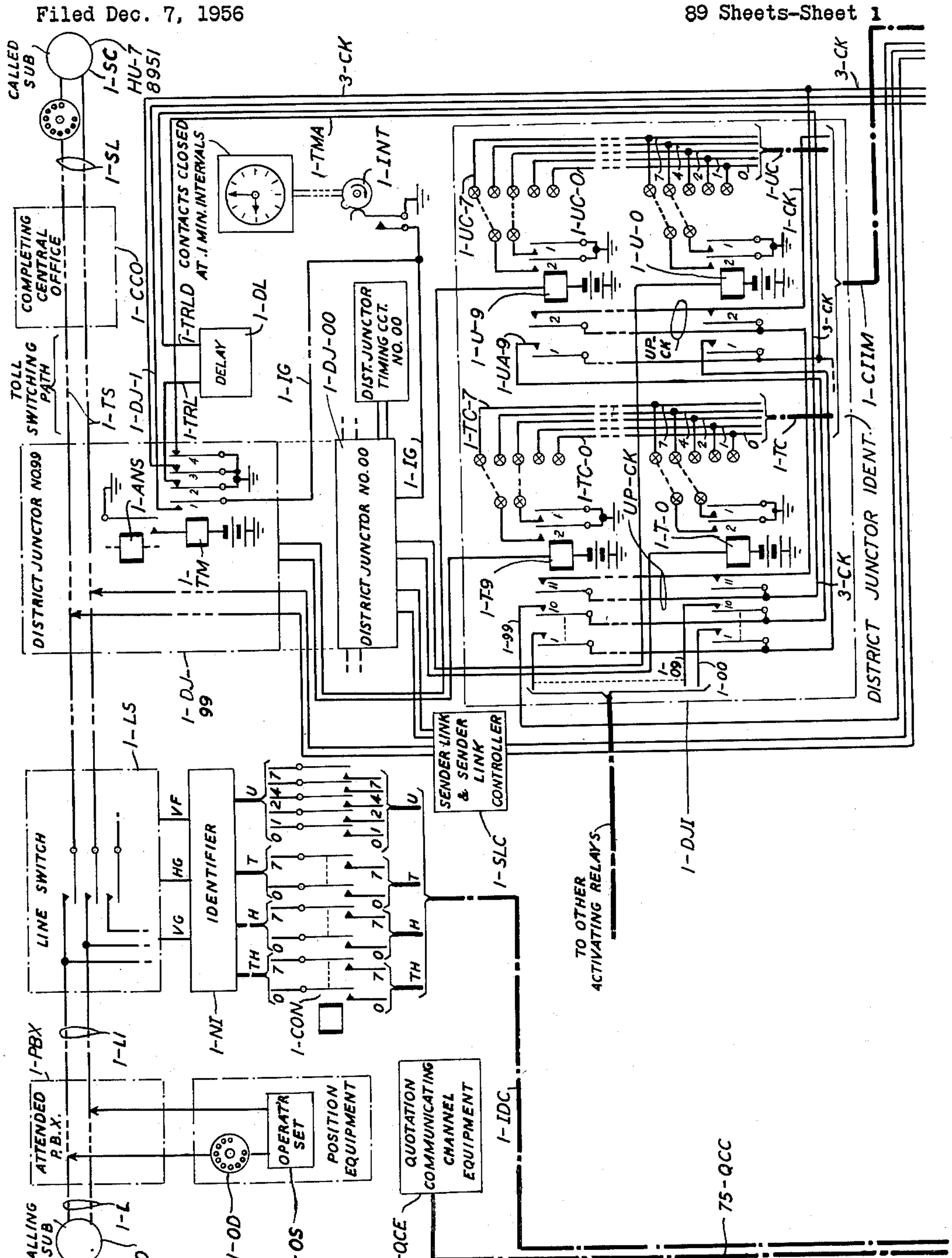

FIG. 1

INVENTORS N. S. TERRY
E. VROOM

BY [signature]

ATTORNEY

AUTOMATIC DETERMINATION OF TOLL CALL CHARGES

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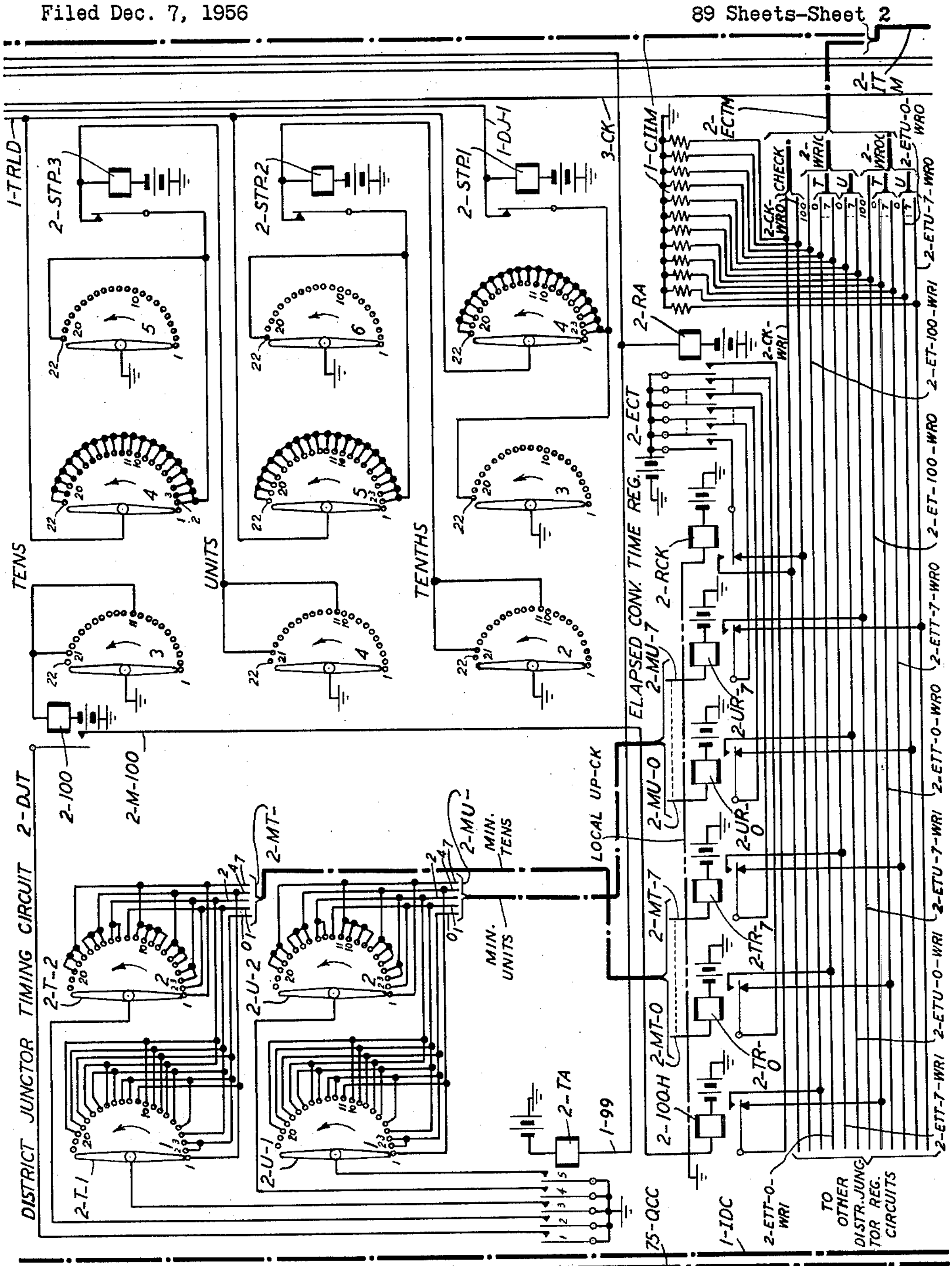

FIG. 2

INVENTORS N.S. TERRY
E. VROOM
BY
ATTORNEY

May 16, 1961 N. S. TERRY ET AL 2,984,704

AUTOMATIC DETERMINATION OF TOLL CALL CHARGES

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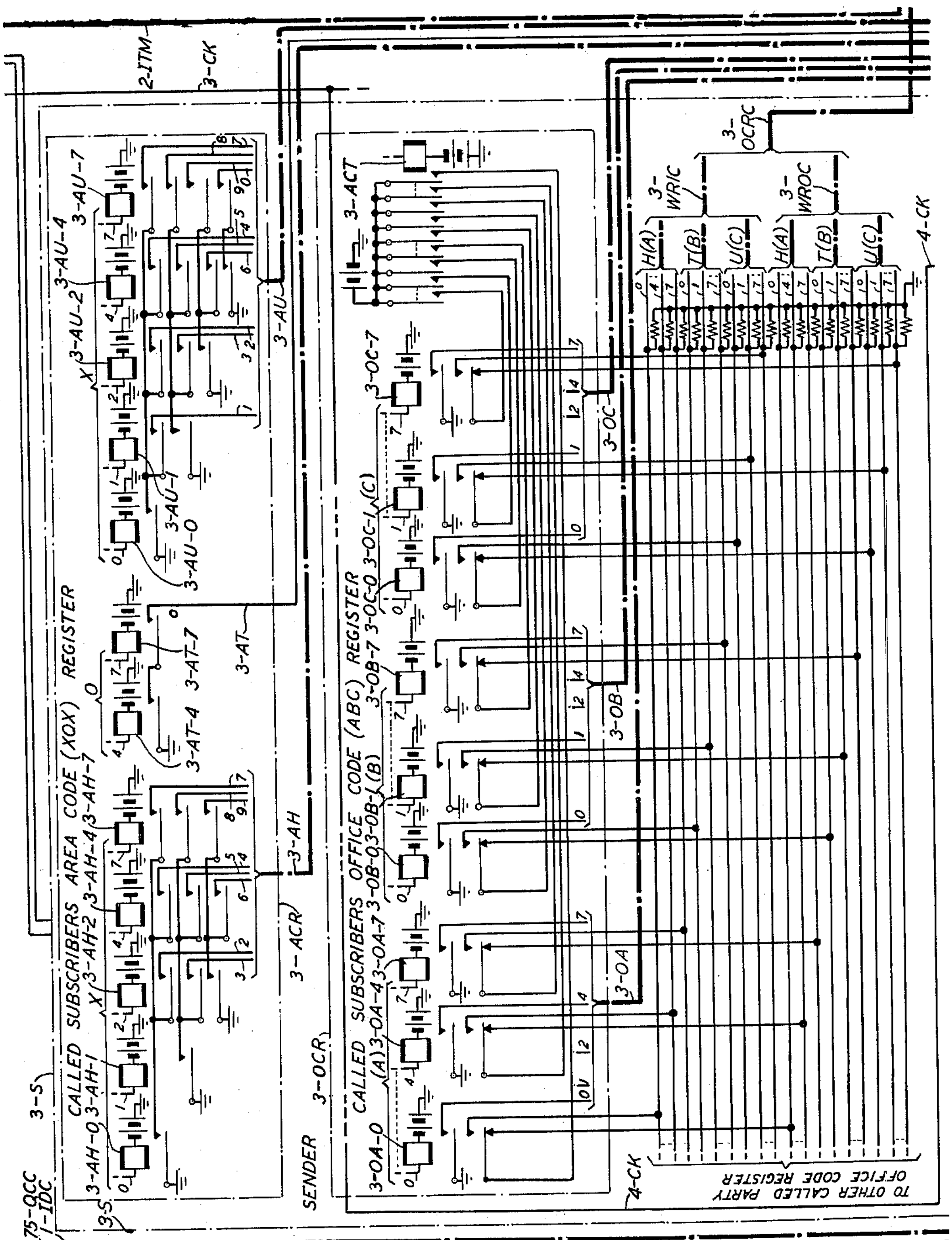

FIG. 3

INVENTORS N.S. TERRY
E. VROOM

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May 16, 1961 N. S. TERRY ET AL 2,984,704

AUTOMATIC DETERMINATION OF TOLL CALL CHARGES

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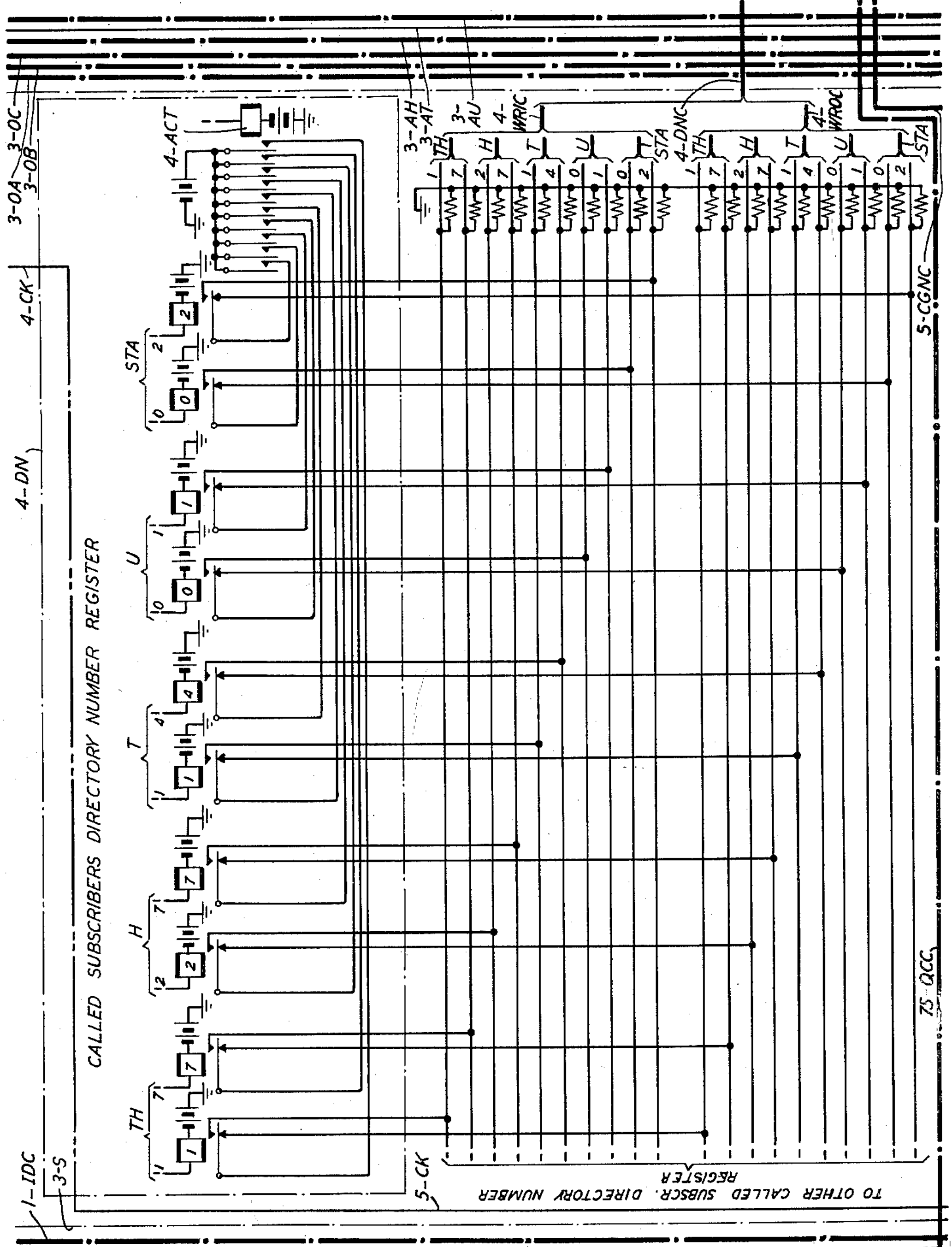

FIG. 4

INVENTORS N.S.TERRY
E.VROOM
BY [signature]
ATTORNEY

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AUTOMATIC DETERMINATION OF TOLL CALL CHARGES

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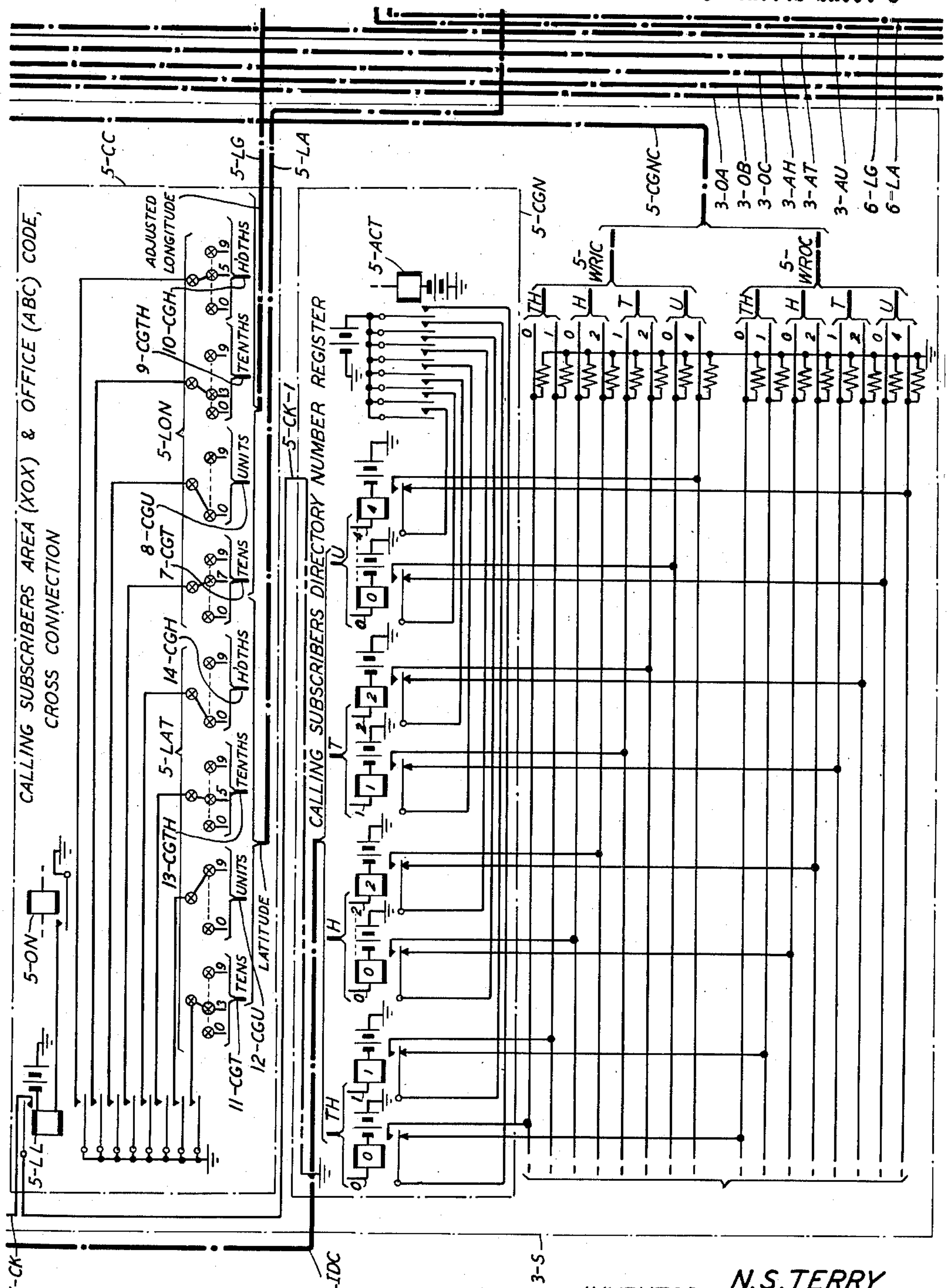

FIG. 5

INVENTORS N.S.TERRY
E.VROOM

BY [signature]

ATTORNEY

AUTOMATIC DETERMINATION OF TOLL CALL CHARGES

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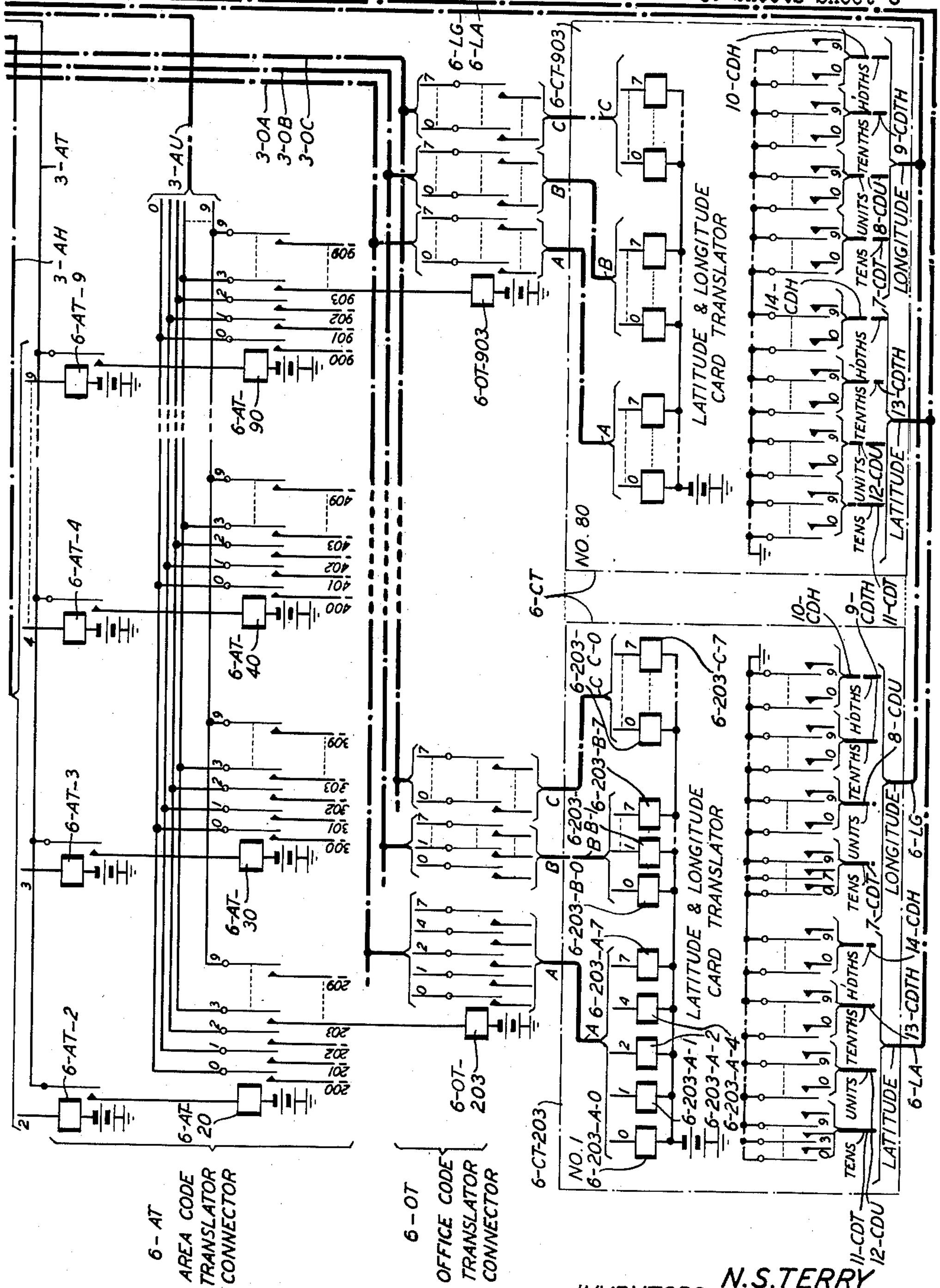

FIG. 6

INVENTORS N.S.TERRY
E.VROOM
BY [signature]
ATTORNEY

AUTOMATIC DETERMINATION OF TOLL CALL CHARGES

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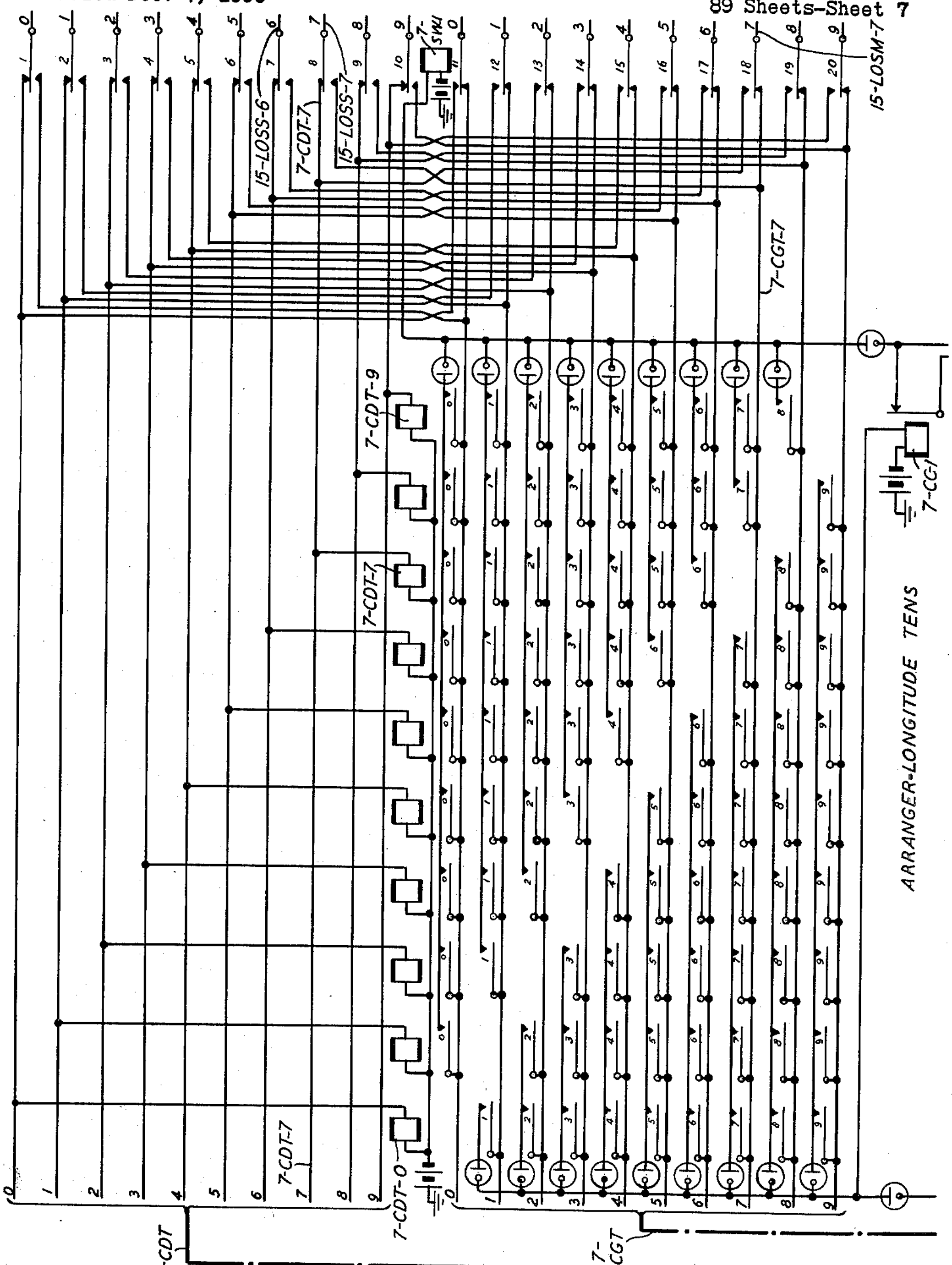

FIG. 7

INVENTORS N.S.TERRY
E.VROOM
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ATTORNEY

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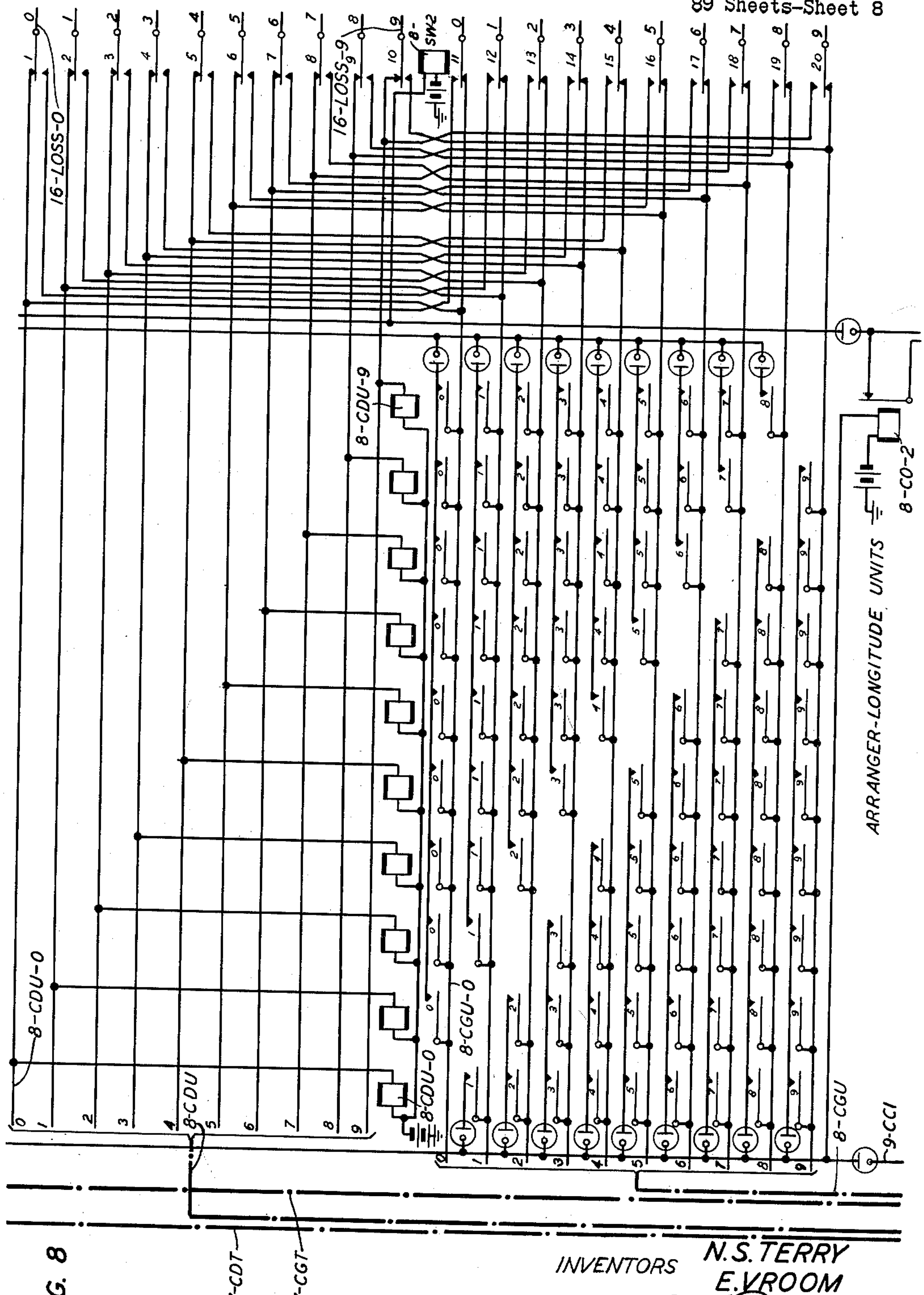

FIG. 8

INVENTORS N.S. TERRY
E. VROOM
BY [signature]
ATTORNEY

AUTOMATIC DETERMINATION OF TOLL CALL CHARGES

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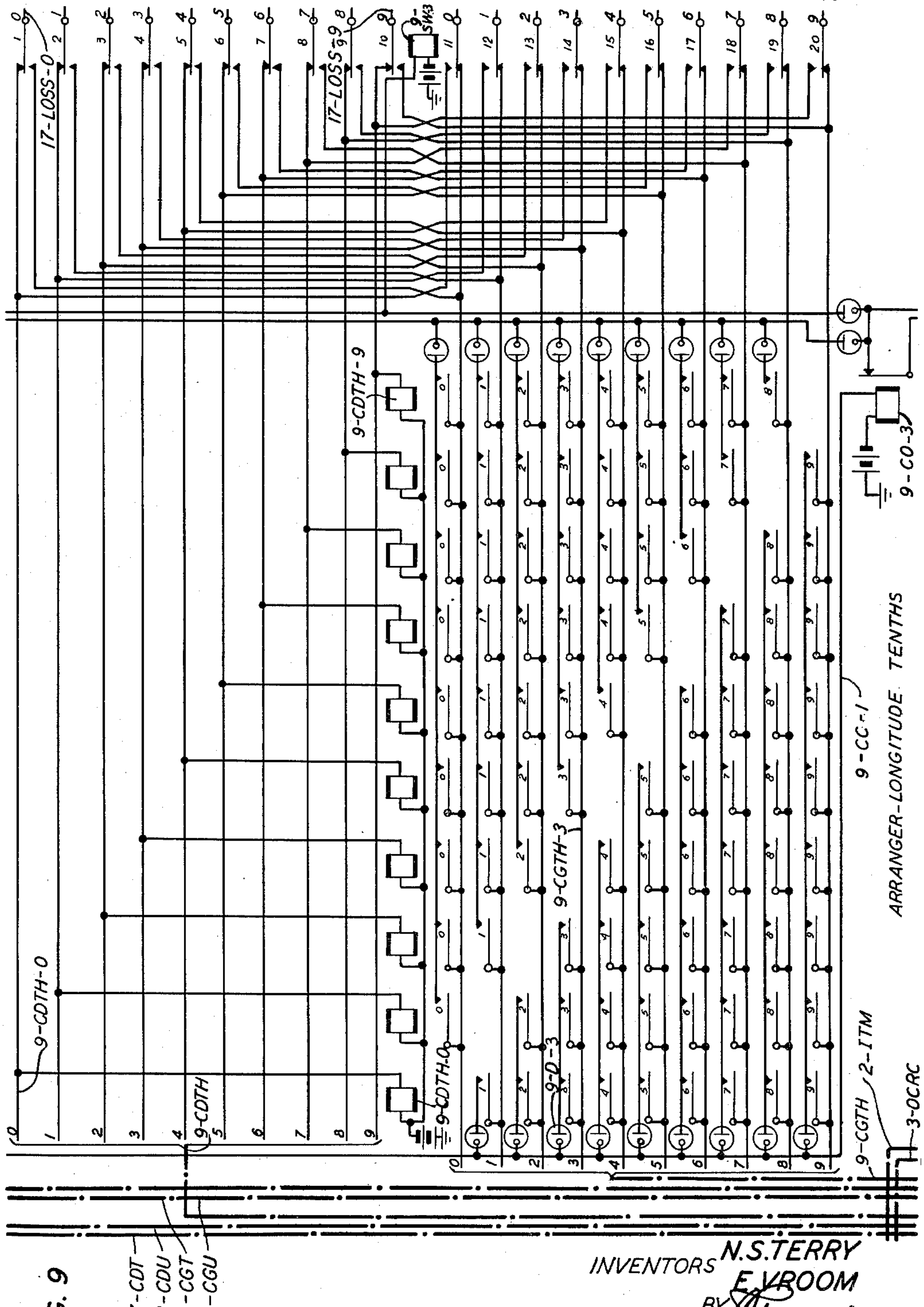

