of relay 544. Relay 544 at armature 545 and its working contact disconnects ground from conductor 34, thereby bringing about the release of relay 618 and the transmission of an answering signal to exchange A in the manner previously described. This answering signal extinguishes the supervisory lamp at the toll operator's position in exchange A, thereby informing the operator that the subscriber at substation T2 has again answered.

Returning now to the point where the supervisory lamp at the toll operator's position in exchange A was lighted responsive to the disconnection of the called subscriber, the operator now removes the plug P1 from the jack J1. Relay 196 releases and removes ground from the hold conductor 1, thereby opening the circuit of relay 212 of voice frequency repeater R1. Relay 212 releases and at armature 213 and its working contact disconnects ground from conductor 265 and connects this conductor to the impulse conductor Z. At armature 214 and its working contact it opens the locking circuit of relay 218, at armature 215 and its working contact it removes the ground shunt from armature 235 of relay 233 and the associated weighted spring contact, at armature 216 and its working contact it removes ground from the busy conductor 2, and at armature 217 and its working contact it opens a point in the locking circuit of relay 257.

Relay 218 begins to release and as soon as armature 220 closes its resting contact a circuit is closed from ground at the working contact of armature 243 and said armature, armature 222 and its working contact, armature 229 and its resting contact, resting contact of armature 220 and said armature, upper winding of relay 218, to battery. The energization of the upper winding of the relay is sufficient to hold the relay in its first step with armatures 222 and 224 still operated, but the remaining armatures in engagement with their resting contacts. A circuit is, therefore, closed from ground at armature 248, armature 222 and its working contact, armature 223 and its resting contact, winding of relay 225, to battery.

Relay 225 energizes and at armature 227 and its working contact completes a circuit for the timing relay 233. At armature 229 and its resting contact it opens the circuit for the upper winding of relay 218 and allows this relay to completely release. At armature 226 and its working contact it connects ground to the sending conductor Y, thereby operating relay 306 of tone group TG1. Relay 306 in turn operates the relay 300, thereby connecting the tone generating circuit to the outgoing trunk conductors 20 and 21. At armature 308 and its working contact, relay 306 connects the plate circuit of sending tube 310 to conductor X which extends over armature 237 and its resting contact, armature 219 and its resting contact, armature 202 and its resting contact, to frequency F2 conductor 267. Alternating current having a frequency of forty-two cycles per second is thereby connected to the plate circuit of the sending tube 310 and a release signal consisting of thousand cycle current interrupted forty-two times per second is transmitted over the trunk line conductors 20 and 21. Since in this case the ground connection is removed from armature 234 of relay 233, the shunting circuit of relay 225 is not completed until armature 235 of relay 233 maintains its contact with its weighted spring armature, which, as previously stated, is about three times as long as the time required for armature 234 to maintain its contact with its weighted spring armature.

When armature 235 finally completes its contact with its weighted spring armature, a circuit is completed from ground, armature 235 and its working contact, armature 234 and its working contact, to the upper terminal of the

winding of relay 225. Relay 225, therefore, releases and at armature 226 and its working contact disconnects ground from the sending conductor Y, thereby terminating the release signal. At armature 228 and its working contact it opens its own locking circuit, at armature 227 and its working contact it opens the circuit of relay 233, at armature 231 and its resting contact it again prepares a circuit for relay 218, and at armature 230 and its working contact it disconnects the last ground connection to the busy conductor 2.

Ground has now been removed from the hold conductor 1 and the busy conductor 2 and relay 167 in toll selector TS1 accordingly releases. The equipment in the automatic exchange A has now been restored to its normal condition.

The long release signal consisting of one thousand cycle current interrupted at a rate of forty-two times per second is received by tone group TG2 and operates the tuned reed relay 422 which in turn opens the circuit of relays 643, 649, and 663 at a corresponding rate. Relay 649 responds to this signal and its vibrating armature 650 operates armature 651, thereby opening the circuit of relay 646. Relay 646 releases and at armature 647 and its working contact opens a point in the impulsing circuit and at armature 648 and its working contact it opens the locking circuit of relay 600 which accordingly releases. Relay 600, in releasing, at armature 604 and its working contact opens a point in the circuit of the polarizing winding of relay 639, at armature 609 removes ground from the busy conductor 29, and at armature 610 and its working contact removes ground from the hold conductor 33.

The removal of ground from hold conductor 33 brings about the release of relay 500. Relay 500, in releasing, at armature 509 and its working contact opens the locking circuit of relays 539, 547, and 512. At armature 510 and its resting contact it completes the circuit for release magnet 534 over off-normal springs 528, and the toll selector TS2 accordingly releases. The removal of ground at armature 509 and its working contact also opens the locking circuit of relay 531 which releases and in turn opens the circuit of relay 567. The selector TS2 and its associated repeater and tone relay group have now restored to normal.

The release of the toll selector TS2 removes ground from the control conductor 42 extending to the trunk circuit TC2, thereby allowing relay 746 to release. At armature 748 and its working contact relay 746 opens the circuit of relay 749, and at armature 747 and its working contact it opens a point in the bridge circuit across the outgoing trunk conductors. Relay 749 releases and at armature 752 and its working contact opens the locking circuit of relay 754, at armature 750 and its working contact removes ground from the test conductor 41, and at armature 753 and its resting contact closes a loop circuit across the outgoing trunk conductors 774 and 775 through relay 771. Since battery is connected across these trunk conductors at the toll transmission selector, relay 771 operates and at armature 772 and its working contact opens the locking circuit of relay 760. Relay 760 releases and at armature 762 and its working contact it removes the last ground connection from the test conductor 41, thereby rendering this trunk circuit available to selectors, at armatures 761 and 766 it removes the short-circuit from condensers 767 and 768, and at armature 765 and its working contact it opens the bridge circuit including relay 771. After an interval relay 771 releases and again prepares the locking circuit of relay 760.

As the loop circuit to the toll transmission selector S2 and connector C2 has now been opened, these switches release in the manner clearly described in the above-mentioned patent to Tharp. All the apparatus used in the establishment of a connection from the toll operator at exchange A to substation T2 in exchange B has now been released and is in its normal condition.

In case the operator at the toll board A is the first to release, the voice frequency repeater R1 and the one group TG1 transmit the release signal over conductors 20 and 21 to exchange B in the manner pointed out above. This brings about the release of the toll selector TS2, thereby removing ground from the control conductor 42 extending to trunk circuit TC2. Relays 746 and 749 are accordingly released in the manner pointed out above and the relay 771 is bridged across trunk conductors 774 and 775 extending to the toll transmission selector S2. Relay 760 remains locked energized to the back contacts of armature 772 and at armature 762 and its working contact maintains ground on test conductor 41 to prevent the seizure of the trunk circuit TC2 by any selector, such as TS2. When the called party replaces his receiver, battery is connected to trunk conductors 774 and 775 and relay 771 operates to open the locking circuit of relay 760 in the manner previously described. Relay 760 releases and at armature 765 opens the circuit of relay 771, thereby allowing this relay to release. Thus it is seen that the release of the toll train is controlled by the last party to disconnect.

In the foregoing explanation of the establishment of a call from the toll operator at exchange A to a substation such as T2 in exchange B, the utility and function of relay 639 in the voice frequency dialling repeater R2 was omitted for clarity. The purpose and operation of this relay will now be explained.

