

April 21, 1942.

F. S. KINKEAD ET AL

2,280,292

TELETYPEWRITER SWITCHING SYSTEM

Filed July 17, 1940

8 Sheets-Sheet 1

FIG. 1

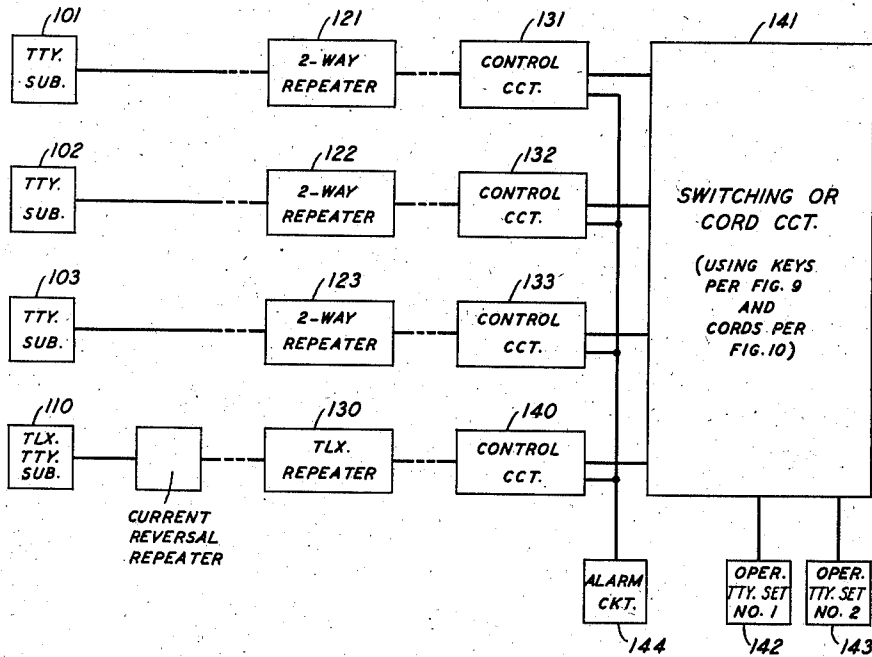


FIG. 9

FIG. 2	FIG. 4	FIG. 5	FIG. 6
FIG. 3		FIG. 7	

FIG. 10

FIG. 2	FIG. 4	FIG. 8
FIG. 3		FIG. 7

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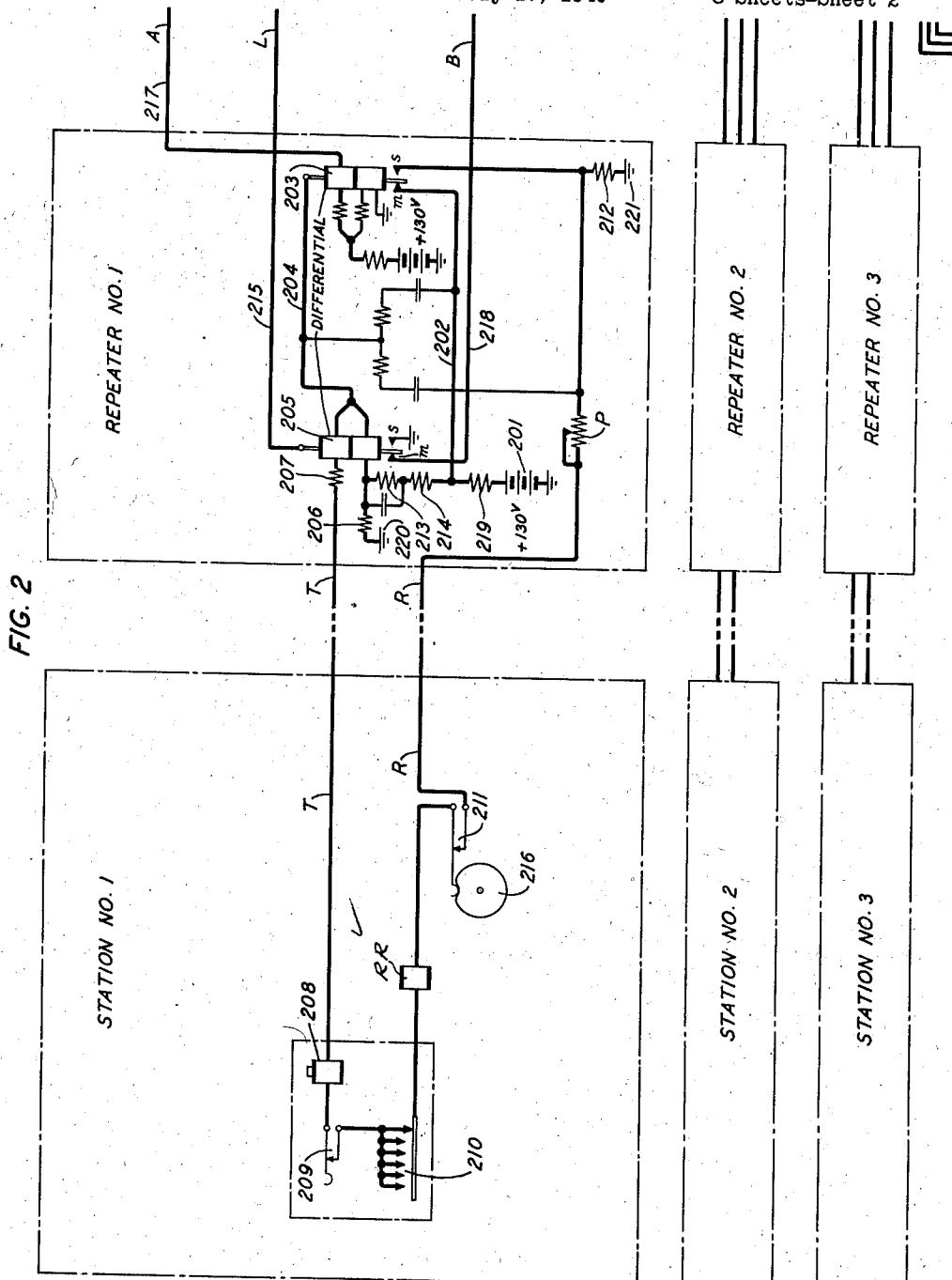
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8 Sheets-Sheet 2



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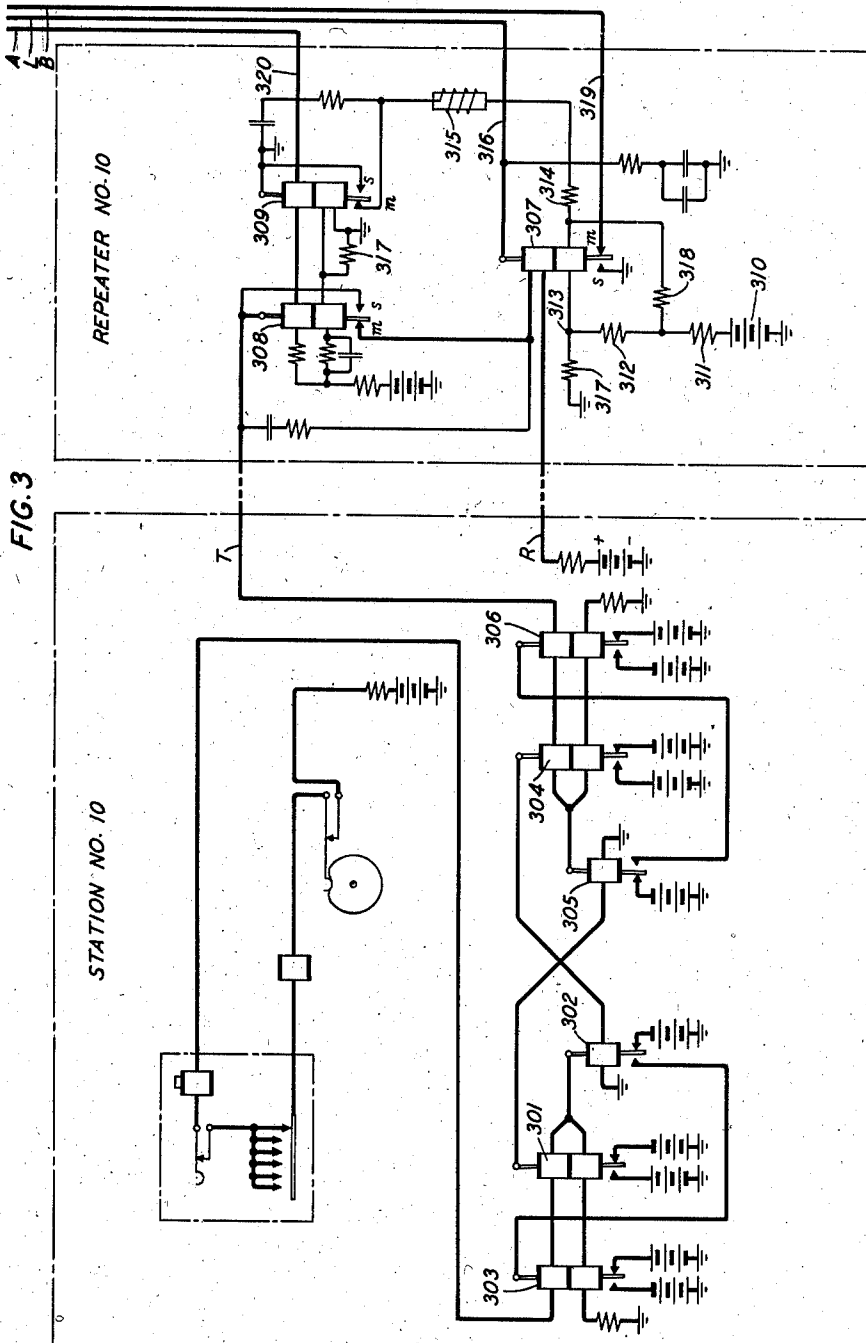
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TELETYPEWRITER SWITCHING SYSTEM

