Nov. 21, 1967 J. F. RETTIG ETAL 3,354,268

SYNCHRONIZING CIRCUIT FOR CONCENTRATOR SIGNALING SYSTEM

Filed Feb. 14, 1964 51 Sheets-Sheet 1

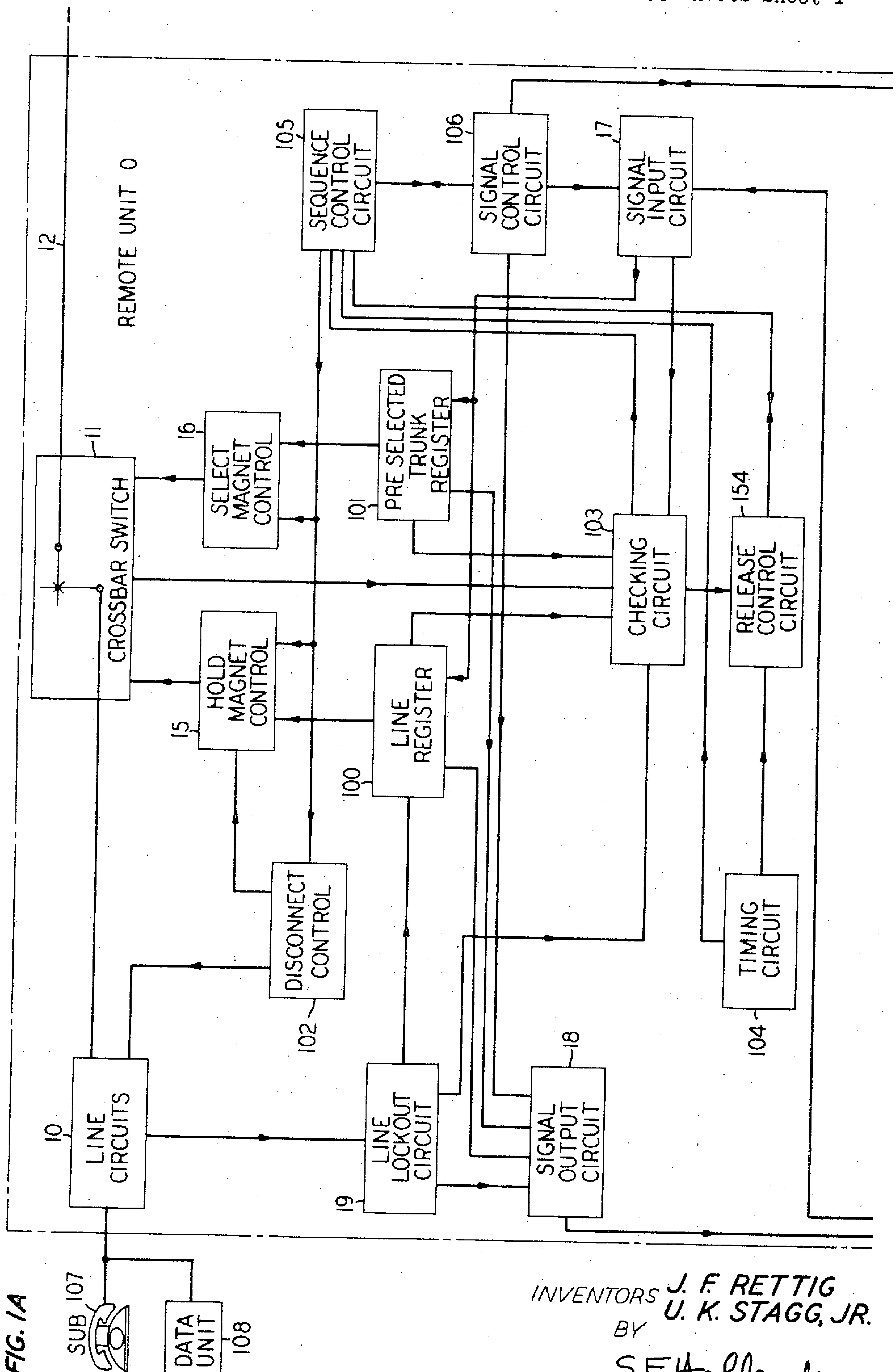

FIG. 1A

INVENTORS J. F. RETTIG
U. K. STAGG, JR.
BY
S E Hollander
ATTORNEY

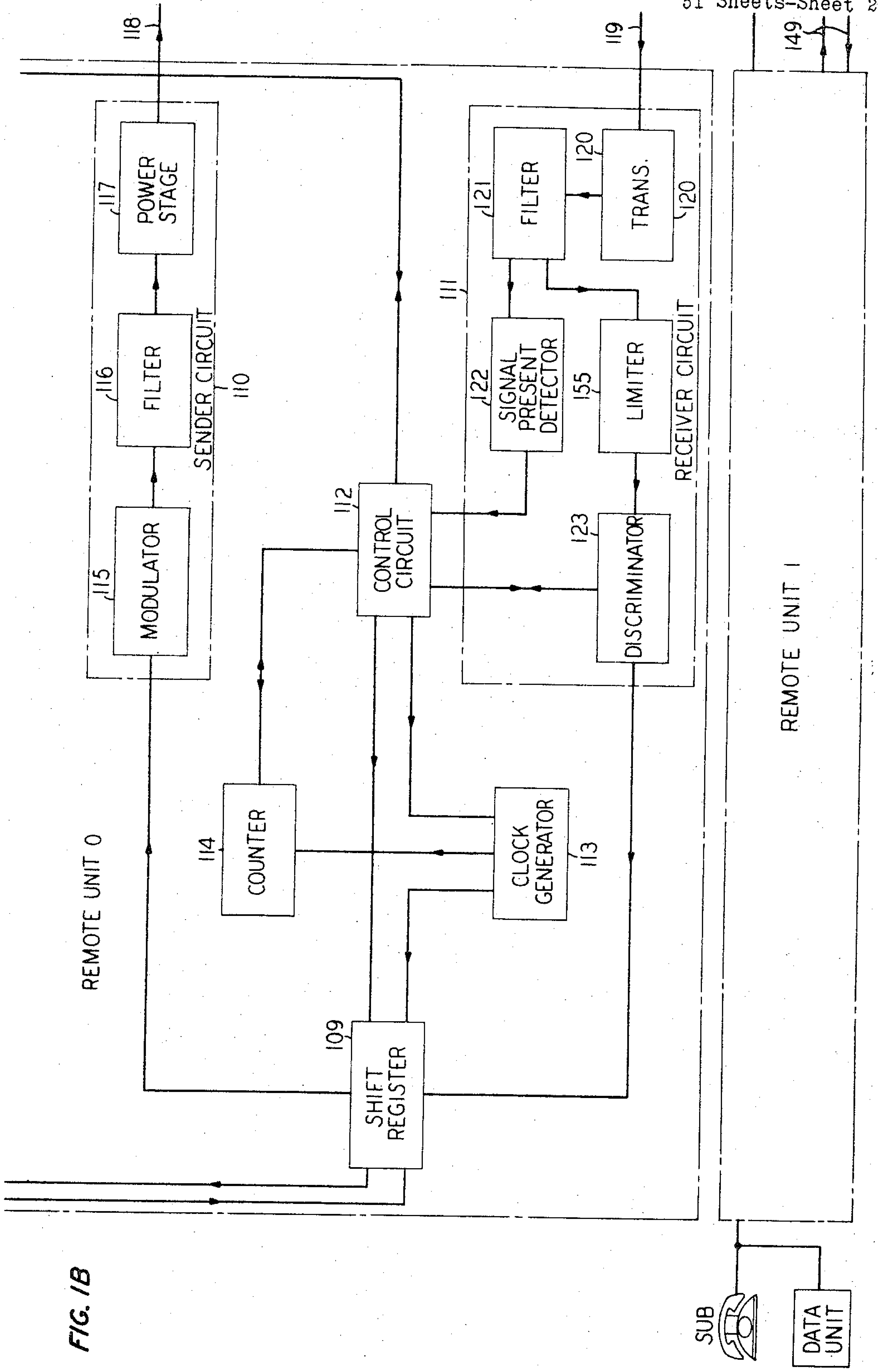
118
119
149
POWER STAGE
117
FILTER
116
MODULATOR
115
SENDER CIRCUIT
110
FILTER
121
TRANS.
120
120
111
SIGNAL PRESENT DETECTOR
122
LIMITER
155
RECEIVER CIRCUIT
DISCRIMINATOR
123
CONTROL CIRCUIT
112
COUNTER
114
CLOCK GENERATOR
113
SHIFT REGISTER
109
REMOTE UNIT 0
REMOTE UNIT 1
SUB
DATA UNIT

FIG. 1B

SYNCHRONIZING CIRCUIT FOR CONCENTRATOR SIGNALING SYSTEM

Filed Feb. 14, 1964

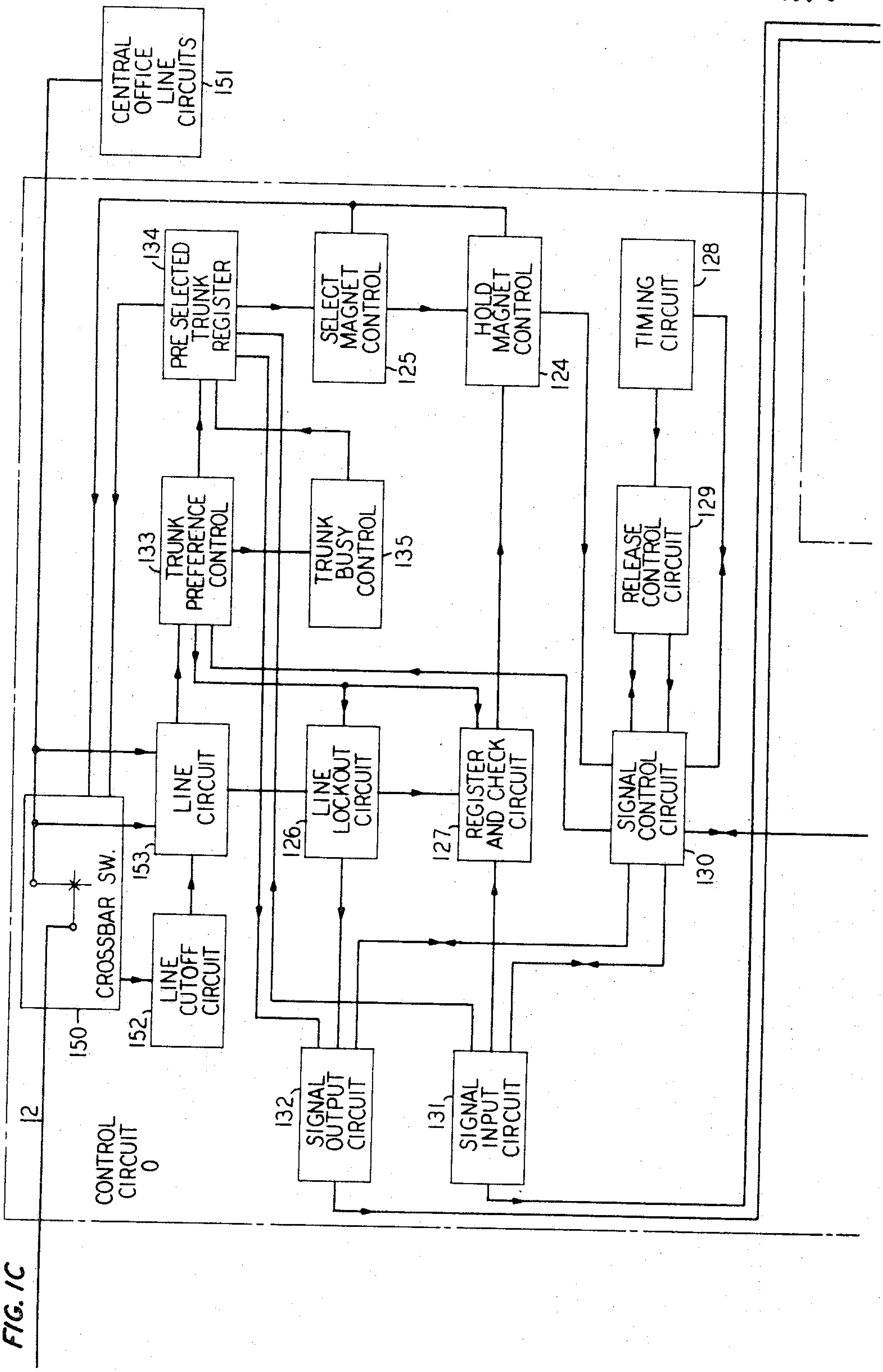

FIG. 1C

SYNCHRONIZING CIRCUIT FOR CONCENTRATOR SIGNALING SYSTEM

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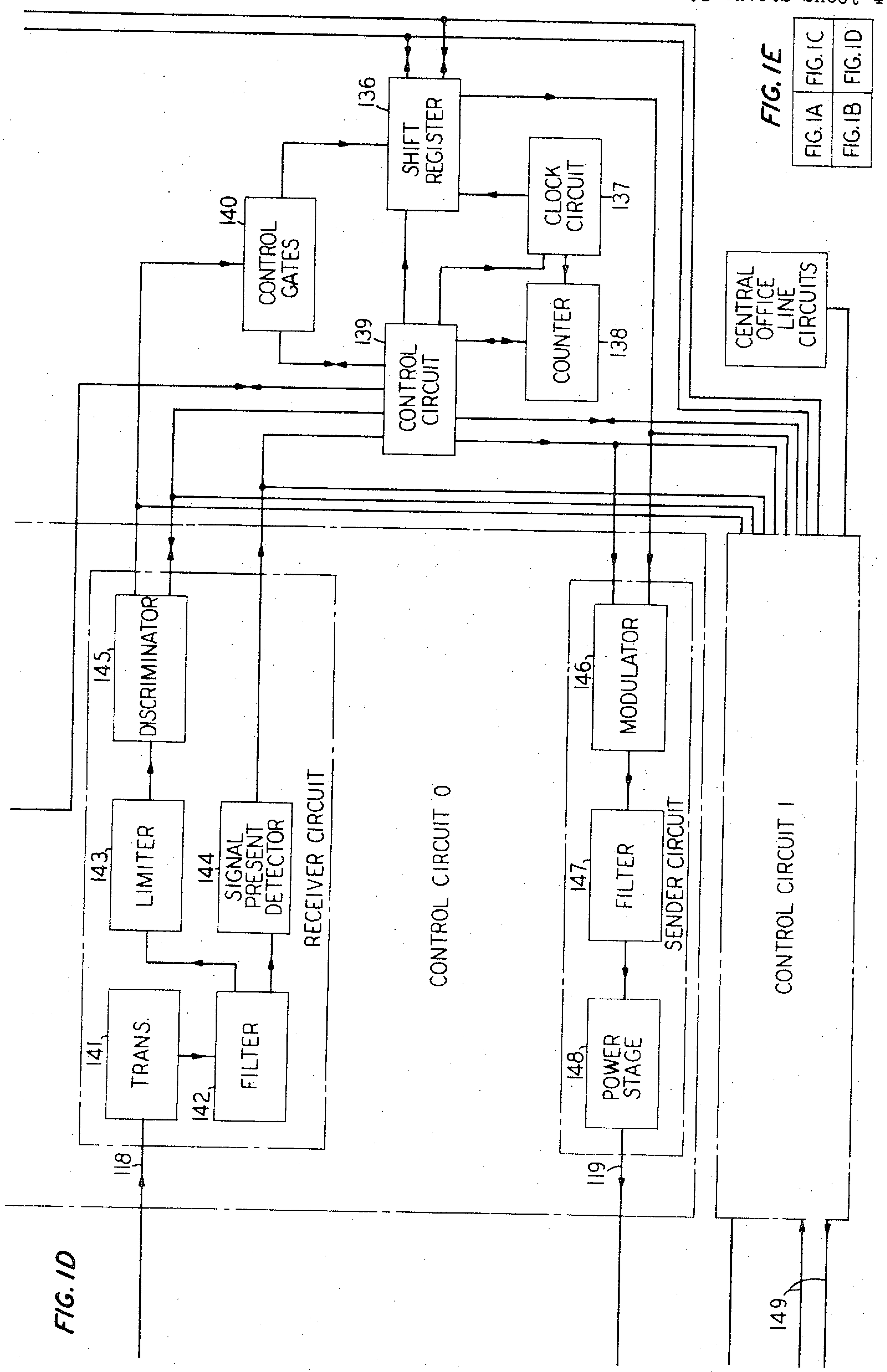

FIG. 1D

SYNCHRONIZING CIRCUIT FOR CONCENTRATOR SIGNALING SYSTEM

Filed Feb. 14, 1964 51 Sheets-Sheet 5

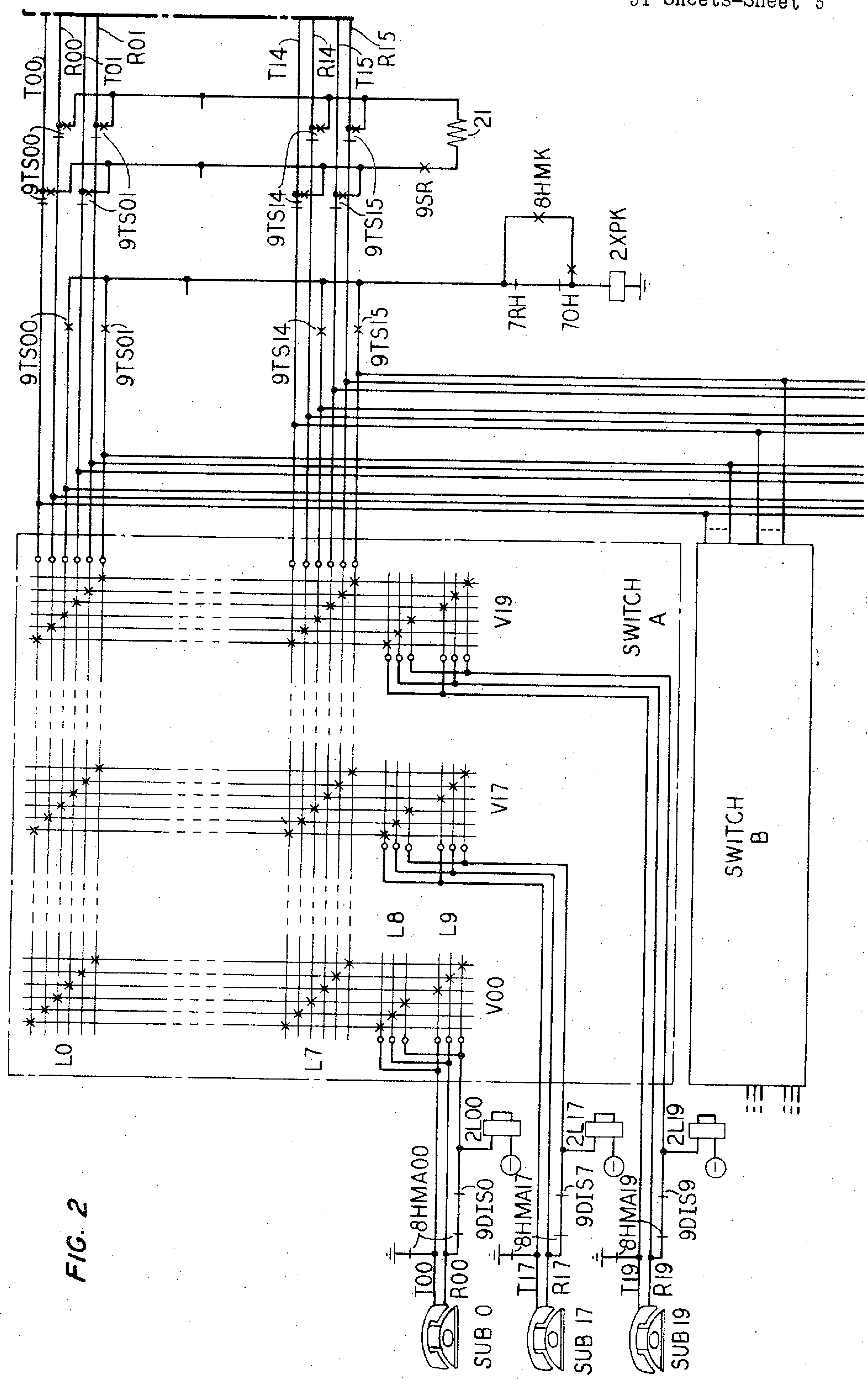

FIG. 2

SYNCHRONIZING CIRCUIT FOR CONCENTRATOR SIGNALING SYSTEM

Filed Feb. 14, 1964

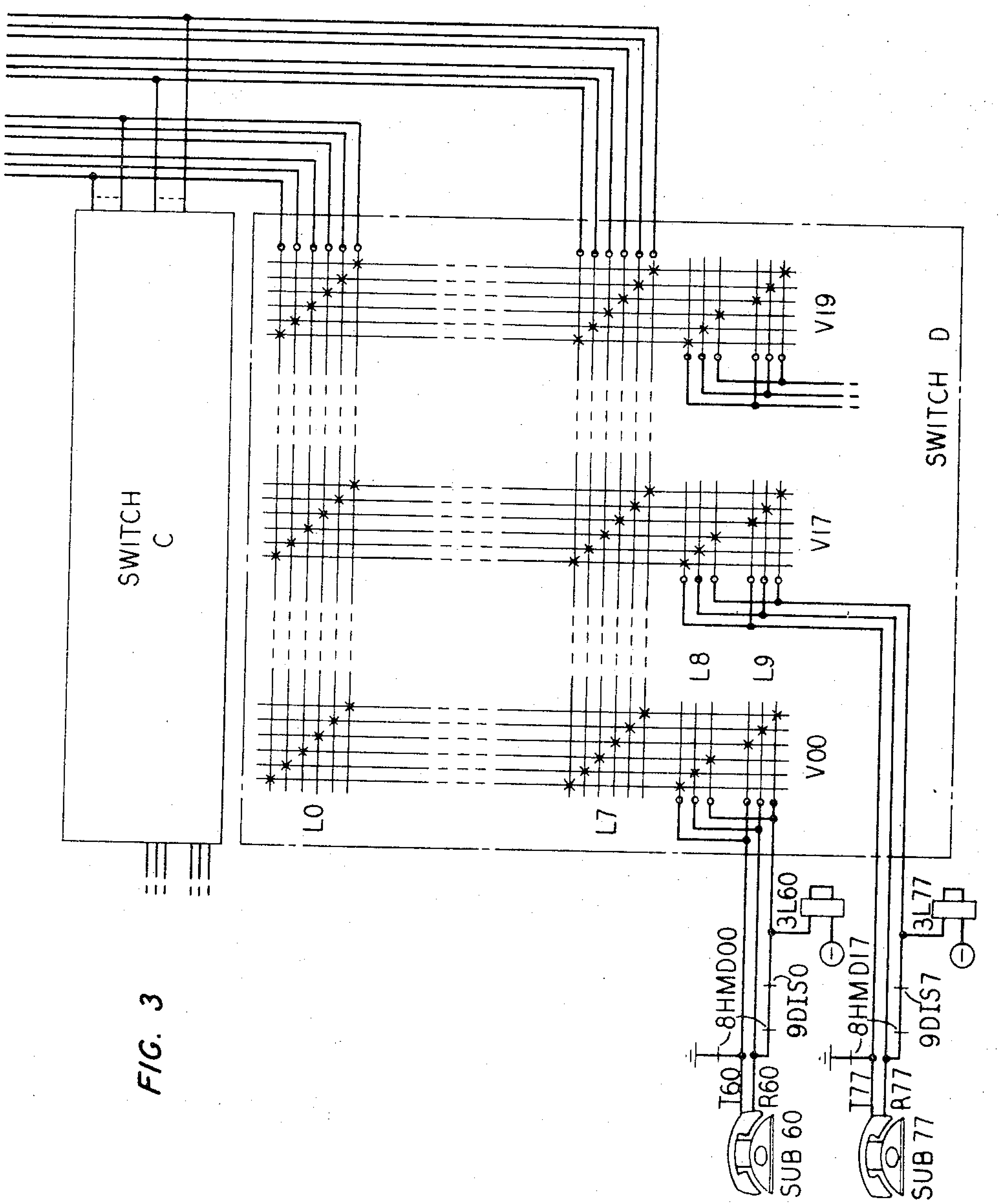

FIG. 3

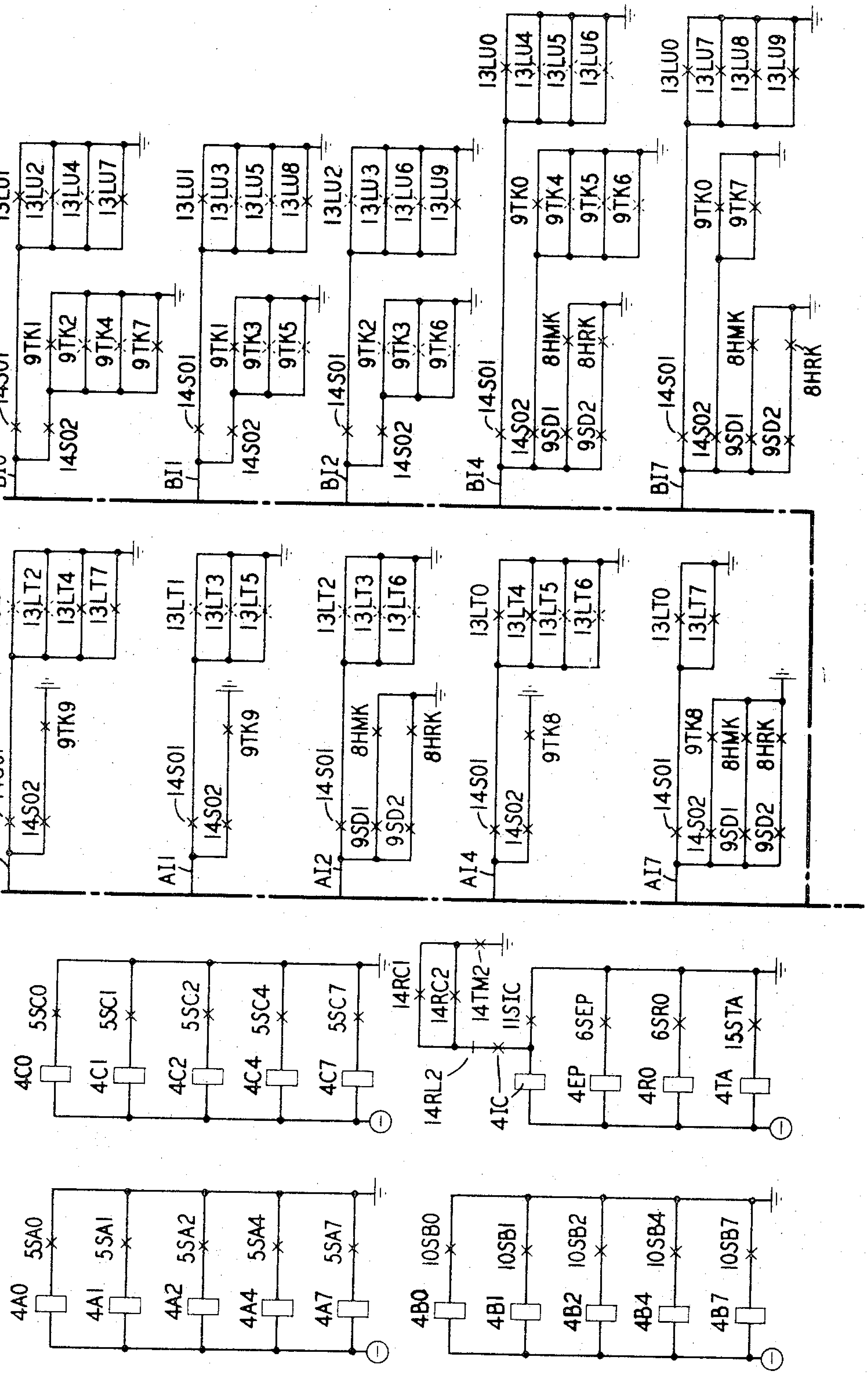
13LU0
13LU4
13LU5
13LU6
13LU7
13LU8
13LU9
13LU1
13LU2
13LU3
9TK0
9TK1
9TK2
9TK3
9TK4
9TK5
9TK6
9TK7
8HMK
8HRK
14S01
14S02
9SD1
9SD2
B10
B11
B12
B14
B17
13LT0
13LT1
13LT2
13LT3
13LT4
13LT5
13LT6
13LT7
9TK8
9TK9
A10
A11
A12
A14
A17
5SC0
5SC1
5SC2
5SC4
5SC7
4C0
4C1
4C2
4C4
4C7
14RC1
14RC2
14TM2
11SIC
14RL2
4IC
6SEP
6SR0
15STA
4EP
4R0
4TA
5SA0
5SA1
5SA2
5SA4
5SA7
4A0
4A1
4A2
4A4
4A7
10SB0
10SB1
10SB2
10SB4
10SB7
4B0
4B1
4B2
4B4
4B7

FIG. 4

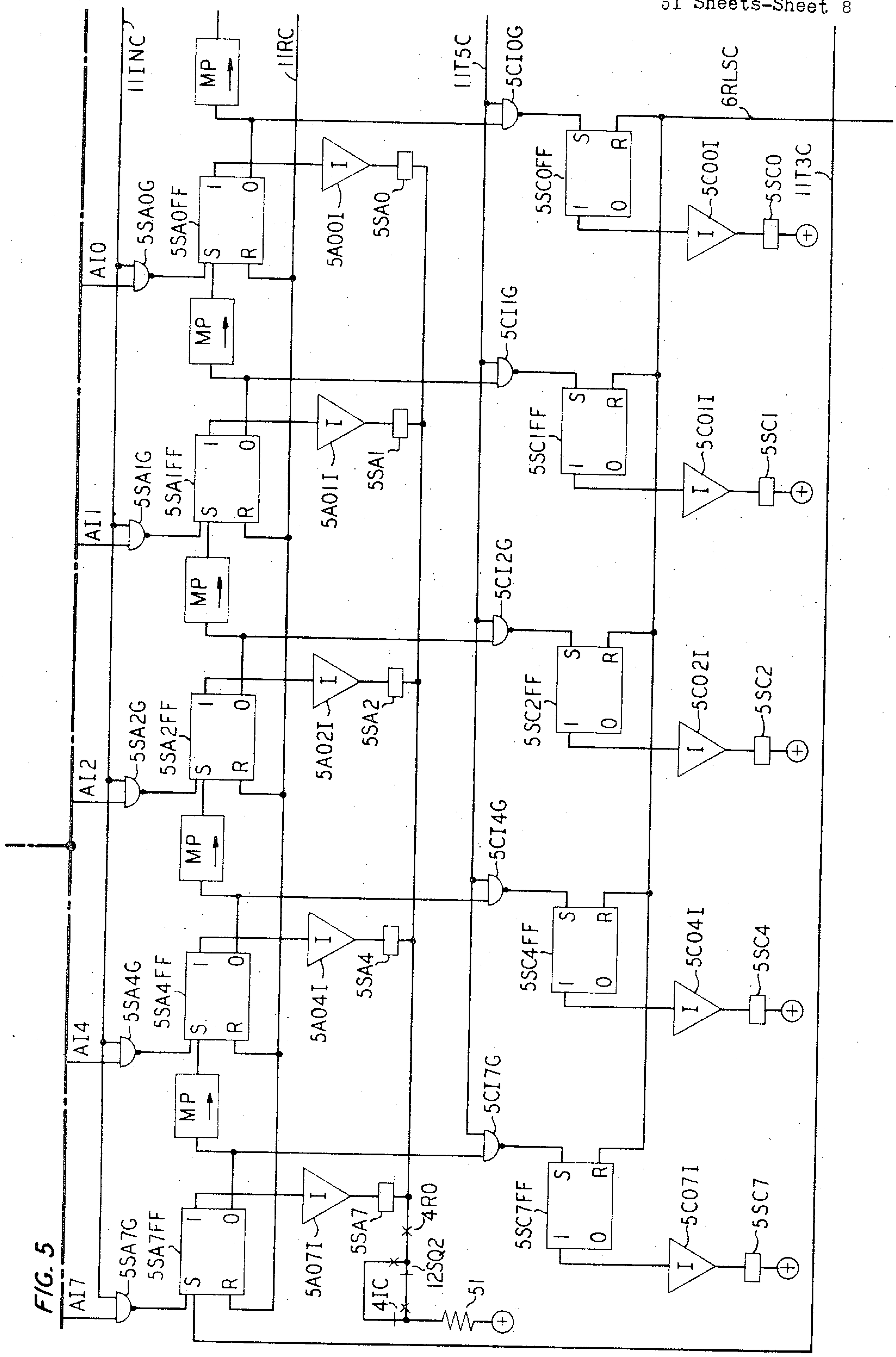
11INC
11RC
11T5C
5CI0G
6RLSC
11T3C
MP
AI0
5SA0G
5SA0FF
5A00I
5SA0
5SC0FF
5C00I
5SC0
AI1
5SA1G
5SA1FF
5A01I
5SA1
5CI1G
5SC1FF
5C01I
5SC1
AI2
5SA2G
5SA2FF
5A02I
5SA2
5CI2G
5SC2FF
5C02I
5SC2
AI4
5SA4G
5SA4FF
5A04I
5SA4
5CI4G
5SC4FF
5C04I
5SC4
AI7
5SA7G
5SA7FF
5A07I
5SA7
5CI7G
5SC7FF
5C07I
5SC7
4R0
12SQ2
4IC
51

FIG. 5

SYNCHRONIZING CIRCUIT FOR CONCENTRATOR SIGNALING SYSTEM

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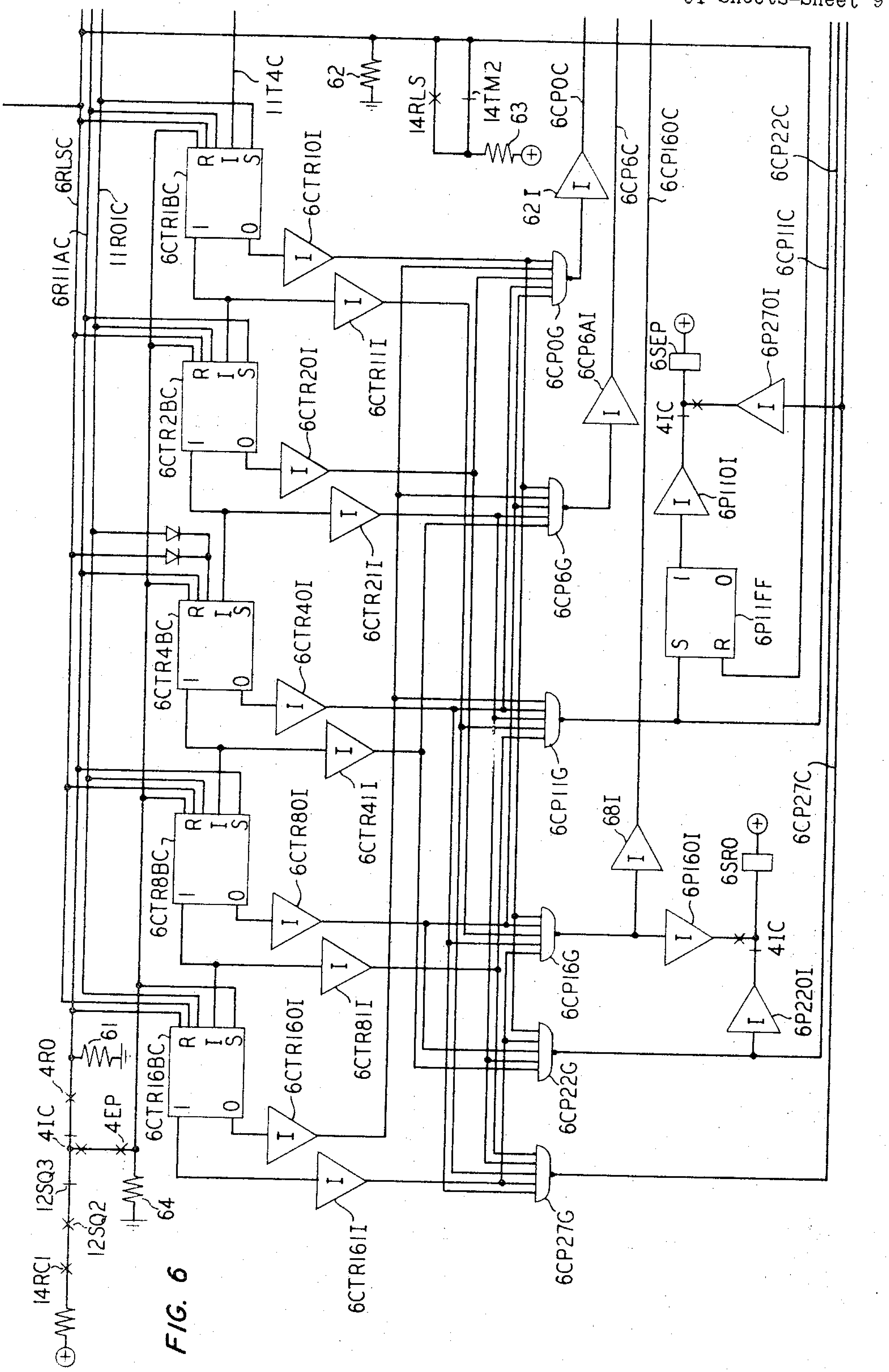

FIG. 6

SYNCHRONIZING CIRCUIT FOR CONCENTRATOR SIGNALING SYSTEM

Filed Feb. 14, 1964

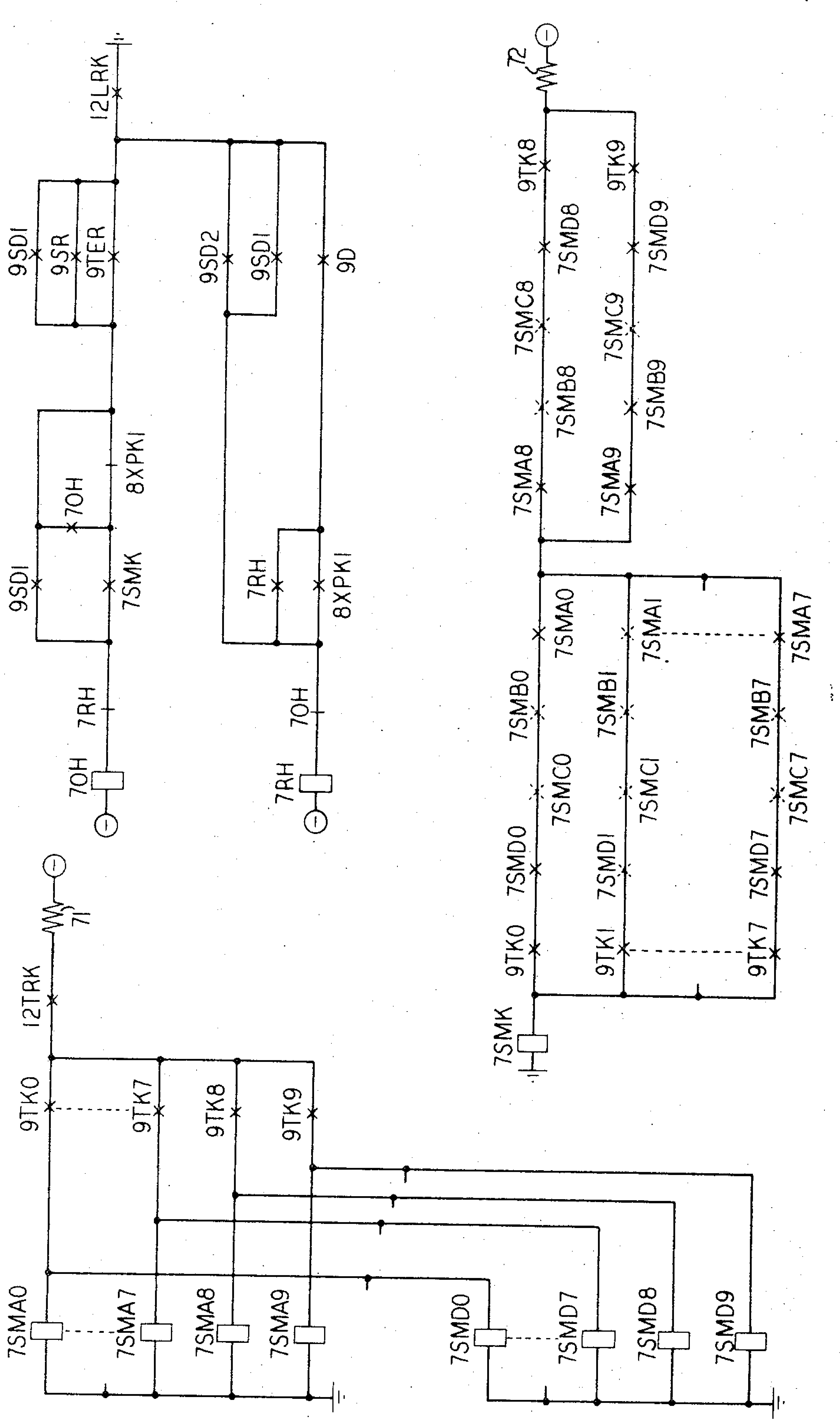

FIG. 7

SYNCHRONIZING CIRCUIT FOR CONCENTRATOR SIGNALING SYSTEM

Filed Feb. 14, 1964

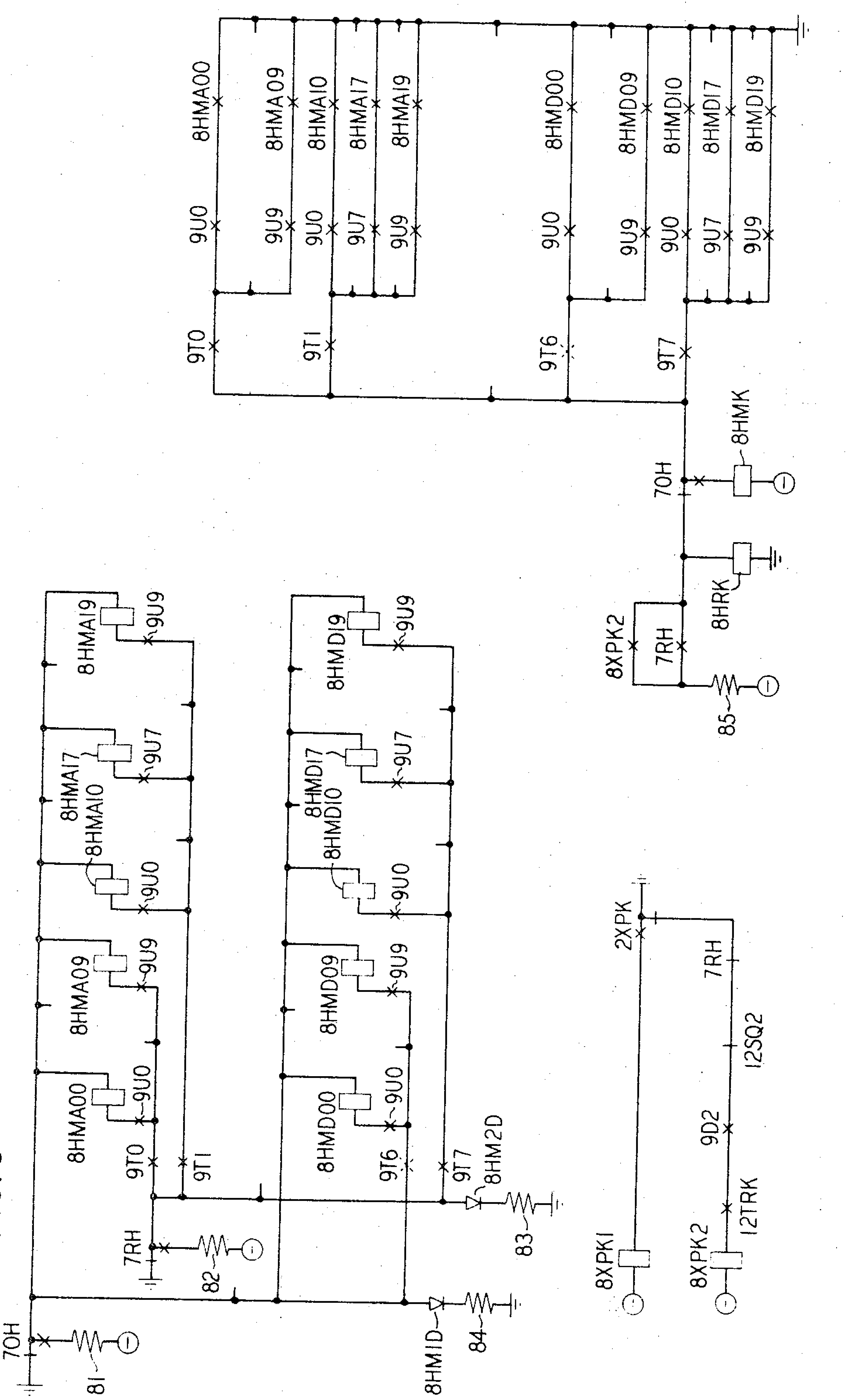

FIG. 8

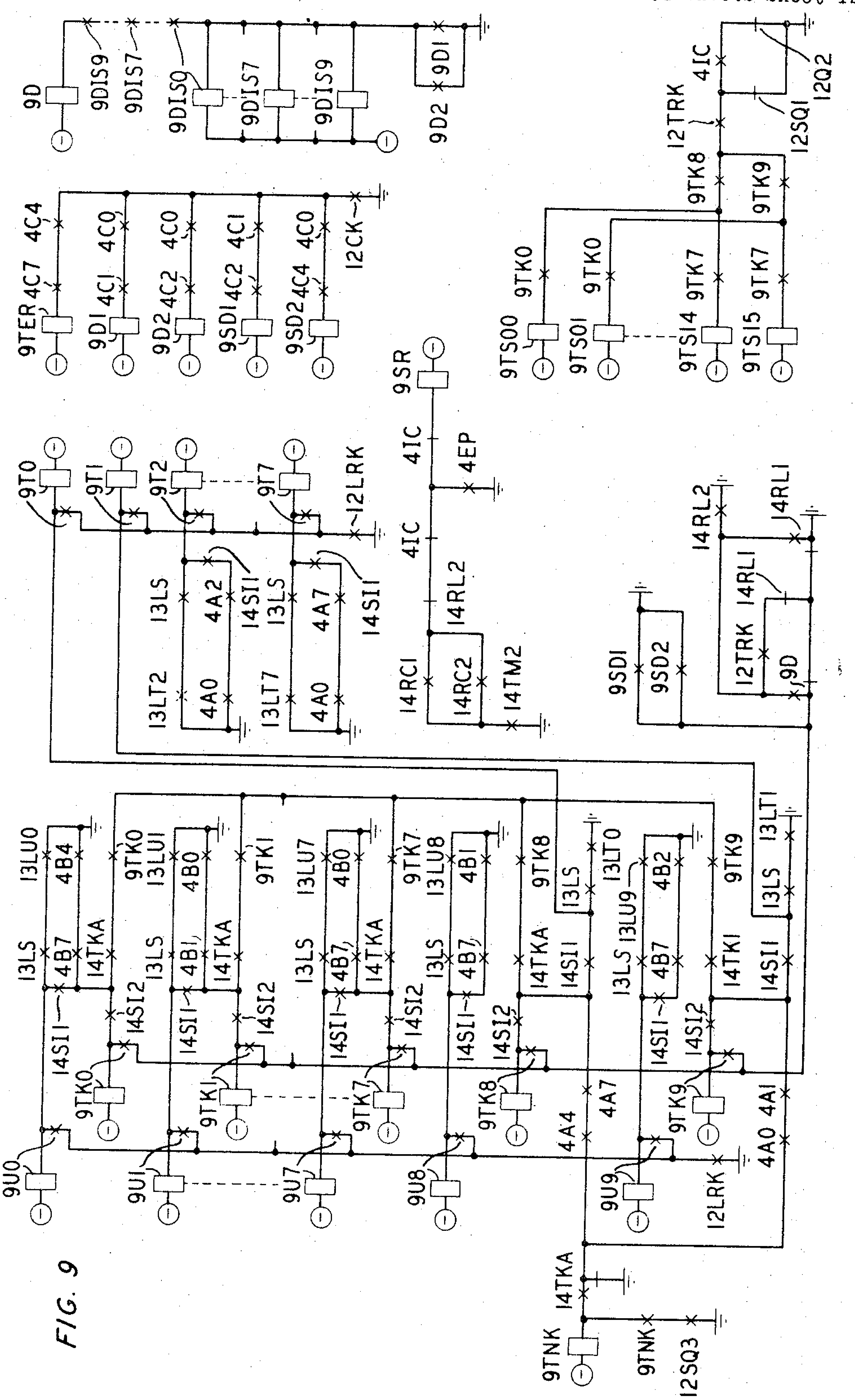

FIG. 9

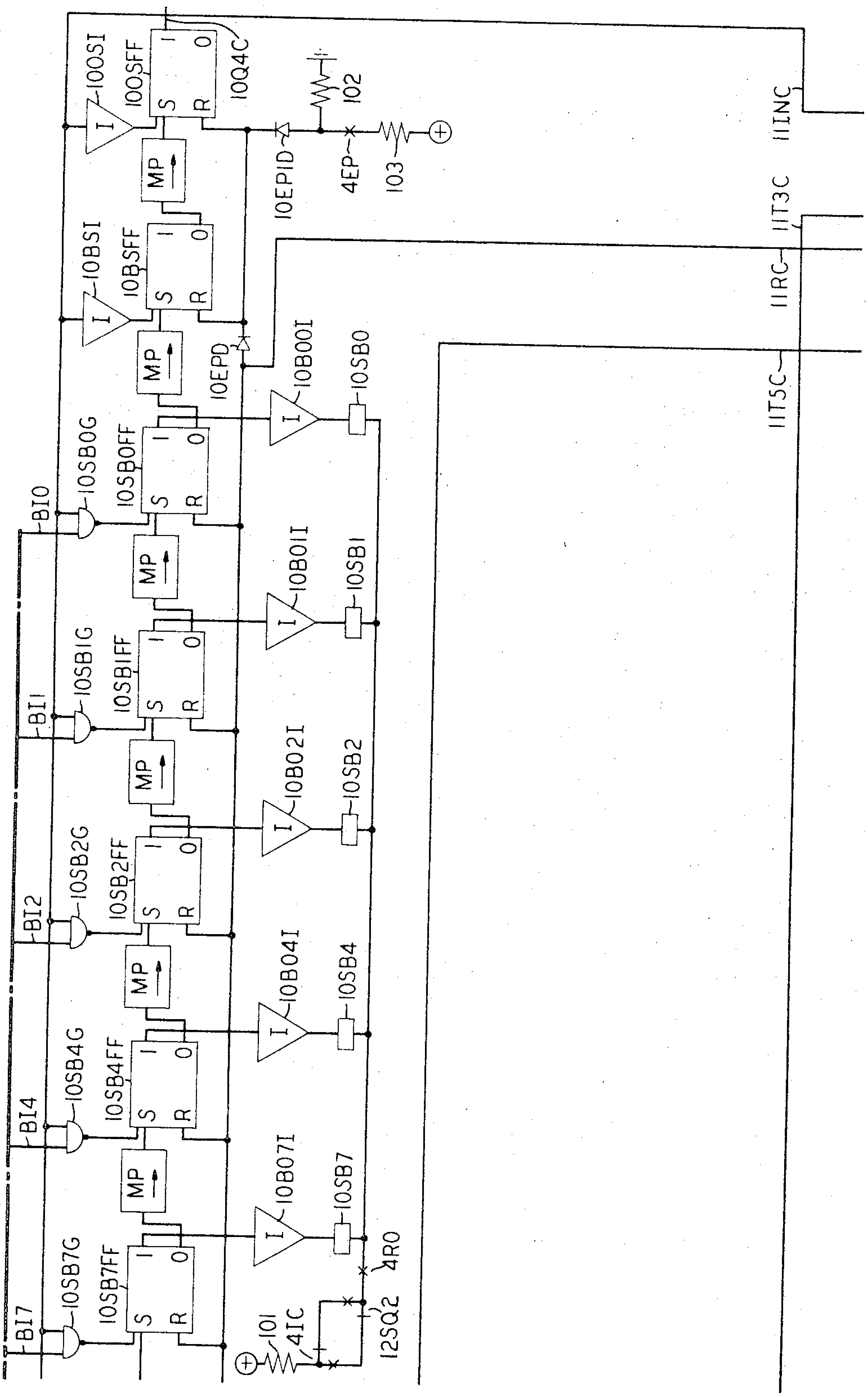
100SI
100SFF
10Q4C
102
10EPID
4EP
103
11NC
11T3C
11RC
11T5C
10BSI
10BSFF
10EPD
10B00I
10SB0
10SB0G
10SB0FF
BI0
10B01I
10SB1
10SB1G
10SB1FF
BI1
10B02I
10SB2
10SB2G
10SB2FF
BI2
10B04I
10SB4
10SB4G
10SB4FF
BI4
10B07I
10SB7
10SB7G
10SB7FF
BI7
4R0
101
4IC
12SQ2
MP
S
R
I
0