Referring to Fig. 6 of the drawings, it is seen that when ground is intermittently removed from the receiving conductor 22 responsive to the receipt of dialling impulses or thousand-cycle signalling current interrupted at frequencies F1 or F2, the circuits of the tuned reed relays 643 and 649 and of the lower winding of relay 663 are intermittently interrupted. Relay 663 controls the operation of the toll selector TS2 and succeeding switches in the toll train by connecting ground to the impulse conductor at armature 664 and its resting contact responsive to thousand cycle current interrupted at dial speed. However, when a signalling current is received interrupted at frequencies F1 or F2 the circuit of relay 663 is also interrupted and armature 664 would ordinarily be released to send ground impulses over the impulsing conductor 35, thereby interfering with the operation of the switches and causing chattering of relays during the time that the switches are in talking condition. Also, in case the toll operator wishes to release the connection after it has been partially set up, the release signal consisting of thousand cycle current interrupted at frequency F2 would intermittently release relay 663, thereby sending impulses over the impulsing lead to the automatic switches. The operation of the repeating relay 746 of the trunk circuit TC2 causes a short-circuit to be placed across the trunk conductor

which would interfere with the incoming line signal. It is also desirable to prevent the possible operation of relay 663 by voice currents after the talking circuit has been established. In order to eliminate these difficulties, the polarized relay 639 has been provided.

This relay is of the type disclosed in Patent No. 1,673,884, granted June 19, 1928, to Harold C. Pye. The lower winding of the relay is the polarizing winding while the upper winding is the operating winding. When relay 600 is operated as soon as a call is received, the lower winding of relay 639 is energized from ground, armature 664 and its working contact, working contact of armature 604 and said armature, lower winding of relay 639, to battery. This energizes the polarizing winding which is not of sufficient strength to operate the relay, but which is sufficiently strong to maintain the relay energized after it has once been operated. When dialling impulses are received, the circuits of the tuned reed relays 643 and 649 and the relay 663 are interrupted at normal dial speed which is ten impulses per second. Relays 643 and 649 do not respond to these interruptions, but relay 663 releases at each interruption of its circuit and at armature 664 and its resting contact transmits corresponding ground impulses to operate the automatic switches. Each time it releases its armature, it opens the circuit of the lower polarizing winding of relay 639.

The polarizing winding of relay 639 is wound on the heel end of the core while the operating winding is wound on the armature end of the core as fully disclosed in the above-mentioned patent to Pye. A magnetic shunt is provided from a point on the core between the two windings to the armature end of the relay and this magnetic shunt member forms a back stop for the armature. Thus, normally, with the polarizing winding energized, the major portion of the magnetic flux passes through the lower half of the core, through the shunting member and back stop, and thence by way of the armature and heel piece to the lower end of the core. A smaller amount of flux passes entirely through the core and through the air gap between the core and armature and then through the heel piece back to the other end of the core.

Referring to Fig. 6, it is seen that the operating or upper winding of relay 639 is normally shunted from ground at armature 626 and its resting contact. Under the above conditions, when the circuit of the polarizing winding is opened the magnetic flux passing through the shunt member of the relay immediately collapses while the smaller amount which is passing through the upper portion of the core and is tending to attract the armature to the core persists for an interval due to the short-circuited operating winding. Thus the flux tending to attract the armature to the core persists for an interval while the flux holding the armature against the back stop immediately collapses, and as a result the relay is operated for an instant each time the circuit of the polarizing winding is opened.

When dialling impulses are being received at the rate of ten per second, relay 663 releases at each impulse and opens the circuit of the polarizing winding, thereby causing relay 639 to snap up for an instant. However, the relay immediately falls back and has released by the time the circuit to its polarizing winding is again completed by the operation of relay 663. Thus it is seen that when dialling impulses are being received, relay 639 operates momentarily each time an impulse is received but again drops back before the circuit to its polarizing winding is closed, and, therefore, does not remain operated. However, when signalling current is received which is interrupted at frequency F1 or F2, which in this case has been assumed to be thirty cycles per second and forty-two cycles per second, respectively, one of the relays 643 or 649 is operated responsive to the interruptions of current and relay 663 is also released at each interruption. Each time relay 663 releases the circuit is interrupted for the polarizing winding of relay 639 and this relay operates in the manner described above. However, in this case the succeeding impulse follows before relay 639 has had time to release and the relay is still operated when the circuit of the polarizing winding is again closed by the operation of relay 663. As was previously stated, the polarizing winding is of sufficient strength to maintain the relay operated once it has been operated. Relay 639 is, therefore, held operated when relay 663 again operates and at armature 640 and its working contact it completes a locking circuit for relay 663 extending from ground, armature 664 and its working contact, working contact of armature 604 and said armature, working contact of armature 640 and said armature, upper winding of relay 663, to battery. Thus it is seen that when signalling current being interrupted at frequency F1 or F2 is being received, relay 663 locks energized so that it will not respond to each interruption of its circuit and cause interference with the incoming signal. However, this arrangement does not interfere with the repeating of the dialling impulses by relay 663, since in this case relay 639 has each time released before relay 663 again operates.

It will be noted that the upper or operating winding of relay 639 is shunted by ground through armature 626 and its resting contact of the signal sending relay 625. Thus on an incoming call, after the connection has been set up and an idle line connected with, relay 625 operates to transmit a supervisory signal to the calling operator in the manner explained above. At armature 626 and its resting contact it removes the short circuit from the upper or operating winding of relay 639 and this relay operates and at armature 640 and its working contact completes a locking circuit for the upper winding of relay 663 in multiple with its own polarizing winding. Thus relays 663 and 639 are locked in operated position as soon as dialling has been completed and an idle line connected with. These relays remain locked up until relay 600 releases in response to the release signal from the calling exchange.

From the foregoing, it is clear that the arrangement just described provides for the locking up of relay 663 when signals are received at other than dial speed and as soon as the connection has been set up and before the talking circuit is established. This prevents any false operation of this relay which might interfere with received signals or with conversation taking place over the toll line.

Call from toll board in exchange A to substation T3 in exchange C

It will now be assumed that the toll operator at exchange A receives a request for a connection to a substation in exchange C, such as the sub-

station T3, shown in the trunking layout of Fig. 10. The operator inserts the plugs P1 and P2 of cord circuit CC1 and dialling cord DC1 into the jacks, such as J1 and J2 of an idle trunk circuit extending to exchange B. Responsive to the seizure of the trunk, the voice frequency repeater R1 and tone group TG1 transmit a calling signal of uninterrupted thousand cycle current over the trunk line to prepare the equipment in exchange B in the manner previously described. The toll operator upon hearing the dial tone returned from selector TS2 in exchange B proceeds to dial the digits of the called number. The first digit in this case will be the digit 0 to select the desired exchange, and this is followed by the four digits in the called subscriber's number.

Responsive to the dialling of the digit 0, toll selector TS2 is operated ten vertical steps and at the end of the series of impulses it automatically rotates over the tenth level until it finds an idle trunk extending to exchange C. It will be assumed that the trunk seized by selector TS2 is that available over conductors 36, 37, 38, and 39 and terminating in toll selector TS3, repeater R3, and tone group TG3. In order to expedite the explanation of the call it will be assumed that the toll selector TS1, repeater R1, and tone group TG1 are the switches associated with the trunk extending to automatic exchange C. It will further be assumed that the toll selector TS1 is seized by toll selector TS2 over conductors 9, 10, 11, and 12.