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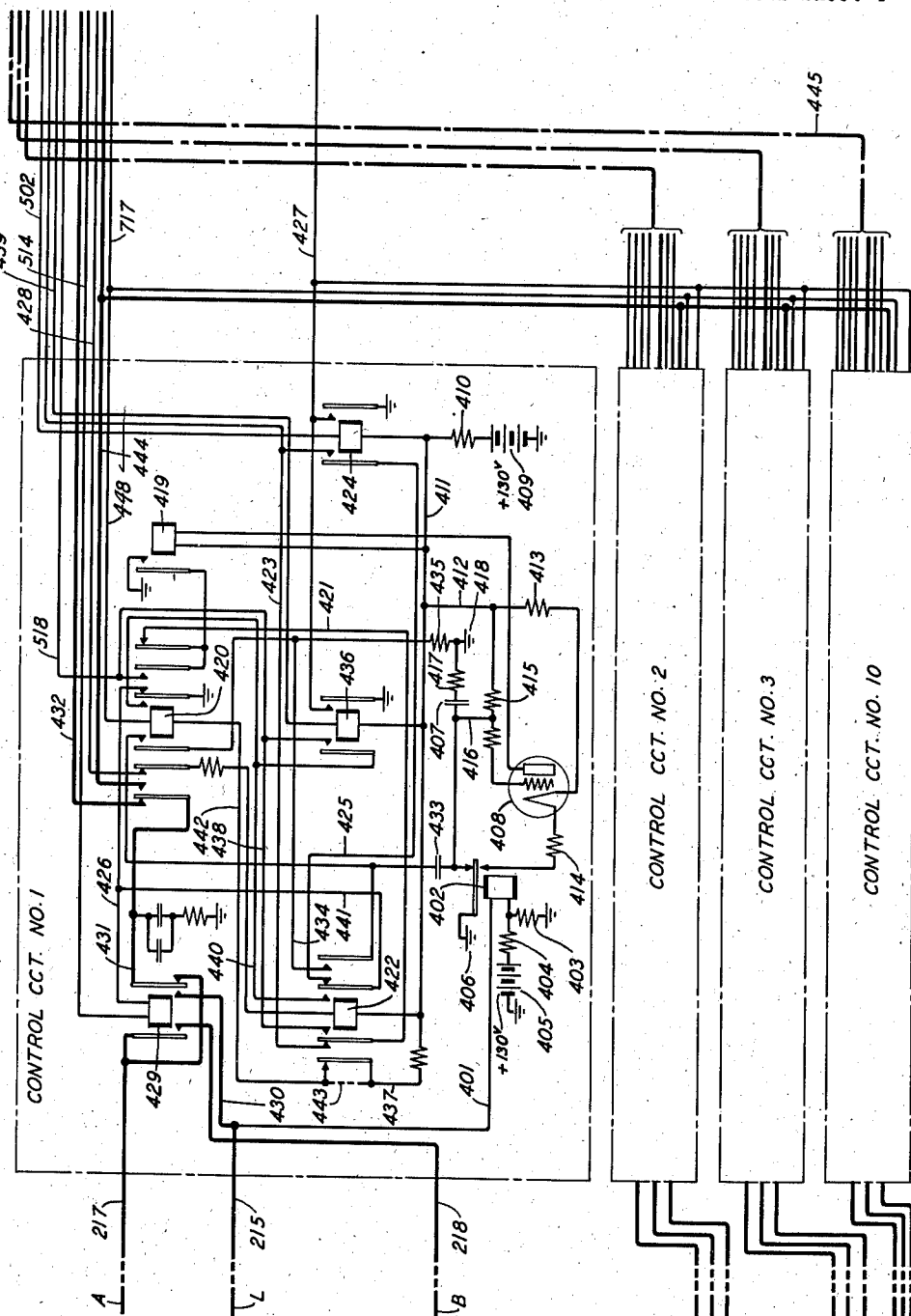
2,280,292

TELETYPEWRITER SWITCHING SYSTEM

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FIG. 4



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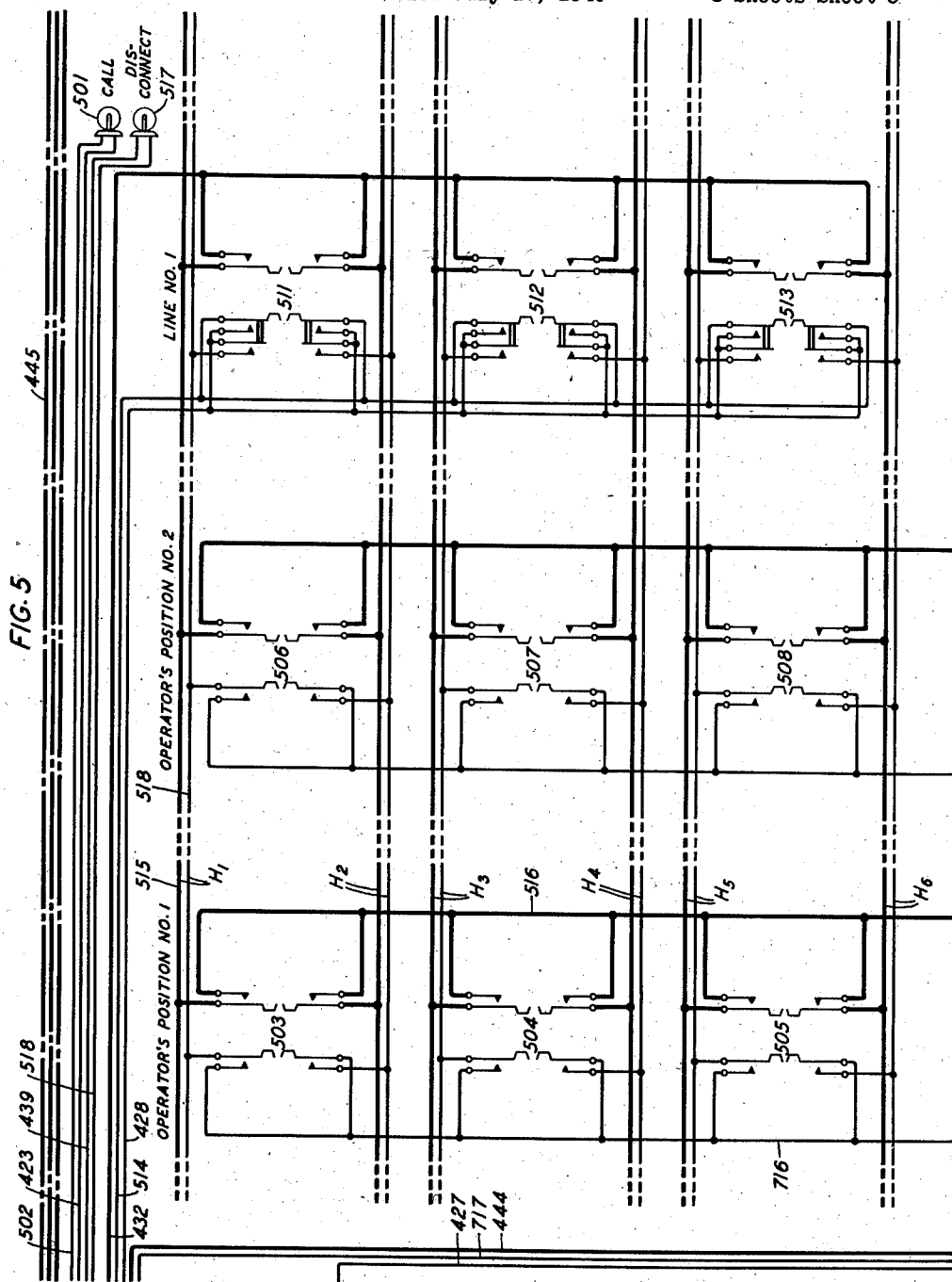
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TELETYPEWRITER SWITCHING SYSTEM