FIG. 9

INVENTORS N.S.TERRY
E.VROOM
BY [signature]
ATTORNEY

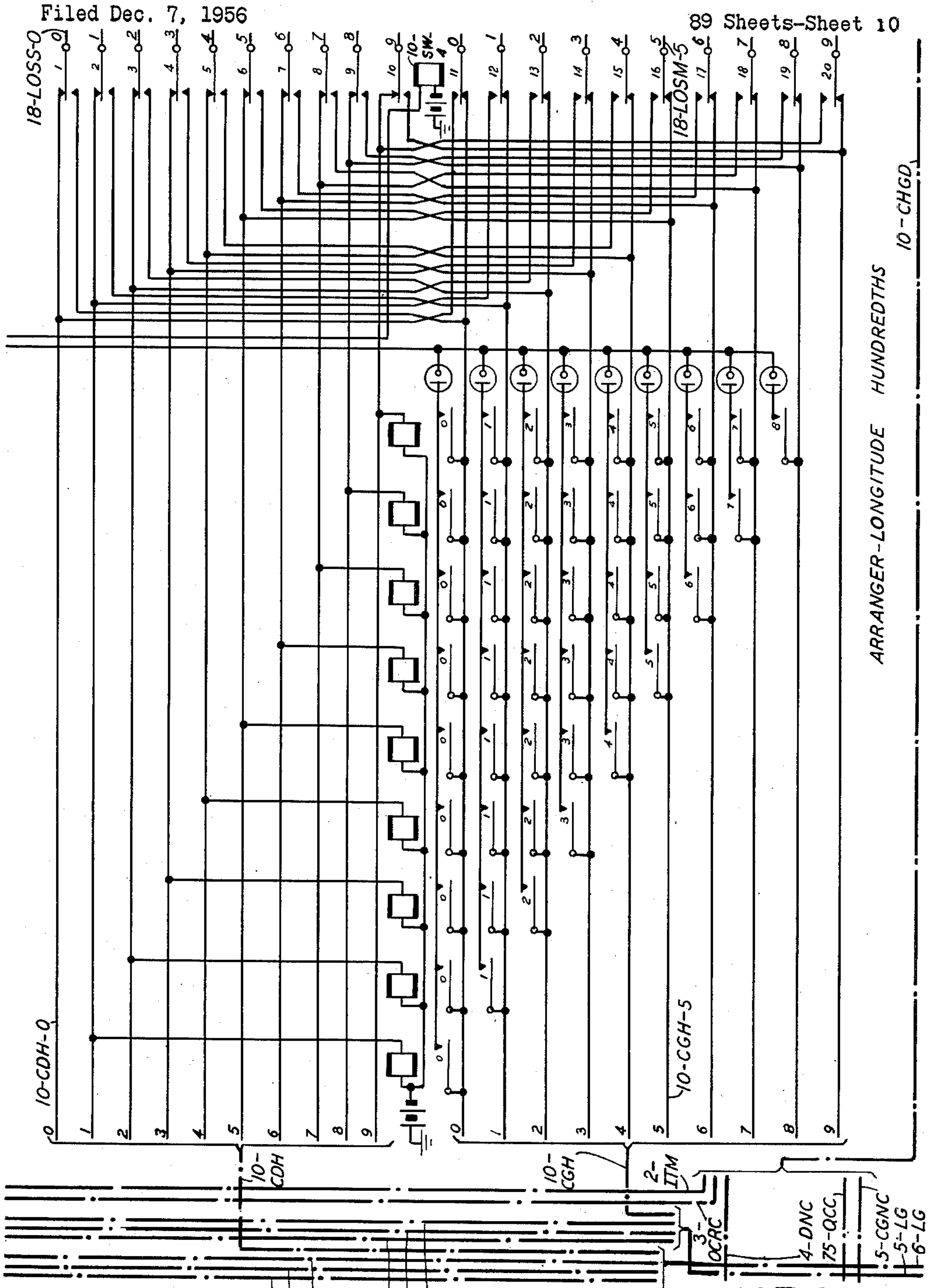

FIG. 10

INVENTORS N.S. TERRY
E. VROOM
BY [signature]
ATTORNEY

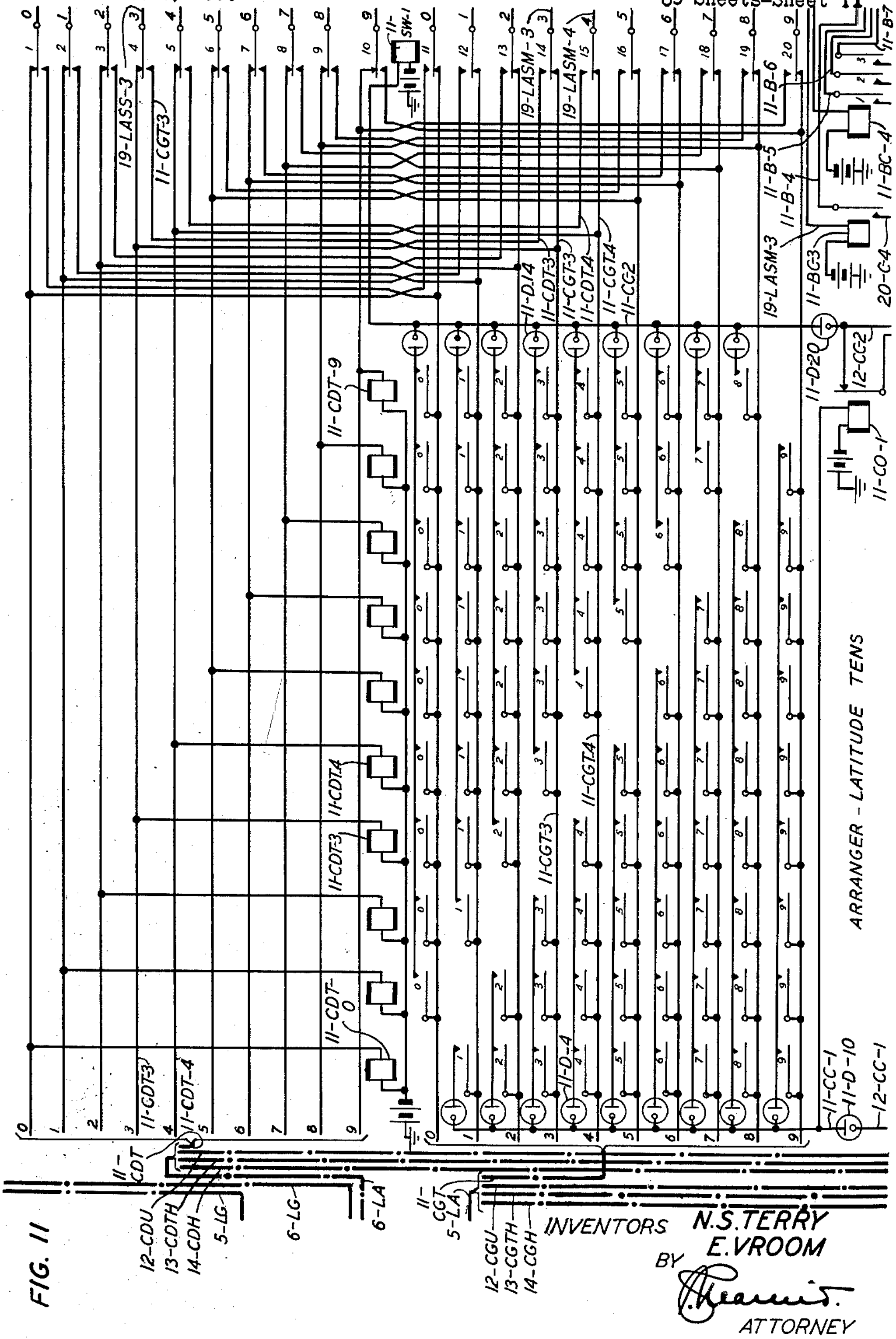
ARRANGER - LATITUDE TENS
INVENTORS N.S.TERRY
E.VROOM
BY
ATTORNEY

FIG. 11

May 16, 1961 N. S. TERRY ET AL 2,984,704

AUTOMATIC DETERMINATION OF TOLL CALL CHARGES

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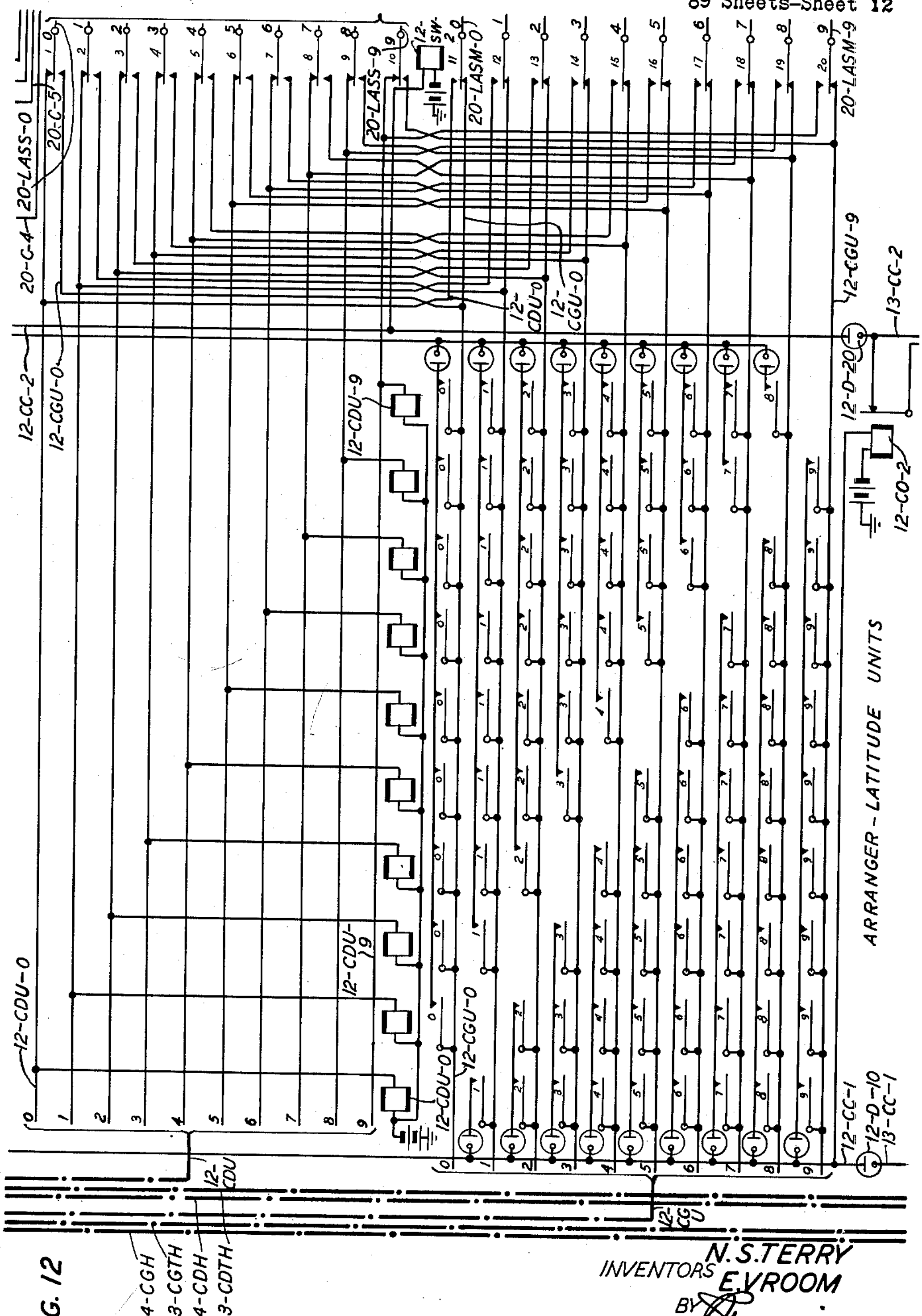

FIG. 12

INVENTORS N.S.TERRY
E.VROOM

BY [signature]

ATTORNEY

AUTOMATIC DETERMINATION OF TOLL CALL CHARGES

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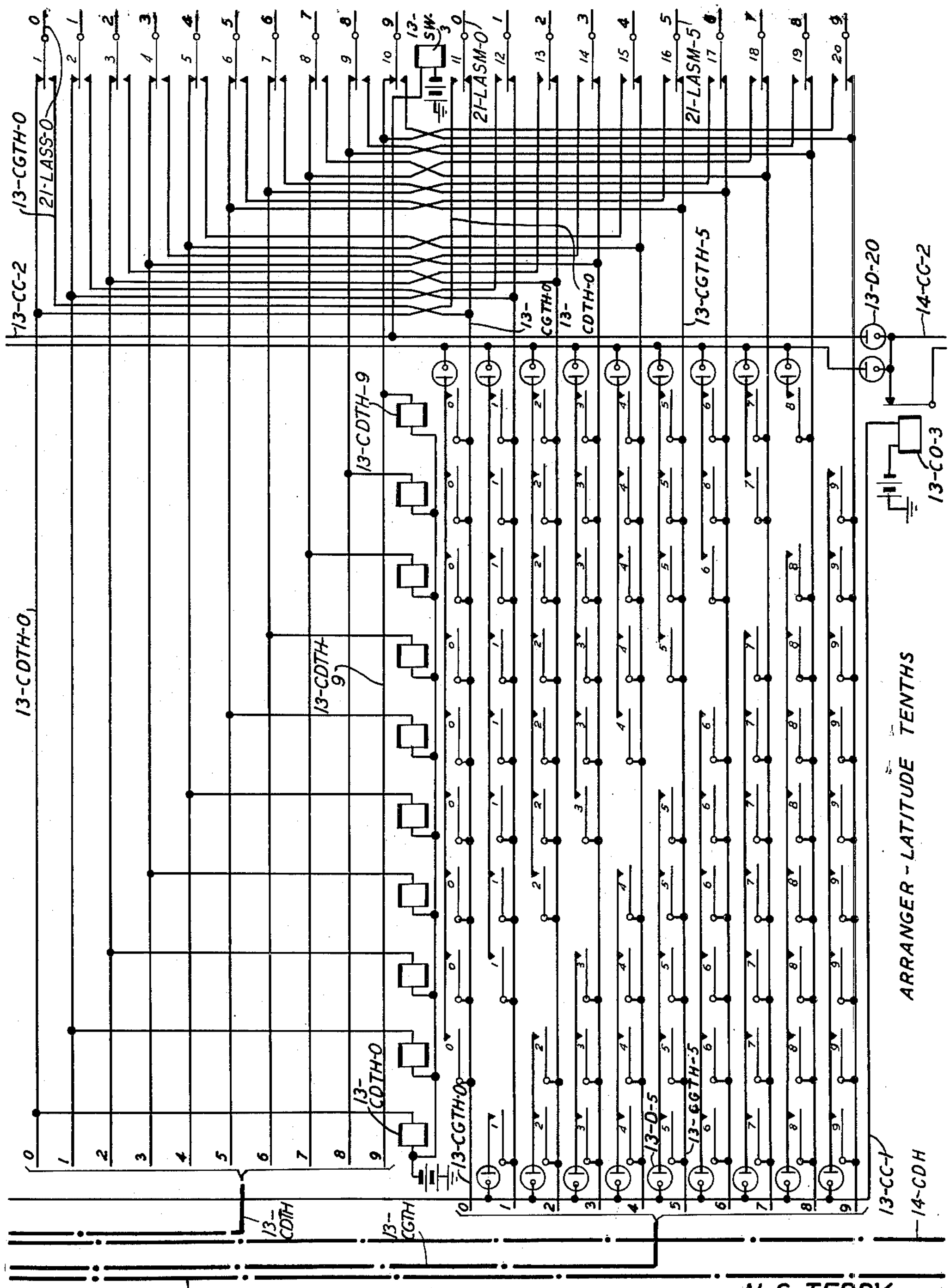

FIG. 13

INVENTORS N. S. TERRY
E. VROOM
BY
ATTORNEY

May 16, 1961 N. S. TERRY ET AL 2,984,704

AUTOMATIC DETERMINATION OF TOLL CALL CHARGES

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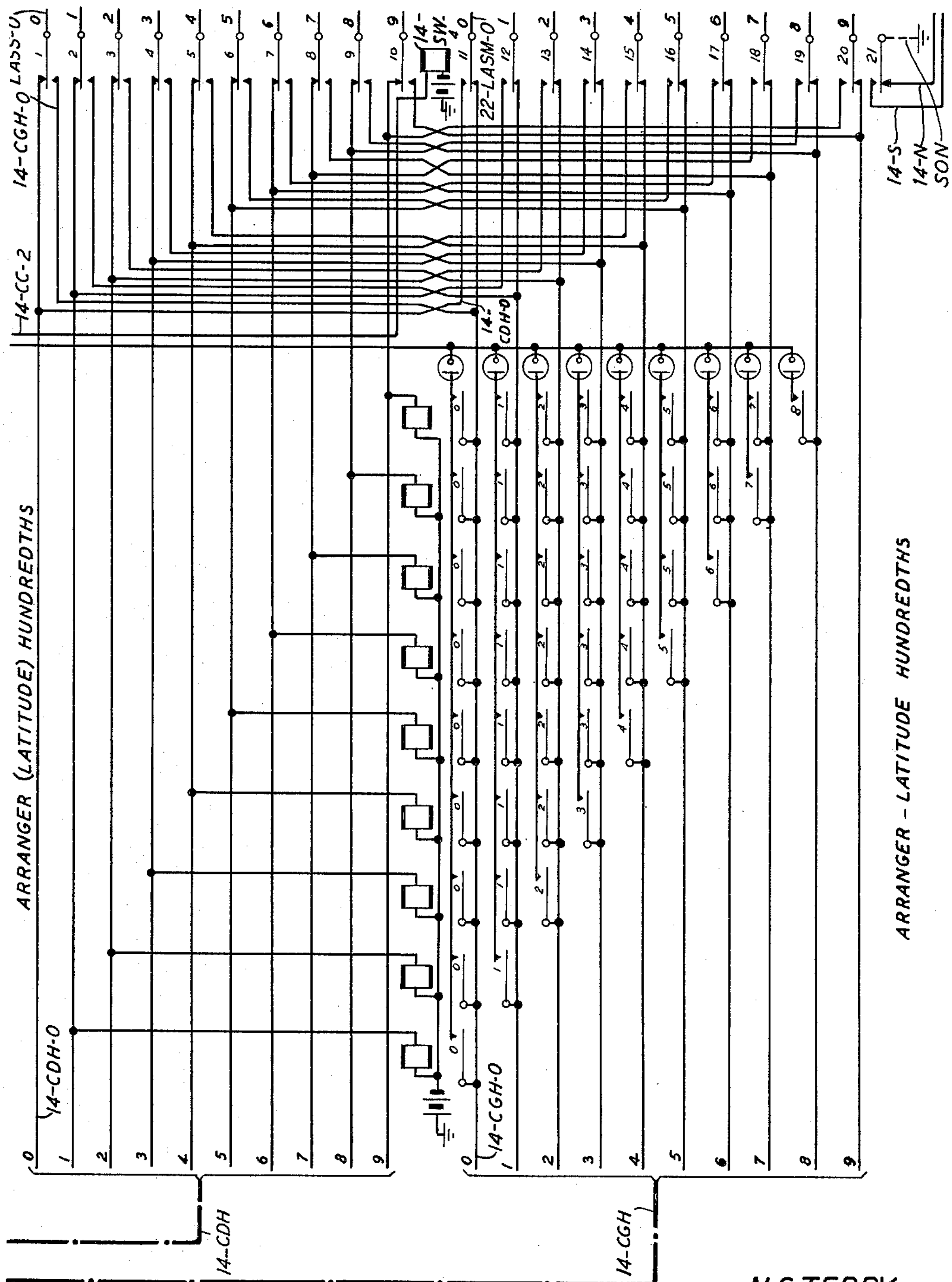

FIG. 14

INVENTORS N.S.TERRY
E.VROOM
BY
ATTORNEY

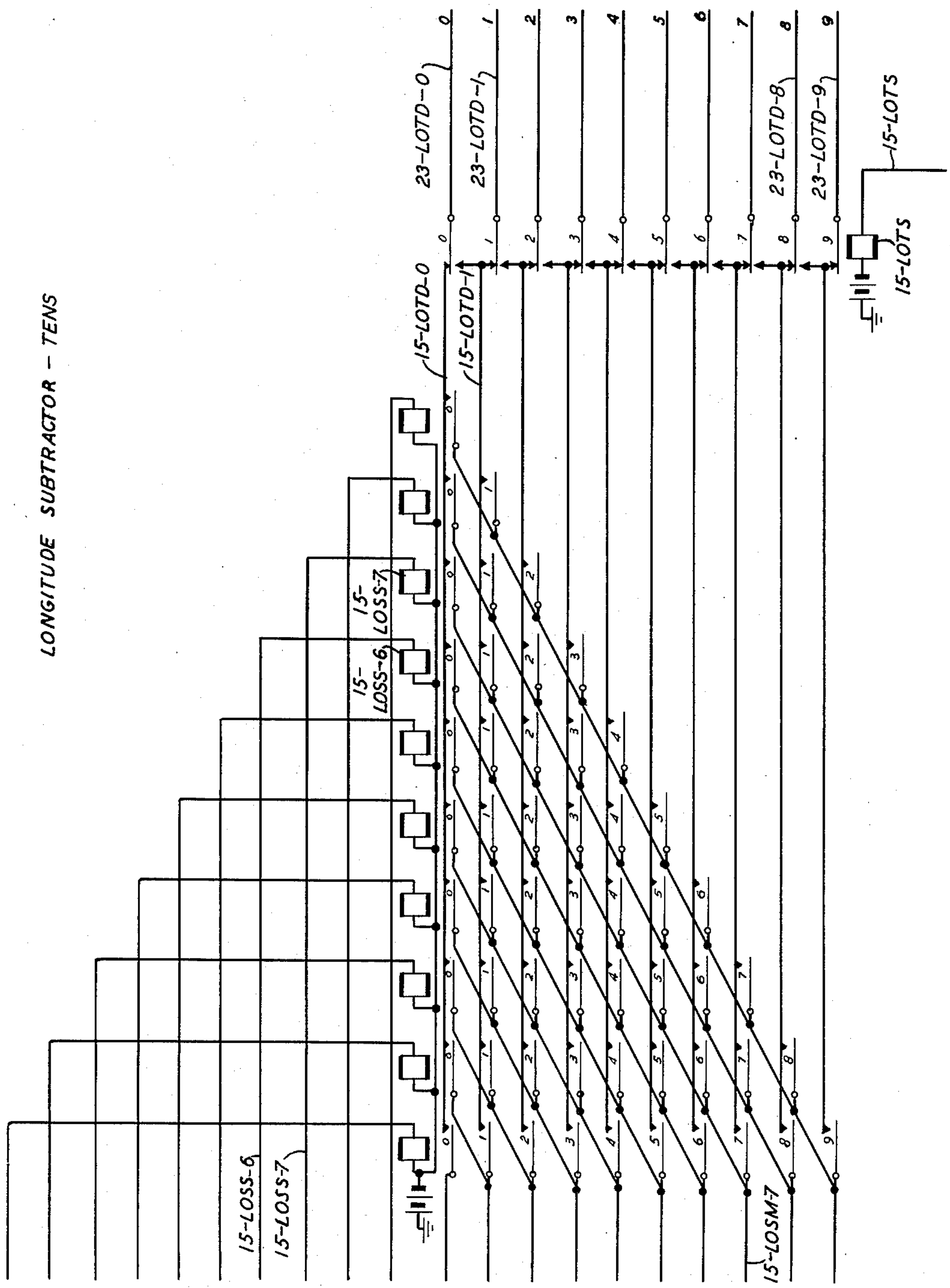

FIG. 15

INVENTORS N.S. TERRY
E. VROOM
BY
ATTORNEY

AUTOMATIC DETERMINATION OF TOLL CALL CHARGES

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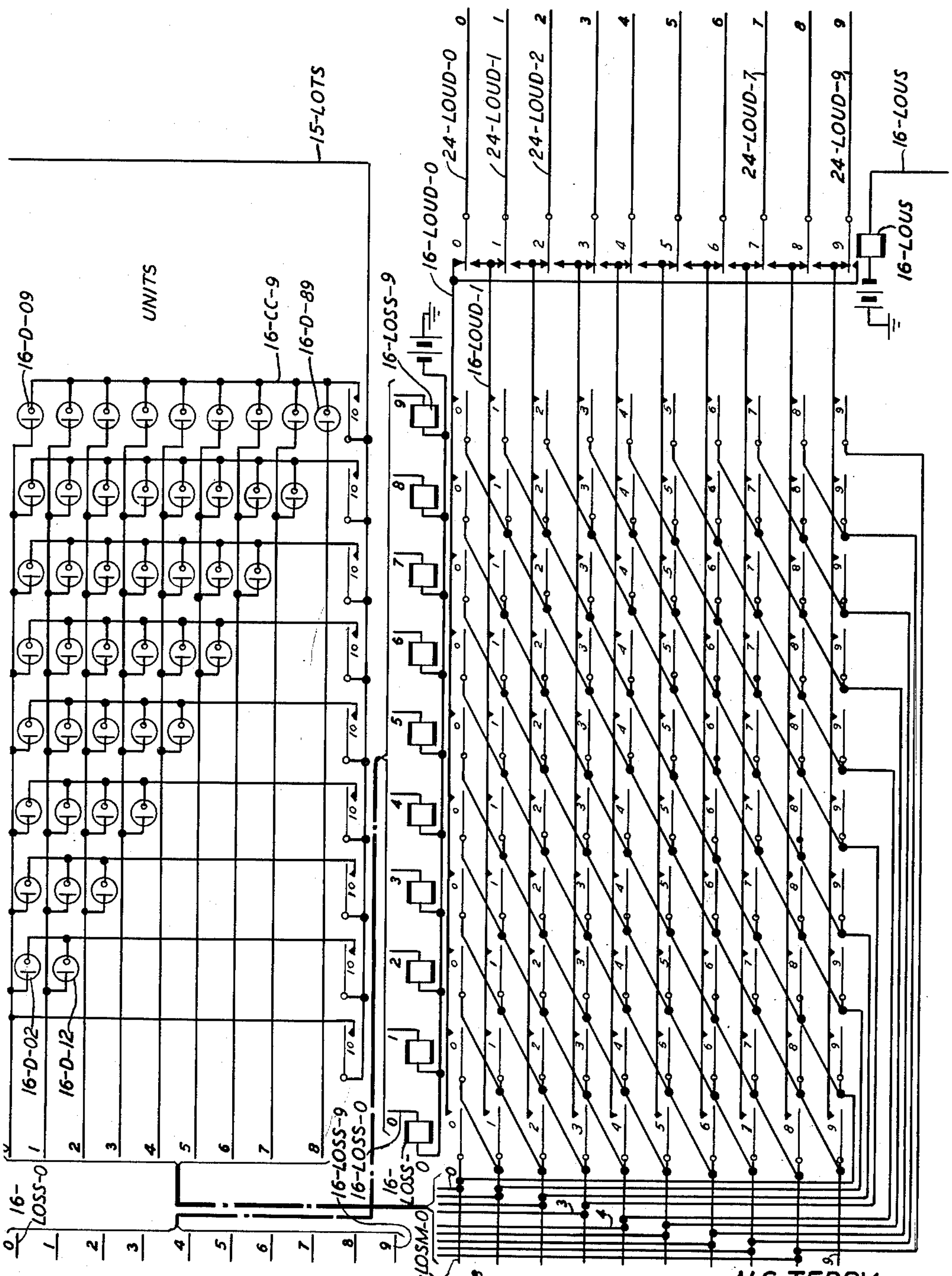

FIG. 16

INVENTORS N.S. TERRY
E. VROOM
BY
ATTORNEY

AUTOMATIC DETERMINATION OF TOLL CALL CHARGES

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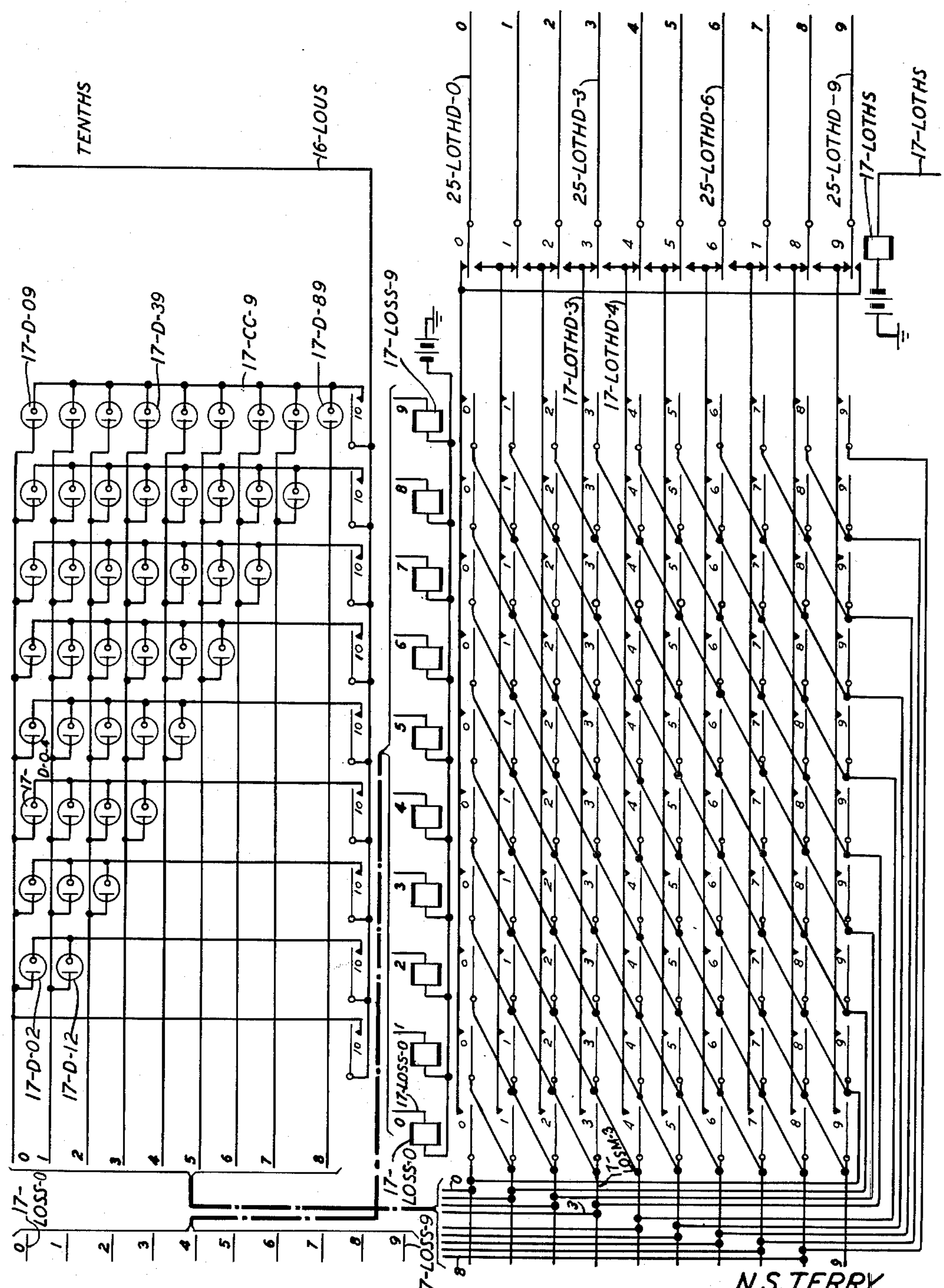

FIG. 17

INVENTORS N.S. TERRY
E. VROOM
BY [signature]
ATTORNEY

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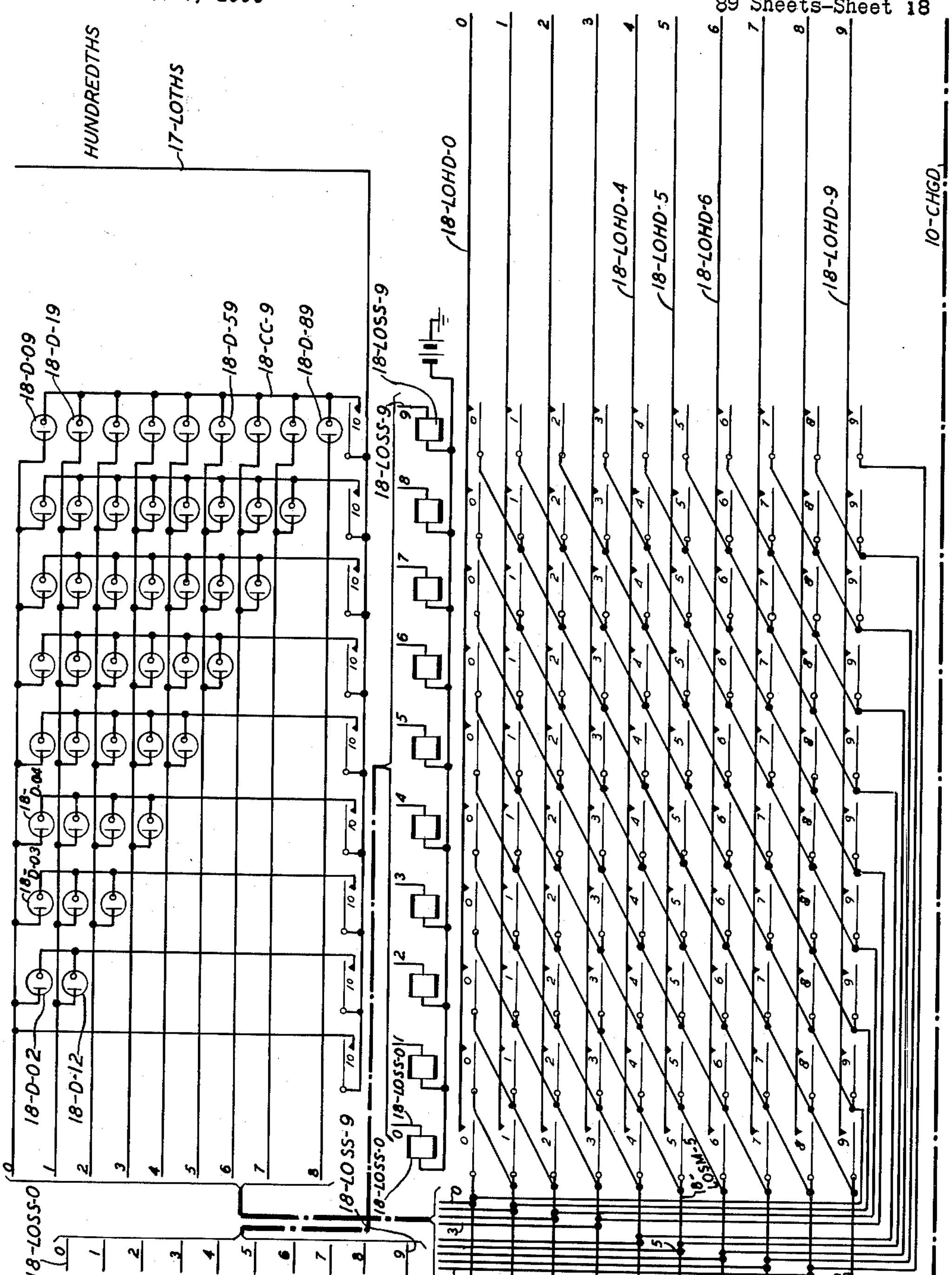

FIG. 18

INVENTORS N.S. TERRY
E. VROOM

BY

ATTORNEY

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AUTOMATIC DETERMINATION OF TOLL CALL CHARGES

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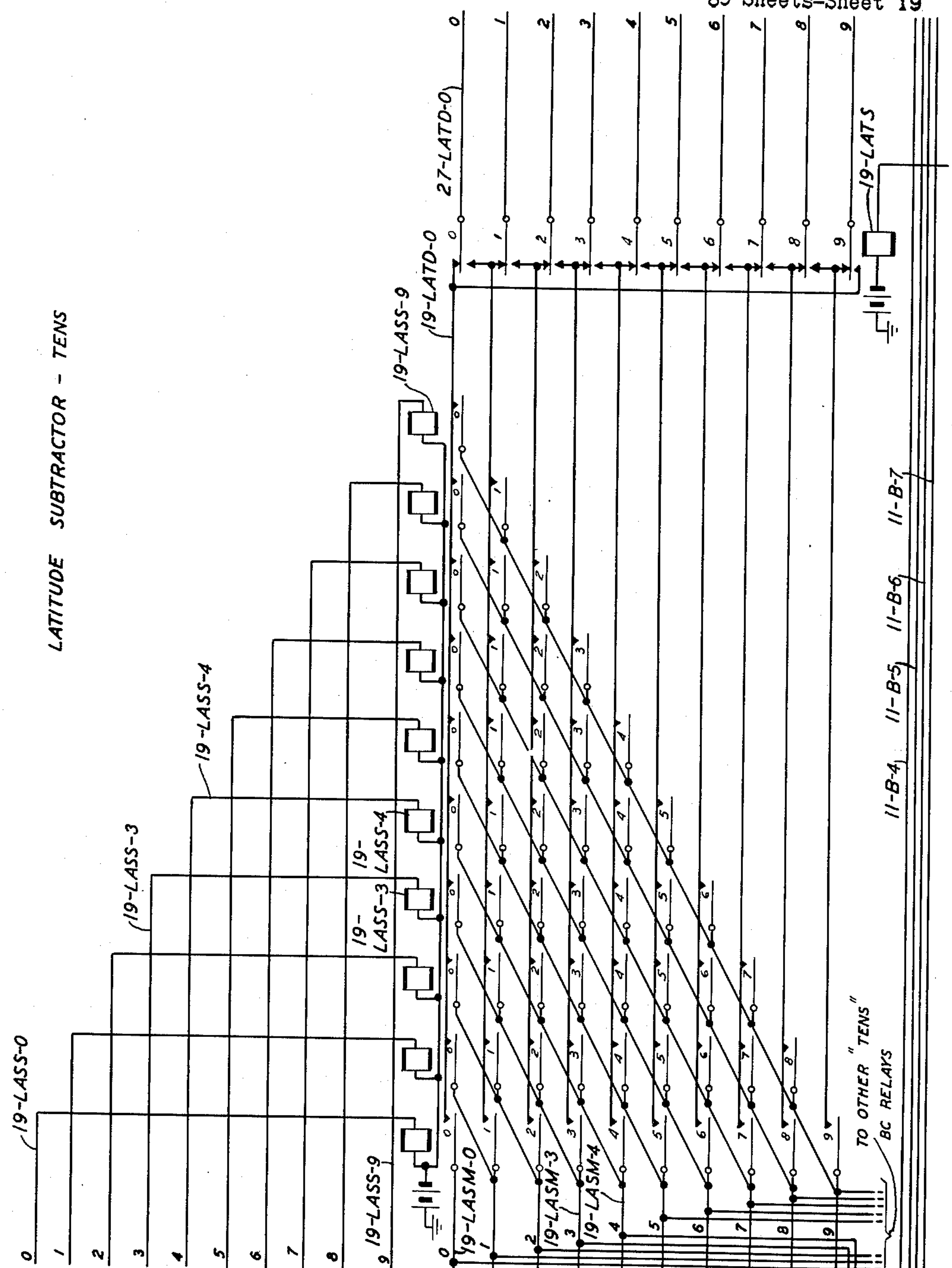