As soon as the wipers of selector TS2 are operated into engagement with the trunk extending to selector TS1, ground is sent forward over wiper 589 from ground at the working contact of armature 583 and said armature, wiper 589 and associated bank contact, conductor 37, conductor 10, (Fig. 1), contacts 101, conductor 1, resting contact of armature 206 (Fig. 2) and said armature, winding of relay 212, to battery. In this case the negative line wiper 538 does not encounter a battery potential through the winding of a relay, such as relay 754 of trunk circuit TC2, as is the case in which the call is for a subscriber in exchange B, and relay 547 does not operate. Relay 212 operates in the above-traced circuit and at armature 214 and its working contact completes the circuit for the two windings of relay 218 in series. At armature 215 and its working contact it prepares a shunting circuit for relay 225, at armature 216 and its working contact it grounds the busy conductor 2, at armature 217 and its working contact it prepares a locking circuit for relay 257, and at armature 213 it disconnects the sending conductor Z from conductor 265 and connects ground to the latter conductor.

Relay 218 begins to operate but as soon as armature 222 engages its working contact a circuit is completed from ground, working contact of armature 248 and said armature, armature 222 and its working contact, armature 229 and its resting contact, resting contact of armature 220 and said armature, to the junction point of the two windings of relay 218. The lower winding of this relay is thereby shunted out and since the upper winding is not of sufficient strength to operate the relay completely, the relay remains in its first step with armatures 222 and 224 engaging their respective working contacts. The ground from armature 248 is also extended over armature 222 and its working contact, armature 223 and its resting contact, winding of relay 225, to battery. Relay 225 operates and at armature 227 and its working contact completes the circuit for relay 233, at armature 228 and its working contact completes its own locking circuit, at armature 229 and its resting contact opens the shunt circuit of the lower winding of relay 218, thereby allowing this relay to operate completely, and at armature 226 and its working contact connects ground to the sending conductor Y, thereby operating relays 306 and 300 in the tone group TG1 and bringing about the connection of the tone generating equipment to the outgoing trunk line conductors 20 and 21, which in this case are assumed to correspond to conductors 44 and 45 extending to exchange C.

An uninterrupted splash of thousand cycle current is thereby transmitted over the trunk line to exchange C and this splash of current is terminated as soon as armature 234 of relay 233 engages its weighted spring working contact, thereby shunting the winding of relay 225 and allowing this relay to release. Relay 225 in releasing brings about the release of relays 306 and 300 of tone group TG1, thereby terminating the calling signal, at armature 227 and its working contact it opens the circuit of relay 233, at armature 228 and its working contact it opens its own locking circuit, and at armature 229 and its resting contact it again prepares a shunting circuit for the lower winding of relay 218.

The calling signal of uninterrupted thousand cycle current transmitted over the trunk line conductors 44 and 45 to exchange C is received by the toll selector TS4, repeater R4, and tone group TG4 (Fig. 10) and prepares this equipment for operation.

The succeeding digits of the called number dialled by the toll operator in exchange A are transmitted in the form of impulses of one thousand cycle alternating current over trunk line conductors 20 and 21 to tone group TG2 in exchange B. The tuned reed relay 422 responds to these impulses and interrupts the circuit of relay 663 of repeater R2 a corresponding number of times in the manner previously explained. Each time relay 663 releases it grounds the impulse conductor 35, thereby operating relay 518. Each time relay 518 operates in accordance with the digits of the called number, it completes a circuit from ground, working contact of armature 520 and said armature, armature 586 and its working contact, resting contact of armature 549 and said armature, wiper 590 and associated bank contact, conductor 38 (conductor 11), armature 164 and its resting contact, conductor 15, winding of relay 300, to battery. Relay 300 operates at each impulse of the dialled digits and connects the tone generating equipment to the outgoing trunk conductors 20 and 21 corresponding to trunk conductors 44 and 45 extending to exchange C.

These impulses of thousand cycle alternating current are received in exchange C by tone group TG4 and repeater R4 and serve to operate toll selector TS4, the toll transmission selector S3, and the toll connector C3 in the same manner as explained for the operation of toll selector TS2, toll transmission selector S2, and toll connector C2 in the explanation of the establishment of a connection from the toll operator in exchange A to subscriber T2 in exchange B. When an idle line is connected with, battery is connected to the line conductors by the toll transmission selector S3, which brings about the transmission of a supervisory signal by repeater R4 and tone group TG4 over trunk line

conductors 44 and 45 extending to exchange B. This signal consists of one thousand cycle alternating current interrupted at frequency F3 or at fifty-four interruptions per second. The signal is received over trunk line conductors 44 and 45 (conductors 20 and 21), thereby causing the tuned reed relay 322 to open its contact 324 at the rate of fifty-four times per second. This interrupts the circuit to tuned reed relays 254 and 260 at a corresponding rate and relay 254 responds and opens its contact 256, thereby opening the circuit of relay 252 and allowing this relay to release.

Relay 252 in releasing completes the circuit of relay 257 which operates and at armature 258 and its working contact completes a circuit for itself dependent upon ground at the armature 262 of relay 260. At armature 259 and its working contact it completes a circuit from ground, working contact of armature 259 and said armature, conductor 3, winding of relay 163, to battery. Relay 163 operates and at armatures 165 and 166 and their working contacts connects the battery-feed coil 162 across the two line conductors 9 and 12 extending from the banks of toll selector TS2. The connection of battery over wipers 588 and 591 of toll selector TS2 brings about the operation of relay 544 which in turn grounds the supervisory conductor 34 to send a supervisory signal consisting of thousand cycle current interrupted at frequency F3 over trunk line conductors 20 and 21 to exchange A to light the supervisory lamp in the operator's cord circuit in the manner previously described.

When the called subscriber answers, battery is removed at the toll transmission selector S3, thereby causing the voice frequency equipment in exchange C to transmit an answering supervisory signal consisting of thousand cycle alternating current interrupted at frequency F4 or sixty-six times per second. This signal is received by tone group TG3 in exchange B, and the relay corresponding to relay 260 in repeater R1 responds to this signal, and at armature 262 and its normally closed contact opens the locking circuit of relay 257. Relay 257 releases and at armature 259 and its working contact removes ground from the supervisory conductor 3, thereby bringing about the release of relay 163. Relay 163 in releasing removes the battery connections from the incoming line conductors extending to selector TS2, thereby allowing relay 544 to release and remove ground from the supervisory lead 34. This brings about the release of relay 618 in its two steps and the subsequent operation of relays 625 and 633 to transmit a corresponding answering supervisory signal over trunk line conductors 20 and 21 to automatic exchange A to put out the supervisory lamp at the operator's position.

At the end of the conversation, when the subscriber at substation T3 replaces his receiver, battery is again connected to the line conductors extending to the trunk circuit TC3, in the manner previously described. This brings about the transmission of a disconnect signal by the voice frequency equipment in exchange C, in the manner previously described in connection with the equipment in exchange B on a call from the toll operator in exchange A to a subscriber in exchange B. The disconnect signal is received over trunk line conductors 20 and 21 (conductors 44 and 45) and again brings about the operation of the tuned reed relay 254 which opens the circuit of relay 252 and allows this relay to release. Relay 252 at armature 253 and its resting contact completes the circuit of relay 257 which operates and locks itself operated at armature 258 and its working contact. At armature 259 and its working contact it again grounds the supervisory conductor 3, thereby operating relay 163 which bridges the battery feed coil 162 across the line conductors extending to selector TS2. Relay 544 in selector TS2 responds to this connection of battery to the line conductors, and at armature 545 again connects ground to supervisory conductor 34 to cause the repeater R2 and tone group TG2 to send out a corresponding disconnect signal over trunk line conductors 20 and 21 to exchange A to again light the supervisory lamp at the operator's position and inform her that the called subscriber has replaced his receiver.

