

Aug. 22, 1939.

F. J. SINGER

2,170,038

TELEPHONE AND TELEGRAPH EXCHANGE SYSTEM

Original Filed Oct. 3, 1935

4 Sheets-Sheet 1

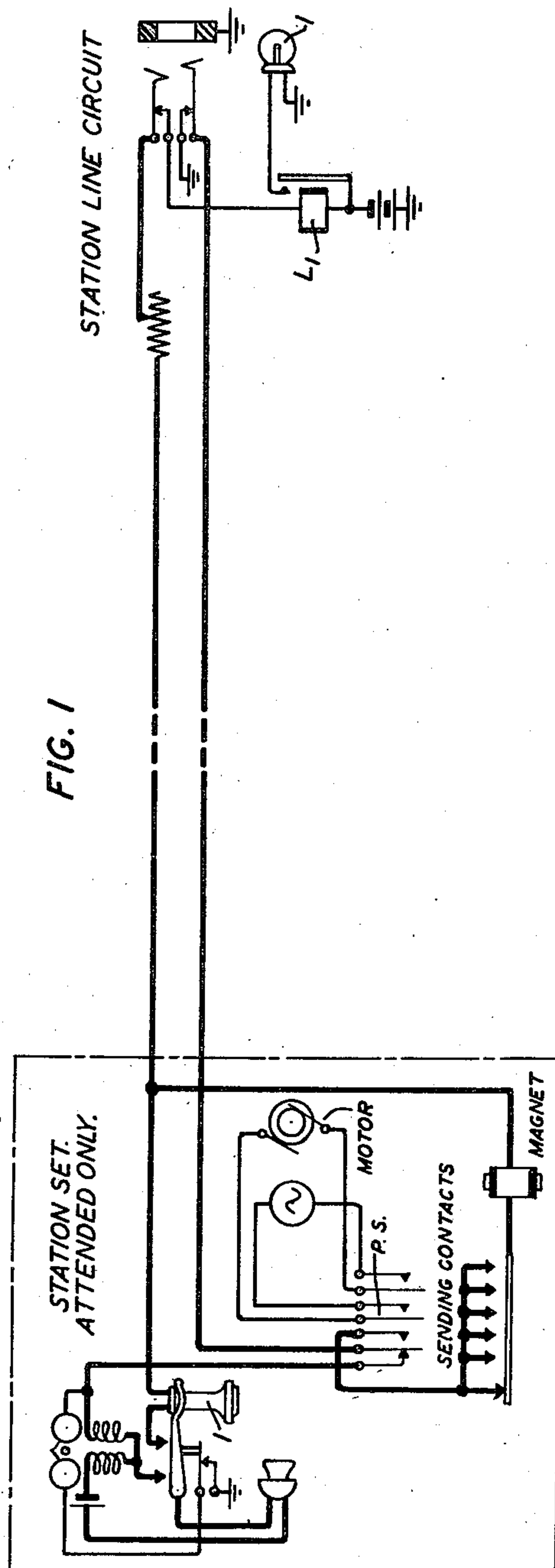


FIG. 1

FIG. 7

FIG. 1	FIG. 2	FIG. 3, 4, 5 OR 6
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INVENTOR
F. J. SINGER
BY *g. H. H. H.*
ATTORNEY

Aug. 22, 1939.

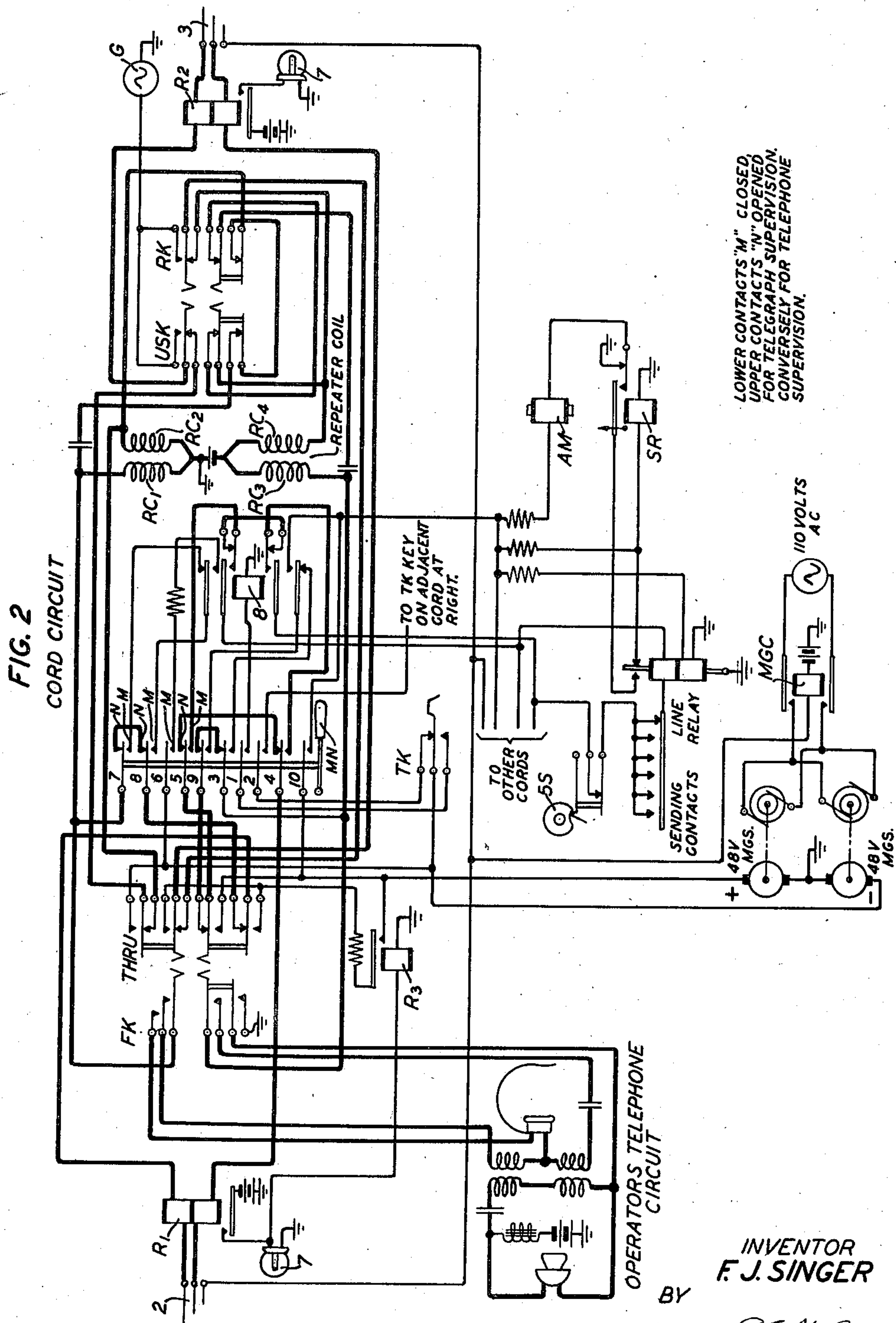
F. J. SINGER

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TELEPHONE AND TELEGRAPH EXCHANGE SYSTEM