FIG. 10

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SYNCHRONIZING CIRCUIT FOR CONCENTRATOR SIGNALING SYSTEM

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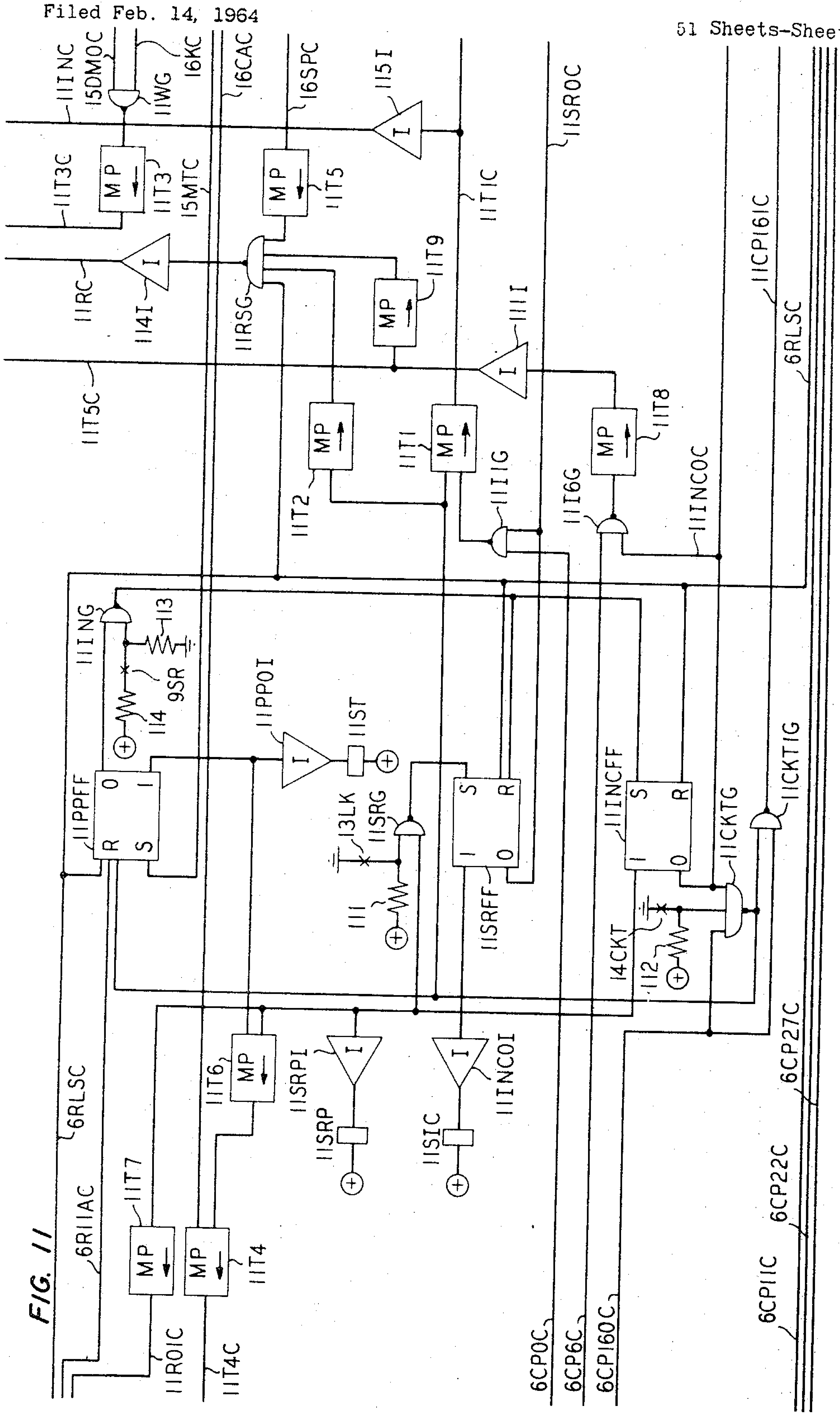

FIG. 11

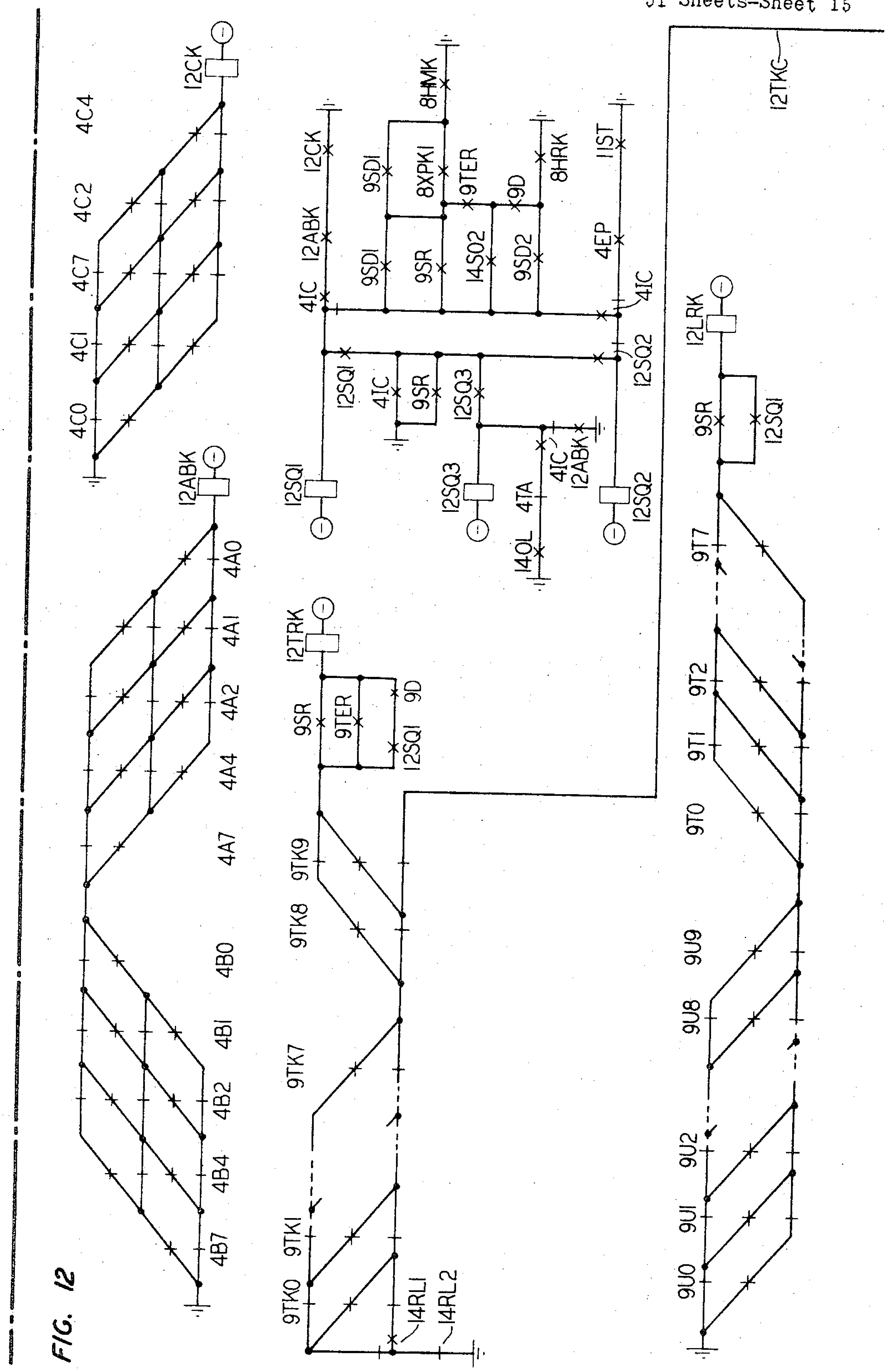
12CK
4C4
4C2
4C7
4C1
4C0
12ABK
4A0
4A1
4A2
4A4
4A7
4B0
4B1
4B2
4B4
4B7
8HMK
9SD1
8XPK1
9TER
9D
8HRK
11ST
4EP
4IC
12ABK
9SR
14SO2
9SD2
12SQ1
12SQ2
12SQ3
4TA
14OL
12TRK
9TK9
9TK8
9TK7
9TK1
9TK0
14RL1
14RL2
12TKG
12LRK
9T7
9T2
9T1
9T0
9U9
9U8
9U2
9U1
9U0

FIG. 12

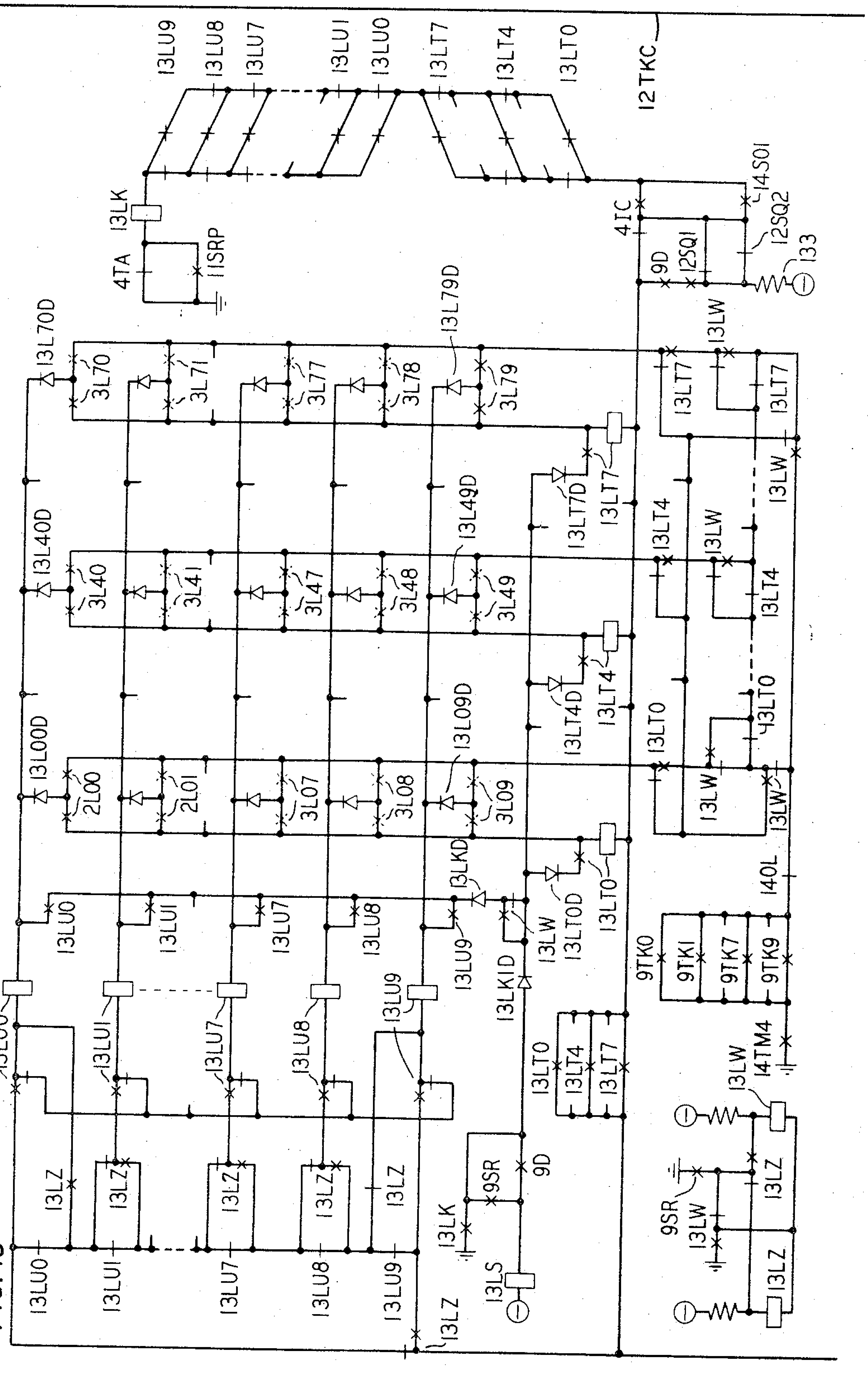

FIG. 13

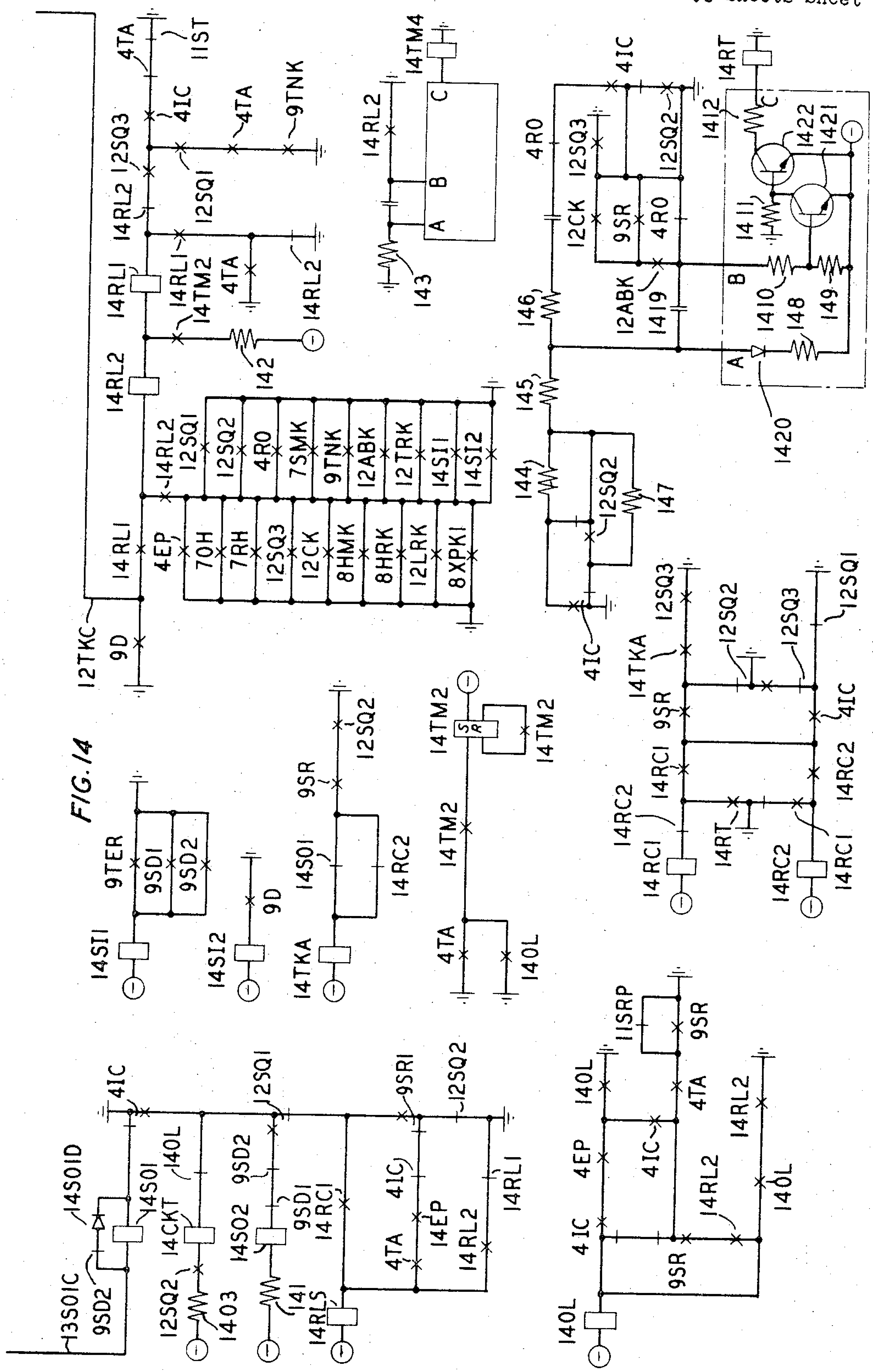

FIG. 14

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SYNCHRONIZING CIRCUIT FOR CONCENTRATOR SIGNALING SYSTEM

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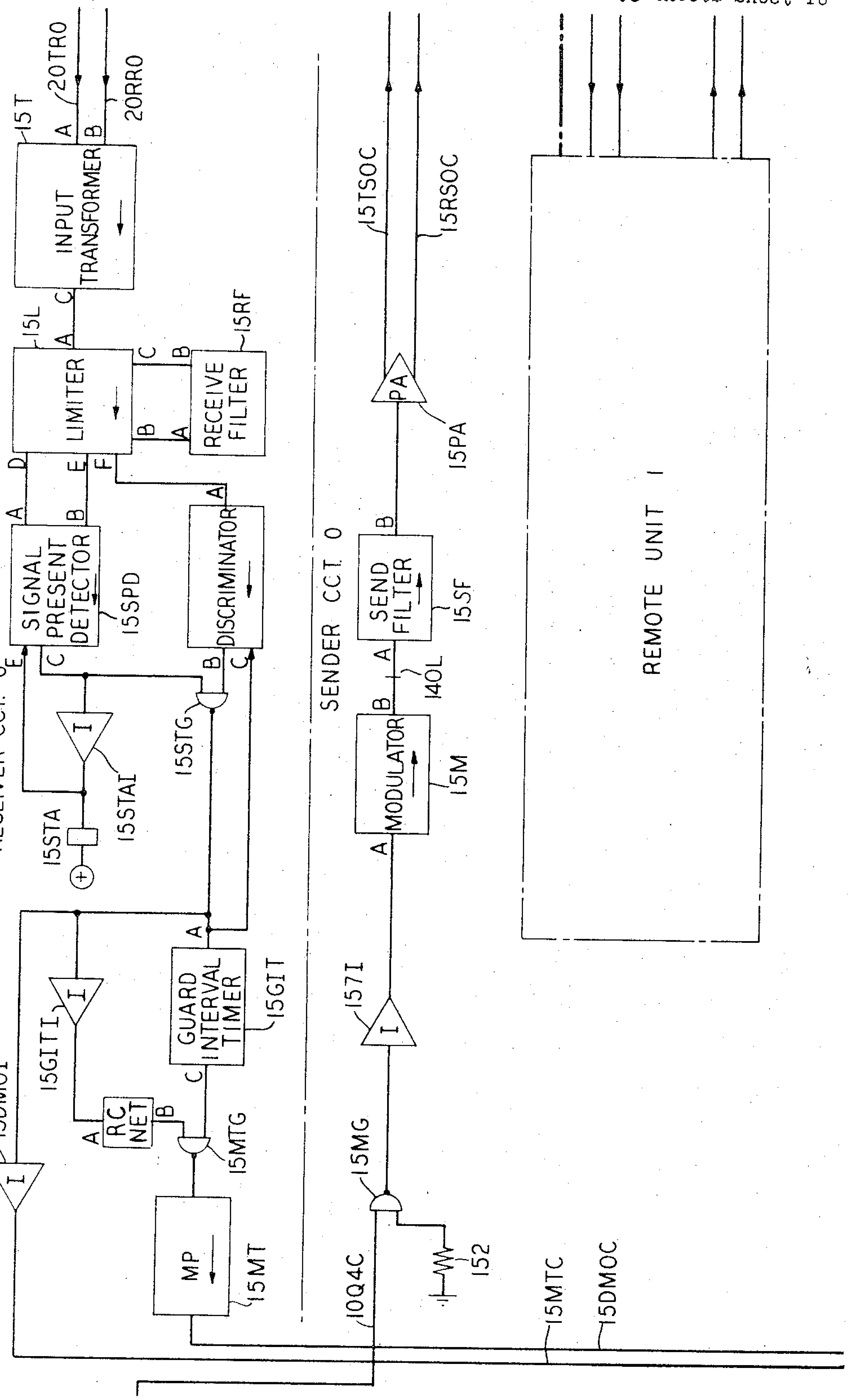

FIG 15

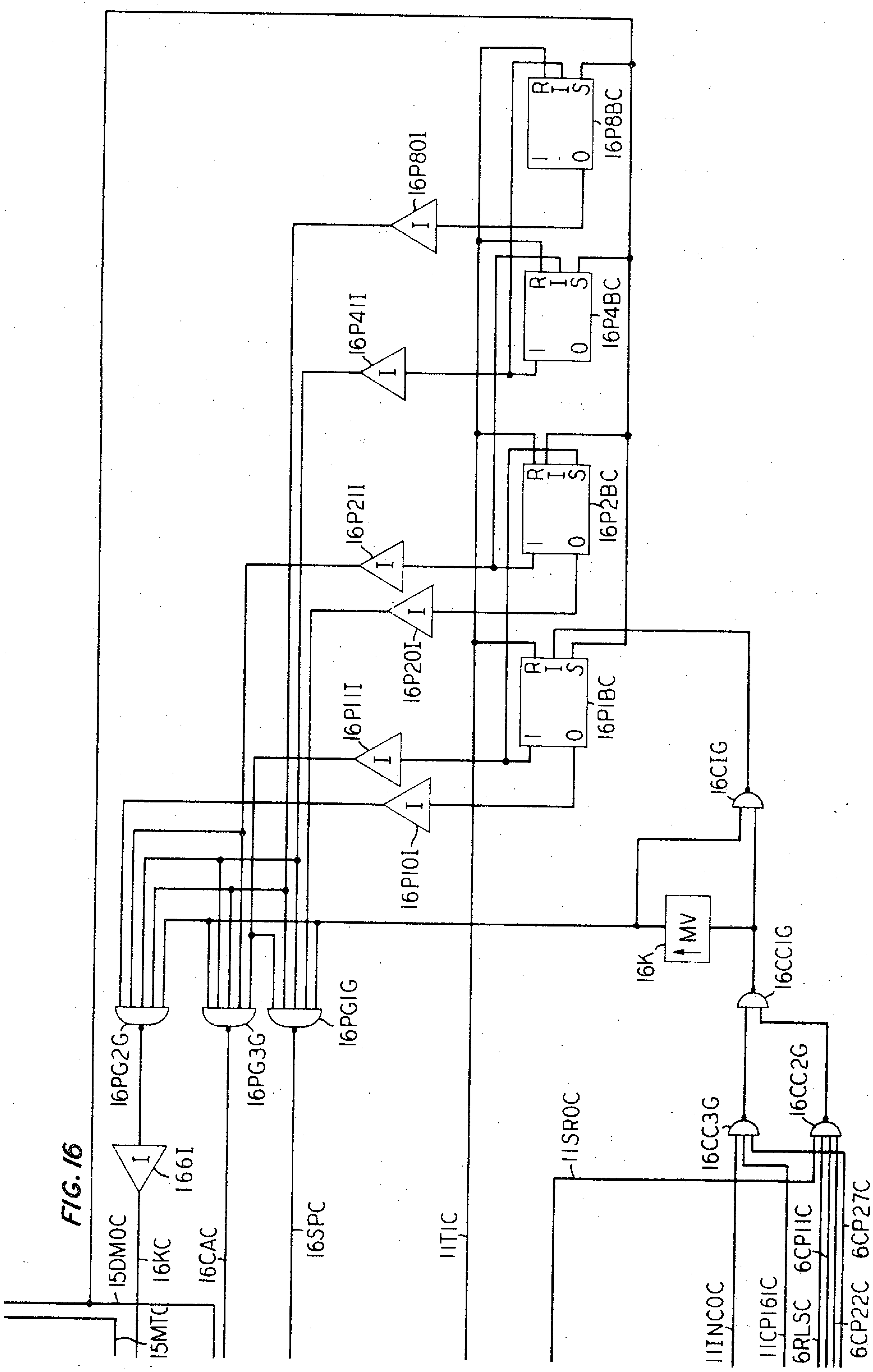
16P8BC
16P8OI
16P4BC
16P4II
16P2BC
16P2II
16P2OI
16P1BC
16P1II
16P1OI
16C1G
16K
MV
16CC1G
16CC2G
16CC3G
16PG1G
16PG2G
16PG3G
166I
15DMOC
15MTC
16KC
16CAC
16SPC
11T1C
11SROC
11INCOC
11CP161C
6RLSC
6CP11C
6CP22C
6CP27C
R
I
S
O

FIG. 16

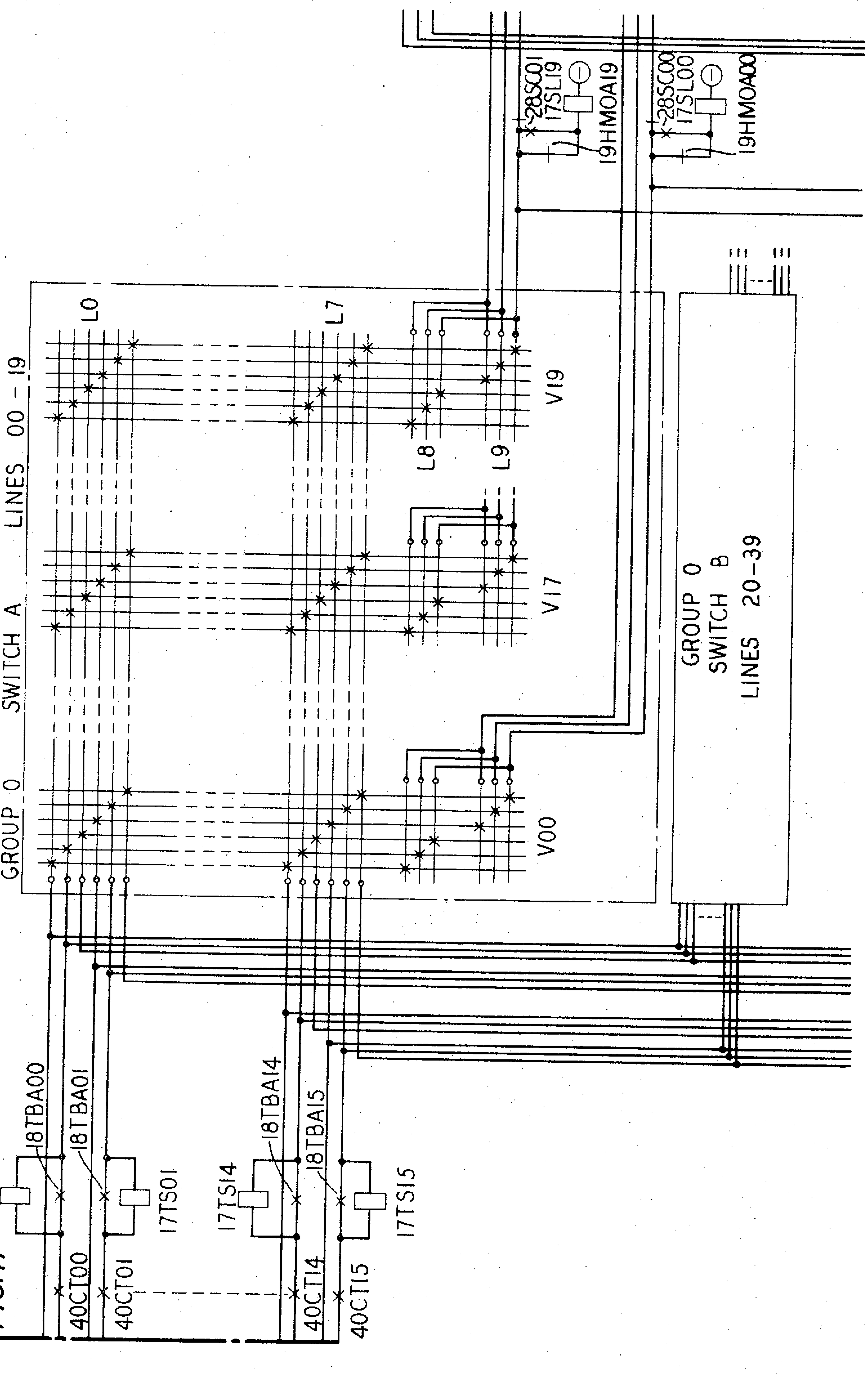
28SC01
17SL19
19HMOA19
28SC00
17SL00
19HMOA00
L0
L7
L8
L9
V19
V17
V00
GROUP 0 SWITCH A LINES 00 - 19
GROUP 0
SWITCH B
LINES 20-39
18TBA00
18TBA01
17TS00
17TS01
18TBA14
18TBA15
17TS14
17TS15
40CT00
40CT01
40CT14
40CT15

FIG. 17

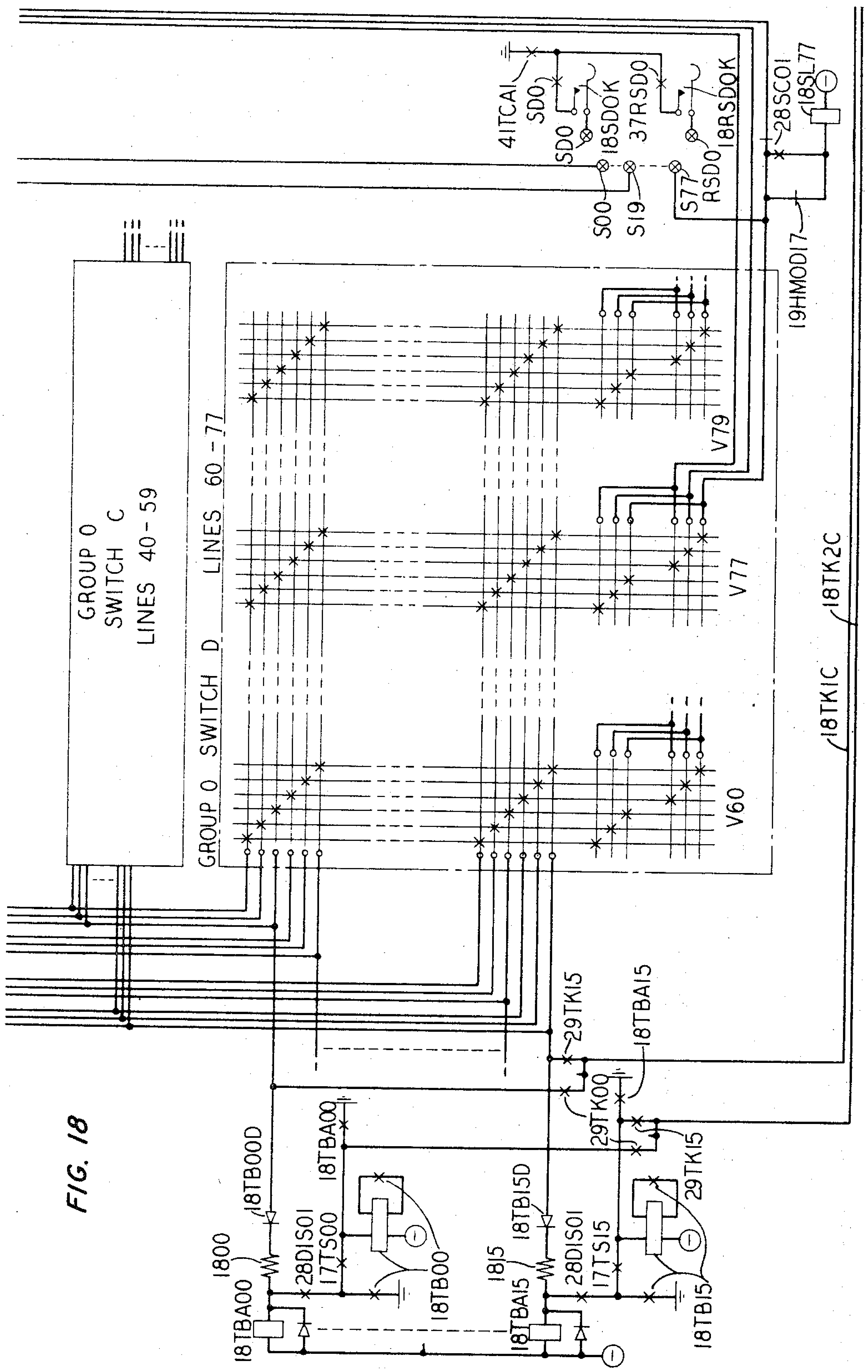
GROUP 0
SWITCH C
LINES 40 - 59
GROUP 0 SWITCH D LINES 60 - 77
V79
V77
V60
41TCA1
SD0
SD0
18SDOK
37RSD0
18RSDOK
RSD0
S00
S19
S77
28SC01
18SL77
19HMOD17
18TK2C
18TK1C
29TK15
18TBA15
29TK00
29TK15
18TBA00
18TB00D
1800
18TBA00
28DIS01
17TS00
18TB00
18TB15D
1815
18TBA15
28DIS01
17TS15
18TB15

FIG. 18

SYNCHRONIZING CIRCUIT FOR CONCENTRATOR SIGNALING SYSTEM

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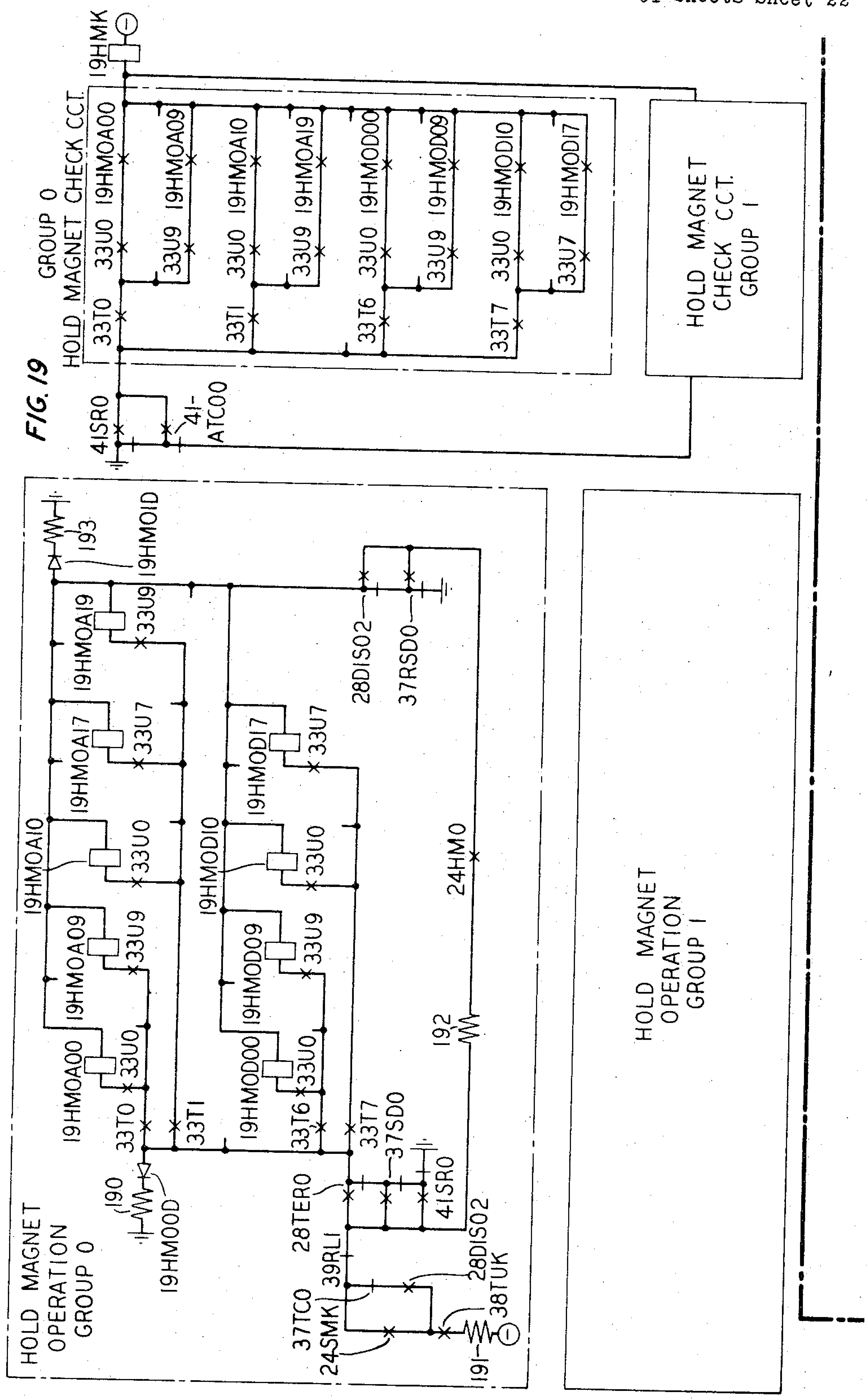


FIG. 19

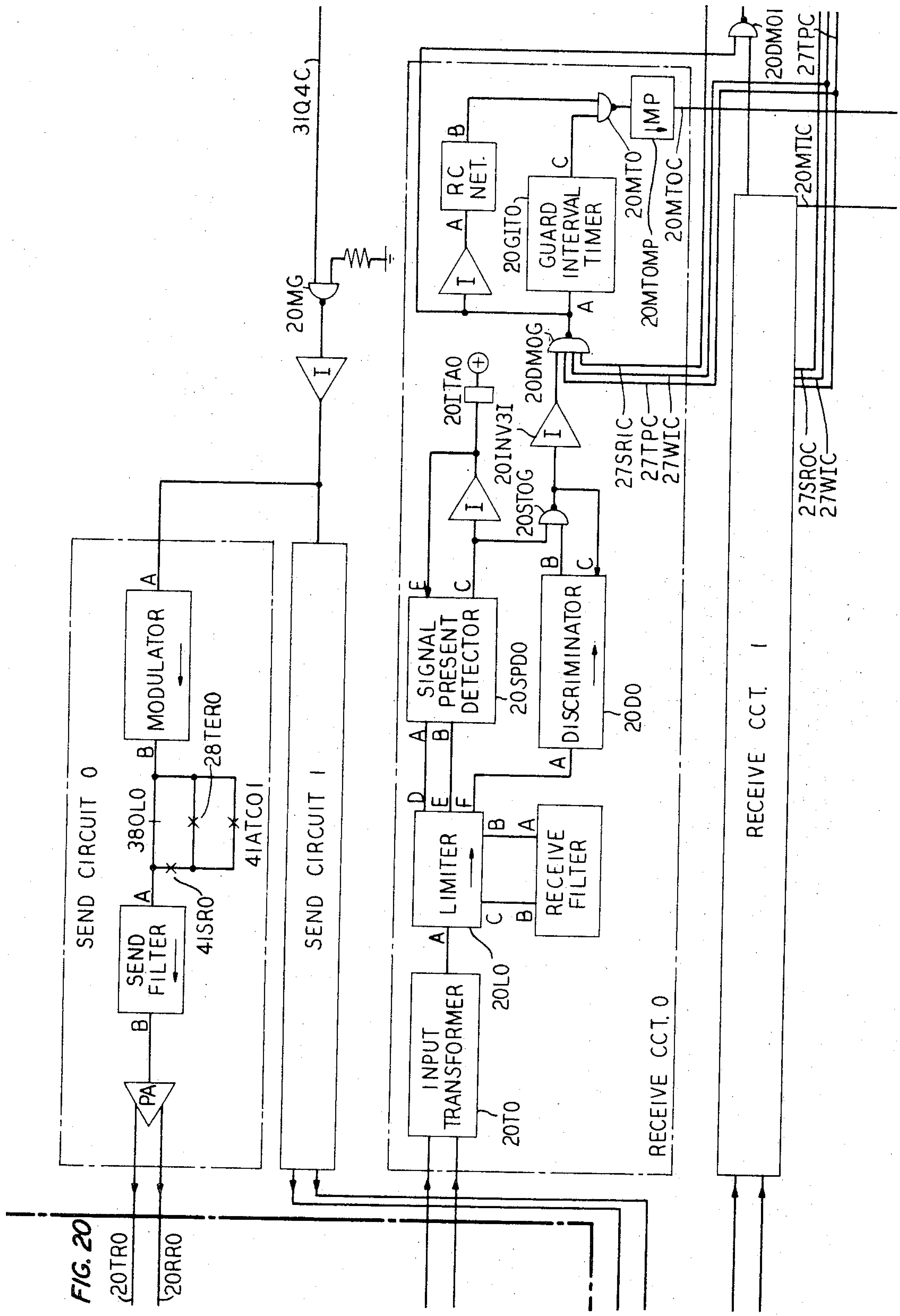

SEND CIRCUIT 0
SEND FILTER
MODULATOR
PA
SEND CIRCUIT 1
INPUT TRANSFORMER
LIMITER
RECEIVE FILTER
SIGNAL PRESENT DETECTOR
DISCRIMINATOR
GUARD INTERVAL TIMER
RC NET.
IMP
RECEIVE CCT. 0
RECEIVE CCT. 1
20TRO
20RRO
38OLO
28TERO
41SRO
41ATCO1
31Q4C
20MG
20TO
20LO
20SPDO
20DO
20STOG
20INV31
20ITAO
20DMOG
20GITO
20MTOMP
20MTO
20MTOC
20DMOI
27TPC
20MTIC
27SRIC
27WIC
27SROC

FIG. 20

SYNCHRONIZING CIRCUIT FOR CONCENTRATOR SIGNALING SYSTEM

Filed Feb. 14, 1964

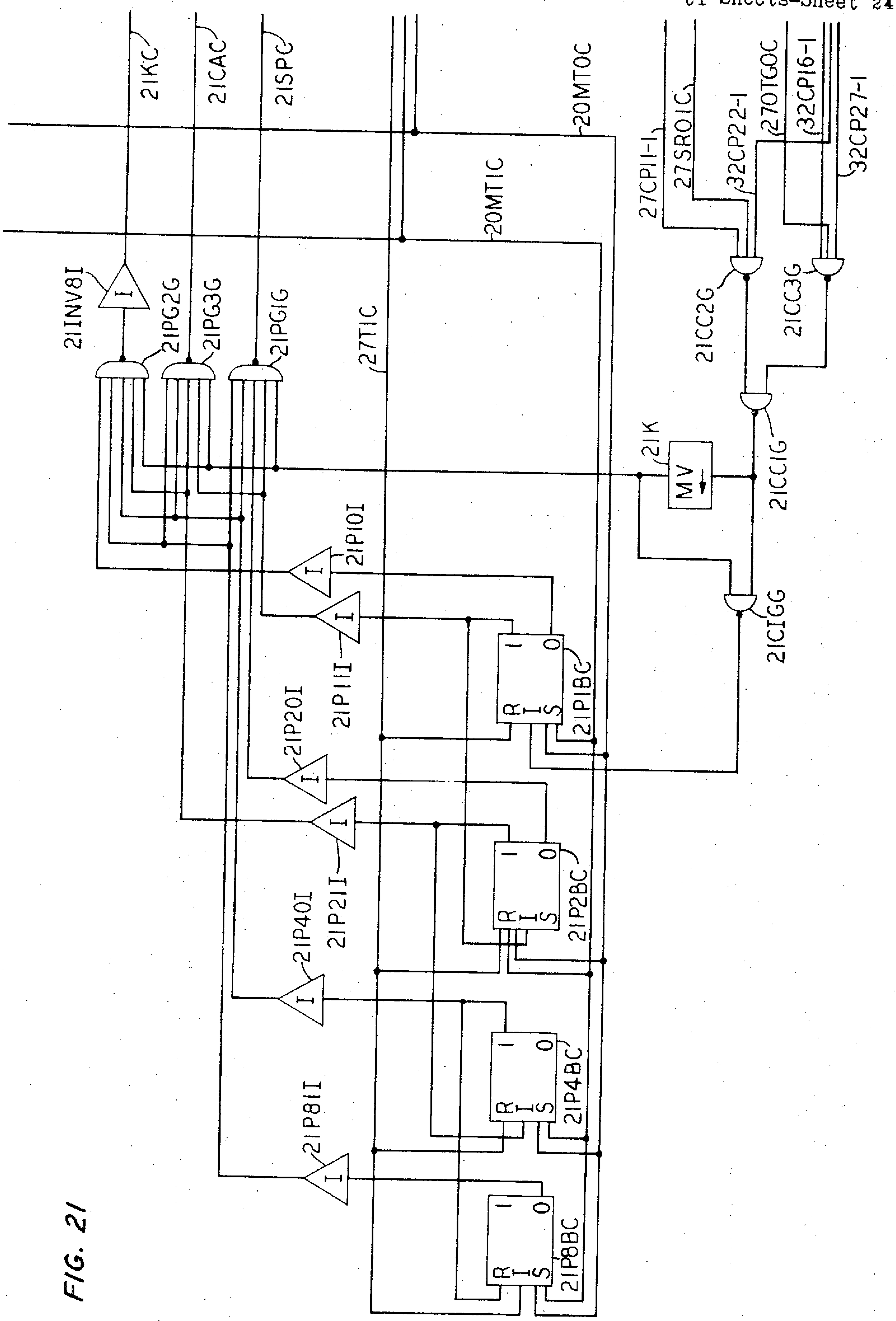
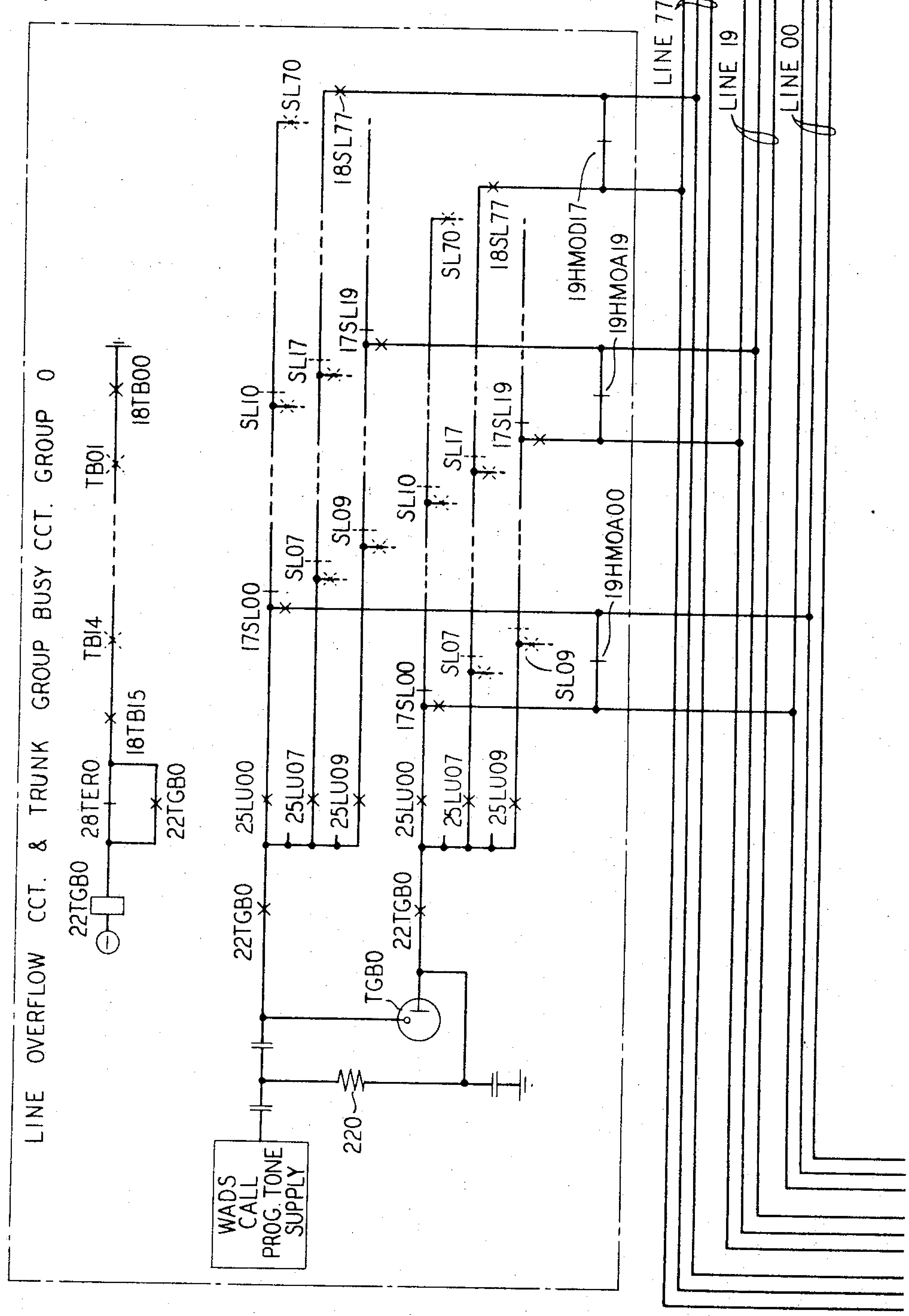