When the toll operator removes plug P1 from jack J1, a release signal of thousand cycle alternating current interrupted at frequency F2 or forty-two interruptions per second is transmitted over trunk line conductors 20 and 21 to exchange B to bring about the operation of the tuned reed relay 649 which opens the circuit of relay 646, thereby disconnecting ground from the winding of relay 600 and allowing this relay to release. The release of relay 600 brings about the release of the toll selector TS2, in the manner previously described. When selector TS2 releases it removes ground from conductor 37 (conductor 10), thereby removing ground from the hold conductor 1 and allowing relay 212 to release. Relay 212 in releasing brings about the release of relay 218 to its first step which results in the operation of relay 225 to start the transmission of the release signal over trunk line conductors 44 and 45 (conductors 20 and 21) by the tone group TG1. At armature 227 and its working contact, relay 225 energizes relay 233 which after an interval maintains its armature 235 against the weighted spring working contact, thereby shunting relay 225 and causing this relay to release to terminate the release signal.

The release signal is transmitted over trunk line conductors 44 and 45 to the voice frequency equipment in exchange C and brings about the release and restoration to normal of all the switches and equipment in this exchange in the manner previously described in connection with exchange B. All the apparatus used in the establishment of a connection from the toll board in exchange A to substation T2 in exchange C has now been released and is in its normal condition.

Calls from the toll operator in exchange B to subscribers in exchange A or subscribers in exchange C are established in the same manner as described in detail in connection with a call from a toll operator in exchange A to a subscriber, such as T2, in exchange B. The toll operator at exchange C can also establish connections to subscribers in exchange B in the same manner. Calls from the toll operator in exchange C may be established to subscribers, such as T1, in exchange A by way of exchange B in a manner similar to that just described in detail in connection with a call from the toll operator in exchange A to the subscriber T3 in exchange C. Thus it is seen that any one of the toll operators may establish a connection to any subscriber in either of the other exchanges direct by dialling and without the assistance or intervention of a second toll operator.

Call from the toll operator in exchange A to the toll operator in exchange B

It will now be assumed that the toll operator at exchange A desires to secure some information from the toll operator at exchange B or desires that the toll operator at exchange B shall complete the requested connection. In this case the operator in exchange A inserts plug P1 of the cord circuit CC1 into jack J1, thereby bringing about the transmission of a calling signal to exchange B consisting of uninterrupted thousand cycle current in the manner previously explained. This calling signal prepares the equipment in exchange B for operation.

The toll operator at exchange A then operates her ringing key, thereby transmitting ringing current over the line outgoing from the toll board. This ringing current passes through condenser 146 and operates relay 144, thereby completing a circuit from grounded busy conductor 2, resting contact of armature 107 and said armature, armature 145 and its working contact, armature 108 and its resting contact, conductor 5, winding of relay 236, to battery. Relay 236 operates and at armature 238 and its working contact grounds the sending conductor Y, thereby bringing about the operation of relays 306 and 300 to connect the tone generating equipment to the outgoing trunk conductors 20 and 21. At armature 237 and its working contact it connects the plate circuit of the sending tube 310 over conductor X to the source of alternating current of frequency F1 available over conductor 271. A signal of one thousand cycle current interrupted at frequency F1 or thirty cycles per second is thereby transmitted over trunk line conductors 20 and 21 to exchange B, as long as the ringing key at the operator's position is held operated.

This ringing signal is received at tone group TG2 over conductors 20 and 21 and brings about the operation of the tuned reed relay 422 at the rate of thirty times per second. Relay 422 accordingly interrupts the circuit of relays 643, 649, and 663 at a corresponding rate. Relay 639 operates at the first release of relay 663 and is still operated when relay 663 again operates and closes a circuit to the polarizing winding of relay 639 and this relay, therefore, locks energized and also locks relay 663 energized so that this relay will not respond thereafter to the ringing signal. Relay 643 responds to the ringing signal when its circuit is opened at the rate of thirty times per second and the vibrating reed 644 operates armature 645, thereby opening the circuit of relay 641. Relay 641 releases and at armature 642 and its resting contact connects ground over conductor 31, off-normal springs 530, armature 523 and its resting contact, through the upper winding of relay 521, to battery.

Relay 521 operates in its first step and at armature 526 and its working contact completes a locking circuit for itself from grounded armature 509 and its working contact. However, relay 521 cannot operate completely as long as its lower winding is shunted by the ground extended over conductor 31. The ground on conductor 31 also extends through the upper winding of relay 556, to battery. Relay 556 operates and at armatures 560 and 561 it completes the following circuit for the ring-up relay at the toll operator's position: from generator, armature 569 and its resting contact, working contact of armature 560 and said armature, armature 593 and its resting contact, condenser, winding of ring-up relay, resting contact of armature 599 and said armature, armature 561 and its working contact, resting contact of armature 568 and said armature, to generator ground. The ring-up relay operates in this circuit and at contacts on this relay brings about the lighting of a calling lamp at the operator's position to inform her that she is being signalled over the trunk extending from exchange A.

When the operator at exchange A releases the ringing key she terminates the calling signal. Relay 643 ceases to vibrate its tuned reed armature 644 and the circuit of relay 641 is again closed. Relay 641 operates and at armature 642 and its working contact removes ground from conductor 31, thereby allowing relay 556 to release and cut off the generator from the calling relay at the toll operator's position in exchange B. As soon as ground is removed from conductor 31, the lower winding of relay 521 is no longer shunted, and this relay operates completely over both of its windings in series. At armature 522 and its working contact it prepares a circuit for relay 536, at armature 523 and its resting contact it opens its initial energizing circuit, at armature 527 and its working contact it completes an operating circuit for relay 512 which operates and at armature 515 and its working contact locks itself operated to armature 509, and at armature 525 and its working contact it completes a circuit from the grounded hold conductor 33, resting contact of armature 538 and said armature, armature 525 and its working contact, conductor 34, resting contact of armature 631 and said armature, both windings of relay 618 in series, to battery.

Relay 618 begins to operate and in its first step closes its armatures 622 and 624 and their working contacts. The closure of armature 622 completes the circuit from ground, working contact of armature 648 and said armature, armature 622 and its working contact, armature 629 and its resting contact, resting contact of armature 620 and said armature, to the junction point of the two windings of relay 618. The lower winding of relay 618 is thereby shunted out and since the upper winding is not of sufficient strength to completely operate the relay, it remains in its first step position. A circuit is also closed from ground at armature 648, armature 622 and its working contact, armature 623 and its resting contact, winding of relay 625, to battery. Relay 625 operates and at armature 626 and its working contact it brings about the operation of relays 400 and 406 of the tone group TG2 to connect the tone generating equipment to the trunk line conductors 20 and 21. At armature 629 and its resting contact it opens the shunting circuit of the lower winding of relay 618 and allows this relay to completely operate. At armature 627 and its working contact it completes the energizing circuit for relay 633.

A supervisory signal is thereby transmitted to exchange A and this signal is terminated when relay 625 is shunted through armature 634 and its weighted spring working contact when relay 633 has operated. Relay 625 thereupon releases and opens the circuit of relay 633 at armature 627 and its working contact, at armature 626 and its working contact it opens the circuit of relay 406 which releases and brings about the release of relay 400 and the termination of the supervisory signal. Since relays 600 and 618 were operated at this time, the supervisory signal transmitted to exchange A consisted of one thousand

cycle alternating current interrupted at frequency F3 or fifty-four times per second.