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4 Sheets-Sheet 2



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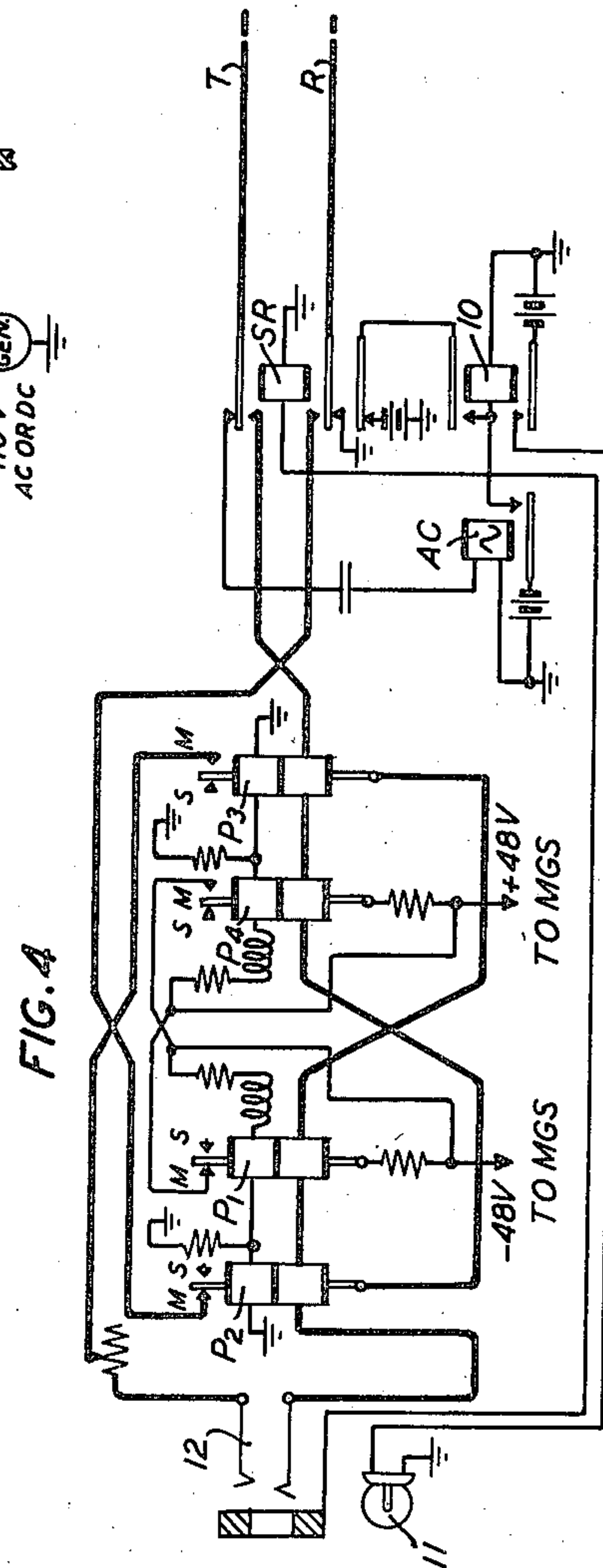
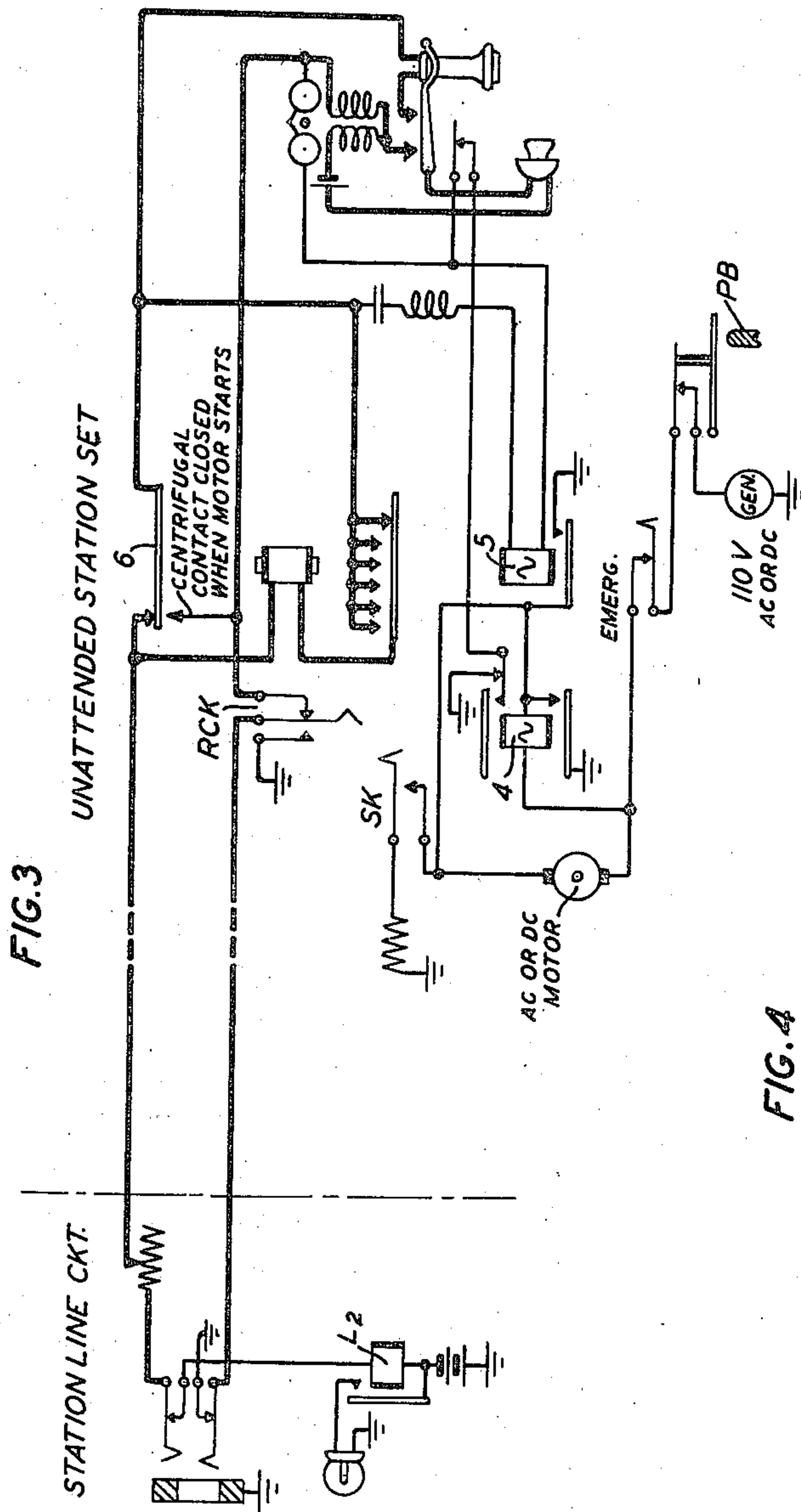
F. J. SINGER

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TELEPHONE AND TELEGRAPH EXCHANGE SYSTEM

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4 Sheets-Sheet 3



INVENTOR
F. J. SINGER

BY

98708

ATTORNEY

Aug. 22, 1939.

