

Feb. 16, 1937.

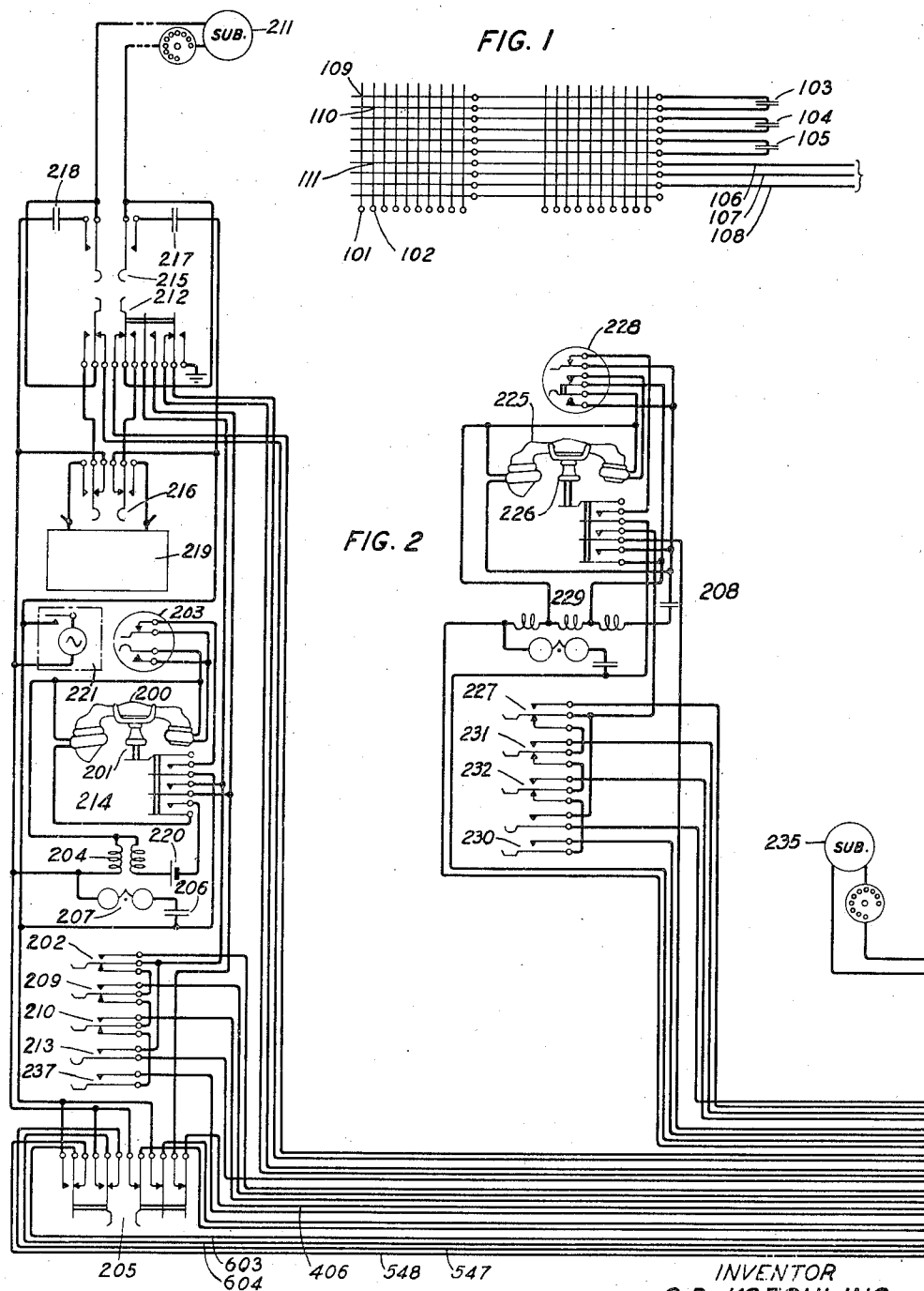
C. D. KOECHLING

2,071,075

TELEPHONE SYSTEM

Filed July 20, 1935

5 Sheets-Sheet 1



Feb. 16, 1937.

C. D. KOECHLING

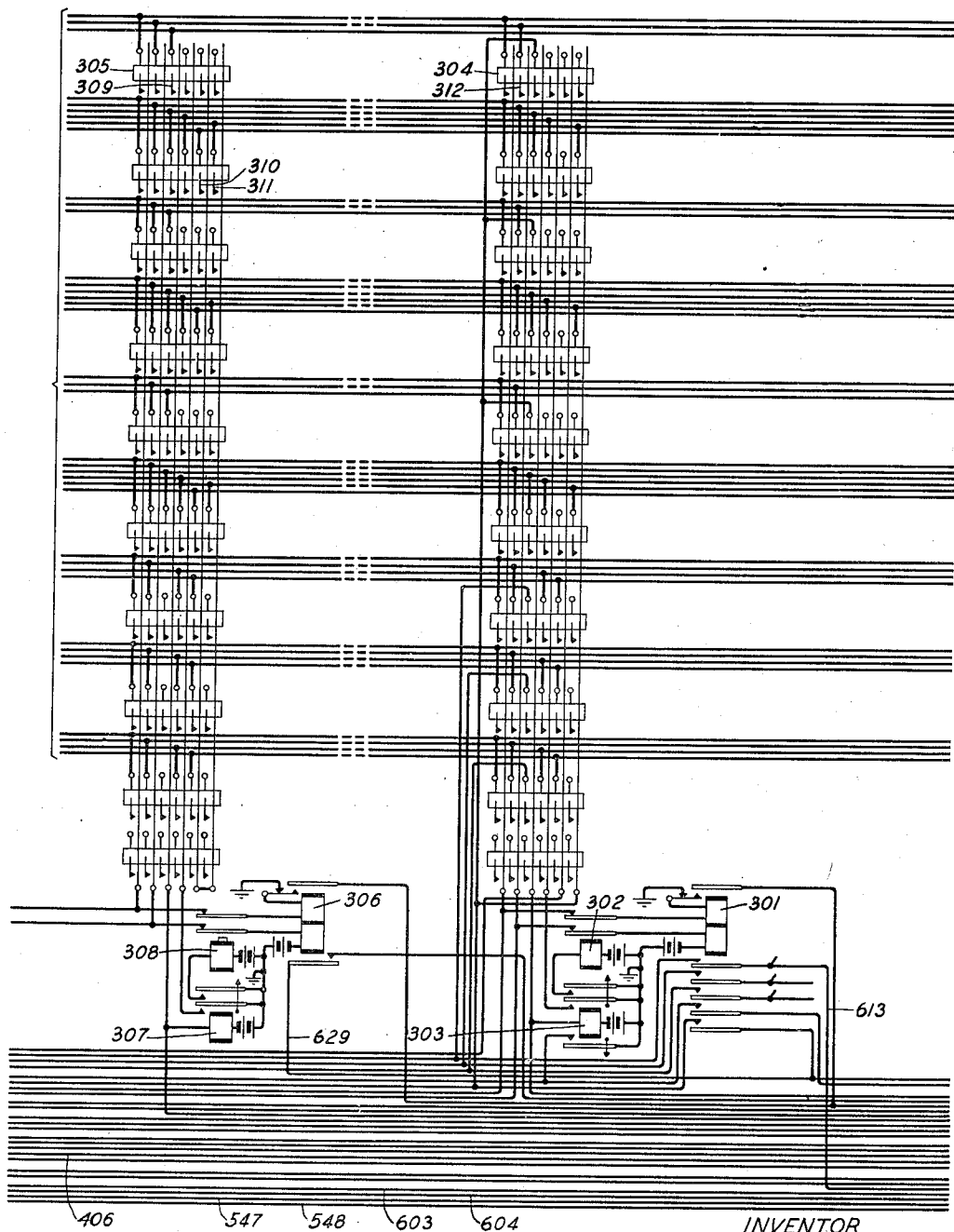
2,071,075

TELEPHONE SYSTEM

Filed July 20, 1935

5 Sheets-Sheet 2

FIG. 3



INVENTOR
C. D. KOECHLING
BY *W. R. McManey*
ATTORNEY

Feb. 16, 1937.