The supervisory signal is received over trunk line conductors 20 and 21 and operates tuned reed relay 322 at the rate of fifty-four times per second, thereby interrupting the circuits of relays 254 and 260 a corresponding number of times. Relay 254 is designed to respond to this frequency, and at armature 256 and its normally closed contact it opens the circuit of relay 252 which releases, and at armature 253 and its resting contact completes the circuit for relay 257. Relay 257 operates and at armature 258 and its working contact completes its own locking circuit, and at armature 259 and its working contact connects ground to a supervisory conductor 3, thereby bringing about the operation of relay 163 at toll selector TS1. Relay 163, in operating, at armatures 165 and 166 connects the battery-feed coil 162 across the trunk line conductors extending to the toll board, thereby causing the operation of the supervisory relay in the cord circuit CC1 and the lighting of the supervisory lamp to inform the toll operator that the operator at exchange B is being signalled.

When the operator at the toll board in exchange B notes that she is being signalled over the trunk accessible over jack J3, she inserts plug P3 of cord circuit CC2 in jack J3. Relay 596 operates and at armature 597 extends ground over armature 522 and its working contact, upper winding of relay 536, to battery. Relay 536 operates and at armature 538 and its resting contact it removes ground from the supervisory conductor 34, thereby opening the circuit of relay 618 of the repeater R2. Relay 618 starts to release but as soon as armature 620 engages its resting contact a circuit is closed from ground, working contact of armature 648 and said armature, armature 622 and its working contact, armature 629 and its resting contact, resting contact of armature 620 and said armature, upper winding of relay 618, to battery. This upper winding is sufficient to maintain the relay in its first step position and a circuit is then closed over armature 622 and its working contact, armature 623 and its resting contact, winding of relay 625, to battery.

Relay 625 operates and at armature 626 and its working contact grounds the sending conductor 23, thereby operating relays 400 and 406 in tone group TG2 to connect the tone generating equipment to the outgoing trunk conductors 20 and 21. At armature 627 and its working contact relay 625 closes an energizing circuit for relay 633, at armature 628 and its working contact it completes its own locking circuit, and at armature 629 and its resting contact it opens the circuit for the upper winding of relay 618 and allows this relay to release. The alternating current source of frequency F4 is connected to the plate circuit of tube 410 over conductor 24 from conductor 668 since relay 600 is operated and relay 618 is in its normal position. The duration of the supervisory signal is determined by the time required for armature 634 to maintain its contact with its weighted spring working contact.

When armature 634 closes its working contact, relay 625 is shunted and releases. At armature 626 and its working contact it opens the circuit of relay 406 which releases and opens the circuit of relay 400, thereby disconnecting the tone generating equipment and terminating the supervisory signal. At armature 629 and its resting contact relay 625 again prepares a circuit for the upper winding of relay 618 and at armature 631 and its resting contact it prepares a circuit for the two windings of relay 618 in series. The supervisory signal consisting of thousand cycle alternating current interrupted at sixty-six cycles per second is received by tone group TG1 in exchange A and the tuned reed relay 322 accordingly interrupts the circuit of relays 254 and 260 at a corresponding rate. Relay 260 responds to the signal and at armature 262 opens the locking circuit of relay 257. Relay 257 releases and at armature 258 and its working contact opens its own locking circuit and at armature 259 and its working contact removes ground from the supervisory conductor 3, thereby opening the circuit of relay 163, allowing this relay to release. Relay 163 in releasing removes the battery connection through coil 162 from the trunk line conductors extending to the toll operator, thereby allowing the supervisory relay in cord circuit CC1 to release and extinguish the supervisory lamp.

The two operators may now carry on a conversation. When the toll operator in exchange B removes plug P3 from jack J3, relays 596 and 536 release and the latter relay at armature 538 and its resting contact again completes the circuit from grounded conductor 33 to conductor 34, thereby again bringing about the operation of relays 618, 625, and 633 to transmit a supervisory signal to exchange A consisting of one thousand cycle alternating current interrupted at frequency F3 or fifty-four cycles per second. This lights the supervisory lamp in the cord circuit at the toll board in exchange A and informs the operator that the toll operator at exchange B has disconnected.

When the operator at exchange A removes the plug P1 from jack J1 relay 196 releases and removes ground from the hold conductor 1, thereby bringing about the release of relay 212. Relay 212, in releasing, at armature 214 and its working contact opens the circuit of relay 218 which starts to release but as soon as armature 220 engages its resting contact a circuit is completed from ground at armature 248, armature 222 and its working contact, armature 229 and its resting contact, resting contact of armature 220 and said armature, upper winding of relay 218, to battery. Relay 218, therefore, remains in its first-step position and completes a circuit for relay 225 over armature 222 and its working contact and armature 223 and its resting contact. Relay 225 operates and at armature 226 and its working contact connects ground to conductor Y to bring about the connection of the tone generating equipment to the outgoing trunk conductors, and at armature 227 and its working contact completes the circuit for relay 233. One thousand cycle alternating current interrupted at frequency F2 or forty-two times per second is thereby transmitted over the outgoing trunk line conductors 20 and 21 to exchange B as a release signal. The duration of the signal is timed by the time required for armature 235 to maintain its contact with its weighted spring working contact. When this circuit is closed, relay 225 is shunted and releases, thereby terminating the release signal to exchange B and bringing about the release of all the equipment in exchange A.

The release signal is received by tone group TG2 in exchange B and relay 422 responds and opens the circuit of relays 643, 649, and 663 at a corresponding rate. Relay 649 responds and

at armature 651 opens the circuit of relay 646. Relay 646 releases and at armature 648 opens the holding circuit of relay 600 which releases and restores all equipment in exchange B to its normal position.

Call from the toll operator in exchange A to the toll operator in exchange C

It will now be assumed that the toll operator in exchange A wishes to converse with the toll operator in exchange C for the purpose of securing information or to have the latter operator complete a call. In this case the toll operator in exchange A inserts the plug P1 into jack J1, thereby bringing about the transmission of a calling signal consisting of a splash of uninterrupted thousand cycle current over the trunk line to exchange B. This calling signal prepares the selector TS2 and associated repeater R2 and tone group TG2 for operation on an incoming call in the manner previously explained. The operator at exchange A now dials the digit 0 to operate selector TS2 to the tenth level from which it automatically rotates over the bank contacts of the level to select an idle trunk extending to exchange C. It will be assumed that the trunk comprising conductors 44 and 45 and terminating in selector TS3 and associated repeater R3 and tone group TG3 is the one selected by selector TS2 over conductors 36 to 39, inclusive.

Since the operation of the equipment in exchange A on an outgoing call such as is to be described has been previously described in connection with a call from a toll operator in exchange A to a toll operator in exchange B, and since the operation of the equipment in exchange C in the present connection is the same as the operation of the equipment in exchange B just described in connection with a call from the toll operator in exchange A to the toll operator in exchange B, the operation of the equipment in exchange A and exchange C will not be explained in connection with the establishment of this connection. The operation of selector TS3 and repeater R3 and tone group TG3 will, therefore, be explained with reference to Figs. 1, 2, and 3 of the drawings and it will be assumed that the circuits shown in detail in these figures are the circuits of the equipment terminating the trunk comprising conductors 44 and 45 and extending from exchange C.