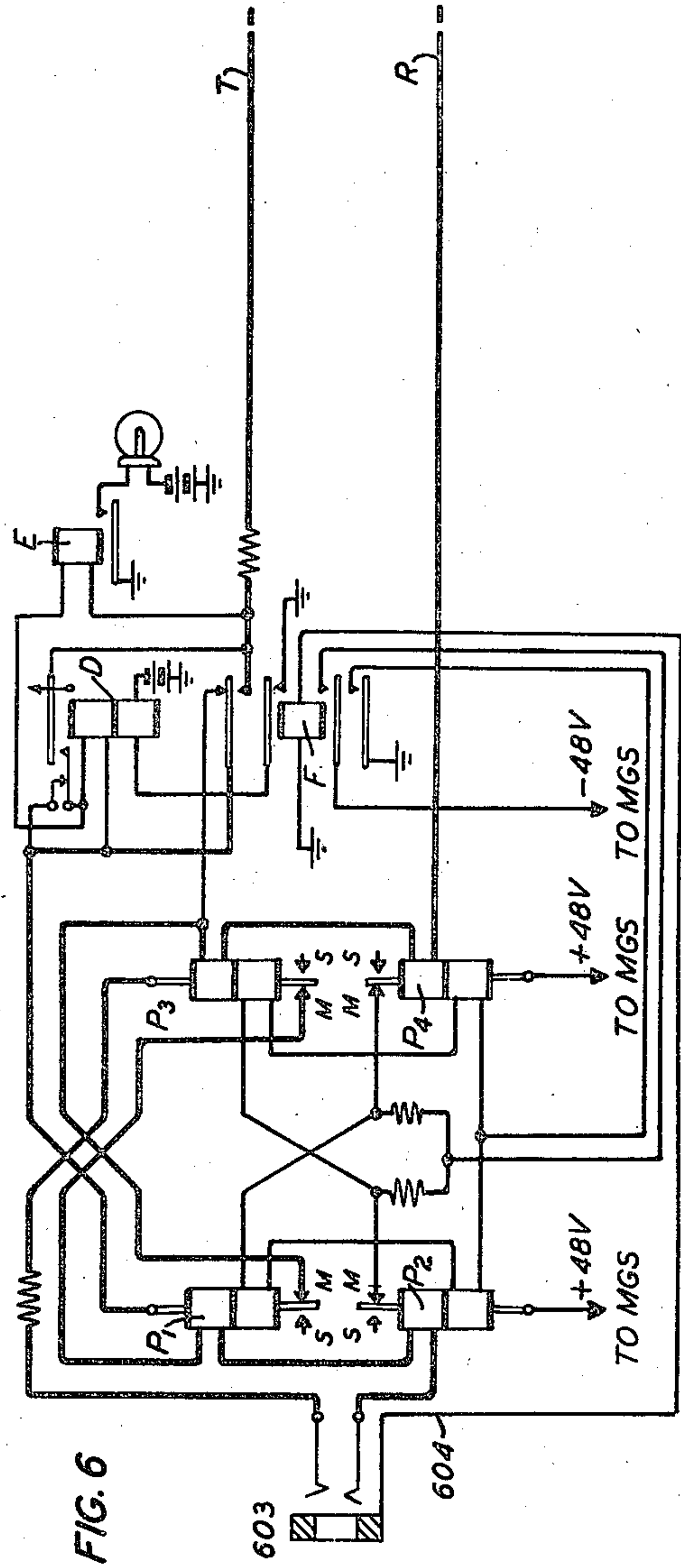
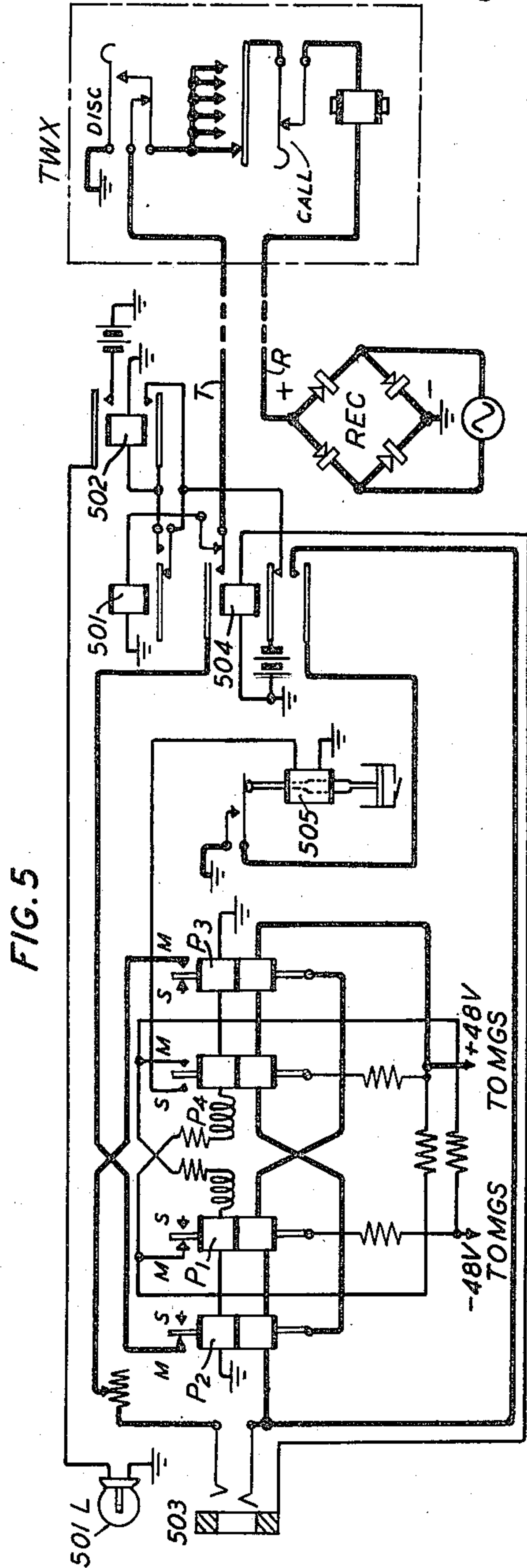
F. J. SINGER

2,170,038

TELEPHONE AND TELEGRAPH EXCHANGE SYSTEM

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4 Sheets-Sheet 4



INVENTOR
F. J. SINGER
BY
gc for
ATTORNEY

UNITED STATES PATENT OFFICE

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TELEPHONE AND TELEGRAPH EXCHANGE
SYSTEMFred John Singer, Rockville Centre, N. Y., as-
signor to American Telephone and Telegraph
Company, a corporation of New YorkContinuation of application Serial No. 43,413,
October 3, 1935. This application July 9, 1936,
Serial No. 89,828

22 Claims. (Cl. 179—4)

This application is a continuation of applica-
tion Serial No. 43,413, filed October 3, 1935.