FIG. 19

INVENTORS N.S.TERRY
E.VROOM
BY
ATTORNEY

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AUTOMATIC DETERMINATION OF TOLL CALL CHARGES

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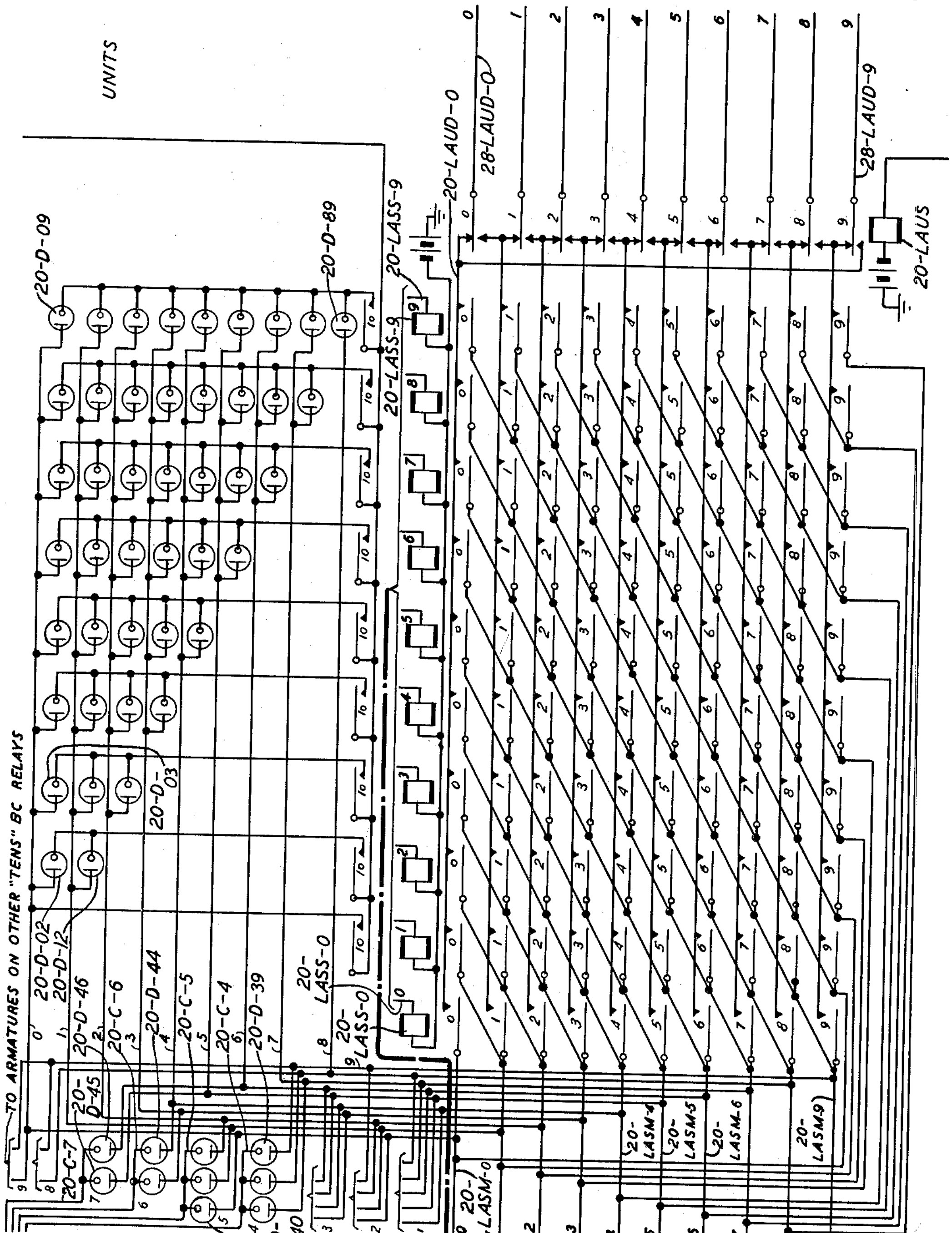

FIG. 20

INVENTORS N.S. TERRY
E. VROOM

BY [signature]

ATTORNEY

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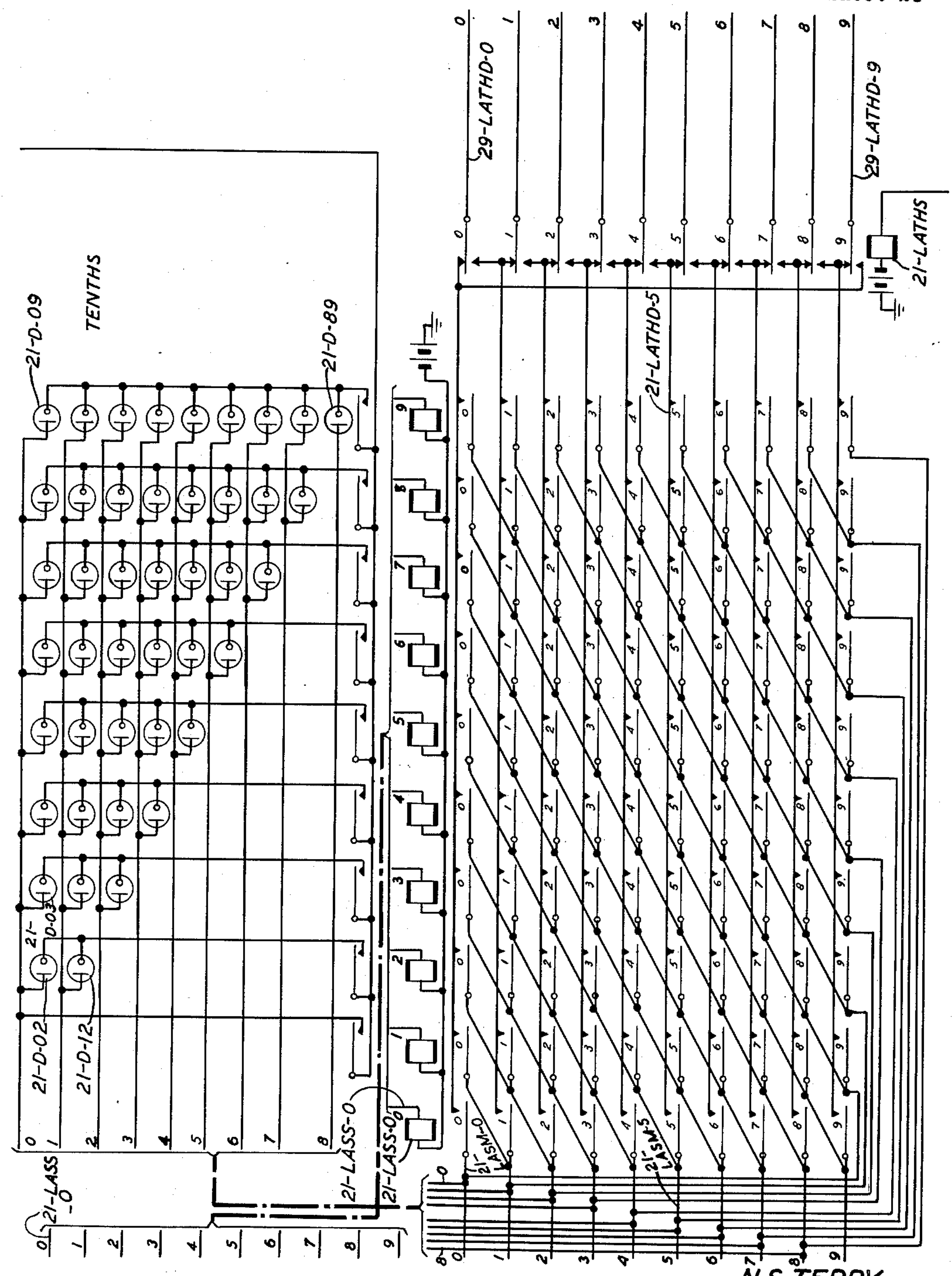

FIG. 21

INVENTORS: N.S. TERRY
E. VROOM
BY [signature]
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AUTOMATIC DETERMINATION OF TOLL CALL CHARGES

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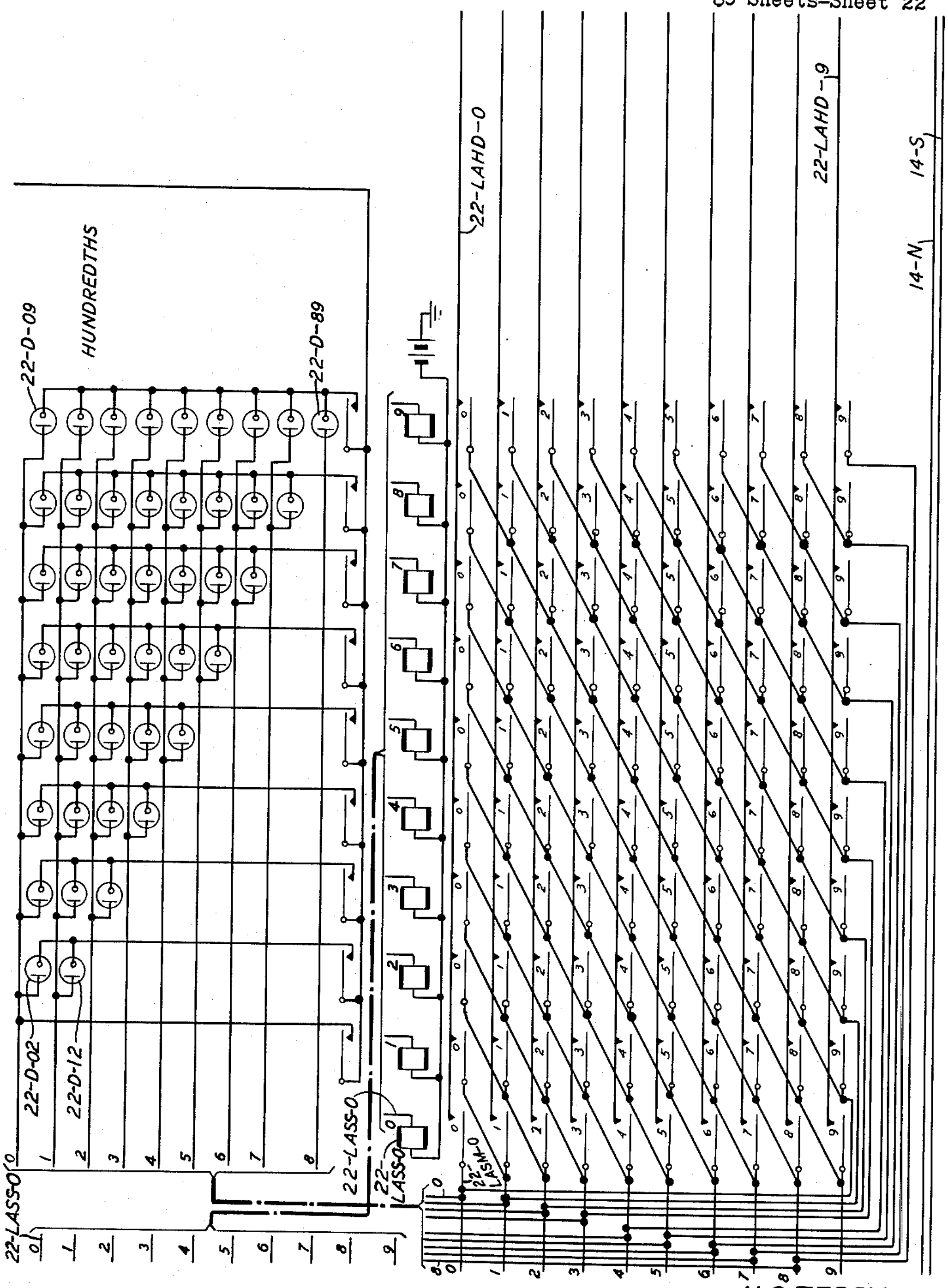

FIG. 22

INVENTORS: N.S. TERRY
E. VROOM
BY [signature]
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AUTOMATIC DETERMINATION OF TOLL CALL CHARGES

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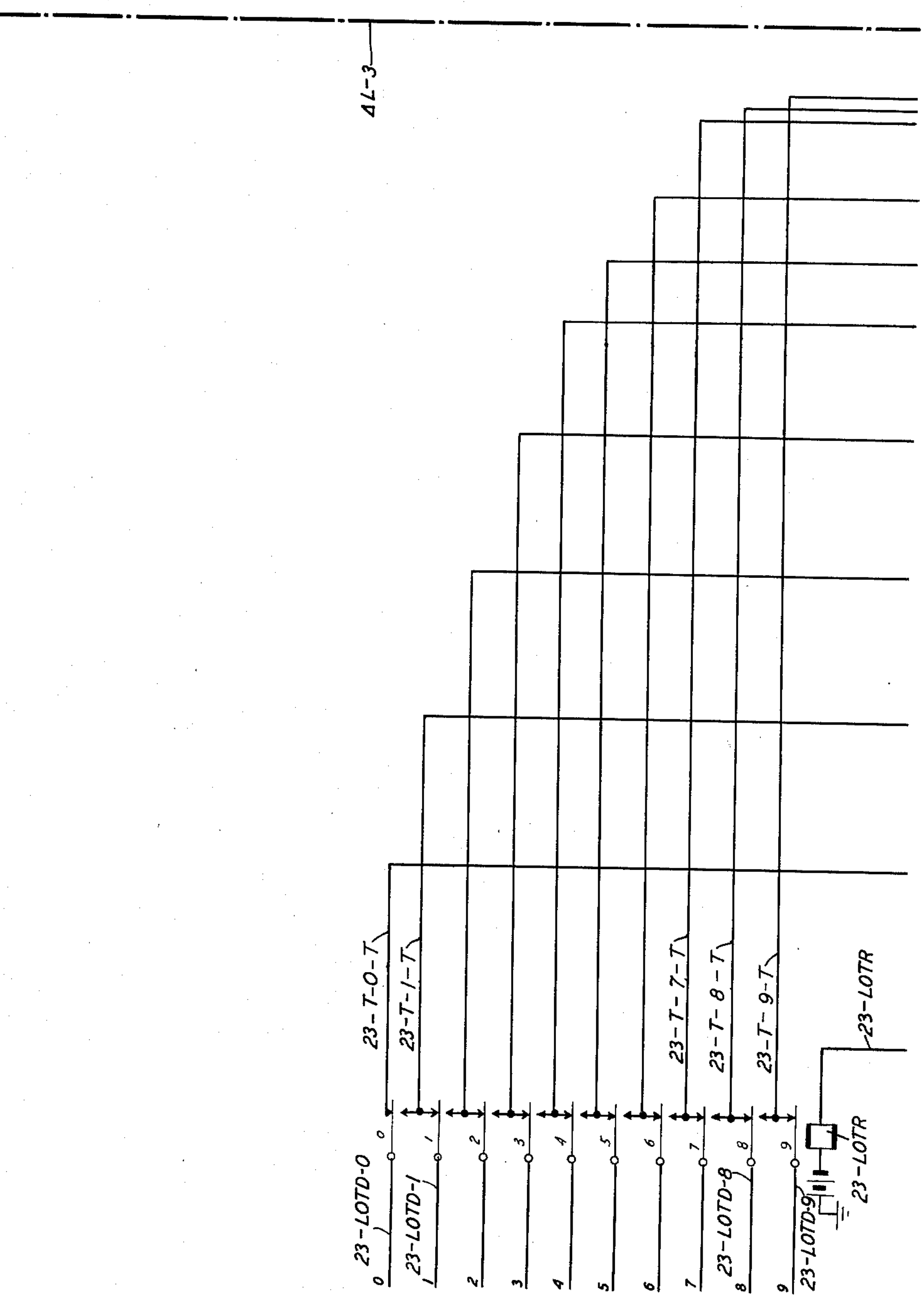

LONGITUDE NUMBER ROUNDING CIRCUIT - TENS

FIG. 23

INVENTORS: N. S. TERRY
E. VROOM
BY [signature]
ATTORNEY

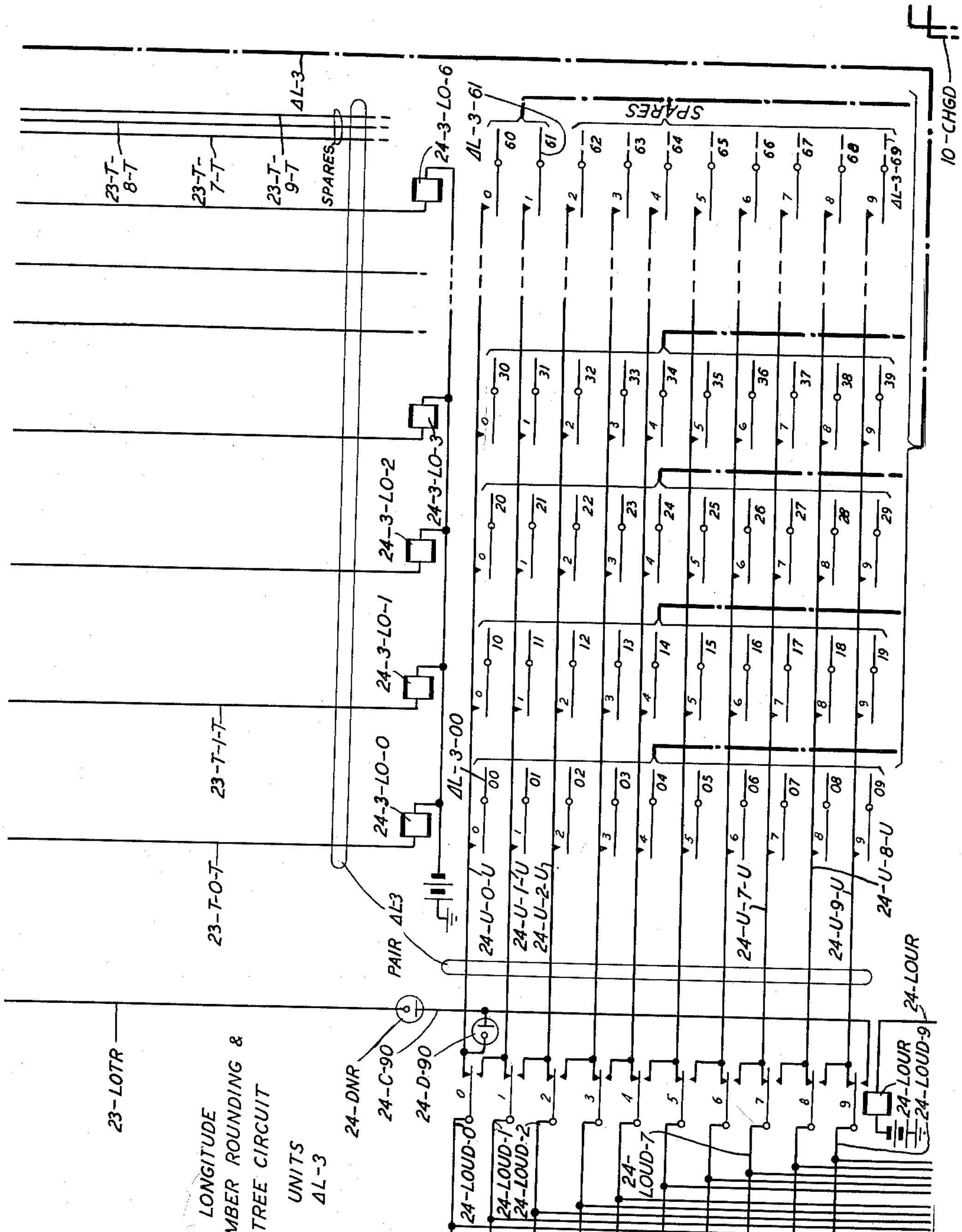

FIG. 24

INVENTORS: N.S.TERRY
E.VROOM

BY [signature]

ATTORNEY

AUTOMATIC DETERMINATION OF TOLL CALL CHARGES

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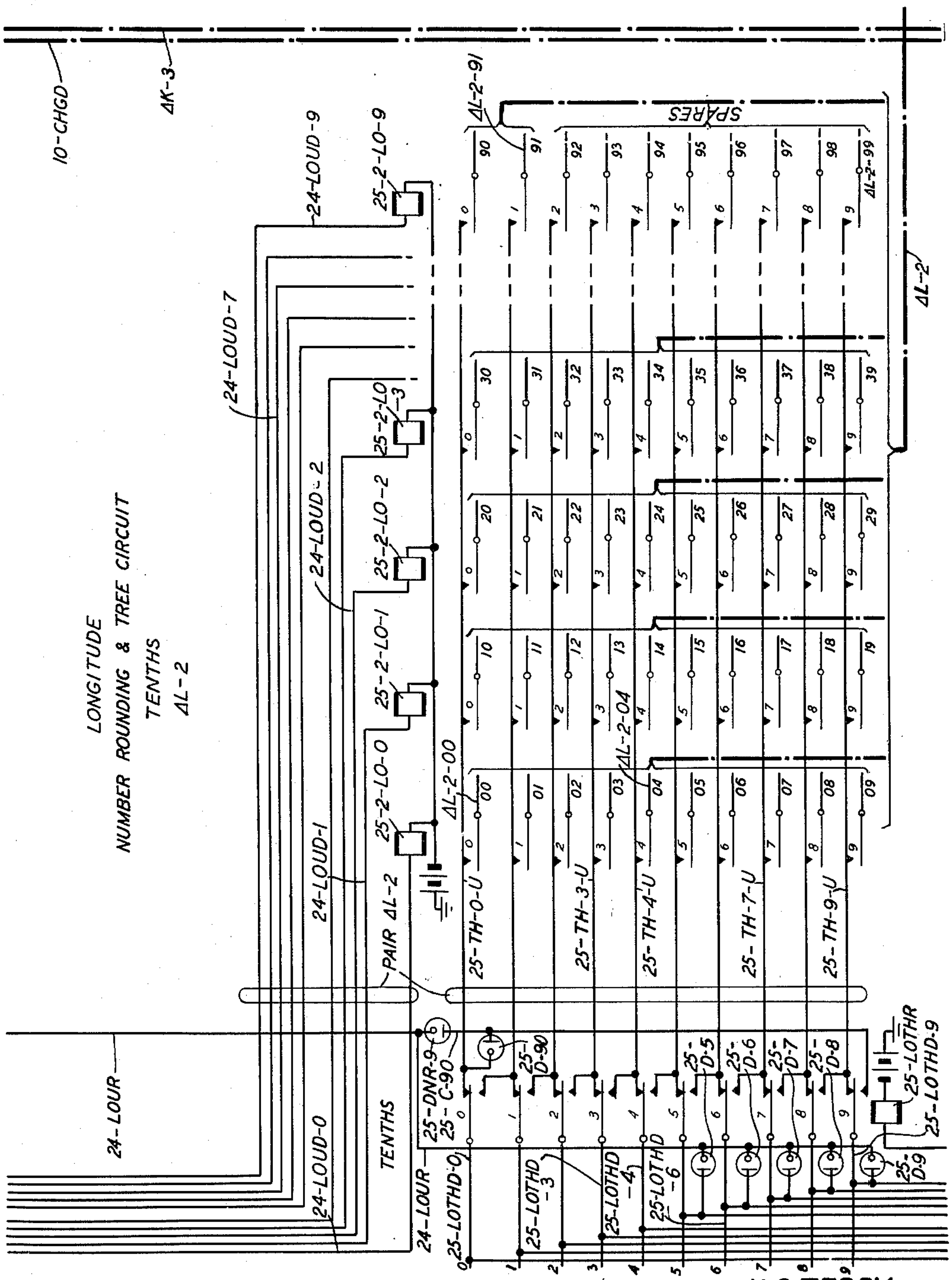

FIG. 25

INVENTORS: N.S.TERRY
E.VROOM
BY
ATTORNEY

May 16, 1961 N. S. TERRY ET AL 2,984,704

AUTOMATIC DETERMINATION OF TOLL CALL CHARGES

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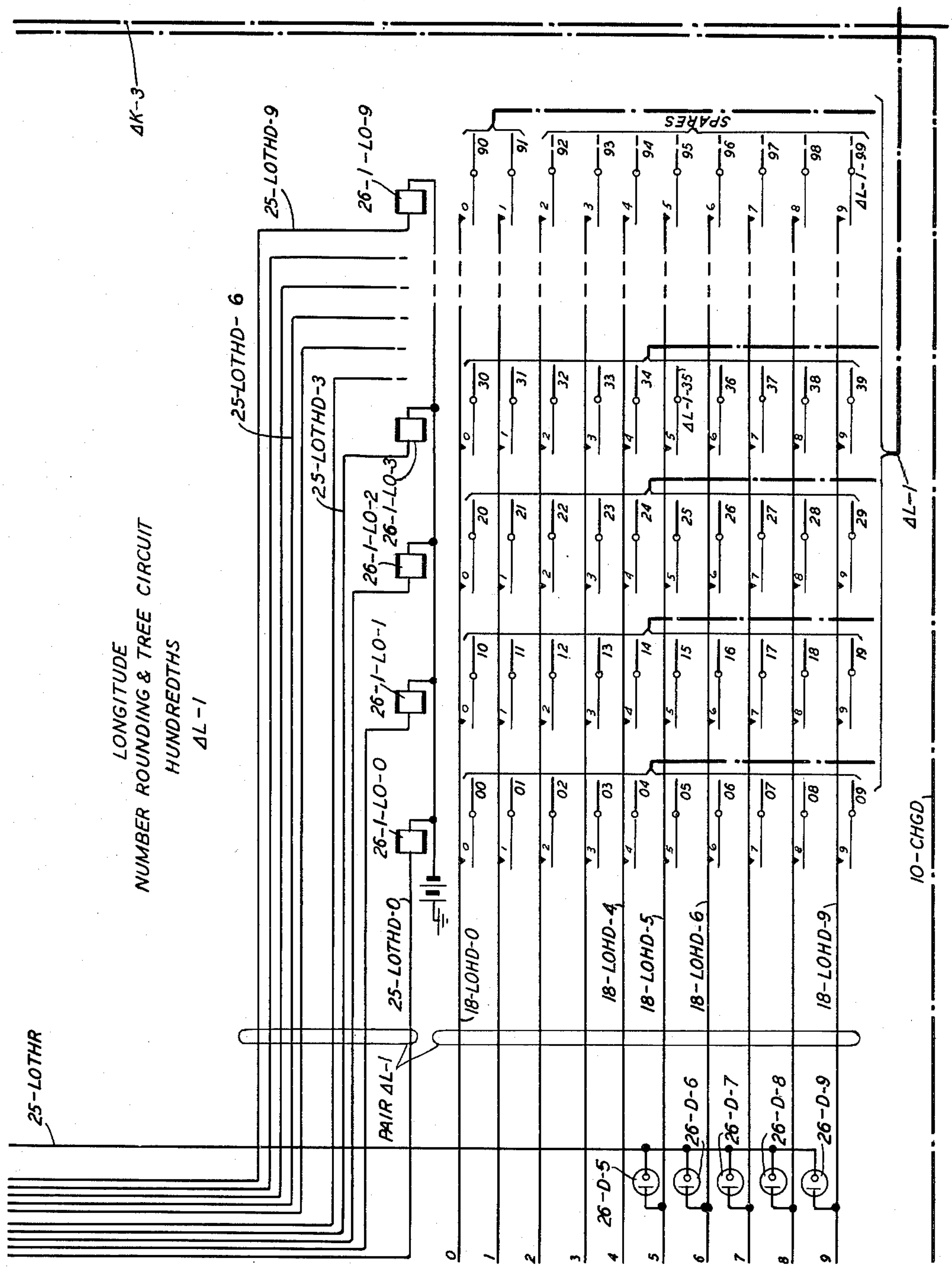

FIG. 26

INVENTORS: N.S.TERRY
E.VROOM
BY
ATTORNEY

AUTOMATIC DETERMINATION OF TOLL CALL CHARGES

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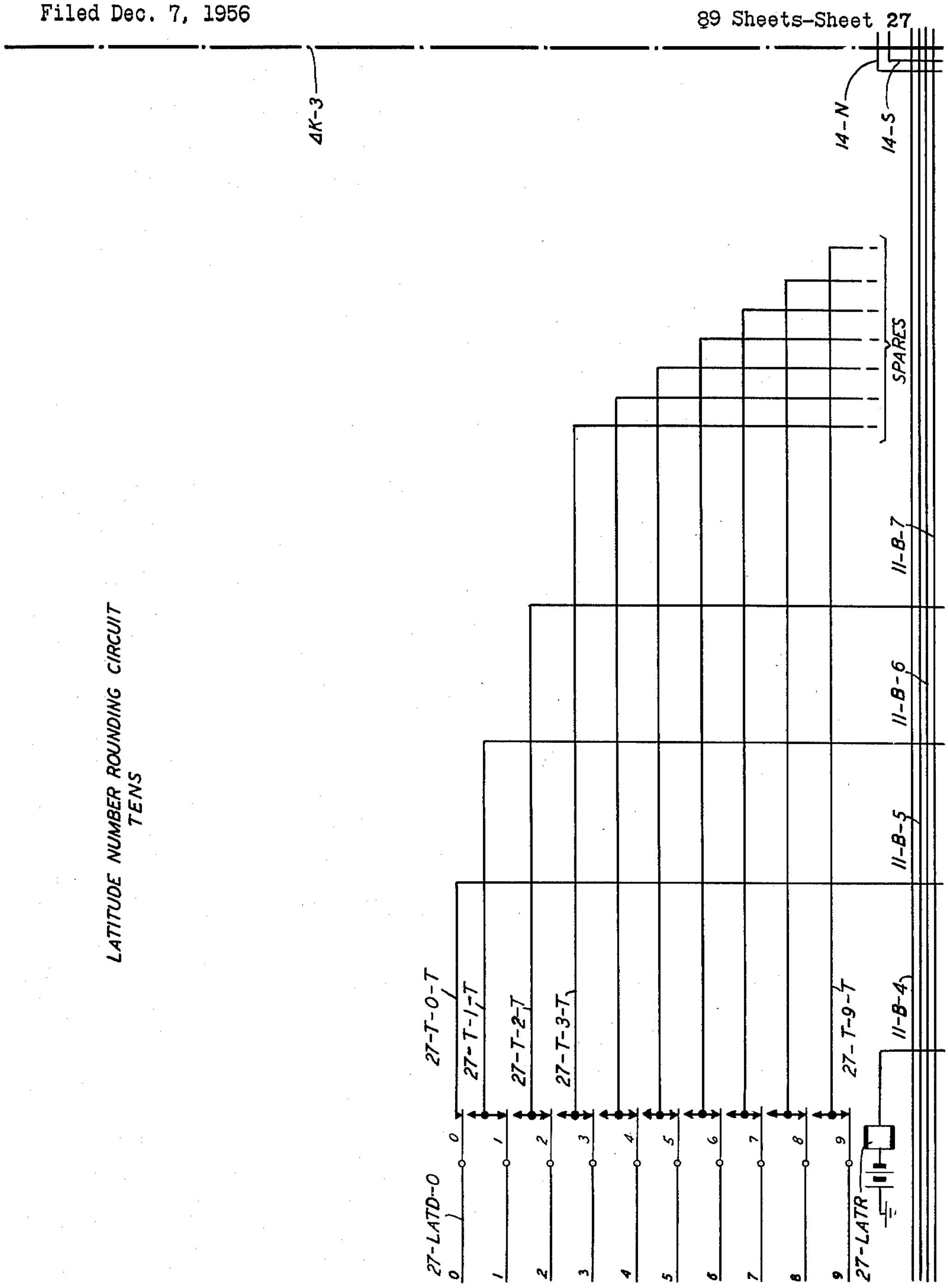