FIG. 21

SYNCHRONIZING CIRCUIT FOR CONCENTRATOR SIGNALING SYSTEM

Filed Feb. 14, 1964

FIG. 22



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SYNCHRONIZING CIRCUIT FOR CONCENTRATOR SIGNALING SYSTEM

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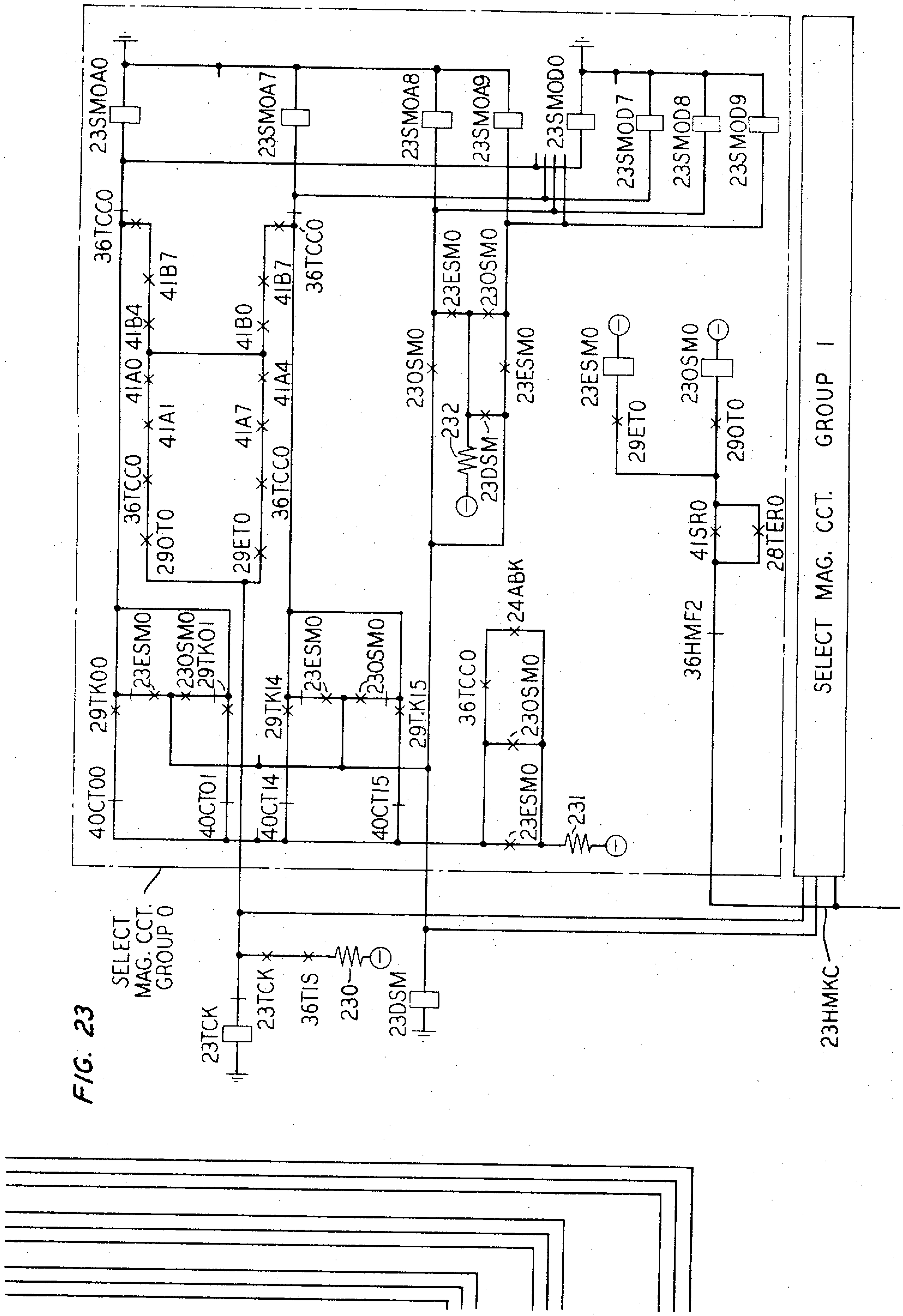

FIG. 23

Nov. 21, 1967 J. F. RETTIG ETAL 3,354,268

SYNCHRONIZING CIRCUIT FOR CONCENTRATOR SIGNALING SYSTEM

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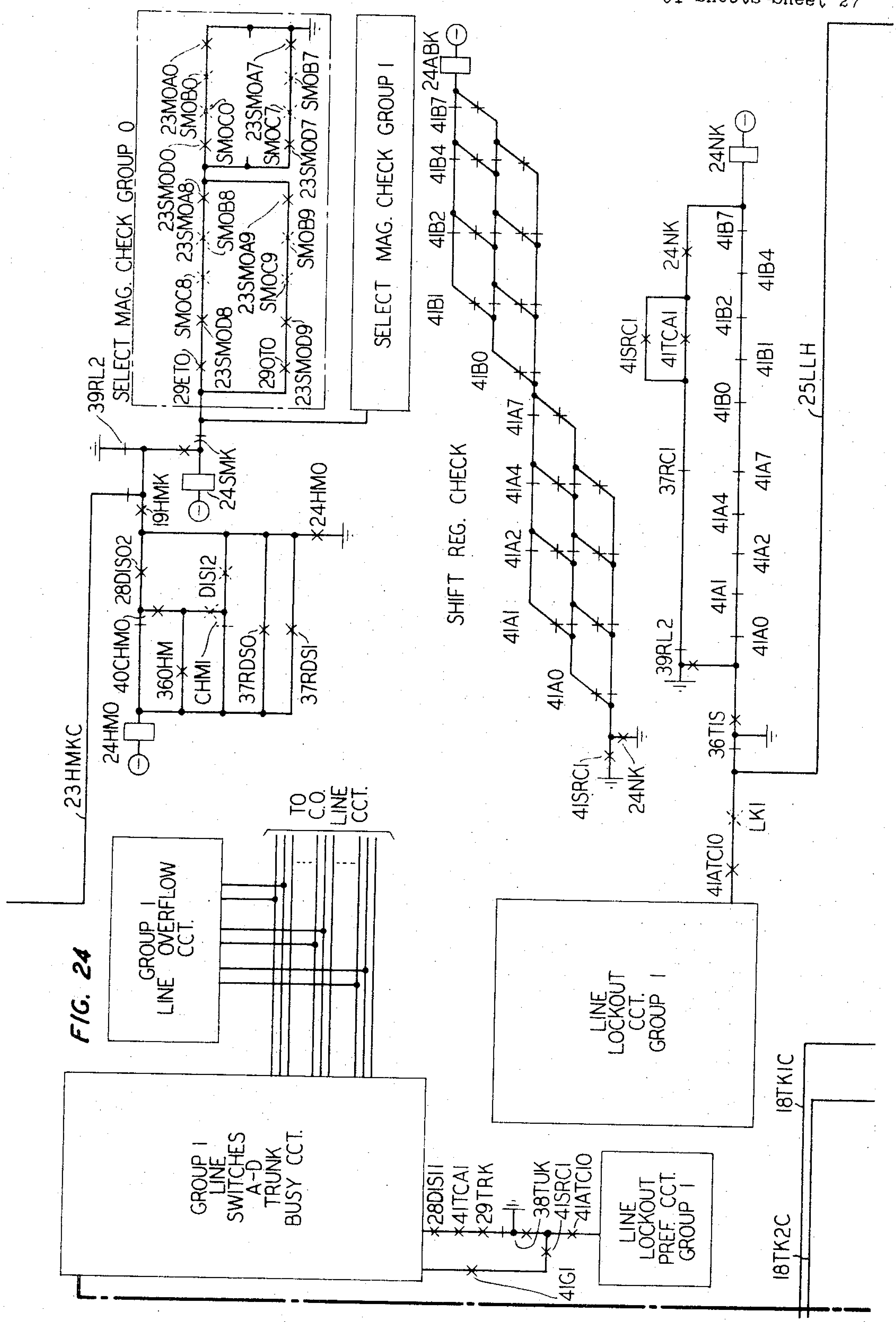

FIG. 24

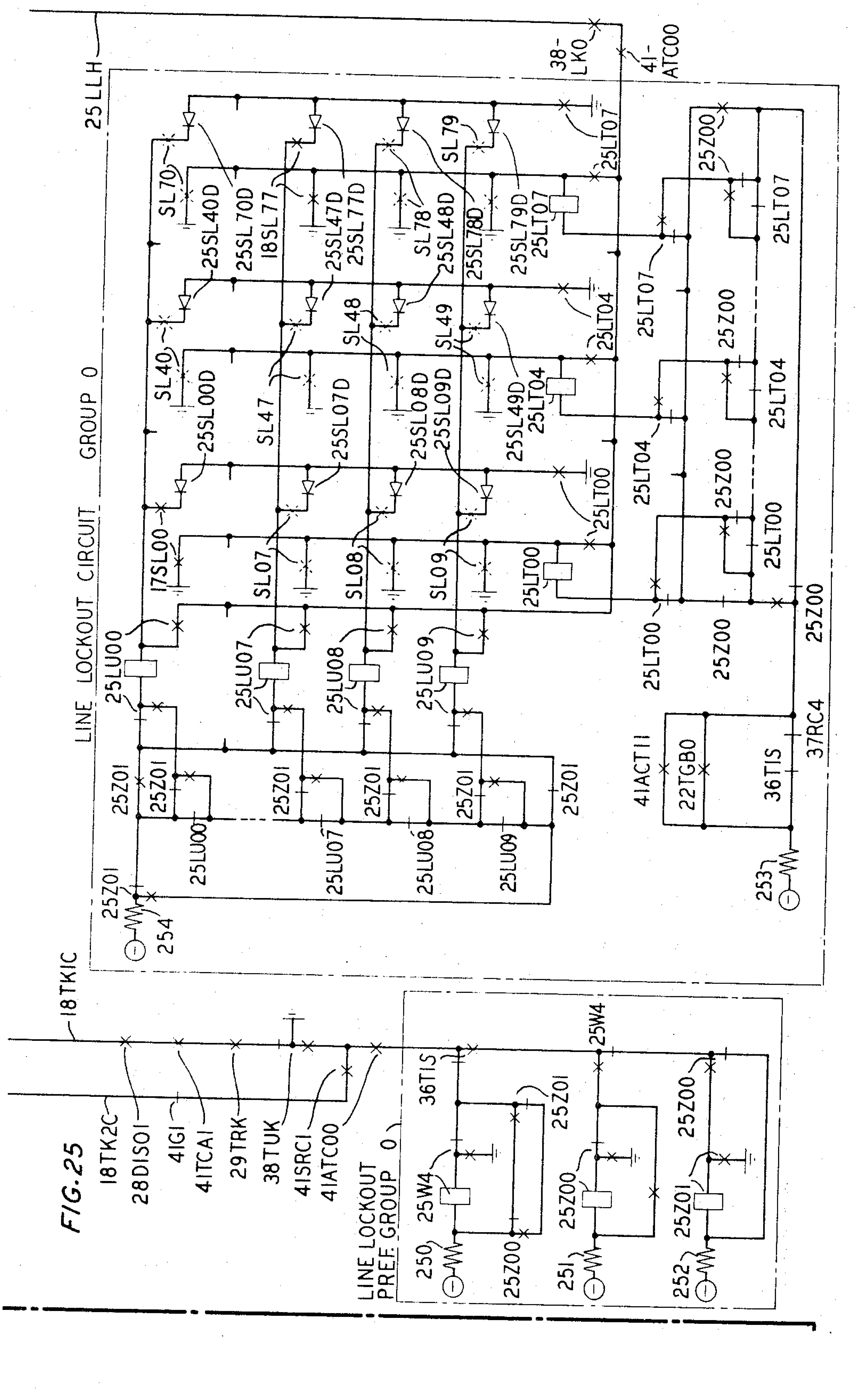
25LLH
38-LKO
41-ATC00
LINE LOCKOUT CIRCUIT GROUP 0
25LT07
25LT04
25LT00
25Z00
25Z01
25LU00
25LU07
25LU08
25LU09
37RC4
36TIS
22TGB0
41ACT11
253
254
18TK1C
18TK2C
28DIS01
41G1
41TCA1
29TRK
38TUK
41SRC1
41ATC00
LINE LOCKOUT PREF. GROUP 0
25W4
250
251
252

FIG. 25

SYNCHRONIZING CIRCUIT FOR CONCENTRATOR SIGNALING SYSTEM

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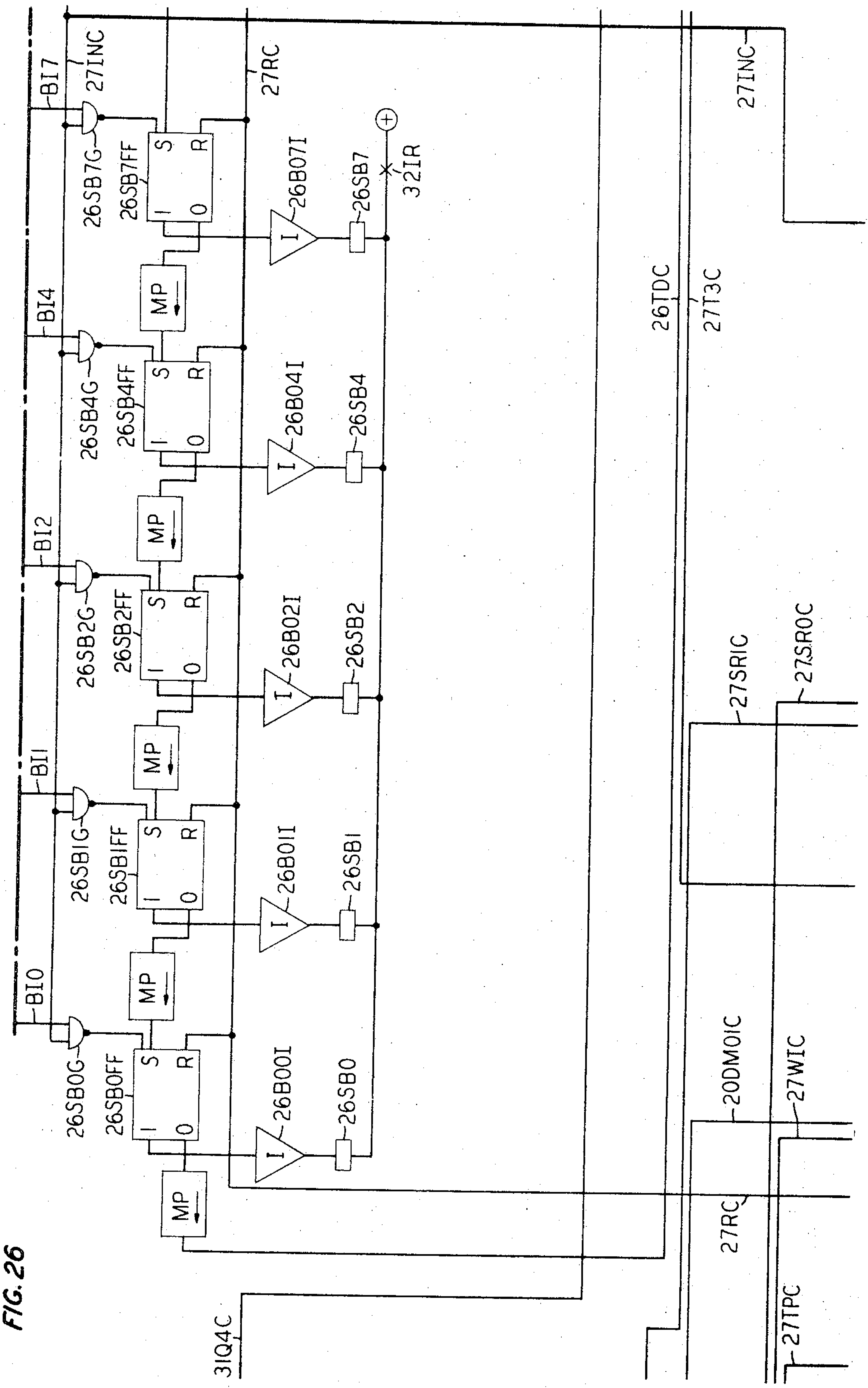


FIG. 26

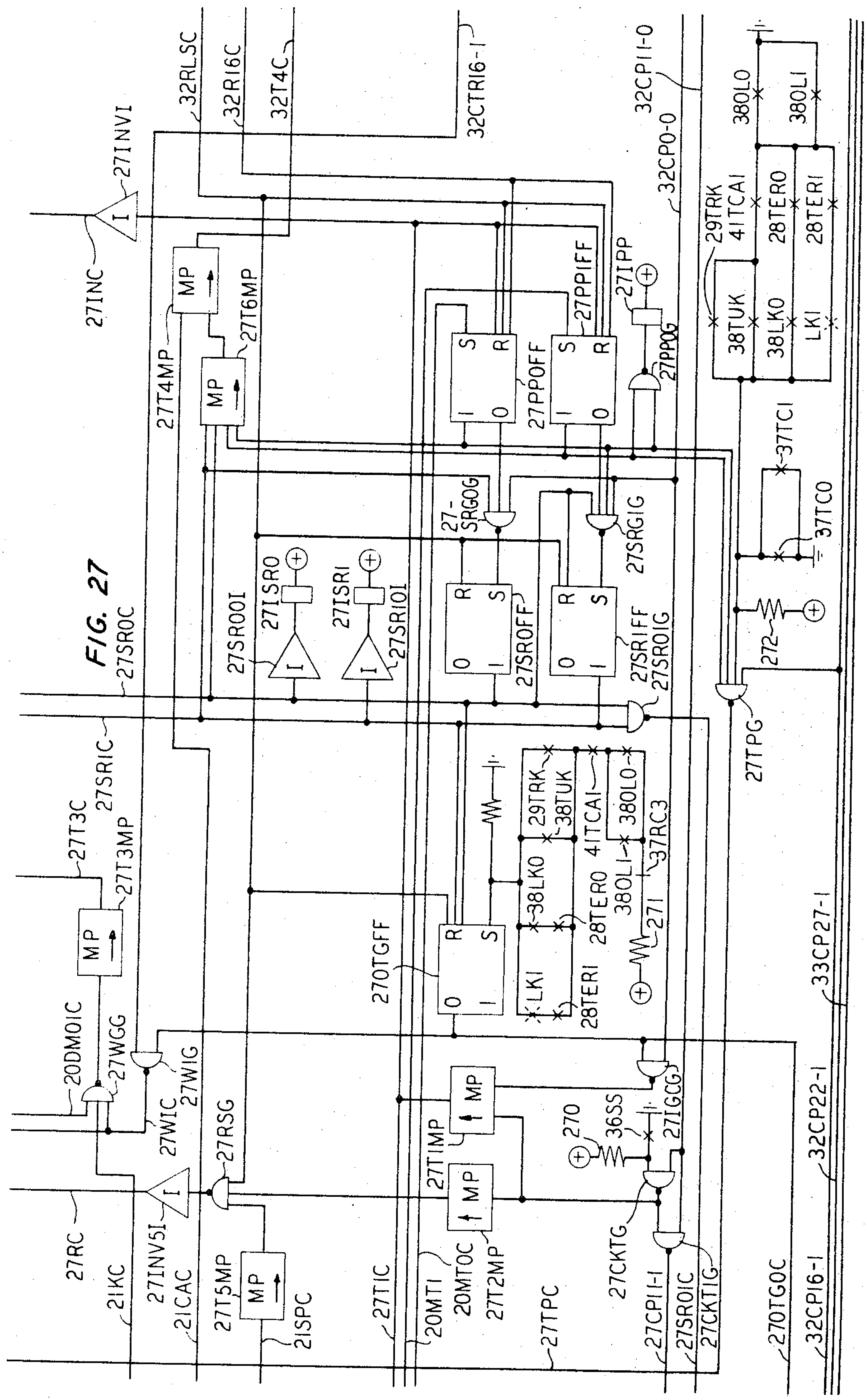
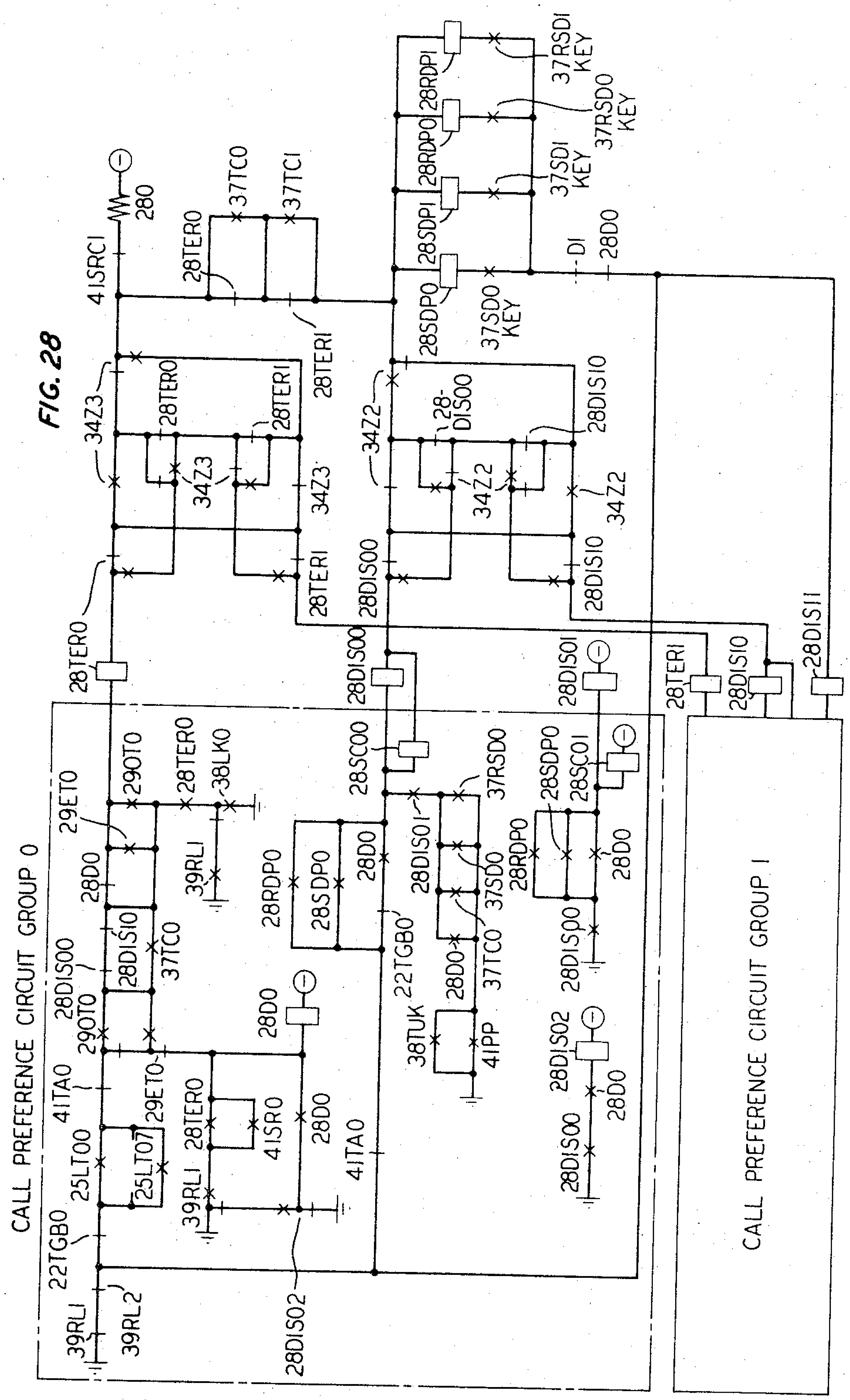

27INVI
32RLSC
32RI6C
32T4C
32CTRI6-I
32CPII-0
32CP0-0
380LO
380LI
29TRK
4ITCAI
28TERO
28TERI
38TUK
38LKO
LKI
27INC
27T4MP
27T6MP
MP
27PPOFF
27PPIFF
27IPP
27PPOG
37TCI
37TCO
27-SRGOG
27SRGIG
27ISRO
27ISRI
27SROOI
27SRIOI
27SROFF
27SRIFF
27SROIG
27SROC
272
27TPG
27SRIC
27T3C
27T3MP
270TGFF
37RC3
271
33CP27-I
20DMOIC
27WGG
27WIG
27WIC
27RSG
27TIMP
270
36SS
27IGCG
32CP22-I
27RC
21KC
27INV5I
21CAC
27T5MP
21SPC
27TIC
20MTI
20MTOC
27T2MP
27TPC
27CKTG
27CPII-I
27SROIC
27CKTIG
270TGOC
32CPI6-I

FIG. 27

FIG. 28


CALL PREFERENCE CIRCUIT GROUP 0
CALL PREFERENCE CIRCUIT GROUP 1

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SYNCHRONIZING CIRCUIT FOR CONCENTRATOR SIGNALING SYSTEM

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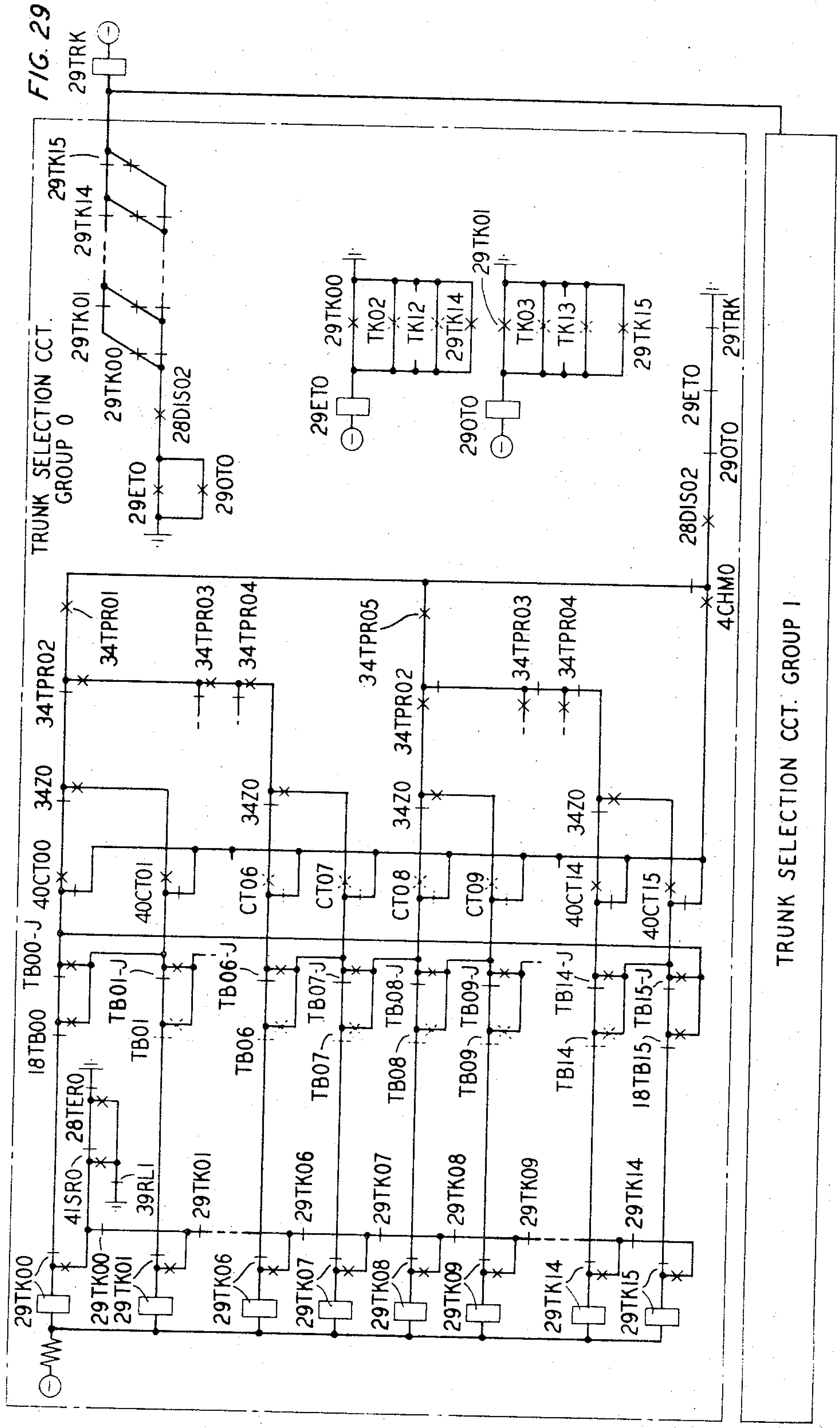
FIG. 29



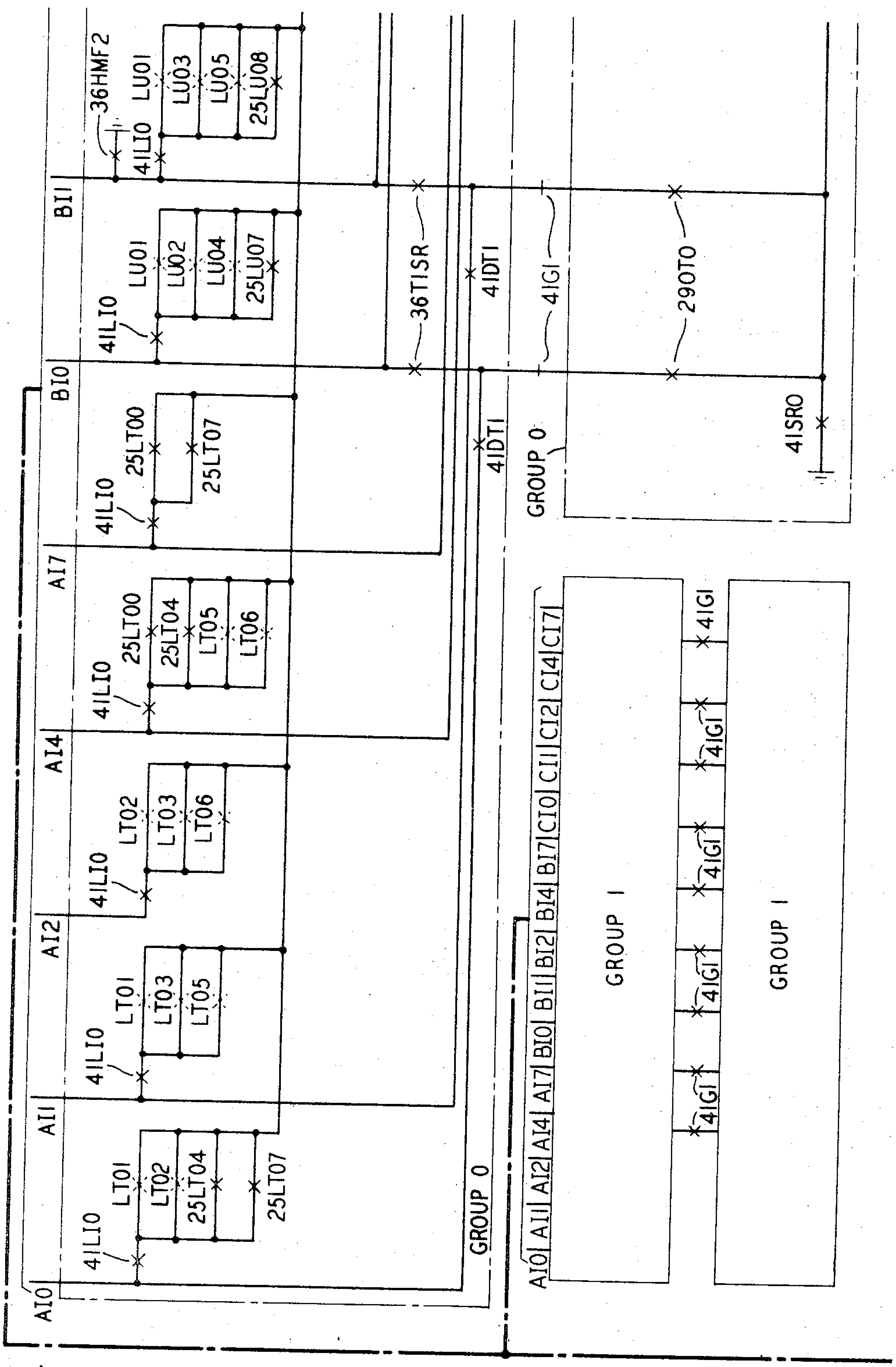

36HMF2
41LI0
LU01
LU03
LU05
25LU08
B11
LU02
LU04
25LU07
36T1SR
41DT1
41G1
29OTO
B10
25LT00
25LT07
GROUP 0
41SR0
A17
25LT04
LT05
LT06
A14
LT02
LT03
A12
LT01
A11
25LT07
A10
A10 A11 A12 A14 A17 B10 B11 B12 B14 B17 C10 C11 C12 C14 C17
GROUP 1

FIG. 30

SYNCHRONIZING CIRCUIT FOR CONCENTRATOR SIGNALING SYSTEM

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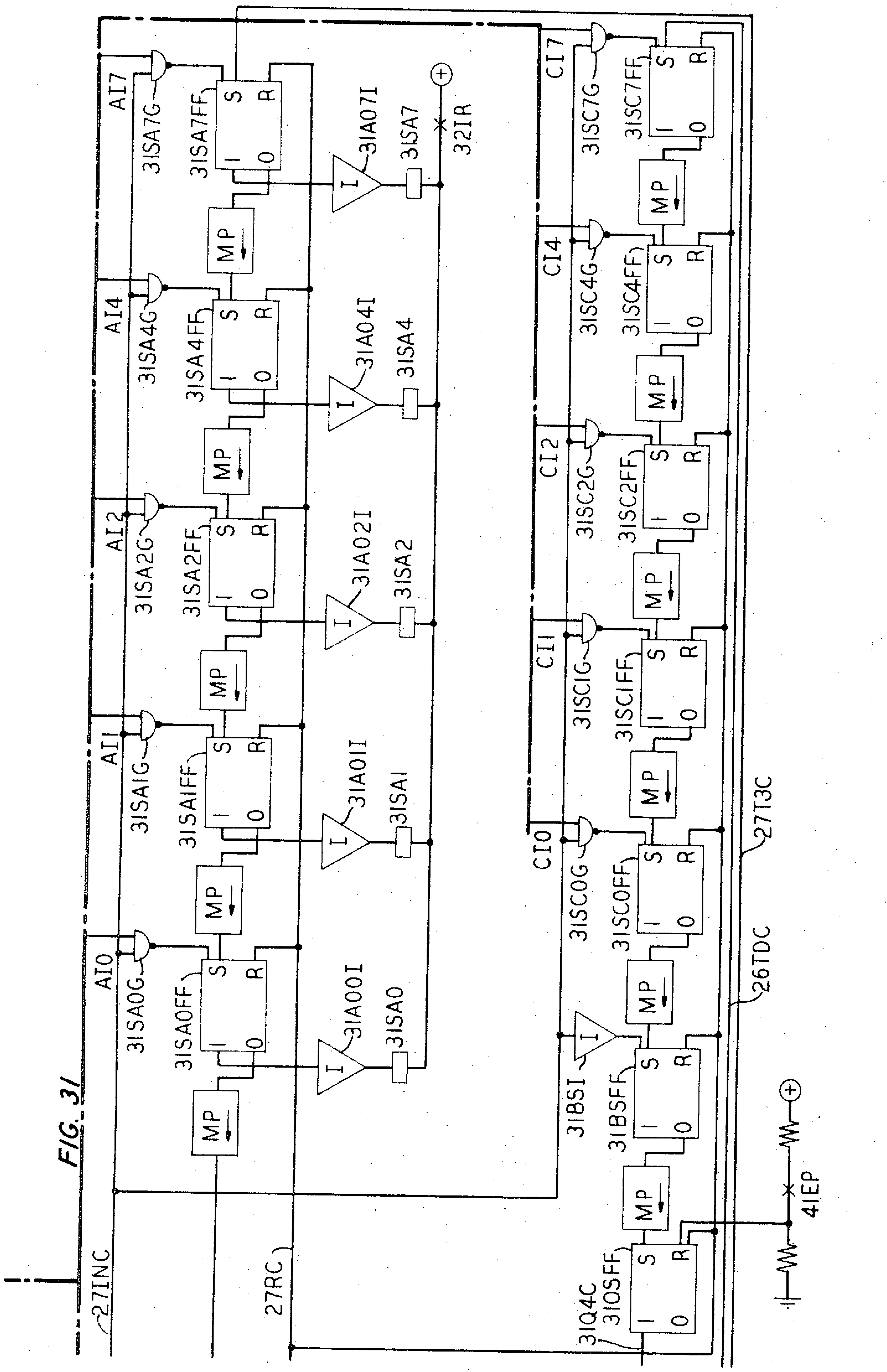
FIG. 31



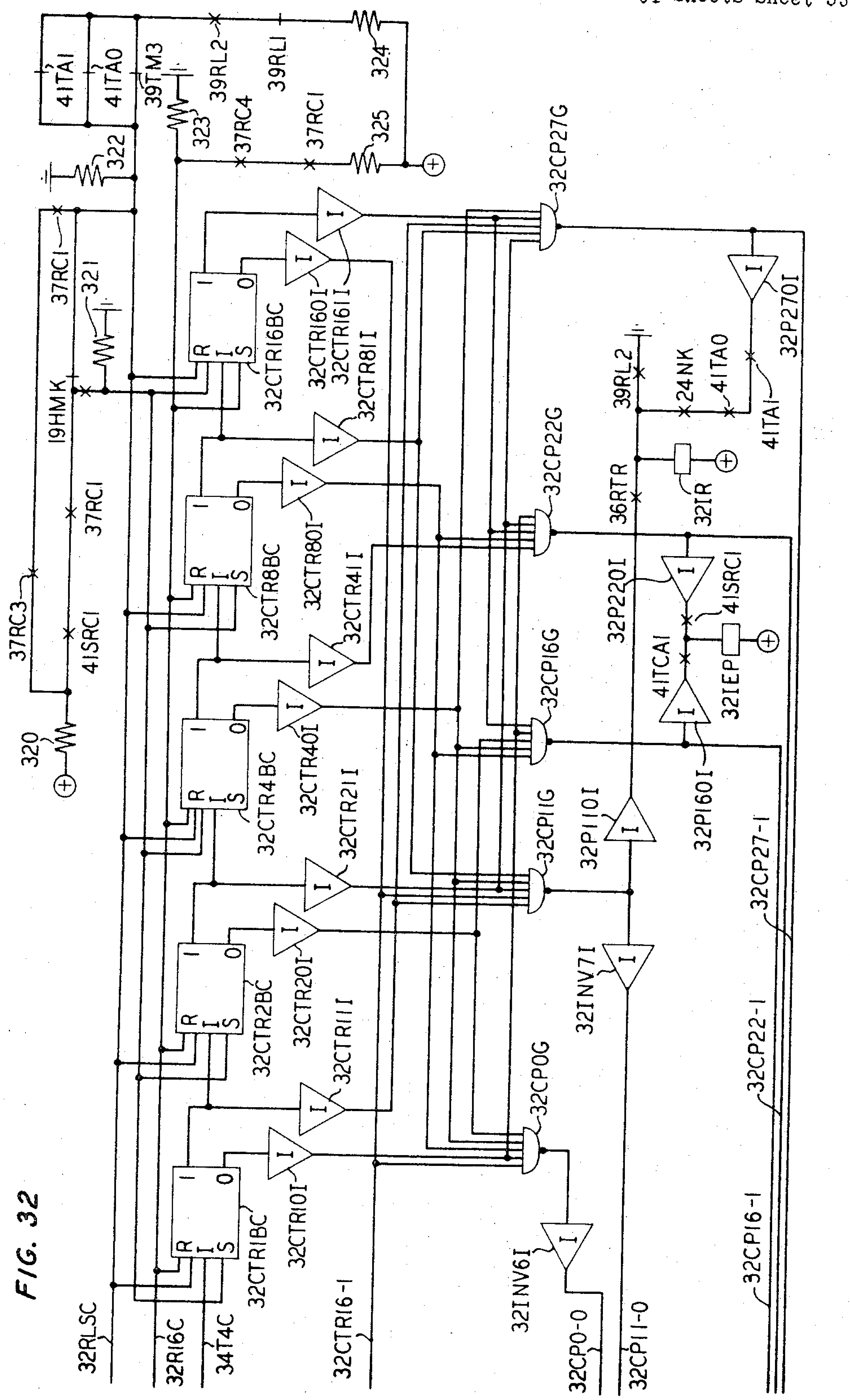

41ITA1
41ITA0
39TM3
39RL2
39RL1
323
324
325
37RC4
37RC1
322
321
37RC1
19HMK
37RC1
37RC3
41SRC1
320
32CP27G
32CTR16BC
32CTR160I
32CTR161I
32CTR81I
32P270I
39RL2
24NK
41ITA0
41ITA1
36RTR
32IR
32CP22G
32CTR8BC
32CTR80I
32CTR41I
32P220I
41SRC1
41TCA1
32IEP
32CP16G
32CTR4BC
32CTR40I
32CTR21I
32P160I
32CP11G
32P110I
32CP27-1
32CTR2BC
32CTR20I
32CTR11I
32INV7I
32CP22-1
32CTR1BC
32CTR10I
32CP0G
32INV6I
32CP16-1
32RLSC
32RI6C
34T4C
32CTR16-1
32CP0-0
32CP11-0

FIG. 32

SYNCHRONIZING CIRCUIT FOR CONCENTRATOR SIGNALING SYSTEM

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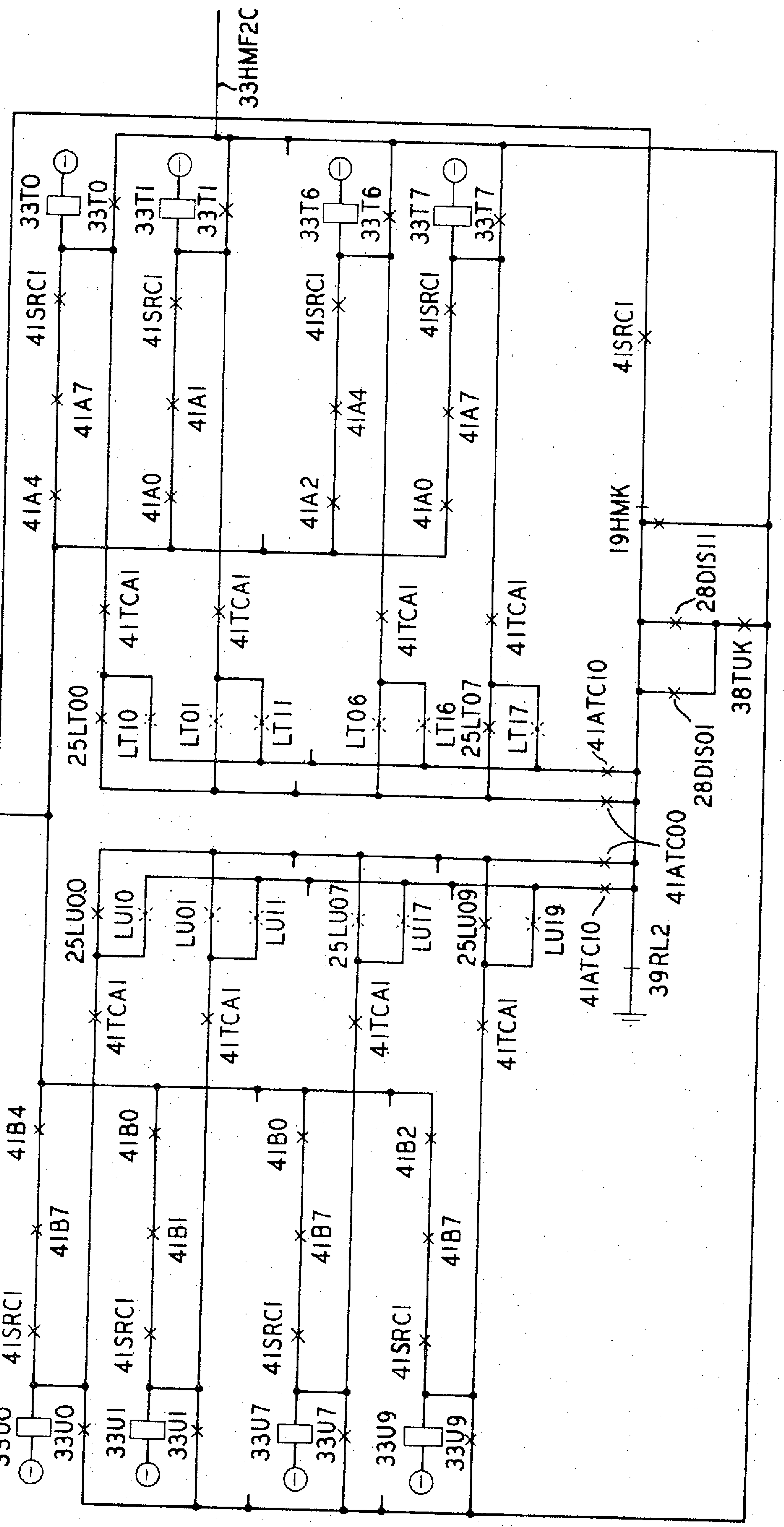

FIG.33
REGISTER CCT.