This invention relates to combined telephone
and teletypewriter systems.

5 An object of the invention is to adapt a tele-
phone private branch exchange so that it may
function also as a teletypewriter private branch
exchange. By providing each substation on the
private branch exchange with a teletypewriter in-
10 strument and the usual accessories and by pro-
viding the central office of the private branch ex-
change with a suitable cord circuit, intercom-
munication by teletypewriter may be had between
stations on the private branch exchange. In this
15 case no teletypewriter need be employed at the
central office of the private branch exchange as
all the intercommunicating circuits may be set
up and supervised by telephony. If, however, it
is desired to connect the teletypewriter private
20 branch exchange system with a general tele-
typewriter exchange system, a suitable teletype-
writer instrument and other accessories at the
private branch exchange central station are em-
ployed.

25 A system in accordance with the invention is
quite flexible. Where a teletypewriter at the
private branch exchange switchboard is desired,
no telephones will be required at the switchboard
or station. If, however, it is desired to give tele-
30 phone service over the lines of the private branch
exchange, a telephone may be furnished. In
private branch exchanges including a large num-
ber of lines it will be more economical to provide
a teletypewriter at the private branch exchange
35 than to provide telephones at all the stations and
in such case the telephones may be omitted in
case telephone service is not desired.

40 A feature of the invention is furnishing of tele-
typewriter service at an unattended station, that
is, the station may receive messages to be print-
ed on the teletypewriter machine even though no
person is in attendance. To this end the system
as described herein includes the necessary equip-
ment for this purpose.

45 A feature of the invention is a teletypewriter
trunk circuit which is associated at one terminal
with a private branch exchange and at the other
terminal to any of the usual switchboards which
are employed in teletypewriter switching service.
50 By means of this trunk circuit any local station
on the private branch exchange may be con-
nected to the teletypewriter central office for com-
munication through the central office with any
outside teletypewriter subscriber in the usual
55 manner.

A feature of the invention is the furnishing of
teletypewriter service over telephone lines by
means of a universal cord circuit adapted for
either telephony or telegraphy. The telegraph
service is on a direct current impulse basis and no
voice frequency carrier oscillators, modulators
or demodulators are required.

A further feature of the invention is a cord cir-
cuit having one end adapted to supply current of
one polarity to the tip of a line and the other end
10 to supply current of the other polarity to the ring
of another line so that both sources of current
of different polarities and both lines are con-
nected in series.

Another feature is to increase the universality
15 of combined telephone and teletypewriter switch-
boards so that either end of a cord may be con-
nected to any one of various types of lines or
trunk circuits.

Although described as a private branch ex-
change one or more features thereof may be used
20 as a public central office.

In the accompanying drawings:

Fig. 1 discloses a local station circuit and line
equipment therefor at the central office;

Fig. 2 discloses the cord circuit arrangements
25 at a private branch exchange; for greater uni-
versality the circuit may be provided with switches
or connecting points M which are closed when the
exchange includes a teletypewriter equipment to
the used for supervision and switches or connect-
30 ing points N which are closed when the exchange
uses telephone equipment exclusively for super-
visory purposes;

Fig. 3 discloses a local station line and station
35 equipment for unattended service;

Figs. 4 and 6 disclose two forms of line ter-
minating equipment of trunks for interconnect-
ing the line of a local station such as those of
Figs. 1 or 3 or the operator's teletypewriter in-
40 strument with a remote central teletypewriter
exchange system (not shown); and

Fig. 5 shows a trunk circuit which may be em-
ployed when a substation is at a great distance
45 from the private branch exchange.

OPERATION OF SYSTEM — TELEPHONE METHOD—
OPERATOR AT SWITCHBOARD HAS NO TELETYPE-
WRITER

(a) General description of cord circuits

50 The key FK functions to connect the operator's
telephone set with the line circuit; the key RK
is a ringing key; key THRU when operated con-
nects a line to which plug 2 is connected to a line
to which plug 3 is connected for teletypewriter 55

intercommunication; key USK serves to start the motor of an unattended subscriber's station; relay 8 functions under the control of a contact on switch MN and key TK to connect the operator's teletypewriter to appropriate points in the cord circuit; relay MGC starts the motor generator set when any plug is connected to a line jack.

(b) *Substation operator calls, operator answers*

Under this heading it will be assumed either that the switchboard operator has no teletypewriter or does not use it for supervisory purposes. In the cord circuit of Fig. 2 all contacts M are opened and all contacts N closed by the switch MN.

The substation operator at Fig. 1 lifts the receiver from the switchhook. Line relay L₁ operates and lights lamp 1. The operator observes lamp 1, plugs answering plug 2, Fig. 2, into the line jack, and operates front key FK connected to the operator's telephone circuit OTC. When any cord circuit is connected to a jack a sleeve circuit starts the motor generator sets MGS to supply a suitable direct current in preparation for teletypewriter communication. The calling substation operator and the called private branch operator communicate over obvious circuits. The substation operator gives information telephonically as to the station desired and the operator plugs the calling plug 3 into the jack of a called line which we will assume is the line of Fig. 3.

(c) *Operator rings called station—Called station answers*

The called station is rung by the operator depressing the ringing key RK intermittently which applies 20-cycle ringing current from the ringing generator G over the ring side of the loop through the ringer at the called station to ground. The generator G may be located at the switchboard of the private exchange system or at a nearby central telephone or telegraph office. During ringing the relay R₂ follows the pulsations of the ringing current and causes lamp 7 in the cord circuit to flash. The subscriber answers by lifting the receiver of Fig. 3. The operators at stations 1 and 3 are then in telephonic communication and may talk to one another over a circuit through the repeating coils RC₁, RC₂, RC₃, RC₄ functioning as a transformer which may readily be traced from tip of plug 2 to tip of plug 3 and from ring of plug 3 to ring of plug 2; all connections N are closed, all connections M are opened. For this purpose, gang switch MN may be in the "up" position. The operator may monitor or retire from the circuit by restoring key FK. In tracing this circuit let it be also remembered that coils RC₁, RC₂, RC₃ and RC₄ are telephone repeating coils or voice frequency autotransformers. The private branch exchange system therefore serves as a telephone exchange system. Disconnect or recall supervisory signals are in accordance with standard telephone practice and will be readily understood.

(d) *Telephone service from substation to central office*

For this service the operator of the switchboard will be provided with a standard cord circuit (not shown). The calling station will designate a connection to a central telephone exchange and the switchboard operator will substi-

tute the plug of the standard cord in the jack in place of plug 2 and connect the line of Fig. 1 or any other similar substation line to the central office by means of a telephone line terminating at a jack (not shown) at the switchboard of Fig. 2. The circuit for telephone communication over the line connected to the plug 2 may be traced as follows:—Beginning at battery in the repeating coil, winding RC₁, contacts 7 and 8 of switch MN, to tip of plug 2, over the line and back to the ring of plug 2, contacts 4 and 5 of switch MN, contact of key THRU, contacts 9 and 3 of switch MN, and branch RC₃ of the repeating coil back to the point of beginning. The circuit for the line connected to the plug 3 may be traced as follows: Beginning at battery in the repeating coil, through winding RC₂ over a contact of key THRU, over a left-hand normal contact of key USK, over tip of plug 3, through the line and back to the ring of plug 3, over a contact of key THRU, over a right-hand normal make of key RK, and through winding RC₄ to the point of beginning. By operating key FK the operator's telephone circuit will have its microphone energized over an obvious path and its receiver connected in shunt to the telephone circuit through the coils RC₁ and RC₃ as just traced.