After the operator at exchange A has dialled the digit 0 to select the trunk extending from exchange B to exchange C, she operates the ringing key in her cord circuit to signal the toll operator at exchange C. The operation of the ringing key causes the ringing signal consisting of one thousand cycle alternating current interrupted at frequency F1 or thirty cycles per second to be transmitted over trunk line conductors 20 and 21 extending to exchange B. This ringing signal is received by tone group TG2 and repeater R2 and brings about the operation of relay 643, which, at armature 645 opens the circuit of relay 641. Relay 641 releases and at armature 642 and its resting contact places ground on conductor 31 to bring about the operation of relay 556. Relay 556, at armatures 558 and 559 and their working contacts, connects ringing current to the outgoing line conductors over wipers 588 and 591. This ringing current is extended over conductors 36 and 39 to selector TS3 and is received over conductors 9 and 12 (Fig. 1) to operate relay 144. Relay 144 operates and at armature 145 and its working contact completes a circuit from the grounded busy conductor 2, resting contact of armature 107 and said armature, armature 145 and its working contact, armature 108 and its resting contact, conductor 5, winding of relay 236, to battery. Relay 236 operates and at armature 238 and its working contact grounds conductor Y to bring about the connection of the tone generating equipment to the outgoing trunk line comprising conductors 44 and 45 and extending to exchange C. At armature 237 and its working contact it connects the plate circuit of the sending tube over conductor X to conductor 271 to supply frequency F1 or thirty cycle current to the plate circuit of the sending tube.

A ringing signal of thousand cycle current interrupted at thirty cycles per second is thereby transmitted over the trunk line conductors 44 and 45 extending to exchange C as long as the toll operator in exchange A keeps her ringing key depressed. This ringing signal is received by the toll selector TS4, repeater R4 and tone group TG4 in exchange C and brings about the operation of a relay, such as relay 121, Fig. 1, in its first step. When the operator at exchange A releases her ringing key, the ringing signal is terminated and the relay, such as 121, associated with the selector TS4 in exchange C operates completely and brings about the transmission of a supervisory signal consisting of thousand cycle alternating current interrupted at frequency F3 or fifty-four cycles per second over trunk line conductors 44 and 45 to exchange B. This brings about the operation of relay 254, the release of relay 252, and the operation of relay 257 in repeater R1 and the latter relay at armature 259 and its working contact grounds the supervisory conductor 3 which brings about the operation of relay 163 in toll selector TS1.

Relay 163 operates and at armature 164 and its working contact connects ground over conductor 11, conductor 38, wiper 590, armature 549 and its resting contact, working contact of armature 586 and said armature, armature 520 and its resting contact, resting contact of armature 533 and said armature, lower winding of relay 536, to battery. Relay 536 operates and at armature 537 and its working contact completes a circuit from the grounded hold conductor 33, armature 524 and its resting contact, armature 537 and its working contact, supervisory conductor 34, resting contact of armature 631 and said armature, through the two windings of relay 618 in series, to battery. Relay 618 operates in its first step and brings about the operation of relays 625 and 633 in the manner previously described to transmit a supervisory signal over trunk line conductors 20 and 21 to exchange A. This signal consists of one thousand cycle alternating current interrupted at frequency F3 or fifty-four cycles per second. The supervisory signal is received at exchange A by the voice frequency control equipment and brings about the lighting of the supervisory lamp in the operator's cord circuit CC1.

When the toll operator at exchange C answers the call by inserting the plug of her cord circuit into the trunk jack, the relay in selector TS4 corresponding to relay 136 of selector TS1 operates and removes ground from the supervisory lead, thereby causing the voice frequency equipment to transmit an answering signal consisting of one thousand cycle alternating current interrupted at frequency F4 or sixty-six times per second. This answering signal is received at ex-

change B by tone group TG3 (TG1) and brings about the operation of tuned reed relay 260 in repeater R1, which opens the locking circuit of relay 257 and allows this relay to release and remove ground from the supervisory conductor 3. The removal of ground from supervisory conductor 3 opens the circuit of relay 163 and allows this relay to release, thereby removing ground from conductors 11 and 38 and opening the circuit of the lower winding of relay 536. Relay 536 releases and at armature 537 and its working contact opens the ground connection to supervisory lead 34, thereby bringing about the release of relay 618 to repeat the answering signal of one thousand cycle current interrupted at the rate of sixty-six times per second over the trunk conductors 20 and 21 extending to exchange A. This signal is received by the voice frequency equipment in exchange A and brings about the extinguishing of the supervisory lamp at the operator's position.

The two operators may now converse, and at the end of the conversation when the operator in exchange C removes her plug from the trunk jack, the relay corresponding to relay 136 of toll selector TS1 releases and at armature 138 and its resting contact connects ground to the supervisory lead extending to the voice frequency equipment. This brings about the transmission of the disconnect signal consisting of thousand cycle current interrupted at frequency F3 over trunk line conductors 44 and 45 extending to exchange B. The signal is received at exchange B and again operates tuned reed relay 254 and releases relay 252. Relay 252 at armature 253 and its resting contact closes a circuit for relay 257 which locks energized at armature 258 and its working contact, and at armature 259 and its working contact grounds the supervisory conductor 3 thereby bringing about the operation of relay 163. Relay 163 operates and at armature 164 and its working contact grounds the toll conductor 11 extending over wiper 590 of toll selector TS2, thereby energizing the lower winding of relay 536 and causing this relay to operate. Relay 536 at armature 537 and its working contact again grounds the supervisory conductor 34, thereby bringing about the operation of relay 618 and causing the voice frequency equipment to transmit the disconnect signal over trunk conductors 20 and 21 to exchange A to again light the operator's supervisory lamp.

When the operator at exchange A removes the plug P1 from jack J1, a release signal consisting of one thousand cycle alternating current interrupted at frequency F2 or forty-two times per second is transmitted over trunk line conductors 20 and 21 to exchange B where it brings about the operation of relay 649 and the release of relay 646. Relay 646 in releasing brings about the release of toll selector TS2, thereby removing ground from conductor 37 and conductor 10 extending to toll selector TS1. Removal of ground from conductor 10 brings about the release of relay 212, which opens the circuit of relay 218 and allows this relay to release. The release of the two-step relay 218 causes the voice frequency equipment to transmit a release signal, consisting of one thousand cycle current interrupted at frequency F2, over trunk line conductors 44 and 45 to bring about the release of the equipment in exchange C in a manner previously described.

The toll operator in exchange B can establish connection with the toll operator in exchange A or C and the toll operator in exchange C can establish a connection with the toll operator in exchange B in the same manner as described for the establishment of a connection from the toll operator in exchange A to the toll operator in exchange B. The toll operator in exchange C can also establish connection with the toll operator in exchange A by way of the equipment in exchange B in the manner just described for a connection from the toll operator in exchange A to the toll operator in exchange C.

Fig. 8 of the drawings shows a perspective view of the mechanical structure of one form of a tuned reed relay which is particularly adapted to be used as the thousand cycle tuned reed relay which responds to the basic frequency used for signalling in the system of the present invention. The relay consists of a cast base 50 having a circular hole in the center thereof. The two electromagnets 62 polarized by a permanent magnet are mounted on a lower plate 51 which is fastened to the bottom of the base 50 with the electromagnets 62 projecting through the hole in the base. Upon a raised portion at one end of the base 50 is mounted the tuned reed 61 which is securely clamped at one extremity by means of the clamping blocks 54 and 55. The reed passes through other clamping blocks 59 and 60 which together with block 58 are slidably mounted in a channel formed by the side pieces 53. These blocks are maintained in alignment by pins 73. The blocks are arranged to be moved back and forth by means of the adjusting screw 56, thereby changing the length of the vibrating portion of the reed which extends out over the poles of the electromagnets 62.

A screw 57 is threaded in block 58 with its lower end against the clamping block 59, so that when the length of the reed has been properly adjusted by means of screw 56, the screw 57 is tightened thereby permanently clamping reed 61 between blocks 59 and 60.