C. D. KOECHLING

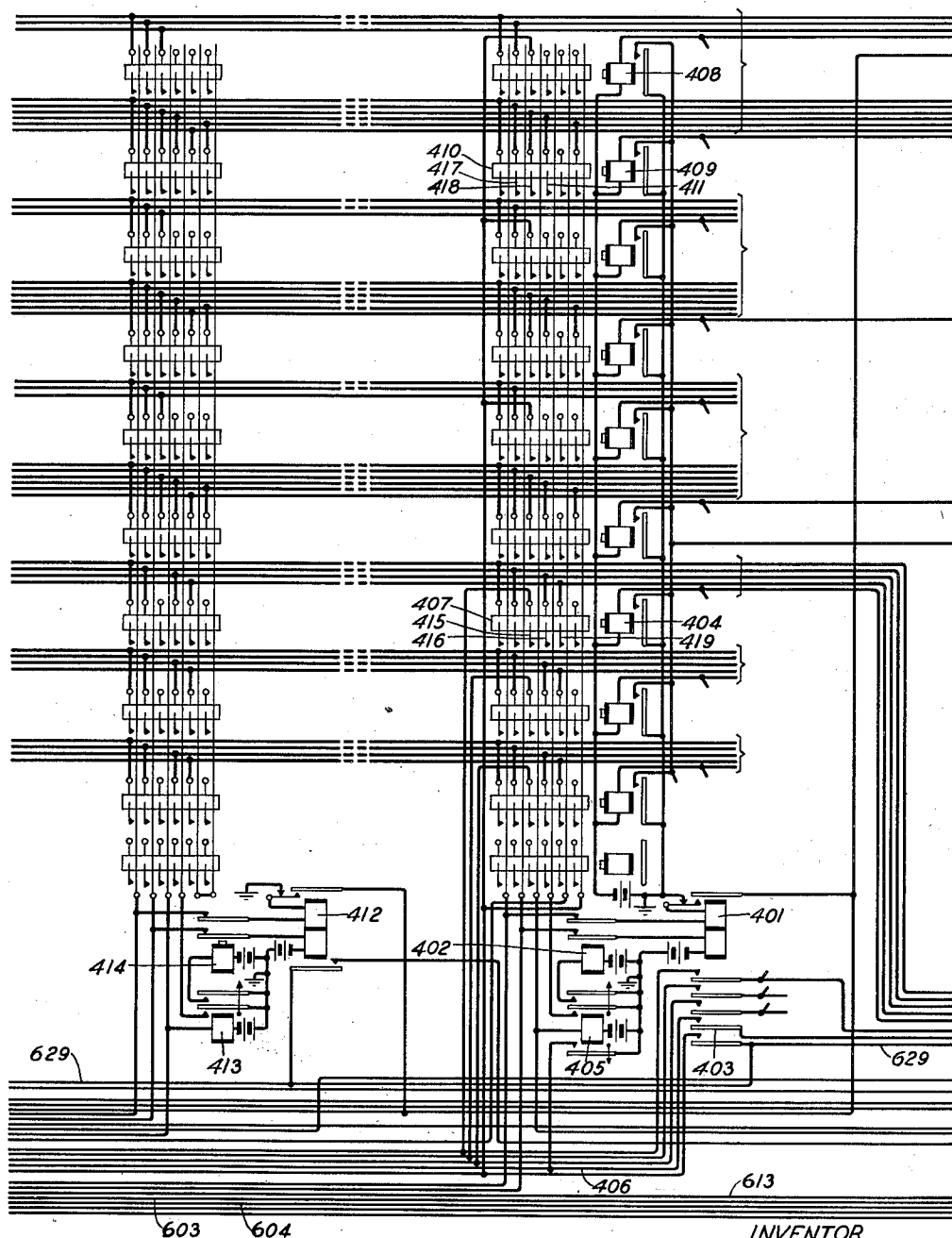
2,071,075

TELEPHONE SYSTEM

Filed July 20, 1935

5 Sheets-Sheet 3

FIG. 4



INVENTOR
C. D. KOECHLING
BY *W. T. Kennedy*
ATTORNEY

Feb. 16, 1937.

C. D. KOECHLING

2,071,075

TELEPHONE SYSTEM

Filed July 20, 1935

5 Sheets-Sheet 4

FIG. 5

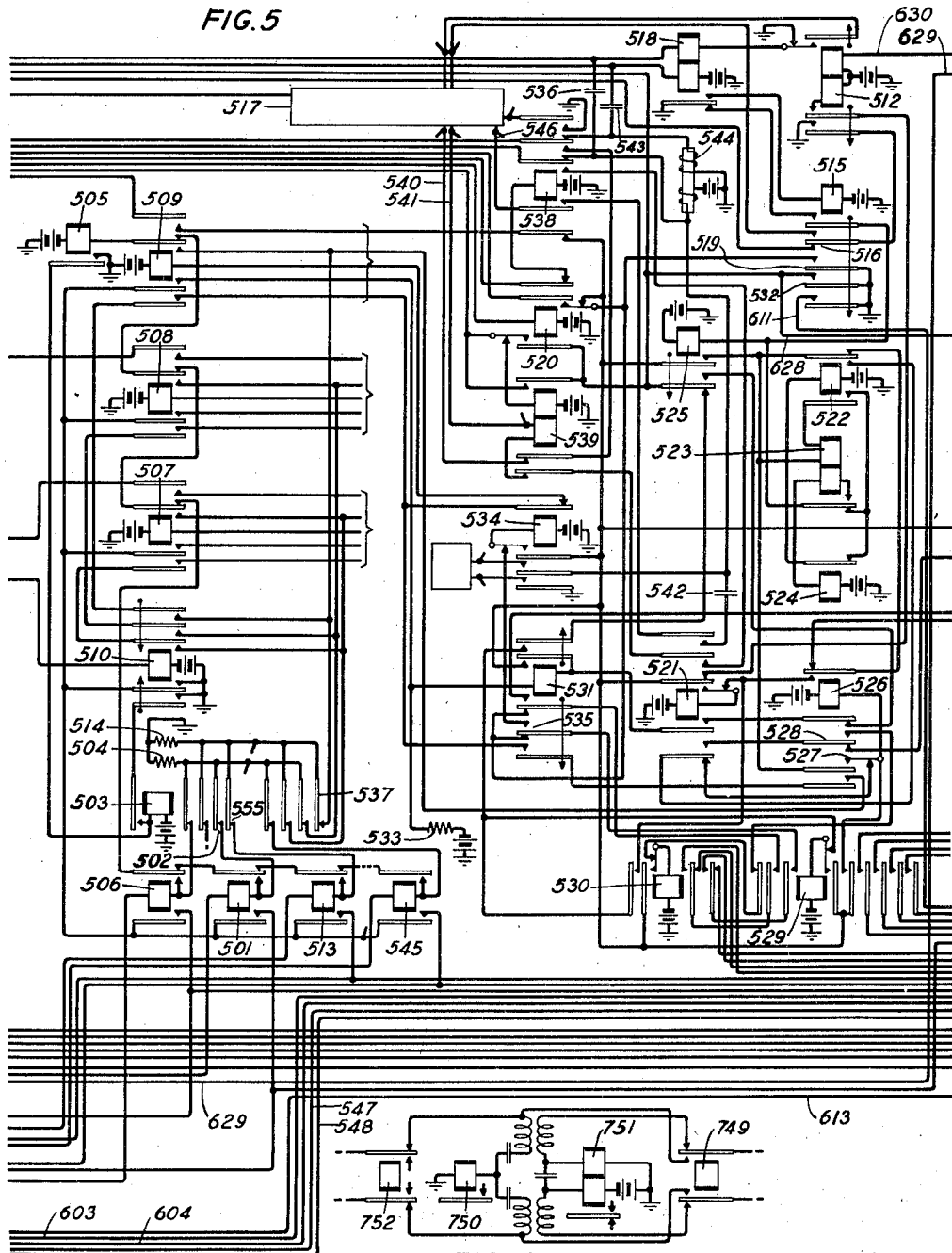


FIG. 7

INVENTOR
C. D. KOECHLING
BY *C. D. Koehling*
ATTORNEY

Feb. 16, 1937.