(e) *Teletypewriter communication—No teletypewriter at switchboard*

In certain small installations no teletypewriter may be desired at the switchboard owing to the expense, but it will be desired to have teletypewriter as well as telephone communication between substations. In this case the switchboard operator—as soon as the called substation has been called as described above under heading (c) and has answered—may by telephone instruct both the substation operators to start their teletypewriter motors for teletypewriter communication. Upon receiving their approval telephonically the switchboard operator retires from the circuit by restoring key FK and operates the key THRU. The operator at the substation of Fig. 1 operates power switch PS and the called operator at a similar substation does likewise. In the case of a station such as Fig. 3—adapted for unattended service—which is temporarily attended, the operator holds down start key SK and restores the receiver to the switchhook while holding the key down. The motors at both substations start. At the station of Fig. 3 the relay 4 (which is an alternating current relay in the case of a 110 volt alternating current power supply) operates and holds the motor circuit closed; it also opens the path to ground of the ringer R and distant control alternating current relay 5. The centrifugal contact 6 in the teletypewriter instrument—a standard device commonly employed on such instruments—connects the teletypewriter sending contacts and receiving magnet across the line. The operators at the stations of Figs. 1 and 3 may now communicate by teletypewriter. The communication circuit may be traced from +48 volts at motor generator set MGS over an operated contact of key THRU, contacts M of switch MN, and normally made contacts of relay 8, ring of plug 2, back over the tip of plug 2, operated contacts of key THRU, ring of plug 3, back over tip of plug 3, normal contact of key USK, and operated contact of key THRU back to -48 volts on set MGS; both subscribers' lines are thus in a series circuit.

(f) Unattended station start

Assume the called station unattended and adapted for unattended teletypewriter service. The switchboard operator will operate the unattended start key USK. This applies 20-cycle ringing current from generator G to the tip of the loop of the called station of Fig. 3 over an obvious circuit and operates the alternating current control relay 5. Since the receiver is on the switchhook this has the same effect as operating key SK would have and the motor is started. When the centrifugal switch contacts 6 close the switchboard operator is notified because the differential relay R2 then fails to follow the ringing impulses and lamp 7 stays dark. The operator releases key USK and operates key THRU. Messages may then be received and printed at the station of Fig. 3. In case of calling a station by telephone and receiving no answer this arrangement may be used to leave word in writing at the calling station as to who called and request the called party to telephone the calling party.

(g) Recall or disconnect signal

Either substation operator at a station like Fig. 1 may send a disconnect signal to the operator by placing her telephone receiver on the switchhook with power switch PS closed and a recall signal by operating switchhook up and down with power switch PS closed. These operations would cause lamp 7 to light in the one case and to flash in the other. From an unattended station such as that of Fig. 2 the corresponding signals are sent by means of the switchhook with the centrifugal contact 6 on its back or upper contact.

OPERATION OF SYSTEM—TELETYPEWRITER SUPERVISION METHOD

The operator at the switchboard has a teletypewriter machine; all switches M are closed; all switches N are open.

(a) Substation calls, operator answers

The substation attendant calls the operator by closing the power switch PS. This starts the substation teletypewriter motor over an obvious circuit and closes the line. Relay L₁ operates, and lights lamp 1.

The switchboard operator observes the lamp and operates the key TK, and puts plug 2 into the line jack. When any plug is in any jack the motor generator sets MGS begin to operate. Key TK connects the teletypewriter in series with the 48 volt direct current supply from the motor generators and the line by operating relay 8. Circuit: From +48 volts, contacts of relay 8, contacts of key THRU, contact of relay 8, line relay and sending contacts of teletypewriter TTY, contacts of key 5S, contacts of relay 8, ring of loop, substation teletypewriter line magnet and contacts, tip of loop, contacts of key THRU, contact of relay 8, and to ground through -48 volts. Slow release relay SR operates and anti-spin magnet AM is deenergized. The purpose of relay SR and magnet AM is to prevent the operator's teletypewriter from "spinning" indefinitely in case the line circuit is opened and remains open. When the line relay of the teletypewriter has remained on its back contact for an interval the slow release relay SR releases and magnet AM is energized. This magnet is provided with mechanism to keep the teletypewriter

from spinning. The substation and switchboard operators communicate by teletypewriter.

(b) Operator calls—Called station answers

The operator rings by operating key RK as in the telephone method previously described.

The called party answers by starting the station motor. Lamp 7 stops flashing. Key THRU is operated. This puts the calling and called stations and switchboard operator in communication in a series circuit with the + and -48 volt supply. The called station announces his number and the stations communicate. The switchboard operator may retire from monitoring at any time by releasing key TK to its normal position.

(c) Unattended station start

This is accomplished the same as in the telephone supervision method. After the motor of the teletypewriter of the called station has started the calling substation sends any desired communication which is written down upon the machine of the called station.

OPERATION AFTER CONNECTION IS ESTABLISHED

(a) Recall signal

When a connection is established either substation may recall the operator. In the case of a station equipped for "attended only" service the operator may do this by operating the power switch PS intermittently. At the station adapted for unattended service the operator operates the recall key RCK intermittently. In either case the cord circuit relay R₁ or R₂ will energize when the switch PS or the key RCK at the station opens the line and flash the lamp 7 in the corresponding end of the cord circuit.

When the station on the side of the cord corresponding to relay R₁ recalls and operates relay R₁ it also causes relay R₃ to operate. Operation of relay R₃ substitutes the voltage source of 48 volts positive from the motor generator set MGS for the 48 volts positive previously supplied over the line of Fig. 1. The circuit is from ground through the +48 volt direct current generator of the sets MGS to contact of relay R₃, through a resistance equivalent to the line resistance, over a contact of key THRU to the same side of the line of the station of Fig. 3 as the +48 volts is connected when power switch PS is closed to the motor of the station of Fig. 1. The station connected to the side of the cord including relay R₂ may therefore recall even though the other station is recalling at the same time.

(b) Disconnect signal

To give a disconnect indication to the switchboard operator either substation may stop the teletypewriter motor thereat. In the case of an unattended receiving station the motor may be stopped by sending from the calling station or from the switchboard operator's station a special signal such as "upper case H" (or any otherwise unemployed upper case code combination). This operates a motor stopping pull bar, designated PB in Fig. 3, in a well-known manner when a printer of a type in common use equipped with suitable mechanism is employed at the unattended station. The attendant at the calling station (if of the attended type) will always send the "upper case H" before operating the power switch PS to idle position. When the substation motor stops the corresponding relay R₁ or R₂ will operate and light the cord lamp 7.