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SYNCHRONIZING CIRCUIT FOR CONCENTRATOR SIGNALING SYSTEM

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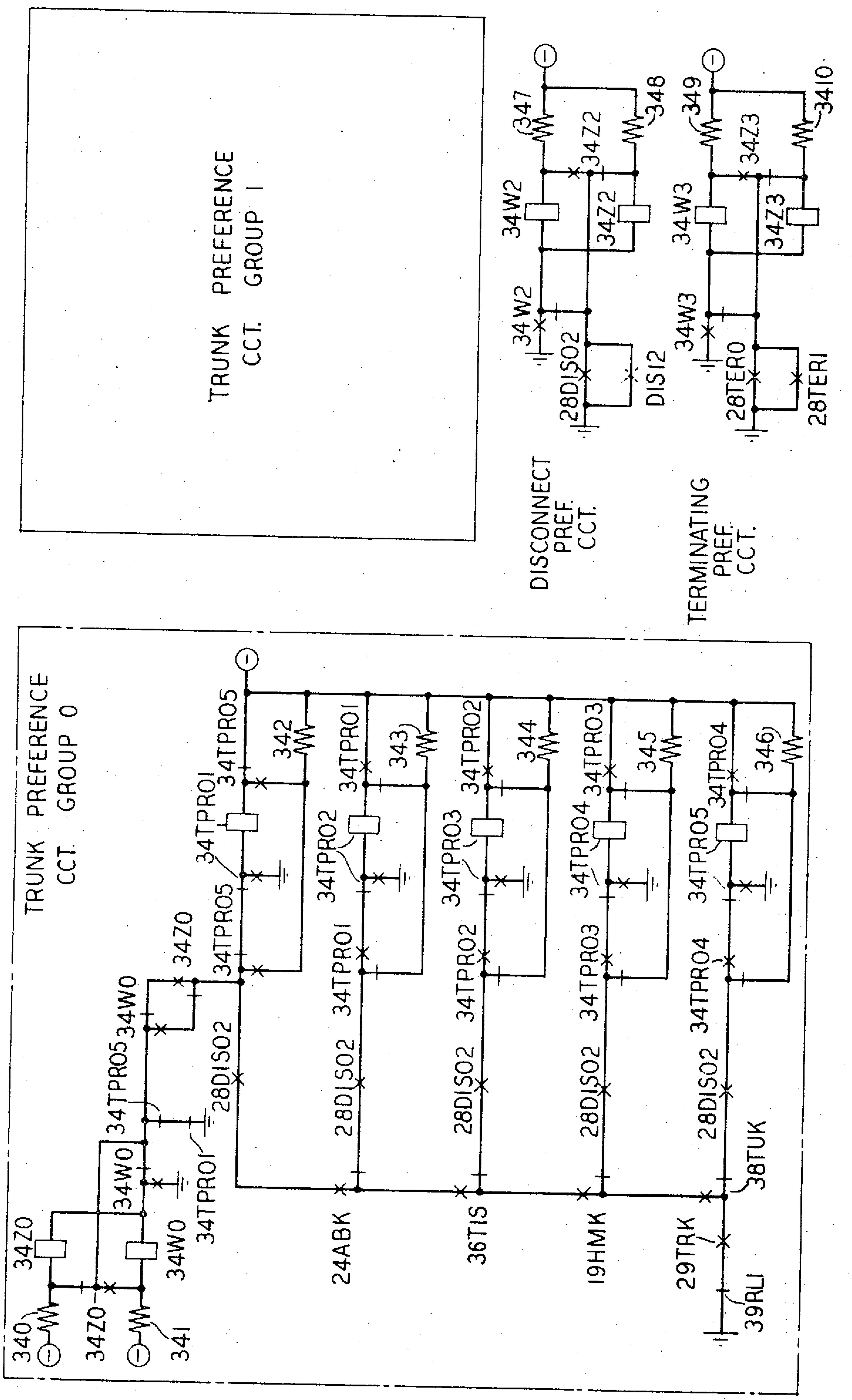

FIG. 34

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SYNCHRONIZING CIRCUIT FOR CONCENTRATOR SIGNALING SYSTEM

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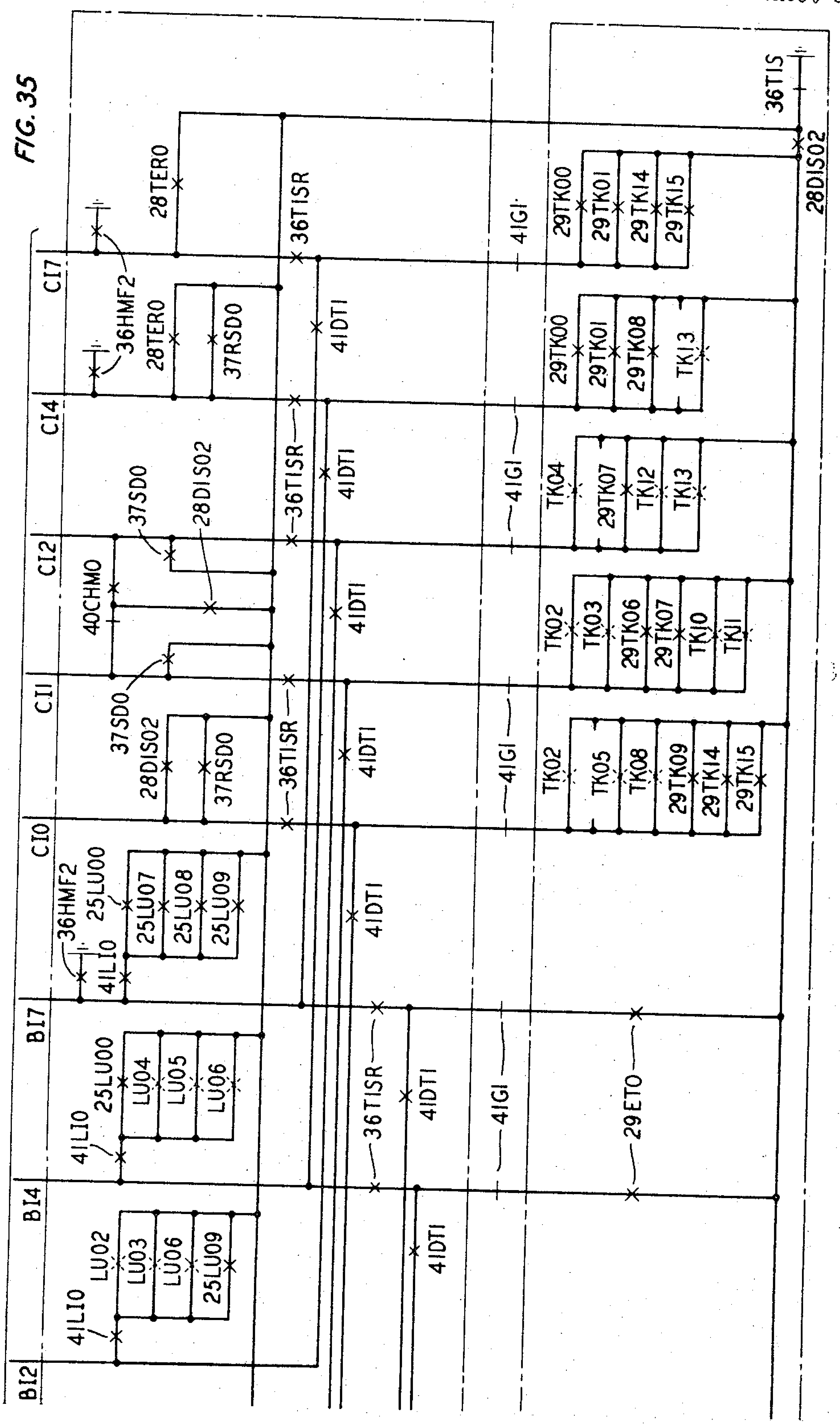

FIG. 35

SYNCHRONIZING CIRCUIT FOR CONCENTRATOR SIGNALING SYSTEM

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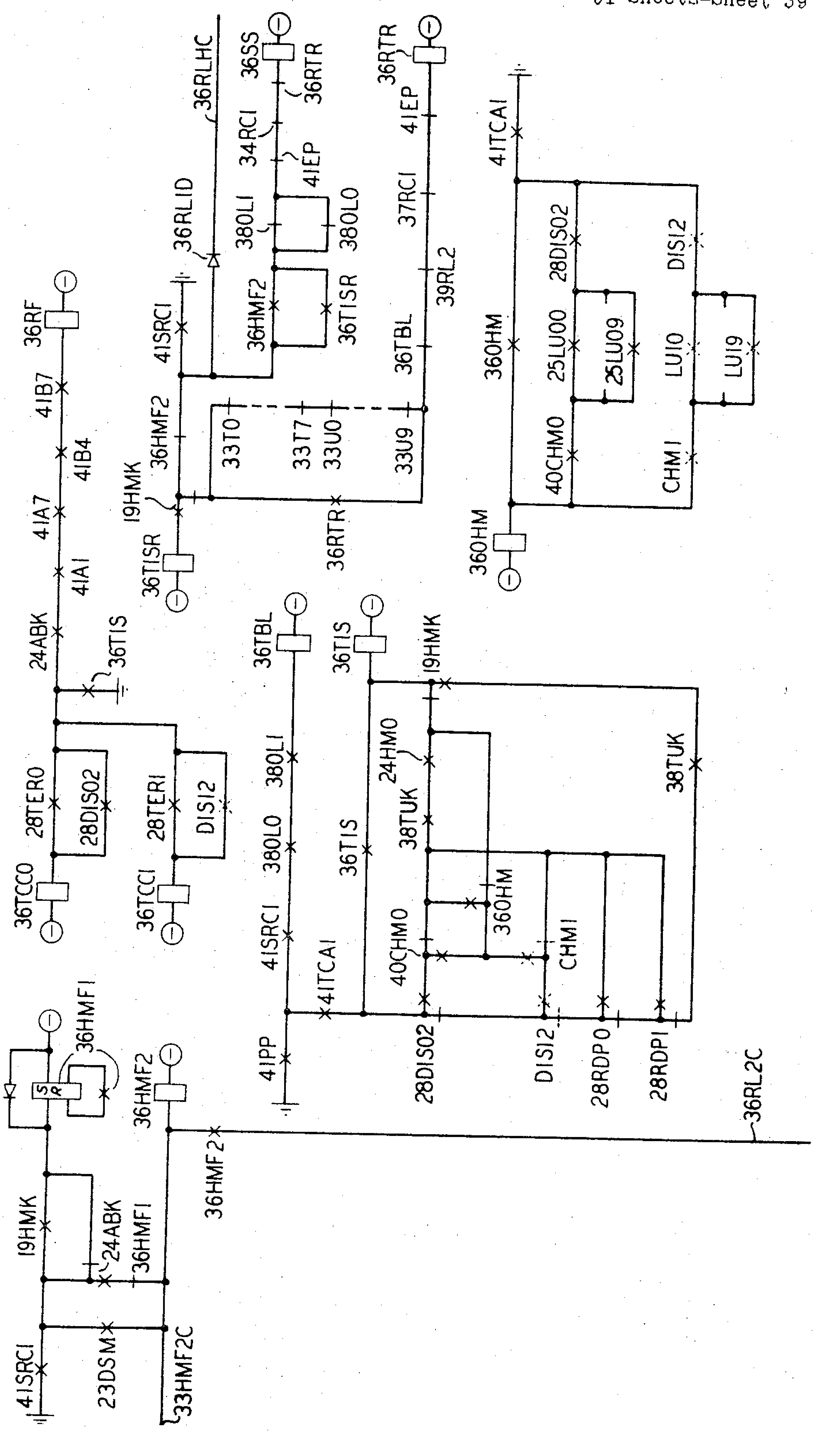
FIG. 36



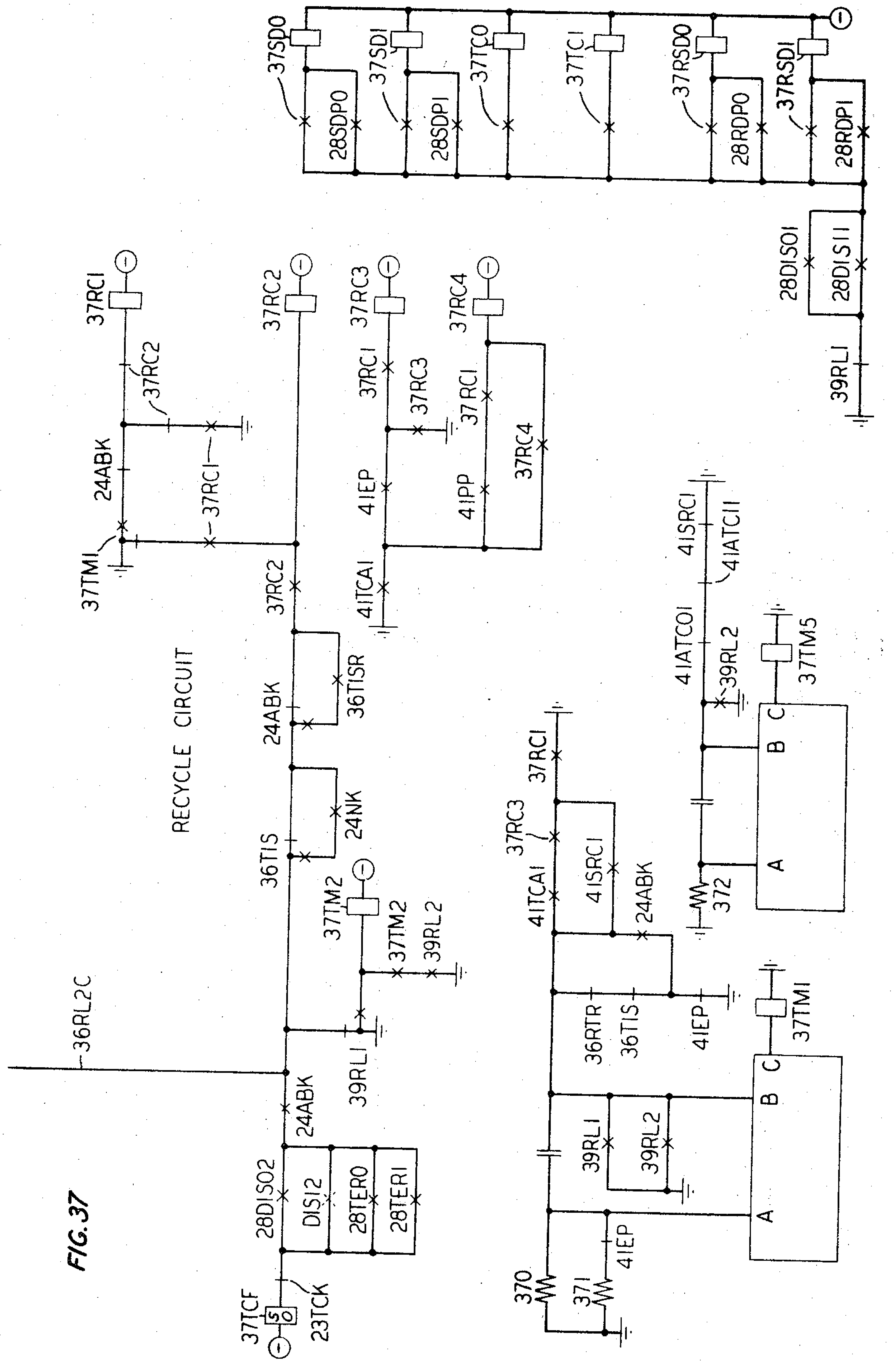

37SDO
37SDI
37TCO
37TCI
37RSDO
37RSDI
28SDPO
28SDPI
28RDPO
28RDPI
28DISOI
28DISII
39RLI
37RCI
37RC2
37RC3
37RC4
24ABK
37TMI
41EP
41PP
41ITCAI
RECYCLE CIRCUIT
36TISR
24NK
36TIS
37TM2
39RL2
36RL2C
28DISO2
DISI2
28TERO
28TERI
37TCF
23TCK
41SRCI
41ATCII
41ATCOI
37TM5
372
36RTR
370
371
A
B
C

FIG. 37

FIG. 38

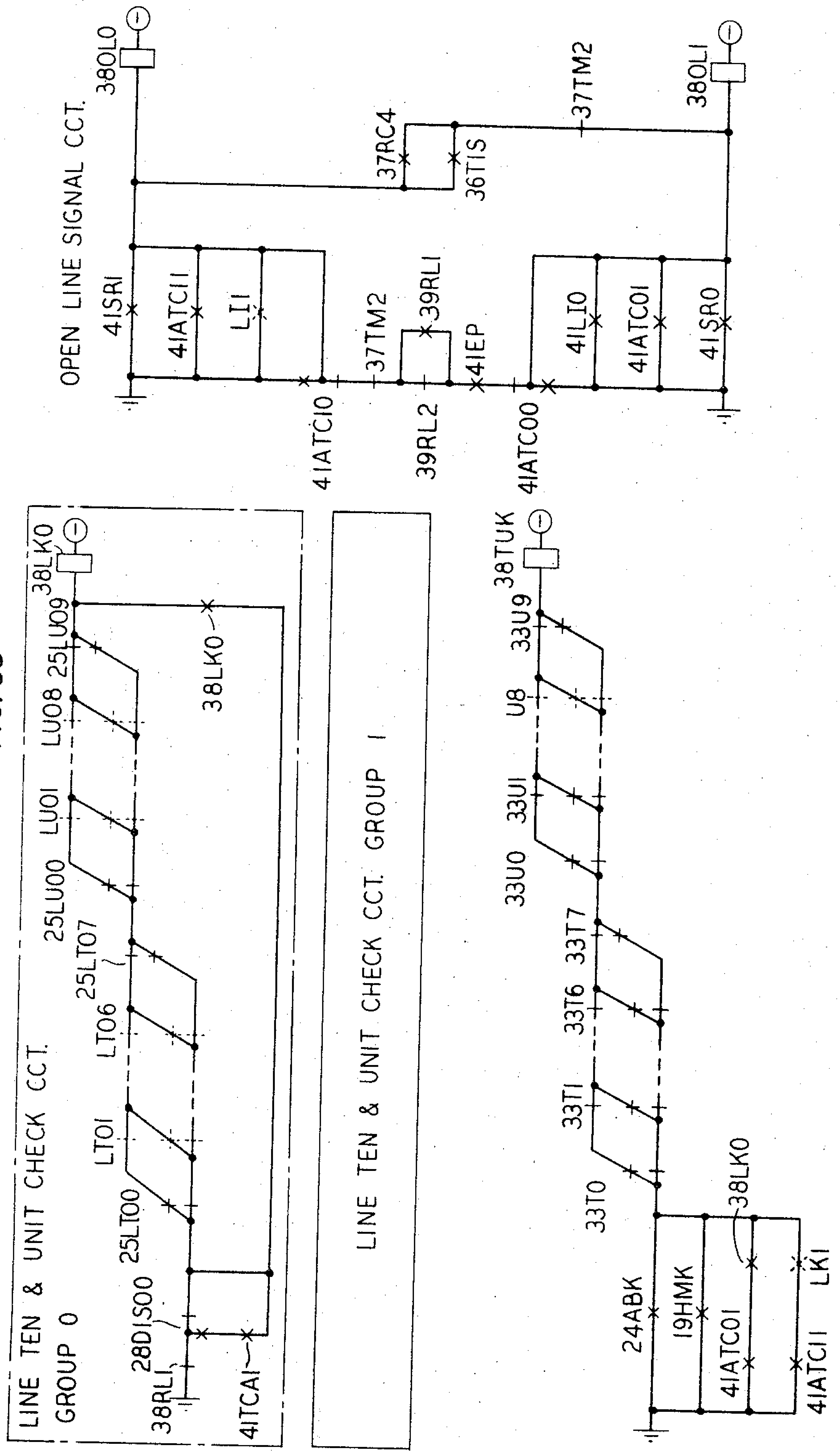
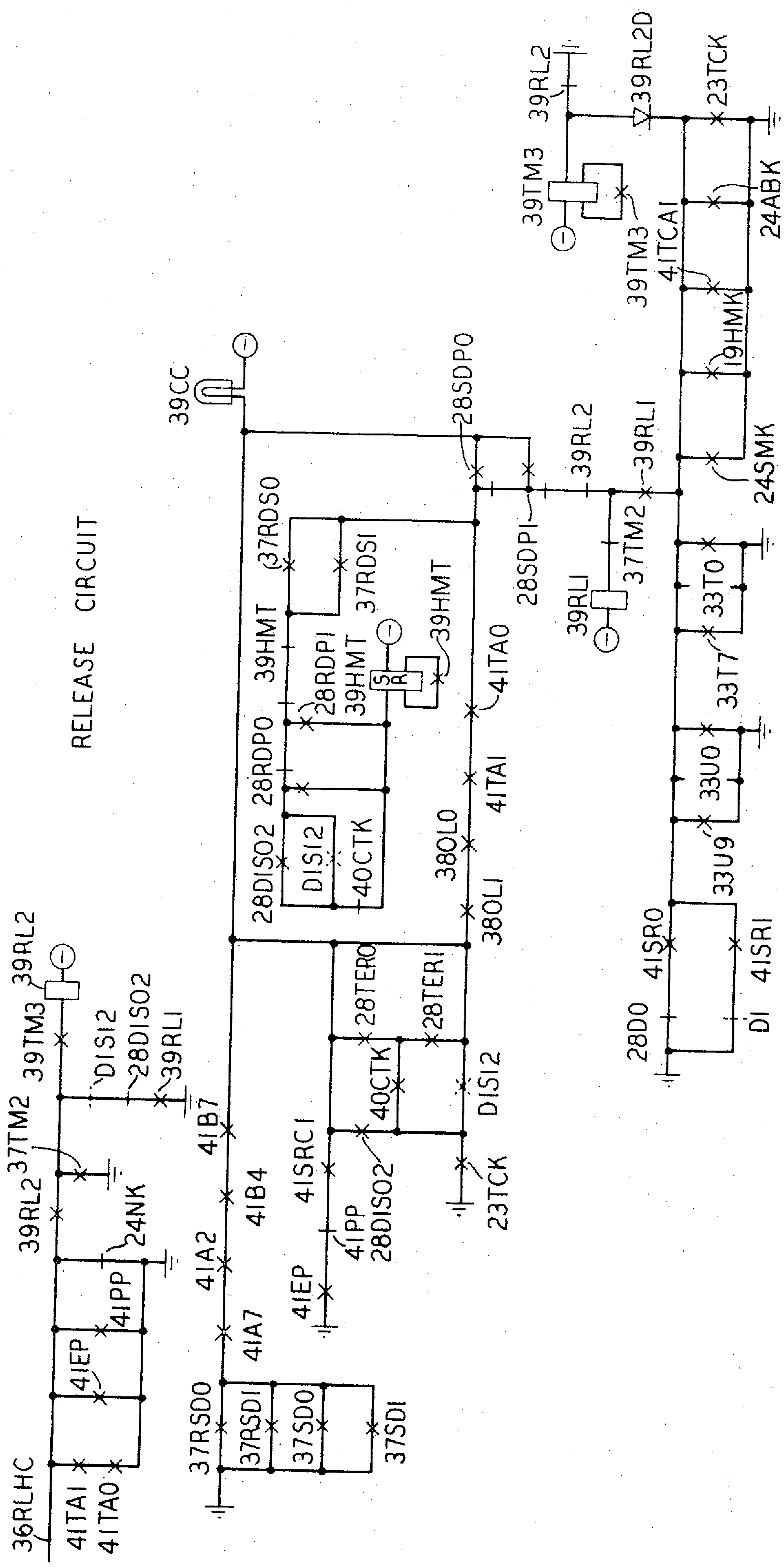

OPEN LINE SIGNAL CCT.
38OLO
38OLI
37RC4
36TIS
37TM2
41SRI
41ATCII
LII
41ATCIO
37TM2
39RLI
39RL2
41EP
41ATCOO
41ILIO
41ATCOI
41SRO
LINE TEN & UNIT CHECK CCT. GROUP 0
38LKO
25LUO9
LUO8
LUOI
25LUOO
25LTO7
LTO6
LTOI
25LTOO
28DISOO
38RLI
41TCAI
LINE TEN & UNIT CHECK CCT. GROUP I
38TUK
33U9
U8
33UI
33UO
33T7
33T6
33TI
33TO
38LKO
24ABK
19HMK
41ATCOI
LKI
41ATCII

FIG. 39

RELEASE CIRCUIT



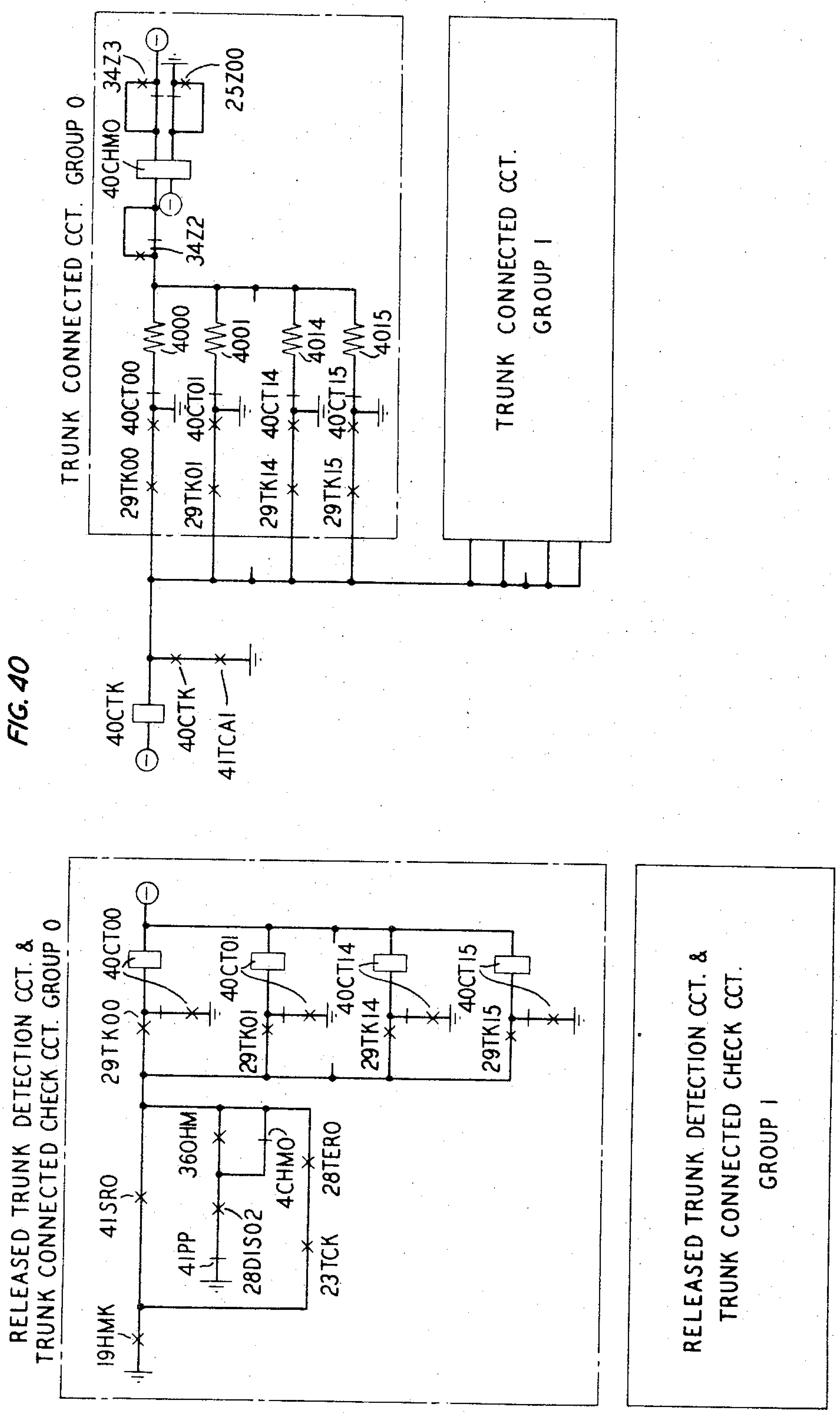

TRUNK CONNECTED CCT. GROUP 0
TRUNK CONNECTED CCT. GROUP I
RELEASED TRUNK DETECTION CCT. & TRUNK CONNECTED CHECK CCT. GROUP 0
RELEASED TRUNK DETECTION CCT. & TRUNK CONNECTED CHECK CCT. GROUP I
40CHMO
34Z3
25Z00
34Z2
4000
4001
4014
4015
29TK00
40CT00
29TK01
40CT01
29TK14
40CT14
29TK15
40CT15
40CTK
41TCA1
19HMK
41SRO
36OHM
4CHMO
41PP
28DIS02
28TERO
23TCK

FIG. 40

SYNCHRONIZING CIRCUIT FOR CONCENTRATOR SIGNALING SYSTEM

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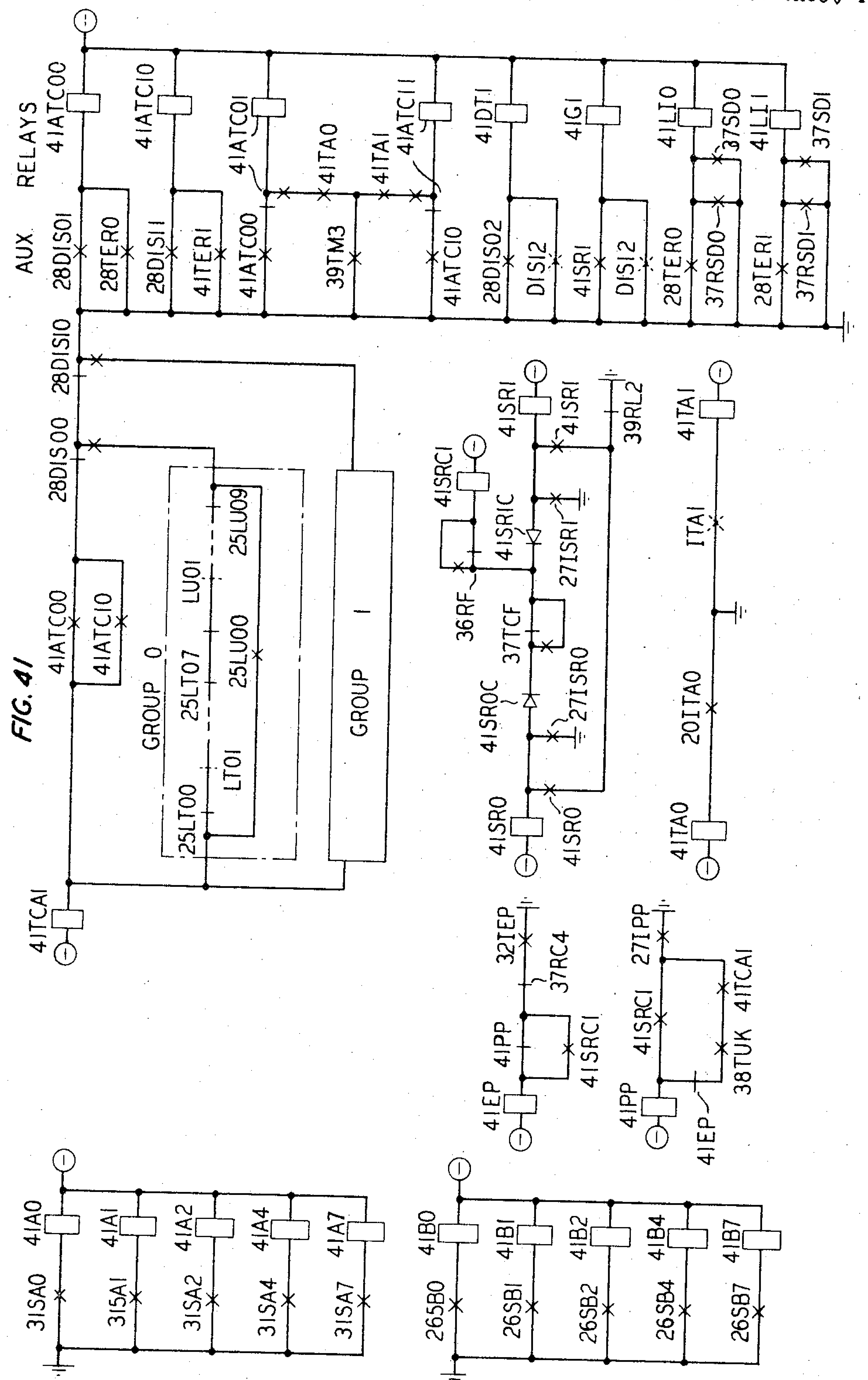

FIG. 41

SYNCHRONIZING CIRCUIT FOR CONCENTRATOR SIGNALING SYSTEM

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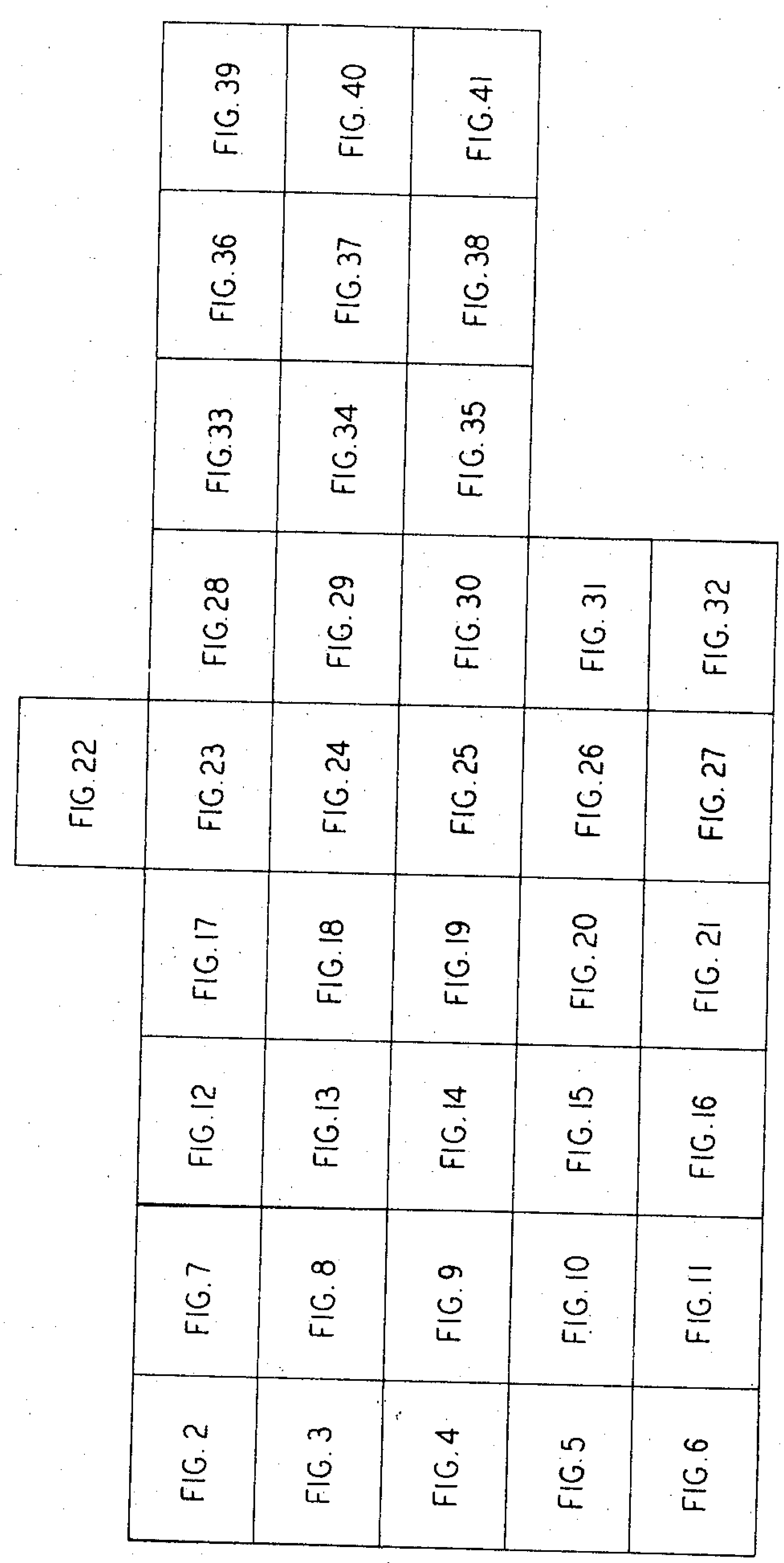
FIG. 41A



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SYNCHRONIZING CIRCUIT FOR CONCENTRATOR SIGNALING SYSTEM

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FIG. 45

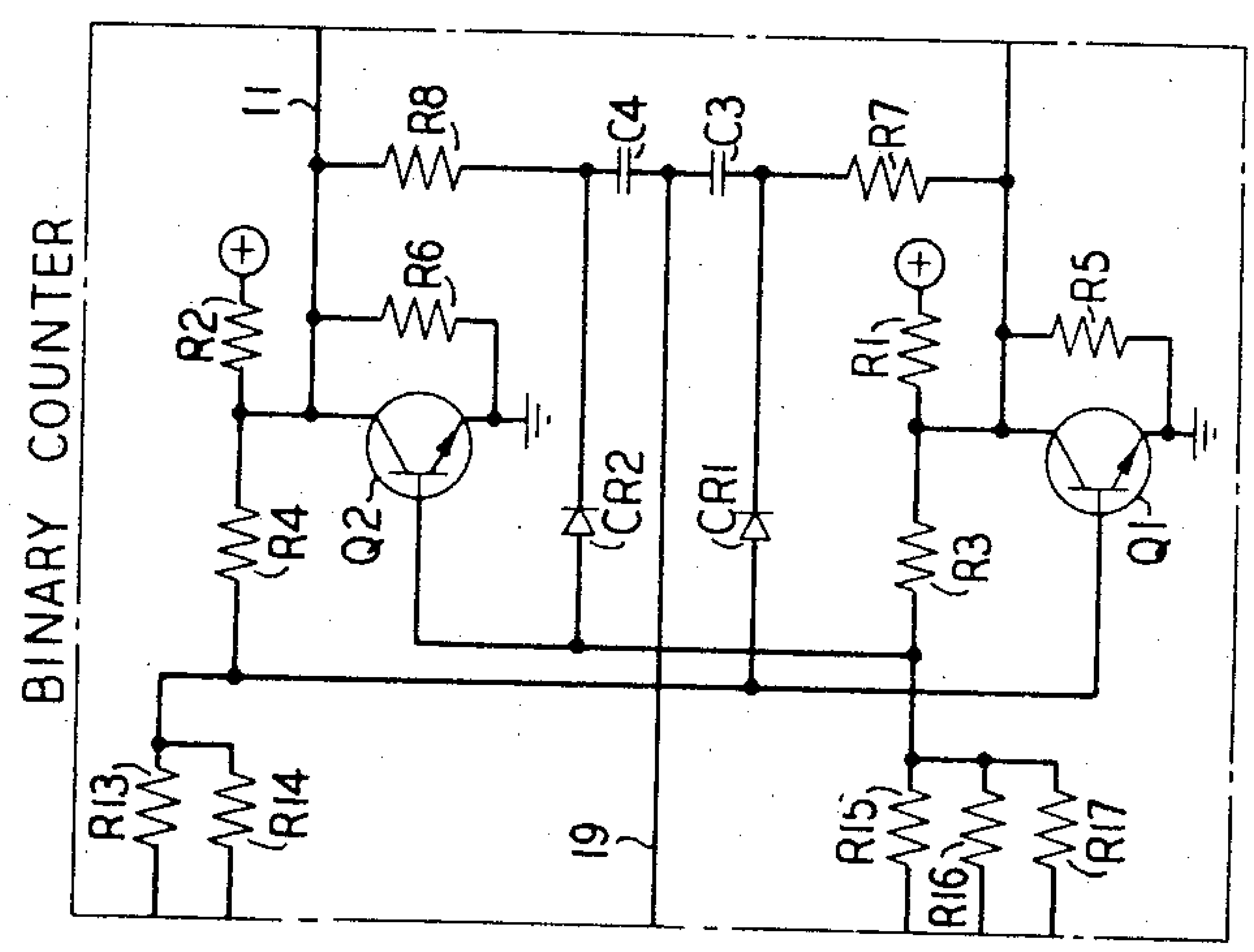


FIG. 45A

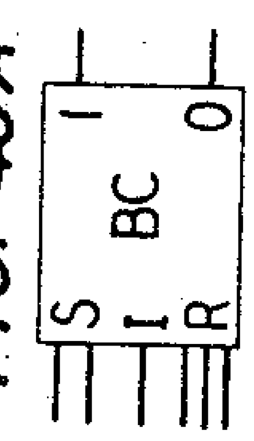


FIG. 42A

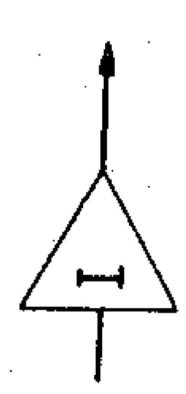


FIG. 43A

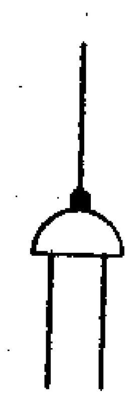


FIG. 44A

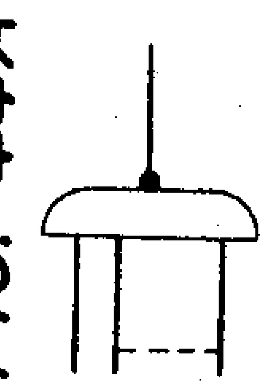
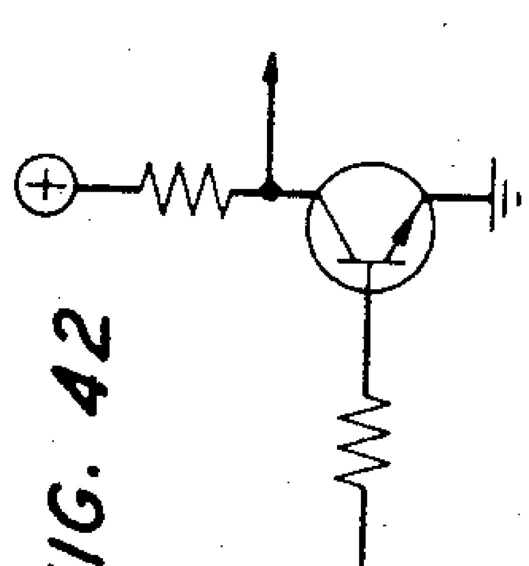
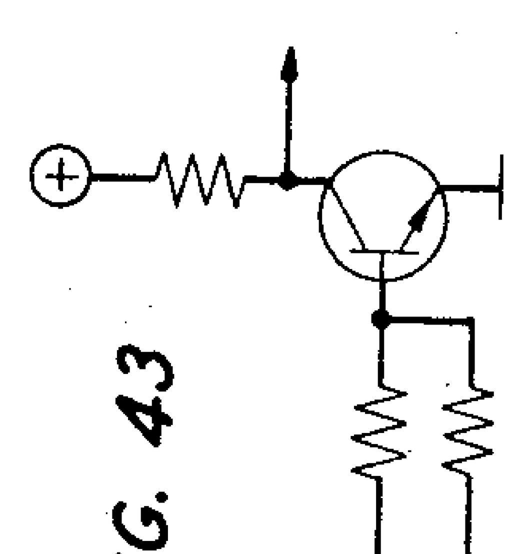