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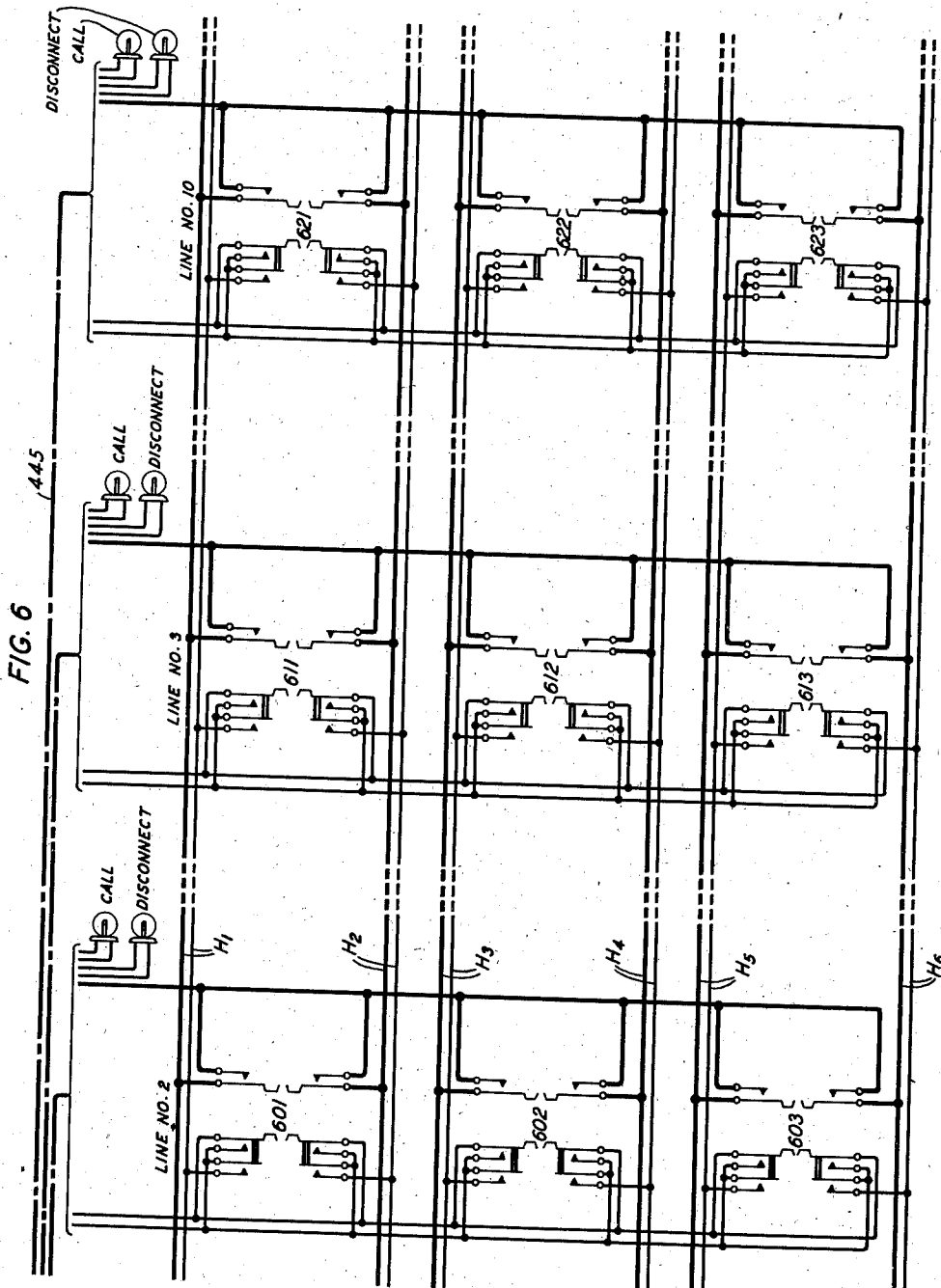
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TELETYPEWRITER SWITCHING SYSTEM

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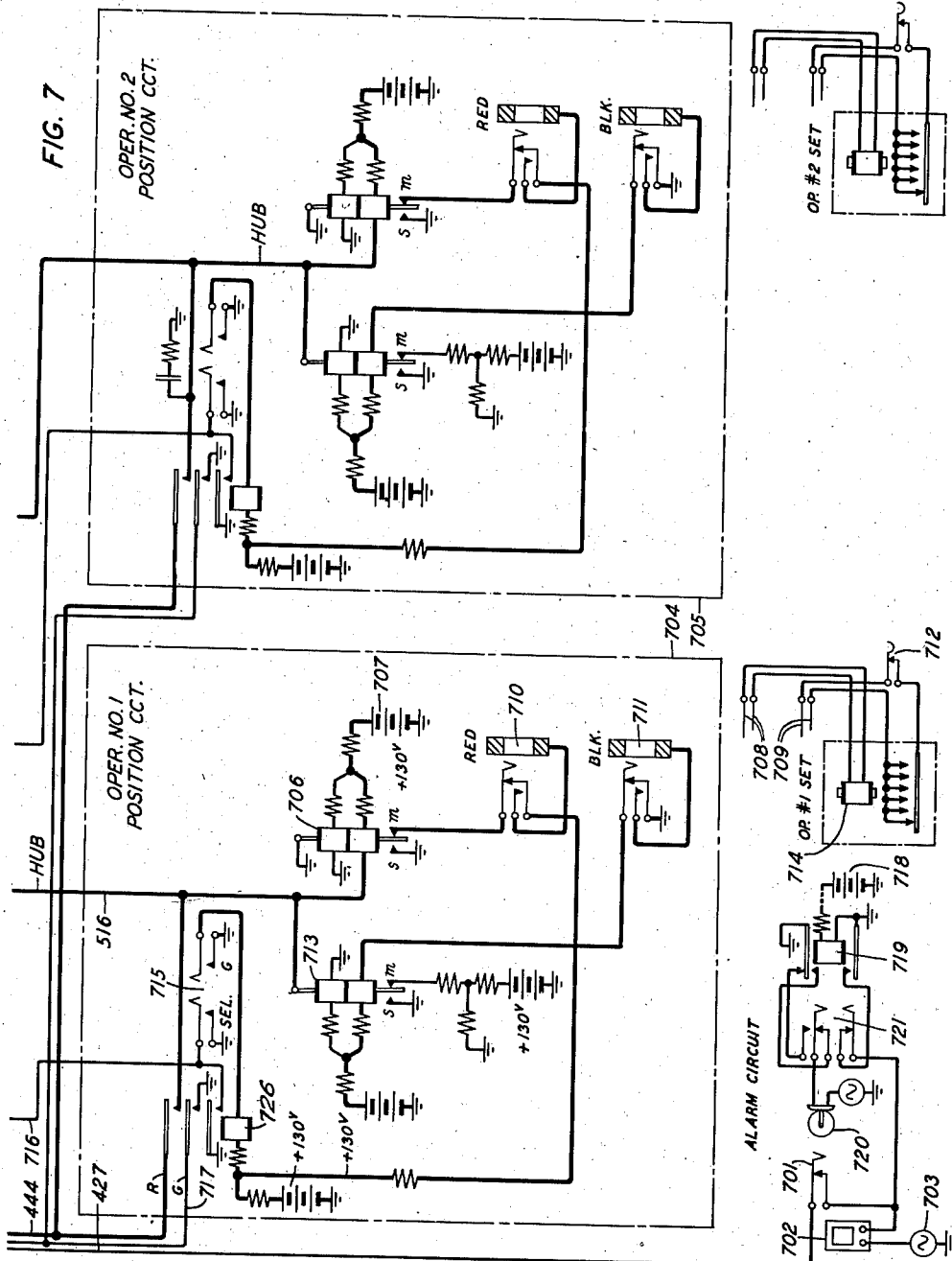
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TELETYPEWRITER SWITCHING SYSTEM

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8 Sheets-Sheet 7



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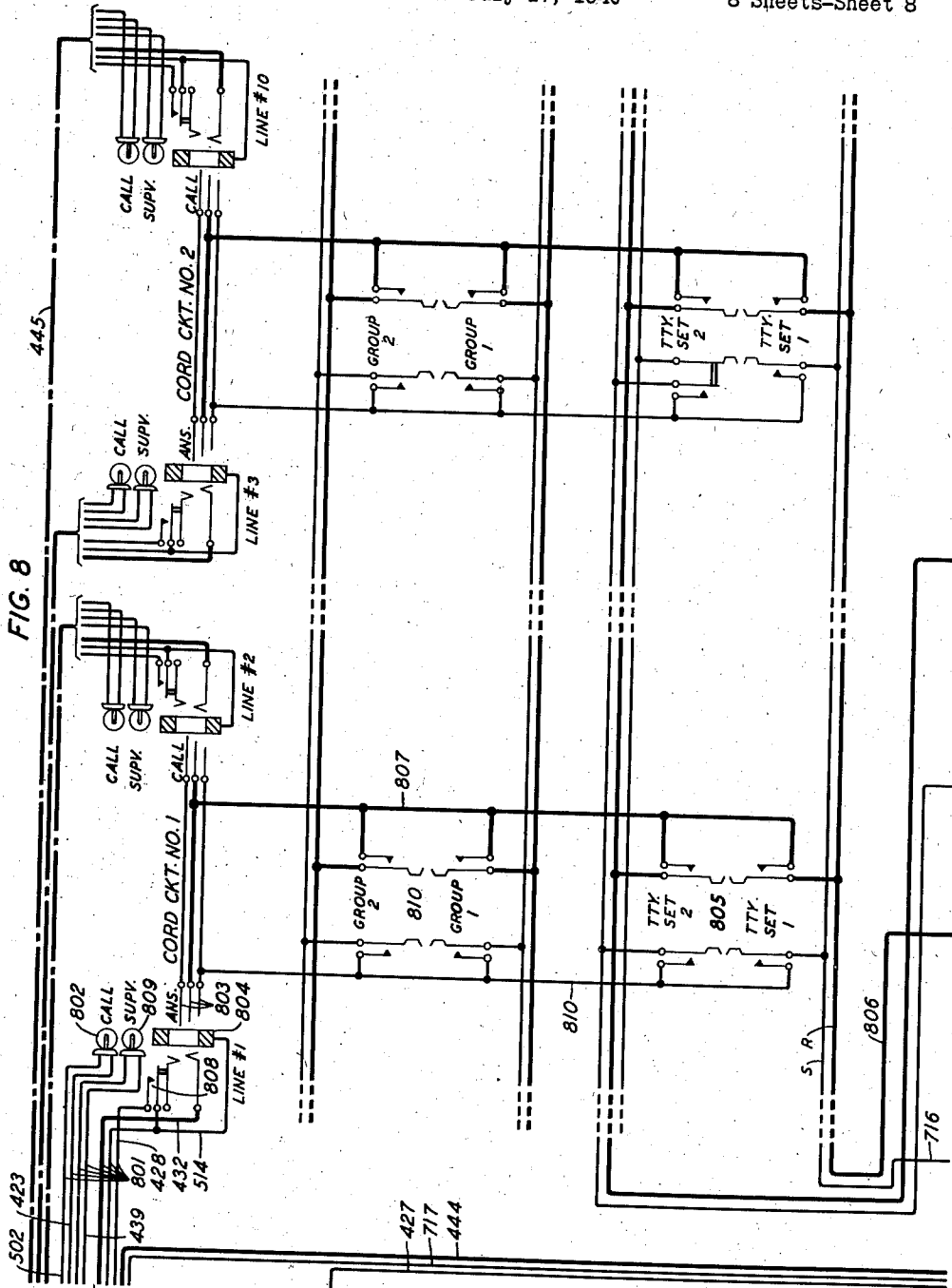
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TELETYPEWRITER SWITCHING SYSTEM