If only one cord lamp is lighted the switchboard operator may reoperate key TK and challenge the station not yet disconnected and connect that station to another station or recall the disconnected station or take other appropriate action.

CONNECTION TO OUTSIDE TELETYPEWRITER EXCHANGE

In the previous discussion the arrangements described have been with reference to intercommunication between stations of a private branch exchange such as would be suitable for a company plant or a small local installation. Whenever the operator's teletypewriter TTY and connections M are provided the addition of a trunk such as that of Fig. 4 will enable any station of the private branch exchange to communicate over the trunk to a teletypewriter exchange system and its subscribers, such as is described in the application of Locke and Kinkead, Serial No. 459,684, filed June 7, 1930, or patent to Lane No. 1,965,383, granted July 3, 1934.

It will be noted that the trunk termination of Fig. 4 includes a telegraph repeater through which all telegraph impulses are relayed for the conveyance of telegraphic intelligence over the loop. This repeater consists of four polarized relays P₁, P₂, P₃ and P₄ together with battery sources and other elements usual in such repeaters. These elements will be well understood by those skilled in the art and no detailed description is required. See Herman Patent 1,601,799, granted October 5, 1926.

(a) Incoming call

Let it be assumed that the trunk extends to a central station equipped according to the Patent No. 1,965,383, and that conductor T corresponds to conductor T of Fig. 1 of that application. The appearance of the trunk at the line jack of the central office is the same as the appearance of a subscriber's line of said application. In the case of an incoming call the central office operator will apply 20-cycle ringing current to the conductor T as described. This will operate the relay AC which will cause the operation of relay 10, which locks up over an obvious circuit and lights lamp 11 over an obvious locked-up circuit. The operator observes lamp 11 and plugs a cord plug 2 into jack 12. The sleeve relay SR on the trunk operates. This opens the holding path of relay 10 and lamp 11 becomes dark. The private branch exchange operator operates key TK and communicates with the central office operator. Upon receiving the desired information the local office operator connects to the desired substation as described above in the case of a substation to substation call. If the substation wishes to recall the local office operator, this may be done also in the same manner as in a substation to substation call. If the local exchange operator wishes to recall the central exchange operator this may be done by removing plug 2 from jack 12 and immediately reconnecting it and waiting until the central office operator answers. The effect of this operation at the central office will be obvious from a consideration of the Lane Patent 1,965,383. In brief, removal of the jack will ground ring R and open tip T to direct current. This will put a flashing recall on lamp 158 of the Lane patent as described therein.

The substation connected to the cord circuit of Fig. 2 will disconnect in the usual manner but in this case upon noting a single disconnect lamp 7 the operator at the local office will pull down both plugs of the cord circuit. Removal of the

cord plug from jack 12 will cause the release of relay SR which will ground ring conductor R and open tip conductor T. This will light a disconnect signal lamp at the central office corresponding to lamp 158 of the Lane patent.

(b) Outgoing call

When the operator at the local exchange office of Fig. 2 wishes to extend a call over the trunk TR either to connect a substation or to communicate from her own teletypewriter, she will plug the rear plug 3 of the cord circuit into the jack 12. This will close the tip and ring together by operation of relay SR. In a manner disclosed in the Lane patent the call lamp at the central exchange will light. The operator will respond in the usual manner and communication between operators, extension of the call to distant stations, recall and disconnect will be accomplished in obvious manners.

CONNECTIONS TO STATIONS HAVING NORMALLY CLOSED LOOPS

If the private branch exchange has one or more substations located at such a distance that the resistance of a loop thereto would be too large, i. e., over 2000 ohms, such a station may be connected to the private branch exchange of Fig. 2 on a closed loop basis over a line which may include two-way single line repeaters and line terminating equipment according to Fig. 5. Let it be assumed, for example, that the substation is according to the right-hand end of Fig. 5 hereof. It is like that of the Lane Patent 1,979,273, granted November 6, 1934, except that a two-wire line is used in place of the one-wire line of Fig. 1 of said patent. Let it be assumed (as was assumed in the patent) that the substation printer includes that well-known and commonly employed mechanism whereby the printer motor is started on opening and closing the line and is stopped by a special code combination or combinations. (See Morton et al. Patent 1,931,672, dated October 24, 1933.) Relays P₁, P₂, P₃ P₄ constitute a repeater and the remaining elements of Fig. 5 will be understood from the following description:

Operating procedure

The operator at the outlying station TWX opens the line circuit by the call key CALL to initiate a call. Prior to opening the line circuit current normally flows from the negative terminal of the rectifier REC over the conductor R, through the substation, over conductor T to ground through relay 501. Upon opening the circuit, the circuit of the slow release relay 501 is opened and relay 501 releases and connects battery to operate relay 502. In operating, relay 502 connects battery to light the line lamp 501L and locks itself up so that it does not release when relay 501 releases. The private branch exchange operator observes the lamp 501L and places plug 2 in jack 503. This connects battery to relay 504 from the sleeve of the cord and energizes relay 504 which performs several functions. Its first function is to transfer the tip of the line T from the slow release relay 501 to the repeater at the make contact of the relay P₂. Relay 504 also removes battery from the winding of relay 502 so that it cannot reoperate if relay 501 should release. Relay 504 also prepares a circuit from the ring of the jack to the armature of the dashpot relay 505. The line circuit T, R is now connected through the repeater on one side and the other side of the repeater is connected into the cord circuit of the station of

Fig. 2. The private branch exchange operator may communicate with the substation and connect the substation to any other substation or over a trunk circuit, such as that of Fig. 4, to a teletypewriter central office.

If the substation operator wishes to send a recall or disconnect communication she does so by opening the line for ten or more seconds by manual operation of key DISC or otherwise, the exact time being determined by the adjustment or characteristics of the relay 505, this time exceeding that of the operation of relay 505 by a few seconds. Opening the line deenergizes the line winding of relay P4 which places its armature on the back contact, thereby applying battery to relay 505 and opening the transmission circuit through jack 503. When relay 505 operates it applies ground to the ring of jack 503, thereby unbalancing relay R1 or R2, as the case may be, and lighting a cord lamp 7. When the DISC key is completely restored the armature of relay P4 returns to the front contact closing the transmission circuit. Relays 505 and R1 or R2 release and cord lamp 7 goes out. The private branch exchange operator should challenge to determine whether the signal is intended for a recall or disconnect. In the case of a disconnect the operator receives no response to the challenge and removes the plug from jack 503 whereupon the circuit resumes its normal condition by an obvious sequence of operations.

If the private branch exchange operator wishes to call the substation, she places plug 3 into jack 503 and opens and closes the line for a short interval by sending any character from the sending contacts with the key TK operated. The result is to start the substation printer motor whereupon a message may be sent to the unattended printer or a teletypewriter bell signal sent to call the substation operator. It will be understood that the 48-volt voltage supply with the repeater of Fig. 5 may be taken from the motor generator sets MGS and that when the private branch exchange is idle the trunk equipment has no current drain except from the rectifier REC. It will also be obvious that the rectifier may be located at the outlying substation for one-wire communication, in which case the conductor R terminates at the substation instead of extending back to the private branch exchange. It will also be obvious that the usual closed line type of telegraph repeaters may be included at any point in the line T, R if the line is electrically too long to operate without them.