FIG. 27

INVENTORS: N.S.TERRY
E.VROOM
BY [signature]
ATTORNEY

May 16, 1961 N. S. TERRY ET AL 2,984,704

AUTOMATIC DETERMINATION OF TOLL CALL CHARGES

Filed Dec. 7, 1956 89 Sheets-Sheet 28

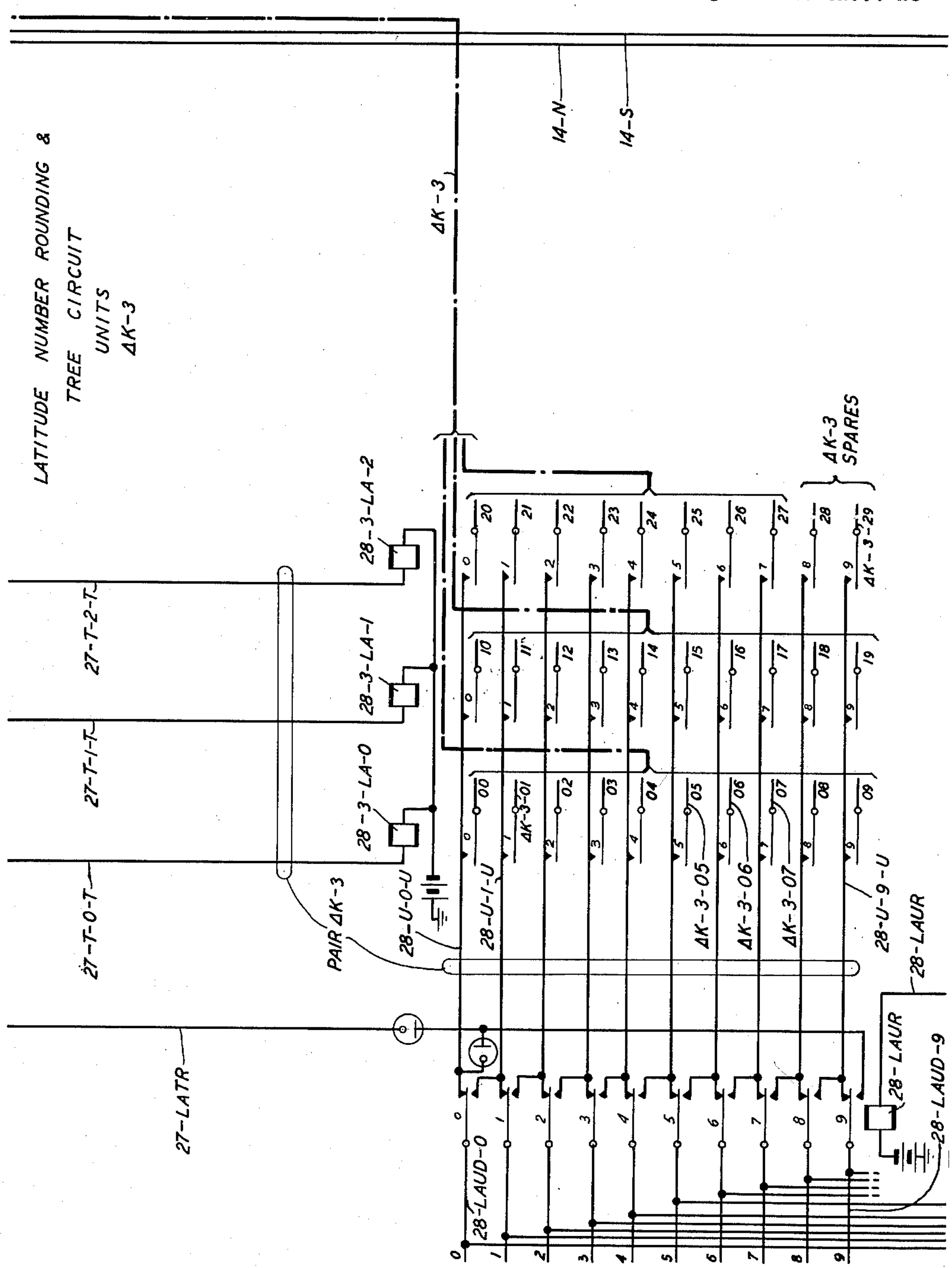

FIG. 28

INVENTORS: N.S. TERRY
E. VROOM
BY
ATTORNEY

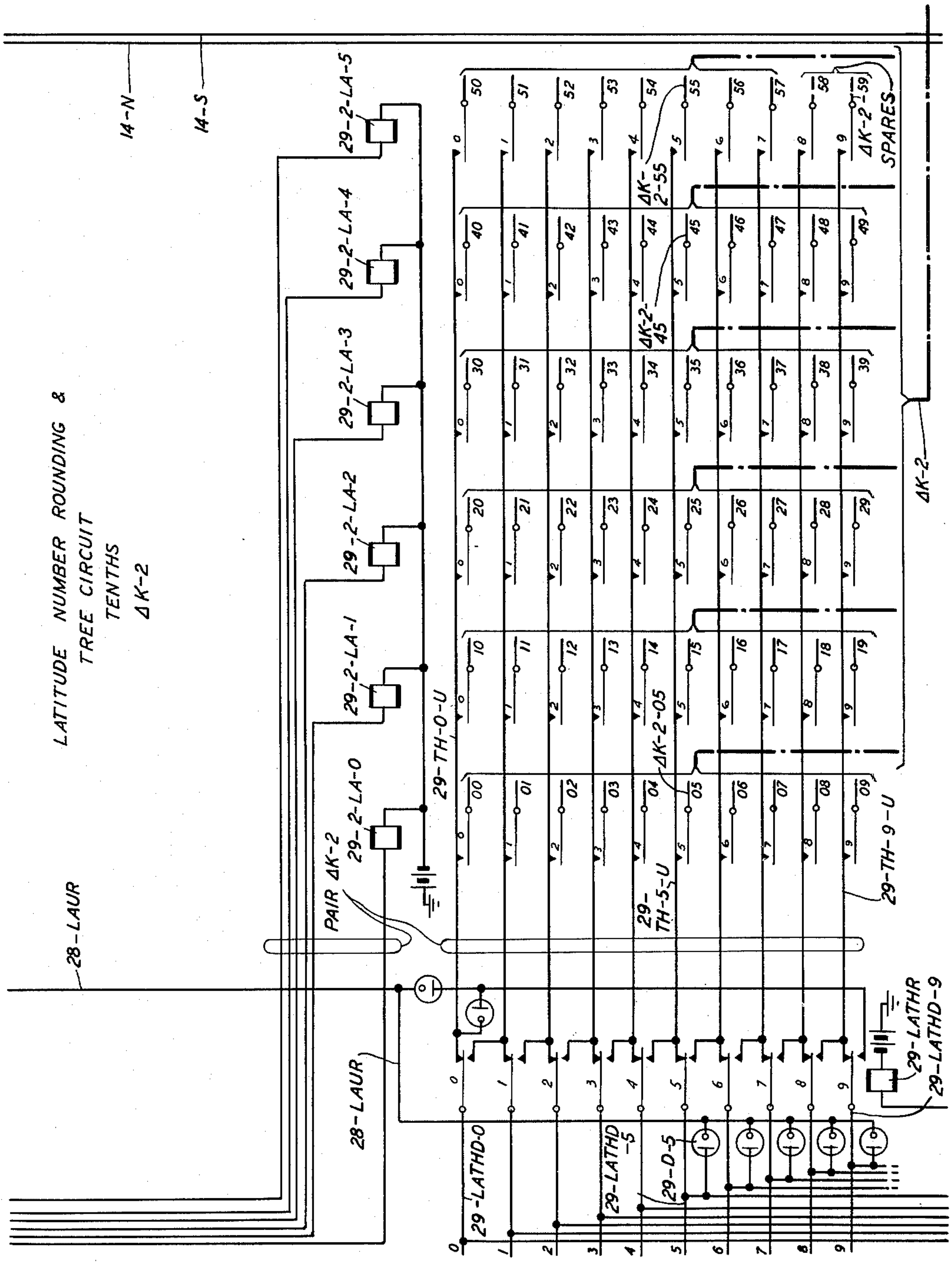

FIG. 29

INVENTORS: N.S.TERRY
E.VROOM
BY [signature]
ATTORNEY

AUTOMATIC DETERMINATION OF TOLL CALL CHARGES

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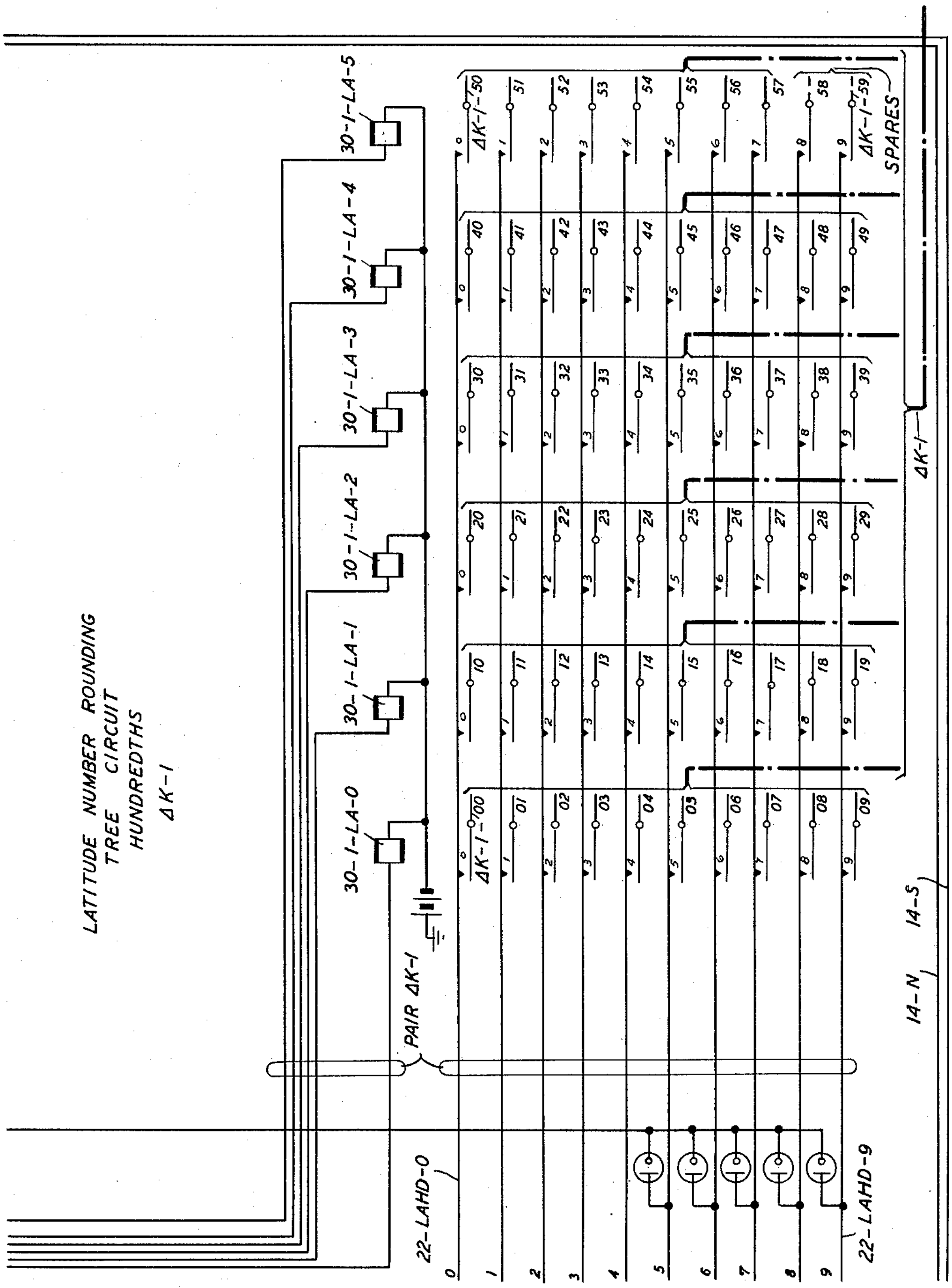

FIG. 30

INVENTORS: N.S.TERRY
E.VROOM
BY [signature]
ATTORNEY

May 16, 1961 N. S. TERRY ET AL 2,984,704

AUTOMATIC DETERMINATION OF TOLL CALL CHARGES

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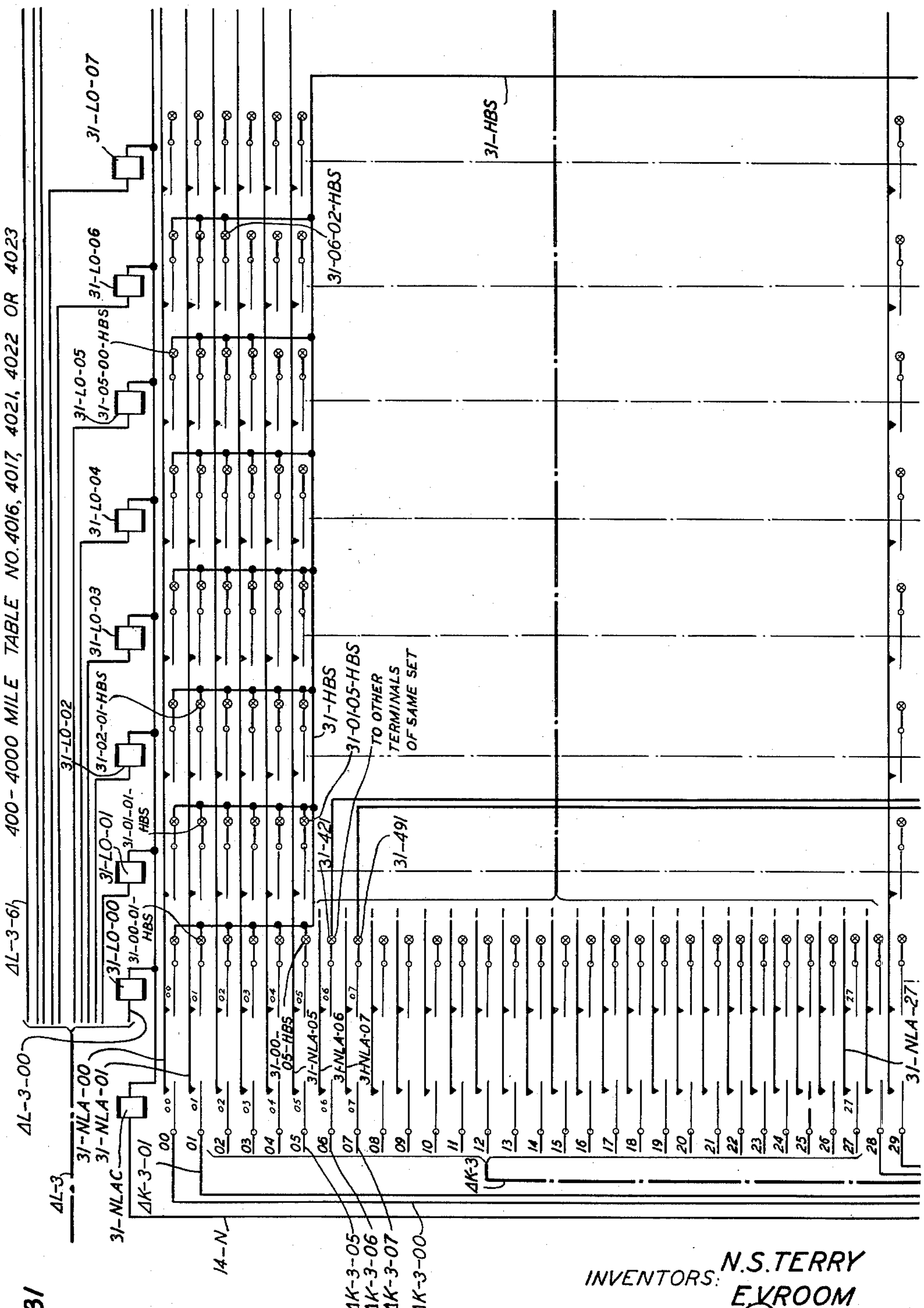

FIG. 31

INVENTORS: N.S. TERRY
E. VROOM
BY [signature]
ATTORNEY

AUTOMATIC DETERMINATION OF TOLL CALL CHARGES

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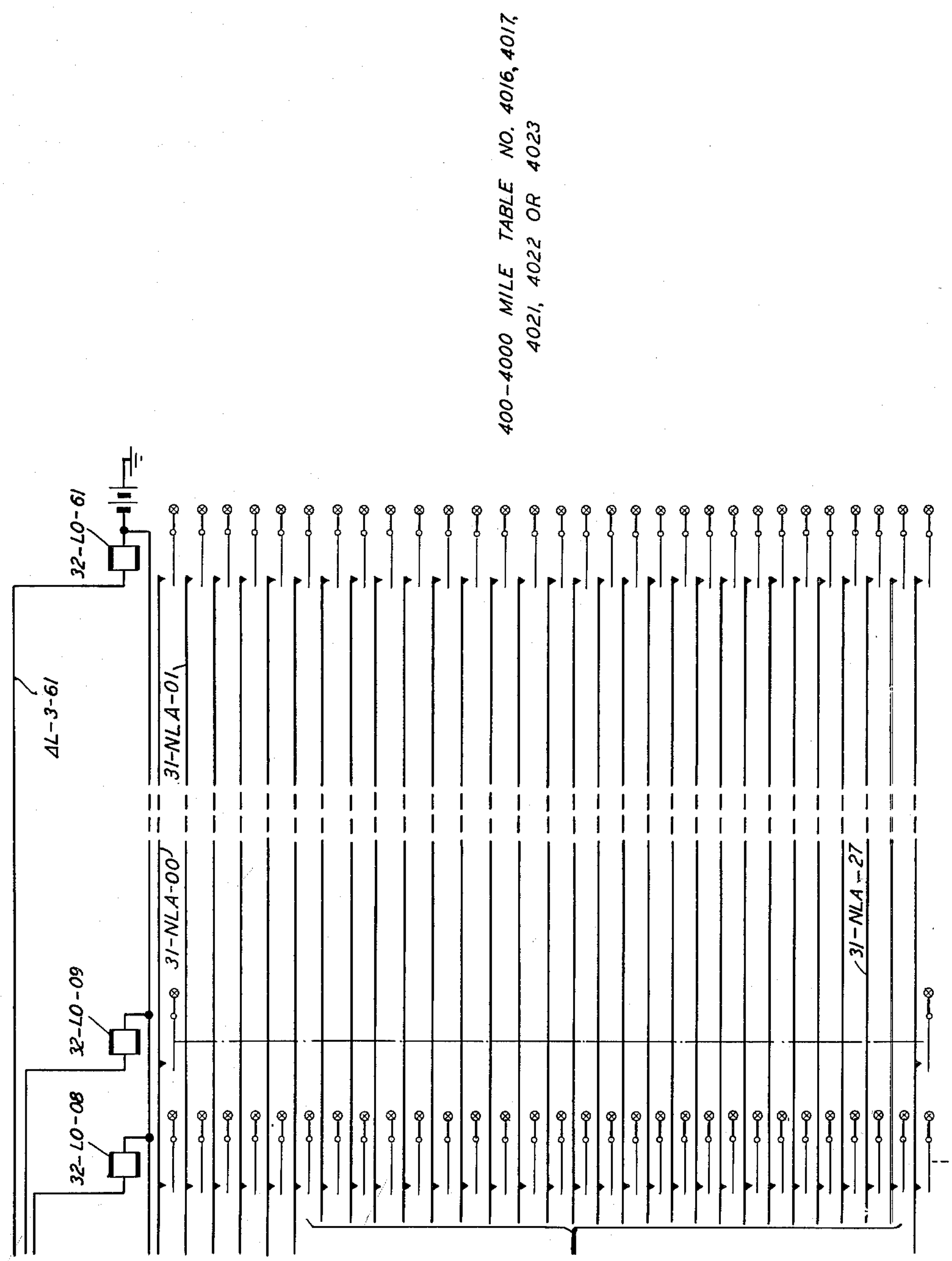

FIG. 32

INVENTORS: N.S.TERRY
E.VROOM
BY [signature]
ATTORNEY

AUTOMATIC DETERMINATION OF TOLL CALL CHARGES

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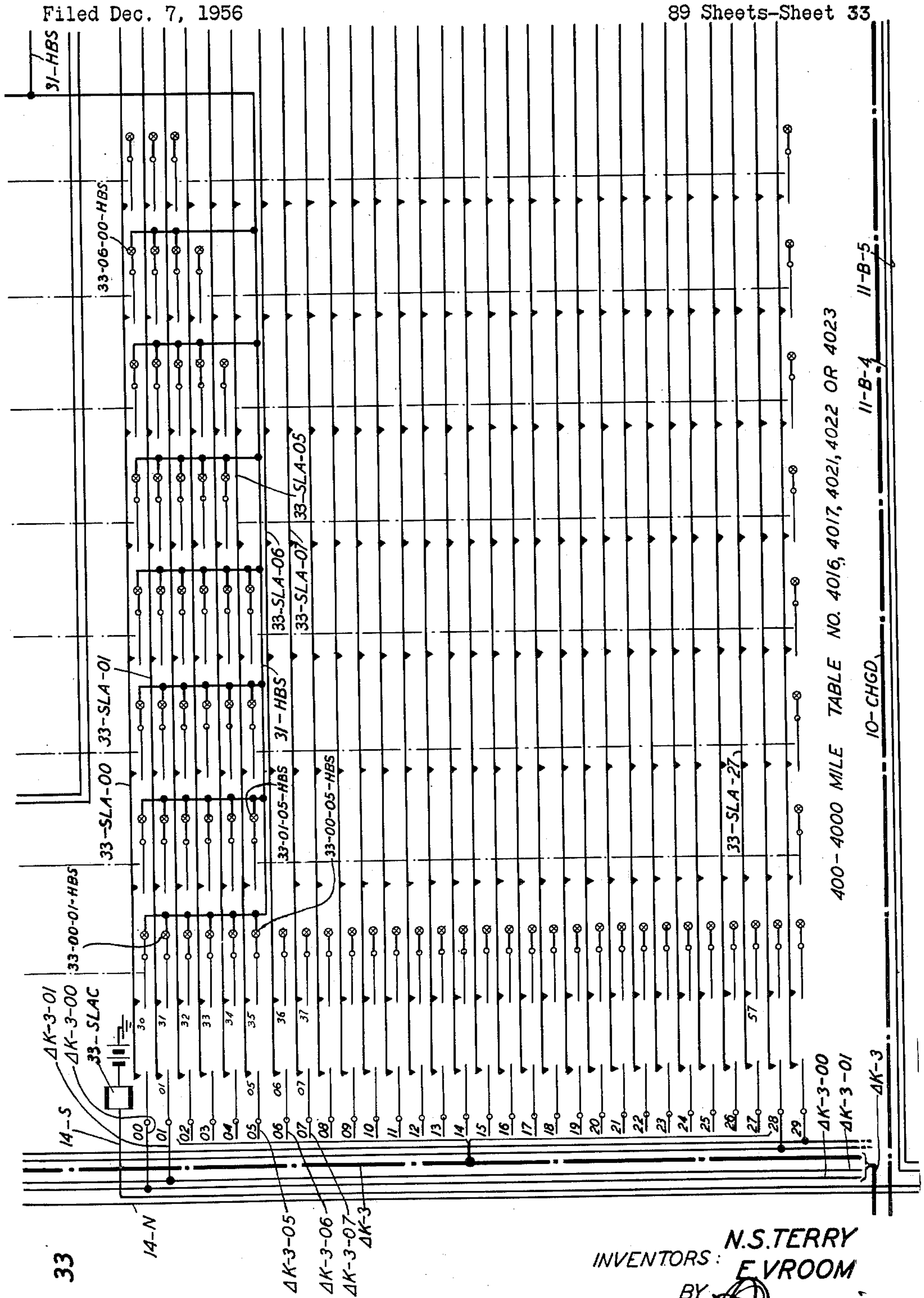

FIG. 33

INVENTORS: N.S.TERRY
E.VROOM
BY
ATTORNEY

AUTOMATIC DETERMINATION OF TOLL CALL CHARGES

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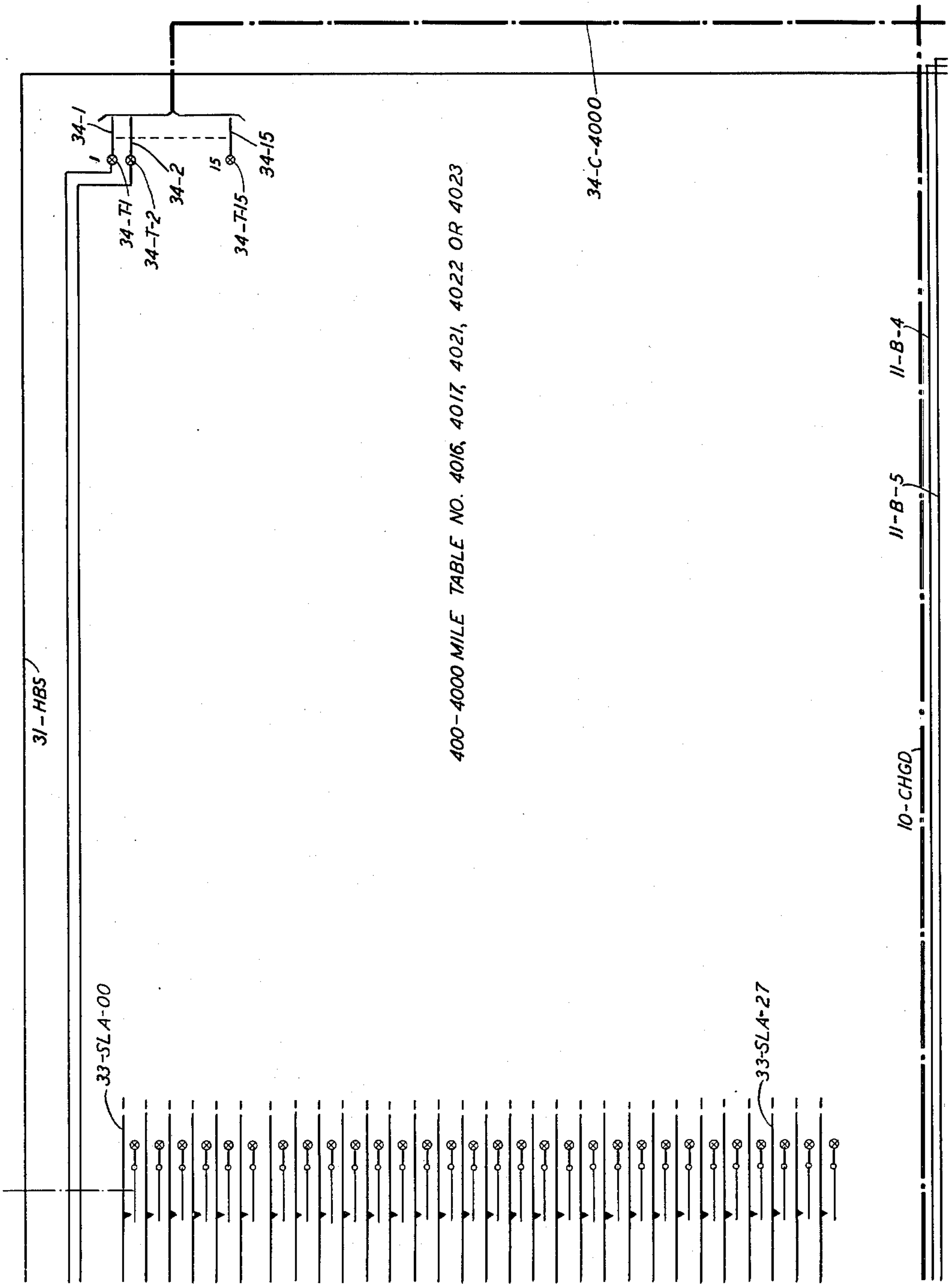

FIG. 34

INVENTORS: N.S.TERRY
E.VROOM
BY
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AUTOMATIC DETERMINATION OF TOLL CALL CHARGES

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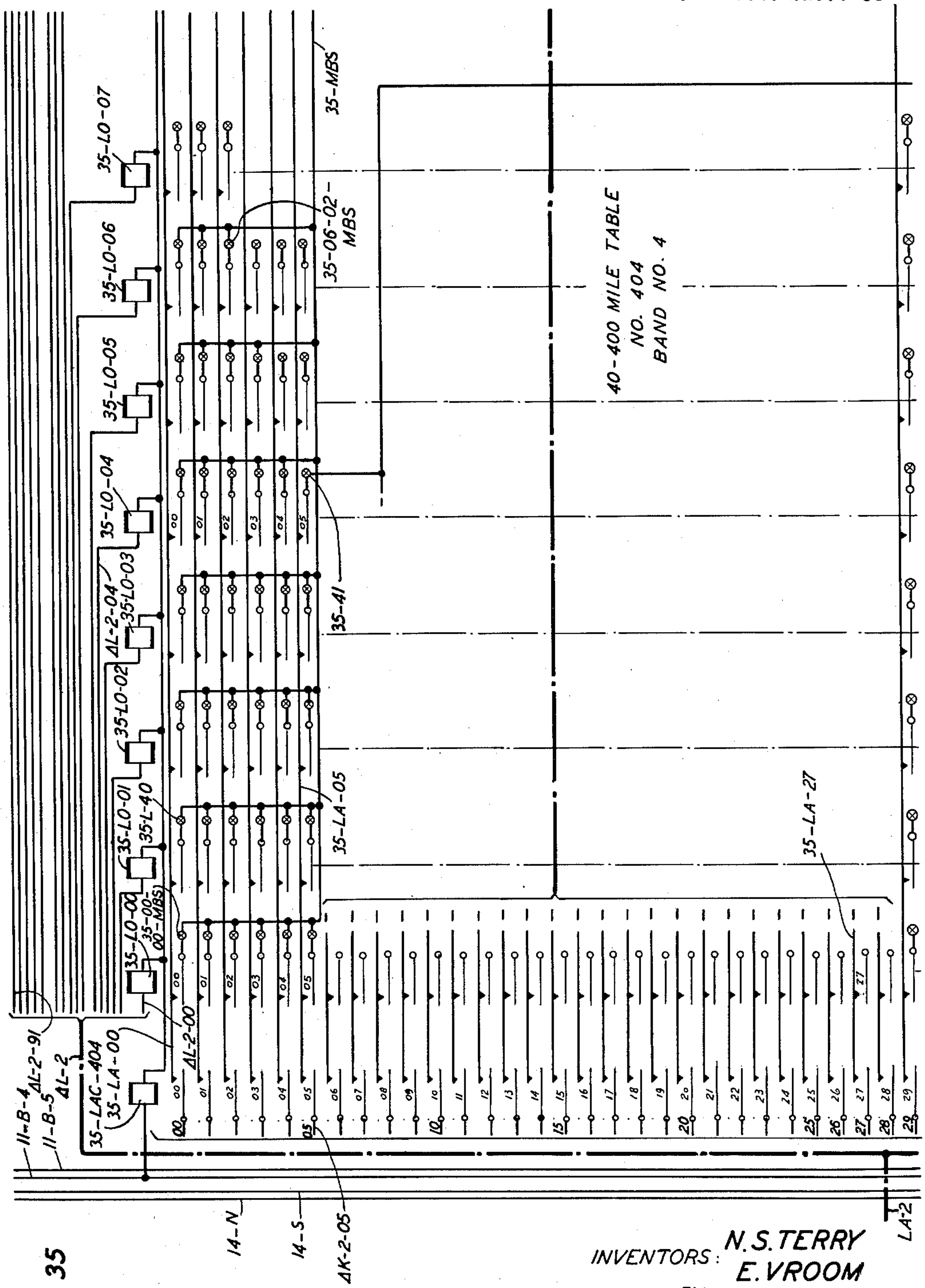

FIG. 35

INVENTORS: N.S. TERRY
E. VROOM
BY
ATTORNEY

AUTOMATIC DETERMINATION OF TOLL CALL CHARGES

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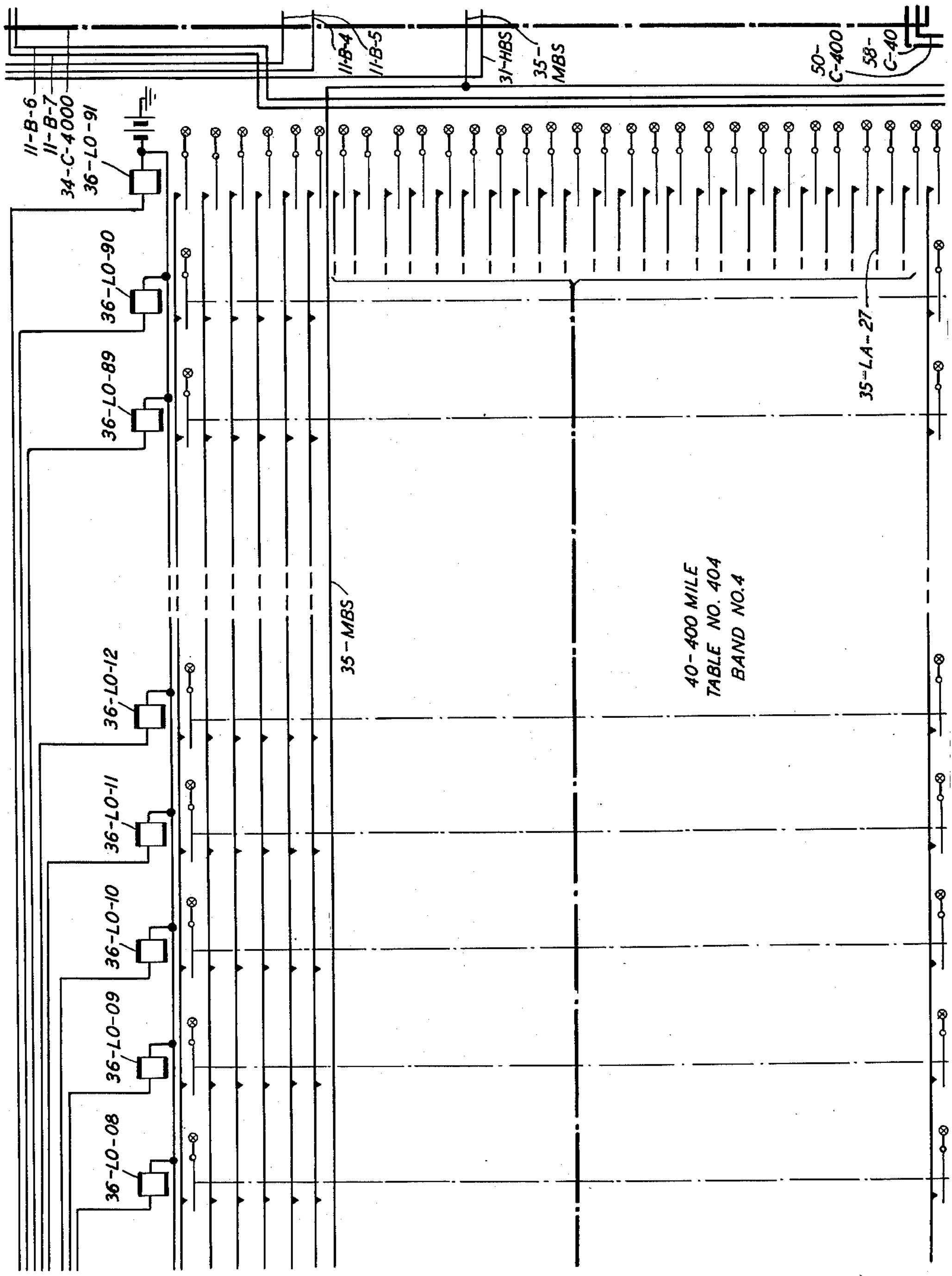

FIG. 36

INVENTORS: N.S.TERRY
E.VROOM
BY [signature]
ATTORNEY

AUTOMATIC DETERMINATION OF TOLL CALL CHARGES

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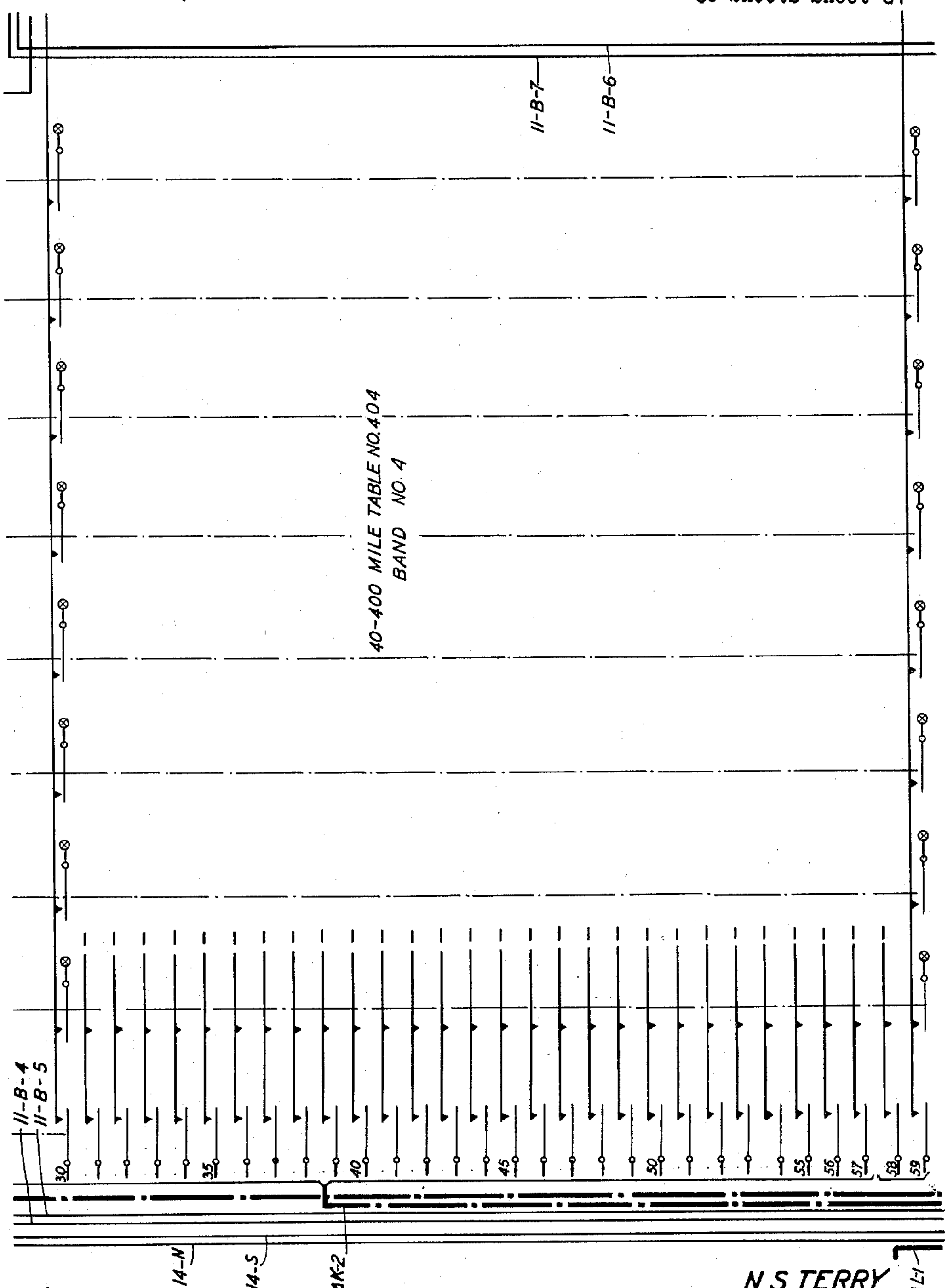