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8 Sheets-Sheet 8



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UNITED STATES PATENT OFFICE

2,280,292

TELETYPEWRITER SWITCHING SYSTEM

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Application July 17, 1940, Serial No. 345,893

8 Claims. (Cl. 178—2)

This relates to printing telegraph systems and more particularly to switching arrangements adapted to give service to stations connected to a main station in an intercommunicating teletypewriter system.

The system is particularly useful in banks, and manufacturing concerns as well as press associations and police departments wherein it is highly desirable to provide broadcast and conference facilities for not only the main station but also for each of the local and the outlying stations.

An object of the invention is to meet a wide variation in intercommunicating system requirements with a minimum effect on the cost.

Another object is to provide a closed line circuit which will indicate incoming calls, provide proper supervision and facilitate broadcasting control.

Another object is to provide an arrangement whereby lines may be connected to a common circuit for hub transmission.

According to the present invention, a teletypewriter intercommunicating system is provided wherein a manually operated switchboard at a switching center is used for terminating a plurality of local loops from near-by stations and extension lines from outlying stations. Each of the loops and lines is in series connection with a repeater at an intermediate location and a line control circuit at the switching center. Each of the control circuits is connected to a row of keys whereby each line may be extended through any one of six hub circuits to either of two operators' teletypewriter sets. Two rows of keys are provided for respectively connecting two operators' teletypewriter sets to the hub circuits, one key of each row being in engageable relation with each hub circuit. The key arrangement for interconnecting lines may be replaced by a cord connecting system, each cord of the system containing keys for connecting the operator's set and for arranging the lines in broadcast groups as desired. There is provided selective or general broadcast facilities for use by either operator or station attendant, or subscriber, with individual acknowledgement from each line, selective or general conference facilities without individual acknowledgement, and unattended station service. The normal capacity of the switchboard is ten lines with a provision for a maximum of twenty-two lines. More than one switchboard with appropriate toll line facilities may be used in larger systems.

a normal arrangement wherein may be made five simultaneous through-connections with a possibility of six if a path, or hub circuit, is not reserved for broadcast.

5 Another feature is the broadcast facility whereby the switchboard operator and the station attendant are able to broadcast over a selective or general connection with individual acknowledgement from each station.

10 Another feature is the establishment of a conference circuit over a selective or general connection without individual acknowledgement.

Another feature is the closed loop with timed spaced signals for station calls and station disconnects.

15 Another feature is the provision of unattended service which permits starting and stopping the teletypewriter motor at a distant station from the switchboard at the switching center.

20 Another feature is the optional provision of means whereby a line circuit may be automatically arranged for broadcast in such a manner that interference with it from a subscriber using another line circuit will be impossible while an operator at the main station switchboard is broadcasting to a group of subscribers.

Another feature is the provision of means for establishing of interconnection of lines and connection between lines and operators' teletypewriter sets by keys and inverse neutral circuits, the latter circuits herein referred to as "hub" circuits.

GENERAL DESCRIPTION

The present system is adapted for either key or cord circuit switching. Each of the line circuits which terminate in the switchboard includes a loop repeater and a supervisory control circuit. Two types of loop repeaters are provided, one for each of the local loops and the other for each extension line. The extension lines are of considerable length and are referred to herein as the toll line extension circuits. The line circuits operate on a closed loop basis and therefore each station teletypewriter equipment is furnished with means to "start-on-close-after-break" and with "stop-signal-motor-control-arrangement." The inverse neutral method of operation, also known as the hub circuit method, is employed in the basic switching circuits of the system herein described. Each of the repeaters in the line circuits is arranged to be connected by means of the switching keys at the switchboard to a hub so that the attendants at stations connected to the line circuits may com-

A feature of the invention is the provision of

municate with each other either individually or in broadcast or in conference arrangements. The sides of the repeaters connected to the subscribers' stations are arranged to use a single polarity balanced, or differential, type of loop and the armatures of the repeating relays are arranged by means of the switching key to be connected to a common electrical point such as a hub circuit. In the idle condition equal impedances and voltages will be presented by all repeaters to a hub circuit through the windings of all the send relays to a potentiometer and no current will flow through the upper windings of the send relays. All these send relays will normally be held in a marking condition by current through their respective lower windings and all loops will therefore be closed. From the description which hereinafter follows, it will be seen that a relatively simple interconnecting arrangement is provided at the switchboard because from a transmission standpoint it is necessary to switch only one wire and for conference and broadcast circuits, additional stations may be readily connected and disconnected from the hub circuit as desired without additional design complications.

Loop repeaters for local loops

Stations located within the mileage resistance limitation for loop operation, say about 35 miles, are connected to the switchboard through a two-relay loop repeater. The relays of this type of repeater are known as the send and the receive relays. The side of the repeater connected to the switchboard is adapted for connection to a 130-volt inverse neutral circuit, or hub circuit, and the loop side of the repeater is a balanced, or differential, loop arrangement with positive 130-volt battery when marking and ground for spacing. The bias winding of the receive relay is connected to a potentiometer which supplies a voltage to prevent the receive relay operating to spacing when a space signal is sent to the loop.

For loop extension circuits

Stations served over loop extension circuits are connected to the switchboard through a three relay repeater. The repeater of this type comprises a send, a receive and a hold relay. The switchboard side of the repeater is adapted for connection to a positive 130-volt inverse neutral, or hub circuit, and the other side is connected to an open-wire grounded telegraph line and is arranged to transmit signals of 60-milliampere current and "no current." The hold relay is required, in addition to the send and receive relays, to maintain a marking condition for the receive relay when signals are transmitted to the loop.

Operator's teletypewriter circuit

This circuit is also called the "operator's" set or position circuit and consists, from a transmission standpoint, of an inverse neutral loop repeater with a send and a receive relay. The hub lead to the key switching circuit is connected to the armature of the send relay and the line winding of the receive relay. The receive relay is held on its marking contact in the idle condition due to current through its bias winding and no current flows in the line winding since both sides are connected to taps on a positive 130-volt battery (one tap being located at the marking contact of the send relay). Also, when idle, current flows through both windings of the

send relay and the current flowing through the line winding is a marking current of sufficient value to overpower the spacing effect of the bias winding.

Two separate and independent connections are made to the teletypewriter, one for the sending contacts and the other to the receiving or printer magnet. The send relay is responsive to signals from the sending contacts of the teletypewriter and when this relay is spacing, it applies ground to the hub circuit of an established connection and also to the line winding of the receive relay. The receive relay operates on signals sent from the teletypewriter and thereby provides "local" copy. The receive relay transmits signals to the teletypewriter, or printer, magnet on an open and close basis.

Conference connection

By reference to the key switching circuit it will be seen that one or more station keys may be operated to the same level and a conference connection, that is, two-way communication between all interconnected stations will be established. In this case individual supervision on disconnect or acknowledgment will not be obtained because an open signal of five-second duration sent by any station will be received by all control circuits and all supervisory lamps will light and the operator will not know who is sending the signal.

Broadcast connection

Three forms of broadcast connections may be established. They are a selected and a general broadcast from the switchboard operator and a broadcast by any station to a group of stations selected by the operator.

Selected broadcast

The operator operates the broadcast key in one of the operator's set circuits to the selected position and an operator's set key in the same set circuit to the level from which the broadcasting is to take place. Line keys for the desired stations are also operated to the same level as the operator's key. A short break signal is sent by the operator and all stations start simultaneously.