TRUNK CIRCUIT TO OPEN LOOP CENTRAL OFFICE

Let it be assumed that it is desired to extend the loop TR of Fig. 4 to a central office and that the distance is too great for a non-repeated loop. Let it also be assumed that the nearest central office is according to the application of Locke and Kinkead, Serial No. 459,684, filed June 7, 1930. The trunk TR of Fig. 4 may extend to the central office through line extension equipment or a toll channel such as disclosed in Figs. 6 or 7, respectively, of the Locke-Kinkead application, Serial No. 459,684, filed June 7, 1930. The operation will be readily understood from the foregoing description of Fig. 4 and from the disclosure of said application. In such case the private branch exchange of Fig. 2 and the line terminating equipment of Fig. 4 replaces one of the distant outlying stations of the Locke-Kinkead system.

TRUNK CIRCUIT TO CLOSED LOOP CENTRAL OFFICE

Another type of central office operates on a closed loop basis. Let it be assumed that it is desired to connect the private branch exchange circuit of Fig. 2 to such type of central office. In this case the circuit arrangement according to Fig. 6 may be employed. Relays P1, P2, P3 and P4 of this figure constitute a repeater and the other relays and equipment will be understood from the following description of the operation. Let it also be supposed that the line T, R extends to a central office like that of Lane et al. Patent 1,979,273, granted November 6, 1934 and that the circuit of Fig. 6 hereof is substituted for the subscriber's station of Fig. 1 of said patent and that the apparatus at the exchange end of said line is the same as is illustrated in said patent. Repeaters, such as TR of the said patent, may or may not be included in the trunk circuit and it will be assumed that the battery supply indicated as being at the subscriber's station is in series with the line at the private branch exchange or at the repeater nearest to the private branch exchange.

(a) Call from private branch exchange to central office

Referring to Fig. 6 the relay D is held operated by current supplied over the loop TR from the central office and the relay E normally has its winding short circuited. The relay F is normally unoperated. The relays P1, P2, P3 and P4 may stand with their armatures in any position when the circuit is idle. Their position is immaterial because the loop circuit is normally closed independently of the contacts of these relays. However, it will be understood that when the operator places a plug 2 in the jack 603 relays P1 and P2 will be placed in the positions shown in the drawings. This will occur because the motor generator sets MGS will start and supply positive and negative voltages to the various battery supply points on the repeater circuit of Fig. 6. The operator then operates the key TK and opens the circuit across the tip and ring of the jack 603 by operating the break key (not shown) of her teletypewriter set. This causes the relay P1 to operate to its open contact and repeats the open line condition to the central office over the loop TR, thereby causing the line lamp at the central office to be lighted as will be understood from a perusal of Patent 1,979,273. Relay P2 will operate its armature to its open contact and reverse the direction of current through the auxiliary winding of relays P3 and P4 to hold them on their closed contacts. Upon closure of the break key and the proper response by the operator at the central office communications between the operators will be established whereupon any desired communication circuit between substations or subscribers' stations connected to the private branch exchange and the central office may be established.

(b) Call from the central office to the private branch exchange

The central office exchange operator plugs into the line jack and sends a break signal of short duration. The relay D releases and short circuits its line winding so that it will not reoperate upon closure of the line. The relay E operates and likewise the trunk lamp TL and a night alarm circuit may be included with the trunk lamp TL in the usual manner, if necessary. The

private branch exchange operator answers by placing plug 2 into jack 603. This energizes the repeater circuit from the motor generator set MGS and operates relay F by connecting battery
 5 to the lead 604 at the jack 603. Relay D operates over a contact of relay F. A contact of relay F also short-circuits the line winding of relay D and the winding of relay E. This extinguishes the lamp TL. The relay F supplies ground and
 10 negative 48 volts to the biasing network of the repeater; this may be from motor generator set MGS. The operators may now communicate and set up any desired communication circuit through their respective switchboards.

15 (c) *Disconnect signals*

To send a disconnect communication to the central office the operator at the private branch exchange opens the line for five seconds. This
 20 may be accomplished by timed manual operation of the break key in the operator's teletypewriter set or by operation of the special key 5S.

No provision is made for a disconnect indication from the central teletypewriter exchange office to the private branch exchange office. Dis-
 25 connection in such case will be accomplished by some subscriber on the circuit sending a disconnect code combination to stop the motors of the various teletypewriters on the circuit, or by a
 30 substation on the private branch exchange disconnecting, which will light one disconnect lamp connected in the cord circuit of Fig. 2. Upon this occurring the private branch exchange operator will note the lighted lamp as either a recall
 35 or disconnect signal and if no response is received after challenging will first send a disconnect signal to the central office by operating key 5S and will then pull down both plugs of the
 40 cord.

40 GENERAL DISCUSSION

In general all the features of the foregoing description will not be employed in a single private branch exchange system. Only occasionally
 45 may it be necessary for a substation to be connected to the private branch exchange system over arrangements according to Fig. 5. It will generally be unnecessary to have more than one kind of trunk to a central office, dependent upon
 50 the equipment of the nearest and most convenient central office. If the private branch exchange is to be used for only local teletypewriter service between substations, no operator's teletypewriter equipment need be provided because the super-
 55 vision may be carried on telephonically as previously described. In any case, the substations may communicate telephonically with each other or with the private branch exchange operator (if the operator is provided with telephone equip-
 60 ment) and such communication will be possible whether or not trunk lines to outside teletypewriter offices are provided. By using special telephone cords of a kind well understood in the art and, hence, not described herein in detail, sub-
 65 stations on a private branch exchange may be connected to a telephone central office. In this case it will be necessary for the operator to substitute such a cord circuit for the cord circuit shown in Fig. 2 for the purpose of connecting the
 70 jack of the substation line to a jack of a line (not shown) to the telephone central office.

Viewed solely from the standpoint of a teletypewriter exchange the cord circuit of Fig. 2 and associated equipment connects the substation
 75 line without the use of a central office repeater

and the current flow for each line is in a similar direction. All the telephone equipment may be omitted in which case the telegraphic features constitute a type of exchange circuit effectively
 5 usable as a teletypewriter exchange system with teletypewriter supervision. Many operating advantages will be observed to be present in the system as disclosed or various subcombinations thereof employed to set up particular communi-
 10 cation circuits. In general, the private branch exchange has no current drain when idle and may thus be shut down conveniently during nights or holidays but nevertheless provision is made so that when a call on the teletypewriter office is re-
 15 ceived a watchman or other attendant may be informed by means of the bell of the night alarm circuit so that necessary steps may be taken to receive the call and, if desired, to extend it to a substation of the private branch exchange on an
 20 unattended basis for receiving the message.