FIG. 37

INVENTORS: N.S.TERRY
E.VROOM
BY [signature]
ATTORNEY

May 16, 1961 N. S. TERRY ET AL 2,984,704

AUTOMATIC DETERMINATION OF TOLL CALL CHARGES

Filed Dec. 7, 1956 89 Sheets-Sheet 38

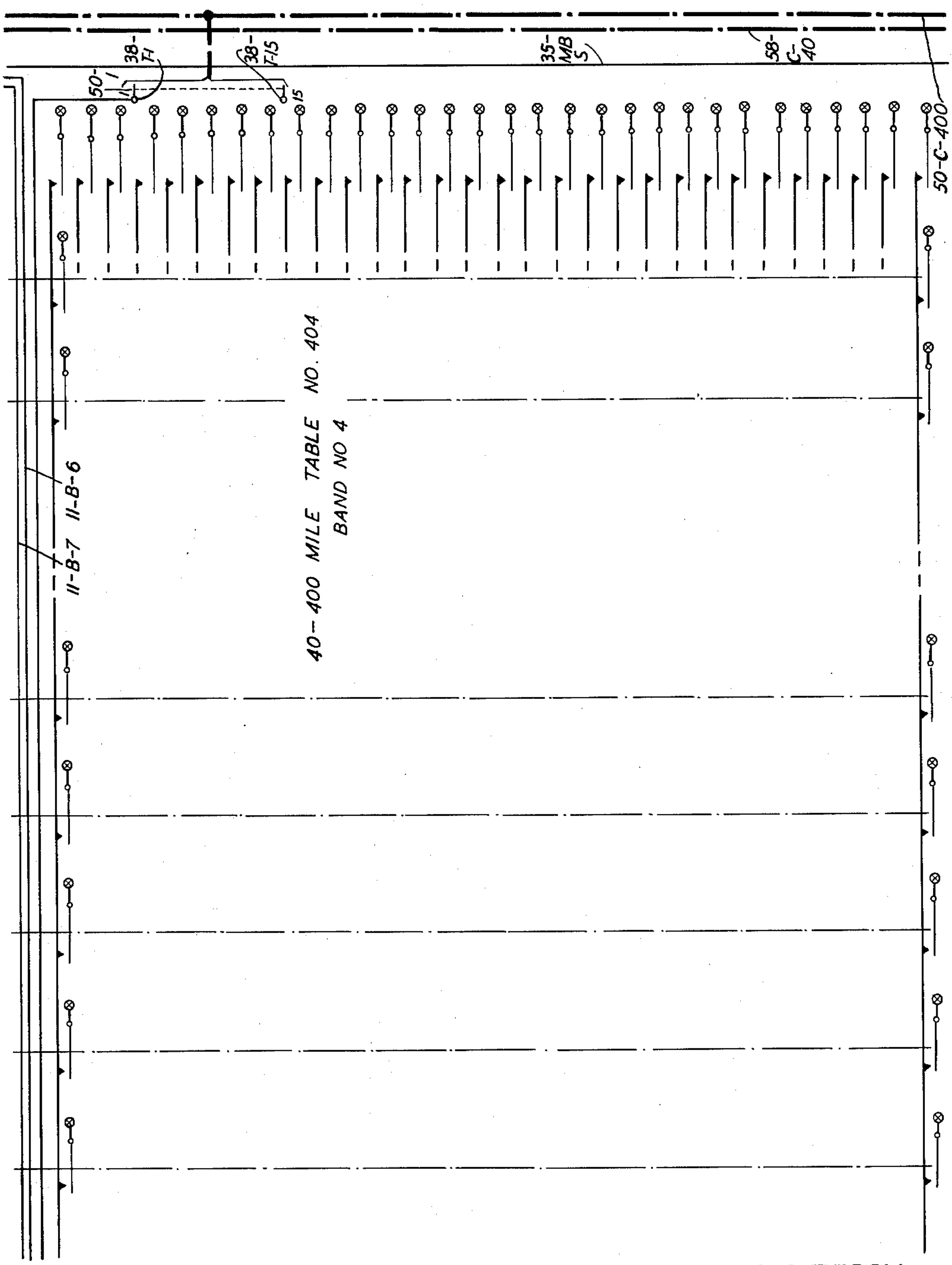

FIG. 38

INVENTORS: N.S. TERRY
E. VROOM
BY
ATTORNEY

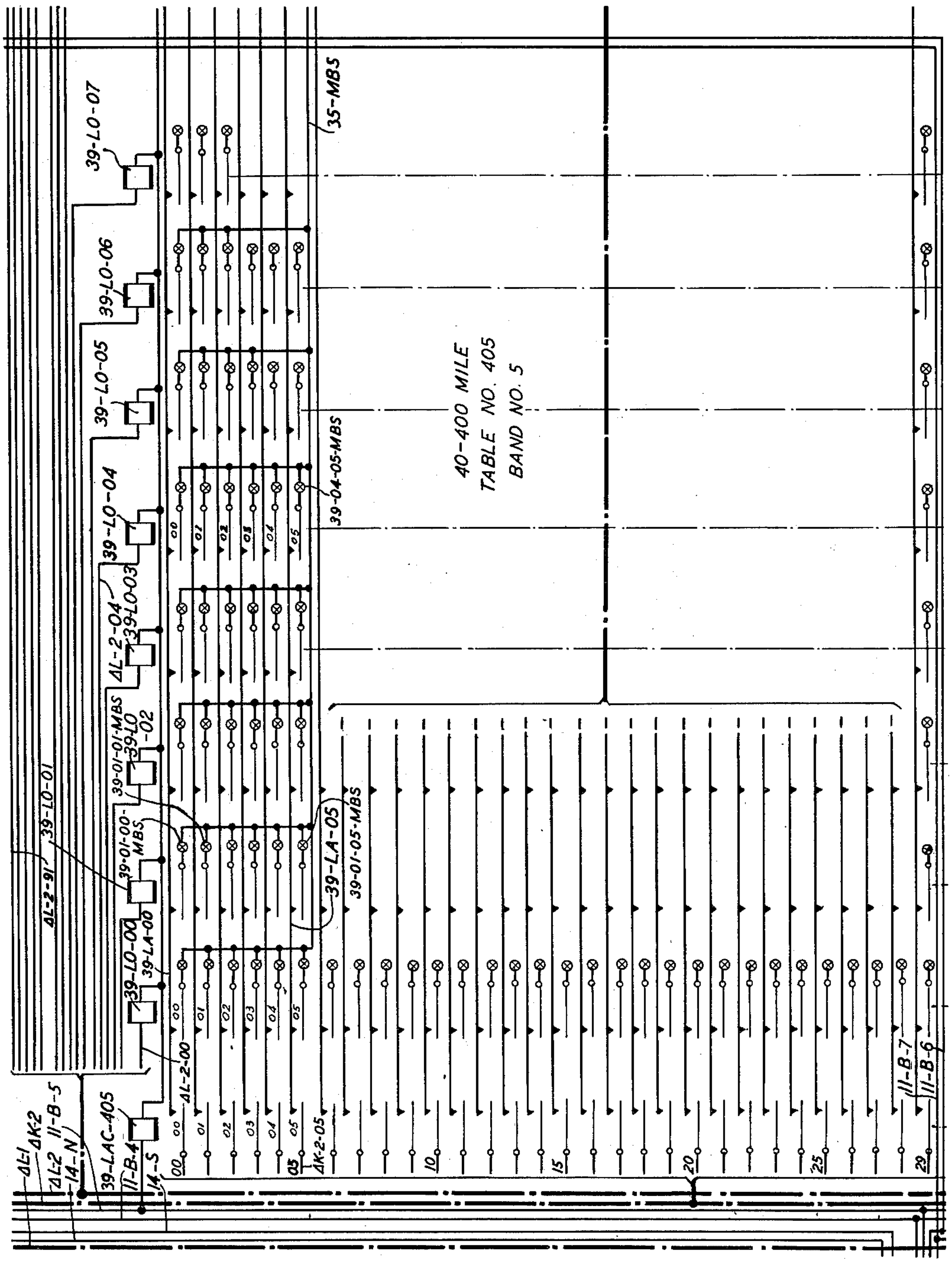

FIG. 39

INVENTORS: N. S. TERRY
E. VROOM
BY
ATTORNEY

May 16, 1961 N. S. TERRY ET AL 2,984,704

AUTOMATIC DETERMINATION OF TOLL CALL CHARGES

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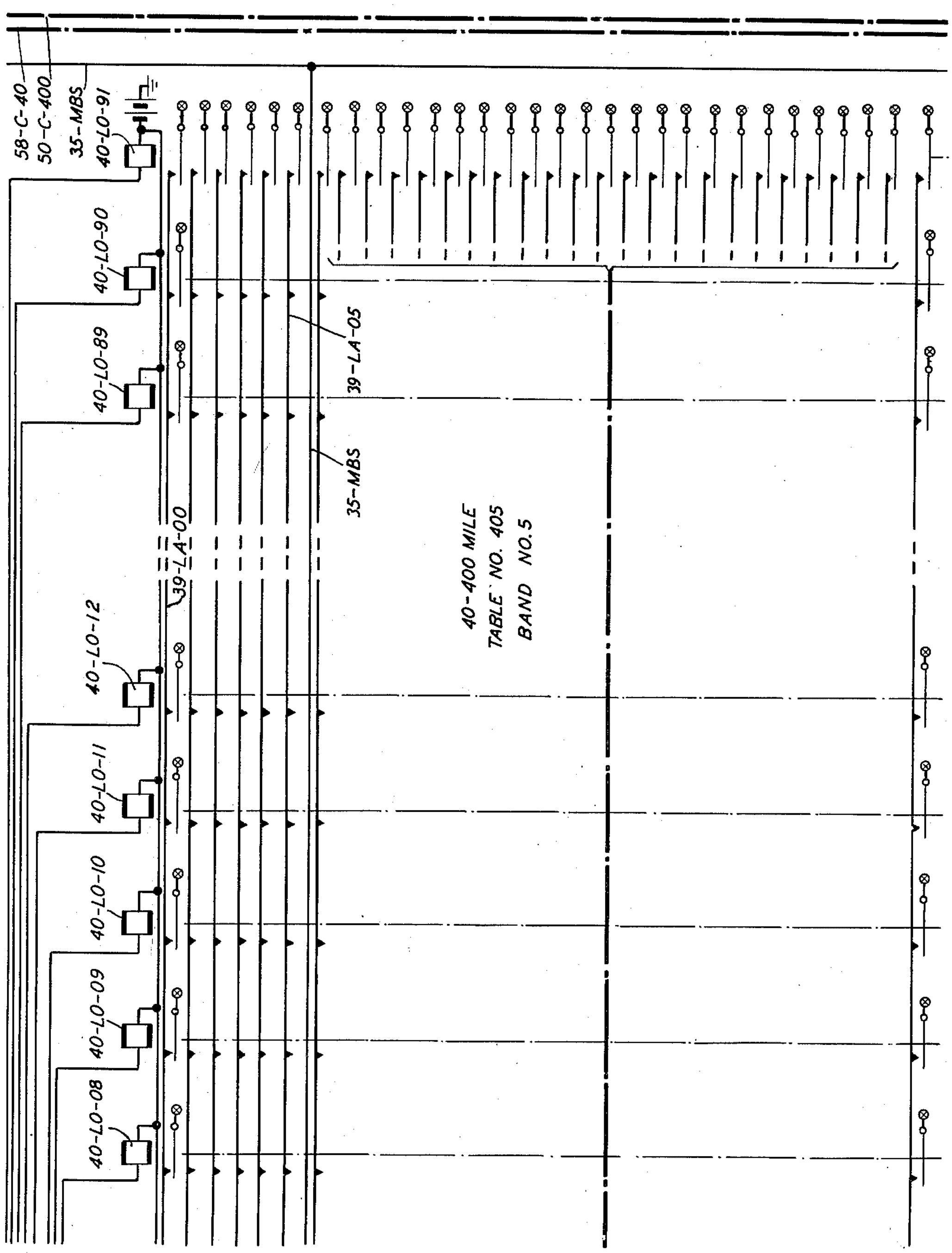

FIG. 40

INVENTORS: N.S.TERRY
E.VROOM
BY
ATTORNEY

AUTOMATIC DETERMINATION OF TOLL CALL CHARGES

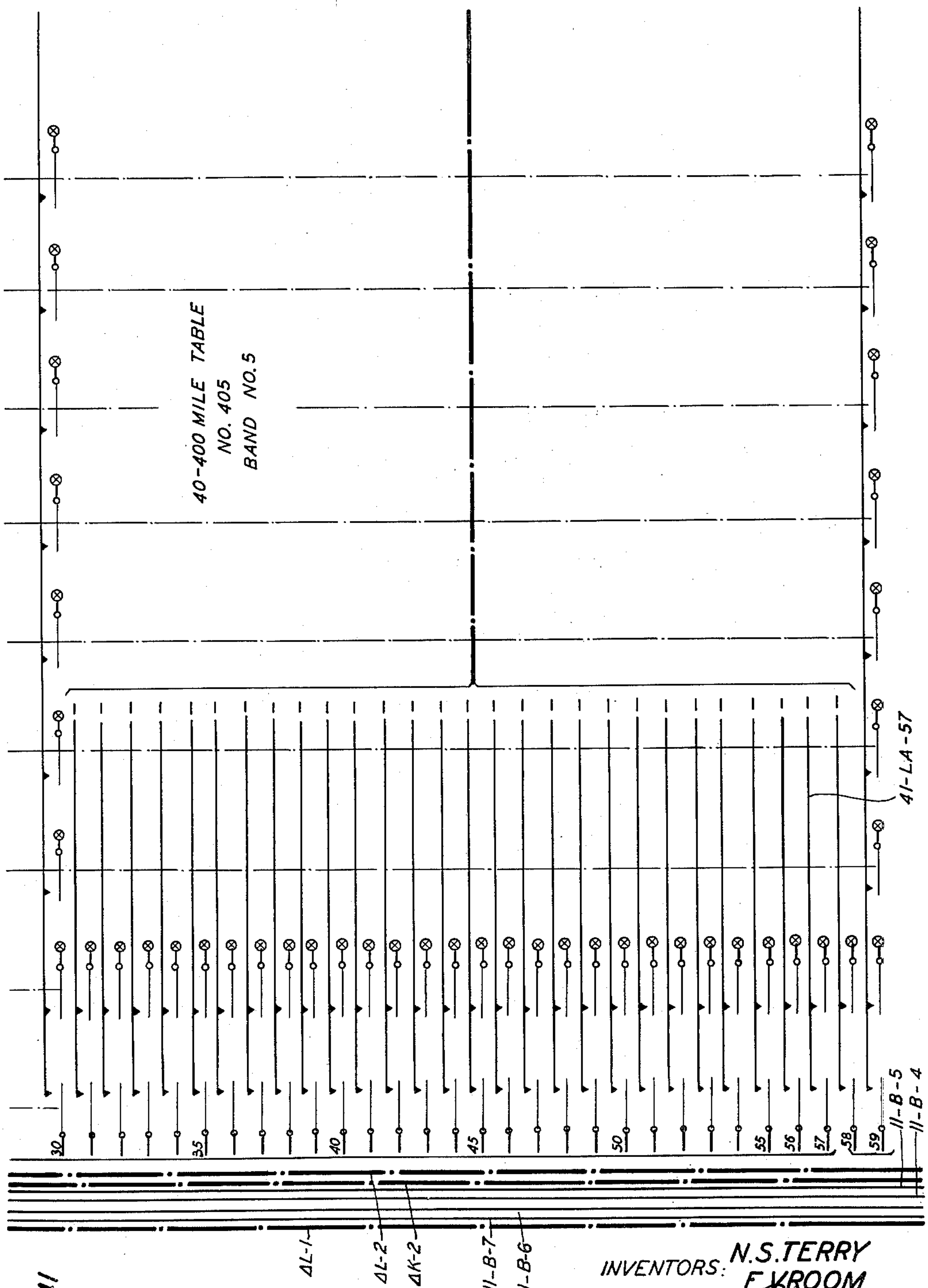

FIG. 41

INVENTORS: N.S.TERRY
E.VROOM
BY
ATTORNEY

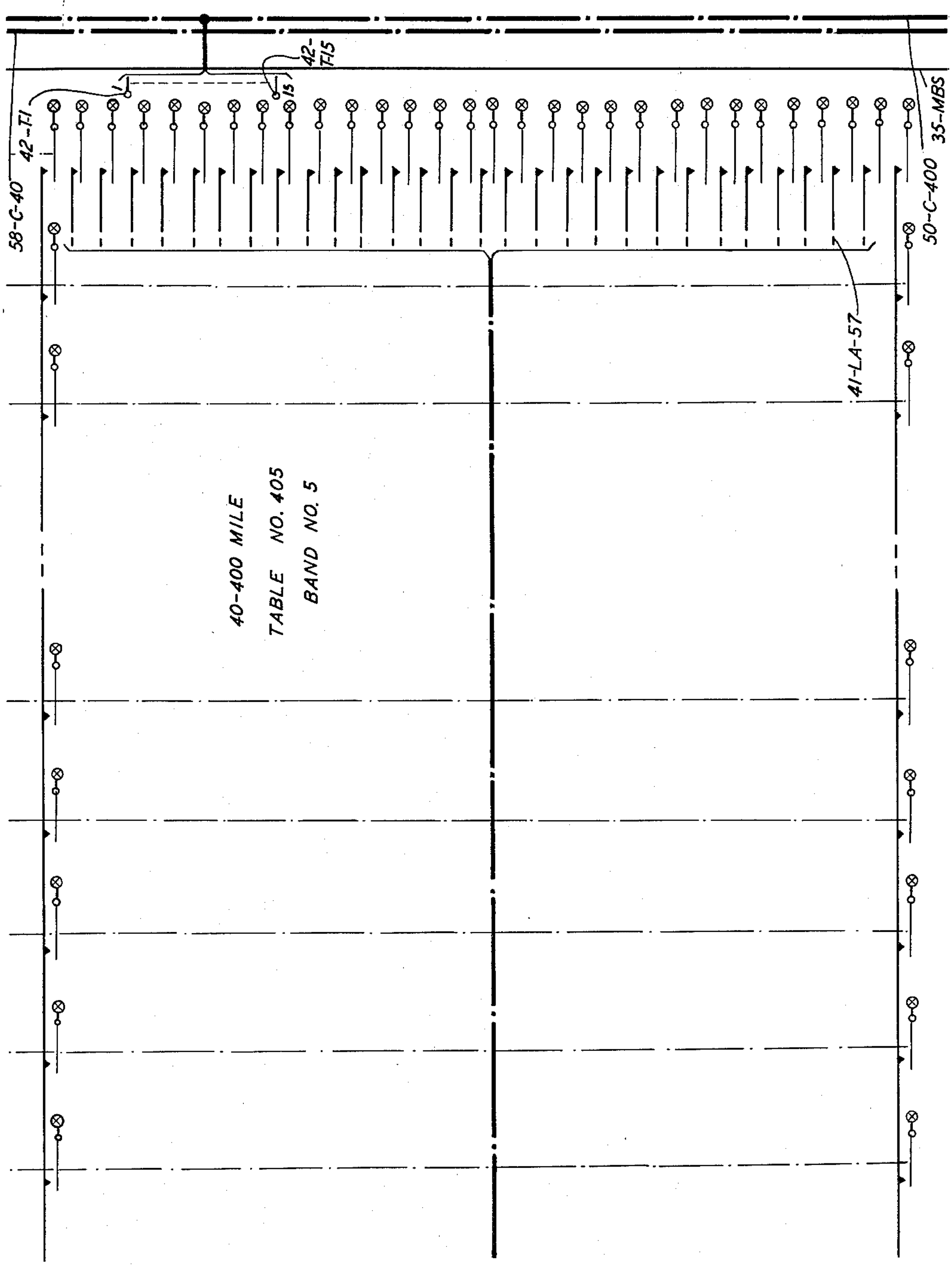

FIG. 42

INVENTORS: N.S. TERRY
E. VROOM
BY [signature]
ATTORNEY

AUTOMATIC DETERMINATION OF TOLL CALL CHARGES

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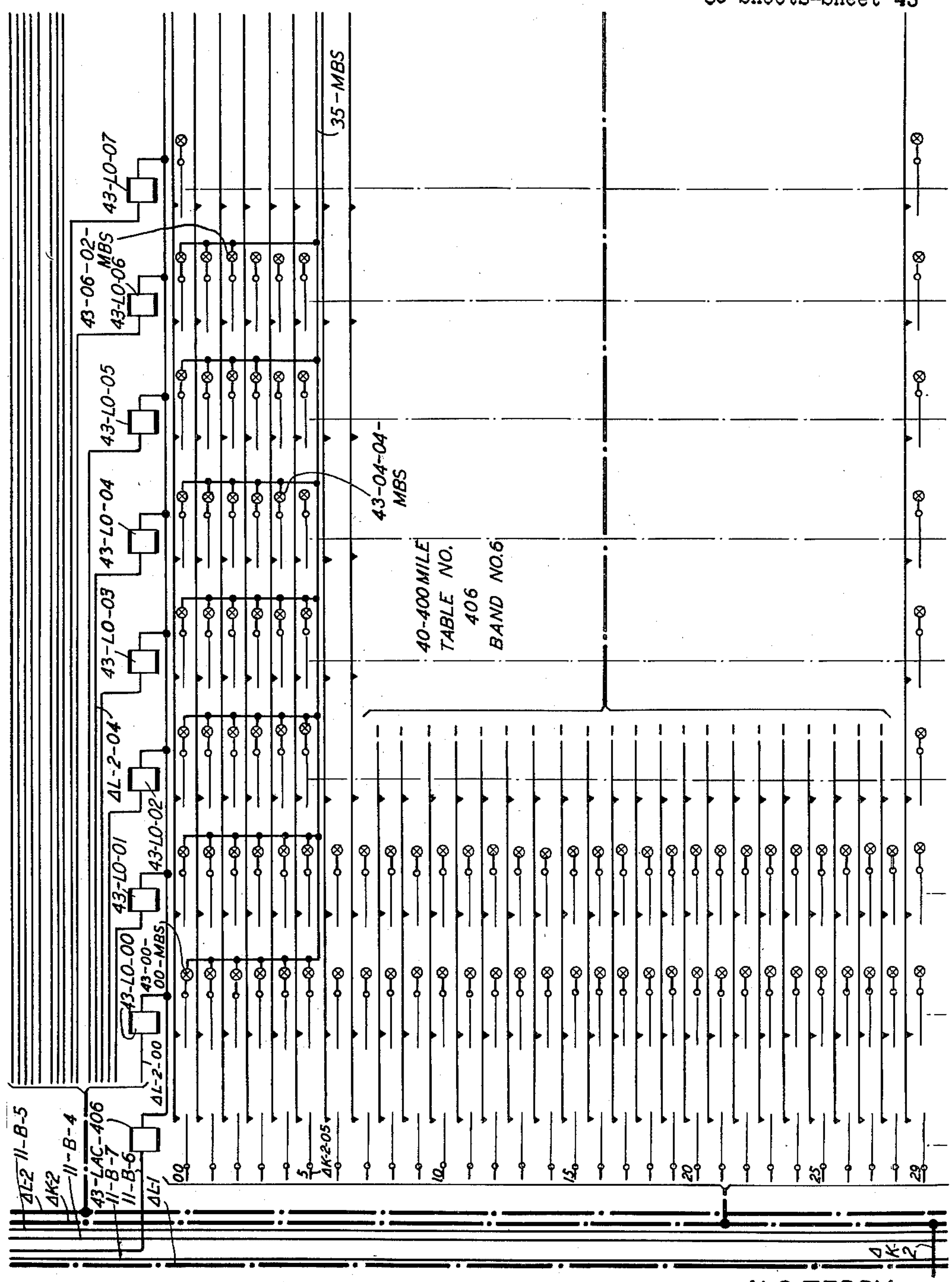

FIG. 43

INVENTORS: N. S. TERRY
E. VROOM
BY
ATTORNEY

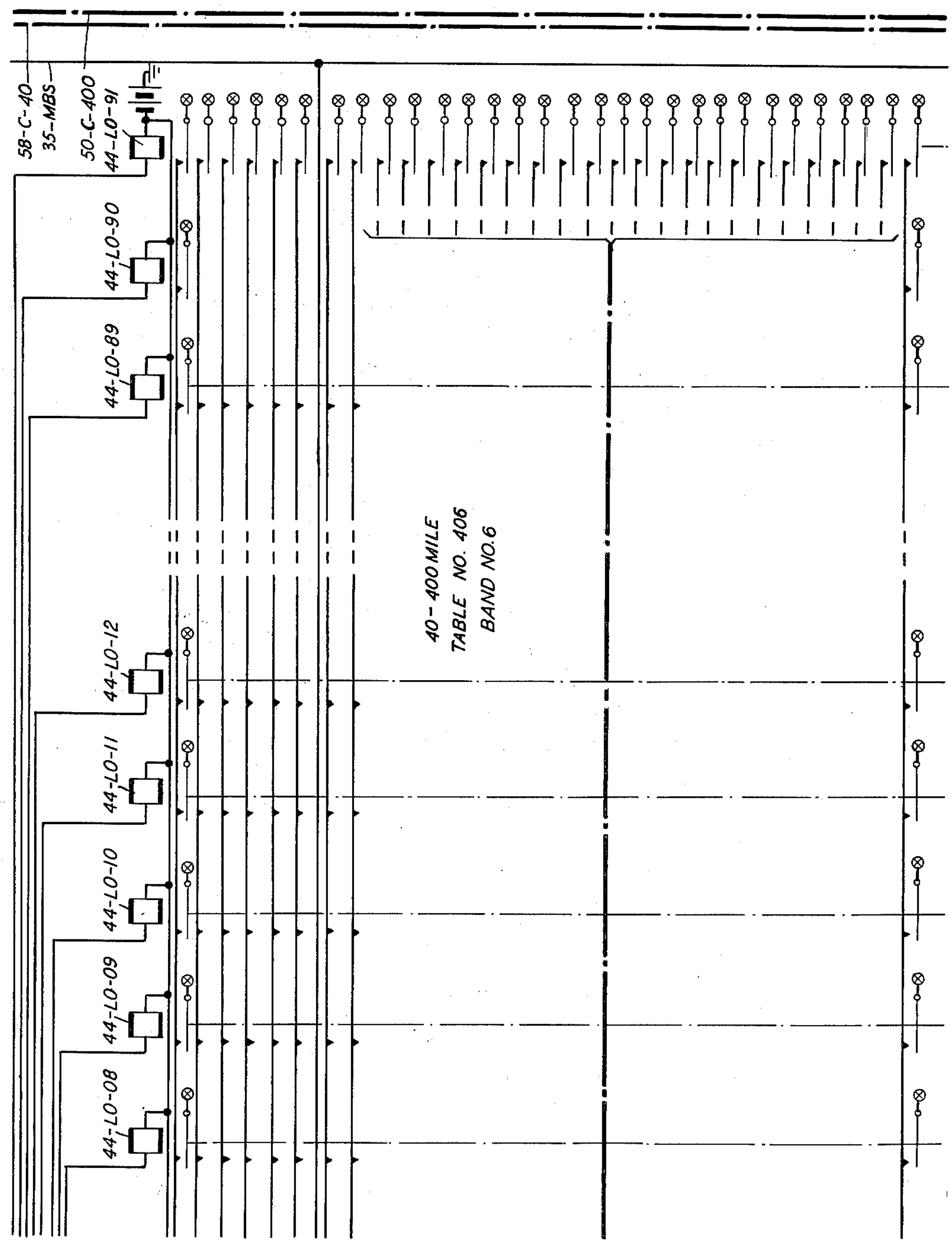

FIG. 44

INVENTORS: N.S.TERRY
E.VROOM

BY

ATTORNEY

May 16, 1961 N. S. TERRY ET AL 2,984,704

AUTOMATIC DETERMINATION OF TOLL CALL CHARGES

Filed Dec. 7, 1956 89 Sheets-Sheet 45

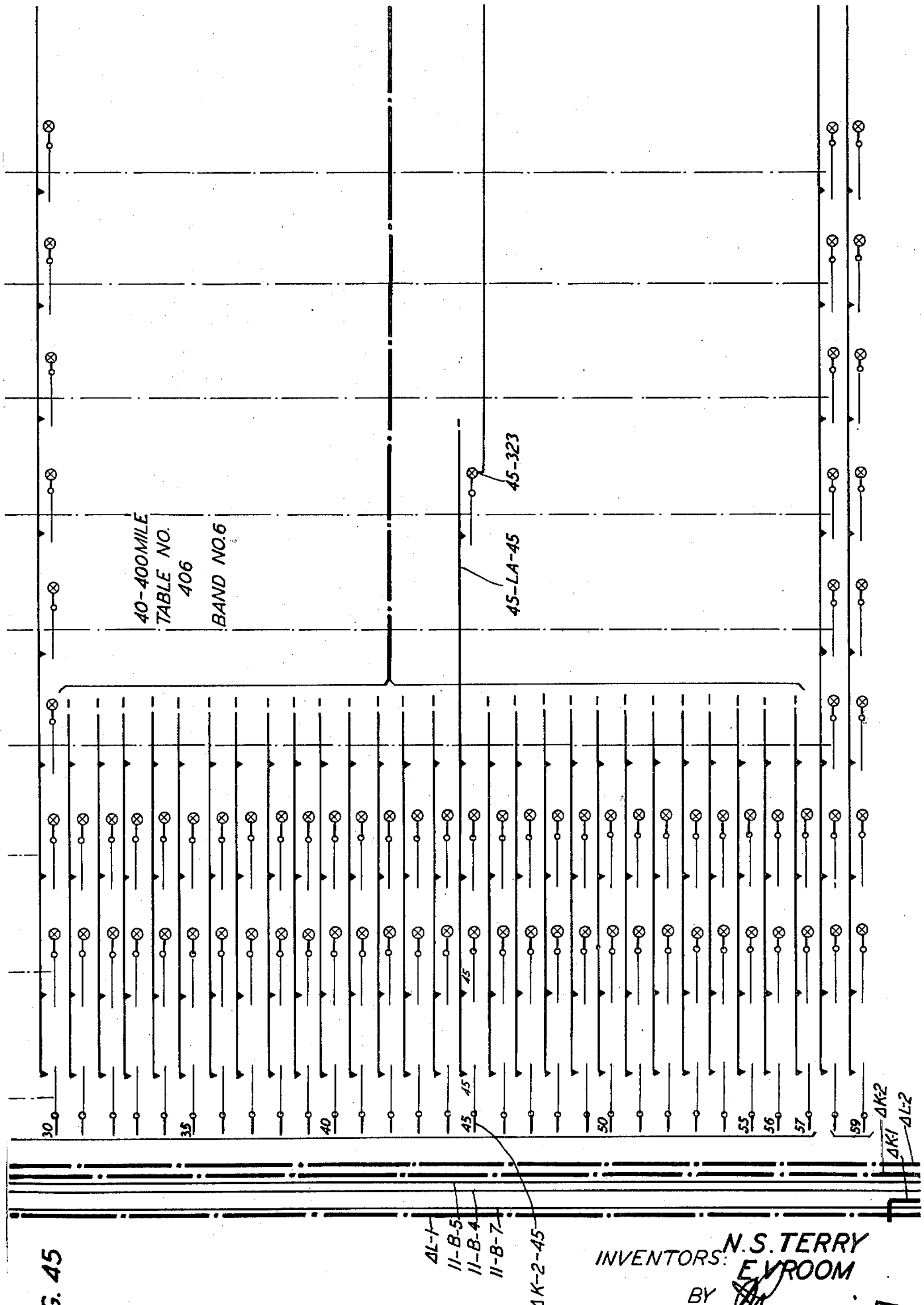

FIG. 45

INVENTORS: N.S. TERRY
E. VROOM

BY

ATTORNEY

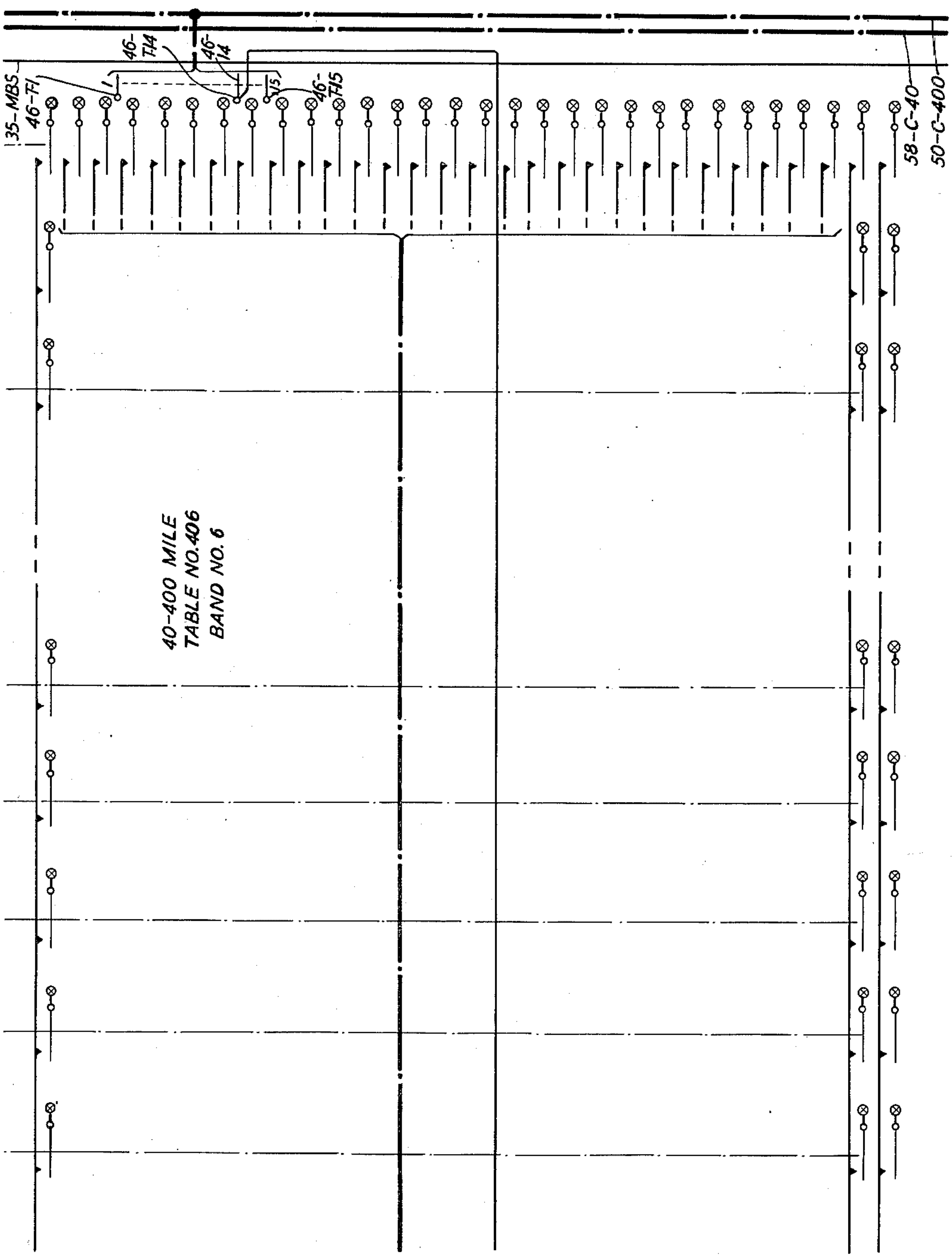

FIG. 46

INVENTORS: N.S. TERRY
E. VROOM
BY [signature]
ATTORNEY

AUTOMATIC DETERMINATION OF TOLL CALL CHARGES

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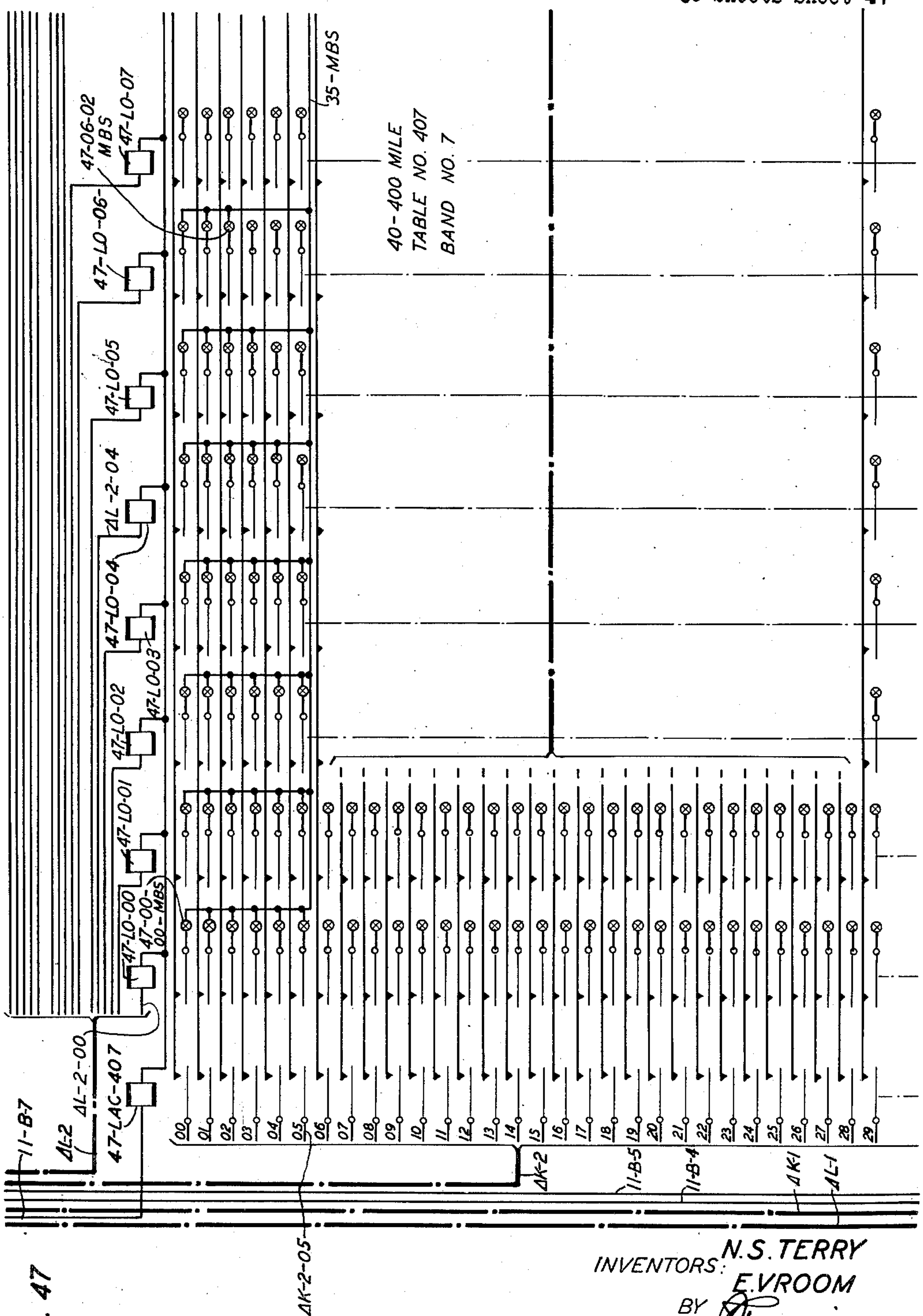