General broadcast (seizure and non-seizure)

A general broadcast to a portion or all the stations of a network may be arranged on a predetermined basis by the use of particular wiring connections associated with the broadcast relay in each of the control circuits. For a common or a general broadcast connection, the operator operates a broadcast key in one of the operator's set circuits to the group position and if no stations other than those in the predetermined group are to receive the broadcast method, no line keys or operator's keys are operated. Individual acknowledgment will be obtained as in the selected broadcast arrangement.

Station broadcast

A station may broadcast to a group of stations selected by the operator by using two levels of switching keys, that is, two hubs in the switching circuit. These key operations establish a one-way circuit to all stations receiving the broadcast and the operator at the switchboard and the attendant at the station transmitting the broadcast, may communicate on a two-way basis. Individual acknowledgment of the broad-

cast method will be obtained from all stations arranged for one-way service.

Referring to the drawings:

Fig. 1 shows a diagrammatic arrangement of the complete teletypewriter intercommunicating system having a plurality of local loop subscribers' stations and an outlying subscriber's station connected to a main station;

Fig. 2 shows, somewhat in detail, a subscriber's station of the local loop type connected to a repeater and well known in the art, and in diagrammatic form, two other stations and associated repeaters of types respectively similar to those shown somewhat in detail. The repeaters are of the two-way half duplex type and are particularly adaptable for use in local subscribers' loops;

Fig. 3 shows, somewhat in detail, another subscriber's local loop station. This local loop station, however, is connected first through a pair of terminal repeaters and then through another type of repeater adapted for toll lines. The last-mentioned repeater is used in lines arranged to furnish service to subscribers at distant outlying points;

Fig. 4 shows, in detail, at a main switching office, a closed line control circuit individual to the local subscriber's station shown in detail in Fig. 1. Three other control circuits are shown in diagrammatic form respectively associated with the other subscribers' stations shown in Figs. 1 and 2;

Figs. 5 and 6 show at the main switching office, key switching circuits respectively connected to the control circuits of Fig. 4 and other key switching circuits respectively connected to the operator's teletypewriter sets. By means of these key switching circuits any line circuit may be connected to any one of the operator's teletypewriter sets or to one or more of the remaining line circuits;

Fig. 7 shows the operator's position and teletypewriter sets respectively connected to their associated key switching circuits;

Fig. 8 is the cord switching circuit which may be used as an alternative for the key switching circuit shown in Figs. 5 and 6;

Fig. 9 is a relative arrangement of the figures representing the system when the key switching circuits are used; and

Fig. 10 is a relative arrangement of the figures representing the system wherein the cord switching circuits are used.

Referring to Fig. 1, blocks 101, 102, 103, etc. represent station apparatus and circuit equipment for subscribers' stations respectively connected to the main station over local loop circuits and block 110 represents the station apparatus and circuit equipment at one of several outlying subscribers' stations located at considerably greater distances from the main office than the local subscribers' stations. Each of the local subscribers' stations and each of the outlying stations are connected at the main station as shown, that is, through a two-way half duplex repeater and a control circuit, in series, to the operator's switchboard. The outlying station is connected through a pair of current reversing terminal repeaters in addition to the loop two-way half duplex repeater. The two-way half duplex repeaters used in the local subscribers' loops are of a different type than those used in the outlying subscribers' station lines. They will be hereinafter described. There may be as many local subscribers' stations and as many outlying sub-

scribers' stations as can be satisfactorily operated in an intercommunicating system. The system shown herein is provided with nine local subscribers' stations 101, 102, 103, etc., and one of the outlying subscribers' stations 110, nine loop repeaters 121, 122, 123, etc. of one type, and one repeater 130 of another type, and ten control circuits 131, 132, 133, etc. The ten control circuits terminate in either key switches or jacks, as desired, at the main station switchboard. Connected to the switchboard and adapted for connection to any of the subscribers' lines are operators' teletypewriter sets 142 and 143. An alarm circuit 144 is adapted to be connected, in common, directly to all the control circuits.

DETAILED DESCRIPTION

Assume that the line circuit for subscriber's station No. 1, shown in the upper part of Fig. 2, is idle. The line TR is closed in a circuit traceable from a tap of a potentiometer comprising grounded positive battery 201, resistances 219, 214, 213 and 206, conductor 202, left-hand, or marking, contact and armature of polarized relay 203, conductor 204, through the upper and lower windings, in parallel, of polarized relay 205, the path through the lower winding extending through the artificial line 206 to ground, and the path through the upper winding extending through resistance 207, conductor T, through the winding of printer magnet 238, break key 209, transmitting contacts 210, through the winding of receiving relay RR, normally closed contacts of five-second break key 211, conductor R, potentiometer P, resistance 212 to ground. Relays 203 and 205 are of the differential type and constitute the send relay and the receive relay respectively of repeater No. 1. The subscriber's station shown somewhat in detail in Fig. 2 is of the well-known type which has a normally closed line circuit somewhat of the type disclosed in United States Patent 2,114,023, granted to F. S. Kinhead on April 12, 1938, which shows a motor operating circuit of the remote control type. The receiving relay RR may be identified with its corresponding relay shown in the patent.

Local subscriber calls

To start the motor of the teletypewriter at subscriber's station No. 1, the subscriber will open break key 209 (corresponding to break key 136 of United States Patent 2,114,023) for an interval of approximately one second duration. This will operate relay RR whereby a sequence of operation takes place in a manner described in the patent and the subscriber's teletypewriter motor starts operating when the key 209 is closed after the open interval of one second duration. The line circuit for subscriber's station No. 1 includes, as hereinbefore stated, a repeater No. 1 designed to operate half duplex and repeat telegraph signals in both directions between a 130-volt, 20-milliampere current subscriber's loop circuit and a 130-volt inverse neutral, or hub, circuit. The only adjustment on the repeater is a potentiometer P of, say 3500 ohms, which is used for adjusting the loop current; a receive relay 205 of the polarized type is provided to receive signals from the subscriber's loop circuit and to repeat them into the inverse neutral, or hub, circuit. The send relay 203, also of the polarized type, is provided to receive signals from the inverse neutral, or hub, circuit and to repeat them into the subscriber's loop circuit.

When the loop circuit is closed at key 209 after

the open interval of one-second duration, the repeater circuit of repeater No. 1 is in the marking condition, as shown, due to a small current, say 20 milliamperes, flowing in the circuit hereinbefore traced through the upper winding of relay 205. Adjustments for this current may be made by means of potentiometer P in the circuit extending through the upper winding of the relay, whereby the armature of relay 205 is normally held in its left-hand, or marking, position.

During the open interval of one second duration caused by break key 209 being operated, a spacing signal is transmitted from the loop and relay 205 is then operated to its spacing, or right-hand, position under the influence of the current flowing through the lower winding of the relay. When relay 205 operates to its spacing, or right-hand, position, ground at the spacing contact is applied to the armature of relay 205, conductor 215, conductor 401, through the winding of line relay 402, to a tap on the potentiometer comprising resistance 403 and ground and resistance 404 and grounded battery 405. Relay 402 operates and disconnects at its armature and back contact ground connection 406 from condenser 407 and at its front contact connects ground connection 406 to the filament of vacuum tube 408 thereby causing the filament to light in a circuit traceable from grounded positive battery 409, resistance 410, conductors 411 and 412, resistance 413, filament of tube 408, resistance 414, front contact and armature of relay 402, to ground connection 406. With ground connection 406 removed from condenser 407, grounded positive battery will now be permitted to flow through resistances 410, conductors 411 and 412, resistance 413, conductor 416, condenser 407, resistance 417, to ground connection 418. When condenser 407 has assumed a sufficient positive charge, the grid of tube 408 will assume this positive potential and cause plate current to flow through the winding of plate relay 419. Relay 419 will, therefore, operate. Relay 419, upon operating, will connect ground over its armature and contact to a circuit which extends over the outermost right-hand armature and contact of relay 420, conductor 421, inner armature and back contact of relay 422, conductor 423, through the filament of call lamp 501, conductor 502, through the winding of call relay 424, resistance 410, to grounded positive battery 409. Call lamp 501 will light and relay 424 will operate in series with the lamp. Relay 424, upon operating, locks up in a circuit traceable from grounded positive battery 409, resistance 410, through the winding of relay 424, conductor 502, call lamp 501, conductor 423, contact and left-hand armature of relay 424, conductor 425, back contact and inner right armature of relay 422, conductors 441 and 426 to ground at the back contact and innermost right-hand armature of broadcast relay 420. Relay 424, upon operating, also closes at its right-hand armature and contact a circuit extending over conductor 427, release key 701, audible alarm 702, source 703 of ringing current to ground. Audible alarm 702 operates to give the operator an audible signal in addition to the call signal of lamp 501. Audible alarm may be released by operating key 701. Relay 424 will remain in a locked position and call lamp 501 will be maintained lighted until the subscriber's call has been answered by the operator.

Operator answers a call

The operator answers the call by operating one of the keys 511, 512 and 513 to its upper or lower

position depending upon which one of the hub circuits H₁, H₂, H₃, H₄, H₅ and H₆ is idle. Assume that hub H₁ is idle, then key 511 will be operated to its upper position. The operator at the time of operating key 511 will also operate either key 503 or 506 to its upper position in order to connect one or the other of the operator's position circuits 704 and 705 to the calling line extended from subscriber's station No. 1. The operation of key 511 to its upper position closes a circuit extending from grounded positive battery 409, conductor 411, through the winding of relay 422, middle left armature and contact of relay 420, conductor 428, upper inner left-hand contacts of key 511, conductor 514, through the winding of relay 429, to ground at the back contact and innermost right-hand armature of relay 420. Relays 422 and 429 operate in series.