FIG. 42



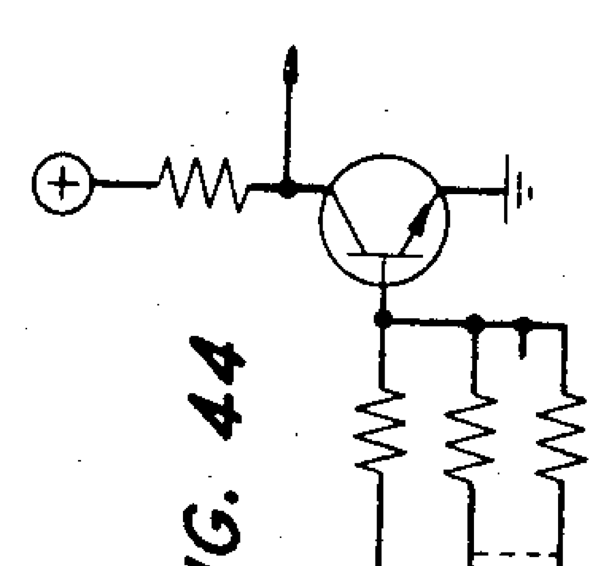
ONE INPUT OR NOT GATE

FIG. 43



TWO INPUT OR NOT GATE

FIG. 44



MULTI-INPUT OR NOT GATE

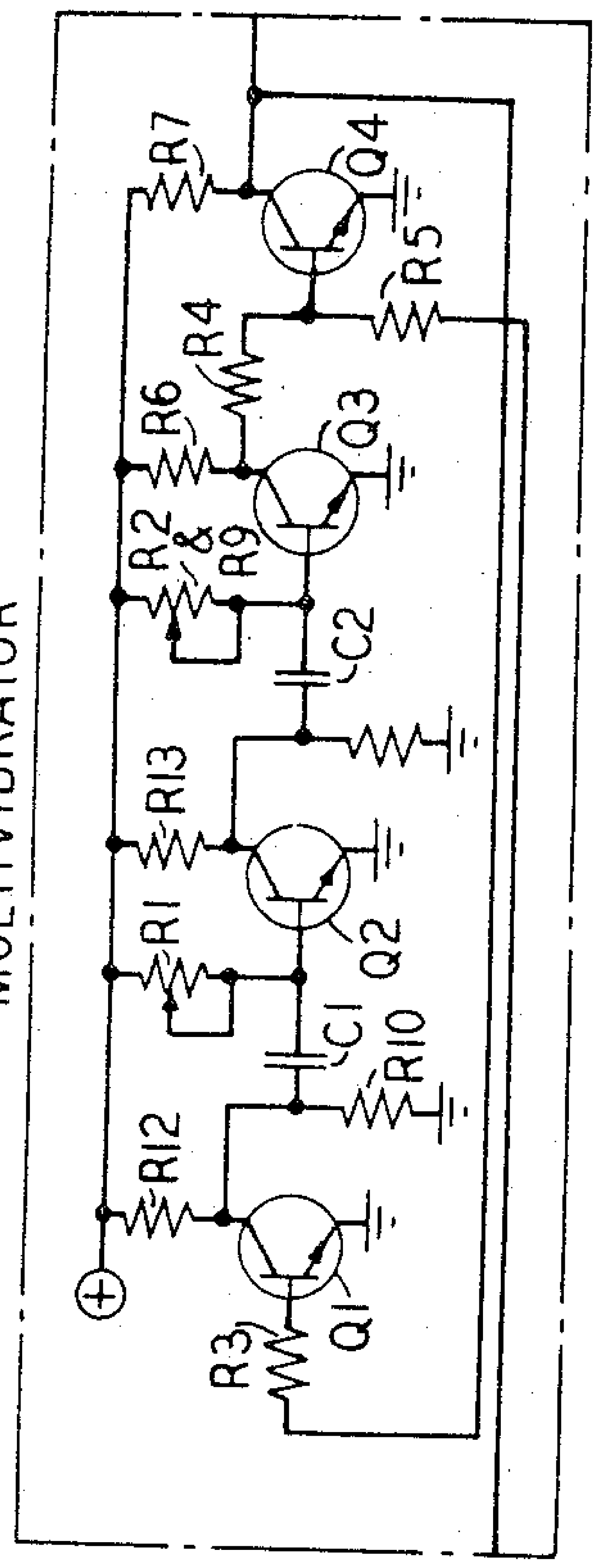


FIG. 48

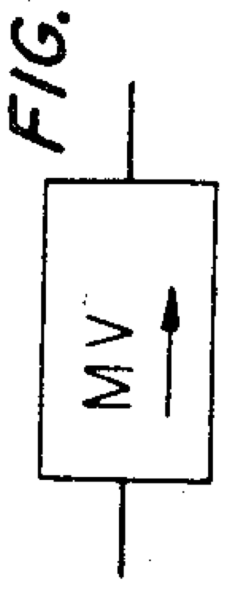


FIG. 48A

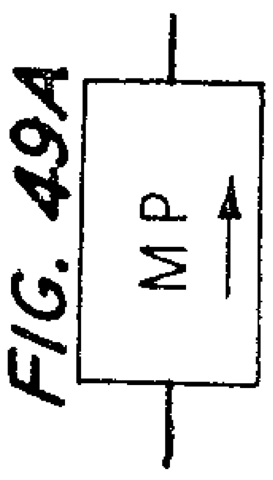


FIG. 49A

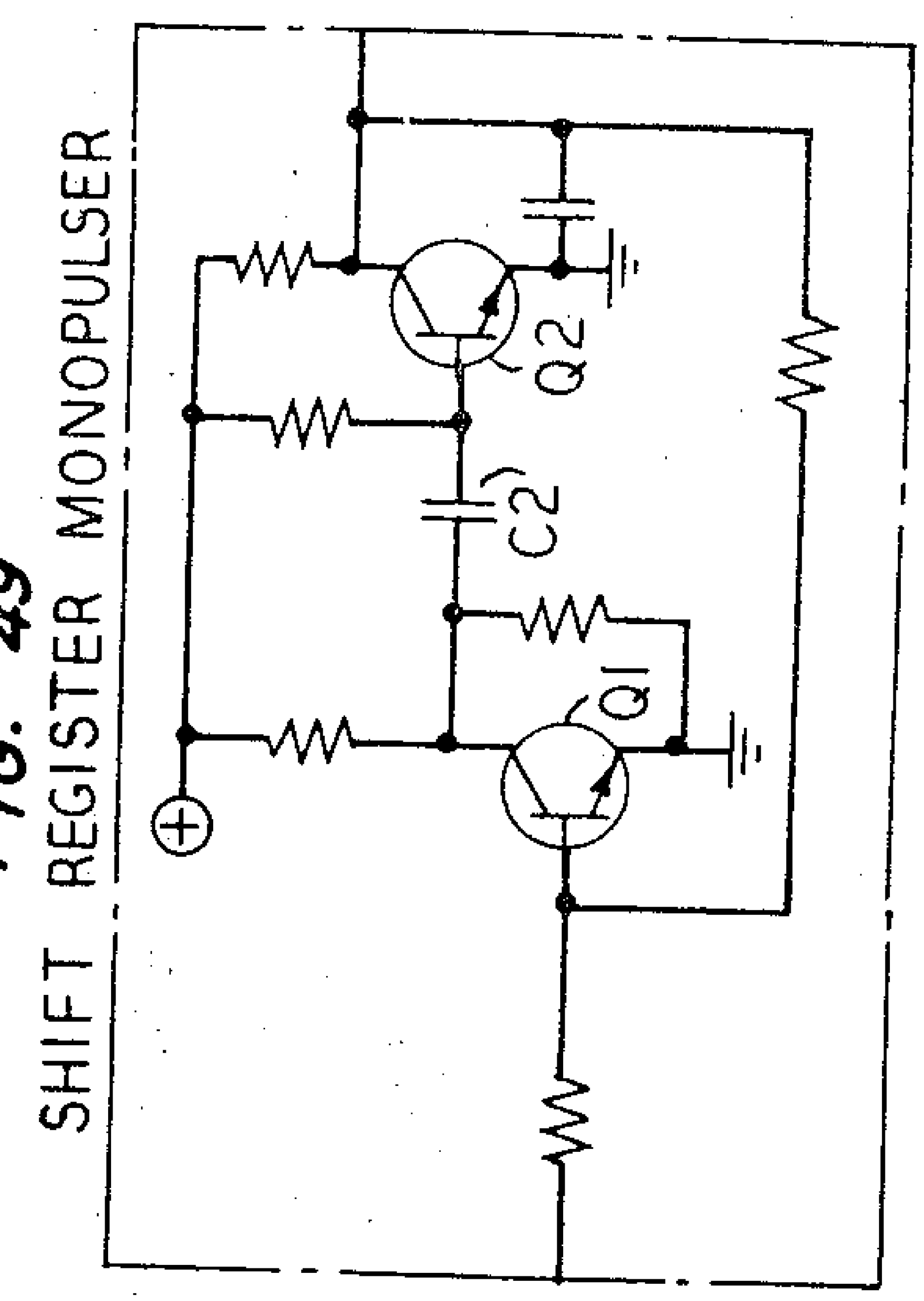


FIG. 49

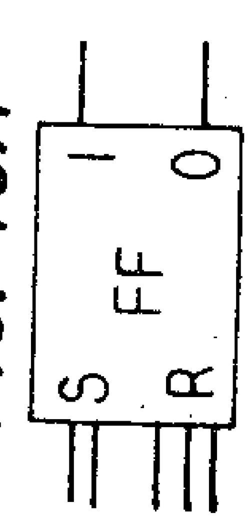


FIG. 46A

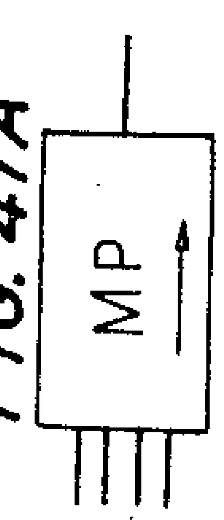


FIG. 47A

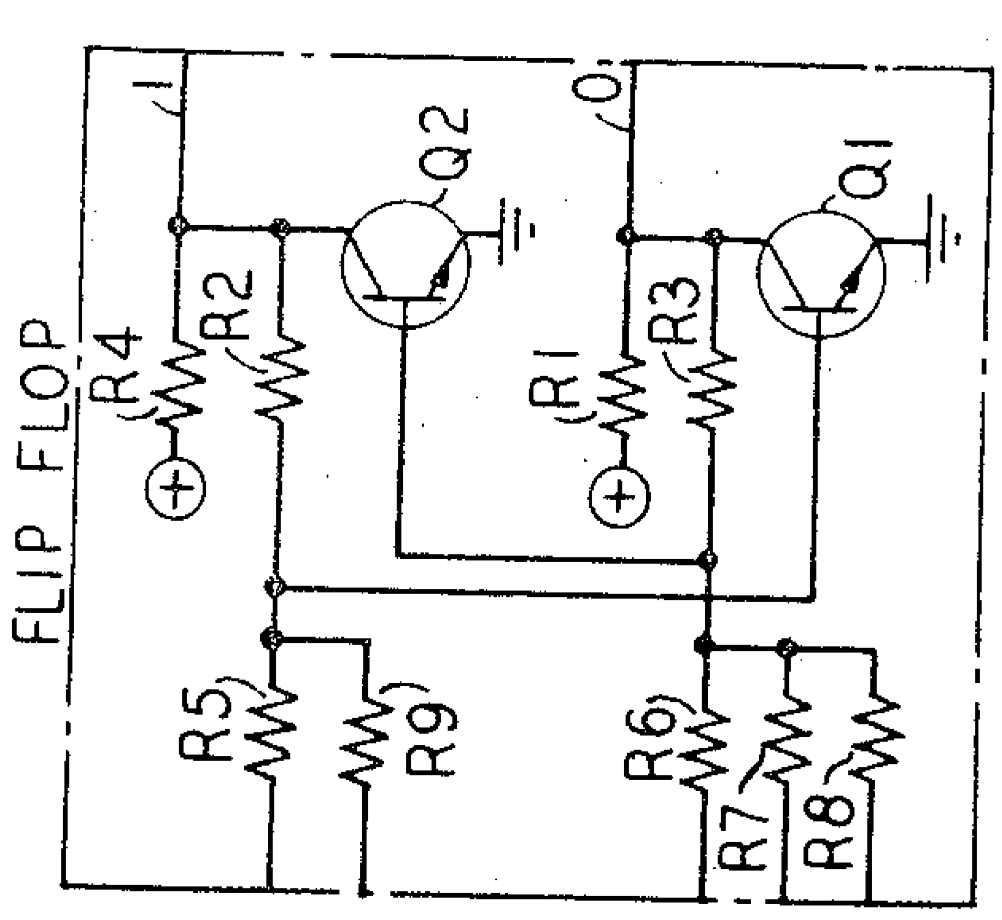


FIG. 46

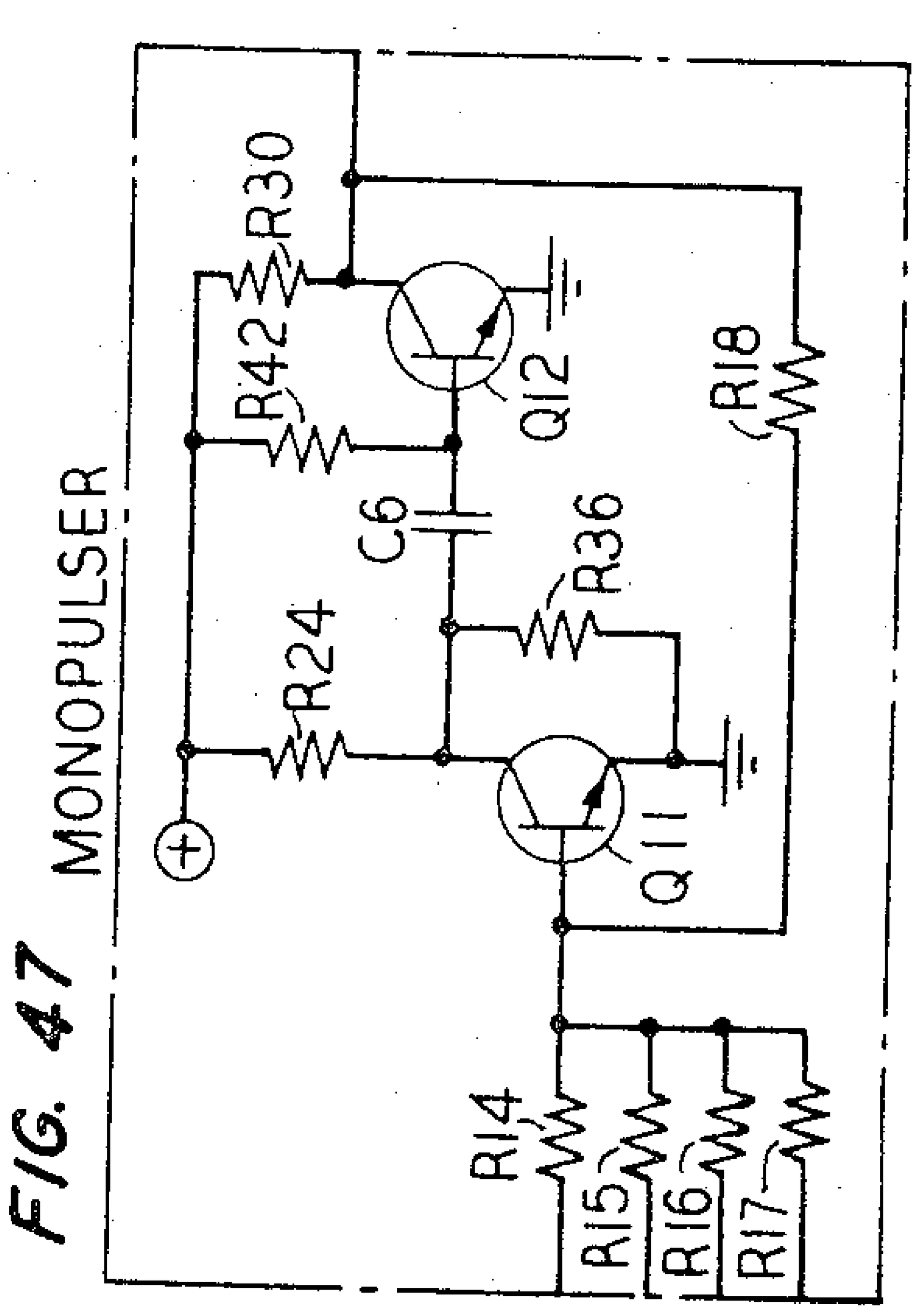


FIG. 47

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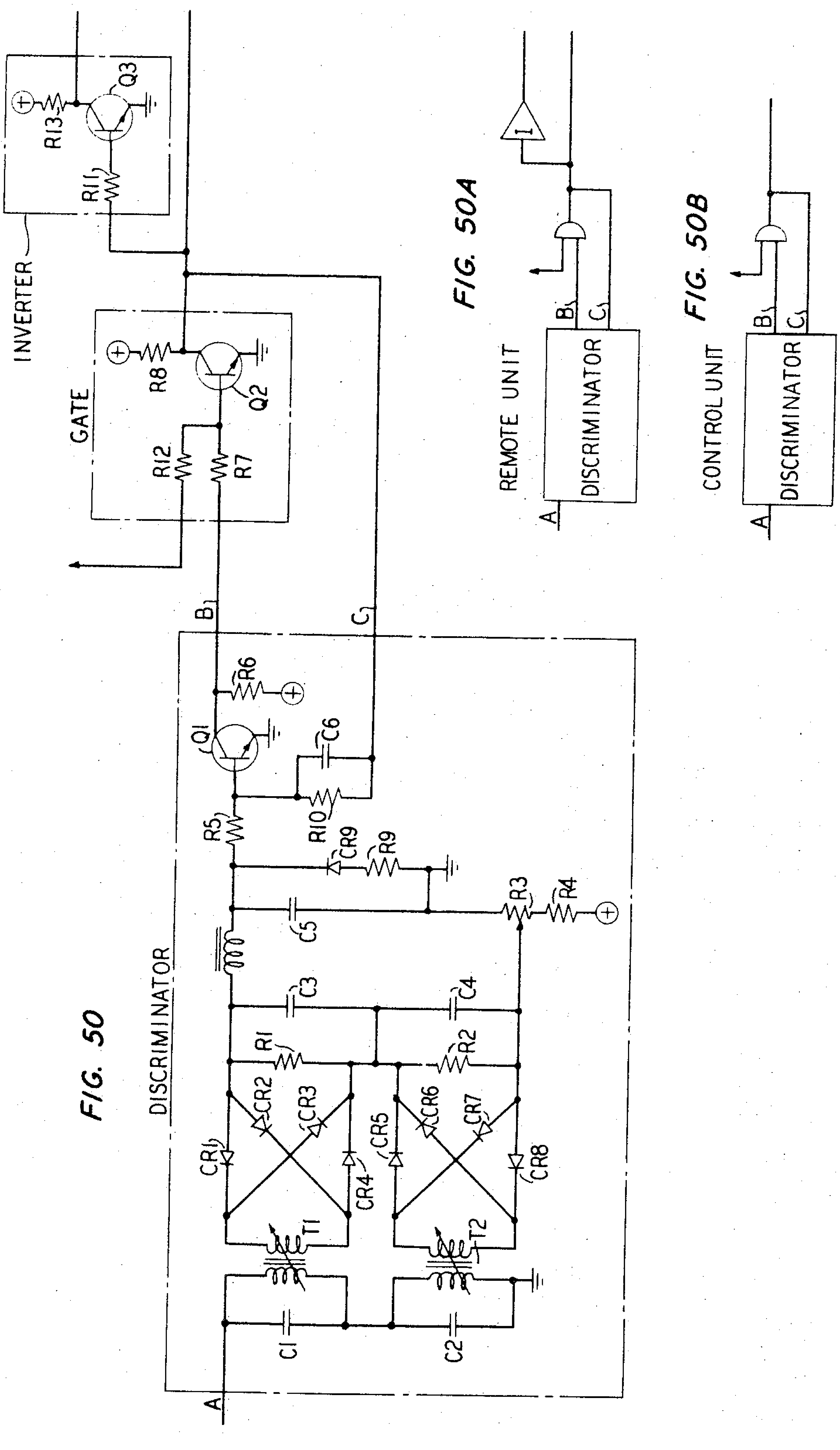

FIG. 50

FIG. 50A

FIG. 50B

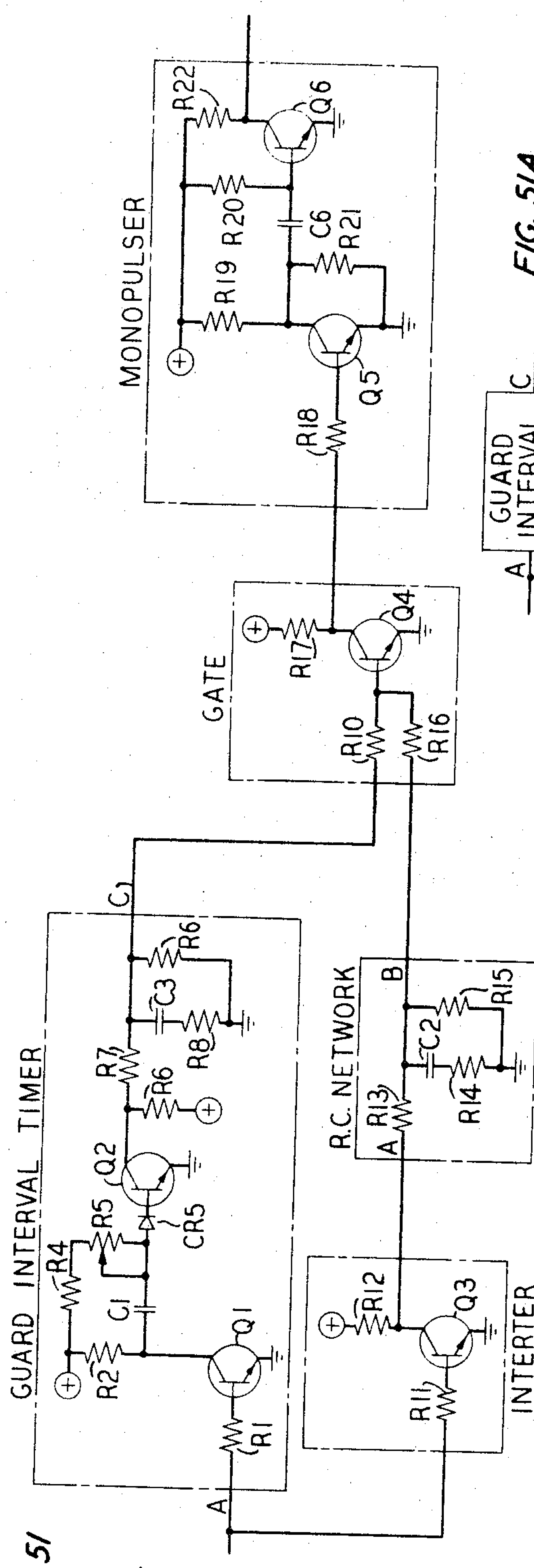

FIG. 51

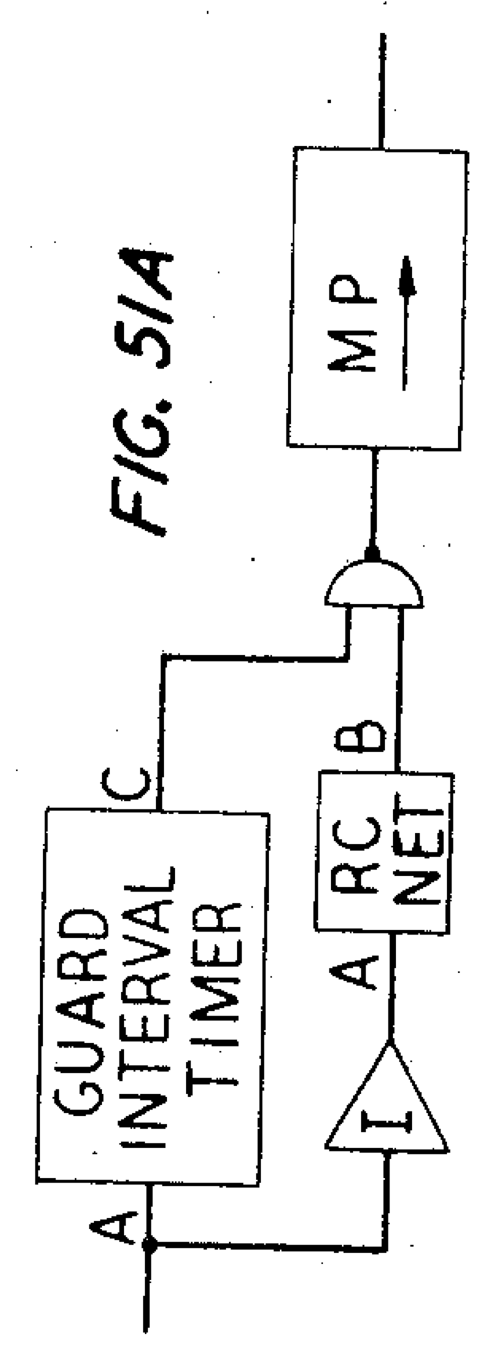

FIG. 51A

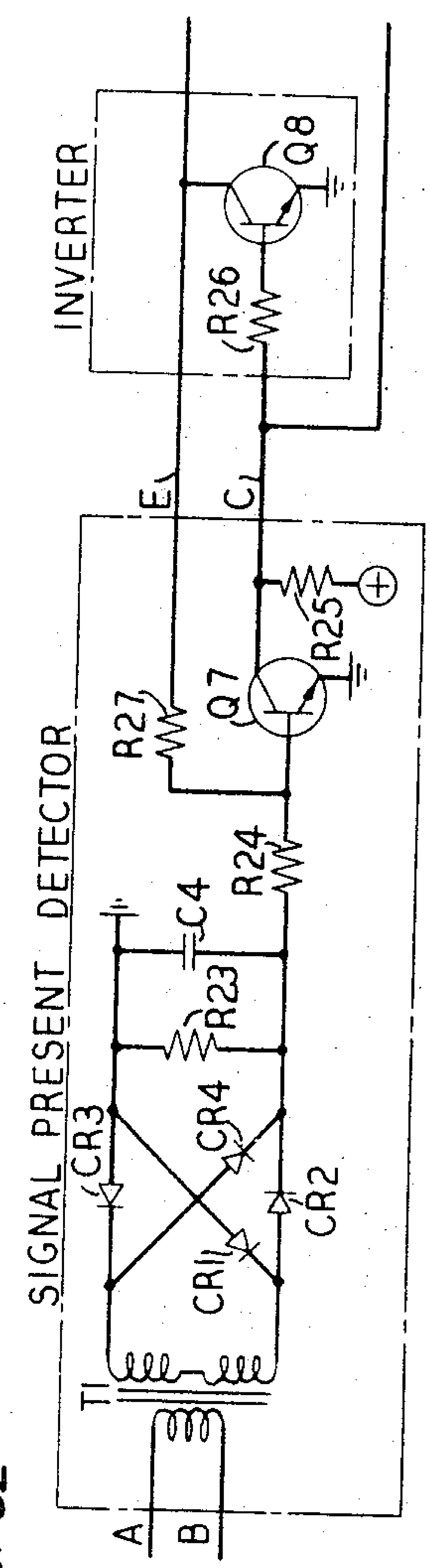

FIG. 52

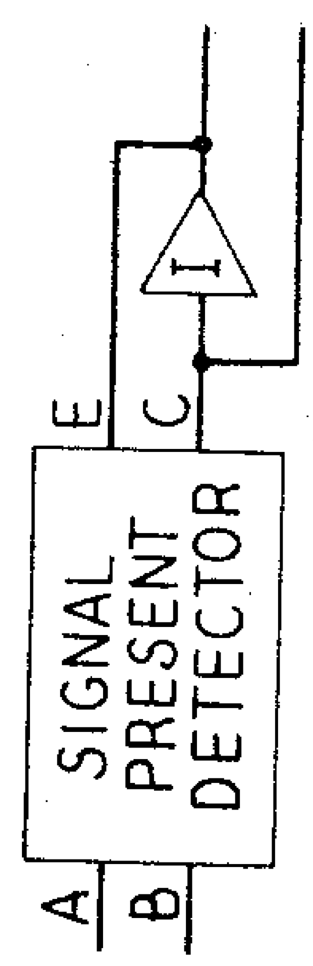

FIG. 52A

SYNCHRONIZING CIRCUIT FOR CONCENTRATOR SIGNALING SYSTEM

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FIG. 55

SEND FILTER

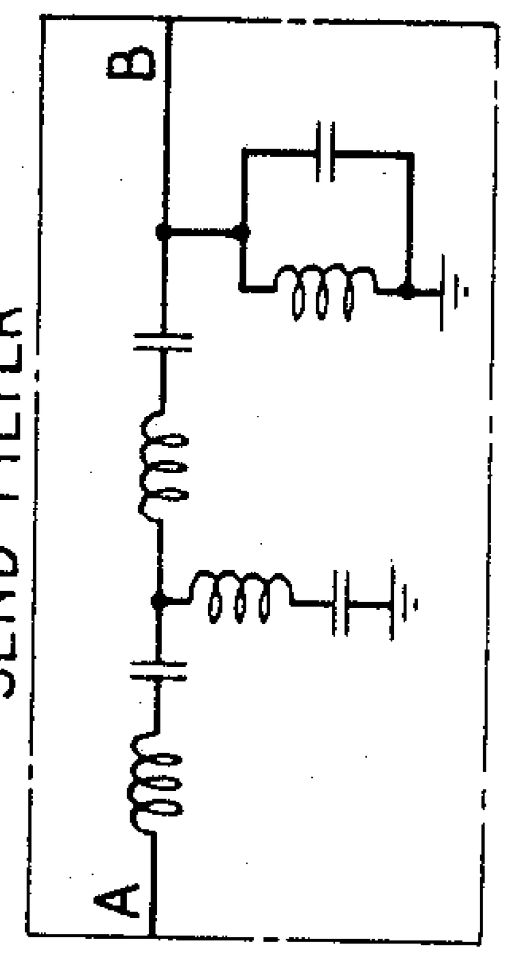

FIG. 55A

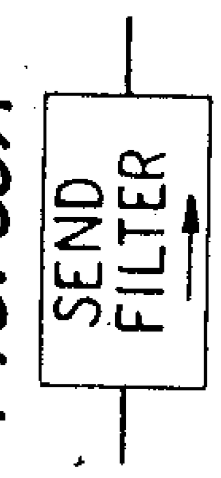

FIG. 53A

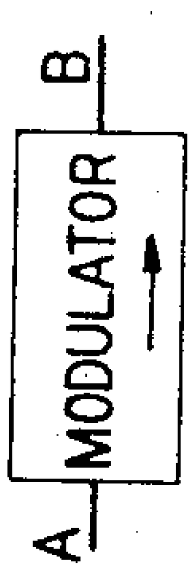

FIG. 54A

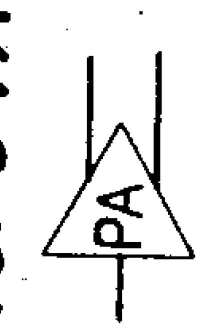

FIG. 53

MODULATOR

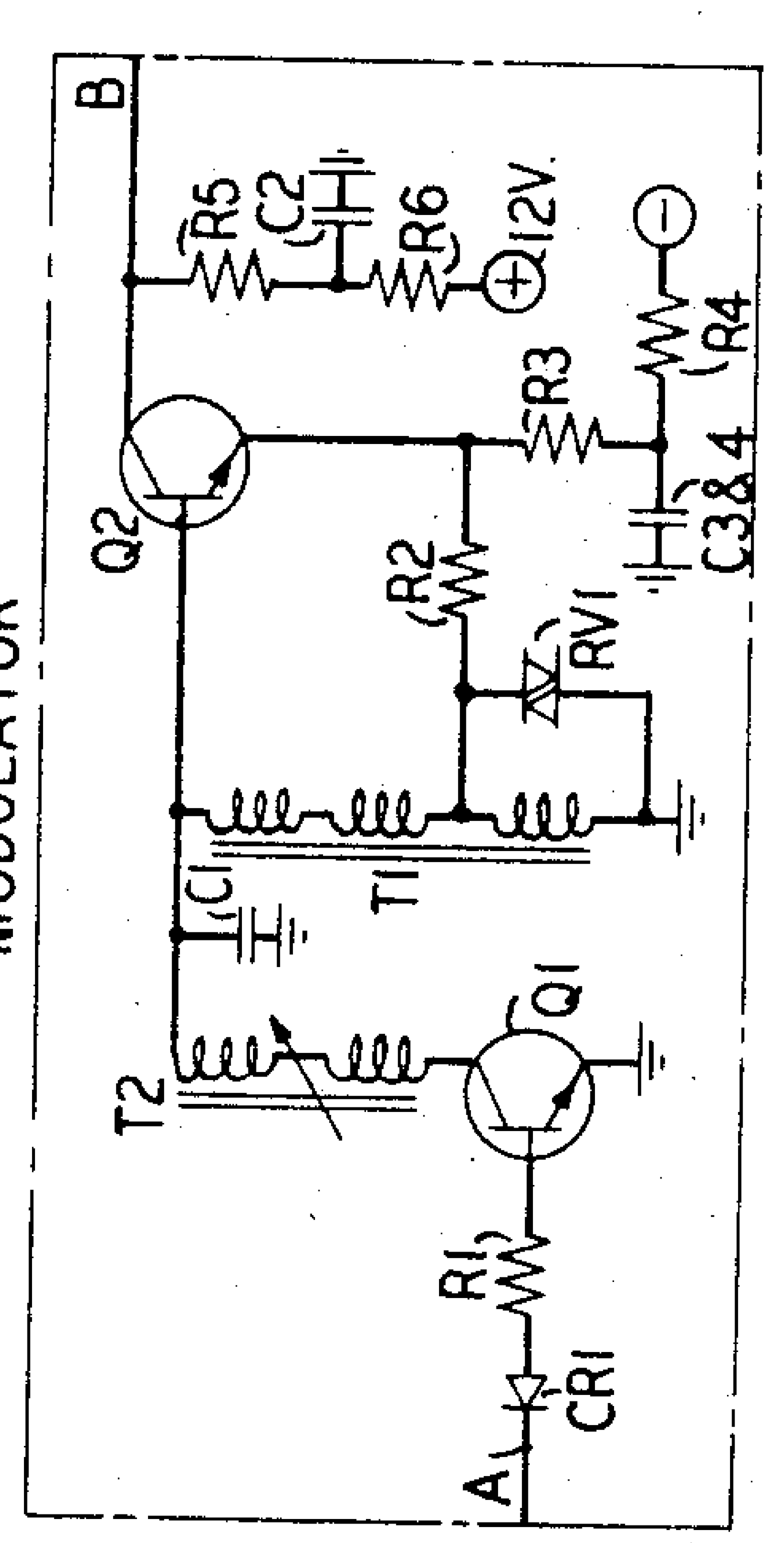

FIG. 54

POWER AMPLIFIER

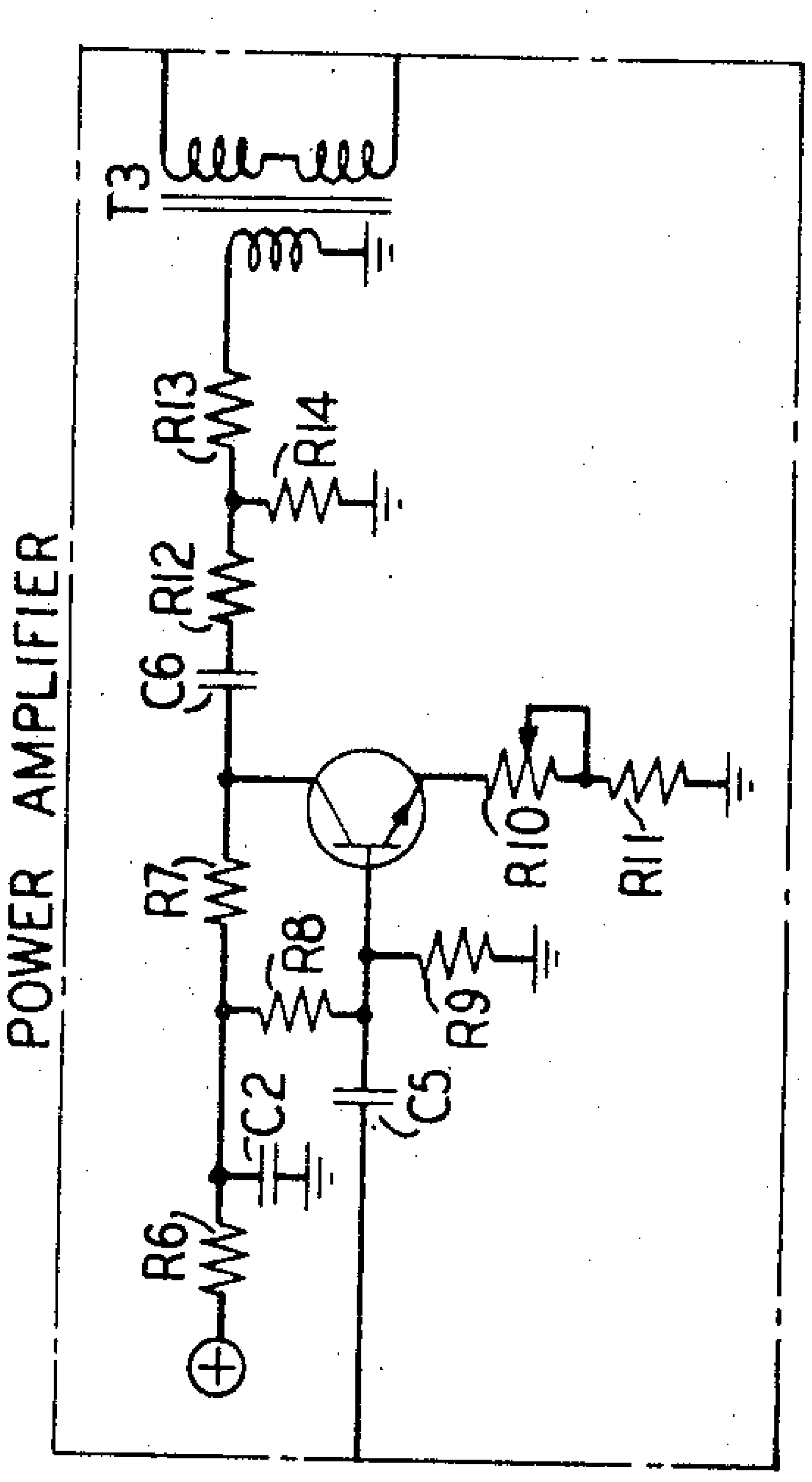

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FIG. 57A

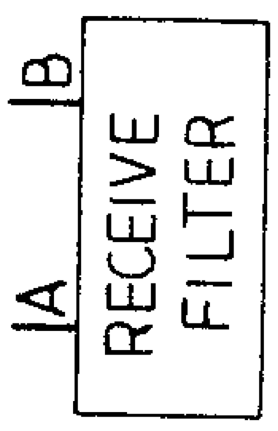


FIG. 56A

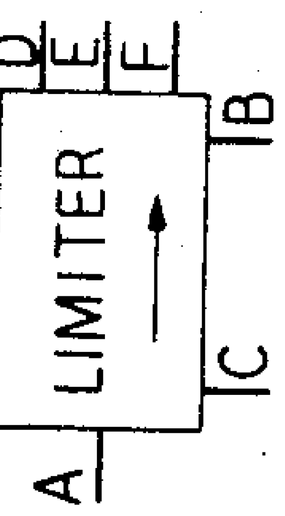


FIG. 57

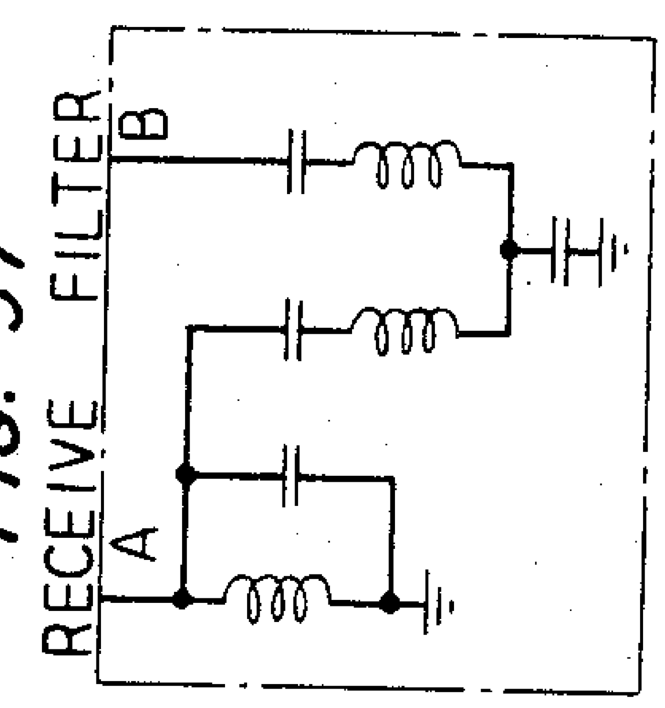
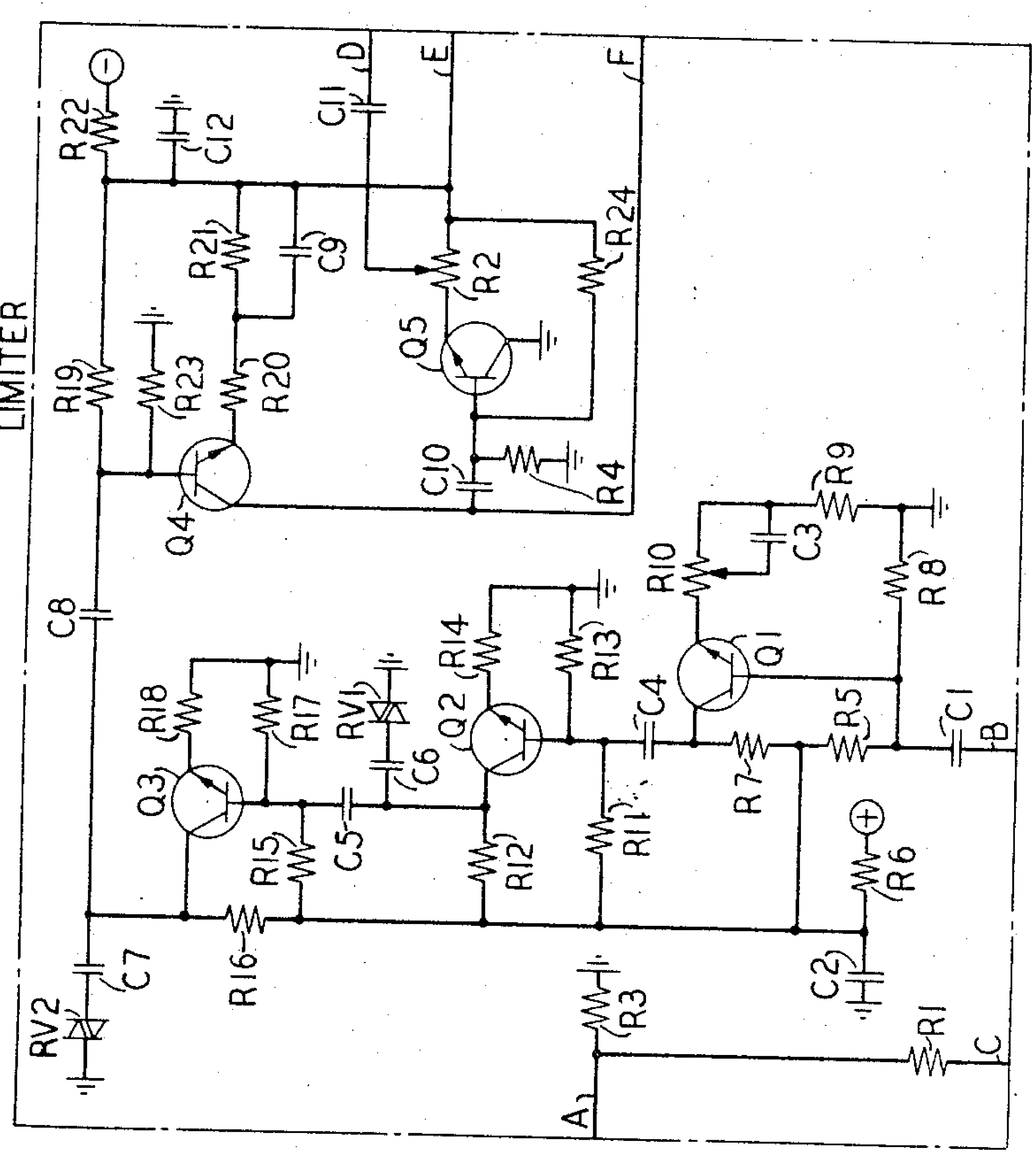


FIG. 56



United States Patent Office

3,354,268

Patented Nov. 21, 1967

1

3,354,268

SYNCHRONIZING CIRCUIT FOR CONCENTRATOR SIGNALING SYSTEM

John F. Rettig and Uberto K. Stagg, Jr., Columbus, Ohio, assignors to Bell Telephone Laboratories, Incorporated, New York, N.Y., a corporation of New York

Filed Feb. 14, 1964, Ser. No. 344,981
15 Claims. (Cl. 179—18)

ABSTRACT OF THE DISCLOSURE

A system is disclosed for concentrating a large number of telephone lines at a remote switching unit and extending connections from the lines over a smaller number of trunks on a shared basis to a central office. These connections are established through crossbar switches, controlled by both electronic and electromechanical control circuitry and coordinated by signals from a signaling facility interconnecting the remote unit with the central office. The facility includes circuits for sending and receiving pulses and maintaining a synchronous relationship between sending and receiving units.

This invention relates to telephone line concentrator systems and more particularly to synchronizing circuits for controlling such signaling systems. Telephone line concentrator signaling systems may be categorized in two general groups. The first would include so-called asynchronous signaling systems in which information transmitted from the remote unit to the central office and vice versa is not predicated on any synchronous operation between the two distant units. The other group includes synchronous signaling arrangements in which a signaling device at the control unit is required to maintain a synchronous relationship with the signaling device at the remote unit.

An illustration of the former type of operation may be seen in Patent 3,022,382 of J. C. Ewin of February 20, 1962. Therein, information transmitted from the remote unit to the central office and vice versa need not include timing or other signals which dictate the beginning and end of blocks of signal intelligence.

The latter type of signaling arrangement is characterized by that shown in Patent 3,033,937 of W. C. Jones of May 8, 1962. In the Jones disclosure, local counting arrangements which operate in synchronism with a central office counter are utilized to provide timing information at the remote unit.

One of the difficulties which resides in the use of synchronous signaling systems and, in part, negates the many advantages residing therein is the literal necessity for maintaining synchronism between the two distant units. In short, a synchronous signaling system is capable of delivering a considerable quantity of information with only a minimum of signal traffic provided that the timing means at the remote unit is adapted to accurately establish the individual bits or words comprising the intelligence information.

For example, if the control unit is delivering binary information using two distinct frequencies, transmission of the 0 frequency may be utilized to transmit three successive 0's if the same frequency is permitted to persist for three bit intervals. Similarly, transmission of the 1 frequency is sufficient if permitted to persist for four bit intervals to transmit four successive 1's. Obviously, however, it is vital to recognize the accurate persistence or bit duration of the particular frequency in order that the appropriate number of 1 and 0 bits may be recorded.

Certain prior arrangements undertook to insure the accuracy of the local counting or timing unit by "slaving" the local counter to the distant counter and also by transmitting framing or resynchronizing bits at frequent intervals to insure continued synchronization between the oscillator at the central office and the oscillator at the remote unit.

Unfortunately, the disadvantage inherent in this type of resynchronization resides in the necessity for transmitting a considerable volume of data which is unrelated to required intelligence information, (i.e., relating to telephone connections and the like) but instead is relegated exclusively to the function of restoring synchronism between the distant units. Since telephone concentrator operation is predicted on the desirability of minimizing the number of channels between a group of remote substations and the central office, the necessity for providing channel capacity for the synchronizing information is, at least in part, self-defeative.

It is therefore an object of this invention to provide for the synchronization of a local unit with the incoming signal received from a distant unit while permitting the clock mechanisms at both units to remain completely free-running.

Still another object of this invention is to provide for the synchronization of two distant signaling units by controlling frequency dividers responsive to the operation of clock mechanisms or oscillators at those units.

These and other objects and features of the invention may be realized in a specific illustrative embodiment in which a synchronizing circuit for use between two distant signaling elements of a telephone line concentrator does not attempt to effect a continuous synchronization of the clock mechanisms at both units but instead is effective to periodically synchronize a pair of frequency dividers respectively responsive to the clock mechanisms in the distant units. In essence, the operation relates to the transmission of synchronizing signals at the initiation of each message and at space-to-mark transitions. On receipt of a synchronizing signal at the beginning of a message, the frequency divider at the receiving unit and the oscillator at the receiving unit are quiescent. An accurate timing element at the receiving unit which is triggered in response to the reception of the synchronizing signal is effective to measure a predetermined time and to set the local frequency divider or counter to a count which should have been achieved during the measured time interval if the local oscillator or clock mechanism had been actively advancing the frequency divider.

Since the distant oscillator had been operating and controlling the distant counter during the same time interval, the two counters are now at the same count (neglecting transmission time delays) and the local oscillator at the receiving unit is now triggered to advance the frequency divider at the receiving unit. Under these conditions the two counters are maintained in synchronism although it is apparent that the oscillators which drive the counters are operating wholly independently. An advantage to be derived from this type of operation resides in the relative frequencies of the oscillator and the counter which may, for example, be in the ratio of sixteen times lower in the counter. Under these considerations the oscillator at the remote unit may be permitted to drift a considerable number of cycles from the oscillator at the receiving unit without effecting a loss of synchronism between the two counters.

A feature of this invention includes facilities for synchronizing the signaling circuits in a concentrator system while permitting the clock mechanisms at both units to remain free-running.

A feature of this invention includes arrangements for resynchronizing the counter at the distant unit with respect to the counter at the transmitting unit on each space-to-mark transition of the signaling frequencies.

Still another feature of this invention includes arrangements for providing a binary counter at the transmitting unit and receiving unit which divides the frequency of the respective oscillators connected thereto in order that the oscillators may drift apart in frequency without effecting a loss of synchronism between the two counters.

Still another feature of this invention includes an accurate timing arrangement responsive to preliminary pulses transmitted from the distant unit for metering a predetermined time interval indicative of the count in the counter at the transmitting unit.

Another feature of this invention includes facilities in a receiving unit responsive to a timer thereat for advancing the counter at the receiving unit to a count corresponding to that in the counter at the transmitting unit.

Another feature of this invention includes facilities responsive to the operation of a timing arrangement at the remote unit for initiating the operation of an oscillator at the remote unit which in turn drives a binary counter thereat in synchronism with the counter at the transmitting unit.

Still another feature of this invention includes shift register means for storage of a preliminary pulse or synchronizing signal prior to the transmission of control signals represented by mark and space frequencies indicative of a particular line or trunk.

Another feature of this invention includes facilities at a receiving unit responsive to the reception of the synchronizing or preliminary pulse for actuating the timing interval of the timer thereat.

A further feature of this invention includes facilities for governing the operation of an accurate timing circuit in a receiving unit to meter the length of a received pulse for discrimination between legitimate signals and transients or "hits."

These and other objects and features of the invention may be more readily apprehended from an examination of the following specification, appended claims and attached drawing in which:

FIGS. 1A–1D include a specific illustrative embodiment of the invention in outline form;

FIGS. 2–16 show the details of a remote unit **0** shown in outline form in FIGS. 1A and 1B;

FIGS. 2–3 show the crossbar switches of the magnetic latching type for the remote unit;

FIG. 4 includes the relay circuitry responsive to the shift register circuitry of FIGS. 5 and 10;

FIG. 5 shows a portion of the shift register circuitry utilized in storing information received from and transmitted to a central office;

FIG. 6 includes the cascaded binary cells utilized in timing control operations;

FIG. 7 includes the select magnet circuitry for the crossbar switches of FIGS. 2 and 3;

FIG. 8 shows the hold magnet circuits for the crossbar switches of FIGS. 2 and 3;

FIG. 9 includes call preference and trunk preference and control relays;

FIG. 10 shows additional shift register circuitry which operates in conjunction with that of FIG. 5;

FIG. 11 includes timing flip-flop elements utilized in the control operations of the concentrator;

FIG. 12 shows checking circuitry for use in conjunction with the line and trunk identification relays;

FIG. 13 includes identification equipment for determining the tens and units designations of a service requesting line;

FIG. 14 shows additional timing, checking and release circuitry utilized in the control functions of the concentrator;

FIG. 15 includes the receiving and transmitting equipment for use in conjunction with comparable equipment at the control units for transmitting and receiving control information;

FIG. 16 includes the binary counter circuitry responsive to the local oscillator for timing the concentrator control operations;

FIGS. 17–41 include the detailed circuitry of the control unit shown in outline form in FIGS. 1C and 1D;

FIGS. 17 and 18 show the crossbar switch circuitry for control unit **0**;

FIG. 19 includes the hold magnet operating and control circuitry for the crossbar switches of FIGS. 17 and 18;

FIG. 20 discloses the transmitting and receiving equipment of the control unit for use in conjunction with the comparable equipment of FIG. 15;

FIG. 21 includes the binary counting circuitry responsive to the oscillator at the control unit for determining the timing of concentrator control functions;

FIG. 22 includes circuitry effective in response to busy conditions on lines and trunks;

FIG. 23 includes the select magnet operating and control circuitry for the crossbar switches of FIGS. 17 and 18;

FIG. 24 includes checking circuitry for the shift register and select magnets of FIG. 23;

FIG. 25 includes relay circuitry for preventing double seizure on a terminating call and also preference control circuitry;

FIG. 26 shows a portion of the shift register circuitry utilized in storing information received from and transmitted to the remote unit;

FIG. 27 includes additional timing circuitry for governing the control functions of the concentrator;

FIG. 28 includes call preferance control circuitry for remote unit **0** in detail and for remote unit **1** in outline form;

FIG. 29 includes the details of the trunk selection circuitry for both remote units;

FIG. 30 includes the contacts of relays responsive to the binary cells of the shift register;

FIG. 31 includes additional shift register circuitry used in conjunction with that of FIG. 26;

FIG. 32 includes a binary counter for use in governing the timing of control functions in the control unit of the line concentrator;

FIG. 33 shows the relays used in registering the identification of a line being serviced;

FIG. 34 includes the relay circuitry for determining trunk preference for utilization in conjunction with the selection circuitry of FIG. 29;

FIG. 35 shows additional relay contact circuitry responsive to the shift register;

FIGS. 36 and 37 include additional relay circuitry for exercising control functions in the line concentrator;

FIG. 38 includes the check circuitry for the line identification;

FIG. 39 includes relay circuitry for use in releasing the control relays of the control unit;

FIG. 40 includes trunk verification and checking circuitry;

FIG. 41 includes auxiliary input relay circuitry;

FIG. 41A shows relative disposition of FIGS. 2–41;

FIGS. 42–44 disclose the detailed circuitry of the Or-Not gates;

FIG. 45 shows the details of the binary counter circuit;

FIG. 46 is a detailed rendition of the circuitry of the flip-flop package;

FIG. 47 shows the details of the monopulser described in FIGS. 2–41 in outline form;

FIG. 48 shows the details of the multivibrator circuit;

FIG. 49 shows the details of the monopulser for use in the shift register shown in outline form in FIGS. 5, 10, 26 and 31;

FIGS. 42A–49A show the symbolic representation of the circuitry set forth in FIGS. 42–49, respectively;

FIGS. 50A and 50B show the symbolic representation of the circuitry set forth in FIG. 50 and located, respectively, at the remote unit and control unit;

FIG. 50 shows the details of the discriminator circuit shown in outline form in FIGS. 15 and 20;

FIG. 51 shows the details of the guard interval timer 15GIT and 20GIT**0/1**;

FIG. 52 shows the details of the signal present detector shown in outline form in FIGS. 15 and 20;

FIG. 53 shows the details of the modulator circuit 15M and 20M**0/1**;

FIG. 54 shows the details of the power amplifier 15PA and 20PA;

FIG. 55 shows the details of the send filter utilized in conjunction with the modulators at both the remote units and the control units;

FIG. 56 shows the details of the limiters 15L and 20L**0/1**;

FIG. 57 shows the components of the receive filter 15FR and 20FR**0/1**; and

FIGS. 51A–57A show the symbolic representation of the circuitry set forth in FIGS. 51–57, respectively. 57, respectively.