The contact arrangement of the relay comprises a contact spring 67 having a turned down end which is adapted to be engaged by the tuned reed 61 when the latter is vibrating. This spring is normally in engagement with the contact spring 66, the position of which may be adjusted, that is, the spring may be raised or lowered, by means of the micrometer adjusting screw 65. These contact springs together with the supporting arm 69, the strap spring 70, and the tension spring 68, are mounted on an assembling block 64. The adjusting screw 71 is tensioned by the strap spring 70 and is threaded through the arm 69 with its lower end in engagement with the tension spring 68. Thereby the tension on the operating contact spring 67 may be adjusted by means of the adjusting screw 71. A screw 72 is secured to the outer end of arm 69 and the lower end of this screw forms a back stop for the operating spring 67. Electrical connections to the electromagnet and to the contact springs are made by means of the terminal assembly 63.

From the foregoing description, it is apparent that the tuning of the relay may be changed within certain limits by means of the adjusting screw 56 which changes the length of the vibrating portion of the reed, thus changing its period of vibration and causing it to respond to current of a different frequency. The position of the two contact springs 66 and 67 and the tension and back stop of spring 67 may then be adjusted so that the relay will operate properly, since the

change in length of the relay will change the amplitude of its vibration.

What is claimed is:

1. In a telephone system, the combination of a toll line with means at one end thereof for transmitting over said toll line impulses of a voice frequency alternating current at certain intervals, signalling means at the opposite end of said toll line responsive only to said alternating current impulses received at said intervals, means at the opposite end for transmitting over the toll line impulses of said same voice frequency alternating current at certain different intervals, and signalling means at the originating end of said toll line responsive only to said alternating current impulses received at said different intervals.

2. In a telephone system, the combination of a toll line with means at one end thereof for transmitting over said toll line impulses of a voice frequency alternating current at a first and a second rate, automatic switches at the distant end of said toll line, means responsive only to said alternating current impulses received at said first rate for operating said automatic switches, other means responsive only to alternating current impulses received at said second rate for releasing said automatic switches, means at the distant end of said line for transmitting over said line impulses of said voice frequency alternating current at a third and a fourth rate, and signalling means at the originating end of said toll line selectively responsive to said alternating current impulses received at said third and fourth rates.

3. In a telephone system, a toll line connecting a first and a second exchange and terminating in an operator's position in the first exchange and in automatic switching apparatus in said second exchange, means in said first exchange responsive to the seizure of said toll line for transmitting an uninterrupted alternating current of voice frequency thereover to prepare said automatic switching apparatus for operation, means for transmitting impulses of said alternating current at a first rate to operate said automatic switching apparatus and at a second rate to release the same, and means in each second exchange for transmitting impulses of said alternating current over said trunk line at a third and a fourth rate as supervisory signals to said operator's position.

4. In a telephone system, a toll line terminating in an operator's position in a first exchange and in automatic switching apparatus in a second exchange, means in said first exchange for transmitting over said toll line uninterrupted alternating current of voice frequency to prepare said automatic switching apparatus for operation, means in said first exchange for transmitting impulses of said alternating current at two different rates to operate and release said apparatus, respectively, and means in the second exchange for transmitting impulses of said alternating current at two other different rates for supervisory purposes.

5. In a telephone system, a toll line connecting two exchanges and terminating in a toll board and in automatic switching apparatus in each exchange, means in each exchange for generating an alternating current of a particular voice frequency and for interrupting said current at four different rates, means responsive to the seizure of said toll line at one exchange for preparing the apparatus therein to transmit said current interrupted at the first two rates and to receive said current interrupted at the second two rates, and means responsive to said last means for preparing the switching apparatus in the other exchange to transmit said current interrupted at said second two rates and to receive said current interrupted at said first two rates.

6. In a telephone system, a toll line extending from a toll board in one exchange and terminating in a toll board and automatic switching apparatus in a second exchange, means responsive to the seizure of said toll line at the toll board in the first exchange for transmitting uninterrupted alternating current of a particular voice frequency over said toll line to prepare the equipment in the second exchange for operation, means in the first exchange for transmitting impulses of said current over said toll line at two different rates, means in the second exchange responsive only to impulses of said current received at one rate for operating said automatic switching apparatus, and means responsive only to impulses of said current received at the second rate for signalling the toll board in the second exchange.

7. In a telephone system, two serially-related toll lines, means at the originating end of the first toll line for transmitting thereover impulses of voice frequency alternating current at two different rates, means at the distant end of said first toll line responsive to said impulses for connecting said first toll line to said second toll line and for thereafter repeating said impulses at said two rates over said second toll line, automatic switches at the distant end of said second toll line, and means responsive to received impulses at said two rates for operating and releasing said switches, respectively.

8. In a telephone system, the combination of two interconnected toll lines with means at the originating end of the first toll line for transmitting thereover impulses of voice frequency alternating current at two different rates, signalling means at the distant end of the second toll line responsive only to said impulses received at said rates, means at the distant end of the second toll line for transmitting thereover alternating current impulses of said voice frequency at two further different rates, signalling means at the originating end of said first toll line responsive only to said impulses received at said two further rates, and means at the interconnecting point of said two toll lines responsive to said alternating current impulses received at any of said rates over either toll line for repeating like impulses at a like rate over the other toll line.

9. In a telephone system, a toll line terminating in a toll board, control equipment associated with said toll line, means in said control equipment for generating alternating current of a particular voice frequency and for interrupting said current at a number of different rates, selective means responsive to said current interrupted at said different rates, means responsive to the seizure of said toll line at said toll board for preparing said control equipment to transmit said current interrupted at certain of said rates and to receive said current interrupted at the other rates, and means responsive to the seizure of said toll line at its distant end for preparing said control equipment to receive said current interrupted at said certain rates and to transmit said current interrupted at said other rates.

10. In a telephone system, a toll line terminating in a toll board, control equipment associated with said toll line, means in said control equipment for generating alternating current of a particular voice frequency, means for transmitting impulses of said current over said toll line at a number of different rates, means responsive to the seizure of said toll line at said toll board for causing said control equipment to transmit uninterrupted alternating current of said voice frequency over said toll line for a short period and for preparing said control equipment to transmit impulses of said current at certain of said rates, and means responsive to the receipt of uninterrupted alternating current of said voice frequency over said toll line for preparing said control equipment to transmit impulses of said current at the others of said rates.

11. In a telephone system, a toll line terminating in a toll board, means responsive to the seizure of said toll line at said toll board for transmitting uninterrupted alternating current of a particular voice frequency over said toll line, means responsive to dialling impulses received from said toll board for transmitting over said toll line impulses of said current at a certain rate, a supervisory signal at said toll board, means selectively responsive to impulses of alternating current of said voice frequency received over said toll line at a second and a third rate for controlling said supervisory signal, and means responsive to the release of said toll line at the toll board for transmitting over said toll line impulses at a fourth rate.

12. In a telephone system, a toll line terminating in automatic switching apparatus, means responsive to the receipt of uninterrupted alternating current of a particular voice frequency for preparing said automatic switching apparatus for operation, means responsive to the receipt of impulses of said current at a first rate for operating said automatic switching apparatus to extend a connection, means for transmitting over said toll line impulses of alternating current of said voice frequency at a second and a third rate for supervisory signals, and means responsive to impulses of said current received over said toll line at a fourth rate for releasing said automatic switching apparatus.