Relay 429, upon operating, connects together conductors 217 and 218 in order to cut through the receiving element, or relay 205, of the repeater No. 1. It also connects conductor 215 from the receiving element of repeater No. 1 to the transmission lead which extends to the selected operator's position set. Assume that the operator has selected position set 704, relay 429, upon operating, extends conductors 215 and 430 over its front contacts and right-hand armature to a circuit traceable over conductor 431, outermost left-hand armature and back contact of relay 429, conductor 432, upper right-hand contacts of operated switch 511, conductor 515 of hub H₁, upper right-hand contacts of key 503 in an operated position, conductor 516, through the lower winding of receive relay 706 to grounded positive battery 707.

Relay 422, upon operating, closes a circuit extending from grounded positive battery 409, resistance 410, conductors 411 and 412, resistance 415, conductor 416, condenser 433, outer right armature and contact of relay 422, conductor 434, resistance 435 to ground connection 418 thereby placing condenser 433 in parallel with condenser 407 in order to increase the charging time constant from one second to five seconds for supervisory purposes. Also relay 422, upon operating, opens at its back contact and inner right armature the locking circuit for relay 424 to extinguish call lamp 501 and prepares a locking path for the subsequent operation of disconnect relay 436. Relay 422, upon operating, also opens at its outer left armature and contact the operating circuit for relay 420 if the system is arranged for non-seizure broadcast operation. In the event that the system is arranged for seizure broadcast operation, the outer left armature and contact of relay 422 are omitted and conductor 437 as shown by the dash line 443 is furnished.

The operator by plugging cords 708 and 709 into jacks 710 and 711, respectively, connects the teletypewriter set No. 1 to her position circuit 704. The system is now arranged for communication between the subscriber's station No. 1 and the operator at position set 704. During the transmission of signals from the subscriber's station to the switchboard operator, polarized relay 706 will follow the operation of relay 205 and thereby repeat the transmitted signals to the printer magnet in teletypewriter set No. 1. Relay 402 will also follow the signals repeated by relay 205 but since open intervals of five seconds duration are now necessary to cause plate current to flow in tube 408, the operation of relay 402 serves no useful function at this time other than to

maintain condensers 433 and 407 in a discharged state.

During the transmission of signals from the switchboard operator to the subscriber's station, polarized relay 713 will follow the signals transmitted from transmitting contacts of the operator's teletypewriter set No. 1 and relay 706 responds to the operation of relay 713 to give a local copy of the transmitted message. Relay 713 also repeats the locally transmitted signals over the communication circuit to the subscriber's station No. 1, the communication circuit being traceable, as hereinbefore described, over conductors 513, 515, 432, 431, 430, 215, armature and marking, or left-hand, contact of relay 205, conductors 218 and 217, through the upper winding of send relay 203 to grounded battery. Relay 203 will follow the signals transmitted from the operator's teletypewriter set No. 1 and repeat them through the parallel windings of differential relay 205. The path for recording the transmitted signals includes the winding of printer magnet 208 at subscriber's station No. 1. Printer magnet 208, in response to the transmitted signals, causes the message incoming at subscriber's station No. 1 to be printed. Relay 402 responds to the signals incoming at subscriber's station No. 1 but the operation of this relay, like hereinbefore stated, serves no useful function at this time.

Subscriber disconnects

A subscriber disconnects by operating the five second break key 216 which when operated completes a revolution in an interval of five seconds duration. This opening of the line circuit causes the receiving relay 205 of repeater No. 1 to operate to a spacing condition whereby ground is connected to conductor 215 to operate relay 402. In this case, however, due to relay 422 being operated, condenser 433 will be connected in parallel with condenser 407 in order to increase the timing constant from one second to five seconds. After an interval of approximately five seconds, a sufficient positive potential will be impressed upon the grid of tube 408 causing plate current to flow through plate relay 419 which will operate. Since relay 422 has previously been operated, the operation of relay 419 will connect a ground at its armature and contact to a circuit extending over the outermost right-hand armature and contact of relay 420, conductor 421, inner left armature and front contact of relay 422, conductors 438 and 518, disconnect lamp 517, conductor 439, through the winding of disconnect relay 436, conductor 411, resistance 410, to grounded positive battery 409. The closure of this circuit will light disconnect lamp 517 and operate relay 436 in series with the lamp. Relay 436, upon operating, closes a locking circuit for itself traceable from grounded positive battery 409, resistance 410, conductor 411, through its winding, conductor 439, lamp 517, conductors 518 and 438, contact and left-hand armature of relay 436, conductor 440, front contact and inner right-hand armature of relay 422, conductors 441 and 426 to ground at the back contact and innermost right-hand armature of relay 420. Also relay 436, upon operating, closes, at its right-hand armature and contact, a circuit extending over conductor 427 to the audible alarm 702 to operate the alarm. Relay 436 will remain locked in an operated position and disconnect lamp 517 will remain lighted until the operator has restored the line key 511. Key 511, upon being restored to normal, restores the line control circuit shown in

Fig. 4 to normal. After the subscriber has transmitted the open signal of five seconds duration, the subscriber should stand by for an acknowledgment by the operator and then inform the operator that a disconnect is desired. The subscriber may then either turn off the power through his teletypewriter by the operation of an upper case character on his teletypewriter or leave this function to the operator. The operator may do this by a similar operation on her teletypewriter. The subscriber should under no circumstances send a disconnect signal and then turn off the power as the operator will immediately challenge the validity of the disconnect and hence automatically again start up the subscriber's teletypewriter. A substantial line opening or a teletypewriter signal will perform this function.

Operator originates a call

Assume that operator's position circuit 704 is selected for use and that the connection desired is with subscriber's station No. 1, the operator, upon originating a call for such a connection, operates keys 503 and 511 to their respective upper positions whereby the operator's position set 704 is connected over hub H1 to line No. 1. As hereinbefore described, conductors 428 and 514 are interconnected at the inner upper left-hand contacts of key 511 to close a circuit for operating relays 422 and 429 in series. Conductors 217 and 218 from the loop repeater will be cut through and conductor 215 will be connected to the communication conductor which extends over conductors 431 and 432 and the closed right-hand contacts of keys 511 and 503 respectively. The operator is now directly connected to the subscriber at station 1. However, the subscriber's teletypewriter has not yet been started. Momentary operation of break key 712 by the operator which causes a spacing condition to be transmitted to the hub circuit H1 and thence to the subscriber's teletypewriter at station No. 1, will start the motor of the subscriber's teletypewriter as described in U. S. Patent 2,114,023, supra. The operator may now cause the message to be typed directly on the subscriber's teletypewriter or, as is well known in the art, may attract the attention of the attendant at subscriber's station No. 1, by actuating a bell signal character on her teletypewriter in order to cause a bell (not shown) at the subscriber's station to ring for calling purposes. When the connection is established the hub circuit H1 is in a marking condition and the receive relay 706 of the operator's position set 704 will be maintained in a marking position, as shown, by the current flowing through its upper winding. When transmission takes place on the hub circuit H1, a spacing condition which consists of a direct ground, will be intermittently connected to the hub circuit which will cause line current to flow through the lower winding of receive relay 706; this line current being sufficiently in excess of the biasing current in the upper winding of relay 706 will cause relay 706 to follow these spacing signals. The intermittent operation of relay 706 will actuate the printer magnet 714 of the operator's teletypewriter set No. 1 and the teletypewriter will record the communication. When the operator wishes to transmit to any subscriber connected to the hub, operation of the keyboard on her teletypewriter set No. 1 will cause the sending contacts of the teletypewriter to be intermittently opened which will cause send relay 713 to follow these signals, since with no current con-

dition in the lower winding the biasing current in the upper winding will operate relay 713 to its spacing or left-hand contact. Intermittent operation of relay 713 to its spacing contact will connect ground to the hub which will cause functioning as described for relay 706 to any receiving circuit connected to the hub.

A spacing signal transmitted from the inverse neutral leg, or hub circuit, to the subscriber's loop, applies ground to a circuit extending over conductor 215, armature and marking, or left-hand, contact of relay 205, conductor 218, contact and left-hand armature of relay 429, conductor 217, through the upper winding of relay 203 to grounded positive battery. The ground applied to the upper winding of relay 203 sets up a current that is greater than the current flowing through the lower winding of relay 203 and the relay operates to its spacing, or right-hand, position. Relay 203, upon operating to its right-hand position, changes the potential applied to the apex of the balanced subscriber's loop from +130 volts to ground. Since the balanced, or lower, winding of relay 205 is connected to a potentiometer through which current flows from grounded positive 130-volt battery 201 over resistances 219, 214, 213, and 206 to ground connection 220 and the subscriber's loop is terminated at ground connection 221, the operation of relay 203 reduces the current flow in the loop and in upper winding of relay 205 to zero while the current in the lower winding of relay 205 is reversed so that relay 205 will not operate to spacing. Therefore, the signals repeated by relay 203 are recorded at the printer at subscriber's station No. 1.