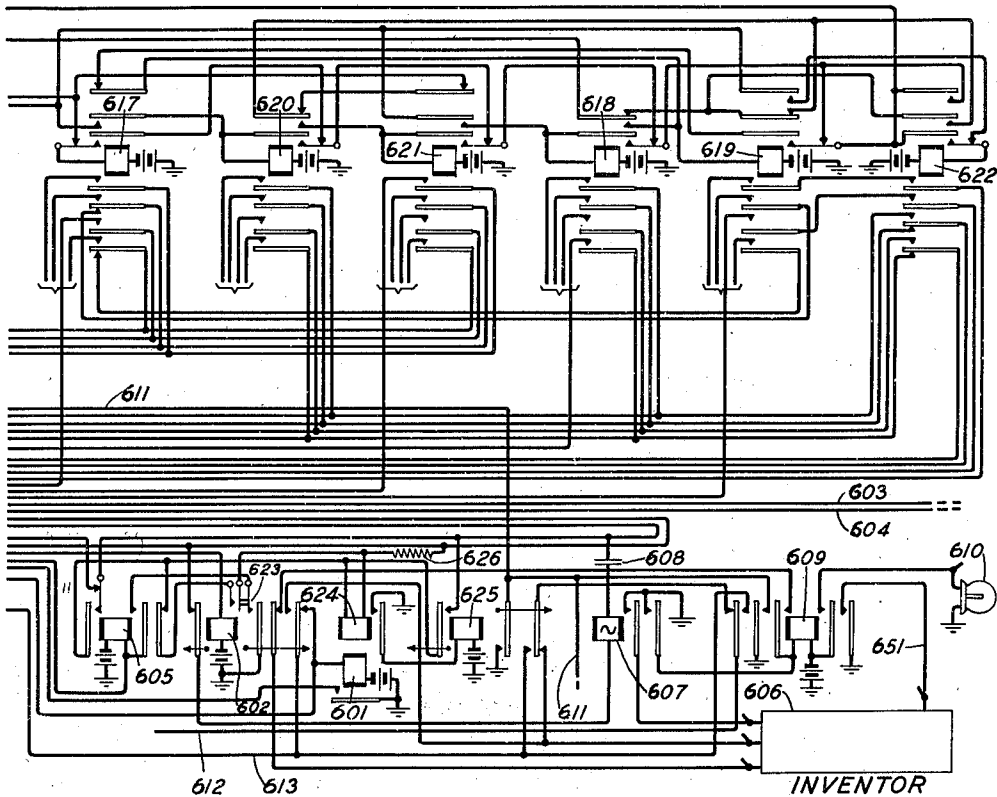
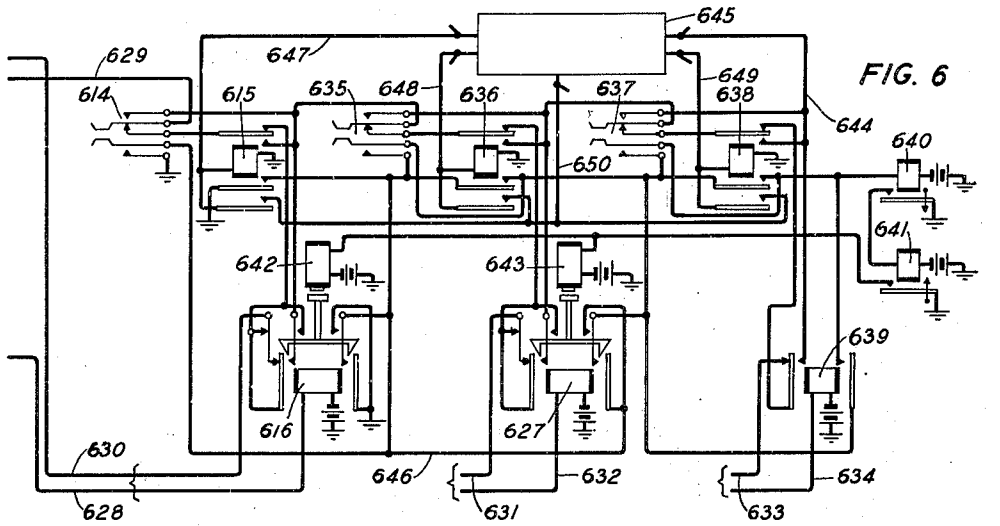
C. D. KOECHLING

2,071,075

TELEPHONE SYSTEM

Filed July 20, 1935

5 Sheets-Sheet 5



INVENTOR
C. D. KOECHLING
BY *[Signature]*
ATTORNEY

UNITED STATES PATENT OFFICE

2,071,075

TELEPHONE SYSTEM

Charles D. Koechling, Floral Park, N. Y., assignor
to Bell Telephone Laboratories, Incorporated,
New York, N. Y., a corporation of New York

Application July 20, 1935, Serial No. 32,312

11 Claims. (Cl. 179—18)

This invention relates to telephone systems and particularly to small capacity automatic telephone systems in which cross-bar switches are employed.

An object of the invention is to provide improved and economically arranged systems for automatically establishing connections between the telephone lines and between lines and trunks.

Heretofore, systems have been provided for establishing connections between two subscribers' lines in a single cross-bar switch unit by means of links having line finders and selector branches for connecting the two lines at two cross-connecting points of the switch. A system of this kind is disclosed in the patent to L. R. Waller 1,567,309 of December 29, 1925. Systems have also been provided in which, in addition to connections between two subscribers' lines over a link, connections may be established from subscribers' lines to trunks. A system of this kind is disclosed in the patent to E. E. Hinrichsen 1,567,054 of December 29, 1925.

A feature of the present invention is an arrangement, in a system in which connections are established between two subscribers' lines in a switch by means of links, whereby such subscribers' lines may be arranged in groups and in which means is responsive to the calling of a first line in any of said groups for establishing a connection through an idle link from the calling line to a second line in said group if said first line is busy.

Another feature is an arrangement in a system of this kind in which connections may be established between a subscriber's line and a trunk, whereby if a trunk has been called and connected to and a key at the calling subscriber's station is actuated, a holding condition is established on this connected trunk so that the calling subscriber may hang up his receiver and release his line from this trunk and whereby the same or any other calling subscriber's line may establish a connection to the held trunk and remove the holding condition.

Another feature of this invention is an arrangement in which the establishing of the connection from a calling subscriber to an idle link is effected by the calling subscriber removing his receiver from the switchhook and operating a key at his station and in which the establishing of a connection to a trunk is effected by the calling subscriber lifting his receiver from the switchhook and operating a key corresponding to the particular trunk desired.

The invention has been illustrated in connection with the following drawings in which:

Fig. 1 shows diagrammatically how lines, links and trunks are arranged on a cross-bar switch in a small capacity automatic telephone system;

Figs. 2 to 7 show the various features of the invention applied in detail to a small capacity automatic telephone system;

Fig. 2 shows a master station arranged to originate local and trunk calls, to extend trunk calls to another station which is ordinarily arranged for local service only and to make trunk calls on an emergency basis; a station arranged to originate local and trunk calls but without the other features of the master station, and a station arranged to make and receive local calls only;

Figs. 3 and 4 show in detail four vertical units and nine horizontal levels of a cross-bar switch together with the line equipment associated with the lines to which the vertical units are connected; and

Figs. 5 and 6 show the mechanism for allotting the links in rotation; one link circuit in detail for recording dial pulses and extending the connection to the desired line and one trunk circuit in detail for extending calls to the central office, while

Fig. 7 shows signaling apparatus used in magne-neo areas.

Fig. 1 shows schematically the arrangement of the station lines, the links and the trunks on a cross-bar switch. The station lines appear on the vertical units, a station such as 235 (Fig. 2) may appear on vertical unit 101 and one such as 208 may appear on vertical unit 102. Three link circuits 103, 104 and 105 appear on the six uppermost horizontal levels and provide for three simultaneous inter-station connections. Three trunk circuits 106, 107 and 108 appear on the three next lower levels to provide service from the stations to control offices. The lowermost horizontal level is not used in the system disclosed in the drawings but might be utilized for another trunk circuit or for other purposes. By this arrangement the station appearing on vertical unit 101 can communicate with the station appearing on vertical unit 102 over link 103 by the operation of the contacts at cross-points 109 and 110 and in a similar manner the station appearing on vertical unit 102 can originate or answer a call from the central office over trunk 106 by the operation of the contacts at cross-point 111.