The above-referred-to circuitry is jointly described in the present specification and in application Serial No. 344,980, filed on even date herewith of Rettig-Riedel-Stagg-Trumbull and also application Serial No. 344,863, filed on even date herewith of A. R. Trumbull.

In describing the invention, the subject matter has been given a general treatment followed by a detailed description in accordance with the following index:

INDEX

1.—GENERAL DESCRIPTION

Referring now to FIGS. 1A through 1D which show the concentrator in outline form, it is seen that the single control unit at the office serves two remote units **0** and **1**, the former being shown in outline form and the latter generally.

1.1 *General description of major components*

A number of subscribers which may illustratively total as many as seventy-eight at each remote unit are coupled to line circuits **10** in the office. The lines are further extended to crossbar switch network **11** by means of which they are coupled to a relatively smaller number of trunks **12**. The trunks in turn extend to a similar crossbar switch **150** at the central office control unit. At that location the lines are reexpanded through the switch to a number of line circuits **151** in the office equal in number to the remote substation lines.

The electromechanical portion of the remote unit **0** is shown in FIG. 1A and includes control facilities **15** for selecting the particular hold magnet (unique to a line) and select magnet facilities **16** (unique to a trunk) to extend connections therebetween. In addition, a signal input circuit **17** and signal output circuit **18** act as buffers between the electronic circuitry of FIG. 1B and the electronic circuitry of FIG. 1A. A line lockout circuit **19** includes facilities responsive to the energization of a relay in line circuit **10** to identify the relay and deliver the information to the line register **100**.

The trunk register and preselection circuit **101** is adapted to receive information from the control unit indicative of a preselected trunk and the disconnect control circuit **102** is effective when directed by the control unit to disconnect a particular line from a trunk which is preselected for the next service request or terminating call.

Substantially all operations in the electromechanical circuitry are checked in checking circuit **103**. A timing circuit **104** is effective when the performance time of a particular function exceeds a predetermined time interval to effect a release of the equipment and to recycle or reinstitute the same function through sequence control circuit **105**.

A signal control circuit **106** at the remote unit is effective to energize the electronic circuitry in preparation for signal transmission or reception. Release control circuit **107** is operative to supervise the release of all of the control circuitry in the electromechanical equipment and ultimately the only devices remaining operated in the electromechanical portion are the hold magnets which are magnetically latching and, therefore, do not require a continuous power supply as explained herein.

A data unit **108** adapted to initiate and receive data messages is used in conjunction with each substation **107**. Thus, an off-hook condition at the substation will initiate a combined data transmission path and speech transmission path through the concentrator in the manner explained herein.

All of the signal transmission to and from the control unit is effected by high speed electronic circuitry shown in outline form for remote unit **0** in FIG. 1B. The point of ingress and egress for information to the electronic circuitry is the shift register **109** which is adapted to deliver information in parallel to the electromechanical equipment as well as receive information in parallel from the electronic equipment through the buffer stores **17** and **18**. Moreover, the shift register is arranged to deliver information serially to the sender circuit **110** and to receive information in serial form from the receiver circuit **111**. The over-all sequence of operation of the electronic circuitry is reposed in control circuit **112**. The basic program of operation of the shift register in receiving and transmitting information is controlled by the clock generator **113** and the number of program repetitions is measured by counter **114**.

The basic elements of the sender circuit include a modulator **115** responsive to binary conditions at the output of shift register **109** to deliver corresponding mark or space signals on a frequency shift basis through filter **116** and power amplifier **117** over control conductors **118** to a corresponding receiver for remote unit **0** at the control unit.

Transmission from the second unit to the remote unit **0** takes place over control conductors **119**, transformer **120** and filter **121** where the signal is delivered to a signal present detector **122**. The latter meters the time during which a signal pulse is applied to verify that the transmission is a valid signal and that it exceeds a predetermined length and is not a "hit" or transient, spurious signal. If the signal is valid the control circuit **112** as well as the clock generator **113** are activated and specific signals are delivered from filter **121** through limiter **122** to the discriminator **123** which identifies the signals as mark or space and delivers corresponding binary indicia to the shift register **109** which at this time is advanced under control of the clock generator **113**.

The equipment in the control unit includes (FIG. 1C) a hold magnet control and select magnet control **124** and **125** which perform functions analogous to controls **15** and **16** of the remote unit. The line lockout circuit **126** acts in response to sleeve relays in the line circuit **153** in a manner analogous to the response of line lockout circuit **19** to the line relays of line circuit **10**. The information translated in line lockout circuit **126** is delivered to register and check circuit **127**. The timing circuit **128**, release control circuit **129** and signal control circuit **130** perform functions similar to their counterparts at the remote unit. The preference control circuit **133** is effective to determine the trunk which is preselected for the next service request or terminating call. The trunk thus selected is stored in the preselected trunk register **134**. The trunk busy control **135** ascertains the number of trunks which are in the busy condition.

The electronic logic circuitry of FIG. 1D is similar to the equipment in the remote unit with the exception that separate sender and receivers are utilized for remote unit **0** and remote unit **1** although the shift register **136** and the related control equipment is common to both remote units.

1.2 *Synchronization*

An essential aspect of the transmitting and receiving facilities which are shown in further detail in FIGS. 2–41

include equipment for synchronizing counter **114** of the remote unit **0** with the counter **138** of the control circuit in the central office.

Essentially, this operation is predicated on the interaction of equipment in the control circuit **112**, the clock generator **113** and the counter **114**. As shown in further detail in FIG. 16, the clock generator includes a multivibrator **16K** and a number of gating circuits **16PG1G** through **16PG3G**, inclusive. These in turn control the stepping of shift register **109** and the storage therein and reading out of information. Counter **114** is directly responsive to the operation of the multivibrator **113** and the control gates to count the number of gate sequences to the shift register. In effect, the binary counter also acts as a frequency divider in converting the 3200 pulses per second multivibrator output to 200 pulses per second.

At all times the multivibrator included within the clock generator **113** of the remote unit of FIG. 1B and the corresponding multivibrator included within the clock generator **137** of FIG. 1D are permitted to operate independently and no effort is made to key one from the other or to "slave" one to the other.

Instead, the counter **114** and the counter **138** are intermittently set at the same count by use of the guard interval timer (not shown but see timer **15GIT** of the remote unit or the corresponding timer **20GIT-** of the control unit) depending on the direction in which information is being transmitted. Thus, on a service request or originating call wherein information respecting line identity is transmitted from the remote unit to the control unit via the shift register **109** and the sender circuit **110**, the information is preceded by a start signal. During the start signal, the clock generator **113** is active and the corresponding counter **114** continues to count the pulses distributed by the clock generator. However, the clock generator **137** of the remote unit is not yet active at this time and the counter **138** thereat continues to register a count of 0. An accurate timing circuit (not shown, see timer **20GIT-**) which is triggered by the start pulse measures a predetermined interval of time, illustratively 4.06 milliseconds. If the start signal persists for that length of time, the guard interval timer interprets the signal as genuine (rather than a "hit" or other transient disturbance) and energizes the control circuit **139** to set the counter **138** at the count (illustratively, thirteen) which would have been achieved if the clock generator **137** had been active from the time of the initial reception of the start pulse. Since the clock generator **113** of the remote unit has indeed been active during this period, the counter **114** at the remote unit also registers a count of 13. Consequently, both counters are in synchronism (except for transmission delay) and the clock generators **113** and **137**, which are now both active, continue to step the respective counters **114** and **138** in synchronism.

A similar synchronism operation is reeffected each time the intelligence information (subsequent to the start signal) undergoes a space-to-mark frequency transition.

2.—GENERAL DESCRIPTION OF OPERATION

2.1 *Service request call*

It will be assumed for purposes of illustration that a subscriber at substation **107** is initiating a service request call. When substation **107** goes off hook, a line relay (not shown—but shown in detail in FIG. 2) unique to the calling subscriber's line in line circuit **10** is operated. The line lockout circuit **19** is energized to operate a particular tens relay and units relay identifying the calling line. Thereafter the information is transferred to the line register circuit **100** and checked in the checking circuit **103**.

Under the control of circuit **106** the information stored in the line register is delivered through buffer circuitry **18** to the shift register **109**. The signal control circuit **106** delivers a start signal to the electronic control circuit **112** which initates the operation of the clock generator **113** to activate the shift register **109** and the counter **114** for the purpose of delivering the line identification to the control unit.

The information from the shift register **109** is delivered through modulator **115** which converts the binary conditions in the shift register to corresponding mark and space signals and thereafter through filter **116** and power stage **117** over control conductors **118** to the receiver circuit for remote unit **0** at the central office.

When the signal present detector **144** recognizes a legitimate signal (as distinguished from a "hit" or transient), it enables the control circuit **139** which in turn energizes clock circuit **137** to govern the storage of the line identity in the shift register **136**. In the interim, the control signal pair **149** extending to the remote unit **1** is disabled to prevent the transmission of a service request by that unit, and in consequence, the remote unit **1** disables the signal pair to the control unit.

When it is determined that the complete line identity has been received in shift register **136**, the line information thus stored is transfered on a parallel basis through signal input buffer circuitry **131** to the line register and check circuit **127**. When the line information is registered and check in the circuitry of FIG. 1C, the hold magnet control circuit **124** is energized to operate the hold magnet unique to the line requesting service, the select magnet having been previously operated. At the remote unit, in the interim, the select magnet corresponding to the preselected trunk was operated followed by the operation of the hold magnet unique to the service requesting line.

The trunk identity of the trunk at the control unit utilized on the call is delivered to signal output circuit **132** and subsequently transferred to the shift register **136** in parallel. The information thus transferred represents the identity of the actual trunk utilized in completing the call.

At this time, a procedure is initiated for transmitting to the remote unit the identity of the trunk stored in the shift register. It should be noted that the remote unit is already aware of the identity of the preselected trunk and, in fact, has presumably connected the service requesting line to the preselected trunk by the operation of the select and hold magnets as described above. However, to verify that the trunk actually utilized in completing the connection at the remote unit is the same as the trunk actually utilized in completing the connection at the control unit, the shift register **136** is activated under control of clock circuit **137** to transmit the actual trunk identity to the remote unit through modulator **145**, filter **147**, amplifier **148** and conductors **119** to the receiver circuit at the remote unit. This information is stored in the shift register **109** in the manner described above and when the transmission of trunk information is completed, the electronic logic circuitry including control circuit **112** delivers a read-out signal to signal control circuit **106** which in turn effects the storage of the trunk information in signal input buffer circuit **17** in parallel. The trunk number is thereafter delivered to the trunk register circuit **101** where it is compared with the trunk number actually used in completing the connection at the remote unit.

Subsequent to the transmission of trunk information by the control unit, the signal pair to the remote unit **0** is disabled (opened). In response thereto, remote unit **0** releases trunk register **101** and in turn causes the signal pair **118** to the control unit to be opened to prepare the control unit for release.

The control unit thereafter enables or closes the signal pair **119** to the remote unit effecting the release of the solid state logic circuitry and the control relays at the remote unit. When the release is checked by release circuit **107**, the signal pair **118** to the control unit is again closed causing the release of the equipment in the control circuit as governed by release control **129**.

At this time all of the electronic logic circuitry is quiescent except for the continuous transmission of the spacing signal by the sender circuits. Since the hold magnets of the crossbar switches **11** and **150** are magnetically latched, a path may be traced from substation **107** and data unit **108** through line circuit **10** (from which all bridging impedances have been removed), crossbar switch **11**, preselected trunk **12**, crossbar switch **150** to the unique termination in the central office line circuits **151** to which substation **107** and data unit **108** would have been connected if directly connected to the office. Since the central office is unaware that the central office line circuit unique to the concentrator line is, in fact, not directly terminated at the central office, it proceeds to service the call in a conventional manner by the return of dial tone, etc.

When the digits of the called substation have been dialed and the central office extends the connection, conversation and/or data transmission takes place in the conventional manner. However, when the conversation or data transmission is completed and the substation **107** is returned to the on-hook condition, the train through the central office is released but the vertical magnets in the crossbar switches **11** and **150** unique to the calling subscriber's line remain held operated or magnetically latched. Thus, although the subscriber at substation **107** has returned to the on-hook condition, a direct connection extends through the concentrator switching network to the central office line termination unique to the substation line. Moreover, all but one of the illustrative sixteen trunks are maintained in this "cut-through" condition and, in consequence, 15 of the approximately 80 substations are always directly connected to the office. The advantages of such an arrangement include the possibility of continuing service to those substations despite a complete failure in operation of the concentrator and, moreover, the "recall" time, i.e., the time required to make a second call after the substation returns to the on-hook condition, is correspondingly diminished since the operating time of the concentrator is no longer effective.

2.2 *Terminating call*

A terminating call is initiated in the central office line circuits **151** when the office grounds the line sleeve lead (not shown but see FIGS. 17 and 22) in the conventional manner. The line is identified in consequence of the operation of a relay in the line circuit **153** and corresponding identifying relays in the line lockout circuit **126**. The information representing the line identification of the called line is stored in register **127** and the select magnets associated with the preselected trunk are operated by select magnet control **125**. During the registration of the line identification, the signal pair **149** to remote unit **1** is disabled (assuming the called line is in remote unit **0**). In consequence, the remote unit **1** disables the signal pair to the control unit. The receiving circuit in the control unit detects that the signal pair from the remote unit has been disabled.

After registration is completed and checked, the line identification is transferred to the shift register **136** through signal output circuit **132**. At this time the electronic logic circuitry energizes the shift register **136** to transmit the line identification to the remote unit in a manner analogous to that described above for transmission of line information during a service request call.

At this time the hold magnet control circuit **124** operates and checks the hold magnet in the crossbar switch **150** unique to the line being called.

At the remote unit the information transmitted is stored in the shift register **109**. The select magnets associated with the preselected trunk are operated by select magnet control **16**. Upon completion of transmission, the line information is delivered in parallel from the shift register through the signal input circuit **17** to the line register circuit **100**. Upon registration of the line information, the hold magnet control **15** energizes the appropriate hold magnet.

When the hold magnet is operated, the number of the trunk used on the call is delivered through the signal output circuit **18** to the shift register **109** and is thereupon transmitted to the control circuit. The signaling circuitry in the control until receives the information and thereupon opens the signal pair **118** to the remote circuit. Upon completion of transmission of the trunk identity, the remote unit opens the signal pair to the control unit.

Again, the control unit detects the opening of the signal pair from the remote unit and delivers the trunk identity to register **127** where it is stored. The trunk number thus received is compared with the trunk number used for the actual connection at the control unit and if these numbers agree, the electromechanical equipment in the control unit is partially released and the signal pair to the remote unit is again closed. The closure of the signal pair **119** is detected in the remote unit and results in the release of the equipment thereat. When appropriate release is varified, the signal pair **118** to the control circuit is closed, in turn causing the release of the equipment at the control circuit.

2.3 *Disconnect call*

A disconnect call is initiated following each service request or terminating call. The trunk selected for disconnection is ascertained in a manner explained hereinafter in detail and the line coupled to the selected trunk is identified. The sequence of operations for a disconnect call is similar to that described above for a terminating call except that no select magnet will be operated and instead the hold magnets will be released. Moreover, the number of the trunk to be disconnected is sent to the remote unit instead of the line number.

2.4 *Service denial call*

A service denial call is utilized, in part, for preventing trouble conditions on a substation line from holding a trunk out of service. In effect, the service denial call prevents origination or termination of calls to the service denied line.

The sequence of operations for a service denial call is similar to that described above for a terminating call but the select magnets are not operated. Thus, when the hold magnets are operated alone, no crosspoint contacts are closed and the line is cut off. The denial condition remains in effect until a release service denial call is made which too is similar in operation to a terminating call with the exception that the select magnets are not operated and the hold magnets are released.

3.—DETAILED DESCRIPTION OF MAJOR COMPONENTS

3.1 *Line and trunk switching*

3.11 REMOTE UNIT

Referring to FIGS. 2 and 3 at the remote unit and corresponding FIGS. 17 and 18 at the control unit, crosspoint networks of the magnetic latching type described in an article entitled "Magnetic Latching Crossbar Switches" in the Bell System Technical Journal, September 1960, at page 1351, are utilized. The magnetic latching facilities include hold magnets (vertical magnets) which remain operated until deliberately released. No additional power drain ensues once the vertical magnets have been operated. Since the delayed disconnect arrangement described generally above, wherein 15 of the 16 trunks normally will be connected to lines at all times, will be utilized, the power savings are apparent.

As shown in FIG. 2, the lines to be concentrated are coupled to the verticals of the crossbar switch whereas the trunks are connected to the switch horizontals. Thus, for switch A of FIG. 2, 20 lines, **0–19**, are coupled to the verticals and 16 trunks including conductors **T00** and **R00** through **T15** and **R15** are coupled to the horizontals. Switch levels **L8** and **L9** are used for selecting one of the two trunks coupled to each horizontal level **L0–L7** (of which only **L0** and **L7** are shown). In this manner, substation **0** may be connected to either trunk **T00** and **R00** or **T01** and **R01** depending on which steering level switch, **L8** or **L9**, is closed.

3.12 CONTROL UNIT

A substantially similar analysis may be made with respect to the switches shown in FIGS. 17 and 18. Here again, 20 lines are coupled to the verticals of four switches, A–D (of which only A and D are shown in detail). Two lines are reserved for testing purposes and are not associated with subscribers. A trunk incoming to switch A of group **0** may be connected to the appropriate line by closing the crosspoint contacts on one switching level, **L0–L7**, and one steering level, **L8** or **L9**. The switches at the control unit depart from those at the remote unit in that a full complement must be provided for the lines of remote unit **1** as well as remote unit **0**. Thus, the switches for remote unit **0** are shown in detail on FIG. 17 and 18 and the switches for remote unit **1** indicated in the drawing as group **1** are shown in outline form in FIG. 24 and are duplicates of the switches shown in FIGS. 17 and 18. The vertical magnets of the crossbar switches in the control unit are also magnetically latching and may be of the type disclosed in the above-referred-to publication.

3.2 *Signaling*

The signaling circuits at the remote and control units are equipped to complement each other and since the sending and receiving circuits for both units are similar, only one need be described. The sending and receiving circuits for the remote unit and control unit are shown in outline form in FIGS. 15 and 20 and in further detail in FIGS. 50–58. The sending circuit includes a modulator shown in FIG. 53, a send filter shown in FIG. 55, and a power amplifier shown in FIG. 54.

The receiving circuit includes a limiter shown in FIG. 56, a receiver filter of FIG. 57, a signal present detector of FIG. 52, and a guard interval timer of FIG. 51.

3.21 SEND CIRCUIT, MODULATOR

Referring first to the send circuit, the frequency of the modulator of FIG. 53 is controlled by a transistor switch **Q1** which has a potential approaching ground applied to the base thereof or an off-normal potential of approximately +6 volts. The tank circuit including inductors **T1** and **T2** and capacitor **C1** is arranged in order that the application of a ground potential to the base of the switch will produce an oscillation frequency of substantially 2025 c.p.s. representing the spacing frequency at the control unit (F2S).

When the input to the base conductor A is changed to +6 volts, the frequency of oscillation is modified to 2225 c.p.s. representing the mark frequency at the control unit (F2M).

The output of the modulator is delivered through a normal contact of relay **38OL0** in the case of the send circuit **0**, in parallel with a combination of make contacts of relays **41SR0**, **28TER0** and **41ATC01** to the send filter of FIG. 55.

3.22 SEND CIRCUIT, FILLER AND POWER AMPLIFIER

The latter filter is a bandpass filter substantially in the range of 2025 c.p.s.–225 c.p.s. and prevents undesired signals from reaching the power amplifier stage. As seen in FIGS. 54 and 55, the output of the send filter is delivered to transistor **Q3** of the power amplifier over capacitor **C5**. The output of the power amplifier is delivered over transformer **T3** to the control pair extending to the appropriate remote unit.

The purpose of providing the contacts of relays **38OL0**, **41ATC01**, **28TER0** and **41SR0** intermediate the modulator and the send filter is to control the path at the output of the modulator. By interrupting this path all signal frequencies emanating from the sender may be interrupted, thereby opening the control pair to the remote unit. As indicated above and also herein in detail, this condition represents a signal to the distant unit to initiate appropriate circuit operations.

3.23 RECEIVE CIRCUIT, FILTER AND LIMITER

The receive circuit shown in FIG. 20 is adapted to receive signals from the control pair which are delivered through the input transformer to the receive filter of FIG. 57. The latter delivers the signals to the limiter of FIG. 56. The input to the limiter circuit is at terminal A of FIG. 56. The output from the limiter is derived at terminals D, E, and F. There are five transistor amplifier stages and two limiter stages.

Transistor **Q1** and its associated biasing resistors **R5**, **R7**, **R8** and **R9** comprise the first stage of amplification along with potentiometer **R10** and capacitor **C3**. Capacitor **C3** is an alternating-current bypass path and is used with potentiometer **R10** to control the gain of transistor **Q1**. Transistor **Q2** with biasing resistors **R11**, **R12**, **R13** and **R14** comprise the second stage of amplification. Capacitor **C6** and varistor **RV1** are the first stage of limiting. The third stage of amplification consists of biasing resistors **R15**, **R16**, **R17** and **R18** with transistor **Q3**. Capacitor **C7** and varistor **RV2** provide the second and final stage of limiting.

Transistor **Q4**, biasing resistors **R19**, **R20** and **R23** and the alternating-current bypass network **C9** and **R21** make up the fourth stage of amplification. The collector load of transistor **Q4** is a tuned circuit combination provided in the discriminator circuits of FIG. 50. The fifth transistor stage (**Q5**) with biasing resistors **R4** and **R24** and potentiometer **R2** is an emitter follower stage which feeds the signal present detector of FIG. 52.

Capacitors **C1**, **C4**, **C5**, **C8**, **C10** and **C11** are used to couple the outputs and inputs of the amplifier stages. Resistor **R6** and capacitor **C2** provide an alternating-current bypass path for the positive power supply; and resistor **R22** and capacitor **C12** provide an alternating-current bypass path for the negative power supply.

3.24 RECEIVE CIRCUIT, DISCRIMINATOR (FIG. 50)

The discriminator of FIG. 50 includes two tuned tank circuits comprising capacitor **C1** and transformer **T1** for the 1020 c.p.s. frequency, and capacitor **C2** and transformer **T2** for the 1270 c.p.s. frequency. The two tank circuits in series represent the load for transistor **Q4** of the limiter described in Section 3.23.

A diode bridge is across the output side of each transformer. Diodes **CR1**, **CR2**, **CR3** and **CR4** form a negatively polarized bridge for the tuned circuit **T1** and **C1**. This tuned circuit recognizes the 1070 c.p.s. frequency and when it is present develops a negative potential across the load resistor **R1**.

Diodes **CR5**, **CR6**, **CR7** and **CR8** form a positively polarized bridge for the tuned circuit **T2** and **C2**. This tuned circuit recognizes the 1270 c.p.s. frequency and develops a positive potential across the load resistor **R2** when it is present. In each case the discriminating network is tuned such that the frequencies are sufficiently far apart to produce resonance for only one tuned circuit per frequency.

Capacitors **C3** and **C4** are smoothing capacitors to filter out the alternating-current ripple after detection. The signals obtained at terminal **1** of inductor **L1** are fed through the low pass filter consisting of inductor **L1** and capacitor **C5** to the base of transistor **Q1**. Provision is made to center the position of the discriminator S-shaped curve by means of potentiometer **R3**.

Normally, with 1070 c.p.s. (space frequency) present, the base of transistor **Q1** is negative thus holding it in the nonconducting or "off" state. This puts +12 volts through resistors **R6** and **R7** to the base of transistor **Q2** to hold it in the conducting or "on" state. With transistor **Q2** "on," the output is "near-ground" potential at the collector of transistor **Q2**. The input terminal to the base of transistor **Q2** and resistor **R11** are used to make transistor **Q2** an "Or-Not-gate." This lead is under control

of the signal present detector (Section 3.25 infra) and will have a "near-ground" potential present when the signal present detector is activated.

When the mark frequency is detected by the discriminator, a positive potential on the base of transistor **Q1** turns it "on." Ground through transistor **Q1**, with "near-input provides an "off-ground" potential output at terminal **1**, will now turn transistor **Q2** "off." This places +12 volts at the collector of transistor **Q2**. Thus, a mark input provides an "of-ground" potential output at terminal **1**, while a space input provides a "near-ground" potential output.

The purpose of resistor **R10** and capacitor **C6** is to provide positive feedback to transistor **Q1** to give sharp transitions at the collector of transistor **Q2** as transistor **Q2** switches on and off.

3.25 SIGNAL PRESENT DETECTOR

The signal present detector is responsive to the space frequency to present a "zero" condition to gate **20ST0G** and inverter **20STA0I**. The latter operates relay **20ITA0** as an indication that the presence of a signal was detected.

The input to the signal present detector comes from the fifth stage of the limiter (FIG. 56). The potentiometer associated with this fifth stage on the limiter controls the input level. This input is coupled through transformer **T1** and rectified by the diode bridge of **CR1**, **CR2**, **CR3** and **CR4**. Resistor **R23** provides the load for the bridge and capacitor **C4** provides a smoothing effect. The rectified signal is fed through resistor **R24** to the base of transistor **Q7**.

With no input signal, transistor **Q7** is in the "off" state. This presents +12 volts through resistors **R25** and **R26** to the base of transistor **Q8**. This "off-ground" potential will turn transistor **Q8** "on." The collector load of transistor **Q8** normally consists of a reed relay (e.g., relay **20ITA0**) to +12 volts connected at the collector terminal. If the rectified signal at the base of transistor **Q7** is sufficiently positive, transistor **Q7** will turn "on." This presents "near-ground" potential to the base of transistor **Q8** to turn it "off." This will remove the "near-ground" potential from the collector to release the relay. Thus, when a valid signal is present, relay **20ITA0** is released, whereas relay **20ITA0** operates when the input to the detector is removed. Resistor **R27** provides positive feedback to transistor **Q7** to give sharp transitions at the collectors of transistors **Q7** and **Q8**.

3.26 GUARD INTERVAL TIMER

The guard interval timer **20GIT0** is triggered by the change from a "zero" condition to a "one" condition, as shown in FIG. 51, and the output thereof changes from a "zero" condition to a "one" condition.

Transistors **Q1** and **Q2** comprise a monopulser type circuit with a timing interval of 4.06 milliseconds. There is no positive feedback from transistor **Q2** to transistor **Q1** thus requiring that the input pulse at the base terminal of transistor **Q1** be equal to or greater than the timing interval of the monopulser. In this manner, the monopulser guards against a false trigger. Thus, a legitimate signal must be present to activate the output of the guard interval timer.

In the normal condition "near-ground" potential is present at a terminal A holding transistors **Q1** and **Q3** in the "off" state. With transistor **Q1** "off," +12 volts through resistors **R4** and **R5** to the base of transistor **Q2**, hold transistor **Q2** in the conducting or ON condition. This presents "near-ground" potential through resistors **R7** and **R10** to the base of transistor **Q4**. However, with transistor **Q3** in the "off" state, +12 volts through resistors **R12**, **R13** and **R16** is also presented at the base of transistor **Q4**. Transistor **Q4** is an Or-Not gate and will be turned "on" if presented with an "off-ground" potential from either transistor **Q2** or transistor **Q3**. Therefore, in the normal state, transistor **Q4** is "on" and supplies "near-ground" potential to the base of transistor **Q5** to hold transistor **Q5** in the "off" state.

Transistors Q5 and Q6 comprise a monopulser type circuit with a timing interval of 20 microseconds. With transistor Q5 turned "off," +12 volts through resistor R20 holds transistor Q6 in the "on" state. This presents "near-ground" potential at the output terminal.

In the normal state, capacitor C1 holds a charge with +12 volts on one side and approximately +0.8 volt on the other side at the base of transistor Q2. If a legitimate signal of "off-ground" potential is now applied at terminal A, transistors Q1 and Q3 both change to the "on" state. When transistor Q1 starts conducting, the voltage on each side of capacitor C1 suddenly drops by approximately 12 volts. Thus, diode CR5 is back biased and removes the base current to transistor Q2 to turn transistor Q2 "off." When transistor Q2 is turned "off," +12 volts through resistors R6 and R10 is present at the base of transistor Q4, and with transistor Q3 now in the "on" state, "near-ground" potential through resistors R13 and R16 is also presented to the base of transistor Q4. At this point, to prevent false circuit operation, transistor Q4 should not change its state. This requires that the "off-ground" potential from transistor Q2 turning "off" must be present before the "off-ground" potential from transistor Q3 turning "on" is removed. To insure that this requirement is met, the delay network of capacitor C2 and resistors R14 and R15 is used to maintain an "off-ground" potential at the base of transistor Q4 until the "off-ground" potential from transistor Q2 is present. In this manner, transistor Q4 remains in the "on" state.

The potential on diode CR5 rises as capacitor C1 charges from +12 volts through resistors R4, R5, and transistor Q1 to ground. After a time interval of 4.06 milliseconds, the potential at diode CR5 is sufficiently positive to forward bias the diode and to turn transistor Q2 back to the "on" state. This replaces the "off-ground" potential provided to the base of transistor Q4 with a "near-ground" potential. The Or-Not condition of transistor Q4 is now satisfied with "near-ground" potential supplied from both transistors Q2 and Q3, and transistor Q4 now turns "off." This presents a high potential to the base of transistor Q5 to turn transistor Q5 "on." In the normal state, capacitor C6 was charged from approximately +0.8 volt at the base of transistor Q6 to +6.4 volts at the collector of transistor Q5. The 6.4 volts is determined by the voltage divider resistors R19 and R21. When transistor Q5 turns "on," its collector drops to a "near-ground" potential. Capacitor C6 couples this drop in voltage to the base of transistor Q6 to turn transistor Q6 "off." Capacitor C6 now charges from +12 volts through resistor R20, capacitor C6 and transistor Q5 to ground causing the base voltage of transistor Q6 to rise until it is sufficiently positive to turn transistor Q6 back "on." The time interval to return transistor Q6 to the "on" state is nominally 20 microseconds. Thus, a legitimate input signal at terminal A results in a 20 microsecond positive output pulse which is delayed by 4.06 milliseconds.

To prevent the possibility of giving an indication when a false "off-ground" potential is removed from terminal A, the delay network of capacitor C3, resistors R8 and R9 is provided. As the false "off-ground" potential is replaced by "near-ground" potential at terminal A, transistors Q1 and Q3 turn "off." When transistor Q1 turns "off," transistor Q2 will turn "on" (since 4.06 milliseconds have not yet elapsed and transistor Q2 was "off"). To prevent transistor Q4 from turning "off," the "off-ground" potential supplied from transistor stage Q3 must be applied to the base of transistor Q4 before the "off-ground" potential from transistor stage Q3 is removed.

A delay circuit in the guard interval timer including capacitor C3 and resistors R8 and R9 insures that the gate 20GIT0I presents a "zero" condition to gate 20MT0G prior to the time that the guard interval timer delivers a "one" condition to the same gate. At the conclusion of the predetermined interval (4.06 milliseconds), the guard interval timer converts back to a "zero" condition since transistor Q2 is again energized over resistors R4 and R5. At this time, gate 20MT0G has a "zero" condition applied to both input leads and therefore delivers a "one" condition to monopulser 20MT0. The latter in turn is arranged to provide a 20 microsecond pulse over conductor 20MT0C to the electronic logic circuitry. As explained above in general terms and hereinafter in detail, this pulse enables the remote unit to be synchronized with the control unit.

3.3 *Synchronization*

In order to synchronize the remote unit and control unit, a multivibrator is provided at each of the units and is shown in outline form for the control unit at FIG. 21 as oscillator 21K and for the remote unit as oscillator 16K. The multivibrator is shown in detail at FIG. 48.

Referring to the operation of the equipment at the control unit, the oscillator 21K delivers pulses at a 3200 p.p.s. rate to the binary cells 21P1BC, 21P2BC, 21P4BC and 21P8BC. The latter divides the 3200 p.p.s. rate by 16 to give the desired 200 p.p.s. rate with a pulse period of 5 milliseconds. The binary cells permit the selection of up to 16 pulses during each pulse period. In the present arrangement of the 16 pulse positions available, only three are utilized.

3.31 SHIFT PULSE

When the oscillator 21K is energized to deliver its 3200 p.p.s. output to the binary counter cells, the four-stage counter acts as a frequency divider to provide a 200 p.p.s. output. In consequence, every 5 milliseconds a pulse sequence is produced from gates 21PG1G, 21PG2G and 21PG3G. A shift pulse is provided whenever gate 21PG1G is energized. As seen from FIG. 21, this condition obtains when binary cell 21P1BC is in the "one" condition, binary cell 21P2BC is in the "zero" condition, binary cell 21P4BC is in the "one" condition and binary cell 21P8BC is in the "zero" condition. At this time, gate 21PG1G will be energized and deliver a pulse over conductor 21SPC, monopulser 27T5MP, gate 27RSG, inverter 27INV51, and conductor 27RC to the reset inputs of the shift register to advance the information stored in the register.

3.32 "WRITE" PULSE

Gate 21PG2G may similarly be shown to be energized when the binary cells 21P1BC–21P8BC are respectively in the condition 0110. When gate 21PG2G is enabled, a pulse is delivered over inverter 21INV81, conductor 21KC, gate 27WGG, monopulser 27T3MP, conductor 27T3C to the input of the first shift register stage 31SA7FF to write a "one" in the first shift register stage.

3.33 CALL PROGRESS PULSE

Similarly, whenever gate 21PG3G is enabled by virtue of the binary number 1110 in the cells 21P1BC–21P8BC, respectively, a pulse is delivered over conductor 21CAC. This signal extends to monopulser 27T4MP and in turn to the input to the call progress counter 32CTR1BC–32CTR16BC of FIG. 32.

Thus, every 5 milliseconds a pulse sequence is produced from the gates 21PG1G–21PG3G as long as oscillator 21K is operated.

The operation of the corresponding gates 16PG1G–16PG3G in response to the remote unit oscillator 16K is similar to that described above for the control unit. In order to synchronize the distant units with each other, the guard interval timer 20GIT0 (see Section 3.26 supra) is arranged to establish a predetermined state in the binary cells equivalent to the state which would have been achieved after 4.06 milliseconds. Thus, if the remote unit initiates transmission to the control unit, the guard interval timer at the control unit will respond to the start pulse and generate a 4.06 millisecond interval. During this interval, oscillator 21K is not yet energized but oscillator 16K is already operating and triggering the gates

16PG1G–16PG3G in the appropriate sequence. After the predetermined interval of 4.06 milliseconds, the guard interval timer 20GIT0 delivers an output through monopulser 20MT0MP and conductor 20MT0C to set cells 21P1BC–21P8BC in accordance with the digits 1011, respectively. During this interval, the corresponding binary counter 16P1BC–16P8BC has been set to the same condition by its local oscillator 16K. At this time, oscillator 21K is energized, as explained herein, and begins to cycle the counter at the prescribed rate. Since the binary cells 16P1BC–16P8BC at the remote unit and 21P1BC–21P8BC at the control unit are in the same condition when oscillator 21K is first energized, synchronism is established between the remote unit and the control unit.

3.4 *Trunk selection*

As explained above in general outline, 15 trunks remain connected through to the office when the concentrator control equipment is idle. As a result, after each service request call or terminating call, all (16) trunks will be connected through and it is essential to disconnect one of the trunks in order to process the next call.

The logic circuitry has been arranged to store the identification of a trunk which is disconnected on a disconnect call for use as the preselected trunk on the next service request or terminating call, thereby enabling the appropriate hold magnets to be operated when the line information is provided.

There are two types of trunk selection functions. The first applies to a situation in which 15 trunks are connected to the office and a service request call or terminating call has been made, thereby necessitating a disconnect call since all of the trunks are now connected through. This is referred to herein as a "normal disconnect" call.

Special provisions have been made to cover the situation where, for some reason, less than 15 trunks are connected to the office. Under these conditions, preference will be accorded to those trunks which are not connected through to the office and the procedure is termed a "special disconnect" call.

3.41 TRUNK PREFERENCE AND SELECTION ON NORMAL DISCONNECT CALL

The trunk preferred for disconnection is determined by a combination of relays 34TPR01–34TPR05 and relays 34Z0 and 34W0. After a trunk has been selected, one or more of these relays is actuated to change the preference of the trunk selected for the next call. In this manner a particular trunk is preferred once during sixteen successive calls.

The trunk preference circuit is arranged to operate relay 34TPR01 when battery is supplied to the circuit.

Thus, a path may be traced from negative battery, resistance 341, winding of relay 34W0, contacts of relay 34W0, contacts of relays 34TPR05 and 34TPR01 to ground. Relay 34Z0 does not operate at this time in view of the ground condition at both sides of the relay winding.

Operation of relay 34W0 closes an operating path for relay 34TPR01 over the normally closed contacts of relay 34Z0. This path may be traced from negative battery, contacts of relay 34TPR05, winding of relay 34TPR01, contacts of relays 34TPR01, 34TPR05, 34Z0, 34W0, 34TPR05 and 34TPR01 to ground.

Operation of relay 34TPR01 completes a locking path for that relay over its own contacts and removes the shunt path from the winding of relay 34Z0. The latter relay now operates over a path from negative battery, resistance 340, winding of relay 34Z0, contacts of relay 34W0 to ground.

Operation of relay 28DIS02, as described hereinafter in consequence of a disconnect call, will cause the preferred trunk relay 29TK- to operate provided that the associated trunk busy relay 18TB- is normal and, moreover, that the trunk busy jack is normal. If either is operated, relay 29TK- representing the first idle trunk will be operated. Thus, assuming that relay 29TK15 is the preselected trunk, a path may be traced for the operation of that relay from negative battery, resistance 290, winding of relay 29TK15, contacts of relay 29TK15, contacts of relays 18TB15, jack TB15–J, contacts of relays 40CT15, 40CHM0, 28DIS02, 290T0, 29ET0 and 29TRK to ground.

The operation of relay 29TK15 will complete a path to the shift register which may be traced in FIG. 35 from ground, contacts of relays 36TIS, 28DIS02, 29TK15, 41G1, 36TISR, conductor C17 to the corresponding shift register stage 31SC7FF. A similar path may be traced over the contacts of relay 29TK15 and conductor CI0. In addition, a circuit is completed for the operation of relay 290T0 over an obvious path.

The operation of relay 29TK15 interrupts the operating path for that relay and provides a holding path over transfer contacts of relay 29TK15 and the contacts of all lower numbered relays, contacts of relays 41SR0, 28TER0 to ground.

Operation of relay 290T0 completes a path extending to the shift register over conductors BI0 and BI1 and removes ground from the operating path of relay 29TK15. Relay 29TRK operates at this time over a path including ground, contacts of relays 290T0, 28DIS02, 29TK00, 29TK01–29TK14, 29TK15, winding of relay 29TRK to negative battery.

Operation of the latter relay completes a path to the solid state logic circuitry to initiate transmission of the trunk information as explained herein in detail. In addition, a ground condition is applied to relay 34TPR05 over a path from ground, contacts of relays 39RL1, 29TRK, 38TUK, 28DIS02, 34TPR04, 34TPR05, (assuming relay 34TPR04 is operated), winding of relay 34TPR05, contacts of relay 34TPR04, resistance 346 to negative battery. Relay 18TBA15 is operated at this time over a path from negative battery, winding of relay 18TBA15, resistance 1815, diode 18TB15D, contacts of relay 29TK15, conductor 18TK1C, contacts of relays 28DIS01, 41TCA1, 29TRK, 38TUK to ground.

The following chart shows sixteen successive calls:

Call	34TPR- Relays Operated From Previous Call	Preferred Trunk	After Trunk Selection the Following Relays—		Condition of 34Z0/1 Relay
			Operate	Release	
		GRP0/1			
1	----------	00	02/12	----------	Released.
2	01/11, 02/12	02	03/13	----------	Do.
3	01/11, 02/12, 03/13	04	04/14	----------	Do.
4	01/11, 02/12, 03/13, 04/14	06	05/15	01/11	Do.
5	02/12, 03/13, 04/14, 05/15	08	----------	02/12	Do.
6	03/13, 04/14, 05/15	10	----------	03/13	Do.
7	04/14, 05/15	12	----------	04/14	Do.
8	05/15	14	01/55	05/15	Do.
9	01/11	01	02/12	----------	Operated.
10	01/11, 02/12	03	03/13	----------	Do.
11	01/11, 02/12, 03/13	05	04/14	----------	Do.
12	01/11, 02/12, 03/13, 04/14	07	05/15	01/11	Do.
13	02/12, 03/13, 04/14, 05/15	09	----------	02/12	Do.
14	03/13, 04/14, 05/15	11	----------	03/13	Do.
15	04/14, 05/15	13	----------	04/14	Do.
16	05/15	15	01/11	05/15	Do.

3.42 TRUNK PREFERENCE AND SELECTION ON SPECIAL DISCONNECT CALL

A special disconnect call is initiated when it is found that more than one trunk in a group has a released relay **40CT-** associated therewith which has resulted in the operation of relay **40CHMO**. As seen in FIG. 40, the latter relay is operated when the contacts of more than one relay **40CT-** are opened. Relay **40CHM0** is biased over its lower winding and the contacts of relay **25Z00**. Assuming that one relay **40CT-** is released, the current in the upper winding and lower winding is approximately equal and the relay is in the released condition. When two or more relays **40CT-** are released (indicating the disconnection of the corresponding trunks) the current in the upper winding of the relay predominates and causes operation of relay **40CHM0**. The latter relay will remain operated until all but one of the relays **40CT-** are operated.

It will be noted that when the current is equal in both windings, relay **40CHM0** remains in the existing condition. Therefore, when one trunk is released, relay **40CHM0** remains released. Once operated however, relay **40CHM0** remains operated until all trunks are released and the current in the lower winding predominates.

Operation of relay **40CHM0** extends a path (in FIG. 29) from ground, contacts of relays **29TRK**, **29ET0**, **29OT0**, **28DIS02**, **40CHMO** and over the contacts of relays **40CT-** having corresponding trunks in the disconnect condition.

Thus, a path is completed for the operation of the lowest numbered relay **29TK-** having a relay **40CT-** in the released condition. Assuming that relay **29TK00** is available, a path may be traced from negative battery, resistance **290**, winding of relay **29TK00**, contacts of relays **18TB00**, (jack TB00–J), contacts of relays **40CT00**, **40CHM0**, **28DIS02**, **29OT0**, **29ET0**, **29TRK** to ground. As in the case of the normal disconnect call adverted to in Section 3.41 supra, a path will be extended over selected leads to the shift register. Moreover, the operation of relay **29ET0** will close an operating path for the trunk check relay **29TRK**. Also, as indicated above, the latter relay will complete a path to initiate the transmission of trunk information and operate relay **18TBA00**.

3.5 *Line identification*

The line identification at the remote unit is determined by the line relay individual to the line at the remote unit, relay **2L-** in the case of the remote unit **0**, whereas the identification at the control unit is determined by the sleeve relay thereat, i.e., relay **17SL-** individual to the line.

In consequence, on a call originating at the remote unit (a service request call) a line identification is obtained in response to the operation of the line relay unique to the line. For example, for relay **2L00** the lockout chains in FIG. 13 indicate the operation of a specific tens relay **13LT0** and a specific units relay **13LU0**.

Thus a path may be traced for the operation of relay **13LT0** from ground, contacts of relays **14TM4**, **9TK0**, **14OL**, **13LW**, **13LT0**, **2L00**, additional contacts of relay **2L00**, winding of relay **13LT0**, contacts of relays **4IC**, **12SQ2**, resistance **133** to negative battery. Moreover, a path may be traced for the operation of relay **13LU0** from ground, contacts of relays **14TM4**, **9TK0**, **14OL**, **13LW**, **13LT0**, **2L00**, diode **13L00D**, winding of relay **13LU0**, contacts of relays **13LU0**, **13LU9**, **13LZ**, **13LU8–13LU0**, additional contacts of relay **13LZ**, contacts of relays **13LT0**, **4IC**, **12SQ2**, resistance **133** to negative battery. The first group of relays including relays **13LT-** identifies one of eight groups of ten lines and the second group of relays designated **13LU-** indicates one of ten groups of eight lines. As will be explained herein, the preference of the lockout circuits for line identification is reversed after each service request call to prevent a faulted line from denying service to the remaining lines.

A similar analysis may be made with respect to relays **25LT-** and **25LU-** at the control unit.

The line identification in each instance is transferred to the shift register over the conductors AI0–AI7 and BI0–BI7 of FIGS. 30 and 35 for the control unit identification equipment and over similarly designated conductors in FIGS. 4, 5 and 10 for the identification equipment at the remote unit.

3.6 *Call preference*

When a call is initiated, the call preference circuit shown in FIG. 28 prevents other types of calls or a call in the other group from starting. Here again, two lockout chains are provided which reverse preference between the groups after each call.

As will be seen herein, the call preference circuit also prevents a terminating call or a disconnect call from being initiated if all the trunks are busy. Moreover, a terminating call cannot start if a trunk has not been preselected.

Assuming that remote unit **0** has initiated a call, relay **41SR0** will be operated in the manner described herein. The contacts of relay **41SRC1** are connected in the call preference circuit of FIG. 28. As shown therein, the terminating preference relay **28TER0** and disconnect preference relay **28DIS0** are arranged in order to prevent the initiation of other types of calls during the processing of a partcіular call. Thus, the operation of relay **28TER0** interrupts the battery supply to the service denial relays **28SDP0** and **28SDP1** as well as the release service denial relays **28RDP0** and **28RDP1**. In addition, the contacts of relay **28TER0** prevent the operation of relay **28DIS00** by opening the battery supply.

Correspondingly, the initial operation of relay **28DIS00** interrupts the operating path for relay **28TER0** at the contacts of relay **28DIS00**.

3.7 *Electronic logic circuitry*

The electronic circuitry utilized in our concentrator is adapted to provide temporary storage of line and trunk information for transmission between the signaling circuit, as described herein, and the electromechanical equipment. In addition, it controls the flow of information between the remote unit and the control unit and determines when all of the information has been transmitted. The individual circuits will now be considered in detail.

3.71 BASIC OR-NOT GATE

Referring to FIG. 42, an Or-Not gate is shown. As seen in FIG. 42, a positive "off-ground" input to the base electrode of the transistor will cause collector current to flow and will change the potential at the output conductor connected to the collector electrode from a potential approaching the positive battery connected to the collector electrode to a potential approaching ground.

Conversely, a ground potential applied to the base electrode would cause the transistor to be nonconducting.

Reference to FIGS. 43 and 44 indicates that a positive potential applied to either of the two inputs of FIG. 43 or the plural inputs of FIG. 44 will cause the respective transistor to conduct and provide a ground potential at the collector electrode thereof.

Since these gates are turned on if one or more inputs are off ground or high, and since the output potential is substantially at ground, the gate circuits perform a logical OR function and, moreover, they also invert. For this reason they have been denominated Or-Not gates.

3.72 FLIP-FLOP

A typical flip-flop circuit is shown in FIG. 46 and includes transistors Q1 and Q2 connected in the conventional arrangement with feedback between the collector and base electrodes of the transistors. Outputs are obtained at the conductors labeled "1" and "0". It being understood that a "one" condition is represented by an "off-ground" potential and a "zero" condition by a ground or "near-ground" potential. Application of an "off-ground" potential to the terminals connected to resistor R5 or R9 applies a positive voltage to the base electrode of transistor Q1 and turns that transistor on. In this condition there is no drive to the base of transistor Q2 and it therefore is in a nonconducting state. The condition in which transistor Q2 is nonconducting and transistor Q1 is conducting, represents the set state of the flip-flop. The "0" output conductor is "near-ground" and the "1" output conductor is "off-ground." Under these conditions the removal of the input pulse will have no effect since the transistor Q1 remains conducting over load resistor R4 and coupling resistor R2.

If at this time an "off-ground" potential is applied to resistor R6, R7 or R8, transistor Q2 is driven into conduction and the collector potential drops to "near-ground" thereby lowering the base potential of transistor Q1 to "near-ground" and diverting current from the base electrode of transistor Q1. In the interim, additional base drive current is supplied to the base electrode of transistor Q2 over resistances R1 and R3. This supply will maintain transistor Q1 in the conducting condition after the input pulse is removed. In consequence, transistor Q1 is in the nonconducting condition and transistor Q2 in the conducting condition representing the reset state of the flip-flop with an "off-ground" potential at the "0" output and substantially a ground potential at the "1" output.

3.73 SHIFT REGISTER

Each stage of the shift register includes a flip-flop circuit and a monopulser which is used to transmit the information which is stored in a cell to the next succeeding cell. Information is stored in a shift register stage by providing a pulse input, for example to resistor R9 of FIG. 46, which as disclosed in Section 3.72 above sets the flip-flop to a "one" condition. As will be seen herein, the insertion of the "one" condition may be in a serial manner from the preceding stage or by a parallel insertion through a gate associated with the flip-flop.

To reset a flip-flop in the shift register, an "off-ground" potential may be applied to resistors R6–R8 as described above. For shifting information between register stages, a shift register monopulser in accordance with FIG. 49 is utilized.

It will be assumed for purposes of illustration that a "one" condition is to be transferred from a shift register stage to a succeeding stage. Assuming that the flip-flop is already in the set or "one" condition, transistor Q1 will be in the ON condition and transistor Q2 of FIG. 46 will be in the OFF condition. The input to the monopulser of FIG. 49 which is taken from transistor Q1 will be "near-ground."