FIG. 47

INVENTORS: N.S. TERRY
E. VROOM
BY
ATTORNEY

May 16, 1961 N. S. TERRY ET AL 2,984,704

AUTOMATIC DETERMINATION OF TOLL CALL CHARGES

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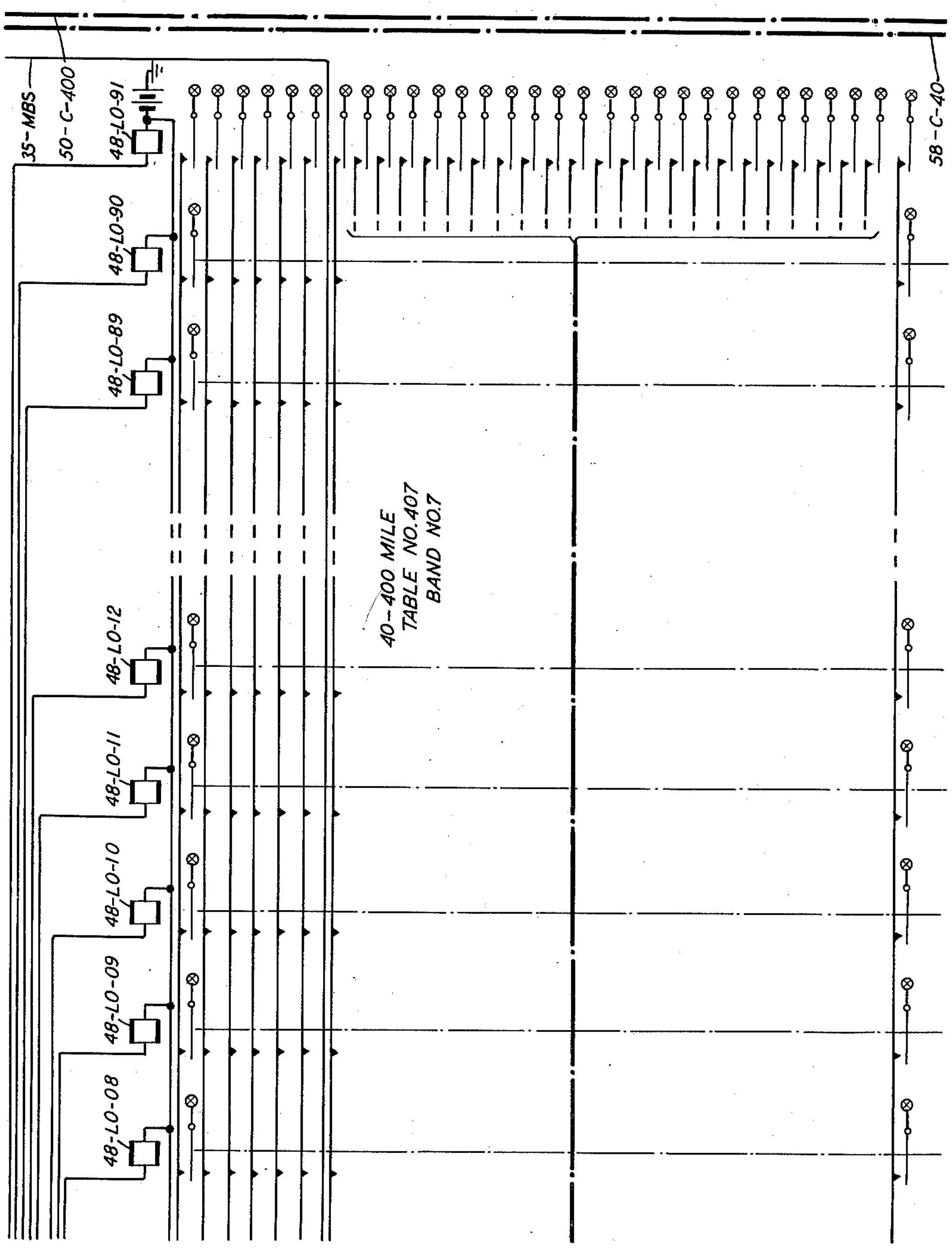

FIG 48

INVENTORS: N.S.TERRY
E.VROOM
BY [signature]
ATTORNEY

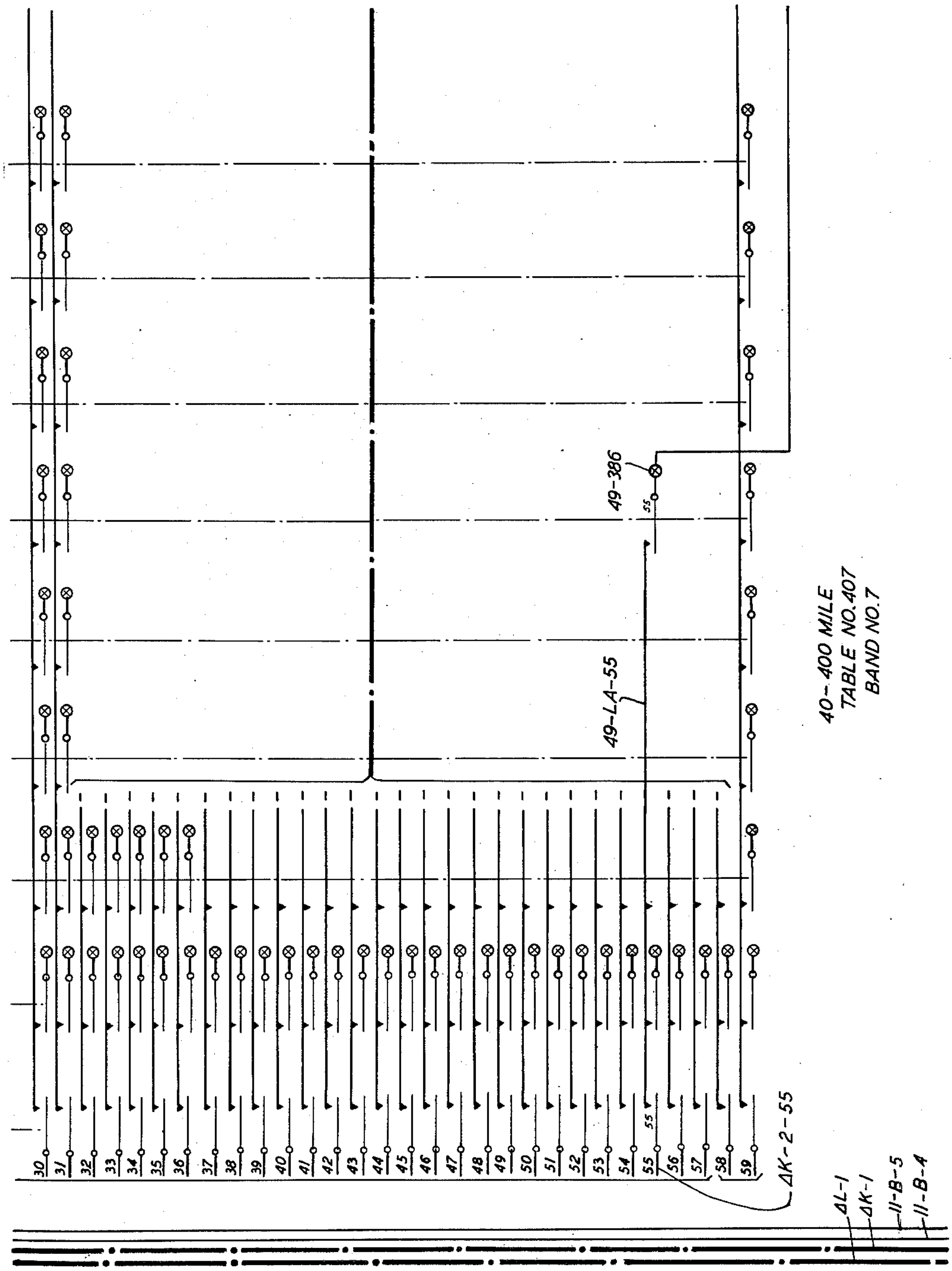

FIG. 49

INVENTORS: N.S.TERRY
E.VROOM
BY
ATTORNEY

May 16, 1961 N. S. TERRY ET AL 2,984,704

AUTOMATIC DETERMINATION OF TOLL CALL CHARGES

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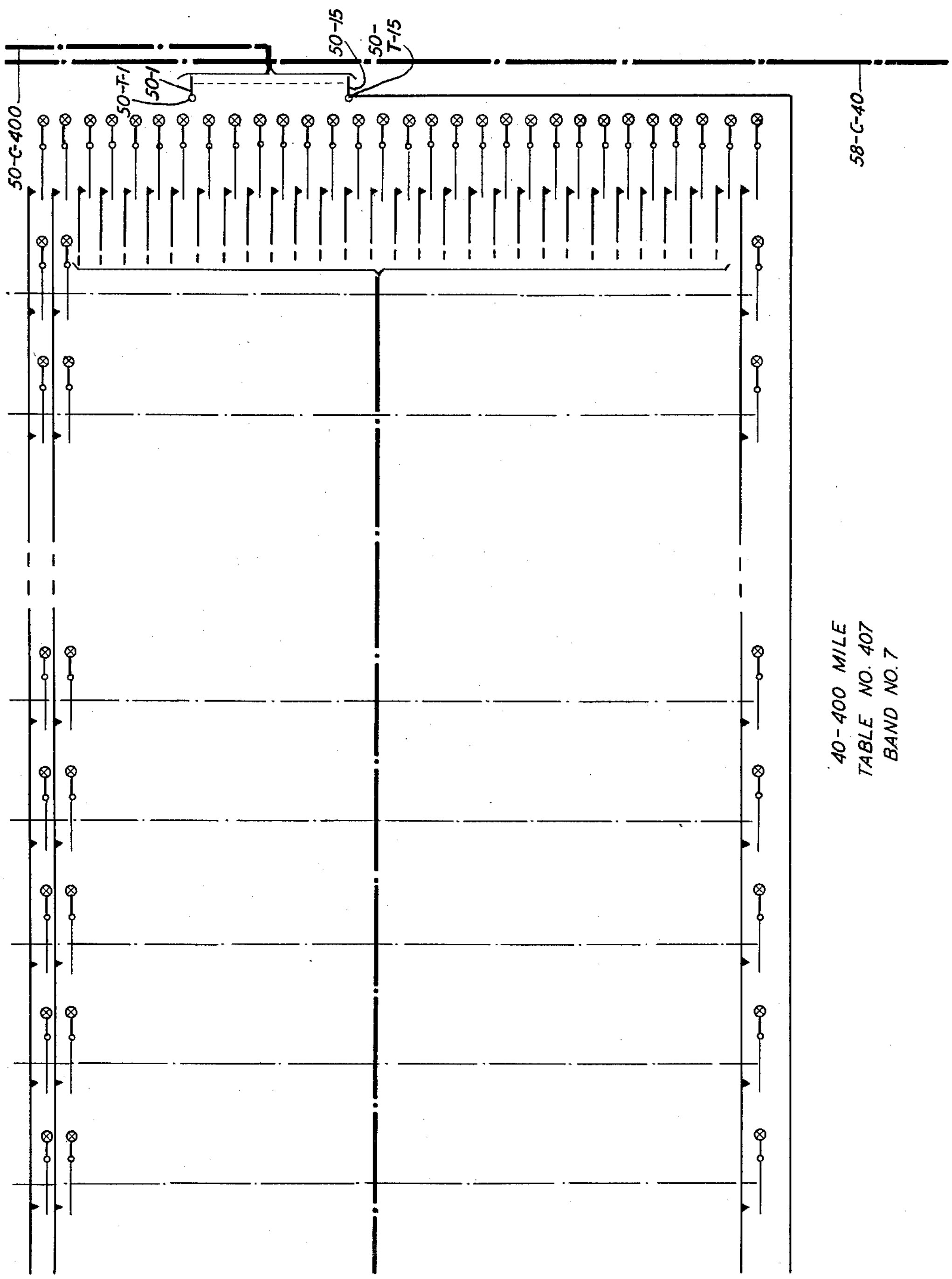

FIG. 50

INVENTORS: N. S. TERRY
E. VROOM
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AUTOMATIC DETERMINATION OF TOLL CALL CHARGES

Filed Dec. 7, 1956

89 Sheets-Sheet 51

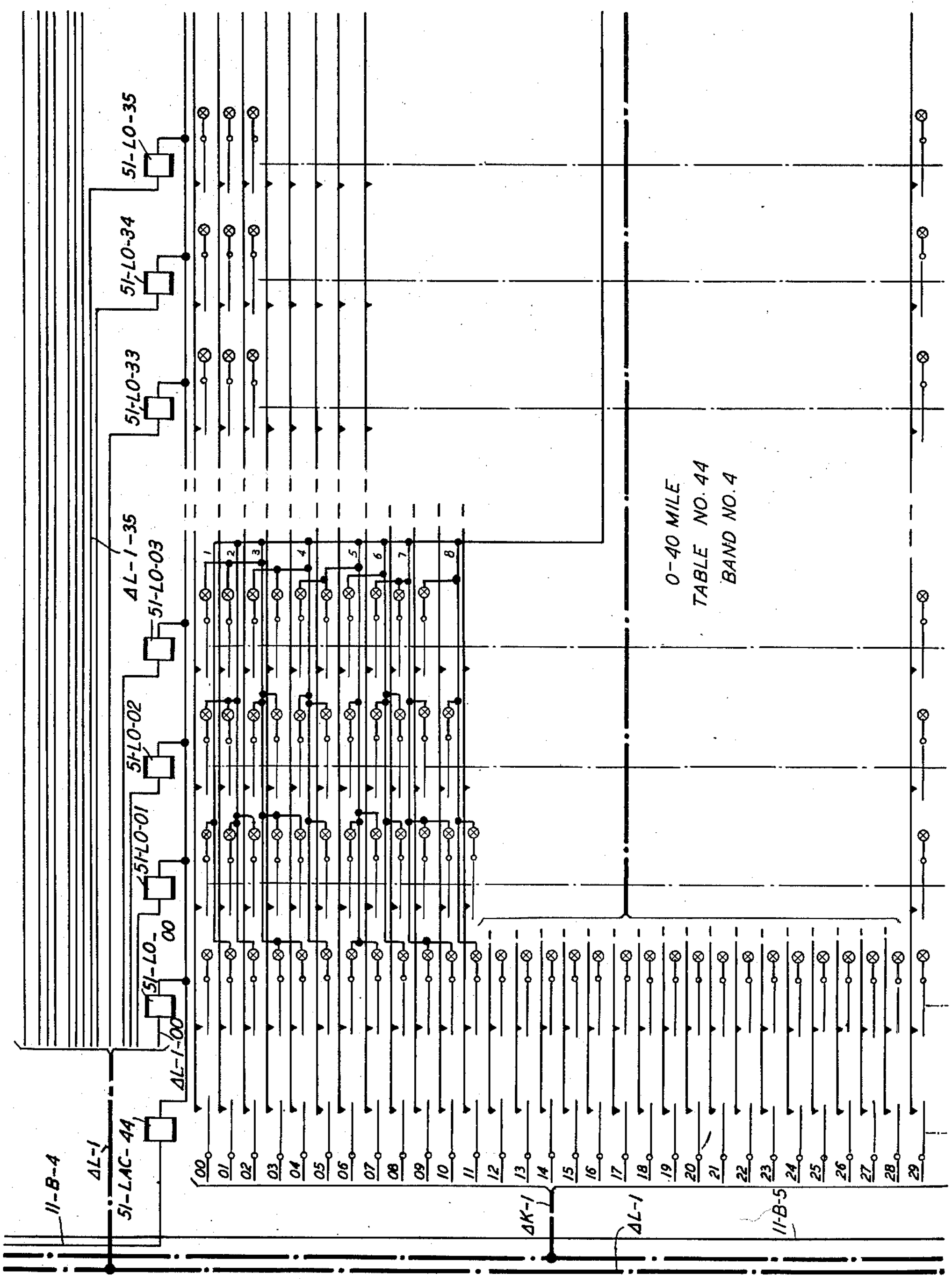

FIG. 51

INVENTORS: N.S. TERRY
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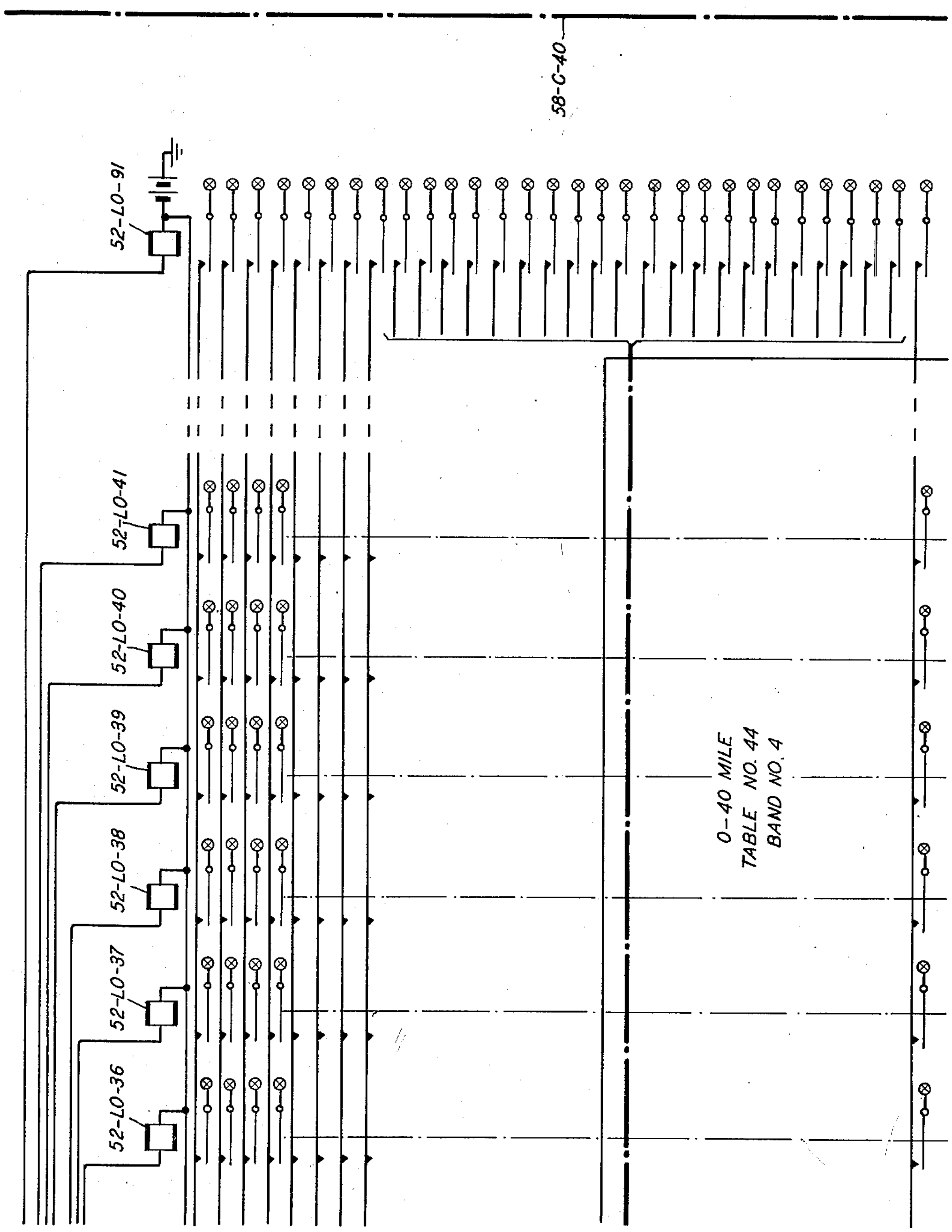

FIG. 52

INVENTORS: N. S. TERRY
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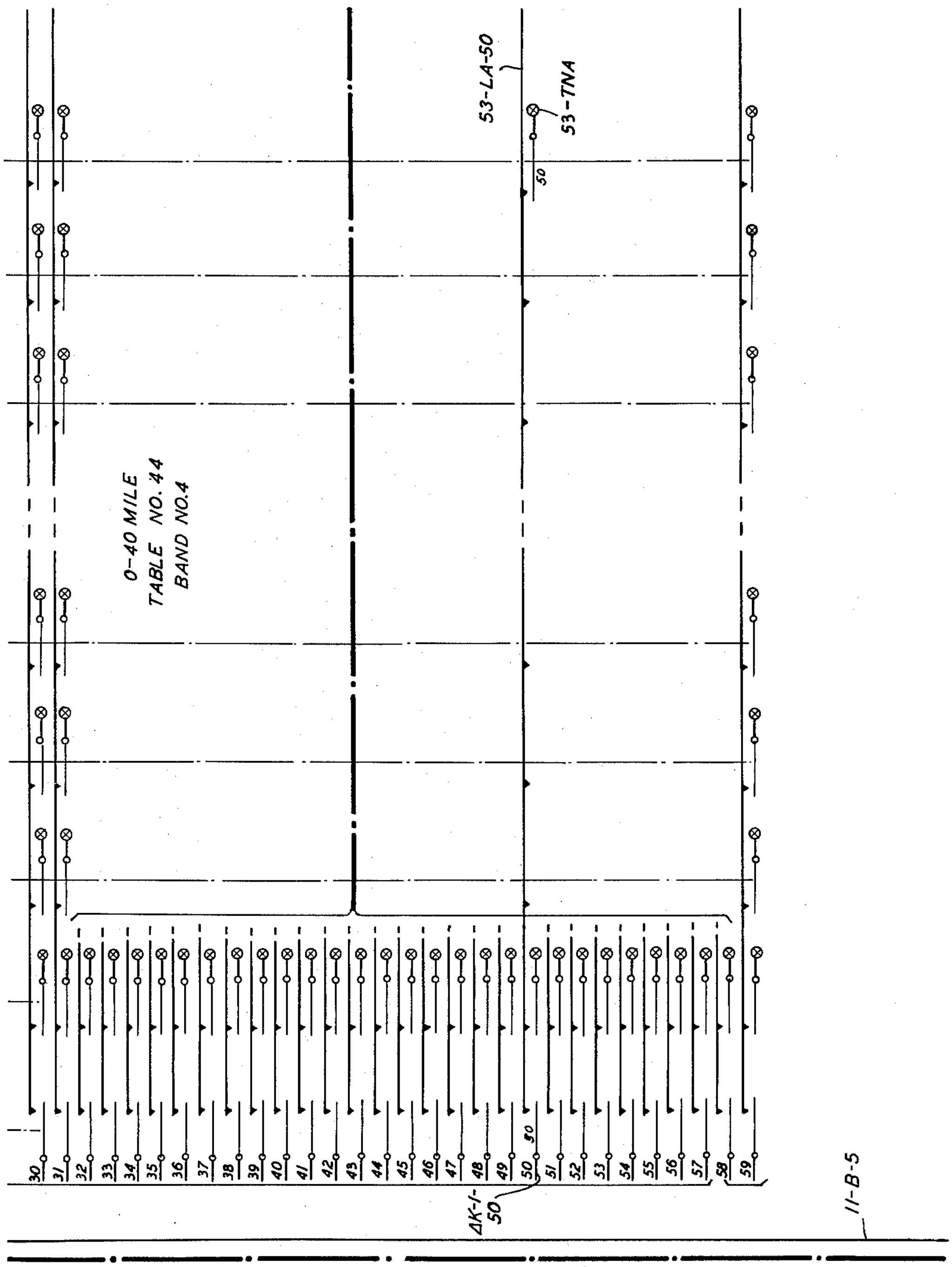

FIG. 53

INVENTORS: N.S. TERRY
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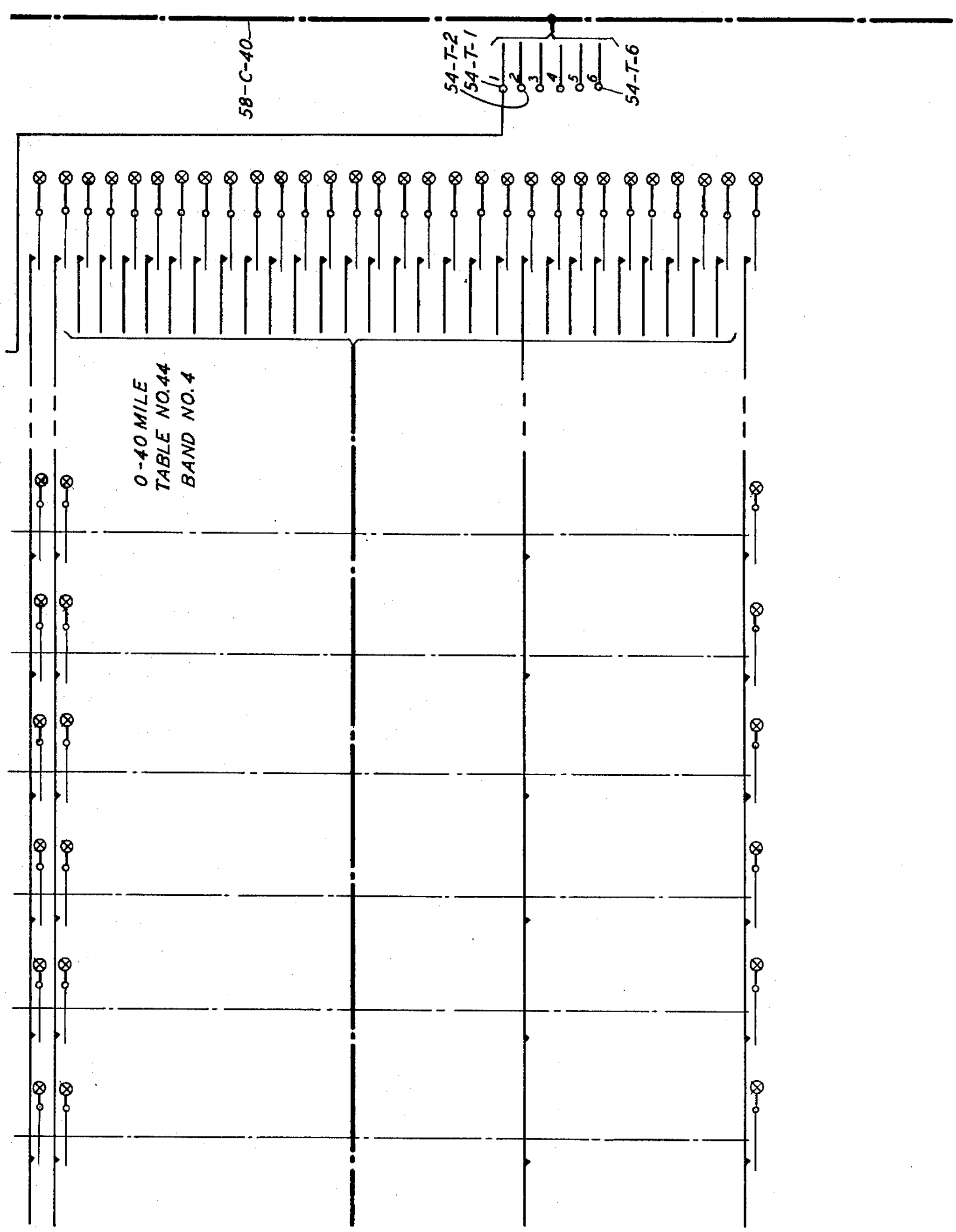

FIG. 54

INVENTORS: N.S.TERRY
E.VROOM

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AUTOMATIC DETERMINATION OF TOLL CALL CHARGES

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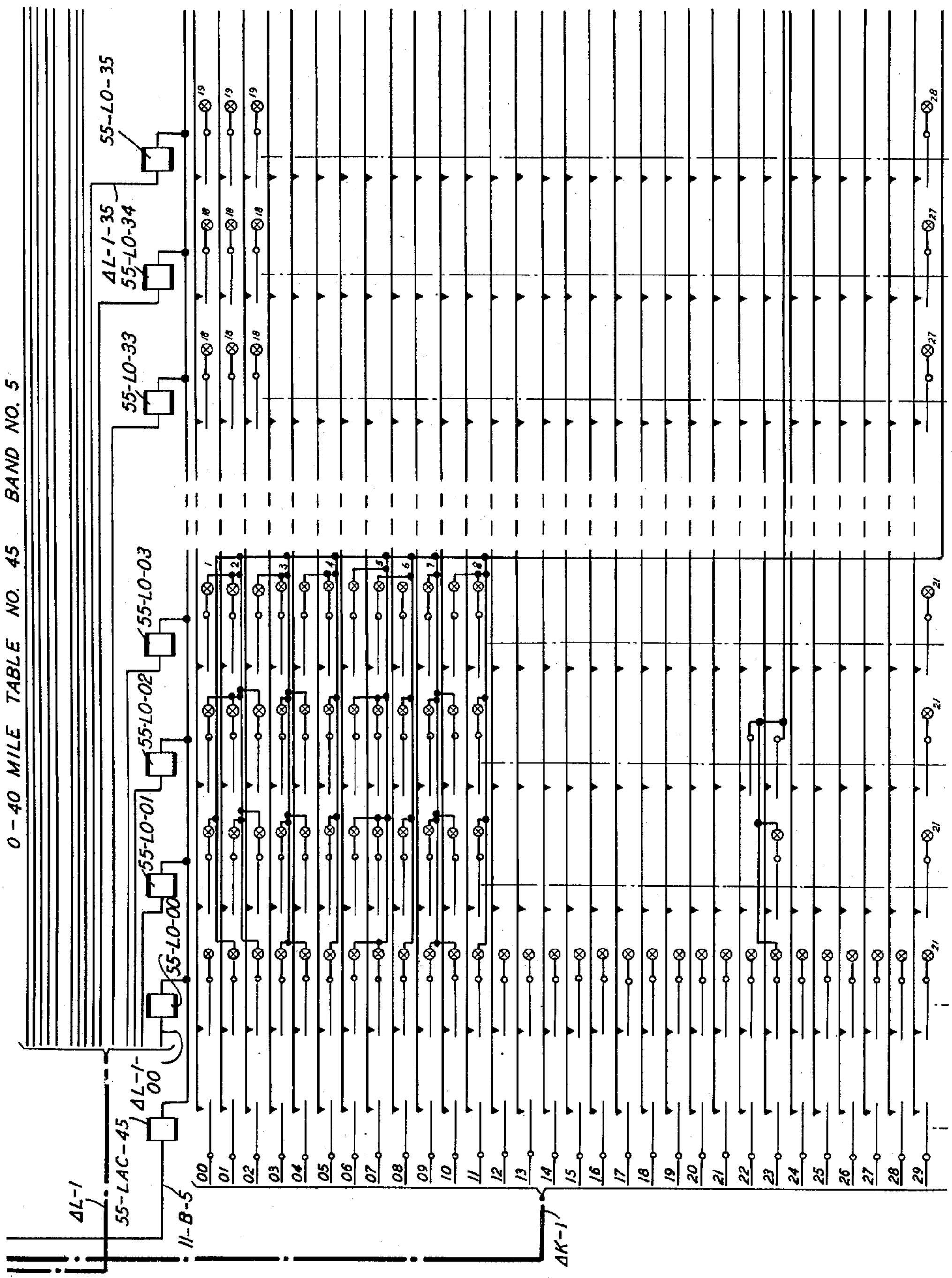

FIG.55

INVENTORS: N.S.TERRY
E.VROOM
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AUTOMATIC DETERMINATION OF TOLL CALL CHARGES

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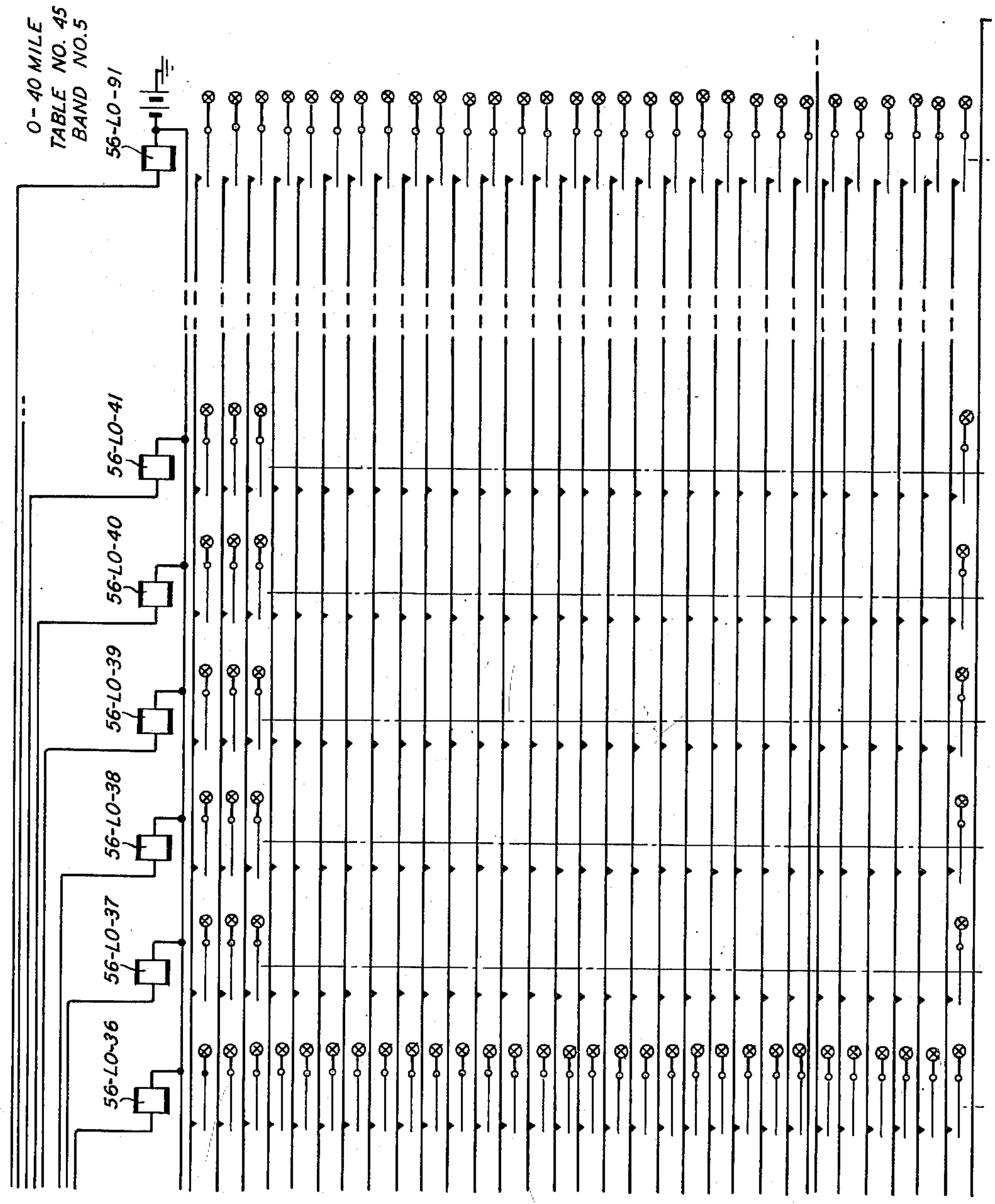

FIG. 56

INVENTORS: N. S. TERRY
E. VROOM
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AUTOMATIC DETERMINATION OF TOLL CALL CHARGES

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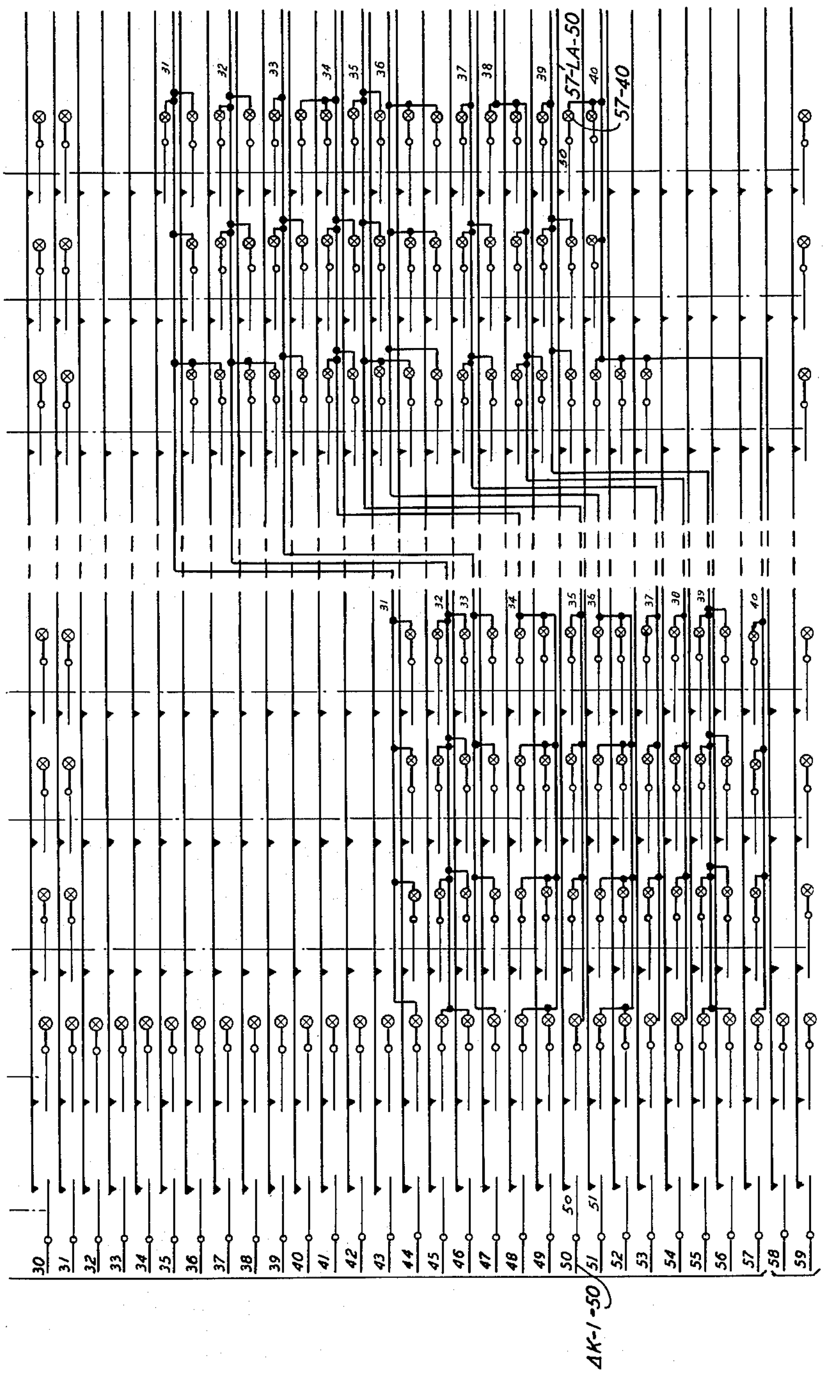