The system as disclosed in Figs. 2 to 7 comprises

an automatic system of the cross-bar type in which all the stations may communicate with each other but only certain ones may make and receive calls over the trunks. The privileged stations are grouped into three classes, the first, exemplified by station 214, is permitted to originate and receive calls over the trunks and in addition may be connected to any trunk which is in use to another station, the second, exemplified by station 208 which may originate and receive calls but does not have the privilege of being connected to a busy trunk and the third (not shown) which may receive but may not originate trunk calls. The trunks are connected to the privileged stations by means of keys individual to each trunk in such a manner that the station circuit is associated with the trunk circuit by operating the key associated with the particular trunk desired. Hold keys are also provided so that a call on any one of the trunks may be answered at one of the stations having this service and held while the station desired is dialed and the person who answers is instructed to pick up the trunk call by operating the appropriate trunk key. This feature makes possible the desirable arrangement of answering all incoming calls at the same point and extending them to the desired stations.

In dial areas, outgoing calls to a central office are dialed in the usual manner and in manual common battery districts the call is passed verbally. In magneto areas additional equipment, shown schematically in Fig. 7, is furnished in the trunk circuit which supplies talking battery to the station connected to it and signals the central office automatically.

Local calls are made from the key stations by operating the local key and dialing in the usual manner. Stations having no trunk privileges are not furnished with any keys but are provided with a dial for local calls.

The operation of the system will now be described in detail.

Outgoing trunk call

Let it be assumed that the subscriber at station 214 shown in Fig. 2 desires to originate a call to a central office. To do this he removes the handset 200 from the cradle 201 and operates key 202 which associates his handset with the first trunk to the central office. The removal of the handset and the consequent operation of the cradle contacts cause the operation of line relay 401. The circuit for this function is traced from ground through the upper back contacts and upper winding of relay 401, upper outer back contacts of relay 402, right-hand middle back contacts of emergency key 205, upper contacts of the switchhook springs associated with cradle 201, pulsing contacts of dial 203, the receiver of handset 200, left-hand winding of induction coil 204, right-hand inner back contacts of key 205, upper inner back contacts of relay 402 to battery through the lower winding of relay 401. Relay 401, operated, disconnects the ground through its back contacts traced above and substitutes a ground through its upper front contacts. This ground is fed through a repeating coil (not shown) in the common circuit 517 in order to give the subscriber busy tone in case all the links or the trunk selected are busy. In operating, relay 401 also closes its five lower front contacts which connect the subscriber station to the common equipment.

It will be assumed that the first trunk (shown in detail in Fig. 6 and associated with key 202)

has been selected and that this trunk is idle. A circuit is now closed from ground through resistance 504, contacts 502 of relay 503, the winding of relay 501, contacts 403 of relay 401, right-hand outer contacts of key 205, middle switchhook contacts associated with cradle 201, front contacts of key 202, lower inner contacts of relay 401 to battery through the winding of relay 501. Both relays 501 and 503 operate in this circuit. The operation of relay 501 causes the operation of select magnet 404 in a circuit traced from ground through the contacts of relay 501 to battery through the winding of select magnet 404. Select magnet 404, operated, moves the fingers of the select magnet bar into a position such that the cross-bar will be operated when the hold magnet operates and through its operated contacts energizes relay 510. Relay 510 operates and causes the operation of cut-off relay 405 in a circuit traced from ground through the lower inner contacts of relay 510, lower contacts of relay 501 to battery through the winding of cut-off relay 405. Relay 405, operated, energizes through its upper outer contacts, vertical magnet 402 and through its lower contacts connects ground to the common conductor 406 to the station subset.

The operation of relay 501 also causes the operation of relay 505 in a circuit traced from ground through resistance 504, contacts 502 of relay 503, upper front contacts of relay 501, back contacts of relay 506 and the other relays similar to relay 506 associated with the other station circuits, upper inner back contacts of relay 507, upper inner back contacts of relay 508, upper inner back contacts of relay 509 to battery through the winding of relay 505. Relay 505, operated, energizes relay 503 which operates and locks to ground through the lower outer contacts of relay 510. The operation of relay 503 opens the operating circuits of relays 506, 501, 513, 545 and the other similar relays associated with the other line circuits (not shown) releasing the one which was operated which in this case was relay 501. The release of relay 501 opens the operating circuit and releases relay 505.

The operation of vertical magnet 402 causes all the springs associated with bar 407 to be operated and also opens the operating path for line relay 401, releasing it. The release of relay 401 opens the operating path of relay 501 causing its release and the release of relay 501 opens the operating path and releases select magnet 404, which in turn releases relay 510 which opens the locking circuit of relay 503 releasing it. The cut-off relay 405 is now held operated through the contacts of the switch. This circuit is traced from ground through the lower contacts of relay 405, conductor 406, right-hand outer contacts of key 205, the middle switchhook contacts associated with cradle 201, front contacts of trunk key 202, contacts 415 associated with bar 407 to battery through the winding of cut-off relay 405. Relay 405 holds magnet 402 operated and the springs associated with bar 407 remain operated after select magnet 404 has been released in accordance with the usual method of operation of this type of switch. The tip, ring, hold and busy conductors in addition to the sleeve conductor are also extended through the switch. Ground on the busy conductor operates the busy relay 502 in a circuit traced from ground through the upper inner contacts of relay 405, contacts 415 associated with bar 407 to battery through the winding of relay 502. The operation of the latter relay opens at its left-hand contacts the in-

coming ringing bridge; removes the winding of relay 601 from conductor 613 to the keys of stations which do not have the privilege of connection to busy trunks and connects this conductor to the common tone circuit in common equipment 606 so that busy tone is returned should the No. 1 trunk key be operated at any of these stations and prepares the hold feature which will be described later.

The closure of the tip and ring conductors through the switch signals the central office over conductors 603 and 604 in the usual manner causing an operator to be connected where this apparatus is located in a manual common battery area or causing dial tone to be returned in dial areas. When this equipment is located in a magneto central office area a special auxiliary apparatus shown schematically in Fig. 7 is interposed in conductors 547 and 548 to supply talking battery to the station line and to signal the central office automatically. The trunk circuit in the former case is traced from central office trunk conductor 603, left-hand outer back contacts of emergency key 205, conductor 548, left-hand back contacts of relay 605, left-hand contacts associated with bar 407, right-hand middle back contacts of key 205, upper contacts associated with cradle 201, pulsing contacts of dial 203, the receiver of handset 200, left-hand winding of induction coil 204, right-hand inner contacts of key 205, the contacts next to the left associated with bar 407, conductor 547, left-hand inner back contacts of key 205 to trunk conductor 604 to the central office. Conversation with the central office operator may now take place in case of a manual extension of the connection and as the station apparatus 214 is shown as the local battery type, talking battery is supplied from battery 220 which is connected in a local circuit including the lower contacts associated with cradle 201, the transmitter of handset 200 and the right-hand winding of induction coil 204. If the connection is to be extended automatically the moving of the dial 203 off normal short-circuits the receiver of handset 201 in accordance with the standard practice for this type of substation apparatus.

Where this equipment is located in a magneto central office area the trunk circuit is the same as that described above except that Fig. 7 is interposed in the trunk circuit to the central office, relay 751 operates, operating relay 752 momentarily which connects ringing current to trunk conductors 603 and 604 as the signal of an incoming call.

To release the connection the handset is replaced on the cradle. This opens the circuits through the switchhook contacts associated with the cradle, the upper set of contacts opening the line circuit, releasing the central office equipment in manual common battery or dial offices in the usual manner or signaling the central office to disconnect by means of Fig. 7 in which the release of relay 751 causes the momentary operation of relay 752, connecting ringing current to the line conductors in the case of a magneto office; the middle set of contacts opening the holding circuit of relay 405, releasing it and in turn releasing magnet 402 which releases the switch and the lower set of contacts opening the local battery transmitter circuit. The release of the switch opens the circuit of the trunk busy relay 602 releasing it

Incoming trunk call

When ringing current is applied to conductors 603 and 604 as the signal of an incoming call, relay 607 operates. In a manual common battery or a dial area where magneto signaling apparatus Fig. 7 is not furnished the circuit for this function is traced from conductor 603, left-hand outer back contacts of key 205, condenser 608, the winding of ringing relay 607, left-hand back contacts of relay 602, left-hand inner back contacts of key 205 to conductor 604. In magneto areas, Fig. 7 is furnished and relay 750 is operated by the incoming ringing current, operating relay 749 and extending the ringing current to relay 607 over the path traced above whenever ringing current is applied to conductors 603 and 604.