Broadcast connection

Means are provided whereby the operator may transmit from either of the teletypewriter sets shown to various groups of subscribers without being interrupted by these subscribers. This so-called broadcasting may be done on either a selective or grouping basis.

Selective broadcast

Assuming that the operator selects position set 704 for selective broadcast, key 715 will be operated to its left-hand, or selective, position. Key 715, upon being operated to its left-hand position will connect ground to conductor 716. Also assuming that hub circuit H₁ is selected for the broadcast, key 503 will be operated to its upper position and therefore conductor 716 will be connected over the outermost upper left-hand contacts of key 503 to conductor 518 of hub circuit H₁. Assume that lines No. 1, No. 2 and No. 3 are to be included in the broadcast, keys 511, 601 and 611 will be operated to their respective upper positions. The ground connection on conductor 716 will therefore be connected at each of switches 511, 601 and 611 to each of two conductors extending to each of the subscribers' stations included in the broadcast. The conductors extending to the subscriber at station No. 1 to which this ground is connected are designated 428 and 514. Conductor 428 extends over the middle left-hand armature and contact of broadcast relay 420, through the winding of relay 422 to grounded positive battery 409 and relay 422 operates. However the ground connected to conductor 514 which extends through the winding of relay 429 to ground at the innermost right armature and back contact of relay 420 causes relay 429 to remain in a released position. Relay 429, in a released position, provides an open

condition between conductor 215 and the communication conductors 431 and 432 which extends over conductor 515 of the hub circuit H₁. Also relay 429, being in a released position, prevents conductor 217 from being connected to conductor 218 and maintains conductor 217 connected transmission conductors 431 and 432. The operator may thus transmit to the subscriber over conductor 217 to the loop repeater. At the same time the operator may receive supervision from the subscriber at station No. 1 over conductor 215. This is important when a group of lines are connected for a broadcast. In the case of the broadcast to subscriber stations No. 2 and No. 3 the function performed and the results obtained are the same as those described herein for subscriber station No. 1.

Group broadcast

For group broadcast the operator may broadcast to any selected group of lines. These lines are arranged beforehand to provide for this service. The operator operates broadcast key 715 to its right-hand, or group, position and ground is thereby connected to the winding of relay 726 in an obvious operating circuit. Relay 726 operates to connect at its innermost upper armature and contact a ground connection to conductor 716 to perform definite functions as hereinbefore described for selective broadcast. At the middle upper armature of relay 726 ground is connected to conductors 717 and 448 in a circuit extending through the winding of broadcast relay 420, conductor 442, conductor 443 (providing the line circuit is arranged on a seizure basis), conductors 437 and 411, resistance 410, grounded positive battery 409. As hereinbefore stated for selective broadcast operation, relay 429 remains in a released position and relay 422 operates. In this case conductor 217 from the loop repeater is connected directly to the operator's position circuit 704 over the outermost left armature and front contact of relay 420, broadcast communication conductor 444, outermost upper armature and contact of relay 716, conductor 516 to grounded positive battery either through the lower winding of relay 706 or the armature and marking contact of relay 713, depending upon whether the communication is being received or transmitted at the operator's position circuit 704. Should the line circuit be not arranged on a seizure basis conductor 443 would be omitted and the operation of broadcast relay 420 would depend on whether this line circuit is in a busy condition. If this line circuit is busy relay 422 will be operated and hence the operating path for relay 420 will be opened and thus prevent broadcast to this line even though it is arranged for group broadcast. As hereinbefore stated, for selective broadcast the operator only can transmit communication signals. The subscribers may, however, transmit supervisory signals to the operator.

Outlying subscriber calls

In cases where the distance between the main station and an outlying subscriber station is in excess of thirty-eight miles a special type of repeater indicated in Fig. 3 as repeater No. 10 is required. Station No. 10 shown in Fig. 3 represents an outlying station connected through a current reversal terminal repeater of a type well known in the art and shown in U. S. Patent 1,935,750 granted to F. J. Singer on November 21, 1933.

The subscriber line circuit is of the same type as that shown for station No. 1 but extends through a differential duplex two-path polar telegraph terminal repeater, as shown, whereof relays 301, 302 and 303 are the send, the receive and the break relays on the station side of the repeater and relays 304, 305 and 306 are the send, the receive and the break relays on the line side of the repeater. The line then extends through a second repeater of the single line type whereof one side operates open and closed to a neutral loop. This operation is accomplished by having the receive relay 307 which receives from the neutral loop and sends into the inverse neutral loop, equipped with a combination bias and holding circuit. The other side of this repeater is arranged for operating into an inverse neutral circuit referred to herein as a hub circuit.

Normal condition of loop repeater

In the normal condition of this repeater when no signals are being transmitted in either direction, current is flowing in the loop circuit which extends back through the terminal repeater to the subscriber station. Relay 307 of the loop repeater and relay 301 to relay 306 of the terminal repeater are thereby held in the positions shown. Under these conditions no current flows in the line side of the loop repeater. Send relay 308 and hold relay 309 are maintained in the positions shown by current of approximately 16 milliamperes flowing through their respective lower windings. The loop or station side of the repeater is closed through the armature and marking, or left-hand, contact of send relay 308. Current flows from grounded positive battery 310 in a circuit traceable through resistances 311 and 312, tap 313 of the potentiometer, through the lower winding of relay 307, resistance 314, retardation coil 315, marking, or left-hand, contact and armature of relay 309 to ground. This current tends to operate relay 307 to its spacing, or left-hand contact, but since it is one-half the magnitude of the current in the loop, relay 307 is held in its marking, or right-hand, position.

Transmission of signals from inverse neutral circuit to neutral loop

A spacing signal from the inverse neutral circuit which is transmitted to the repeater by applying ground to conductor 316 causes a current of approximately 20 milliamperes to flow through the upper windings of relays 308 and 309. Under this condition a current of approximately 4 milliamperes flows in the lower windings of these relays. Since the current in the upper windings is oppositely poled and 16 milliamperes greater than the current flowing in the lower windings, relays 308 and 309 operate to their spacing, or right-hand, contacts. It will be seen that relay 308 will transmit unbiased signals to the neutral loop since the difference in the current in the upper and the lower windings is the same for both the marking and spacing conditions, namely, 16 milliamperes. Due to the fact that the lower winding of relay 309 is shunted by resistance 317, the current flowing in this winding is less than the current flowing through the lower winding of relay 308. Therefore, relay 309 operates to spacing, that is, its right-hand contact before relay 309. Relay 309, upon operating to spacing, causes current in the lower winding of relay 307 to reverse and hold relay 307 in its marking, or right-

hand, position. The reversal of current through relay 307 is accomplished by means of the resistance bridge consisting of resistance 317 as one arm, resistance 312 as the second arm, resistance 318 as the third arm and resistance 314, retard coil 315, left-hand contact and armature of relay 309 to ground as the fourth arm. The lower winding of relay 307 is connected across the bridge points. The resistances are so arranged that when relay 307 is in the position shown, current will flow from grounded positive battery 310, through the lower winding of relay 307 inasmuch as the resistance of path including resistance 314 and retard coil 315 is less than the resistance and the path including resistance 317. Resistances 312 and 318 have approximately the same values.

When relay 309 operates to its spacing, or right-hand, position, current will flow through the lower winding of relay 307 in the opposite direction inasmuch as the path including resistance 314 and retard coil 315 is open. Therefore, before relay 308 operates to its spacing, or right-hand, position and opens the loop circuit, relay 307 will be held on its marking, or right-hand, position.

A marking signal from the inverse neutral circuit which is transmitted to the repeater by removing ground from conductor 316 causes relays 308 and 309 to operate to their marking, or left-hand, position. However, relay 308 operates before relay 309 since the current flowing in the lower winding of relay 308 is greater than that flowing in the lower winding of relay 309. Relay 308 thus closes the loop circuit extending through the upper winding of relay 307 before relay 309 has operated to marking. When relay 309 operates to marking it closes one arm of the bridge circuit previously described and the resultant current flowing in the lower winding of relay 307 tends to operate relay 307 to spacing, but since this current is one-half the magnitude of the current in the loop circuit relay 307 is held in its marking position. In order to further delay the reversal current in the lower winding of relay 307 the retard coil 315 is used to retard the rise in current to this winding after the armature of relay 309 has moved into engagement with its left-hand, or marking, contact.

Transmission of signal from neutral to inverse neutral loop

A spacing signal transmitted from the neutral loop reduces the loop current to zero and the current flowing through the lower winding of relay 307 operates the relay into spacing. Relay 307, upon moving to its spacing position, applies ground to conductor 316 and thus transmits a spacing signal to the inverse neutral circuit. A marking signal transmitted from the neutral loop reestablishes the loop circuit and operates relay 307 to its marking position. Relay 307, upon operating to its marking position, applies battery to conductor 316 and thus transmits a marking signal to the inverse neutral circuit.

Conductors 316, 319 and 320 connect with control circuit No. 10 shown in Fig. 4 in the same manner as conductors 215, 218 and 217, respectively, connect with control circuit No. 1 as hereinbefore described. The conductors comprising the output of control circuit No. 10 are connected as represented by dot-dash lines 445 to the vertical rows of keys designated line No. 10 shown in Fig. 6. The keys associated with line No. 10 are designated 621, 622 and 623 and are

capable of associating line No. 10 with any one of the hub circuits H₁ to H₆. A description of a connection originating at station No. 10 or at either of the operators' teletypewriter sets Nos. 1 and 2, shown in Fig. 7 for extension to stations No. 10 or to two or more of the other stations for broadcast purposes may be established in a manner similar to that hereinbefore described in connection with station No. 1.