0-40 MILE
TABLE NO. 45
BAND NO. 5

FIG. 57

INVENTORS: N. S. TERRY
E. VROOM
BY
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AUTOMATIC DETERMINATION OF TOLL CALL CHARGES

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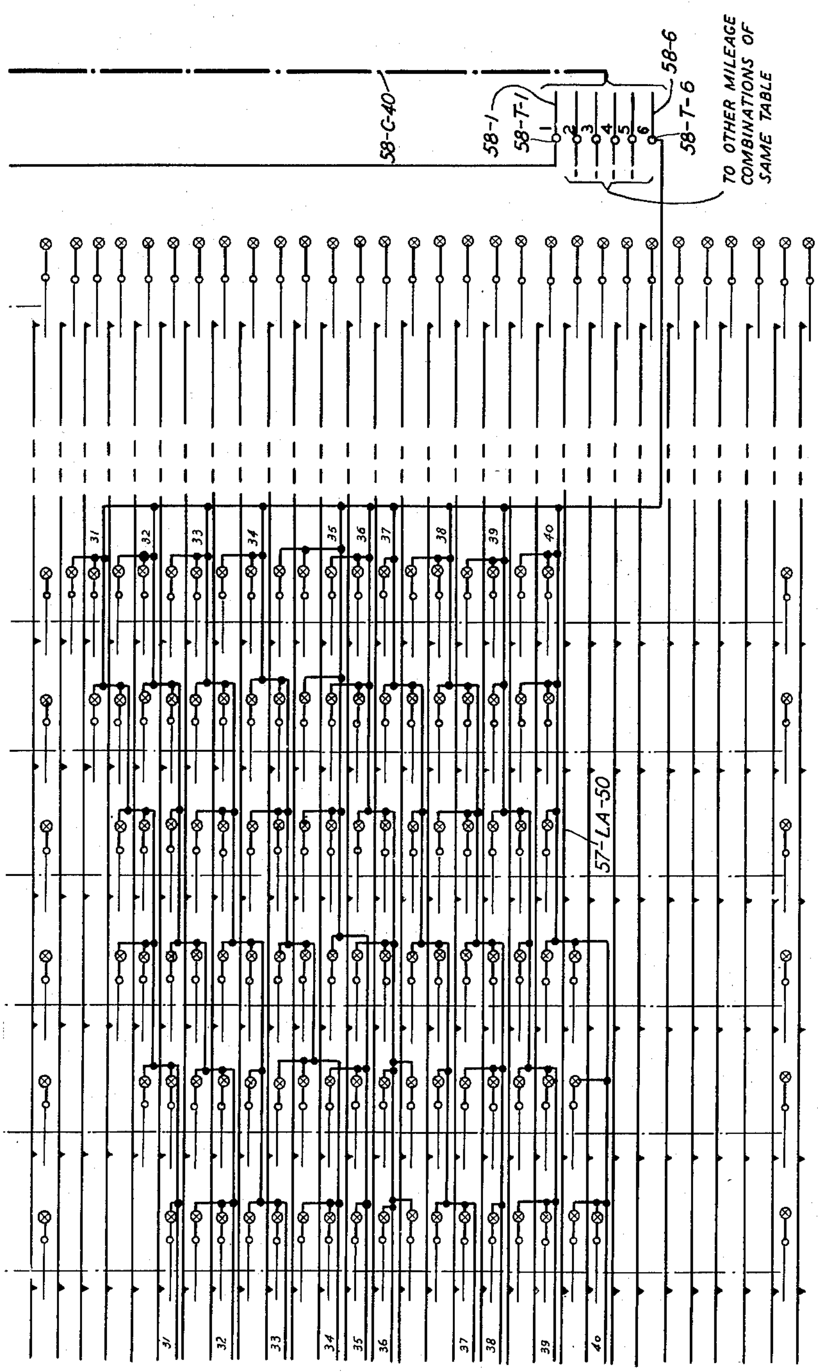

0 - 40 MILE
TABLE NO. 45
BAND NO. 5

FIG. 58

INVENTORS: N. S. TERRY
E. VROOM
BY [signature]
ATTORNEY

AUTOMATIC DETERMINATION OF TOLL CALL CHARGES

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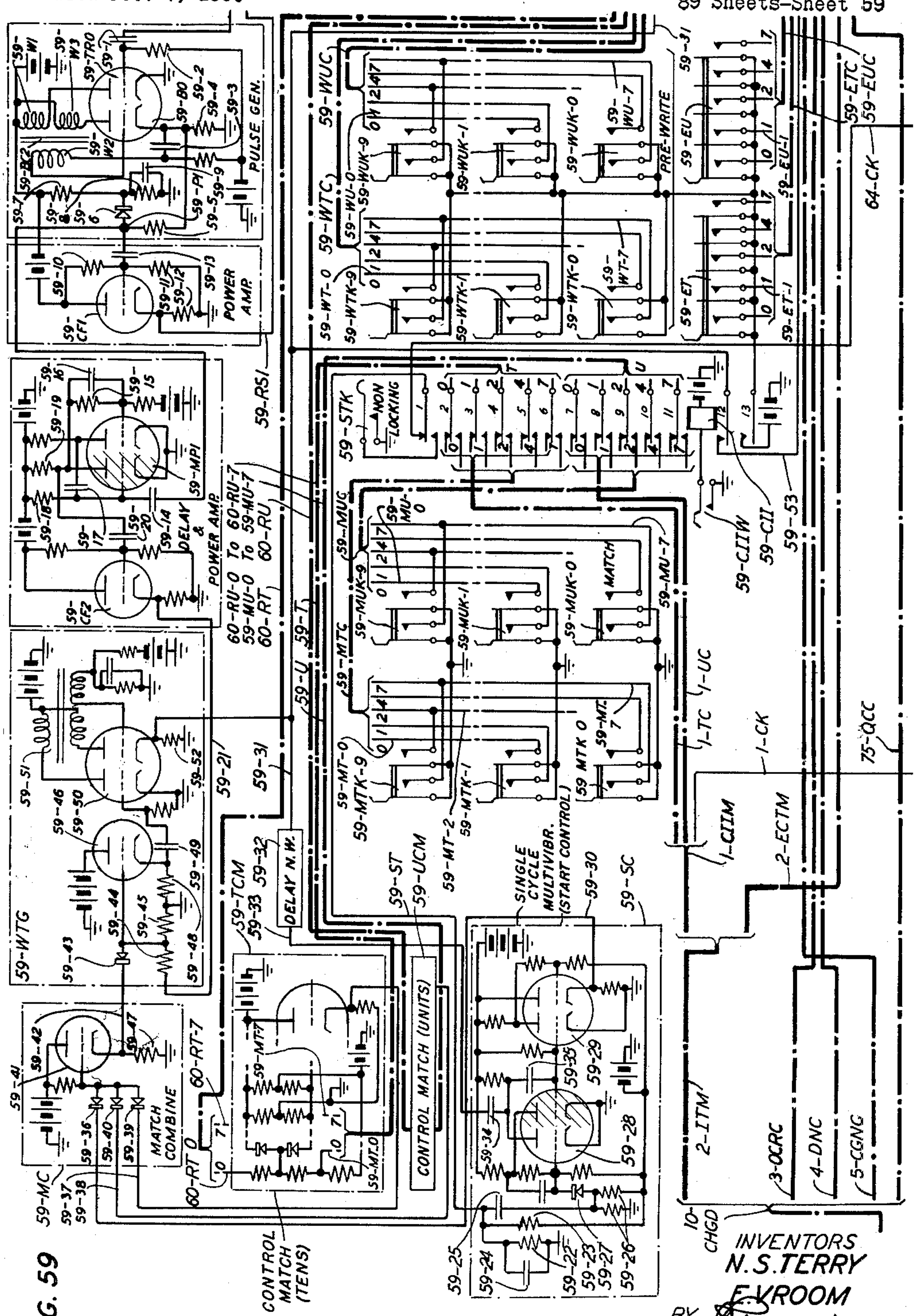

FIG. 59

INVENTORS
N. S. TERRY
E. VROOM
BY
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AUTOMATIC DETERMINATION OF TOLL CALL CHARGES

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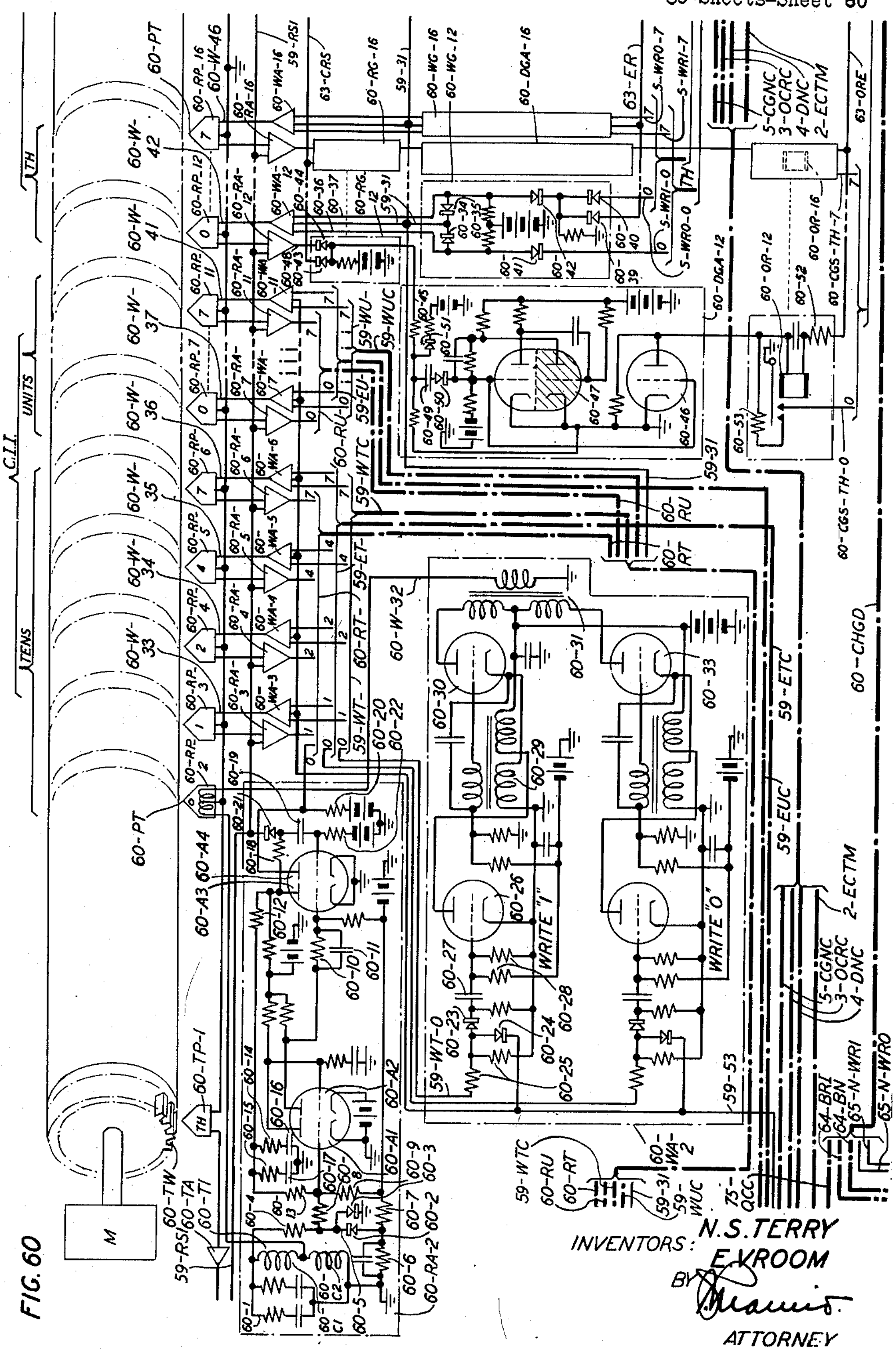

FIG. 60

INVENTORS: N.S.TERRY
E.VROOM
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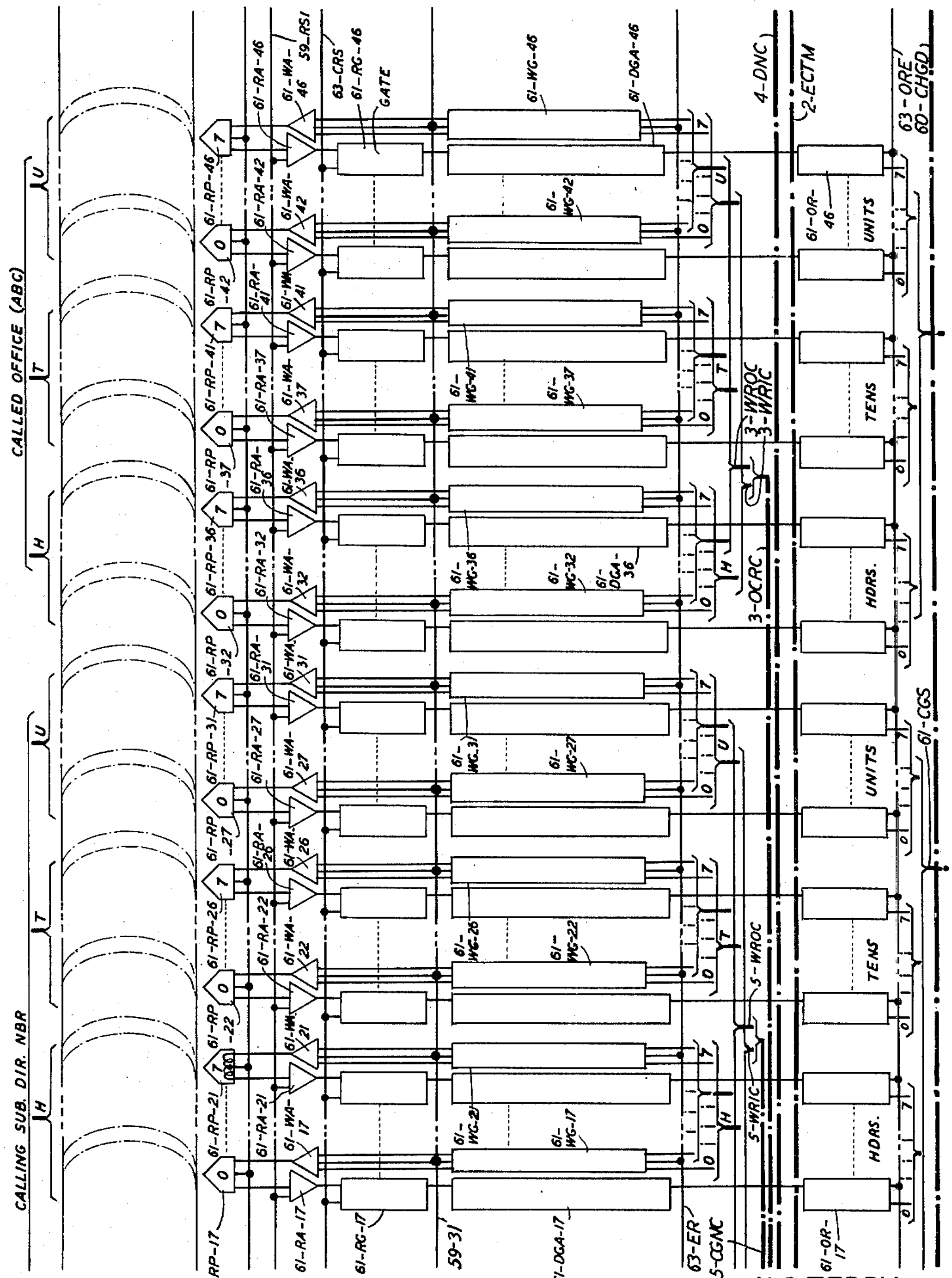

FIG. 61

INVENTORS: N.S. TERRY
E. VROOM

BY

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AUTOMATIC DETERMINATION OF TOLL CALL CHARGES

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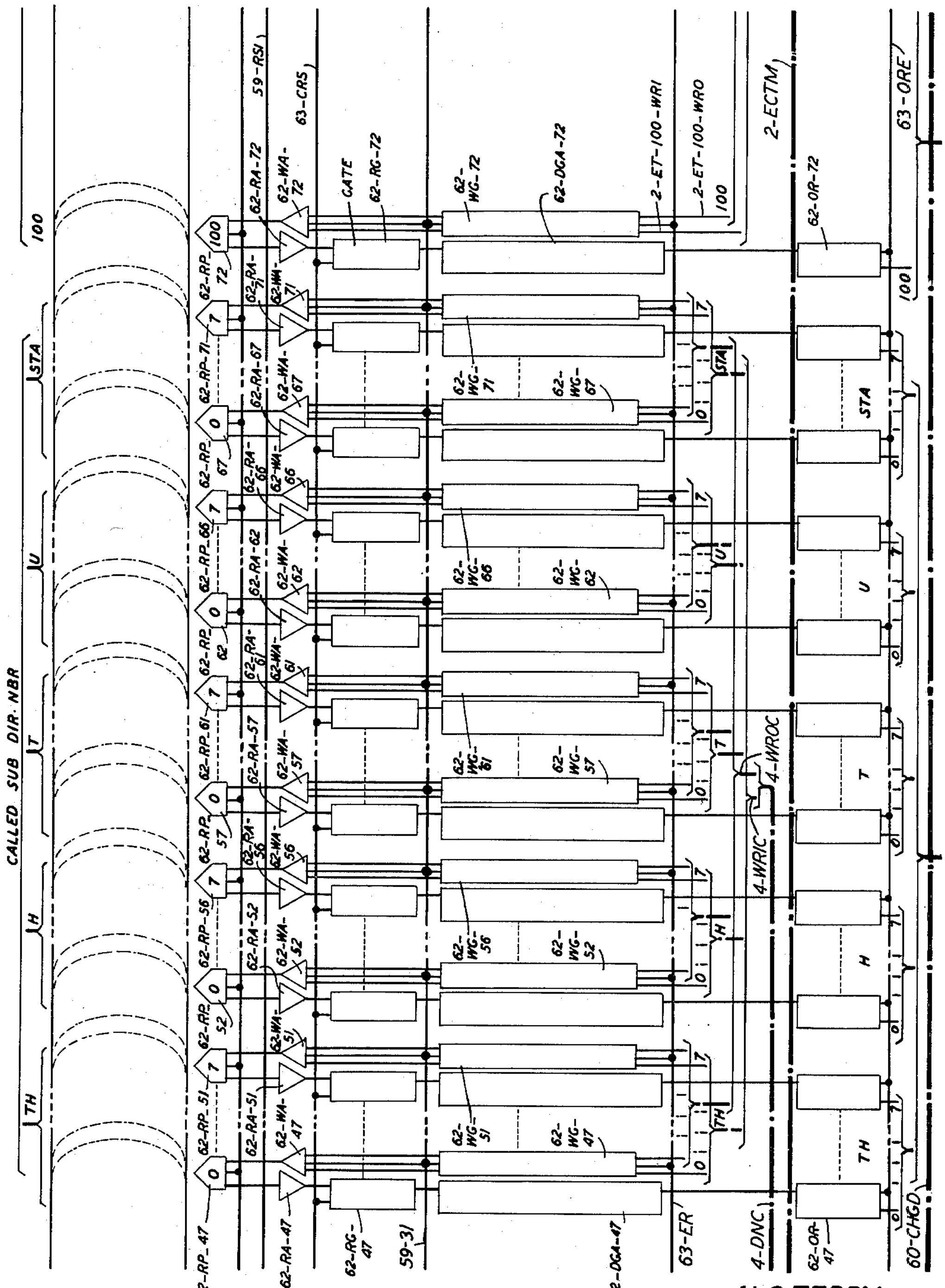

FIG. 62

INVENTORS N.S.TERRY
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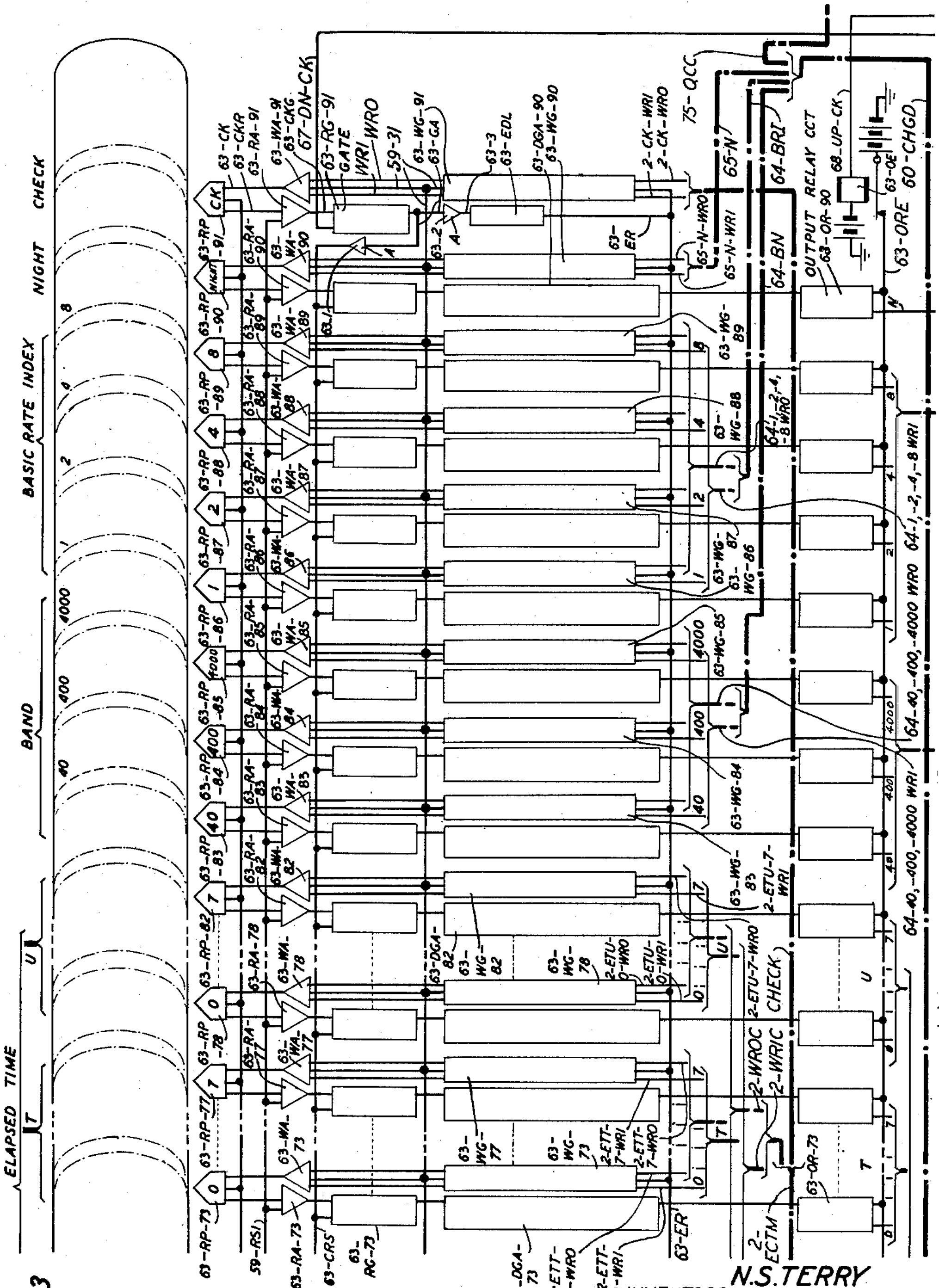

FIG. 63

INVENTORS: N.S.TERRY
E.VROOM

BY

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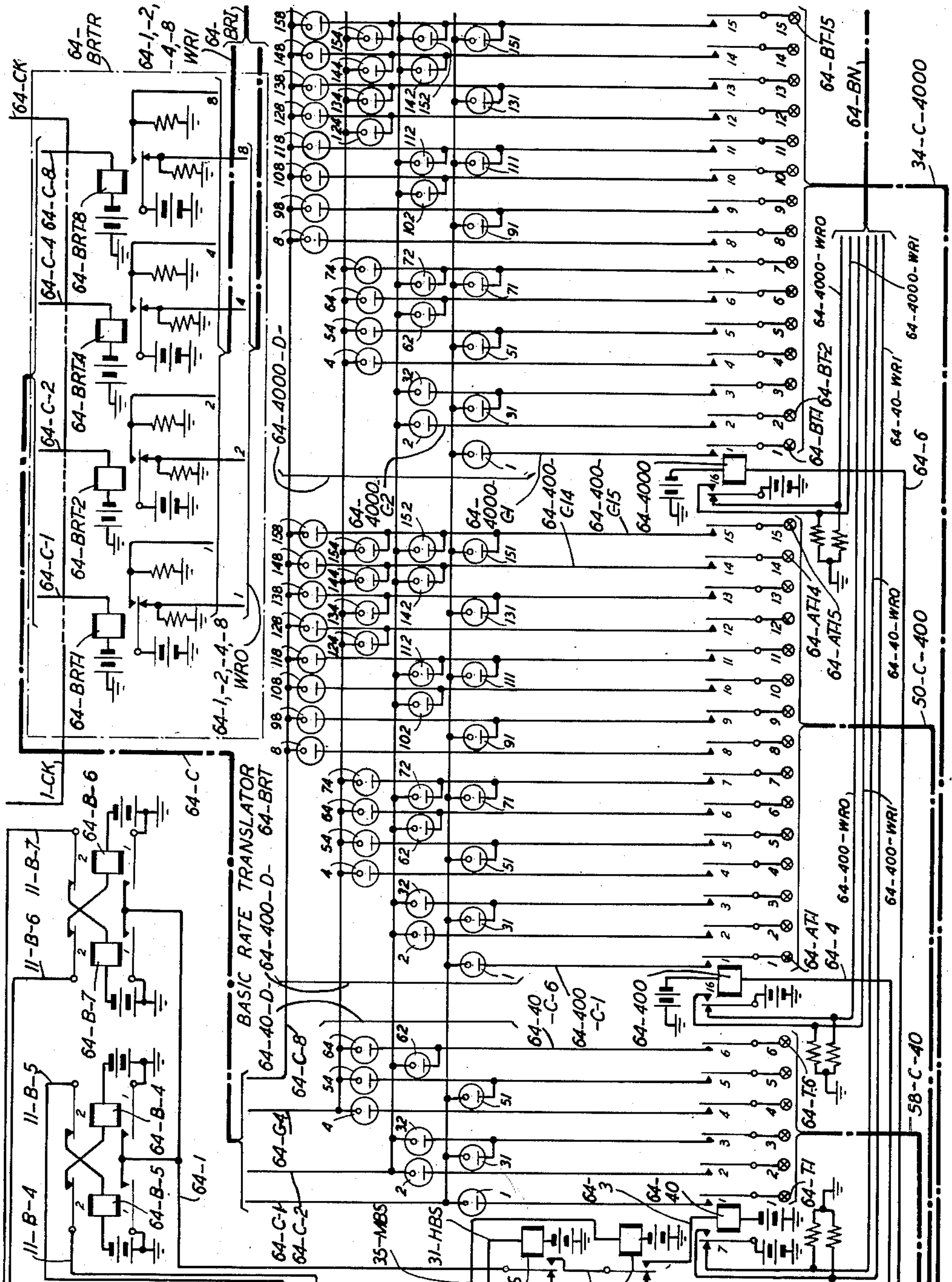

FIG. 64
BASIC RATE TRANSLATOR REGISTER

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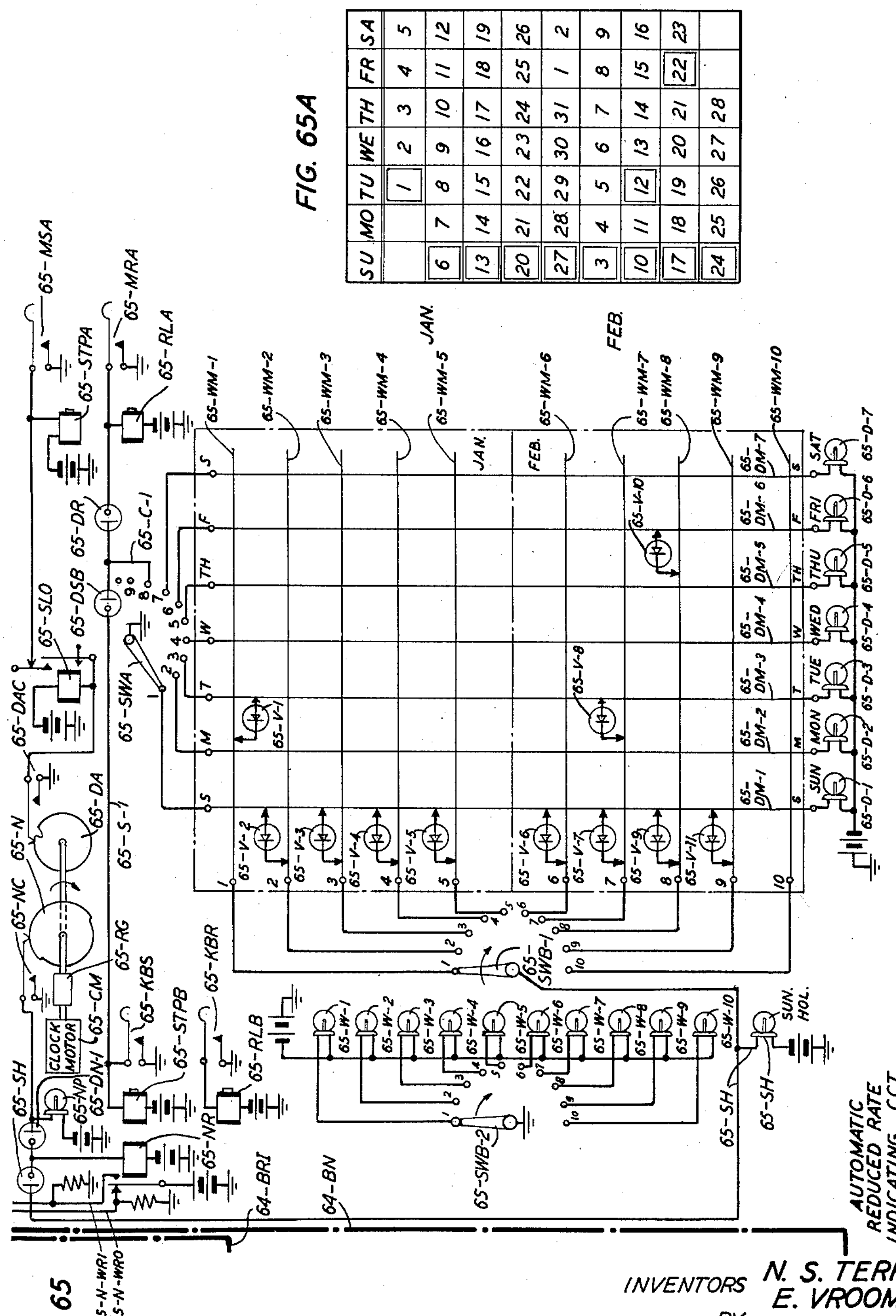

FIG. 65A

FIG. 65

AUTOMATIC REDUCED RATE INDICATING CCT.