The operation of ringing relay 607 through its outer contacts causes the operation of relay 609. Relay 609, operated, locks in a circuit traced from battery through the winding and left-hand inner front contacts of relay 609, right-hand middle back contacts of relay 602 to ground in the common tone, ringing alarm and timing circuit 606. The operation of relay 609 closes ground over conductor 651 to the common circuit 607 which thereupon operates several audible signals (not shown) as an indication of an incoming call; connects battery through its right-hand inner front contacts to the filament of trunk lamp 610 which lights and indicates the trunk on which the call has appeared; connects ground through its left-hand middle front contacts to conductor 611 which operates a relay (not shown) in the power supply circuit and increases the rate of charge of the battery for the duration of the call and through its left-hand outer contacts transfers conductor 612 from the busy tone circuit to conductor 613 so that restricted service stations associated with conductor 612 may be connected to the trunk on incoming calls.

The subscriber at station 214 or at any other station where the audible signal and visible signal 610 appear may answer the call by removing the handset from the cradle and operating the trunk key associated with lamp 610. This connects his telephone instrument to the trunk through the cross-bar switch in the same manner as described previously for an outgoing call. The association of one of the stations with the trunk operates relay 602 as before and the operation of relay 602 opens the locking circuit of relay 609 just described releasing the latter relay and extinguishing the ringing signals. At the completion of the conversation the replacing of the handset on the cradle releases the line and trunk equipment as before.

Station-to-station call

To illustrate the operation of the circuit in making a station-to-station call it will be assumed that the subscriber at station 208 desires to communicate with the subscriber at station 214. To do this he removes handset 225 from cradle 226, operates local key 230 and dials the code of the desired line which in this case is 24.

As explained previously a station-to-station call is completed by means of a link circuit one of which is shown in detail in Figs. 5 and 6. The links are rotated in service in a manner to be described later and for the purposes of illustration it will be assumed that the link shown is the one to be used. The calling subscriber's line is connected to the link in much the same manner as that described previously for a trunk call except

that in this case a relay in the link is operated in series with the relay in the line circuit. Line relay 301 operates in a circuit traced from ground through the upper back contacts and upper winding of relay 301, upper outer contacts of magnet 302, upper switchhook contacts associated with cradle 226, pulsing contacts of dial 228, the transmitter of handset 225, left-hand winding of induction coil 229, upper inner contacts of magnet 302 to battery through the lower winding of relay 301. The series circuit mentioned above now connects relays 512 and 513 together to associate the calling end of the link with the particular station line through the cross-points of the switch.

The circuit for this function is traced from ground through resistance 514, back contacts 555 of relay 503, the winding of relay 513, lower next to the outer contacts of relay 301, middle switchhook contacts associated with cradle 226, the back contacts of keys 227, 231 and 232 in series, operated contacts of key 230, lowermost contacts of relay 301, start conductor 629, upper back contacts of key 614, upper back contacts of relay 515, left-hand back contacts of relay 516, conductor 639 to battery through the upper winding of relay 512. Both relays 512 and 513 operate in this circuit. The operation of relay 512 causes the operation of select magnet 403 in a circuit traced from ground through the lower outer contacts of relay 512, back contacts 516 of relay 515 to battery through the winding of select magnet 403. The operation of select magnet 403 causes the operation of relay 510 as before and with relays 510 and 513 both operated a circuit is closed to operate relay 303 which in turn operates magnet 302 releasing relay 301 as previously described. With select magnet 403 and hold magnet 302 both operated the contacts associated with bar 304 are operated to connect the line circuit to the calling end of the link circuit. The operation of relay 513 also causes the operation of relays 505 and 503 as previously explained.

Relay 510 now operates in a circuit traced from ground through a repeating coil (not shown) in common circuit 517 upper front contacts of relay 512, upper winding of relay 518, left-hand outermost contacts associated with bar 304, uppermost contacts associated with cradle 226, pulsing contacts of dial 228, transmitter of handset 225, left-hand winding of induction coil 229, the contacts 312 associated with bar 304 to battery through the lower winding of relay 518. Relay 518, operated, closes a circuit through its front contacts to energize the winding of relay 515. Relay 515, operated, opens the circuit to select magnet 403 releasing it, prepares the pulsing circuit from the back contacts of relay 518, connects ground to conductor 611 to increase the charging rate of the battery and puts ground on the off-normal conductors to be described later. The release of select magnet 403 releases relays 510 and 503 as before. Relay 512 now locks in a circuit traced from ground through contacts 519 of relay 515, upper inner back contacts of relay 520, upper inner back contacts of relay 521 to battery through the lower inner contacts and lower winding of relay 512. Relay 512 is of the slow-to-release type and does not release during the interval between the opening of the circuit through its upper winding when relay 301 releases and the closure of the locking path through its lower winding just described.

The line and link circuits are now in a condition for dialing, dial tone being furnished through the repeating coil in common circuit 517 through the upper front contacts of relay 512. The subscriber upon receiving dial tone will operate dial 228 in the usual manner, releasing and reoperating relay 518 in accordance with the number dialed which in this case has been assumed to be 24. When the dial is moved off normal the transmitter of handset 225 is short-circuited and the receiver circuit is opened in the usual manner. The release of relay 518 on the first dialing pulse causes the operation of relay 522 in a circuit traced from ground through the back contacts of relay 518, innermost contacts of relay 515, back contacts of relay 523, contacts of relay 524 to battery through the winding of relay 522. Relay 525 also operates on the first pulse in a circuit traced from ground through the back contact of relay 518, innermost contacts of relay 515 to battery through the winding of relay 525. Relay 525 is of the slow-to-release type and does not release during the momentary opening of this circuit during dialing. The operation of relay 522 causes the operation of relay 526. The circuit for this operation is traced from ground through contacts 519 of relay 515, upper inner back contacts of relay 520, inner contacts of relay 525, upper front contacts of relay 522, lower outer back contacts of relay 521, back contacts 527 of relay 526 to battery through the winding of relay 526. Relay 526 locks for the duration of the first train of pulses through its make-before-break contacts in a circuit traced from ground through contacts 519 of relay 515, upper inner back contacts of relay 520, inner contacts of relay 525, to battery through the front contacts 527 and winding of relay 526.

When relay 518 reoperates after the first pulse relay 522 is held operated and relay 523 is operated. Thus when relay 518 operates ground is removed from one side of the winding of relay 523 and it operates in series with relay 522 holding the latter relay operated. This circuit is traced from ground through contacts 519 of relay 515, upper inner back contacts of relay 520, inner contacts of relay 525, upper winding of relay 523, lower contacts of relay 522, contacts of relay 524 to battery through the winding of relay 522. When relay 518 releases on the second dial pulse relay 524 operates and holds relay 523 operated but releases relay 522. This circuit is traced from ground through the back contacts of relay 518, innermost contacts of relay 515, front contacts and lower winding of relay 523 to battery through the winding of relay 524. Relay 522, released, causes the operation of relay 521 in a circuit traced from ground through contacts 519 of relay 515, upper inner back contacts of relay 520, inner contacts of relay 525, upper back contacts of relay 522, upper front contacts of relay 525 to battery through the upper inner back contacts and winding of relay 521. Relay 521 locks through its make-before-break contacts in a circuit traced from ground through contacts 519 of relay 515, upper inner back contacts of relay 520 to battery through the upper inner front contacts and winding of relay 521. Upon the reoperation of relay 518 after the second dial pulse relays 523 and 524 release.

It has been assumed that the number of pulses in the first digit is two. Had it been three, relay 522 would have operated again on the third pulse which would have caused the operation of relay 530. Should a fourth pulse be dialed (for which

there is no code assigned) relay 529 will be operated when relay 522 releases. The operation of relay 529 at this time would prevent connection to any station. At the end of the first train

of pulses relay 525 releases, releasing relay 526.

When relay 516 releases on the first pulse of the second digit relays 522 and 525 are operated as before. The operation of relay 525 causes the operation of relay 531 in a circuit traced from ground through contacts 532 of relay 515, lower outer front contacts of relay 525, lower inner back contacts of relay 526, lower inner front contacts of relay 521 to battery through the winding of relay 531 and resistance 533. Relay 531 locks in a circuit traced from ground through contacts 519 of relay 515, upper inner back contacts of relay 520 to battery through the upper inner front contacts and winding of relay 531 and resistance 533. The operation of relay 522 causes the operation of relay 617 in a circuit traced from ground through contacts 519 of relay 515, upper inner back contacts of relay 520, inner contacts of relay 525, upper front contacts of relay 522, lower outer front contacts of relay 521, back contacts 528 of relay 526, upper outer back contacts of relay 618, upper middle back contacts of relay 619, upper outer back contacts of relay 620, upper outer back contacts of relay 621 to battery through the upper inner back contacts and winding of relay 617. Relay 617 locks in a circuit traced from ground through contacts 519 of relay 515, upper inner back contacts of relay 520, upper inner back contacts of relay 619, upper inner back contacts of relay 621, upper inner back contacts of relay 620 to battery through the upper inner front contacts and winding of relay 617.