When a reset pulse is applied momentarily to resistors R6–R8, the flip-flop is reset in the manner described above. The collector potential of transistor Q1 rises to an "off-ground" potential in FIG. 46 and turns on transistor Q1 of FIG. 49. This triggers the monopulser of FIG. 49 which proceeds to generate an output pulse at the collector electrode of transistor Q2. As capacitor C2 charges, current is delivered to the base electrode of transistor Q2 and when sufficient current flows, transistor Q2 turns ON. Since the output of transistor Q2 is coupled to the input of the following shift register stage, the flip-flop in the following stage is set, representing a transfer of information between the first and second stages of the shift register.

3.74 MONOPULSER

A monopulser circuit used in the solid state logic circuitry is disclosed in detail in FIG. 47. Although monopulsers of different duration are utilized, the over-all format is the same. When a ground potential or no potential is applied to all of the inputs to transistor Q11 of FIG. 47, that transistor is in the OFF or nonconducting condition. Transistor Q12 is energized from positive battery over resistor R42 and the potential at the output terminal connected to the collector electrode of transistor Q12 is substantially at ground. The potential across capacitor C6 at this time is substantially the difference in potential between the collector electrode of transistor Q11 and the base electrode of transistor Q12. Since transistor Q11 is in the OFF condition, the collector potential thereof is determined by a voltage divider action of resistors R24 and R36.

An "off-ground" or positive pulse input to any of the resistors R14–R17 causes transistor Q11 to conduct whereupon its collector potential drops substantially to ground. As a result, a negative pulse is applied at the base of transistor Q12 to drive that transistor to the OFF condition whereupon the collector potential rises above ground. A feedback is provided between the collector electrode of transistor Q12 and the base electrode of transistor Q11 over resistance R18. As a result, the input pulse may be removed without affecting the monopulser operation. The output potential at the collector of transistor Q12 remains "off-ground" until transistor Q12 is again conducting. The duration of the OFF period is determined by resistance R42 and capacitor C6. Transistor Q12 is energized when the voltage across capacitor C6 rises above the potential of the base electrode of transistor Q12. When transistor Q12 is energized, the potential at the output terminal connected to the collector electrode thereof goes toward ground. Moreover, as the collector electrode moves toward ground, the base current to transistor Q11 through resistance R18 is reduced and, as a result, transistor Q11 turns off. Thereupon, the collector potential of transistor Q11 begins to rise. However, the rise is controlled by an R–C network including resistors R24 and R36 and capacitor C6. This time duration constitutes the recycle time of the monopulser.

3.75 OSCILLATOR

The oscillator shown in outline form in FIG. 16 (16K) and in FIG. 21 (21K) is shown in detail in FIG. 48. As indicated above, the purpose of the oscillator is to generate a frequency of 3200 p.p.s. which in conjunction with a four-stage binary counter provides a 200 p.p.s. clock rate.

Basically, the circuit includes a multivibrator which uses an amplifier and an inverter in the feedback path. Transistors Q1 and Q2 are the active elements of the multivibrator. Transistor Q4 is an output amplifier and transistor Q3 is an inverter for completing the feedback path. The input to this circuit is at resistance R5 and the output is connected to the collector of transistor Q4. A ground condition turns the circuit on and an "off-ground" condition turns the circuit off.

Assuming that, initially, resistance R5 has an "off-ground" potential applied thereto, the following conditions exist: transistor Q1 is off and transistors Q2–Q4 are on.

When a ground potential is applied to the input, transistor Q4 turns off since both inputs to transistor Q4 are "near-ground." When transistor Q4 turns off, a positive pulse at its collector electrode is delivered over resistance R3 to turn on transistor Q1. The latter experiences a negative pulse at the collector electrode which is supplied over capacitor C1 to turn off transistor Q2. Transistor Q2 remains off until capacitor C1 has discharged sufficiently to allow the voltage at the base of transistor Q2 to go positive. The discharge path for capacitor C1 is through transistor Q1 and resistance R1.

Since transistor Q3 was initially in the ON condition, transistor Q2 in turning off has no effect on transistor Q3. However, the voltage at the collector of transistor Q2 does not rise immediately due to capacitor C2. The time required for the voltage to rise to the "off" state value is the recycle time.

When transistor Q2 turns on after the discharge of capacitor C1, transistor Q3 is turned off and remains off throughout the discharge period of capacitor C2. This time for discharge is determined by capacitor C2 and resistors R2 and R9. When transistor Q3 turns off, transistor Q4 is turned on and the output at the collector electrode thereof is once more "near-ground" potential. This potential is transferred over resistance R3 to turn off transistor Q1. Capacitor C1 is now prepared to time again when transistor Q1 is turned on. Transistor Q1 turns on when transistor Q3 turns on as controlled by capacitor C2. Under these conditions, a full cycle is completed and subsequent operations continue in the same manner as long as a "near-ground" condition is applied to the terminal coupled to resistor R5.

3.76 BINARY CELL

The binary counters of FIGS. 21 and 32 at the control unit and FIGS. 6 and 16 at the remote unit include as a basic element a binary cell shown in detail in FIG. 45. The cell is equipped with an output amplifier (see FIG. 42) which is arranged to prevent undesirable "loading" of the cell in driving the succeeding stages.

The cell includes transistors Q1 and Q2. Set inputs are applied to resistors R13 and R14 and reset inputs to resistors R15–R17.

Essentially, the cell is a flip-flop circuit with the inclusion of a pulse steering network which provides a memory for steering the negative-going transient of the input pulse to the base of the "on" transistor of the flip-flop.

The steering network includes capacitors C3 and C4 and diodes CR1 and CR2. The input to the steering network is between capacitors C3 and C4.

It will be assumed that the flip-flop including transistors Q1 and Q2 is in the stable condition with transistor Q1 conducting and transistor Q2 nonconducting. The application of a pulse to conductor 19 of FIG. 45 will result in a reversal of conduction in both transistors. The positive portion of the input pulse has no effect since diodes CR1 and CR2 will both oppose positive current flow to the bases of the respective transistors. During the negative-going portion of the input pulse (when the input level drops), this voltage change is reflected as a drop below ground potential through capacitors S3 and C4. Since transistor Q2 is not conducting, the negative pulse will have no effect thereon. However, transistor Q1 in receiving a negative pulse at the base electrode thereof will experience a current diversion from the base of transistor Q1 which therefore becomes nonconductive. The collector potential of transistor Q1 rises and current is steered through resistance R3 to the base of transistor Q2. A regenerative action occurs which causes transistor Q2 to turn on and transistor Q1 to turn off thereby accomplishing the desired change in state of the flip-flop. Capacitors C3 and C4 are arranged with a sufficiently small capacitance to insure that the negative potential causing the state change is applied for a duration limited to that needed for switching.

In connecting these stages in cascade, the drive to a succeeding stage is taken directly from a collector of one of the transistors in the flip-flop and not from the amplifier. This output lead is shown as conductor 11 in FIG. 45 and corresponds to the "one" condition output of the binary cell. The amplifiers are utilized to supply outputs to all other circuits comprising the load on the binary cell.

4.—DETAILED DESCRIPTION OF SERVICE REQUEST CALL

4.1 *Line relay and lockout relay operation*

It will be assumed for illustrative purposes that a call is being initiated by subscriber 0 of remote unit 0. As shown in FIG. 2 when subscriber 0 removes his receiver from the switchhook, a circuit is completed from ground, contacts of hold magnet 8HMA00, tip conductor T00, substation 0, ring conductor R00, contacts of hold magnet 8HMA00, contacts of relay 9DIS0, winding of line relay 2L00 to negative battery. The operation of the line relay unique to the customer's line results in the operation of a particular tens relay 13LT0 and a particular units relay 13LU0 which collectively uniquely identify the calling line. The over-all manner of operation is discussed in Section 3.5 supra.

Thereafter, relay 13LK operates to verify that one, and only one, tens relay and units relay were operated. This path may be traced from ground, contacts of relay 4TA, winding of relay 13LK, normally closed contacts of relays 13LU9–13LU1, contacts of relay 13LU0, normally closed contacts of relays 13LT7–13LT1 (the latter not shown), contacts of relays 13LT0, 14S01, 12SQ2, resistance 133 to negative battery.

The operation of relay 13LK results in the establishment of a locking path for relay 13LT0 which may be traced over the contacts of relay 13LT0, diode 13LK1D, contacts of relay 13LK to ground. Moreover, a locking path may be traced for relay 13LU0 over the contacts of relay 13LU0, diode 13LK1D, diode 13LKD, contacts of relay 13LK to ground.

Relay 13LW is operated over a path from negative battery, resistance 132, winding of relay 13LW, contacts of relay 13LW, diode 13LKD, contacts or relay 13LK to ground. Moreover, the operation of relay 13LK applies a ground signal to gate 11SRG to initiate the operation of the logic circuitry.

Previously, selected relays 9TK- have been operated to designate the preselected trunk.

4.2 *Transfer of information to shift register*

The operation of relays 13LT0 and 13LU0, as described, apply a ground potential to selected gates to the shift register. For example, the operation of relay 13LT0 results in the application of a ground potential on conductors AI4 and AI7 (FIG. 4) coupled to gates 5SA4G and 5SA7G, respectively. This procedure is, in effect, the transmission of information from the electromechanical circuitry through the interface to the electronic logic circuitry. The operation of relay 13LK which applied a ground potential to gate 11SRG results in the energization of that gate (if flip-flop 11INCFF is in the reset condition). The energization of gate 11SRG results in the setting of flip-flop 11SRFF whereupon the "1" output of the flip-flop changes to a "one" condition as described in Section 3.72 supra. This signal at the "1" output energizes gate 11SRPI and results in the operation of relay 11SRP. With counter 6CTR–BC in the reset condition, the output of gate 6CP0G is a "one" condition. This output is inverted in gate 62I to a "zero" condition which is applied over conductor 6CP0C to gate 11I1G. The other input to the gate from the "0" output of flip-flop 11SRFF causes a "one" condition output from gate 11I1G. Monopulser 11T1 is triggered and results in the generation of a 200 microsecond "one" condition pulse. This pulse is applied over conductor 11T1C to the four cells 16P–BC of the clock pulse generator causing them to be reset.

The inverted output of monopulser 11T1 is applied over gate 115I and conductor 11INC to all of the input gates to the shift register. Thus, at gates 5SA4G and 5SA7G, an output is produced which sets flip-flops 5SA4FF and 5SA7FF respectively. In a similar manner, flip-flops 10SB4FF and 10SB7FF are set in view of the application of ground potential from the contacts of relay 13LU0.

Thus, information representing the identification of the calling line has been transferred into the shift register at the remote unit. It will be noted that flip-flop 10BSFF is also set at this time over conductor 11INC. The energization of flip-flop 10BSFF represents the insertion of the preliminary or "start" pulse of the shift register which precedes the line identification transmission.

When flip-flop 11SRFF was set, a "zero" condition at the "0" output thereof was transmitted over conductor 11SR0C to gate 16CC2G to energize that gate as well as gates 16CC1G and to energize oscillator 16K. This oscillator produces 3200 p.p.s. as described in Section 3.75 and in Section 3.3 supra. Moreover, gate 16CIG is enabled from the output of gate 16CC1G and the oscillator 16K. The output of the oscillator is inverted by gate 16CIG and coupled to the input of binary cell 16P1BC. As indicated in Section 3.76, these cells change state when the inputs at terminal I change from a "one" to a "zero" condition. Since the gate 16CIG inverts the output of oscillator 16K, cell 16P1BC changes state when the oscillator changes from a "zero" condition to a "one" condition. Moreover, when oscillator 16K changes from a "zero" condition to a "one" condition, gates 16PG1G, 16PG2G and 16PG3G are disabled. When the oscillator changes from a "one" condition to a "zero" condition, the same gates are enabled permitting the binary cells 16P1BC–16P8BC to be monitored when they are in a stable condition.

The input to gate 16PG1G is such that conductor 16SPC will have a "one" condition thereon when gates 16P1BC and 16P4BC are set and when gates 16P2BC and 16P8BC are reset.

Similarly, gate 16PG2G provides a "1" output to inverter 166I when cells 16P2BC and 16P4BC are set and cells 16P1BC and 16P8BC are reset.

Moreover, it may be seen that gate 16PG3G provides a "1" output to conductor 16CAC when cells 16P1BC, 16P2BC and 16P4BC are set and cell 16P8BC is reset.

It may be shown from the binary conditions assumed by the cells that these outputs represent respectively the fifth, sixth and seventh outputs of oscillator 16K. Since, as indicated above, the oscillator operates at a 3200 p.p.s. rate and the binary cells provide a frequency division to 200 p.p.s., the period is 5 milliseconds. During each 5 milliseconds, gates 16PG1G–16PG3G provide a pulse sequence in that order. The pulses in the sequence are substantially 156 microseconds and are separated by an interval of equal amount. The output from the gate 16PG1G causes a shift register advance, from gate 16PG2G gates information into the shift register, and from gate 16PG3G advances the binary counter 6CTR–BC.

4.3 Transmission of line identification to office

As explained above, the information representing calling line 00 has now been stored in the shift register and the clock circuit of FIG. 16 is operating. The first output from gate 16PG1G energizes monopulser 11T5 to produce a 10 microsecond "one" condition pulse. This causes gate 11RSG to produce a "0" output which is inverted by gate 114I and supplied over conductor 11RC to the reset input of all of the shift register stages.

Since flip-flops 10SB4FF, 10SB7FF, 5SA4FF, 5SA7FF and 10BSFF were all shown to have been storing a "one" condition, they are in consequence of the reset pulse shifted to the "zero" state while the remaining stages are unaffected. Each flip-flop which is reset, produces a transition from a "zero" condition to a "one" condition at the "0" output terminal. (See Section 3.73 supra.) This causes the associated monopulsers to produce a "1" output for a period of 26 microseconds. (See Section 3.74 supra). This output from the monopulser is applied to the next succeeding flip-flop set input terminal. The flip-flop is not set at this time, however, since the input still remains over conductor 11RC. However, since the latter is only 10 microseconds in duration and the monopulser output is 26 microseconds, eventually the input to the reset terminal of each flip-flop is removed and the monopulser output causes the appropriate flip-flops to be reset. Thus, after the termination of the reset input, flip-flops 5SA4FF, 5SA2FF, 10SB4FF and 10SB2FF are set as well as flip-flop 10OSFF. The output of flip-flop 10OSFF is applied over conductor 10Q4C to the modulator gate 15MG and is inverted by gate 157I and presented to the sender circuit for remote unit 0. The application of the input to the modulator 15M results in the transmission of a signal over contacts 140L and the send filter 15SF as well as power amplifier 15PA to the central office representing a start signal. For an explanation of the operation of the sender circuit, reference may be made to Section 3.8 supra.

It will suffice at this time to indicate that the signal is transmitted over conductors 15TS0C and 15RS0C to the receiver circuit 0 for remote unit 0 at the control unit.

This 5 millisecond mark frequency start pulse is interpreted in the control unit after passage through input transformer 20T0, limiter 20L0 and signal present detector 20SPD0.

4.4 Reception of line identification at office control unit

Since the mark frequency start pulse is a valid signal, the output of the signal present detector (Section 3.25 supra) does not change. In addition, the discriminator 20D0 detects the shift from the normal space frequency to the mark frequency and the output thereof changes from a "one" condition to a "zero" condition. This causes the output of gate 20ST0G to change from a "zero" condition to a "one" condition and the output of inverter 20INV3I to change from a "one" condition to a "zero" condition. When the "one" condition signal from gate 20ST0G is applied to guard interval timer 20GIT0 through gate 20DM0G, the output changes from a "zero" condition to a "one" condition. As shown above (Section 3.26), the timer measures a 4.06 millisecond interval and the output thereof changes from a "one" condition to a "zero" condition. Gate 20MT0G is energized and in turn energizes monopulser 20MT0MP to generate a 4.5 microsecond signal which is delivered over conductor 20MT0C and conductor 20MT0 to set flip-flop 27PP0FF. When the latter flip-flop is set, the output of gate 27PP0G shifts from a "one" condition to a "zero" condition to operate relay 27IPP and the output of gate 27SRG0G changes from a "zero" condition to a "one" condition to set flip-flop 27SR0FF.

It will be noted that the setting of flip-flop 27SR0FF indicates a service request call in remote unit 0. Had the call originated in remote unit 1, flip-flop 27SR1FF would have been set.

Gate 27SR01G enables flip-flop 27SR0FF which also effects the operation of relay 27ISR0. The latter in turn causes the operation of relay 41SR0 over an obvious path. Moreover, relay 41SRC1 operates over a path including ground, contacts of relay 27ISR0, diode 41SR0C, contacts of relays 37TCF, 36RF, winding of relay 41SRC1 to negative battery. The setting of flip-flop 27SR0FF results in the disabling of gate 20DMIG (not shown) over conductor 27SR0C thereby denying service to remote unit 1.

The operation of relay 41SR0, as described above, completes an operating path for relay 38OL1 which may be traced from ground, contacts of relay 41SR0, winding of relay 38OL1 to negative battery. In addition, a locking path for relay 41SR0 is completed over the contacts of relay 39RL2 and the normally open contacts of relay 41SR0.

The operation of relay 38OL1 removes signal tone to the remote unit not being served.

The operation of relay 41SRC1, as described above, completes an operating path for relay 36HMF1. This path may be traced from ground, contacts of relays 41SRC1, 24ABK, winding of relay 36HM1 to negative battery. In addition, the operation of relay 41SRC1 removes battery from the call preference circuit relays of FIG. 28 at the contacts of relay 41SRC1. Relay 41PP is operated over the contacts of relays 41SRC1 and 27IPP. In addition, relay 36RTR operates if all of the relays 33T- and 33U- are normal.

The operation of relay 41SR0, as described above, completes an operating path for relay 23ESM0 or 23OSM0 through relay 29ET0 if the preselected trunk is even-numbered or relay 29OT0 if the trunk is odd-numbered. Moreover, relay 23ESM0 is operated in response to relay 29ET0 and relay 23OSM0 is operated in response to relay 29OT0.

Assuming for illustrative purposes the trunk 0 is the preselected trunk, relay 23ESM0 will be operated over a path from negative battery, winding of relay 23ESM0, contacts of relays 29ET0, 41SR0, 36HMF2, conductor 23HMKC, contacts of relays 19HMK, 39RL2 to ground. In consequence of the operation of relay 23ESM0, an operating path is closed to select level 8 as well as the level associated with the preselected relay for trunk 00, i.e., select level 0.

It will be noted that battery is connected through a resistance lamp 231 to each of the select levels to prevent any select level with a false ground from operating. If a select level fails to operate, the operating path to relay 24SMK will not be closed. As a result, the hold magnets of FIG. 24 will be prevented from operating.

When the correct select magnets (which are in the assumed illustration, 23SM0A0 and 23SM0A8 and corresponding magnets in switch B–D) are operated, a path is completed for the operation of relay 24SMK. Thereafter, a path may be traced for the operation of relay 24SMK from negative battery, winding of relay 24SMK, contacts of relays 24SMK, 29ET0, 23SM-, 23SM0A0 to ground.

When the guard interval timer 20GIT0 operates, as described above, to generate a 4.06 microsecond pulse, the flip-flop 27PP0FF is set and the output from the flip-flop is delivered to gate 27TPG to inhibit that gate and deliver preference to the service request call over any call originated in the control circuit.

The control circuit obtains preference by changing the input to gate 27TPG from a "one" condition to a "zero" condition thereby changing the output of the gate from a "zero" condition to a "one" condition and inhibiting gates 20DM0G and 20DM1G (not shown) over conductor 27TPC. Inhibition of the gates resets the guard interval timer 20GIT0 to prevent their subsequent enablement thereby inhibiting flip-flop 27PP0FF.

Preference between the two remote units is controlled by flip-flop 27SR0FF and gate 27SRG0G. When the "1" output of flip-flop 27SR0FF changes from a "zero" to a "one" condition, its application to the reset input of flip-flop 27SR1FF and to gate 27SRG1G to hold the output in the "zero" condition. This arrangement would give preference to remote unit 0 in the event of simultaneous seizure by both remote circuits. The "1" output of flip-flop 27SR1FF is connected to gate 20DN06 to disable the gate when remote unit 1 initiates a call prior to remote unit 0.

When flip-flop 27SR0FF changed from a "zero" condition to a "one" condition, flip-flop 27OTGFF is held in the reset state.

The setting of flip-flop 27PP0FF, as described above, changes the input to monopulser 27T6MP from a "zero" condition to a "one" condition thereby generating a 10 microsecond pulse which is applied to the input of monopulser 27T4MP. The latter also generates a 10 microsecond pulse which is applied to the input to binary cell 32CTR1BC. At the conclusion of the 10 microsecond interval, the output from monopulser T4 shifts to a "zero" condition and causes the setting of cell 32CTR1BC.

The output from flip-flop 27SR0FF is applied to gate 27SR01G which latter changes from a "one" to a "zero" condition providing an output over conductor 27SR01C to gate 21CC2G. The latter energizes gate 27CC1G and enables oscillator 21K. In addition, gate 21CIGG is also enabled. The output of gate 21CIGG is delivered to the first binary cell 21P1BC. These cells, as described for the remote unit, change state when their respective inputs at terminal I change from a "one" to a "zero" condition (see Section 3.76 supra). The gates 21PG1G, 21PG2G and 21PG3G are enabled in a manner similar to that described above for the remote unit, and gates 16PG1G–16PG3G. Here again, the gates are enabled in response to the fifth, sixth and seventh pulses from oscillator 21K.

When monopulser 20MT0MP produced a 4.5 microsecond pulse to set flip-flop 27PP0FF, as described above,

it also advances the counting circuit of FIG. 21 to a state corresponding to the elapsed time measured by guard interval timer 20GIT0. Since the latter produces an output after 4.06 milliseconds, the counting circuit is set to a condition corresponding to the thirteenth pulse from oscillator 21K. Under these conditions, cells 21P1BC, 21P4BC and 21P8BC are set and cell 21P2BC is reset. In consequence, at the time oscillator 21K is energized, the binary cells are already set to a count of 13.

Since the oscillator 16K at the remote unit is also in this condition, control unit counter is in synchronism with the incoming signal and the two distant counters operate with a phase displacement determined by the transmission delay of the signals on the signaling channel.

It will be recalled that the control unit was energized in response to the reception of a 5 millisecond start pulse. This pulse was delivered through the receiver circuit 0 and over gate 20DM01G and conductor 20DM01C to the input to gate 27WGG. The latter gate is energized under control of gate 21PG2G and in turn controls the operation of monopulser 27T3MP to deliver information to the shift register over conductor 27T3C to flip-flop 31SA7FF. In this manner the mark pulse is stored in the shift register.

It will be recalled that at the remote unit, the shift register had stored information in flip-flops 10SB4FF, 10SB7FF, 5SA4FF and 5SA7FF.

The shift register at the remote unit is advanced under control of oscillator 16K and the information stored therein is transmitted to the receiving circuit 0 at the remote unit where it is stored in corresponding stages of the shift register of the control unit in response to the operation of oscillator 21K. In this manner both shift registers are advanced, the shift register at the remote unit being cleared of the line identification information and the shift register at the control unit being loaded with the line identification information, it being understood that the advance of the shift register at the control unit is similar in operation to that explained for the shift register at the remote unit.

In short, the above enumerated procedure has resulted in the transmission of the identification of the calling line (assumed to be line 00) to the electronic logic circuitry at the control unit.

4.5 *Registration of "Early" dial tone start*

Referring now to the remote unit, it is seen that the operation of relay 6SEP, in consequence of the setting of flip-flop 6P11FF as described above, results in the operation of relay 4EP and relay 9SR. Relay 4EP is operated over an obvious path and relay 9SR operates over the contacts of relay 4EP and 4IC. The operation of relay 4EP resets flip-flop 100SFF over a path including positive battery, resistance 103, contacts of relay 4EP and diode 10EP1D. The last flip-flop 100SFF was set since the last bit of line information in the assumed example was a mark.

Operation of relay 9SR results in the operation of relay 13LS over a path including negative battery, winding of relay 13LS, contacts of relays 9SR, 13LK to ground. In addition, a path is completed to relay 12TRK which operates only if one of the trunk relays 9TK0–9TK7 and one of the relays 9TK8 or 9TK9 is operated. Since the selected trunk is assumed to be trunk 0, relay 9TK0 is operated. In consequence, a path may be traced for the operation of relay 12TRK from negative battery, winding of relay 12TRK, contacts of relay 9SR, contacts of relays 9TK9, 9TK8, 9TK7–9TK1, 9TK0, 14RL1, 14RL2 to ground. The previous operation of relays 9TK0 and 9TK8 is in accordance with the preselection trunk 0 as explained above.

The operation of relay 12TRK completes a path through the contacts of relays 9TK0 and 9TK8 to operate relay 9TS00 associated with the preselected trunk. Thus, relay

9TS00 is operated over a path from negative battery, winding of relay 9TS00, contacts of relays 9TK0, 9TK8, 12TRK, 12SQ1 to ground. The operation of relay 9TS00 completes a bridge through resistor 21 on the selected trunk. This path may be traced from conductor T00 of FIG. 2, contacts of relay 9TS00, 9SR, resistance 21, additional contacts of relay 9TS00 to conductor R00. The purpose of this impedance bridge is to initiate transmission of the off-hook signal over the trunk conductor in order that an originating register in the central office may be summoned when the crosspoints in the control circuitry are closed thereby minimizing dial tone delay. The trunk path through the switches is opened at the contacts of relay 9TS00 to prevent surges of current through the crosspoints when they close.

The operation of relay 13LS, as described above, results in the gating of line information to the register circuit (of FIG. 9) and operates the appropriate tens and units relays of the register in accordance with the operated relays representing the service requesting line. Thus, relay 9T0 is operated over a path including negative battery, winding of relay 9T0, contacts of relays 13LS and 13LT0 to ground. Similarly, relay 9U0 is operated from negative battery, winding of relay 9U0, contacts of relays 13LS, 13LU0 to ground.

When the appropriate register relays have been operated, the register check relay 12LRK is operated over a path including negative battery, winding of relay 12LRK, contacts of relays 9SR, 9T7–9T1, 9T0, 9U8–9U1 and 9U0 to ground. The operation of relay 12LRK provides a locking path for the register relays of FIG. 9.

4.6 *Select and hold magnet operation*

At this time, the select magnets of FIG. 7 are operated through the contacts of the selected trunk relay (assumed to be relay 9TK0 and 9TK8) and the trunk check relay 12TRK. As indicated above, two select magnets, one of which is a steering level select magnet, are operated for each connection on each of the switches A–D. Thus, a path may be traced for the operation of relays 7SMA0 and 7SMA8 over a path from negative battery, resistance 71, contacts of relays 12TRK, 9TK0, winding of relay 7SMA0 to ground. An additional path may be traced over the contacts of relay 9TK8, winding of relay 7SMA8 to ground. The select magnet check relay 7SMK is operated from negative battery, resistance 72, contacts of relays 9TK8, 7SMD8, 7SMC8, 7SMB8 (not shown), 7SMA8, 7SMA0, 7SMB0, 7SMC0, 7SMD0, 9TK0, winding of relay 7SMK to ground.

Relay 7OH is operated from negative battery, winding of relay 7OH, contacts of relays 7RH, 7SMK, 8XPK1, 9SR, 12LRK to ground. As a result of the operation of relay 7OH, the operating path for the appropriate hold magnet 8HMA00 is completed from negative battery, resistance 81, contacts of relay 7OH, winding of relay 8HMA00, contacts of relays 9U0, 9T0, 7RH to ground. As indicated above in the general description, the hold magnets are of the magnetic latching type and remain operated until a pulse of reverse polarity is applied as described hereinafter. The hold magnet check relay 8HMK is operated from negative battery, winding of relay 8HMK, contacts of relays 7OH, 9T0, 9U0, 8HMA00 to ground. When the check relay 8HMK operates, a path is completed for the operation of relay 2XPK which may be traced from ground, winding of relay 2XPK, contacts of relays 7OH, 8HMK, 9TS00, sleeve conductor of the line through the crosspoint contacts, sleeve conductor of the trunk, winding of relay 2L00 to negative battery. The operation of relay 2XPK is followed by the operation of relay 8XPK1 over an obvious path. At this time, the crosspoint contacts in the remote unit linking substation 0 to trunk 0 have been closed and checked. Relay 12SQ1 operates over a path from negative battery, winding of relay 12SQ1, contacts of relays 4IC, 9SR, 8XPK1, 8HMK to ground. The operation of relay 12SQ1 results in the release of relay 9TS00 by the opening of the contacts of relay 12SQ1 in series therewith. The latter in turn causes the release of relays 2XPK, 8XPK1, and relay 2L00. The operation of relay 12SQ1 is a progress mark in the electromechanical circuit which indicates that the call has progressed through the stage of hold magnet operation.

In the interim, at the control unit the operation of relay 38TUK, described above, completes an operating path for the hold magnet associated with relays 33T0 and 33U0 which were operated in the manner described above in Section 4.3. Thus, a path may be traced for the operation of hold magnet 19HM0A00 from ground, contacts of relays 37RSD0, 28D1S02, winding of hold magnet 19HM0A00, contacts of relays 33U0, 33T0, 28TER0, 37SD0, 41SR0, 39RL1, 24SMK, 38TUK, resistance 191 to negative battery.

As usual, the operation of the hold magnet is checked by the hold magnet check relay 19HMK over a path from negative battery, winding of relay 19HMK, contacts of relays 19HM0A00, 33U0, 33T0, 41SR0 to ground. The operation of the hold magnet check relay will result in the release of relay 23ESM0. The latter in turn causes the select magnets to release and close an operating path for relay 36TISR from negative battery, winding of relays 36TISR, 19HMK, 36HMF2, 41SRC1 to ground. In addition, a locking path is completed for relays 33U0 and 33T0 over the contacts of relay 19HMK in FIG. 33. Relay 40CT00 is operated in conjunction with the preselected trunk relay 29TK00 from negative battery, winding of relay 40CT00, contacts of relays 29TK00, 41SR0, 19HMK to ground. At this time, relay 40CTK is operated from negative battery, winding of relay 40CTK, contacts of relays 29TK00, 40CT00 to ground. Relay 36RTR releases at the contacts of relay 19HMK and in turn causes the release of relay 32IR as shown in FIG. 32. The release of relay 32IR releases relays 31SA4, 31SA7, 26SB4 and 26SB7 which were operated in the manner described above in Section 4.3. In consequence, the associated relays 41A4, 41A7, 41B4 and 41B7 are released, in turn releasing relay 24ABK.

The operation of relay 40CT00, described above, completes the connection of the line to the transmission facilities as shown by the closing of the contacts of relay 40CT00 in FIG. 17. The closure of the crosspoints in the remote unit were described above. In consequence, a complete connection extends to the calling subscriber. When an off-hook condition is received from the subscriber, relay 17TS00 is operated in series with the preselected trunk. The central office proceeds with a dial tone call which may be, for example, in the manner described in Patent 2,585,904 of A. J. Busch of February 19, 1952, relating to No. 5 crossbar telephone switching systems. When a ground is placed on the sleeve lead in the conventional manner, as described for example in the above-referred-to patent of A. J. Busch, relay 18TBA00 will be operated over a path from negative battery, winding of relay 18TBA00, resistance 1800, diode 18TB00D, sleeve conductor of switch A through the selected cross-points to the ground condition applied in the central office over line 00 of FIG. 22. The operation of relay 18TBA00 in this manner closes a path for the operation of relay 18TB00 over an obvious path. In addition, the winding of relay 17TS00 is short-circuited and relay 17TS00 is released.

At this juncture it may be recognized that a complete path extends to the calling subscriber and he may thereupon proceed to dial information representing the called line number into an originating register (not shown) in the central office.

Nevertheless, at this time a check is undertaken to verify that the line is connected to the correct trunk as explained in the following section.

4.7 *Transmission of trunk information to remote unit*

When relay **36TISR** operates, as described above, paths are completed for the transmission of the trunk information to the electronic logic circuitry of the control unit. Thus, a ground condition is connected through the contacts of the operated relay **41SR0**, contacts of relays **29TK00**, **41G1**, **36TISR**, conductor **CI7** to the input gate of flip-flop **31SC7FF**. A similar path may be traced for conductor **CI4** and flip-flop **31SC4FF**. Thus, the trunk number is stored in the flip-flops **31SC–FF**. The trunk steering level number is stored in flip-flops **26SB–FF**. Specifically, the closure of the contacts of relay **29ET0** results in an input condition over conductors **BI4** and **BI7** to gates **26SB46** and **26SB76**. As usual, the shift register stores this information in response to an input from monopulser **27T1MP** over inverter **27INV1I** and conductor **27INC**. The operation of relay **36TISR** also completes an operating path for relay **36SS** from negative battery, contacts of relays **36RTR**, **34RC1**, **41EP**, **38OL0**, **36TISR**, **41SRC1** to ground. The operation of relay **36SS** results in the initiation of the transmission of trunk information to the remote unit as a result of the closure of the contacts of relay **36SS** in FIG. 27 at the input to gate **27CKTG** and the subsequent energization of oscillator **21K** in the manner described above. The energization of gate **27CKTG** results in the activation of monopulsers **27T1MP** and **27T2MP**. Moreover, the output from gate **27CKT1G** is now a ground condition. Monopulser **27T2MP** generates a 150 microsecond pulse which through gate **27RSG**, inverter **27INV5I** and conductor **27RC** is applied to the reset inputs of the shift register. Monopulser **27T1MP** generates a 200 microsecond pulse which gates information into the register as described above.

In the interim, gates **21CC2G** and **22CC1G** are enabled to generate a sequence of pulses in conjunction with oscillator **21K** and gates **21PG–G** that advance the shift register in the manner described above at Section 3.73. When the counter **32CTR–BC** advances to a count of 22, gate **32CP22G** is enabled and over conductor **32CP22–1** disables gate **21CC2G** arresting oscillator **21K**. In addition, relay **32IEP** is operated over the contacts of relay **41SRC1** and inverter **32P22OI**. The latter is an indication that the trunk identification has been transmitted to the remote unit.

4.8 *Trunk number storage in shift register at remote unit*

It will be recalled that the trunk number is already known at the remote unit and, in fact, that a connection already extends over the preselected trunk to the control unit. Nevertheless, the remote unit receives the information representing the trunk identification as transmitted from the shift register at the control unit for checking purposes.

Thus, when the preliminary pulse is transmitted from the control unit, the guard interval timer **15GIT** is operated, as described in Section 3.26, and flip-flop **11PPFF** (the preliminary pulse flip-flop) is operated in a manner corresponding to its counterpart at the control unit. When flip-flop **11PPFF** is set, the "1" output thereof goes from a "zero" condition to a "one" condition. Relay **11ST** is operated, as a result, over inverter **11PPOI**. In addition, monopulser **11T6** is energized and in turn energizes monopulser **11T4**. Monopulser **11T6** remains disabled while flip-flop **11PPFF** is set as described in Section 3.74. Monopulser **11T4**, however, generates an output pulse when triggered by gate **16PG3G**. Binary counter **6CTR1BC** responds to monopulser **11T4** to change from the set condition to the reset condition and cell **C6TR2CB** in turn changes from the reset condition to the set condition. This condition of the counter corresponds to the reception of the twelfth pulse from gate **16PG3G**. As a result, gate **6CP11G** is disabled and the output thereof is in the "zero" condition which enables gate **16CC2G** over conductor **6CP11C** and, in consequence, energizing oscillator **16K** over gates, **16CC2G** and **16CC1G**. The information from the control unit is stored in the shift register at the remote unit in a manner analogous to that described for the storage of the information representing the line identification at the control unit.

When control **6CTR–BC** reaches a count of 22, gate **6CP22G** is enabled and over conductor **6CP22C** disables gate **16CC2G** as well as gate **16CC1G** and oscillator **16K**. In addition, relay **6SR0** is energized over inverter **6P22OI** and the contacts of relay **4IC**. The latter is an indication that all of the trunk information is received in the electronic logic circuitry and is awaiting transfer to the electromechanical equipment.

4.9 *Trunk number translation and match check at remote unit*

When relay **6SR0** operates, in the manner described above, relay **4R0** is operated over an obvious path and relays **5SA4** and **5SA7** as well as relays **10SB4** and **10SB7** are operated over the contacts of relays **4R0**, **12SQ2**, **4IC** and resistance **101** to positive battery. Relays **4A4** and **4A7**, **4B4** and **4B7**, are also operated over obvious paths. Relay **14TKA** is operated over the contacts of relays **12SQ2**, **9SR**, **14SO1**, winding of relay **14TKA** to negative battery.

Relay **9TNK** operates over a path which may be traced from negative battery, winding of relay **9TNK**, contacts of relays **14TKA**, **4A4**, **4A7**, **14TKA**, **9TK8**, **9TKO**, **14TKA**, **4B7**, **4B4** to ground.

The operation of relay **9TNK** is a vertification that the number of the trunk received is the same as the number of the trunk utilized for the connection. Relay **12ABK** operates as a check that two, and only two, of each of the relays **4A-** and **4B-** are operated. Thereafter, relay **12SQ3** is operated from negative battery, winding of relay **12SQ3**, contacts of relays **4IC** and **12ABK** to ground. Operation of the latter relay is a call progress indication of the successful reception of trunk information.

4.10 *Release of trunk register at remote unit*

When the control circuitry completes the transmission of the trunk information, as described in Section 4.7, it causes the signal pair to the remote unit to be opened at the contacts of relay **38OL0** in the manner described. Since both valid signaling frequencies (mark and space) are missing, the output of the signal present detector **15SPD** is changed from a "zero" condition to a "one" condition (See Section 3.25). In consequence, the output of inverter **15STAI** changes from a "one" condition to a "zero" condition to operate relay **15STA**. When the latter relay operates, relay **4TA** is operated over an obvious path and completes a path for the operation of relay **14RL1**. After the operation of relay **14RL1**, relay **14RL2** is operated.

When relay **14RL1** operates, the locking path for relays **9TK0** and **9TK8** are opened at the contacts or relay **14RL1**. The release of relays **9TK0** and **9TK8** results in the release of relays **12TRK**, **7OH**, **8HMK** and **7SMK**. In addition, select magnets **7SMAO** and **7SMA8** are released at the contacts of the respective trunk relays **9TKO** and **9TK8**.

Operation of relay **14RL2** results in the operation of relay **14OL** over a path from ground, contacts of relays **9SR**, **4TA**, additional contacts of relay **9SR**, contacts of relay **14RL2**, winding of relay **14OL** to ground.

Operation of relay **14OL** results in opening the signaling pair to the control unit at the contacts of relay **14OL** in sender circuit **0** of FIG. 15. As will be shown herein, the control unit responds by enabling the control pair to the remote unit thereby activating signal present detector **15SPD** to release relay **15STA**, in turn releasing relay **4TA**. Release of relay **4TA** results in the release of relay **14RL1**.

When relay **14RL2** has operated and relay **14RL1** has released, as described, relay **14RLS** is operated over the contacts of relays 14RL1 and 14RL2. Thereupon, a reset pulse is transmitted from positive battery, resistance 63, contacts of relay 14RLS, and conductor 6RLSC to reset flip-flops 11PPFF, 11SRFF, 6P11FF, as well as cells 6CTR–BC and the shift register.

When flip-flop 11PPFF resets, the output of inverter 11PPOI changes from a "zero" condition to a "one" condition and releases relay 11ST. In the interim, the resetting of the flip-flops and the shift register result in the release of the associated relays 5SA- and 10SB- as well as the corresponding relays 4A- and 4B-.

The resetting of the counter cells 6CTR–BC changes the output of gate 6CP22G from a "one" condition to a "zero" condition in turn causing the output of inverter 6P22OI to change from a "zero" condition to a "one" condition thereby releasing relay 6SR0 which in turn releases relay 4R0. When flip-flop 6P11FF is reset, the output of gate 6P11OI changes from a "zero" condition to a "one" condition to release relay 6SEP which in turn releases relay 4EP. The latter relay in releasing causes relay 9SR to release and, in consequence, relays 12SQ1–12SQ3 release as well as relay 14TKA. Release of relay 12SQ1 causes the release of relay 12LRK and removes the locking ground from relays 9T0 and 9U0 which thereupon release. The release of all the control relays in turn causes the release of relay 14RL2 which effects the release of relays 14RLS and 14OL. As usual, when relay 14OL releases, the signal pair to the control unit is again closed which serves as a signal to the control unit to complete its own release.

4.11 *Release of electromechanical circuit at control unit*

When the remote unit opens the signal pair to the control unit at the contacts of relay 14OL, as described in the preceding section, relay 2OITA0 is operated by signal present detector 2OSPD0. Subsequently, relay 41TA0 is operated over an obvious path. Relay 39RL1 operates from ground, contacts of relays 41EP, 41PP, 41SRC1, 38OL1, 38OL0, 41TA1, 41TA0, 28SDP0, 28SDP1, 39RL2, 37TM2, winding of relay 39RL2 to negative battery. Operation of relay 39RL1 releases relay 29TK00 corresponding to the selected trunk. The latter in turn causes the release of relay 29ET0. In addition, the operating path for relay 38LK0 is interrupted. Battery is removed from the hold magnet operating circuit at the contacts of relay 39RL2 as well as the call preference circuit. A locking path is completed for relay 39RL1 which checks for the release of relays 33T0, 33U0, 24SMK, 19HMK and 24ABK.

An operating path is completed for relay 28D0 from negative battery, winding of relay 28D0, contacts of relays 41SR0, 39RL1 to ground. Moreover, relay 39RL2 is operated over the contacts of relay 39TM3, contacts of relays 28DIS02 and 39RL1 to ground. Relay 37TM2 is operated over the contacts of relay 39RL1. The operation of relay 39RL2 opens the operating path of relay 39RL1 and relay 39TM3. Relay 24NK is operated over the contacts of relay 39RL2 and the contacts of previously operated relays 41A- and 41B-. In addition, the locking paths for relays 24SMK and 33T0 and 33U0 are opened at the contacts of relay 39RL2. When relays 33T0, 33U0, 19HMK, 24SMK have released and relays 39RL2 and 28D0 have operated, relay 39RL1 releases. If relay 39RL1 did not release before relay 37TM2, the operation of (slow-to-operate) relay 37TM2 opens the operating path of relay 39RL1 and operates an alarm circuit (not shown). The release of relay 39RL1 opens the operating path of relays 37TM2 and 38OL0. The release of relay 38OL0 again closes the signal pair to the remote unit which, as described in the preceding section, will cause the remote unit to close a signal pair to the control unit.

In response to the closure of the signal pair to the control unit, the signal present detector 2OSPD0 again releases relay 2OITA0. When the latter relay releases, relay 41TA0 is released which in turn applies a reset signal in FIG. 32 from positive battery, resistance 324, contacts of relays 41TA0, 39RL1, 39RL2 and conductor 32RLSC to reset cells 32CTR–BC, as well as flip-flops 27PP0FF, 27SR0FF and the shift register flip-flops which were set during the call. When all flip-flops are in the normal condition, the circuit is prepared to receive additional information. The resetting of the flip-flops causes the release of relays 27IPP and 27ISR0. The release of those relays in turn causes the release of relays 41PP, 41SR0, 41SRC1 and 41EP. Release of relay 41SR0 causes the release of relay 38OLO. As seen in FIG. 39 when relay 24NK has operated and relays 41EP, 41SRC1 and 41TA0 have released, relay 39RL2 releases, in turn releasing relay 24NK. Release of relay 38OL1 again restores the connection to the remote unit not being served. Subsequently, when the remote unit serving the call normalizes, the signal pair to the control unit is completed and relay 41ITA0 releases, in turn releasing relay 41TA0.

5.—DETAILED DESCRIPTION OF TERMINATING CALL

5.1 *Start signal to remote unit*

It will be assumed for purposes of illustration that a call is being initiated from a remote central office to subscriber 0 of FIG. 2. The call proceeds through the distant office and the local central office in the conventional manner. Ultimately, in accordance with the above-referred-to patent of A. J. Busch, a ground is placed in the central office line circuit on the sleeve conductor of line 00 of FIG. 22. This results in the operation of relay 17SL00 over the sleeve conductor, contacts of relays 28SC00, 19HMOA00, winding of relay 17SL00 to negative battery. Operation of relay 17SL00 completes a path for the operation of the identifying relays in the line lockout circuit unique to line 00 (and substation 0). Thus, relay 25LT00 is operated and completes a path for relay 25LU00.

Moreover relay 28TER0 is operated over a path from ground contacts of relays 39RL1, 39RL2, 22TGB0, 25LT00, 41TA0, 29OT0, 29ET0, 28DIS00, 28DIS10, 28D0, winding of relay 28TER0, contacts of relays 28TER0, 34Z3, 28TER1, 28TER0, 34Z3, 41SRC1, resistance 280 to negative battery.

It will be noted that the line lockout relays 25LT- and 25LU- are arranged in a chain to prevent other relays in the chain from operating after one relay has gained preference and operated. The preference chains are arranged over the contacts of relay 25Z00 to reverse preference on succeeding calls.

The operation of relay 25LU00 completes a path for relay 38LK0 to check that one, and only one, relay 25LT- and relay 25LU- have operated as shown in FIG. 38. Operation of relay 28TER0, as described above, opens a path at the contacts thereof to relays 28DIS00, 28SDP0 and 28RSDP0. Moreover, a path is completed for the operation of relay 41ATC00 from negative battery, winding of relay 41ATC00, contacts of relay 28TER0 to ground.

Operation of relay 28TER0 also completes an operating path for relay 41LI0 and extends a ground condition to the logic circuitry over gate 27TPG and the contacts of relay 38LK0. Moreover, a path is completed for the operation of relay 23ESM0 associated with line 00. Operation of the relay 41LI0 completes a path through the operated relays 25LT00 and 25LU00 to the shift register circuit as seen in FIG. 30. In consequence thereof, signals are applied to conductors AI4 and AI7 as well as BI4 and BI7 to steer the identification of the called line in the corresponding shift register stages 31SA4FF, 31SA7FF, 26SB4FF and 26SB7FF. Moreover, an operating path is completed for relay 38OL1 which may be traced from negative battery, winding of relay 38OL1, contacts of relay 41ATC01 to ground. Relay 41ATC01 operated over an obvious path including the contacts of relay 41ATC00. The operation of relay 38OL1, as shown in FIG. 27, blocks service request calls from gaining preference and initiates the transmission of line information and call type to the remote circuit. In this respect it will be noted that the stage 31SC4FF and 31SC7FF were operated over conductors CI4 and CI7 and the contacts of relay 28TER0.

Operation of relay 41TSA1, as described above, completes an operating path through relays 41ATC00, 25LT00 and 25LU00 for the corresponding register relays 33T0 and 33U0. Thus, a path may be traced from ground, contacts of relays 39RL2, 41ATC00, 25LU00, 41TCA1, winding of relay 33U0 to negative battery. A corresponding path may be traced for relay 33T0.

5.2 *Transmission of information stored in shift register*

When relays 38OL0, 41TCA1 and 38TUK have operated, additional paths are completed to the electronic logic circuitry to initiate the transmission of the information stored in the shift register. The operation of relay 38OL1, as described above, opens the signal pair to remote unit 1 which is not processing the call. The operation of relay 41ATC01 initiates the operation of the over-all timer circuit of FIG. 37. As discussed above, the operation of relay 38OL1 which opened the signal pair from the control unit to the inactive remote circuit results in the operation of the signal present detector at that remote unit which in turn is operative to remove the spacing frequency normally applied on the control pair to the control circuit. In consequence, the signal present detector 20SPD1 (not shown) detects the removal and operates relay 20ITA1 (not shown).

When flip-flop 27OTGFF is set over a path from positive battery, resistance 271, contacts of relay 38OL1, 41TCA1, 28TER0 and 38LK0, the "0" output thereof returns to the "zero" condition. Since the counter 32CTR–BC is in the normal condition, the output of gate 32CP0G is a "one" condition. This condition is inverted through gate 32INV61 and is delivered over conductor 32CP0–0 to the input of gate 27IGC0. As a result, the output of that gate is transferred to the "one" condition and monopulser 27T1MP is activated to gate the information into the shift register and reset all of the counters 21P–BC as described in Section 4.8. The oscillator 21K is energized under the control of gate 21CC3G and controls the gates 21PG1G through 21PG3G which in turn operate the shift register until gate 32CP16G is energized by the counter which in turn disables gate 21CC3G and arrests the operation of oscillator 21K.

As usual, when the first shift pulse is produced from gate 21PG1G, all of the information in the shift register is transferred and the output of flip-flop 31OSFF changes from a "zero" condition to a "one" condition to transmit the preliminary pulse.

The remainder of the information in the shift register is transmitted in the manner described above for a service request call. After each shift pulse is generated from gate 21PG1G, a "write" pulse is generated by gate 21PG2G. Since the latter pulse is unnecessary at this time, the "write" gate 27WGG is inhibited by gate 27WIG which latter will block all of the "write" pulses until after gate 32CP16G is set and all the information has been transmitted from the shift register at the control circuit.

In the interim at the remote unit, the transmission of the start pulse or preliminary pulse is detected in the usual manner by the signal present detector (Section 3.25) and discriminator (Section 3.24). Gate 15STG is operated, in the manner described above, and the "one" condition signal from the gate is applied to timer 15GIT which in turn energizes gate 15MTG and monopulser 15MT to set flip-flop 11PPFF over conductor 15MTC. When the latter flip-flop is set, the input to inverter 11PP0I changes from a "one" condition to a "zero" condition to operate relay 11ST. In addition, gate 11ING is energized which in turn causes the setting of flip-flop 11INCFF. Relay 11SRP is released and relay 11SIC is operated as well as relay 4IC.