What is claimed is:

1. A telegraph exchange system having a plu-
 25 rality of lines, each line terminating at a central switchboard, each line being provided at a terminal remote from said switchboard with a tele- typewriter and a telephone set, a cord circuit at
 said switchboard for interconnecting said lines, said cord circuit being provided with a telephone operator's subset, sources of current, and keys
 30 whereby said subset may be connected for communication over said lines by telephony, and with keys whereby said lines may be interconnected for direct current impulse telegraph transmission through said cord circuit.

2. A cord circuit for communication systems
 35 terminating in two plugs, each plug having a first terminal and a second terminal, said cord circuit having a transmission path for connecting two lines through a repeating coil for voice communication, a key in said circuit with con-
 40 tacts for connecting into said cord circuit a transmission path between said two lines for telegraphic direct current impulse communication, and means in said cord circuit for supplying tele-
 45 graphic current for such communication, said means supplying positive potential to the first terminal of one of said plugs and negative potential to the second terminal of another of said plugs.

3. A telegraph exchange system having a plu-
 50 rality of lines, each line terminating in a jack at a switchboard, each line being provided at its terminal remote from said switchboard with a teletypewriter and a telephone subset, cord cir-
 cuits for interconnecting said lines, and means in-
 55 cluding telephone and telegraphic supervisory apparatus connectable into said cord circuits whereby communication may be had over said lines to and from a supervisory operator at said switchboard by telegraphy or by telephony.

4. In a system in accordance with claim 3, con-
 60 densers in the telephone communication path of said cord circuit through which the voice waves pass and a key for short-circuiting said condensers to allow telegraph impulses to pass
 65 through said cord circuit without passing through said condensers.

5. In a system in accordance with claim 3, a motor associated with and effective to operate
 70 each teletypewriter, and devices whereby the operator at the central office may start the motor of a called station by remote control.

6. A manual teletypewriter exchange system having a motor generator set for supplying the
 75 exchange and lines extending therefrom, means whereby said set is normally idle, means whereby

an incoming call may be received and indicated to an operator during the idle condition of said set, and means controlled by the connection of any line extending from said station to a link circuit of said station for starting said motor generator set.

7. A manual teletypewriter exchange system having a principal source of operating current supply for supplying the exchange and lines extending therefrom, means whereby said source is normally idle when all said lines are idle, means whereby an incoming call may be received and indicated to an operator during the idle condition of said source, and means controlled by the connection of any line extending from said station to a link circuit of said station for operatively connecting said source to said link circuit.

8. A manual central battery teletypewriter exchange system having a cord circuit with an answering end and a calling end for interconnecting lines, each said line having a jack to which said cord circuit is adapted to be applied, said jack being equally adapted for connection to the answering or the calling end of said cord circuit, said cord circuit furnishing a direct transmission path for teletypewriter signaling impulses without a repeater, and means whereby the direction of current flow is the same over any two lines connected to said cord circuit regardless of whether the answering end or the calling end of said cord circuit is connected to said lines.

9. A teletypewriter exchange having a line terminating thereat, said line including, between the line and the terminating line jack, a telegraph repeater, current supply means for said repeater normally not supplying current thereto, and means whereby connection of a link circuit to said jack supplies current from said current supply means to said repeater.

10. In a system according to claim 9, means whereby an incoming call over said line may be indicated to the operator at said exchange when said current supply means is not supplying current to said repeater.

11. A system in accordance with claim 9, including a normally open line extending from said exchange, a cord circuit in said exchange, and line terminating equipment for the line which includes said repeater being normally closed for direct current, and means included in said cord circuit and associated with said repeater whereby said lines may be interconnected for communication.

12. A teletypewriter exchange system including a central office and a plurality of lines extending therefrom, said lines being furnished with telephone subsets and teletypewriters, and said central office being provided with a cord circuit connectable to said lines and with an operator's telephone subset, a voice current repeating coil in said cord circuit, means whereby an incoming call over one of said lines is received telephonically by said operator and extended telephonically by means of the cord circuit to another line, and a key for disconnecting said coil from said cord circuit, whereby intercommunication between said lines by teletypewriter may occur over the said cord circuit.

13. A system according to claim 12, including a disconnect signal individual to said cord circuit and devices controlling said lamp from the terminus of one of said lines whereby upon the cessation of teletypewriter communication between said lines the operator at the outlying terminus

of said line may give a disconnect signal to the central office operator.

14. A system in accordance with claim 12, including cord circuit supervisory means, and means whereby the operator at the distant terminus of one of said lines may operate said supervisory means to give distinctive disconnect and recall signals to the central office operator.

15. A system in accordance with claim 12, including a central office operator's teletypewriter equipment and two sets of terminals, said terminals being so arranged that the opening of one set and the closing of the other set connects the operator's teletypewriter equipment to said cord circuit and a monitoring key whereby upon such connection the operator may monitor teletypewriter communications proceeding over said lines.

16. A system for connecting lines for intercommunication by teletypewriters comprising a plurality of such lines each provided with a telephone subset and a teletypewriter machine, a central office at which said lines terminate, an operator's cord circuit and an operator's subset at said central office, call means whereby one of said lines may call said operator, a connecting device whereby said operator may receive instructions as to the direction of said call with said subset, means whereby said operator may start the teletypewriter of the called line by remote control from said central office, and means whereby said calling line may be connected over said cord circuit to record a message upon the teletypewriter of the called line.

17. In a teletypewriter exchange system comprising an exchange office, lines having tip and ring conductors extending therefrom, a repeaterless cord circuit having terminal plugs for interconnecting said lines, current sources in said cord circuit for energizing said lines and connections whereby current flow over the tip and ring conductors of two interconnected lines is identical in the two lines.

18. A teletypewriter exchange system comprising a central office having a link circuit for interconnecting lines, lines terminating at said office each consisting of a normally open loop, lines terminating at said office each consisting of a normally closed loop, a connector for electrically closing any one of said lines to said link circuit, and devices controlled by said connectors whereby said link circuit operatively interconnects any two of said lines for teletypewriter intercommunication.

19. A telegraph exchange system comprising one or more lines normally closed when idle and one or more normally opened when idle, a switchboard whereat said lines terminate, a connecting circuit for interconnecting any two of said lines for telegraphic intercommunication therebetween through said circuit by code combinations of impulses.

20. A system in accordance with claim 19, including a supervisory call signal at the switchboard individual to one of said normally closed lines, means operable on the opening of said line to give a call signal to the central office operator.

21. A system in accordance with claim 19, having a call signal individual to and associated with one of said normally opened lines, means operable upon the closure of said line to cause said closed line to give an indication to said central office operator.

22. A line for telegraphic communication comprising a jack having two terminals adapted to constitute parts of a two-wire telegraph impulse

communication path, a telegraph impulse repeater connected to said terminals, a telegraph line adapted to be connected to said repeater on the side thereof opposite that to which said terminals are connected, a supervisory call signal associated with said line and operable thereover, a plug for connection to said jack, third terminals on said plug and jack, a circuit controllable over

said third terminals for connecting said repeater to said line for telegraphic communication between said line and a circuit connected to said plug, and means also controllable over said third terminals for controlling said supervisory call signal. 5

FRED JOHN SINGER.