Cord switching circuits

In the event that it is desired to use cord switching circuits instead of the key switching circuits shown in Figs. 5 and 6, cord switching circuits such as those designated Nos. 1 and 2 in Fig. 8 are adapted to serve substantially the same purpose as the key switching circuits. Each of the line circuits connecting the subscriber stations with the main station terminate at an operator's switchboard in the main station as represented by conductor group 801 for line circuit No. 1. Assuming that a call originates at subscriber station No. 1, a light will appear at call lamp 802 in the same manner as a call appears on lamp 501 as hereinbefore described. The operator at either of the teletypewriter sets Nos. 1 and 2, upon observing the lighted lamp inserts the answering plug 803 of the cord circuit associated with the selected teletypewriter set, say set No. 1, into jack 804. Assuming that teletypewriter set No. 1 is selected for use and answering plug 803 is inserted in jack 804 then the operator's position key 805 is operated to its lower position in order that teletypewriter set No. 1 may be connected to line No. 1. A circuit is now closed from grounded positive battery 707 through the lower winding of polarized relay 706, conductors 516 and 806, lower right contact of key 805, conductor 807, ring conductors of plug 803 and jack 804, conductors 432 and 431. Plug 803, upon being inserted in jack 804, also closes contact 808 whereby conductors 428 and 514 are interconnected to effect the operation of relays 429 and 422 and to thereby cause the extinguishment of call lamp 802. Communication may now take place between the operator and subscriber at station No. 1. The operator upon receiving the information regarding the called subscriber's station may then complete the connection by inserting the call, or opposite, end of cord circuit No. 1 into the line jack of the called line.

Operator originates the call

The operator originates the call by inserting the call end of a cord circuit, for example, cord circuit No. 1 into a line jack of the called line and operates the proper teletypewriter key as hereinbefore described. In this case the call lamp associated with the called line does not light, inasmuch as the contacts corresponding to contacts 808 are closed upon the insertion of the call plug into the line jack. The call plug upon being inserted into the line jack also effects the operation of relays 429 and 422 and the control circuit functions in a manner as hereinbefore described.

Disconnect from subscriber stations

When a subscriber disconnects, the operation of the control circuit is the same as hereinbefore described and the disconnect lamp 809 is lighted. The operator then disconnects by removing the answer and call plugs from the line jacks and restoring the teletypewriter key to normal.

Broadcast

The operator may arrange any line for broadcast transmission. After the connection has been established as hereinbefore described and the operator is connected to the subscriber's station, the operator will operate a broadcast key in the operator's position circuit. The operation of a broadcast key, such as key 715, to its left-hand position, connects ground to conductor 716, lower left-hand contacts of key 805, conductor 810, sleeve conductors of cord circuit No. 1 and jack 804, conductor 514, through the winding of relay 429 to ground at the back contact and innermost right-hand armature of relay 420. Relay 429 having ground at opposite ends of its operating circuit does not operate as hereinbefore described under broadcast conditions. However, the ground connected at key 715 is also connected to conductor 428 which is part of a path extending over the contact and middle left armature of relay 420, through the winding of relay 422; to grounded positive battery 409. With relay 422 operated and relay 429 maintained in a released position, the control circuit operates the same as hereinbefore described. The operator has arranged a line circuit for broadcast with provision being made for supervisory control from the subscriber. In the case of the operator having more than one line circuit arranged for broadcast on the same hub circuit, this individual supervisory control from each subscriber is important as otherwise the operator would not know which subscriber was sending disconnect signals which might be used for broadcast acknowledgment. Since there are two operators' teletypewriter sets available, two broadcast circuits may be established, one by each operator. Each operator may add lines to a broadcast group by inserting the plugs of other cord circuits into those line circuits and operating the teletypewriter key of each cord circuit to the teletypewriter set used in the broadcast.

Conference

The operator may arrange any group of lines for conference with each other. Two separate conference circuits are possible, one branch using one hub grouping and the other branch using the other hub grouping. When a conference connection is requested by a subscriber, the operator will connect the plugs of the cord circuits to the line circuit involved and operate the grouping key for each cord circuit to the same grouping position. For example, grouping key 810 may be operated to either its upper or lower positions. This will connect all these lines to the same hub circuit for hub operation. A second conference circuit would be established in the same manner except that the grouping key for the second group of cord circuits would be operated to the other grouping position thus connecting this group of lines to the other hub for hub operation.

Alarm circuit

Two types of alarm circuit are furnished. One alarm circuit is of the audible type wherein a buzzer, bell or other audible device like that designated 702 may be employed and key 701 is furnished for shutting off the alarm. Another alarm circuit is that for giving or furnishing a signal whenever a fuse in the fuse panel burns out in which event grounded battery 718 and alarm relay 719 are interconnected through the burnt-out fuse whereby the relay operates to light signal lamp 720 and to energize audible signal 702.

By operating key 721, lamp 720 may be extinguished and audible alarm 702 may be disconnected.

What is claimed is:

1. A switching system comprising a plurality of normally deenergized main circuits, a plurality of other normally deenergized circuits, a plurality of groups of operable switching devices for respectively terminating said main circuits, a plurality of other groups of operable switching devices for respectively terminating said other circuits, and a plurality of hub circuits arranged in engageable relation with said main and said other circuits and adapted when two or more devices of different groups are operated to effectively connect two or more of said main circuits.

2. A switching system comprising a plurality of line circuits and individual signaling sets therefor, a plurality of control circuits in engageable relation with said plurality of line circuits respectively, a group of switching devices for each of said control circuits, a plurality of hub circuits, each of which is in engageable relation with the switching devices of different groups, other groups of switching devices and operators' signaling sets respectively connected thereto, and means operable in response to the conjoint operation of one or more of said switching devices of the first-mentioned group and one or more of the switching devices of said other groups to simultaneously interconnect over one or more of said hub circuits one or more of said individual signaling sets and one or more of said operators' signaling sets.

3. A switching system comprising a plurality of circuits and individual signaling sets therefor, a group of switching devices for each of said circuits, a plurality of hub circuits, each arranged in engageable relation with the switching devices of different groups, other groups of switching devices in engageable relation with said hub circuits, operators' signaling sets respectively connected to said other groups, and means common to said hub circuits and operable in one direction for selectively connecting, in conjunction with the operation of two or more switching devices in engageable relation with any one of said hub circuits, two or more of said individual signaling sets, in multiple, to any one of said operators' signaling sets for intersignaling purposes, and operable in another direction for connecting, independent of said switching devices, two or more of said individual signaling sets, in multiple, to any one of said operators' signaling sets for intersignaling purposes.

4. A switching system comprising a plurality of lines and control circuits individual thereto, a plurality of operators' position sets, a plurality of switching device groups respectively terminating said control circuits, a plurality of other switching device groups respectively terminating said operators' position sets, a plurality of hub circuits in engageable relation with corresponding switching devices of each of said plurality of groups, means controlled by said switching devices for preparing a connection between any one of said lines, and one or more of the remaining of said lines, and means in each of said control circuits controlled by any one of said switching devices terminating its particular con-

trol circuit, for transferring the line circuit associated with said particular control circuit from an established signaling connection to a communication connection.

5. A switching system according to claim 4 wherein said switching devices are manually operable keys.

6. A switching system according to claim 4 wherein said switching devices are cord circuits and spring jacks therefor and manually operable keys cooperating with each of said cord circuits.

7. A printing telegraph system comprising a plurality of telegraph lines and control circuits respectively connected thereto, a plurality of operators' position sets, a plurality of switching devices respectively terminating said control circuits, a plurality of other switching devices for respectively terminating said operators' position sets, a plurality of hub circuits, each common to separate terminations of said control circuits and said operators' position sets, means operable in response to the conjoint operation of one or more of said switching devices of the first-mentioned group and one or more of the switching devices of said other groups to simultaneously interconnect over one or more of said hub circuits one or more of said lines and one or more of said operators' position sets, and other means in each of said operators' position sets operable, in one direction, conjointly with each of the switching devices terminating its associated operator's position set and with a terminating switching device of each of said control circuits, to selectively establish a communication connection between said one operator's position set and two or more of said lines over one of said hub circuits, and operable in the other direction and independently of said switching devices and said hub circuit to establish a direct communication circuit between said one operator's position set and the control circuits of a fixed group of two or more of said lines.

8. A printing telegraph system comprising a plurality of telegraph lines each including, in series connection, a repeater circuit and a control circuit, a plurality of operators' position sets and circuits therefor, a plurality of switching device groups respectively terminating said control circuits, a plurality of other switching device groups for respectively terminating said operators' position sets, a plurality of hub circuits, each common to corresponding terminations of said control circuits and said operators' position set circuits, means operable in response to the conjoint operation of one or more of said switching devices of the first-mentioned groups and one or more of the switching devices of said other groups to simultaneously interconnect over one or more of said hub circuits one or more of said lines and one or more of said operators' position sets, and other means controlled by said repeater and said control circuit for permitting supervisory signals to be transmitted to an operator's position set during an established connection between two or more of said lines and an operator's position set.

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