Operation of these relays results in the release of relays 13LU-, 13LT- and 13LK permitting the processing of a terminating call. In consequence, if a service request call was actually in process at this time, the terminating call would be accorded preference. But, if the service request call had advanced to the identification of line information, relay 9SR would have operated to inhibit gate 11ING and prevent the setting of flip-flop 11INCFF. The time at which the starting pulse from the control unit arrives at the remote unit therefore determines the preference. If the pulse arrives before the line identification has been transmitted, the control unit obtains preference. If the pulse arrives after the line identification has been transmitted, the remote unit retains control of the call.

The setting of flip flop 11INCFF, described above, energizes monopulser 11T6 to generate a 10 microsecond "one" condition pulse which is applied to monopulser 11T4. The latter generates a 10 microsecond "one" condition pulse which is applied to binary cell 6CTR1BC. At the end of the timing interval, the cell is set. The "zero" condition from flip-flop 11INCFF is applied to gate 16CC3G over conductor 11INC0C. Oscillator 16K is subsequently energized over gate 16CC1G in the manner described above for a service request call. The operation of the shift register in storing the information transmitted by the control unit is also similar to that described above for a service request call.

Oscillator 16K is arrested by gate 13CC3G when gate 6CP16G of the counter is energized. Thus, a path may be traced through inverter 68I, conductor 6P160C, gate 11CKT1G to gate 16CC3G. It will be noted that when the counter reached a count of 6, gate 6CP6G is energized and a signal is applied through inverter 6CP6AI and conductor 6CP6C to gate 11I6G and monopulser 11T8. The latter applies a 10 microsecond pulse to inverter 111I which in turn energizes (over conductor 11T5C) the inputs to gates 5CI–G. The other input to these gates is from the shift register flip-flops 5SA–FF. Thus, those flip-flops which are set will produce an equivalent setting in the corresponding flip-flops 5SC–FF. Since the call is a terminating call, it is assumed that flip-flops 5SC4FF and 5SC7FF will be set, in turn operating relays 5SC4 and 5SC7. When the latter relays operate, the corresponding relays 4C4 and 4C7 are operated and check relay 12CK is operated, in turn causing the operation of relay 9TER over a path including the contacts of relay 12CK, 4C4 and 4C7. Operation of relay 9TER causes relay 12TRK to operate. Relay 14SI1 is operated over an obvious path to transmit the line identification when it is received to the register.

It will be noted that the operating path for relay 12TRK included the operated contacts of relays 9TK0 and 9TK8. The latter relays were operated to identify the preselected trunk (again assumed to be trunk 0). When the trunk check relay 12TRK is operated, relay 9TS00 associated with the preselected trunk operates and opens the trunk path through the crossbar switches as shown in FIG. 2 to prevent current surges through the crosspoints when they close.

After relay 12TRK is operated, the select magnets 7SMA0 and 7SMA8 are operated in the manner described above and relay 7SMK is operated in the usual manner to verify the correct operation of the select magnets.

When the remote unit has received all of the line identification information, as indicated by the energization of date 6CP16G, relay 6SR0 is operated through inverter 6P160I and the contacts of relay 4IC. Relay 4R0 is operated at the contacts of relay 6SR0 and the appropriate relays representing the line identification are operated, i.e., relays 5SA4, 5SA7, 10SB4 and 10SB7. Relays 4A4, 4A7, 4B4 and 4B7 are thereupon operated in the usual manner and check relay 12ABK is operated. When the latter relay is operated, as well as relay 12CK, relay 12SQ1 operates as a call progress indication indicating reception of line information as well as call type. An operating path for relay 14S02 is now closed to steer the trunk information into the shift register as shown in FIG. 4. Since the preselected trunk is assumed to be trunk 0, information is delivered over conductors AI4, TI7, BI4 and BI7 to the corresponding shift register stages where it is stored.

The operation of relays 4A4, 4A7, 4B4 and 4B7, discussed above, completes a path through the contacts of relay 14SI1 to operate the register relays 9T0 and 9U0 in a manner similar to that discussed for a service request call. As usual, the check relay 12LRK is operated to verify that the register relays have correctly operated. The operation of the hold magnet is similar to that described in Section 4.6.

5.3 *Select magnet operation and hold magnet operation at control unit*

In the interim at the control unit, when relay 23ESM0 is operated, as described above, the select magnets associated with the preselected trunk will operate in the manner described above for a service request call. However, if relay 24SMK fails to operate or if relay 23DSM operates, then relay 37TCF will operate.

Assuming that relay 24SMK operates in the normal manner, as described for a service request call, the appropriate hold magnets associated with the operated relays 33T0 and 33U0 will be closed, also as described above. When the hold magnet 19HM0A00 is operated, the sleeve relay 17SL00 is also operated. A ground condition is applied on the central office sleeve leads through the operated crosspoints to energize relay 18TBA00, also in the manner described for a service request call. Relay 18TB00 operates over an obvious path and the operation of the hold magnet check relay 19HMK causes the release of relay 24ESM0 which in turn releases the select magnets utilized in the call. At this time the networks at both the remote unit and the control unit are operated.

In the interim at the remote unit, when relay 12SQ2 is operated (after the hold magnet is operated) a path is completed for the operation of relay 14CKT which latter energizes gate 11CKTG to reset flip-flop 11PPFF and to trigger monopulser 11T2 which clears the line information by resetting the shift register over gates 11RSG, inverter 1141 and conductor 11INC. Moreover, monopulser 11T1 is energized and over inverter 1151 and conductor 11INC gates the trunk information into the shift register over conductors AI4, AI7, BI4 and BI7. The output of monopulser 11T1 resets counter 16P–BC. Gate 16CC3G is reenabled and oscillator 16K is energized. Again, the gates 16PG1G–16PG3G are operated to advance the information in the shift register through the signaling circuit as described for a service request call. The operation continues until the counter gate 6CP27G changes from a "zero" condition to a "one" condition and disables gate 6CC3G over conductor 6CP27C. Relay 6SEP is operated over inverter 6P270I to indicate that the trunk identification has been transmitted to the control unit.

The trunk information is stored in the control unit in a manner similar to that described for the reception of line information on the service request call with the exception that the oscillator 21K is controlled by gate 16CC3G and the counter is arrested by the energization of gate 32CP27G.

When relay 32IEP is released, in the manner described for a service request call, relay 41EP releases. At this time, relay 41PP is operated over the contacts of relays 41EP, 38TUK, 41TCA1 and 27IPP. The operation of relay 41PP completes an operating path for relay 36TIS. The operation of relay 36TIS completes a path for relay 24NK, in the manner described above, and releases relays 25LT00 and 25LU00. Relay 36TCC0 is operated over the contacts of relays 36TIS and 28TER0. Relay 38OL0 is operated over the contacts of relays 36TIS and 41ATC01.

As usual, the operation of relay 38OL0 opens the signal pair to the remote unit, as shown in FIG. 20, to indicate to the remote unit that the first pulse was received in the control circuit and also conditions the remote circuit for release.

The opening of the signal pair by the control unit is detected as usual in signal present detector 15SPD to cause the operation of relays 15STA and 4TA. The operation of relay 4EP after the trunk information is transmitted in conjunction with the operation of relay 4TA causes the operation of relay 14OL over a path which may be traced from ground, contacts of relays 11SRP, 4TA, 4IC, 4EP, additional contacts of relay 4IC, winding of relay 14OL to negative battery. The operation of relay 14OL opens the signal pair to the control unit which responds by operating relay 20ITA0 as a signal to the control unit to release.

Prior thereto, the operation of relays 20ITA0 and 41TA0 completes an operating path for relay 32IR over the contacts of relay 24NK when gate 32CP27G is operated. The operation of relay 32IR completes a connection to relays 26SB- and 31SA- which operate according to the trunk information stored in the shift register. The relays which are operated in this case representing trunk 0 correspond to relays 26B4, 26B7, 31SA4 and 31SA7. Subsequently, relay 24ABK checks the operation of these relays.

5.4 *Trunk check on terminating call*

As indicated above, the trunk information representing the connected trunk at the remote unit has been transmitted to the control unit and stored in the register thereat. It remains now to verify that the trunk identity transmitted from the remote unit (illustratively trunk 0) is the same as the trunk stored in the register at the control unit.

The operation of relay 24ABK as described above, completes an operating path for relay 36RF which may be traced from ground, contacts of relays 36TIS, 24ABK, 41A1, 41A7, 41B4, 41B7, winding of relay 36RF to negative battery. In addition, a path is prepared for relay 37TCF and relay 23TCK.

It will be noted that relays 36RF and 37TCF are operated only in the event of a trouble condition, relay 36RF in the event of a remote circuit failure and relay 37TCF in the event of a trunk check failure.

The operation of relay 23TCK is effected from negative battery, resistance 231, contacts of relays 24ABK, 36TCC0, 40CT00, 29TK00, 36TCC0, 41B7, 41B4, 41A4, 41A7, 36TCC0, 29ET0, 23DSM, winding of relay 23TCK to ground. The operation of relay 23TCK completes a path for relay 40CT00, which in turn completes the circuit through the ring conductor of the trunk extending to the remote unit as shown in FIG. 17.

Relay 40CTK is operated from negative battery, winding of relay 40CTK, contacts of relays 29TK00, 40CT00 to ground. Select magnet 23SM0A0 is released at the contacts of relay 40CT00. The operation of relay 40CTK completes a path for the operation of relay 39RL1 which in turn opens the locking path for relay 38LK0 as well as the path for hold magnet 19HM00A. In addition, relay 28TER0 is released at the contacts of relay 39RL1. Relay 28D0 is operated as is relay 39RL2. Relay 29TK00 is released at the contacts of relay 39RL1. Release of relay 29TK00 completes a locking path for relay 40CT00.

In addition the release of relay 29TK00 opens the operating path for relay 40TCK and 29AT0.

Relay 28TER0 is released when relay 29ET0 releases and relay 28D0 operates as shown in FIG. 28. The release of relay 28TER0 effects the release of relays 41ATC00, 36TCC0, 41LI0 and causes the operation of relay 22TGB0. The release of relay 41ATC00 in turn causes the release of relays 40TCK and 41TCA1. Release of the latter relay in turn effects the release of relay 24NK, 36TIS and 34RC4. Release of relay 36TIS effects the release of relay 23TCK and relay 38OL0.

Operation of relay **39RL2** as described above, initiates the operation of timer relay **39TM3** and opens the hold path of relays **24SMK**, **33T0** and **33U0**. Release of relay **24NK** interrupts the operating path for relay **24ABK**. Release of relay **33T0** in turn releases relay **19HMK** and the release of relay **38LK0** opens the operating path of relay **38TUK**. Release of the latter relay in turn opens the operating path for relay **41PP**, the release of which causes relay **36TIS** to release.

Operation of relay **39RL1** completes a path for the operation of timer **37TM2**. If relay **39RL1** has not released before relay **37TM2** operates, an alarm (not shown) is energized. However, if the relays associated with the locking path of relay **39RL1** have released and relay **39RL2** has operated, relay **37TM2** is prevented from operating.

As indicated above, relay **38OL0** has released, thereby completing the signal control pair to the remote unit as an indication to the remote circuit to release.

At the remote unit, relays **15STA** and **4TA** are operated in the usual manner, and the operation of relay **41EP** as described above together with the operation of relay **4TA**, effects the operation of relay **14OL**, thereby opening the signal pair to the control unit. When the control unit closed the signal pair as described above, relay **15STA** releases and relay **12SQ3** operates over a path from negative battery, winding of relay **12SQ3**, contacts of relays **41C**, **4TA**, **14OL** to ground. Operation of relay **12SQ3** indicates the successful transmission of trunk information. When relay **12SQ3** is operated, relay **14RL1** operates over a path from negative battery, resistance **142**, contacts of relay **14TM2**, winding of relay **14RL1**, contacts of relays **14RL2**, **12SQ3**, **4IC**, **4TA** and **11ST** to ground. The operation of relay **14RL1** opens the operating path of relay **9TK0** which releases, in turn releasing relays **12TRK**, **20H**, **8HMK** and **7SMK**. In addition, select magnets **7SMA0** and **7SMA8** release and relay **14RL2** operates. When the latter relay operates, relay **14RL1** releases.

The operation of relay **14RL1**, in conjunction with the release of relay **14RL2**, causes the operation of relay **14RLS**, which in turn delivers a release signal as shown in FIG. 6 to the solid state logic circuitry over conductor **6RLSC** which resets flip-flops **11PPFF**, **5SC–FF** and **11INCFF**, as well as cells **6CTR–BC**. When flip-flops **5SC–FF** reset, the associated relays **5SC-** and **4SC-**, as well as relays **9TER** and **14SI1**, are released. The resetting of flip-flop **11INCFF** causes the release of relays **11SIC**, **4IC**, **12SQ1–12SQ3** and relay **14S02**. The release of relay **12SQ1**, effects the release of relays **12LRK**, **9T0**, and **9U0**. The release of the foregoing relays effects the release of relays **14RL2**, **14OL**, and **14RLS**. As usual, when relay **14OL** is released, the path to the control unit is closed.

This transmits a signal to the control unit which releases relay **20ITA0**, as an indication that the remote unit is now in the normal condition. Thereupon, the control unit proceeds to release and to return to the normal condition.

Thus, when relay **20ITA0** is released, the corresponding relay **41TA0** is released. Release of the latter relay transmits a release signal as shown in FIG. 32 to the electronic logic circuitry over conductor **32RLSC**. The release of relay **41TA0** releases relays **41ATC01** and **38OL1**. Since remote unit **0** is processing the call, the release of relay **38OL1** completes the signal pair to the remote unit not being used on the call. The latter remote unit in turn completes its signal pair to the control unit indicating that it is in the normal condition.

The release signal to the solid state logic circuitry over conductor **32RLSC** causes the resetting of flip-flops **27OTGFF**, **27PP0FF**, the shift register flip-flops and the counter binary cells. When flip-flop **27PP0FF** resets, the output of gate **27PP0G** changes from a "zero" condition to a "one" condition and causes release of relay **27IPP**.

The release of the shift register flip-flops effects the release of the associated relays and the resetting of the counter binary cells causes the release of relay **32IR**.

When the shift register output relays have released, the associated relays **41A-** and **41B-** release, causing the operation of relay **24NK**. Release of relay **27IPP**, in turn causes the release of relay **41PP** which together with the release of relay **41TA0** causes the release of relay **39RL2**. Release of relay **39RL2** in turn releases relay **24NK** and the operation of relay **39TN3** to return the circuit to a normal condition.

When relay **20ITA1** (not shown) releases, the associated relay **41TA1** releases thereby allowing calls to be made to both remote units.

6.—DISCONNECT CALL

As indicated in the general description above, a disconnect call is initiated after each service request and terminating call in order to select a trunk for the next succeeding call. A disconnect call is initiated in the control unit when relay **28D0** is operated, as described above, and relay **22TGB0** is normal indicating an idle trunk is available. As indicated in the preceding section, relay **28D0** is operated during the release of the service request or terminating call. It is also operated when there is an attempt to establish a terminating call and a trunk has not been preselected.

Normally, after a service request call or a terminating call, all 16 trunks to the remote unit involved will be connected and a disconnect call is made to release an idle trunk. As will be explained herein in detail, the detection of two or more trunks in the released condition (evidenced by the operation of relay **40CHM0**) will result in a special disconnect call which will select all of the released trunks until all 16 trunks are connected. When a special disconnect call is made the call is similar to a normal disconnect call with the exception that the hold magnet will not be released since the trunk is already released. Moreover, the trunk preference circuit will not be used since only the trunks that are released will be selected. If, during a special disconnect call, it is determined that the trunk was connected to a line and the trunk memory (relay **40CT-**) was not available (indicated by the operation of relay **36OHM**) the appropriate hold magnet will be released.

6.1 Start of disconnect call

Operation of relay **28D0** opens the operating paths to the other relays in the call preference circuit for group O. Moreover, a path is completed for the operation of relays **28SC00** and **28DIS00**. Operation of relay **28DIS00** completes a path for the operation of relay **28SC01** and relay **28DIS01**. Moreover, the preference circuit for group **1** is precluded from initiating a disconnect call. Relay **38LK0** is released at the contacts of relay **28DIS00**. An operating path for relay **41ATC00** is also completed at the contacts of relay **28DIS00**. The operation of relay **28SC00** opens the sleeve conductor to the line equipment at the central office as shown in FIG. 17. This results in the release of relay **17SL00** (assuming that the relays **25LT00** and **25LU00** were operated).

Operation of relay **28DIS01** completes a path for the operation of those relays **18TBA-** which have an operated relay **18TB-** associated therewith. The operation of a particular relay **18TB-** indicates that the particular trunk is busy. The operation of relay **28DIS02** completes a path in FIG. 35 to the shift register over conductors **CI0** and **CI1** to register a disconnect call. Moreover, an operating path is completed for the preferred trunk relay **29TK01** (assuming that trunk **1** is the next preselected trunk) as the trunk is idle and relay **40CHM0** is unoperated. In addition, relay **41DT1** is operated at the contacts of relay **28DIS02**. Operation of the latter relay partially completes a path for extending the trunk information to the shift register as shown in FIGS. 30 and 35. Operation of relay **41ATC00** completes an operating path for relay **38OL1** (not shown) which opens the control pair to the remote unit not being used on the call.

Operation of relay **41TCA1** partially completes an operating path for relays **33T0** and **33U0**.

The information from the electromechanical portion of the control circuit identifying the trunk to be released is gated into the shift register in the usual manner. This information, together with a preliminary pulse, is transmitted to the remote unit. As usual, when the first shift pulse is produced the output of flip-flop **31OSFF** changes from a "zero" condition to a "one" condition.

At the remote unit the reception of a start pulse and the transmission of the type of call information is similar to that discussed above for a terminating call. On a disconnect call, however, relay **9D1** is operated for a normal disconnect call and relay **9D2** for a special disconnect call. The operation of relay **9D1** causes the operation of relays **9DIS0–9DIS9**. The contacts of relays **9DIS0–9DIS9** interrupt the path to relays **2L00–2L09**, respectively. When relay **9D** is operated, the locking path for relays **9TK-** is interrupted to release any such relays that have remained operated from previous calls. Relay **14SI2** is operated over an obvious path. The latter relay steers the trunk information when it is received from the control unit to the trunk register.

The transmission of the trunk information from the control unit and the reception thereof at the remote unit is in accordance with the procedure described above for a terminating call. Assuming that the trunk to be disconnected is trunk TK1, the appropriate relays **5SA-** and **10SB-** will be operated followed by the operation of corresponding relays **4A-** and **4B-**. When the latter relays are operated a path is completed through the contacts of relays **14SI2** to operate relay **9TK0**. This path may be traced from negative battery, winding of relay **9TK0**, contacts of relays **14SI2**, **4B4**, and **4B7** to ground. Since trunk **1** is the preselected trunk, relay **9TK9** is also operated over the contacts of relays **4A2** and **4A7**. The operated relays **4A-** determine the trunk steering level whereas the operating relays **4B-** determine the trunk select level. Relay **12TRK** is operated to check that relays **9TK-** have operated correctly. When relay **12TRK** operates, a path is completed to relay **9TS01** associated with the trunk to be disconnected. The operation of the latter relay opens the path through the switch to prevent current surges and closes a path through the relay associated with the line connected to the trunk which is to be released. Assuming that the line is substation **17**, relay **2L17** will be operated from negative battery, winding of relay **2L17**, sleeve conductor of the trunk, contacts of relays **9TS00**, **7RH**, **7OH**, and winding of relay **2XPK** to ground. Both relays **2L17** and **2XPK** are operated over this path. As a result of the operation of relay **2L17**, the appropriate relays **13LT3** (not shown) and **13LU0** are operated. Again check relay **13LK** operates in the usual manner. When the latter relay operates, relay **13LS** is operated in turn causing the operation of relays **9T3** (not shown) and **9U0**. Thereafter, check relay **12LRK** is operated in the usual manner.

When relay **12LRK** is operated, as described above, a path is completed to operate relay **7RH**. This path may be traced from negative battery, winding of relay **7RH**, contacts of relays **7OH**, **8XPK1**, **9D** and **12LRK** to ground. Operation of relay **7RH** results in the application from negative battery, resistance **82**, contacts of relays **7RH**, **9T1** and **9U7** of a potential to hold magnet **9HMA17** to ground, opposite in direction to that provided for operating the magnet. The reverse current through the hold magnet releases the magnet but prior thereto, relay **8HRK** is shunted over the contacts of relays **7OH**, **9T1** and **9U7** and **8HMA17** to ground. When hold magnet **8HMA17** releases, relay **8HRK** operates over the contacts of relay **7RH** and resistor **85**.

6.2 *Trunk preference on a normal disconnect call*

The trunk preferred for disconnection at the control unit is determined by a combination of trunk preference relays **34TPR01–34TPR05** for group **0** and relays **34Z0** for group **0** and relays **34TPR11–34TPR15** and **34Z1** for for group **1** (not shown) as explained in Section 3.41. After the preferred trunk has been selected, one or more of these relays operates or releases for the next call in order that a particular trunk be preferred once during 16 successive calls.

The preference circuit is arranged to operate relay **34TPR01** initially as explained in Section 3.41 supra. Thereafter, on subsequent calls, the path may be traced from negative battery, contacts of relay **34TPR05**, winding of relay **34TPR01**, contacts of relay **34TPR01**, additional contacts of relay **34TPR05**, contacts of relays **28DIS02**, **24ABK**, **36TIS**, **19HMK**, **38TUK**, **29TRK**, **39RL1** to ground. Relay **34W0** operates over the contacts of relay **34TPR01**. Operation of relay **34W0** completes a path for relay **34TPR01** through the contacts of relay **34Z0** and the contacts of relay **34W0**. Operation of relay **34TPR01** removes the shunt path from relay **34Z0** which operates.

Subsequently, the trunk identity is returned to the control circuit from the remote circuit and a sequence of operations is performed similar to that described in section 5.4.

6.3 *Trunk preference on a special disconnect call*

A special disconnect call is made, as explained above, in Section 3.42, when more than one trunk in a group has a released relay **40CT-** associated therewith in turn causing the operation of relay **40CHM0**. When one relay **40CT-** is released, the current in both windings of relay **40CHM0** is balanced and the relay elements released. When two or more relays **40CT-** are released, the current in the primary winding is sufficient to operate relay **40CHM0**. When relay **40CHM0** is operated, those trunks which have relays **40CT-** and **18TB-** released will complete operating paths to the associated relays **29TK-**.

Assuming the trunks **6** and **7** are released, relays **29TK06** and **29TK07** (not shown) will be operated in turn causing the operation of relays **29ET0** and **29OT0**. It will be seen from FIG. 29 that a holding path is completed for the lowest numbered relay **29TK-**, in this case relay **29TK06**. As usual, check relay **29TRK** is operated. The operation of relay **29TRK** initiates the transmission of trunk information to the remote unit.

6.4 *Line identification on a special disconnect call*

Normally when a special disconnect call is made, a line will not be identified when trunk relay **29TRK** operates and completes a connection through the operated trunk relay **29TK04** to the sleeve of the trunk to be disconnected since the released relay **40CT-** indicates that the trunk is released. In consequence, relay **38TUK** will not be operated to provide a path to release the hold magnets.

However, if relay **40CT-** had been incorrectly released and the trunk remained connected to a line, the ground applied on the sleeve conductor will operate sleeve relay **17SL-** of the connected line. In addition, an operating path will be completed for the line lockout and identification relays associated with the sleeve relay unique to the line connected to the trunk being released.

The operation of the sleeve relay and the line lockout and identification relays completes an operating path for the relays **33T-** and **33U-** associated with the line to be identified. Thereafter, the sequence for a special disconnect call is the same as is a normal disconnect call.

The operation of relay **38LK0** completes a path for the operation of relay **38TUK**. Thereupon, the operation of relay **24HM0** completes a path for releasing the hold magnets associated with the identified line in the manner described above for the remote unit hold magnets.

When the hold magnets release, the operating path for relay 19HMK is opened and relay 34TPR03 is operated, providing that relay 34TRR03 was priorly released and relay 34TR02 was operated.

At the remote unit when relay 12TRK is operated, a path is completed through relays 2XPK, 7RH, 12SQ2, 9D2, and 12TRK to operate relay 8XPK2. Relay 9TS01 is operated and completes a path through relay 2XPK when relay 12TRK is operated. Relay 2XPK will be operated when a line is connected to the trunk on a special disconnect call and thereafter, the call will follow the same sequence as for a normal disconnect call. If relay 2XPK does not operate, relay 8XPK2 will operate and complete a path to operate relay 8HRK. When the latter relay operates, a path is completed to operate relay 12SQ2 which in turn releases relays 9TS01, 5A- and 10SB- as well as the associated relays 4A- and 4B-. Relay 13LK- is released thereby releasing relays 13LT- and 13LU-. When relay 14CKT is operated, a ground is applied to gate 11CKTG which initiates the transmission of the trunk information in the manner described above.

The open line signals between the control unit and the remote unit are the same as those described on a terminating call. The release signal, however, does not effect the release of relays 9TU1 and 9TU9 which instead serve as the preselected trunk on the next service request or terminating call. When relay 14RL1 is operated, a path is closed through the contacts of relay D to operate relay 14RL2. The hold path for relays 9TU1 and 9TK9 is through the contacts of relay 9D and relay 14RL1.

6.5 *Trunk check at control unit*

The trunk checking procedure is similar to that described above for a terminating call with the exception that relay 34TPR01 is operated at the contacts of relay 24ABK. Moreover, the operation of relay 23TCK opens the operating path of relay 37TCF and closes an operating path for relay 39RL1. The operation of relay 39RL1 releases relay 38LK0 and removes battery from the hold magnets. The operating path for relays 28DIS00 and 28SC00 is opened although the hold path remains closed. Relay 28D0 is released at the contacts of relay 39RL1. The release of the latter relay causes the release of relays 28DIS00 and 28SC00. The release of the remaining control relays is similar to that described above for a terminating call as is the release of the solid state logic circuitry. When relay 41ATC01 is released, the operating path for relay 38OL1 is opened in turn completing the singal pair to the remote unit in serving the call.

Release of the relays 41A- and 41B- cause the operation of relay 24NK which in turn causes relay 39RL2 to release. The latter in turn releases relay 24NK.

7.—SERVICE DENIAL CALL

Occasionally, it becomes necessary to "deny" service to a particular customer whose line is functioning abnormally. For example, the subscriber may have received a terminating call and allowed his receiver to remain off hook.

Service may be denied to the substation serving that subscriber by initiating a service denial call from the control unit. Under these conditions, it is necessary for maintenance personnel at the central office to connect the service denial terminal of group 0 or group 1 to one of the terminals of group 0 or group 1. For illustrative purposes, it will be assumed that service should be denied to line 00.

Operation of key 18SD0K results in the operation of relay 28SDP0. The operation of the relay 28SDP0 completes an operating path for relays 28DIS00 and 28SC00. The operation of relay 28SC00 opens the sleeve conductors of all of the lines in the associated group to the central office line circuit as shown in FIG. 17. The operation of relay 28DIS00 completes a path for the operation of relay 28DIS01. Operation of the latter relay completes a locking path to those relays 18TBA- associated with all busy trunks in the group. Relay 41ATC00 is operated over the contacts of relay 28DIS01 and relay 37SD0 is operated at the contacts of relay 28DIS01.

Operation of relay 41ATC00 completes a path for the operation of relay 41TCA1 if all relays 25T- and 25U- are released. Moreover, relay 38OL1 is operated over the contacts of relay 41ATC00 as well as relay 41ATC01. Operation of the latter relay starts the timing cycle of timer 37TM5 and the operation of relay 38OL1 opens the signal pair to the remote unit not being served.

Operation of relay 41TCA2 completes an operating path for relay 17SL00 associated with the line to be denied service.

Operation of relay 37SD0 as described above completes a path for the transmission of service denial class information to the shift register. Thus, conductors CI1 and CI2 are energized over the contacts of relay 37SD0 to indicate a service denial call. In addition, a path is completed for the operation of relay 41LI0 as well as for relay 17SL00. The latter path may be traced from negative battery, winding of relay 17SL00, contacts of relay 19HM0A00, sleeve conductor, terminal S00, terminal SD0, key 18SD0K, contacts of relays 37SD0, 41TCA1 to ground.

Operation of relay 17SL00 initiates a sequence of operations including line identification that are similar to a terminating call with the exception that the select magnets will not be operated. The operation of relay 38TUK completes a path in FIG. 27 to the electronic logic circuitry to initiate the transmission of line information to the remote unit. Moreover, unlike a terminating call relay 17SL00 will not be released when the hold magnet operates nor will the preselected trunk be used or released. Therefore, the associated relay 40CT00 (assuming the selected trunk is trunk 0) will not operate in turn preventing relay 40CTK from operating.

The remote unit responds to the transmission of information relating to the service denial call by operating relay 9SD1 in response to the operation of relays 4C1 and 4C2. Other operations by the remote unit are similar to those for a terminating call with the exception that relays 12TRK, 9TS00, 7SMK, 14S02, 2XPK, 8XPK1 and 2L00 are not operated. As indicated above the select magnets are not operated. Relay 7RH is operated over the contacts of relays 9SD2 and 12LRK. Thus, when the hold magnet is operated no select fingers are engaged to connect the line to a trunk. Moreover, the substation loop is opened at the contacts of relay 8HMA00. In lieu of transmitting the usual trunk signal, a check signal consisting of A digit 9 and B digit 0 is sent to the control unit.

When the control unit receives this information relays 41A2, 41A7, 41B4 and 41B7 are operated, in turn operating relay 24ABK; key 37SD0 may be released at this time to open the operating path for relay 28SDP0. Release of the latter relay causes relay 39RL1 to operate and the circuit is released in a manner similar to that for a terminating call.

8.—RELEASE SERVICE DENIAL CALL

As indicated above the loop to the substation on a service denial call is opened at the contacts of hold magnet 8HMA00 and in consequence the customer has a "dead" line i.e., no dial tone and no sidetone. When the condition necessitates, the line to the subscriber may be reclosed by personnel at the control unit through the initiating of a release service denial call. The call proceeds initially in a manner similar to that of a service denial call except that a release service denial terminal is used. Under these conditions key 37RSD0 is operated in turn operating relay 28RDP0. Thereafter the call proceeds as a disconnect call with the exception that trunk selection will not take place since relay 28DIS02 does not operate nor does relay 29TRK. Moreover, as described above, a service denial call relay 17SL00 (assuming the line is 00) will not release when the hold magnets release.

At the remote unit the circuit operation for a release service denial call is the same as for a terminating call described above with the exception that, relay **9SD2** is operated instead of relay **9TER** and, moreover, relays **12TRK, 9TS-, 7SMK, 14S02, 2XPK, 8XPK1, 2L00** and the corresponding select magnets are not operated. Moreover, relay **7RH** is operated over the contacts of relay **9SD2** and the hold magnet is released instead of operated. In addition, relay **8HRK** operates in place of relay **8HMK** and the same code if used, is a service denial call (A digit 9 and B digit 0) is sent to the control unit.

The response at the control unit to this signal is the same as that for a service denial call. It will be noted that a trunk is not preselected by a service denial call.

9.—TIMING OPERATIONS AND CHECKING CIRCUITS

The preceding description of operation assumed successful completion of each function. Various timing circuits are included which are effective in the event of abnormal operations to recycle the equipment, transmit alarms and prevent other calls from being initiated. In the event of successful call completions, the following timing and checking operations may be ignored.

9.1 *Recycle timing*

The recycle timer associated with relay **37TM1** is similar in over-all aspect to the timer associated with relay **14RT** of the remote unit. For a call originated at the control circuit, the first (longer) interval of the recycle timer is between the end of signaling to the remote unit (characterized by the operation of relay **41EP**) and the reception of a reply signal from the remote end (release of relay **41EP**). The second (shorter) interval is between the start of signaling from the remote end (characterized by the operation of relay **36TIS**) and the operation of relay **24ABK** which indicates that the information has been checked.

When the ground condition is removed from the timing circuit, the transistor timer will respond by operating after a period of time controlled by an RC network. Two timing intervals are available. The one for short timing interval being 100 to 150 milliseconds and the other for a long timing interval being 500 to 600 milliseconds.

A service request call initiates recycle timing when relay **36RTR** operates. If relay **24ABK** does not operate (as seen in FIG. 37) before the short timing interval, relay **37TM1** will operate to close an operating path for recycle relay **37RC1**. The operation of relay **37RC1** recycles the logic circuitry at the contacts of relay **37RC1** in FIG. 32. Operation of relay **37RC1** applies a ground potential to the timing circuit coupled to relay **37TM1** to recycle the timer and cause the operation of relay **37TM1**. Release of the latter relay completes an operating path for relay **37RC2** which in turn releases relay **37RC1**. Release of the latter relay removes the signal condition from the electronic logic circuitry.

Subsequent operation of relay **36RTR** initiates the second operation of the short timing circuit interval of the timer connected to relay **37TM1**.

A terminating call to the remote unit will initiate the operation of the timing circuit when relay **41EP** operates. In the manner described above, relay **37RC1** operates if relay **37TM1** is operated. Operation of relay **37RC1** effects the results described above on a service request and in addition completes an operating path for relay **37RC3**. Operation of the latter relay completes a path to signal the electronic logic circuitry to return to the reset condition as shown in FIG. 32 and, in addition, opens the conductor to flip-flop **270TGFF**. Moreover, the timing circuit is again grounded over the contacts of relay **37RC3** and **41TCA1** to release relay **37TM1**.

Release of the latter relay completes an operating path for relay **37RC2** over the contacts of relay **37RC1**. Operation of relay **37RC2** causes the release of relay **37RC1** which in turn removes the recycle signal from the electronic logic circuitry in FIG. 32. Release of relay **37RC1** effects the transmission of the information stored in the electronic logic circuitry to the remote unit and release of relay **37RC3**. If the remote unit fails to receive the correct information, a trouble signal will be returned instead of trunk information to operate relay **36RF**. The latter relay is operated by the transmission of signals from the remote unit effective to operate relays **41A1, 41A7, 41B4** and **41B7**. Operation of relay **36RF** results in the printing of a trouble record by means not shown herein as not essential to the present invention followed by a trouble release.

A terminating call to the remote unit initiates the second interval of timing for short timing interval for relay **37TM1** when relay **36TIS** operates. If relay **24ABK** does not operate before the end of the timing interval relay **37TM1** operates. Release of relay **41TIS** (due to recycling of the electronic circuit) causes the timer associated with relay **37TM1** to recycle and release relay **37TM1**. Relay **37RC2** operates and releases relay **37RC1**. A subsequent operation of the timer and relay **37TM1** completes a path to relay **37RC2** which effects the printing of a trouble record. Operation of the latter relay will complete an operating path for relay **37RC1** which in turn will cause the operation of relay **37RC4** over the contacts of relay **41PP**. Operation of relay **37RC4** transmits a signal to the electronic logic circuitry to recycle to clock phase **16** as shown in FIG. 32. Moreover, the battery potential is kept from relays **25LT-** of the group being served (by the contacts of relay **41TIS**) and an operating path provided for relay **38OL0** (assuming that group **0** is being served).

9.2 *Timing for release of relay 39RL1*

This function is performed by the timing circuit associated with relay **37TM2**. If relay **39RL1** does not release before the operate time of relay **37TM2** the latter relay will operate which opens the operating path of relay **38OL0** (assuming that remote unit **0** is being served) and opens the operating path of relay **39RL1**. Relay **39RL2** is operated over the contacts of relay **37TM2**.

9.3 *Timing for release of relay 39RL2*

If relay **39RL2** is not released, relay **39TM3** will release to effect the release of relay **39RL2** by means not shown herein as not essential to an understanding of the present invention.

9.4 *Over-all timer*

The operation of relay **41ATC00, 41ATC01** or **41SRC1** will start the operation of the over-all timer circuit associated with relay **37TM5**. If the call is not completed before 12 to 14 seconds relay **37TM5** will operate. The operation of the relay will result in the operation of relay **39RL1**.

9.5 *Hold magnet failure relays*

A service request call operates relay **36HMF1** when relay **41SRC1** is operated over the contacts of relay **24ABK**. When relay **24ABK** operates the operating path for slow release relay **36HMF1** is open. If relay **19HMK** does not operate prior to the release interval of relay **36HMF1** a path is completed for relay **36HMF2** over the contacts of relay **36HMF**. Operation of relay **36HMF2** opens the operating path for relay **36TISR** and closes an operating path for relay **36SS**. In addition the contacts of relay **36HMF2** in FIG. 35 connect a ground contact to the shift register conductors to transmit a trouble signal to the remote unit.

9.6 *Trunk check failure relay*

When the information received from the remote relay has been checked on a two-out-of-five basis as determined by relay **24ABK** on a terminating call an operating path is closed for slow-to-operate relay **37TCF**. If the trunk check is not completed, within the time to operate relay **37TCF**, the operation of that relay will cause a trouble record to be made by facilities not shown herein but well known in the art followed by a trouble release.

Operation of relay **23DSM** opens the operating path for relay **23TCK** which in turn causes relay **37TCF** to operate and generate the same sequence of operation as described above.

9.7 *Hold magnet timing*

If a trouble release occurs on a disconnect or service denial call, relay **39HMT** operates when the hold magnets are closed and relay **19HMK** has operated. The operating path for relay **39HMT** remains closed until relay **40CTK** is operated. Slow-to-release relay **39HMT** releases thereafter and completes a path to operate relay **39RL1**. This interval assures that the hold magnets have sufficient time to build up the magnetic field which keeps the hold magnets magnetically latched.

9.8 *Trunk overflow circuit*

When all trunks are busy in group **0**, relay **22TGB0** is operated. When all trunks are busy in group **1** relay **22TGB1** (not shown) is operated for group **1**. A terminating call effects the operation of the respective relays **17SL-**, **25LT-** and **25LU-** as described above. However, the associated relay **28TER0** or **28TER1** will not operate in view of the contacts of relay **22TGB-** in series therewith. However, a path will be available through the contacts of the operated relays **22TGB-**, **25LU-** and **17SL-** to apply a call progress tone on the ring conductor of the line appearance and to connect the tip and ring conductors to tube TGB0 to trip ringing. When the central office equipment is released ground will be remade from the sleeve conductor in turn causing the release of relay **17SL-** and the associated relays **25LT-** and **25LU-**.

10.—PREFERENCE CONTROL

The preference between terminating calls and service request calls is controlled by the logic circuitry. If a service request call obtains preference relay **27ISR0** is operated in turn causing the operation of relay **41SRC1** which removes battery from the preference relays in FIG. 28.

If simultaneous disconnect and terminating calls occur the operation of relay **28TER0** or relay **28TER1** will remove battery from the preference relays for other calls and the terminating call will obtain preference. The operation of relay **28D0** or the corresponding relay for group **1** will prevent service denial calls from gaining preference and will prevent the operation of relays **28TER0** or **28TER1**.

10.1 *Terminating preference*

When relays **34W3** and **34Z3** are in the normal condition group **0** will be preferred. The operation of relay **28TER0** closes an operating path for relay **34W3** and a shunt path to prevent relay **34Z4** from operating. Operation of relay **34W3** closes an operating path for relay **34Z3**. When relay **28TER0** releases the shunt path of relay **34Z3** is removed causing that relay to operate. Operation of relay **34Z3** changes the preference of the groups and allows group **1** to be preferred. This cycle of operation of relays **34W3** and **34Z3** prevents a failure in one group from affecting calls to the other group.

10.2 *Line lockout preference*

If relays **34W4** and **25Z00–25Z03** are normal the preference in group **0** for relays **25LT-** is from relay **25LT00** to **25LT07**. The preference for relays **25LU-** is from **25LU00** to **25LU09**. When relay **41ATC00** operates on the first call an operating path is completed for relay **34W4**. When relay **36TIS** operates a path is completed for relay **25Z00**. With relay **25Z00** operated, the preference in group **0** is from **25LT07** to **25LT00** and since relay **25Z01** is normal, the preference is from **25LU09** to **25LU00**. When relay **41ATC0** operates on the next call a shunt path is completed which causes relay **34W4** to release. Operation of relay **36TIS** closes an operating path for relay **25Z01**. Operation of the latter relay changes the preference in group **0** from relay **25LU09** to relay **25LU00** and the previously operated relay **25Z00** retains the preference of **25LT07** to **25LT00**. When relay **41ATC00** operates on the next call an operating path for relay **34W4** is completed. Operation of relay **36TIS** causes the release of relay **25Z00**. When only relay **25Z1** is operated the preference in group **0** is from **25LT00** to **25LT07** and from **25LU09** to **25LU00**.

On the following call the operation of relay **41ATC00** causes the release of relay **34W4**. Subsequent operation of relay **36TIS** releases relay **25Z01** and the preference returns to that described initially. This cycle continues and prevents one line from denying service to any other line.

The preference arrangement for group **1** although not shown is similar to that described above.

10.3 *Trunk group busy*

The operating path for relay **22TGB0** is closed when all of the trunk busy relays **18TB-** in the group are operated. Operation of relay **22TGB0** closes the path to the line overflow circuit in FIG. 22 and prevents the operation of relay **28TER0**. In addition, relays **28DIS00** and **28SC00** are prevented from operating.

It is to be understood that the above-described arrangements are illustrative of the application of the principles of the invention. Numerous other arrangements may be devised by those skilled in the art without departing from the spirit and scope of the invention.

What is claimed is:

1. A signaling system including a transmitting unit and a receiving unit, oscillator means at said units, counting means at said units responsive to said oscillator means, and timing means at said receiving unit responsive to a signal indication from said transmitting unit for metering a predetermined time interval and apparatus controlled by said timing means for energizing said counting means at said receiving unit to a predetermined count indicative of said time interval to synchronize said counting means at said units.

2. A signaling system including a transmitting unit and a receiving unit, independently controlled oscillator means in said units, counter means in said units responsive to said oscillator means to record the number of oscillations of said oscillator means, means for energizing said oscillator means at said transmitting unit, timing means at said receiving unit responsive to a signal indication from said transmitting unit for measuring a predetermined time duration, and means responsive to said timing means for setting said counting means at said receiving unit to a count indicative of the time duration of said timing means and for initiating the operation of said oscillator means at said receiving unit to synchronize said counter means at both said units.

3. A signaling system including a transmitting unit and a receiving unit, independently controlled transistor oscillator means at said units, binary counter means at said units responsive to said oscillator means for dividing the frequency of said oscillator means, timing means in said receiving unit responsive to the transmission of a preliminary signal pulse for measuring a predetermined time duration, and means at said receiving unit responsive to the operation of said timing means for supplying pulses to said binary counter means at said receiving unit to establish a count indicative of said time duration prior to the energization of said oscillator means at said receiving unit.

4. A telephone line concentrator signaling system including a transmitting unit and a receiving unit, oscillator means in said units, plural stage binary counter means responsive to said oscillator means, shift register means at said units, means at said transmitting unit for storing binary signals indicative of control information in said shift register means, additional means at said transmitting unit for storing a perliminary pulse signal in said shift register means thereat and for initiating the serial transmission of said signals to said remote unit under control of said oscillator means, timing means in said receiving unit responsive to the reception of said preliminary pulse signal for measuring a predetermined time duration, additional means in said receiving unit responsive to the operation of said timing means for setting said counter means at said receiving unit to a predetermined count indicative of the count achieved in said counter means at said transmitting unit in response to said oscillator means at said transmitting unit for synchronizing said counter means in both said units.

5. A telephone line concentrator signaling system including a transmitting unit and a receiving unit, oscillator means in said units, counter means responsive to said oscillator means, means in said transmitting means for storing binary signals indicative of spaces and marks and for transmitting said signals to said remote unit under control of said oscillator means at said transmitting unit, and means at said receiving unit including timing means responsive to signal transitions from space-to-mark signals for energizing said counter means at said remote unit to a predetermined count corresponding to the count achieved in said counter means at said transmitting unit for synchronizing both said units.

6. A synchronizing system including a transmitting unit and a receiving unit, transistor oscillator means in said units, binary counter means in said units comprising a plurality of tandemly connected flip-flop stages, means for coupling said oscillator means to an initial one of said stages, timing means at said receiving unit responsive to a signal from said transmitting unit for measuring a predetermined time duration, and means coupled individually to each of said stages of said binary counter means and responsive to the operation of said timing means for setting said counter means to a predetermined count indicative of the time duration of said counting means and for thereafter initiating the operation of said oscillator means at said receiving unit.

7. A synchronizing system including a transmitting unit and a receiving unit, independently controlled oscillator means at said units, counting means at said units responsive to said oscillator means, said counting means including a plurality of tandemly connected binary counting means for effecting a frequency division of the oscillations of said oscillator means, means at said transmitting unit effective in response to a service request calling condition for energizing said oscillator means at said transmitting unit to initiate the operation of said counting means thereat, additional means at said transmitting unit effective in response to the energization of said oscillator means for transmitting signals to said receiving unit indicative of said service request calling condition, timing means at said receiving unit responsive to said signals for measuring a predetermined time duration, means at said receiving unit responsive to the operation of said timing means for advancing said counting means at said receiving unit to a predetermined count indicative of said predetermined time duration and for thereafter initiating the operation of said oscillator means at said receiving uint to synchronize said counting means at both said units.

8. A synchronizing system in accordance with claim 7 including in addition means at said receiving unit responsive to subsequent binary signal indications for resetting said counting means at said remote unit to said predetermined count in response to the reoperation of said timing means to maintain synchronism between said counting means at both said units while permitting said oscillator means at both said units to operate independently.

9. A line concentrator synchronizing system including a transmitting unit and a receiving unit, a control channel coupling said units, oscillator means at said units, counting means comprising tandemly connected binary stages at said units, means for coupling said oscillator means to an initial one of said stages for energizing said counting means, transistor timing means at said receiving unit responsive to the transmission of preliminary pulse signals over said channel for measuring a predetermined time duration, means coupling said timing means to each of said stages of said counting means for setting said counting means at said receiving unit to a predetermined count indicative of said time duration prior to the energization of said oscillator means at said receiving unit, and additional means responsive to said timing means for thereafter initiating the operation of said oscillator means at said receiving unit to synchronize said counting means at both said units.

10. A line concentrator synchronizing system including a transmitting unit and a receiving unit, free-running oscillator means at said units, counting means at said units controlled by said oscillator means, means effective on the initiating of transmission of information for energizing said oscillator means at said transmitting unit to energize said counting means thereat and to control the time sequence of information transmission to said receiving unit, transistor timing means at said receiving unit effective in response to the reception of an initial signal from said transmitting unit for verifying that said signal exceeds a predetermined duration, additional means at said receiving unit responsive to the operation of said timing means for establishing a predetermined count in said counting means at said remote unit indicative of said time duration and corresponding to the count effected in said counting means at said transmitting unit during said time duration including means for thereafter energizing said oscillator means at said remote unit.

11. A telephone line concentrator system including a telephone central office, a plurality of remote substation lines, a smaller plurality of trunks extending from said office, remote switching means for coupling said lines to said trunks under control of said office, transmitting and receiving units at said office and at said remote switching means, oscillator means in said units, counter means at said units responsive to said oscillator means for dividing the frequency of said oscillator means, shift register means at said office and at said remote switching means, means at said remote switching means effective in response to a calling condition on one of said lines for identifying said line and for storing binary signals indicative of said line identity in said shift regster means thereat, additional means at said remote switching means for storing a preliminary pulse signal in said shift register means thereat and for initiating the transmission of said signals to said office under control of said oscillator means, and timing means at said office responsive to the reception of said preliminary pulse signal for advancing said counter means at said office to a count corresponding to that effected in said counter at said remote switching means in response to said oscillator means at said remote switching means.

12. A telephone line concentrator system in accordance with claim 11 wherein said timing means includes means for inhibiting the operation of said shift register means at said office when said preliminary pulse is less than a predetermined duration.

13. A telephone line concentrator system in accordance with claim 12 including in addition discriminator means at said office for reenergizing said timing means in response to particular signal transitions in said binary signals.

14. A telephone line concentrator signaling system including a telephone central office, a plurality of remote substation lines, a lesser plurality of trunks extending from said office, remote switching means for coupling

said lines to said trunks under control of said office, transmitting means and receiving means at said office and at said remote switching means, oscillator means coupled to said transmitting means and receiving means, binary counter means comprising a plurality of tandemly connected flip-flop stages responsive to said oscillator means, shift register means at said office and at said remote switching means, means at said office effective in response to a terminating call to a called one of said lines for storing binary signals indicative of said called line in said shift register means, additional means at said office for storing a preliminary pulse signal in said shift register means and for initiating the transmission of said signals by said transmitting means at said office to said receiving means at said remote switching means under control of said oscillator means, guard interval timing means at said remote switching means responsive to the reception of said preliminary pulse for measuring a predetermined time duration, and additional means in said remote

switching means responsive to the operation of said timing means for setting said counter means at said remote switching means to a predetermined count corresponding to the count in said counter means at said office.

15. A telephone line concentrator signaling system in accordance with claim **14** wherein said transmitting means at said office and at said remote switching means includes means for translating said binary signals to corresponding mark and space frequency signals for transmission to said respective receiving means, and discriminating means coupled to said receiving means and responsive to space-to-mark frequency transitions for reenergizing said timing means to advance said counter means to said predetermined count.

No references cited.

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