Relays 620, 621 and 618 now successively operate on the back and front contacts of relay 522 under control of pulse relay 518 over the paths already traced. Each relay operates through its own back contacts and locks through its make before break contacts, opening the locking path and releasing the preceding relay. Had five pulses been dialed, relay 619 would have been operated and relay 618 released. If six had been dialed, relay 622 would have been operated but in this case relay 619 is not released. If more than six pulses had been dialed, relays 617, 620, 621 and 618 would have operated a second time in the same manner as described previously depending on the digit dialed and the operation of each of these relays would have released the previous relay as explained before.

At the completion of the second train of pulses, relay 525 releases and causes the operation of relay 529. This circuit is traced from ground through contacts 532 of relay 515, lower outer back contacts of relay 525, upper outer front contacts of relay 531 to battery through the right-hand inner back contacts and winding of relay 529. Relay 529 locks operated in a circuit traced from ground through contacts 519 of relay 515, upper inner back contacts of relay 520 to battery through the right-hand inner front contacts and winding of relay 529. Relay 526 now operates in a circuit traced from ground through contacts 519 of relay 515, upper inner back contacts of relay 520, right-hand next to the inner front contacts of relay 529 to battery through the winding of relay 526.

A busy test is now made by the connection of busy test relay 534 to the sleeve of the called subscriber's line, ground on the latter indicating

a busy condition. The busy test circuit is traced from battery through the winding and lower inner back contacts of busy test relay 534, front contacts 535 of relay 531, left-hand inner front contacts of relay 529, right-hand outer back contacts of relay 530, lower outer back contacts of relay 622, lower outer front contacts of relay 618, to the sleeve conductor of station line 214, with which sleeve relay 405 is associated. If this line is busy, the sleeve conductor is connected to ground as explained previously and busy test relay 534 operates, opens the circuit to relay 509 to prevent connection to the line and connects busy tone through condenser 536 to the line. If ground is not present on the sleeve of the line circuit relay 534 does not operate and relay 509 operates in a circuit traced from ground through resistance 514, contacts 537 associated with relay 503, lower outer front contacts of relay 526, lower outer front contacts of relay 531, upper back contacts of relay 534 to battery through the winding of relay 509. The operation of relay 509 closes a circuit for the operation of select magnet 409. This circuit is traced from ground through contacts 519 of relay 515, upper inner back contacts of relay 520, lower outer back contacts of relay 538, upper outer front contacts of relay 509 to battery through the winding of select magnet 409. The operation of relay 509 also causes the operation of relay 505 in a circuit traced from ground through resistance 514, contacts 537 of relay 503, upper inner front contacts of relay 509 to battery through the winding of relay 505. The operation of select magnet 409 causes the operation of relay 510 by connecting ground to its winding terminal and the operation of relay 505 causes the operation of relay 503. Relay 510 operated, provides a locking path for relay 503 and short-circuits relay 531, causing it to release. The path over which ground is connected to the right-hand winding terminal of relay 531 has already been described and the path over which ground is connected to the left-hand winding terminal is traced from ground through the lower inner front contacts of relay 510, lower inner front contacts of relay 509 to the left-hand winding terminal of relay 531. The release of relay 531 causes the operation of cut-off relay 405 in a circuit traced from ground through contacts 519 of relay 515, back contacts 535 of relay 531, left-hand inner front contacts of relay 529, right-hand outer back contacts of relay 530, lower outer back contacts of relay 622, lower outer front contacts of relay 618 to battery through the winding of cut-off relay 405. The latter relay operated, operates hold magnet 402 which with the simultaneous operation of select magnet 409 causes the operation of all of the contacts associated with bar 410 in the usual manner.

The operation of the contacts associated with bar 410 closes through the wanted subscriber's line to the terminating end of the link circuit and operates relay 538. The circuit for the latter function is traced from ground through the upper inner front contact of relay 405, contacts 411, upper outer back contacts of relay 520 to battery, through the winding of relay 538. The operation of relay 538 opens the operating circuit of select magnet 409, releasing it which opens the operating circuit of relay 510 releasing it and releasing relay 503 in turn. The operation of relay 538 also connects ringing current through ringing trip relay 539 to the tip and ring conductors of the

wanted subscriber's line while an audible ringing signal is connected to the tip and ring conductors of the calling subscriber's line. The ringing circuit is traced from the ringing current supply from the common circuit 517, over conductor 540, lower inner back contacts of relay 539, upper middle front contacts of relay 538, left-hand contacts associated with bar 410, right-hand middle back contacts of key 205, condenser 206, ringer 207, right-hand inner back contacts of key 205, contacts 417 associated with bar 410, upper inner front contacts of relay 538, upper middle front contacts of relay 521, lower outer back contacts and lower winding of relay 539, conductor 541 to the ringing supply in common circuit 517. The audible ringing tone path is traced from the common circuit 517 over conductor 546, through the lower inner front contacts of relay 538, upper outer front contacts of relay 521, condenser 542, condenser 536, to the tip conductor of the calling subscriber's line.

When the subscriber at the called station 214 answers by removing the handset from the cradle and operating key 237, ringing trip relay 539 operates in the usual manner and locks in a circuit traced from ground through contacts 532 of relay 515, upper front contacts of relay 539, lower back contacts of relay 520 to battery through the upper winding of relay 539. The operation of relay 539 disconnects the ringing current from the called line. Relay 520 now operates through the contacts of key 237 in a circuit traced from ground through the lower contacts of relay 405, right-hand outer back contacts of key 205, middle contacts associated with cradle 201, back contacts of keys 202, 209 and 210 in series, operated contacts of key 208, right-hand contacts associated with bar 410 to battery through the winding of relay 520. Relay 520 remains operated in the circuit just described for the duration of the call and, in operating, opens the operating circuits and releases relays 538, 539, 526, 521, 529 and 618. Cut-off relay 405 is now held operated under control of relay 520 in a circuit traced from ground through contacts 519 of relay 515, the upper inner front contacts of relay 520, contacts 418 associated with bar 410, to battery through the winding of relay 405. The tip conductor of the calling subscriber's line and the ring conductor of the called subscriber's line are connected together through condenser 536 and the upper inner back contact of relay 538 for the transmission of speech and the ring of the calling line and the tip of the called line are connected together through condenser 543 and the upper middle back contacts of relay 538. Talking battery is supplied to the calling subscriber through the windings of relay 518 and to the called subscriber through the windings of retard coil 544.

Upon the completion of the conversation, both subscribers replace the handsets on the cradles. In the case of the calling subscriber this opens the operating circuit of relay 518, releasing it, in turn opening the operating circuit and releasing relay 515. The operating circuit of relay 303 is also opened at the middle contacts associated with cradle 226 and relay 303 releases, releasing hold magnet 302. Cross-bar 304 now returns to its unoperated position releasing the contacts associated with it. The replacing of the handset on the cradle at the called subscriber's station, opens the operating path of relay 520 through the middle contacts associated with cradle 201, releasing this relay. The release of re-

lay 520 removes ground through its upper inner front contacts from the sleeve conductor of the called line, releasing cut-off relay 405. The release of the latter relay opens the operating circuit of hold magnet 402, releasing it and permitting cross-bar 410 to return to its normal position. Both calling and called lines are now in their original or idle condition.

Line hunting

The system is arranged to provide line hunting facilities for some of the lines. This is illustrated in the drawings by the association of lines 26 and 27 in one group and lines 36 and 37 in another group in such a way that if, for example, line 26 is dialed and is found to be busy, the connection is automatically extended to line 27, or, if line 36 is dialed and found to be busy, the connection is automatically extended to line 37. This is done by substituting relay 617 for busy test relay 534 in case line 26 or 36 is dialed.