13. In a telephone system, a toll line terminating in a toll board and in automatic switching apparatus, means responsive to received uninterrupted alternating current of a particular voice frequency for preparing said automatic switching apparatus for operation, means responsive to impulses of said current received over said toll line at a first rate for operating said automatic switching apparatus, means responsive to impulses of said current received over said toll line at a second rate for signalling said toll board, means for transmitting over said toll line impulses of alternating current of said voice frequency at a third and a fourth rate for supervisory signals both on connections over said automatic switching apparatus and to said toll board, and means responsive to impulses of said current received over said toll line at a fifth rate for restoring all equipment to its normal condition.

14. In a telephone system, a toll line terminating in automatic switching apparatus, a source of alternating current of a particular voice frequency, means responsive to uninterrupted current of said frequency received over said toll line for preparing said automatic switching apparatus for operation, means responsive to current impulses of said frequency received over said toll line at a first rate for operating said automatic switching apparatus into engagement with a called line, means effective if the called line is idle for connecting said source to said toll line at a second rate, means responsive to the answering of the called subscriber for connecting said source to said toll line at a third rate, and means responsive to current impulses of said frequency received over said toll line at a fourth rate for releasing said automatic switching apparatus.

15. In a telephone system, a toll line terminating in a toll board, control equipment associated with said toll line, two combinations of circuits in said control equipment, the first including means for transmitting alternating current impulses of a particular voice frequency over said toll line at a first and a second rate and selective means responsive to impulses of said current received over said toll line at a third and a fourth rate, and the second including means for transmitting impulses of said current at said third and fourth rates and selective means responsive to impulses of said current received at said first and second rates, and means for rendering one or the other of said combinations of circuits effective dependent upon whether said toll line is seized at the toll board or at its distant end.

16. In a telephone system, a toll line terminating in a toll board, control equipment associated with said toll line, a normally operative combination of circuits including means for transmitting alternating current impulses of a particular voice frequency over said toll line at two rates and selective means responsive to impulses of said current received over said toll line at two other rates, a second combination of circuits including means for transmitting impulses of said current over said toll line at said two other rates and selective means responsive to impulses of said current received over said toll line at said first two rates, and means responsive to the seizure of said toll line at said toll board for rendering said first combination of circuits inoperative and for rendering operative said second combination of circuits.

17. In a telephone system, automatic switches, a relay, means for controlling said relay by alternating current impulses of voice frequency, means controlled by said relay for operating said switches to extend a telephone connection, and means for locking said relay energized responsive to the extension of said connection to an idle called line and for maintaining said relay energized until said connection is released.

18. In a telephone system, automatic switches, a relay, means for controlling said relay responsive to alternating current impulses of a particular voice frequency, means controlled by said relay for operating said switches to extend a telephone connection responsive to alternating current impulses of said frequency received at a particular rate, and means operated responsive to alternating current impulses of said frequency received at a higher rate and to the extension of the connection to an idle called line for locking said relay energized until the connection is released.

19. In a telephone system, a toll line over which alternating current signals are transmitted, a transformer having its primary winding bridged across said line in the path of said signals, a vacuum tube, a grid circuit for said tube includ-

ing the secondary winding of said transformer, a plate circuit for said tube including a tuned reed relay, and a resistance and a condenser connected in parallel in the grid circuit of said tube effective to maintain the output to said relay substantially constant irrespective of variations in the strength of the incoming signals received through said transformer.

20. In a tuned reed relay, a base plate, a reed having one end secured to said base plate, a clamping block slidably mounted in said base plate between the two ends of said reed, an adjusting screw for moving said block forward and backward along said reed to change the effective length of the reed, a second screw for clamping said block down on said reed in the desired position, a pair of contact springs operated by said reed, and means for securing said contact springs to the base independent of the means for securing said reed.

21. In a reed-operated relay, a tuned reed, a lower contact spring, a micrometer adjusting screw for raising and lowering said contact spring, a second contact spring mounted above said first spring, a turned down portion at the free end of said upper contact spring in position to be operated by said tuned reed, a tensioning spring mounted above said upper contact spring and in contact therewith, and a second adjusting screw for raising and lowering the free end of said tensioning spring to decrease or increase the tension with which said upper contact spring makes contact with said lower contact spring.

22. The method of establishing a connection over a toll line in a telephone system which consists in transmitting from the calling exchange alternating current of a particular voice frequency, in interrupting said current at a number of different rates for different signals, in transmitting from the called exchange alternating current of the same voice frequency, in interrupting said current at a number of other rates for different signals, and in selectively translating the signals received at each exchange into proper switching movements and supervisory functions as determined by the rates of interruption of the voice frequency current.

23. The method of extending a connection from a first exchange to a called line in a second exchange which consists in transmitting from the calling exchange signals comprising voice frequency current interrupted at three different rates, in receiving said signals at the second exchange and translating them into switching movements, in transmitting from the second exchange signals of voice frequency current interrupted at a fourth and a fifth rate, and in receiving said last mentioned signals at the calling exchange and translating them into corresponding supervisory functions.

24. The method of extending a connection from a first exchange to a called line in a third exchange by way of a second exchange which consists in transmitting from the called exchange signals of voice frequency current interrupted at three different rates, in repeating said signals through the second exchange by converting them into direct current signals and then reconverting the latter into signals of voice frequency current interrupted at said three rates, in receiving said signals at the third exchange and translating them into corresponding switching movements, in transmitting from the third exchange signals of voice frequency current interrupted at two other rates, in repeating said signals through the second exchange by converting them into direct current signals and reconverting the latter into signals of voice frequency current interrupted at said two other rates, and in receiving said signals at the first exchange and translating them into corresponding supervisory functions.

25. In a telephone system, a two way trunk line terminating in a repeater, a source of voice frequency current, a combination of circuits for transmitting impulses of said current at several different rates over said trunk line and for selectively responding to impulses of said current at several other rates, a second combination of circuits for transmitting impulses of said current at said other rates and for selectively responding to impulses of said current at said first rates, and means dependent upon whether said trunk line is seized locally or at its distant end for rendering one of said combinations of circuits operative.

26. In a telephone system, a two way trunk line terminating in a repeater, receiving means in said repeater selectively responsive to impulses of alternating current of a particular frequency received at several different rates, other receiving means in said repeater selectively responsive to impulses of said current received at several other rates, means responsive to the seizure of said trunk line locally for rendering said first receiving means operative, and means responsive to the seizure of said trunk line at its distant end for rendering said other receiving means operative.

27. In a telephone system, a two way trunk line terminating in a repeater, means in said repeater for generating alternating current of a particular frequency, transmitting means for transmitting impulses of said current over said trunk line at several different rates, other transmitting means for transmitting impulses of said current over said trunk line at several other rates, means responsive to the seizure of said trunk line locally for rendering said first transmitting means operative, and means responsive to the seizure of said trunk line at its distant end for rendering said other transmitting means operative.

28. In a telephone system, a trunk line terminating in a repeater, means in said repeater responsive to uninterrupted alternating current of a predetermined frequency received over said trunk line for preparing said repeater for operation, means in said repeater selectively responsive to said current interrupted at two different rates for performing two different control functions, and means responsive to said current interrupted at a third rate for restoring said repeater to normal.

29. In a telephone system, a repeater accessible over an incoming line and terminating an outgoing trunk line, means responsive to the seizure of said incoming line for causing said repeater to transmit uninterrupted alternating current of a predetermined frequency over said trunk line, means in said repeater responsive to two different kinds of control exercised over said incoming line for transmitting alternating current of said frequency interrupted at two different rates over the outgoing trunk line, and means responsive to the release of said incoming line for transmitting alternating current of said frequency interrupted at a third rate over said outgoing trunk line.

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