It will be assumed that station 211 whose code is 25 has been called. The operation of the circuit under this condition is the same as previously described until the completion of the dialing of the second digit. At this time, a circuit is closed from the sleeve conductor of the wanted station line to relay 617. This circuit is traced from the left-hand winding terminal of cut-off relay 413, which may or may not have ground connected to it, through the right-hand outer back contacts of key 212, lower next to the outer contacts of relay 619, lower next to the inner contacts of relay 622, right-hand inner back contacts of relay 520, left-hand middle front contacts of relay 529, lower inner front contacts of relay 531 to battery through the upper inner back contacts and winding of relay 617. If station 211 is busy, ground will be present on the sleeve conductor and relay 617 will be operated. Relay 617 operated, locks and connects the sleeve of line 27 to the terminating end of the link in the same way as if 7 had been dialed as the second digit. Busy test relay 535 is now connected to the sleeve of line 27 and the regular busy test is made on that line as previously described. If the sleeve of line 26 had not been grounded, relay 617 would not have operated and with relays 617 and 534 both non-operated, the terminating end of the link would have been connected to line 26 in the line to line call as described previously.

Calls from and to keyless stations

When a keyless station 235 originates a local call, the operation of the circuit is similar in every respect to that just described for key station operation except that the operation of line relay 306 causes the operation of relay 512 directly instead of through the switchhook contacts and the local key as previously described. Also relay 307 is held operated by relay 515 through the contacts of the switch. This circuit is traced from ground through contacts 532 of relay 515, contacts 309 associated with cross-bar 305 to battery through the winding of cut-off relay 307.

If the keyless station 235 is called, the operation of the circuit is the same as that described for a key station with the exception that relay 539 when it operates, due to the removal of the handset from the cradle, connects ground through the cross-points of the switch to operate relay 520. This circuit is traced from ground through contacts 522 of relay 515, upper contacts of relay 539, cross-bar contacts 310, cross-

bar contacts 311 to battery through the winding of relay 520.

Station 211 is also a keyless station and is normally connected to keyless station equipment 412, 413 and 414 through the inner back contacts of transfer key 212. With key 212 in the normal position, as shown, station 211 may originate and receive calls like other keyless stations. It is arranged, however to receive trunk calls extended through the master station 214 as will be described later.

Trunk holding

The system is arranged so that incoming calls from the central office may be answered at one or more stations and held while the desired station is called locally and informed of the call. By operating the trunk key associated with the incoming call the wanted station is connected to the trunk and the holding condition is removed.

To illustrate this arrangement it will be assumed that an incoming call on trunk #1, shown in Fig. 6, has been answered by the attendant at station 214, shown in Fig. 2, and it has been ascertained that station 208 is wanted. The attendant at station 214 thereupon operates hold key 213 momentarily. The operation of this key releases trunk key 202 mechanically and causes the operation of relay 605 in a circuit traced from ground through the lower contacts of relay 405, right-hand outer contacts of key 205, middle contacts associated with cradle 201, contacts of hold key 213, contacts 419 associated with cross-bar 407 to battery through the winding of relay 605. Relay 605, operated, locks through its right-hand inner contacts to ground through contacts 623 of relay 602. The operation of relay 605 opens the central office trunk to station 214 and connects the winding of relay 624 in series with resistance 626 across trunk conductors 603 and 604 to hold the connection to the central office. The winding of relay 624 is normally short-circuited by the right-hand outer back contacts of relay 605 and the right-hand inner front contacts of relay 602. This short circuit is removed however, by the operation of relay 605 and relay 624 operates in the trunk circuit. The operation of relay 624 causes the operation of relay 625. Relay 625, operated, prepared a holding circuit for relay 624 to be described later and connects ground to conductor 611 to increase the charging rate of the battery. The release of key 202 opens the operating circuit, releasing relay 405 which in turn releases hold magnet 402 and cross-bar 407. When this occurs the circuit to relay 602 is opened and relay 602 releases. Relay 602, released, opens the locking circuit of relay 605 which releases. With relays 602 and 609 released and relay 625 operated the winding of relay 601 is connected to conductor 612 so that stations having restricted service may pick up the call and relay 625 is held operated and acts as the holding bridge, the latter circuit being traced from trunk conductor 603, left-hand outer back contacts of key 205, left-hand contacts of relay 625, the winding of relay 624, resistance 626, left-hand inner back contacts of key 205 to trunk conductor 604.

Station 214 may now make a local call to the wanted station in the manner described previously by operating local key 237 and dialing the number of the wanted station on dial 203. It will be assumed that the wanted station is station 208. When the attendant at station 208

has answered and has been informed that a call from the central office is to be picked up on trunk #1 he operates key 227. The operation of this key mechanically releases key 230 which was operated when he answered, releasing his line from the link circuit as previously described. The operation of key 227 now causes the operation of relay 601 in a circuit traced from ground through resistance 514, contacts 555 of relay 503, the winding of relay 513, the lower and next to the outer contacts of relay 301, middle contacts associated with cradle 226, front contacts of key 227, lower inner contacts of relay 301, right-hand outer back contacts of relay 602 to battery through the winding of relay 601. The operation of relay 601 associates station 208 with the trunk circuit as previously described. When relay 602 again operates through the cross points of the switch it short-circuits relay 624. This short-circuiting path is traced from the left-hand winding terminal of relay 624, right-hand outer back contacts of relay 605, right-hand inner front contacts of relay 602 to the right-hand winding terminals of relay 624. Relay 624, released, opens the operating circuit of relay 625 releasing it. The trunk circuit is now connected in the usual way to station 208 under control of the switchhook contacts and keys of this station.

Extension of trunk calls to two wire stations

The system is arranged to extend trunk calls to one or more two wire stations by means of keys located at the master station. In the drawings two wire station 211 is so arranged by means of keys 215, 212 and 216 located at master station 214. With these keys in their normal position the line wires of station 211 are connected through the right inner and left inner back contacts of key 212 to line relay 412 which permits station 211 to make and receive local calls in the manner described previously. If it is desired to extend a trunk call which has been connected to station 214 to station 211 the attendant at station 214 first operates key 215 which connects the line wires of stations 214 and 211 together through condensers 217 and 218 and permits him to monitor on station 211 to ascertain whether or not the station is busy. Having determined that station 211 is not busy key 212 is next operated. The operation of key 212 connects the line wires of station 211 to the line wires of station 214 through the left-hand front contacts and right-hand inner front contacts of key 212 and the right- and left-hand back contacts of key 216; through its right-hand middle front contacts connects a shunt across the middle switchhook contacts associated with cradle 201 to permit station 214 to replace the handset on the cradle without releasing the connection; connects ground through its right-hand outer front contacts to the sleeve conductor of the line equipment associated with station 211 so that this line will test busy to incoming calls and through its right-hand outer back contacts disconnects the cut-off relay 413 so that the latter relay and hold magnet 414 will not operate falsely. The bell at station 111 may now be operated by operating key 216 momentarily, the line circuit being opened at the back contacts of key 216 and ringing current from the common circuit 219 being applied to the line conductors to station 211 through the front contacts of key 216. After station 211 has answered

station 214 may monitor on the conversation or replace the handset on the cradle as desired. At the termination of the conversation key 212 is returned to its normal position.

5

Rotation of links

In order that the links may receive equal wear an arrangement is provided to rotate them in service, that is to preselect them so that they
10 are used in rotation, the first link being used next after the last is reached. Facilities are shown in Fig. 6 to accomplish this for three links. When the first link (shown in detail in Fig. 5) has been used, which condition is indicated by
15 the operation of relay 515, ground through contacts 532 is connected over conductor 628, to battery through the winding of relay 616. Relay 616 operates, locks mechanically and transfers the start conductor 629 from conductor 630 to
20 conductor 631 which is connected to the start relay in the second link similar to relay 512. The start circuit is then traced from ground on start conductor 629, upper back contacts of key 614, upper back contacts of relay 615, left-hand
25 front contacts of relay 616, upper back contacts of key 635, upper back contacts of relay 636, left-hand back contacts of relay 627 to conductor 631 which is connected to battery through the winding of the start relay, similar to relay
30 512 in the second link.

When the second link is used ground is connected to conductor 632 from the relay similar to relay 515 in the second link, operating relay 627 which locks mechanically and transfers start conductor 629 through the left-hand front contacts of relay 627 and the upper back contacts of key 637, the upper back contacts of relay 638 and the left-hand back contacts of relay 639 to conductor 633 which is connected to the start relay
40 similar to relay 512 in the third link. When the third link is used ground is connected to conductor 634 and relay 639 operated. With relays 616, 627 and 639 operated a circuit is closed from ground through the right-hand contacts of
45 relay 616, conductor 646, right-hand contacts of relay 627 and right-hand contacts of relay 639 to battery through the winding of relay 640. Relay 640 operates in this circuit and connects ground to the winding of relay 641 operating the
50 latter. Relay 641, operated, connects ground to the windings of release magnets 642 and 643 operating them and removing the mechanical locks from relays 616 and 627. If links No. 1 or No. 2 or both are still in use at the time link No.
55 3 is seized ground will still be present on conductors 628 or 632 or both and relays 616 or 627 or both will continue in an operated condition. With relays 616, 627 and 639 operated a new call which is evidenced by ground on start lead 629
60 returns busy tone to the calling subscriber by transferring the ground on conductor 629 through the upper back contacts of key 614, upper back contacts of relay 615, left-hand front contacts of relay 616, upper back contact of key 635, upper
65 back contacts of relay 636, left-hand front contacts of relay 627, upper back contacts of key 637, upper back contacts of relay 638, left-hand front contacts of relay 639 to battery through the winding of a relay (not shown) in the common circuit 645 over conductor 644.

If either link No. 1 or No. 2 or both are idle relays 616, 627 or both release when release magnets 642 and 643 operate. In this case the link busy path just traced is opened at either relay
75 616 or 617 as well as the operating path of relay

640 releasing relay 641 and release magnets 642 and 643 and one of the links will be used on the next call as previously explained. When the call which used link No. 3 is ended ground is removed from conductor 634, releasing relay 5
639.

Facilities are provided so that any of the links may be conveniently withdrawn from service for repair or other reasons. Thus the operation of key 614 transfers conductor 624 to the second
10 link and places ground on conductor 646 in effect as if relay 615 were operated. Similarly links No. 2 or No. 3 may be withdrawn from service by operating key 635 or 637. Relays 615, 636
15 and 638 are provided so that the links associated with them will be automatically withdrawn from service in case the battery fuse associated with the individual link operates. This fuse is located in the common timing circuit 645 and when it
20 operates connects battery to conductors 647, 648 or 649 depending on which link is in trouble. Battery on conductor 647 operates relay 615 which transfers the start conductor 629 to the second link and grounds conductor 646. The
25 operation of relays 637 or 638 perform similar functions for the second and third links. When relay 615, 636 or 638 operates due to an operated fuse battery is returned to common circuit 645 over conductor 650 for alarm purposes.

Emergency service to the central office

30

Arrangements for service to the central office on an emergency basis are provided to take care of the possible condition where for any reason
35 no calls can be made through the switch. This is accomplished by the use of emergency switch 205 which when operated disconnects master station 214 from the station relay equipment and connects it directly to the first trunk to the
40 central office. With key 205 operated station 214 may originate and receive calls in the usual manner. Station 214 has been shown with equipment arranged for magneto operation, a local talking battery 220 and signalling generator 221
45 being furnished.

What is claimed is:

1. In a telephone system, a switch, subscribers' lines terminating in said switch, links terminating in said switch, means for establishing a connection from any one of said lines to any particular
50 other one of said lines through a link, and means responsive to the calling of a particular line for establishing a connection through a link from the calling line to another line if said particular line is busy.
2. In a telephone system, a switch, groups of subscribers' lines terminating in said switch, links terminating in said switch, means for establishing a connection from any one of the lines in
55 any one of said groups of lines to any particular line in any one of said groups through a link, and means responsive to the calling of a certain line in any one of said groups for establishing a connection through a link from the calling
60 line to another line in the group of lines in which said certain called line is located if said called line is busy.
3. In a telephone system, a cross-bar switch, subscribers' lines terminating in said switch, some of said lines arranged in pairs, links terminating in said switch, means for establishing a connection
70 from any one of said lines to any particular other one of said lines through an idle link, and means responsive to the calling of a particular line of a pair of lines for establishing a connection through

75

an idle link from the calling line to the other line of said pair if said particularly called line is busy.

4. In a telephone system, a cross-bar switch, subscribers' lines terminating in said switch, links terminating in said switch, means for establishing a connection from any one of said lines to any one of the other lines terminating in said switch through an idle link, means for establishing a connection from any one of said lines to a particular one of said lines through an idle link, and means operated if said particularly called line is busy for establishing instead a connection to another line through said idle link.

5. In a telephone system, a cross-bar switch, subscribers' lines arranged vertically in said switch, links arranged horizontally in said switch, trunks arranged horizontally in said switch, means for establishing a connection from any calling line to any other line through a link, a key at each subscriber's station for each trunk, and means operated by a calling subscriber removing his receiver from the switchhook and actuating a trunk key for establishing a connection from said calling subscriber's line to a corresponding trunk.

6. In a telephone system, a cross-bar switch, subscribers' lines terminating in said switch, links terminating in said switch, means for establishing a connection from a calling line to any other line through an idle link, a relay associated with each line, means for operating the relay associated with the line when said line is busy, means responsive to the calling of a first line in a certain group of lines if said first line is busy and the associated relay is operated for establishing a connection through an idle link from the calling line to a second line in said group.

7. In a telephone system, a cross-bar switch, lines terminating in said switch, links terminating in said switch having a calling branch and a called branch, means for establishing a connection from a calling line through the calling branch of an idle link, means thereafter responsive to digits represented by series of selective impulses incoming over the line for extending the connection through the associated called branch of said link to any line corresponding to the particular digits selected, a cut-off relay associated with each line, means for operating the relay associated with a line when said line is busy, means operative after the digits representing a first line in a certain group of lines have been received for preventing the extension of the connection to said first line if the associated cut-off relay is operated and for extending the connection to a second line in said certain group.

8. In a telephone system, a cross-bar switch, subscribers' lines arranged vertically on said switch, links arranged horizontally on said switch, trunks arranged horizontally on said switch, means for establishing a connection from any calling line to any other line through an idle link, a key at each subscriber's station for each trunk, a trunk holding key at each subscriber's station, means operative by a calling subscriber removing his receiver from the switchhook and actuating

a trunk key for establishing a connection from said calling subscriber's line to the corresponding trunk, means thereafter responsive on the operation of the calling subscriber's trunk holding key for establishing a holding condition on the engaged trunk, means for releasing said calling subscriber's line from said trunk, and means thereafter operative in response to the establishing of a connection from any subscriber's line to said held trunk for removing said holding condition.

9. In a telephone system, a cross-bar switch, subscribers' lines terminating in said switch, trunks terminating in said switch, a key at each subscriber's station for each trunk, a trunk holding key at each subscriber's station, means operative by a calling subscriber removing his receiver from the switchhook and operating a trunk key for establishing a connection between said subscriber's line and the corresponding trunk, means thereafter responsive to the operation of the calling subscriber's trunk holding key for establishing a holding condition on the engaged trunk, means thereafter operative by the calling subscriber replacing his receiver on the switchhook for releasing his line from said trunk, and means thereafter operative in response to the establishing of a connection from any calling subscriber's line to said held trunk for removing said holding condition.

10. In a telephone system, a cross-bar switch, subscribers' lines terminating in said switch, links terminating in said switch, a key at each subscriber's station, trunks terminating in said switch, a key at each subscriber's station for each trunk, means responsive to a calling subscriber removing his receiver from the switchhook and operating said first-mentioned key for establishing a connection between said calling subscriber's line and a link, and means responsive to a calling subscriber removing his receiver from the switchhook and operating a trunk key for establishing a connection from said last-mentioned calling subscriber's line to a corresponding trunk.

11. In a telephone system, a cross-bar switch, subscribers' lines terminating in said switch, links terminating in said switch, a key at each subscriber's station, trunks terminating in said switch, a key at each subscriber's station for each trunk, means responsive to a calling subscriber removing his receiver from the switchhook and operating said first-mentioned key for establishing a connection between said calling subscriber's line and a link, means responsive to digits represented by series of impulses transmitted from said calling subscriber's station over the connected link for connecting the seized link to a called subscriber's line corresponding to the digits transmitted, and means responsive to a calling subscriber removing his receiver from the switchhook and operating a trunk key for establishing a connection from said last-mentioned calling subscriber's line to a corresponding trunk.

CHARLES D. KOECHLING.