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E. VROOM

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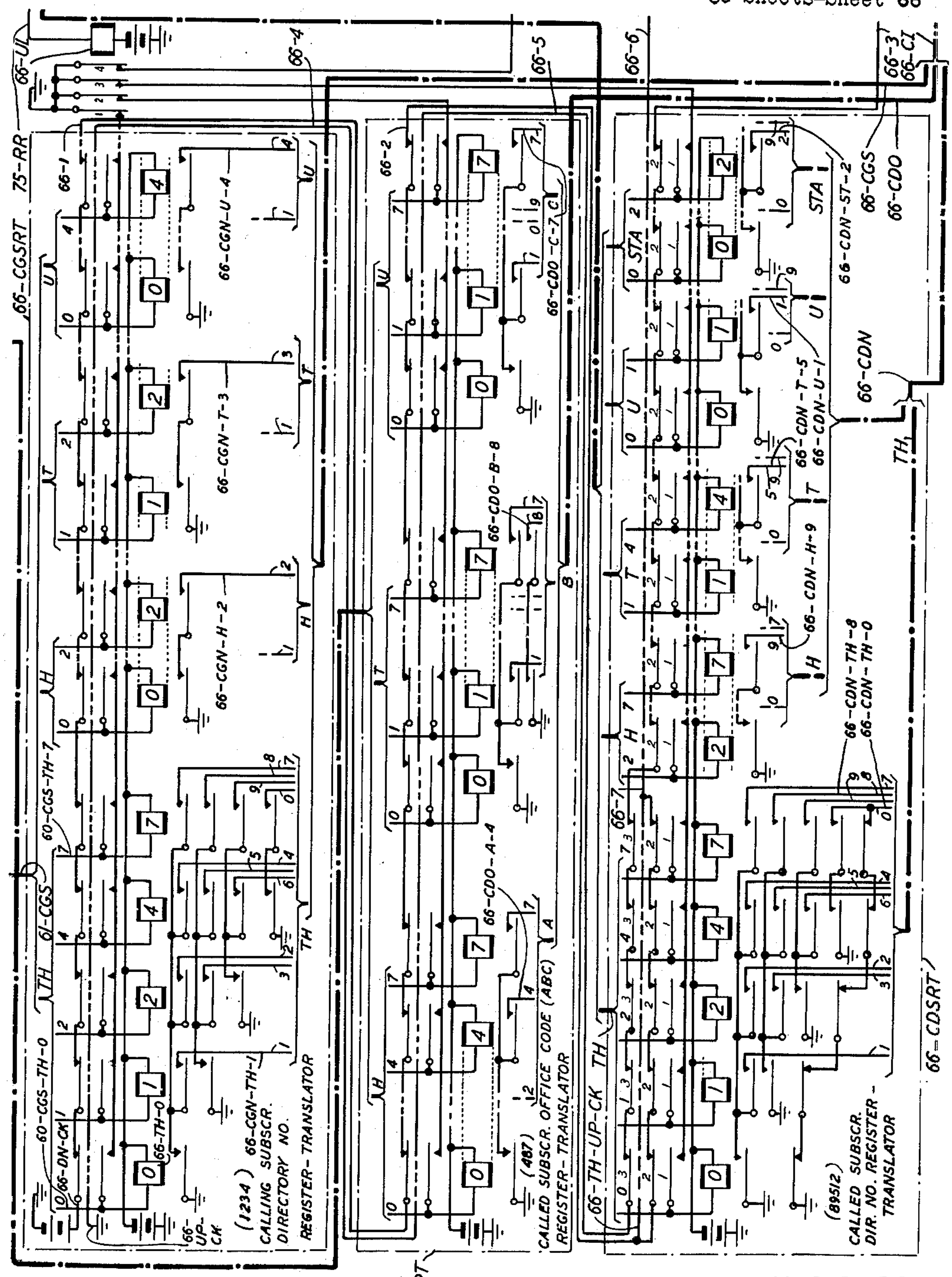

FIG. 66

INVENTORS N. S. TERRY
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BY [signature]

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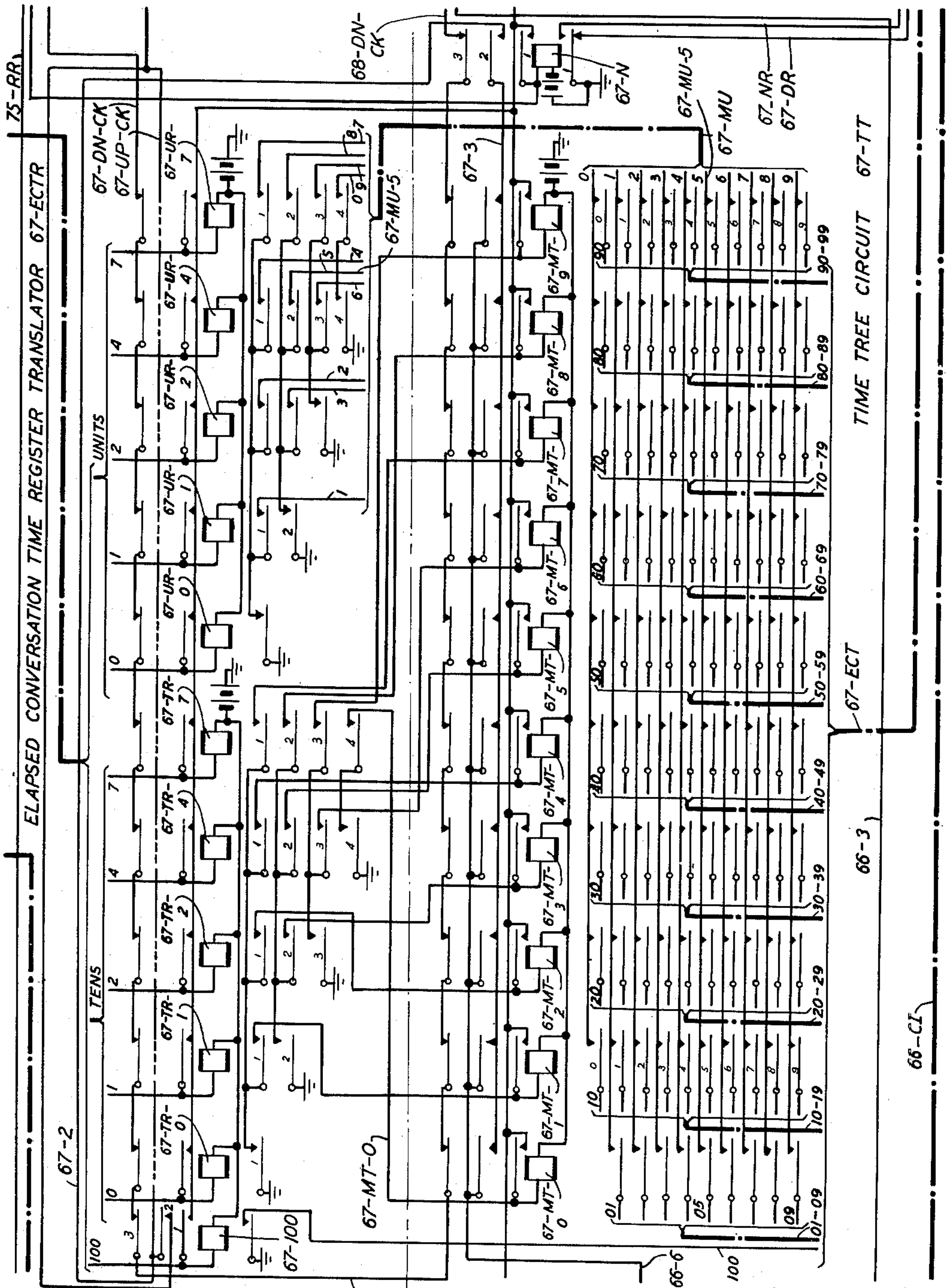

FIG. 67

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E. VROOM
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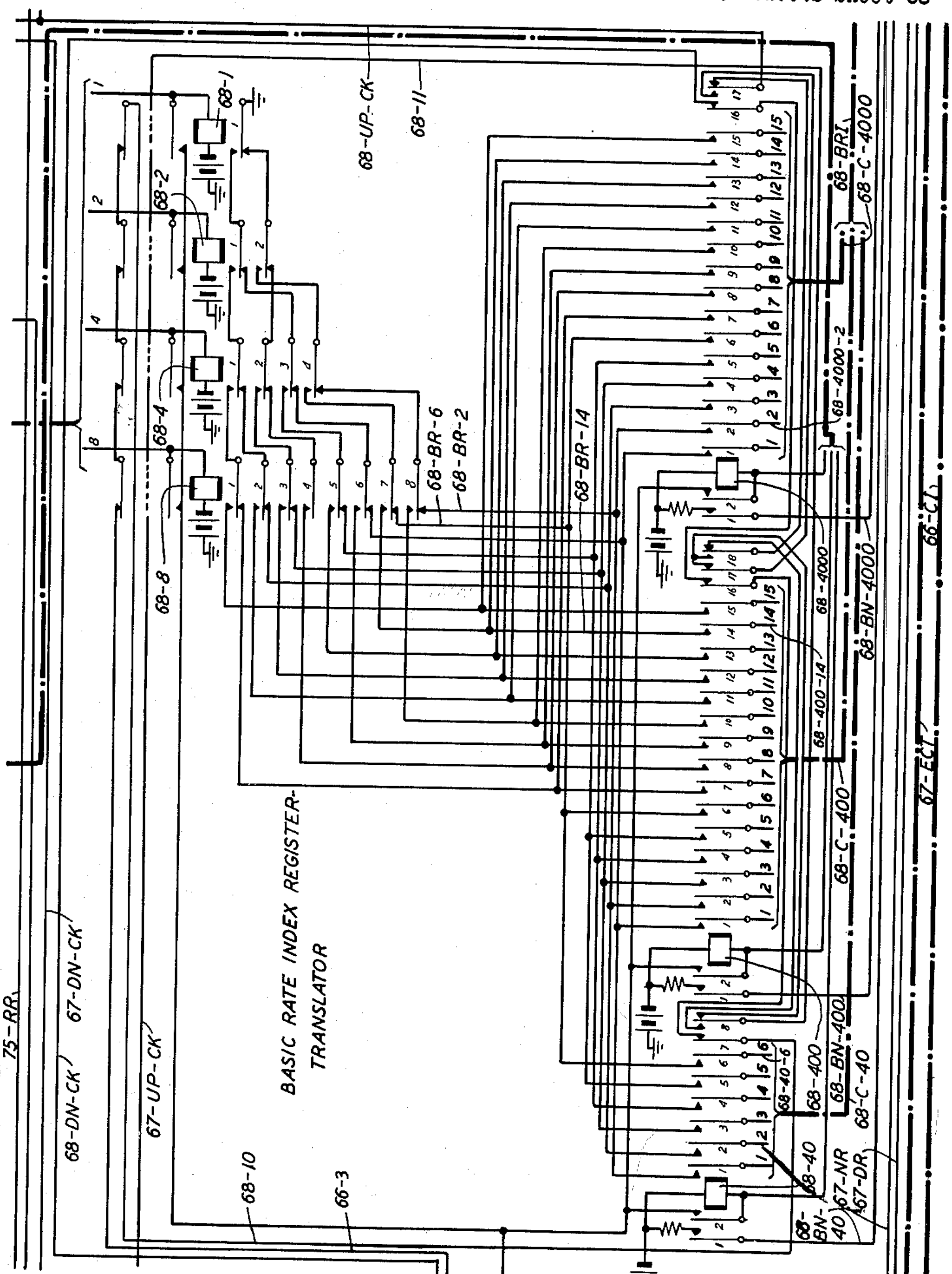

FIG. 68

INVENTORS N. S. TERRY
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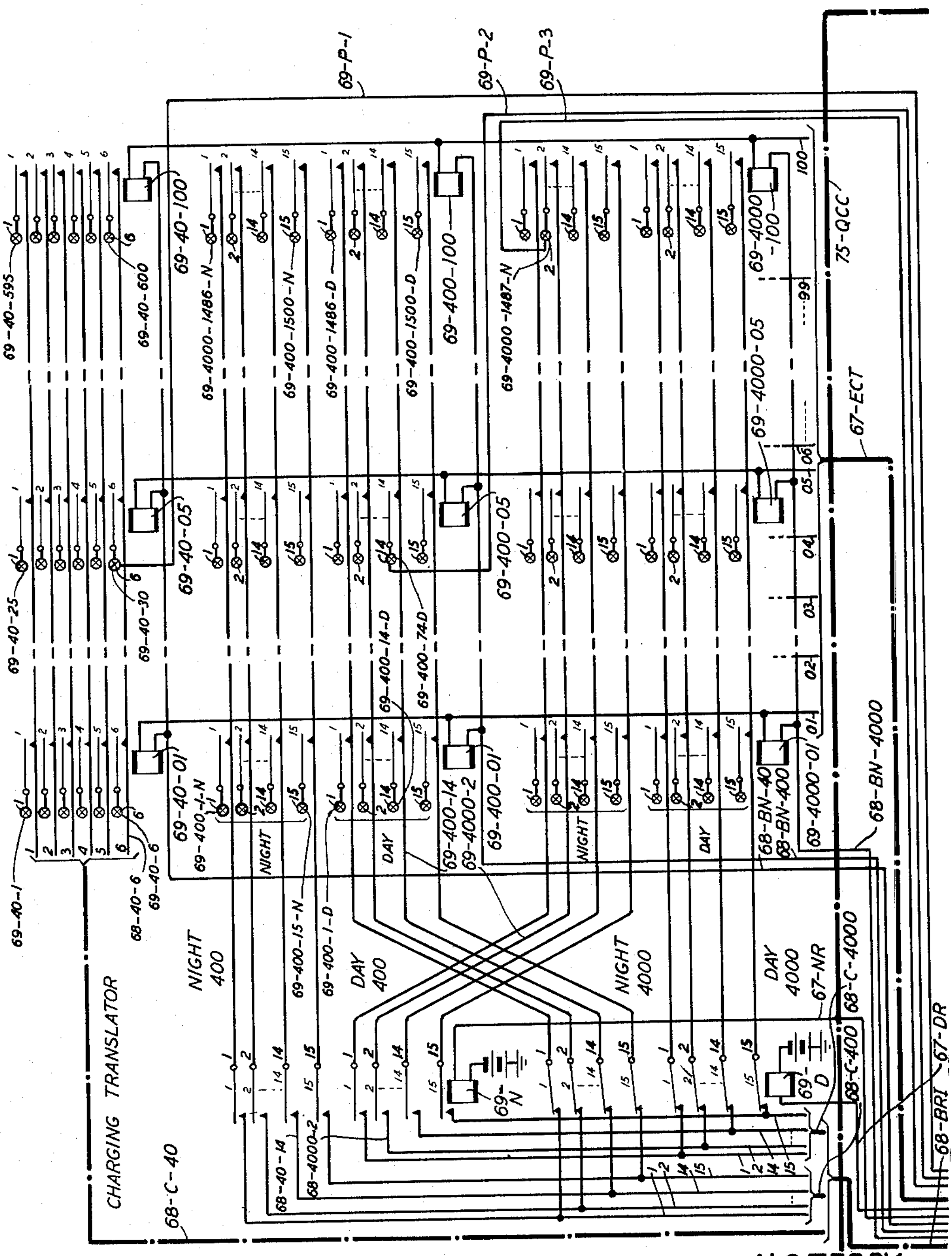

FIG. 69

INVENTORS N.S.TERRY
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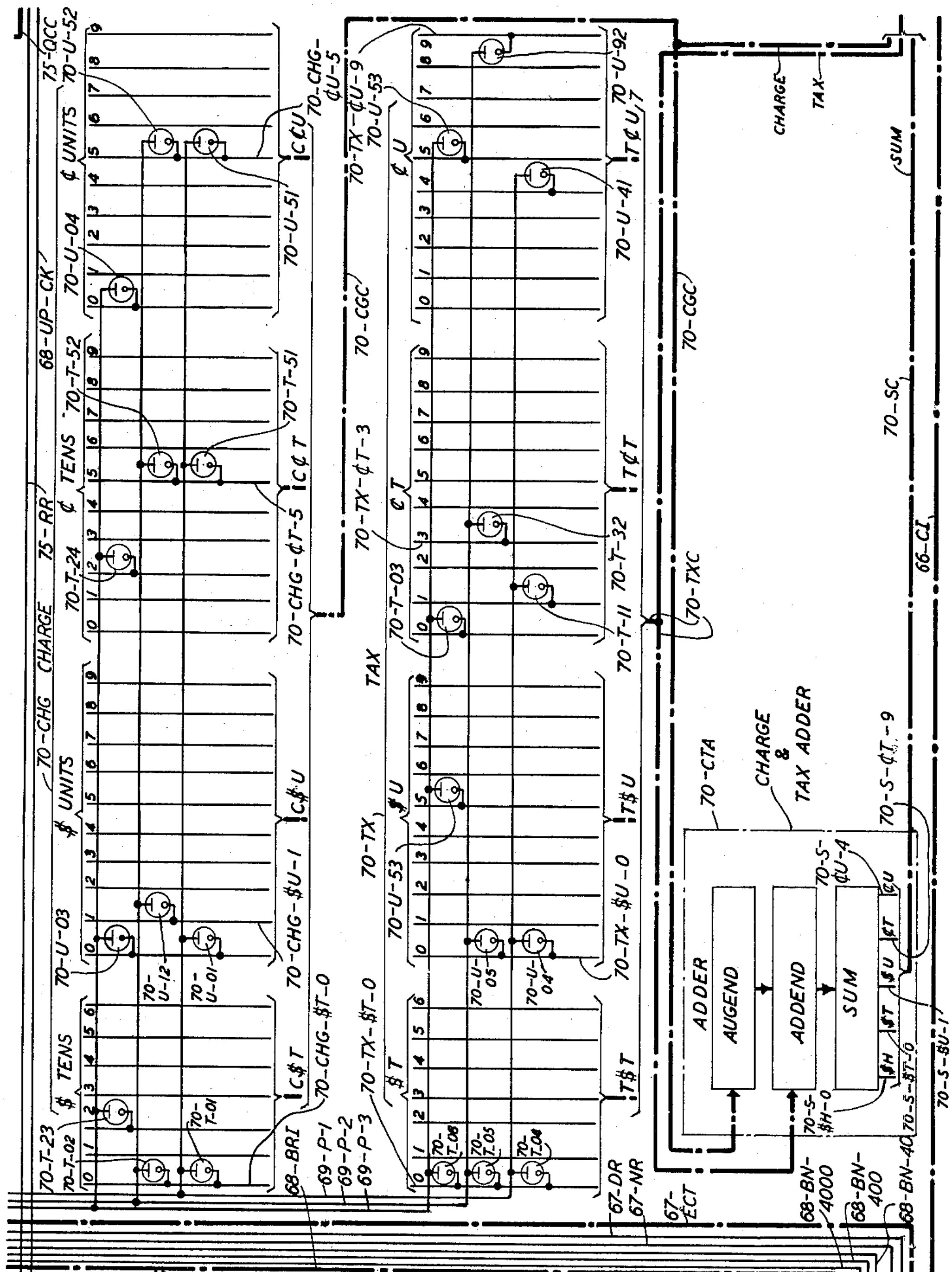

FIG. 70

CHARGE DIODE CROSS-CONNECTING PLAN

TAX DIODE CROSS-CONNECTING PLAN

INVENTORS N. S. TERRY
E. VROOM

BY [signature]

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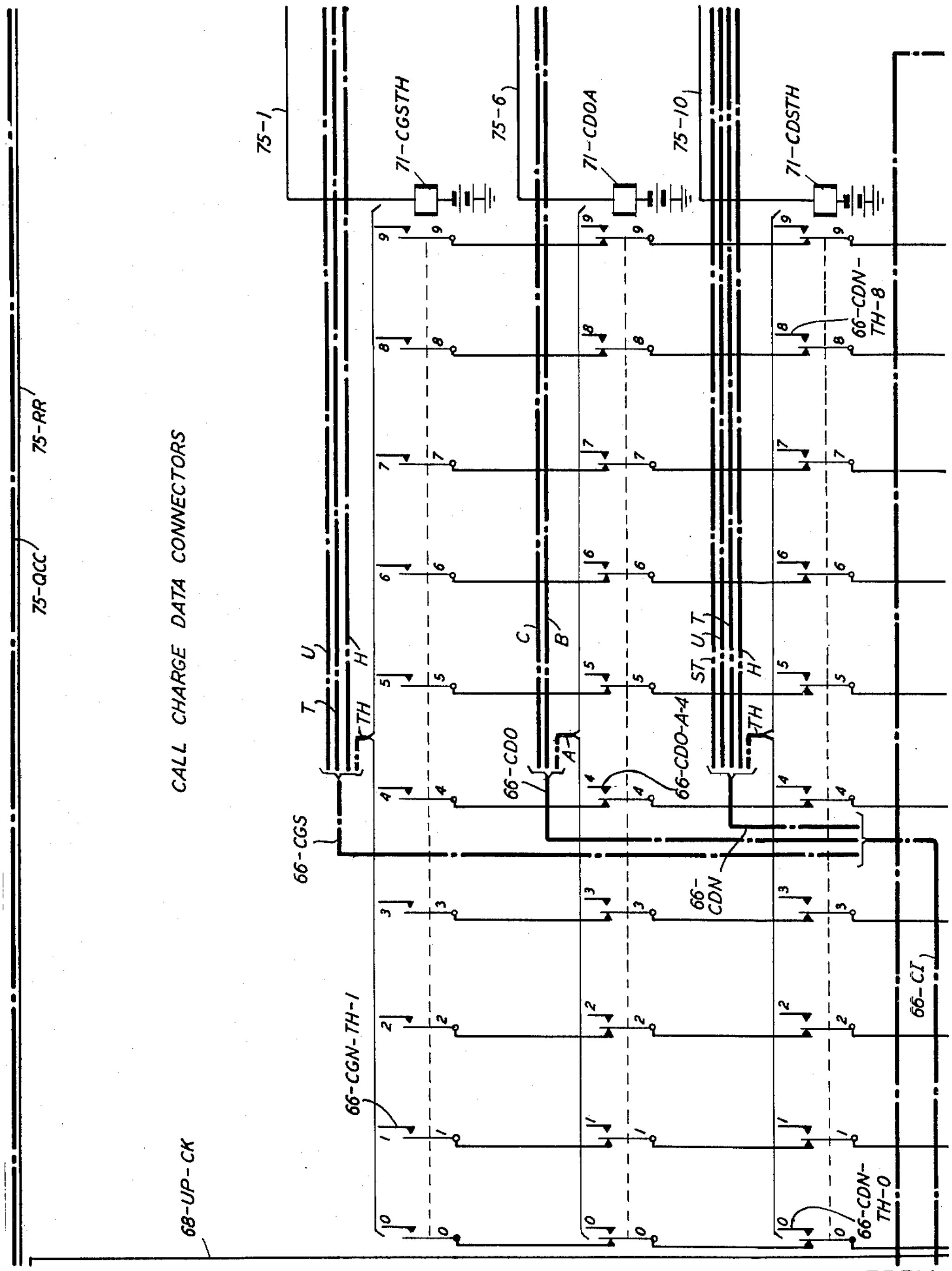

FIG. 71

INVENTORS N. S. TERRY
E. VROOM
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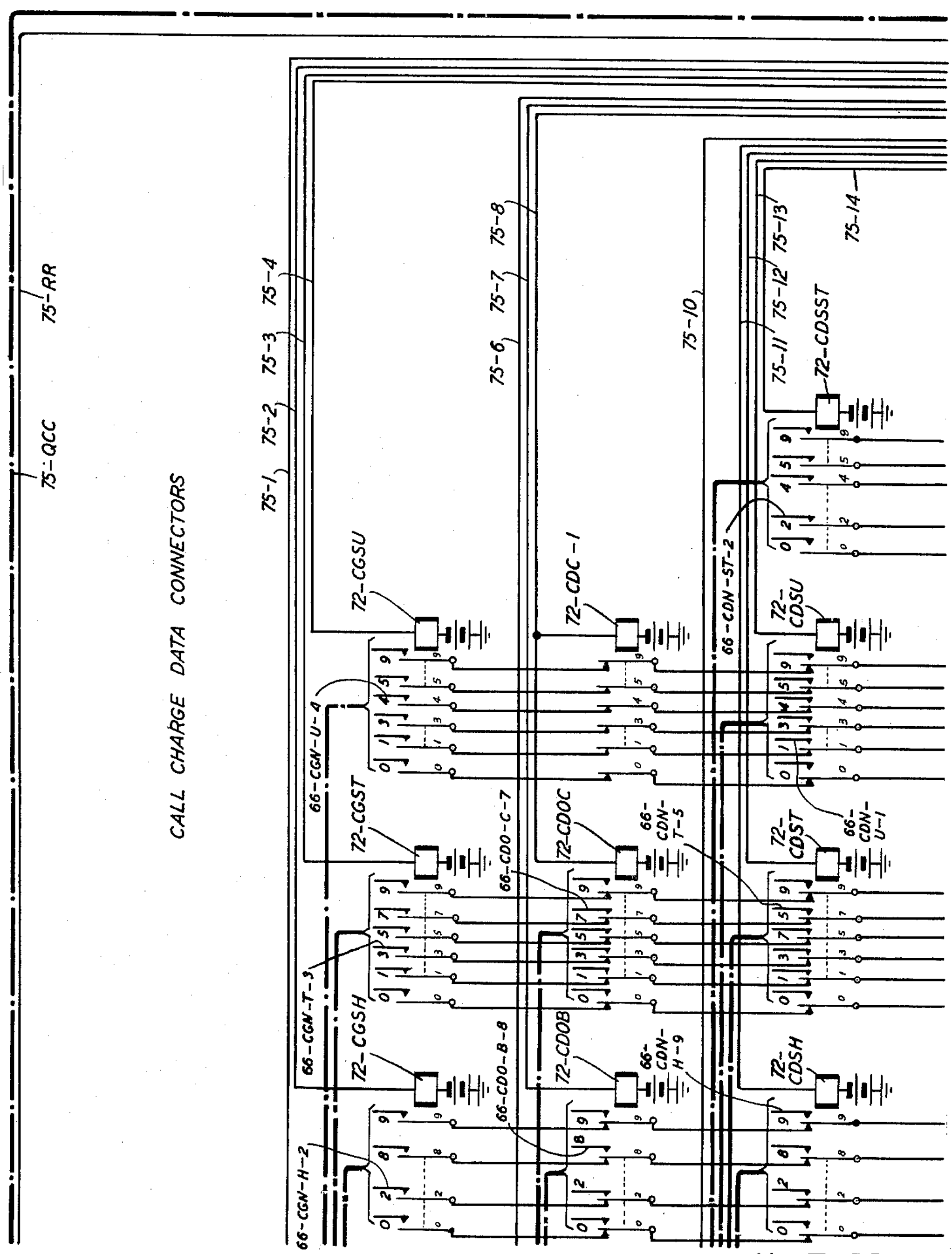

FIG. 72

INVENTORS N.S.TERRY
E.VROOM
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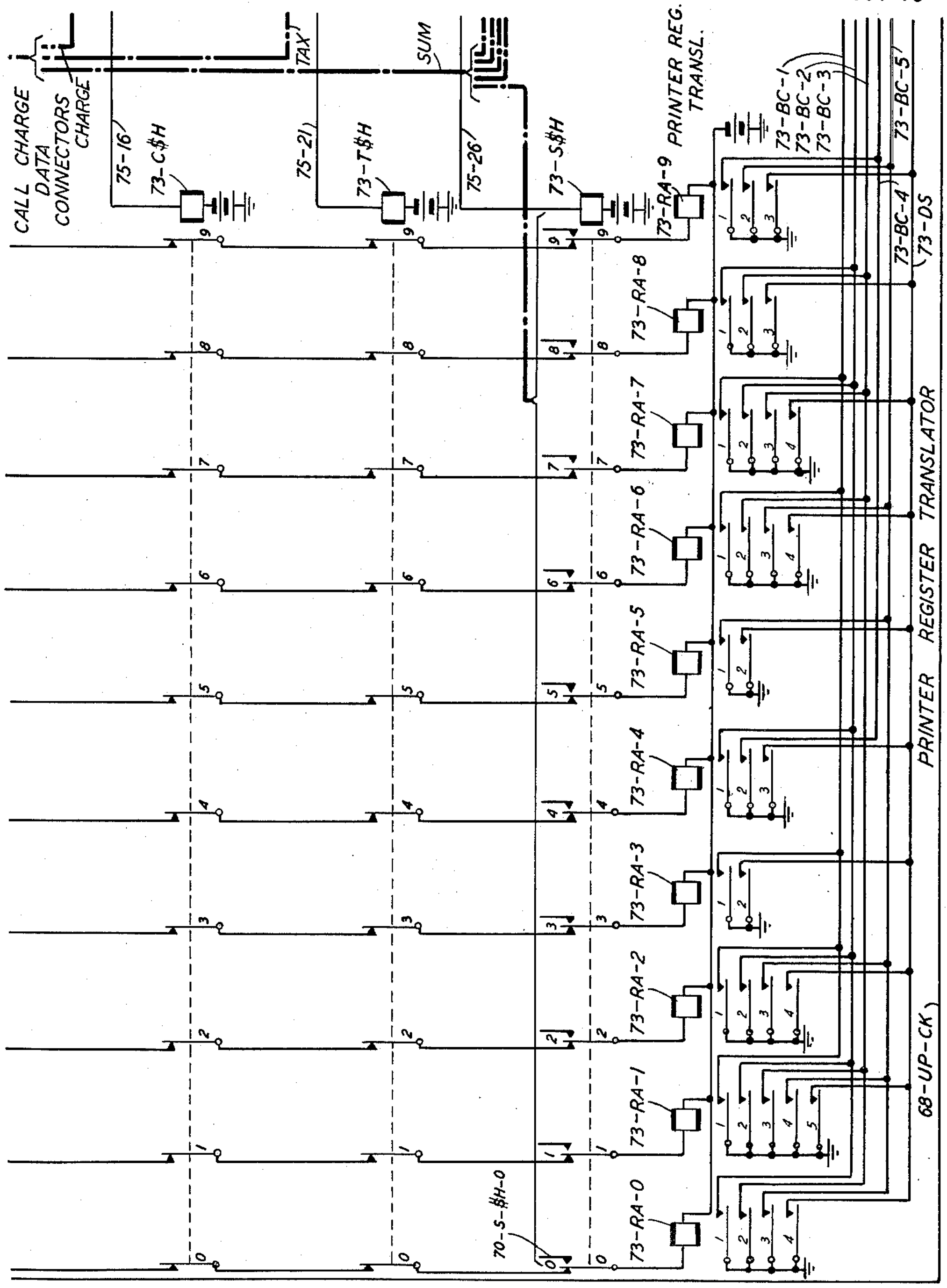

FIG. 73

INVENTORS N. S. TERRY
E. VROOM
BY [signature]
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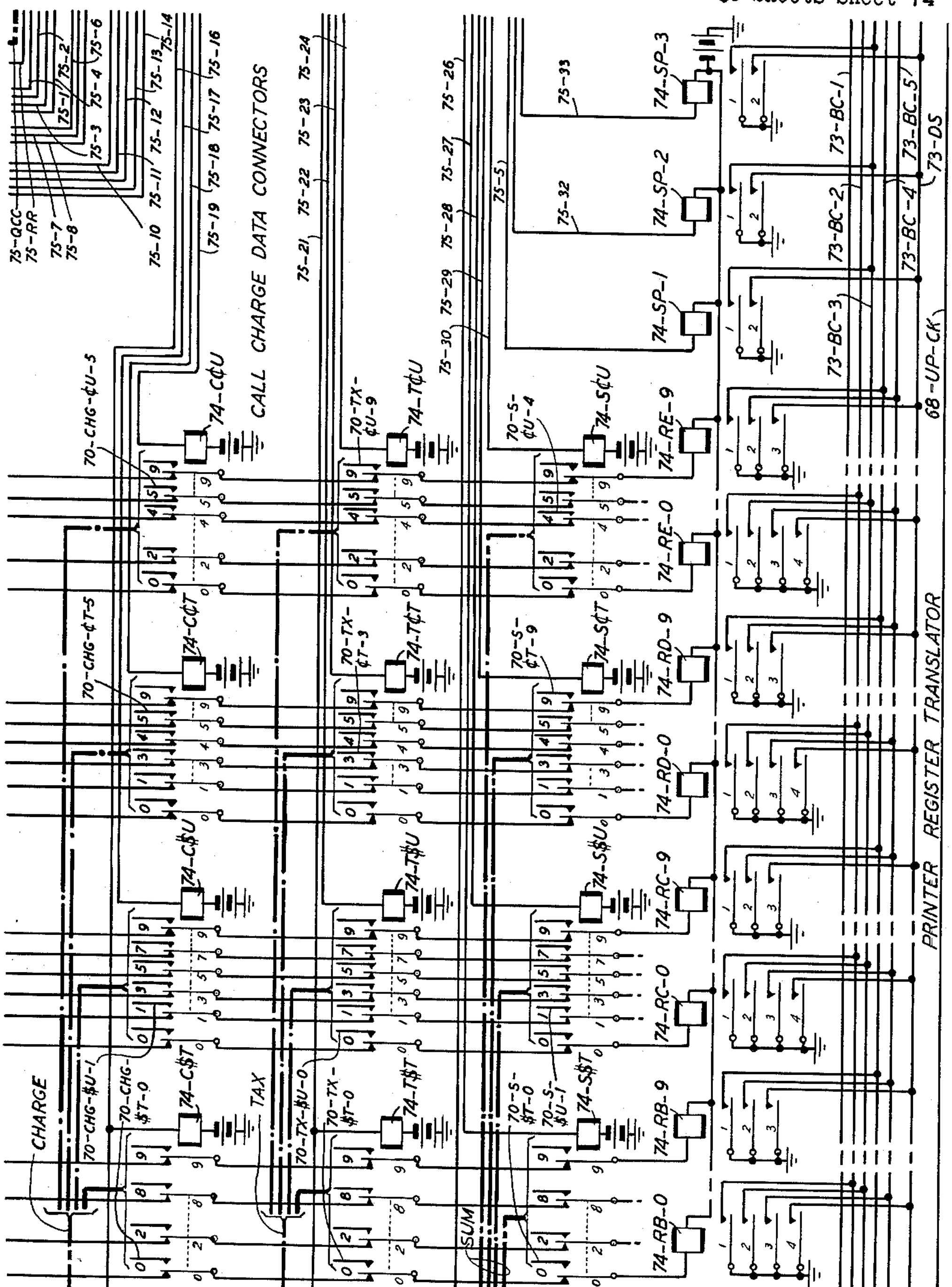

FIG. 74

INVENTORS N. S. TERRY
E. VROOM
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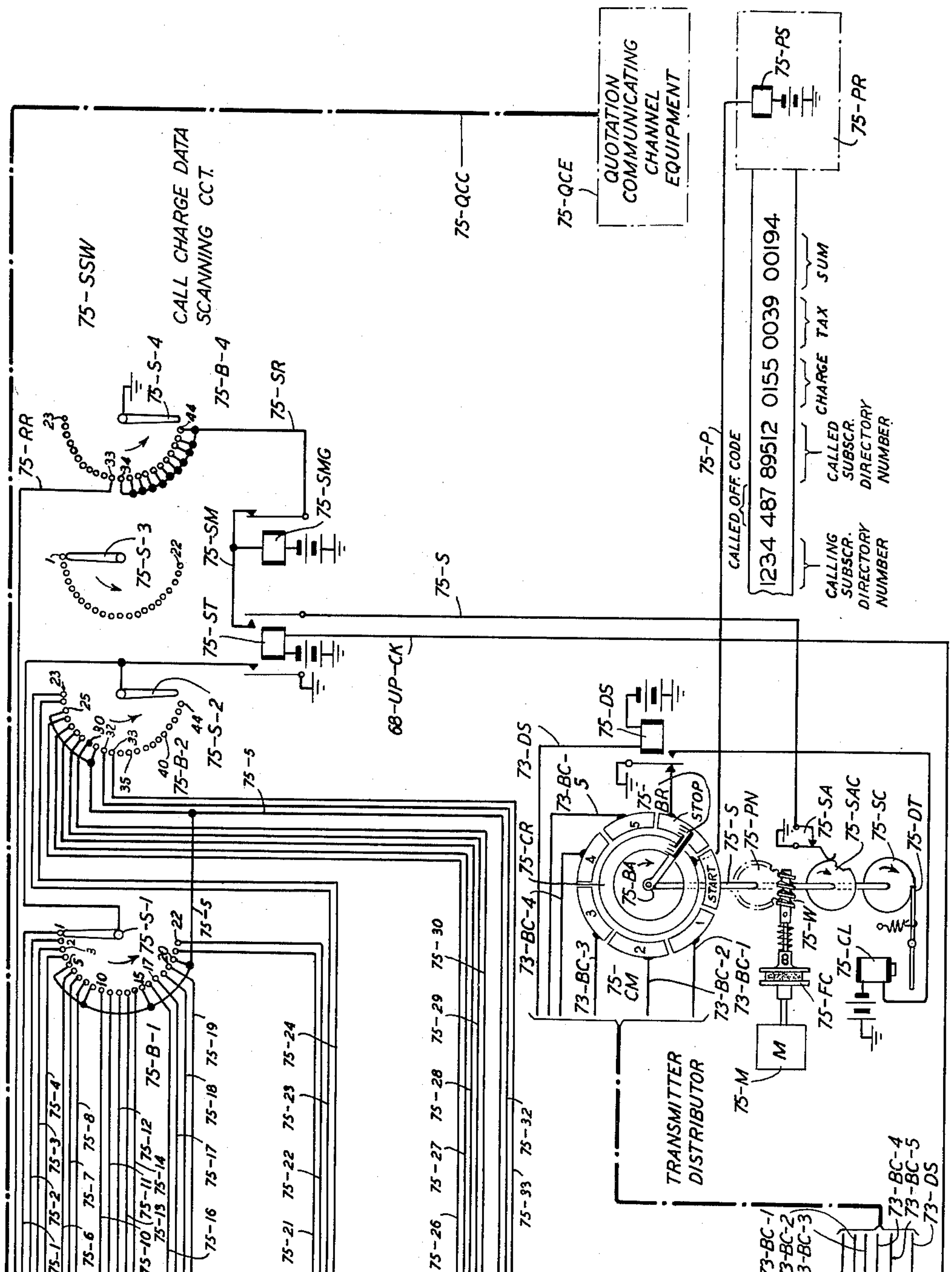

FIG. 75

INVENTORS N. S. TERRY
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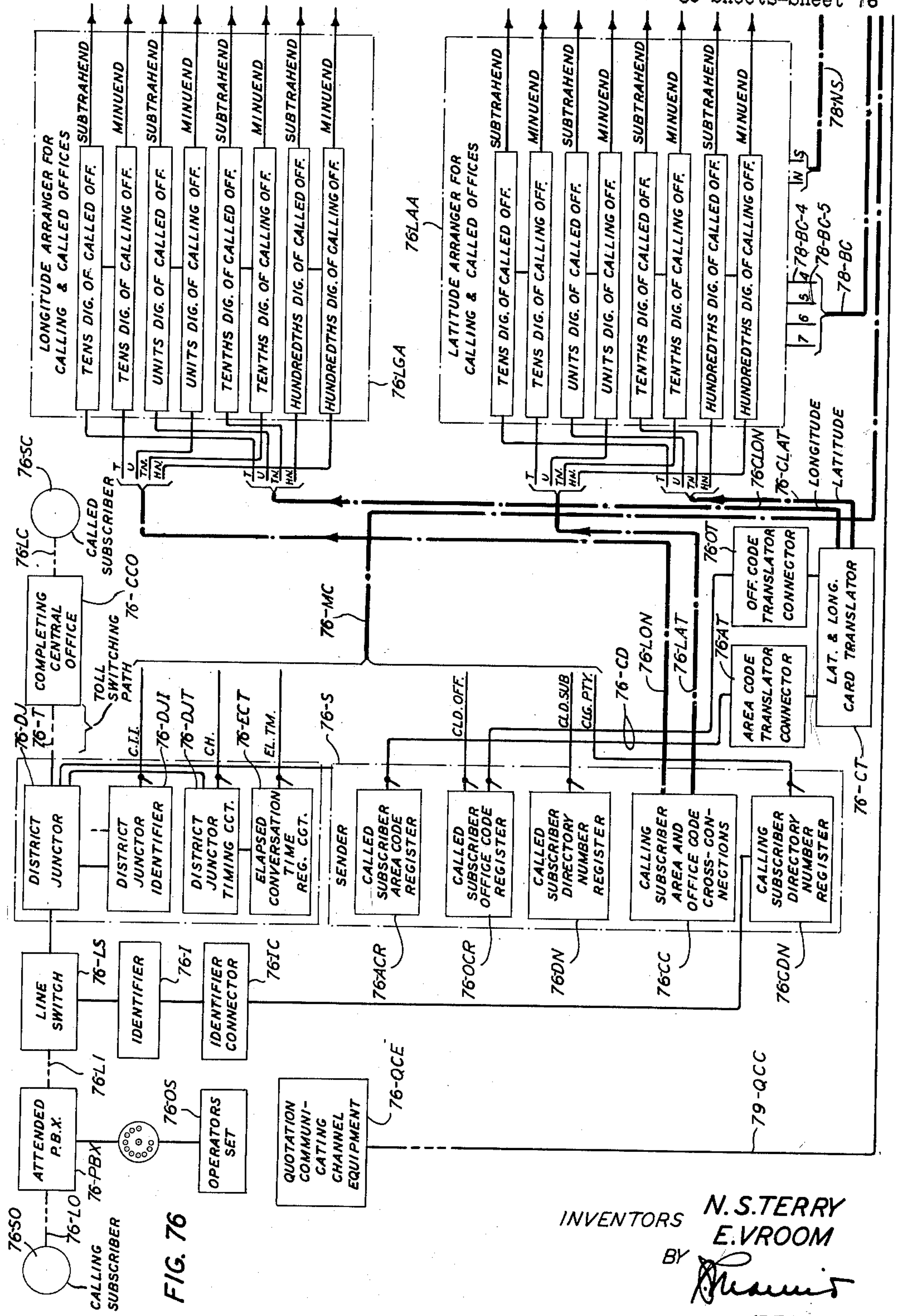

FIG. 76

INVENTORS N. S. TERRY
E. VROOM

BY [signature]

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AUTOMATIC DETERMINATION OF TOLL CALL CHARGES

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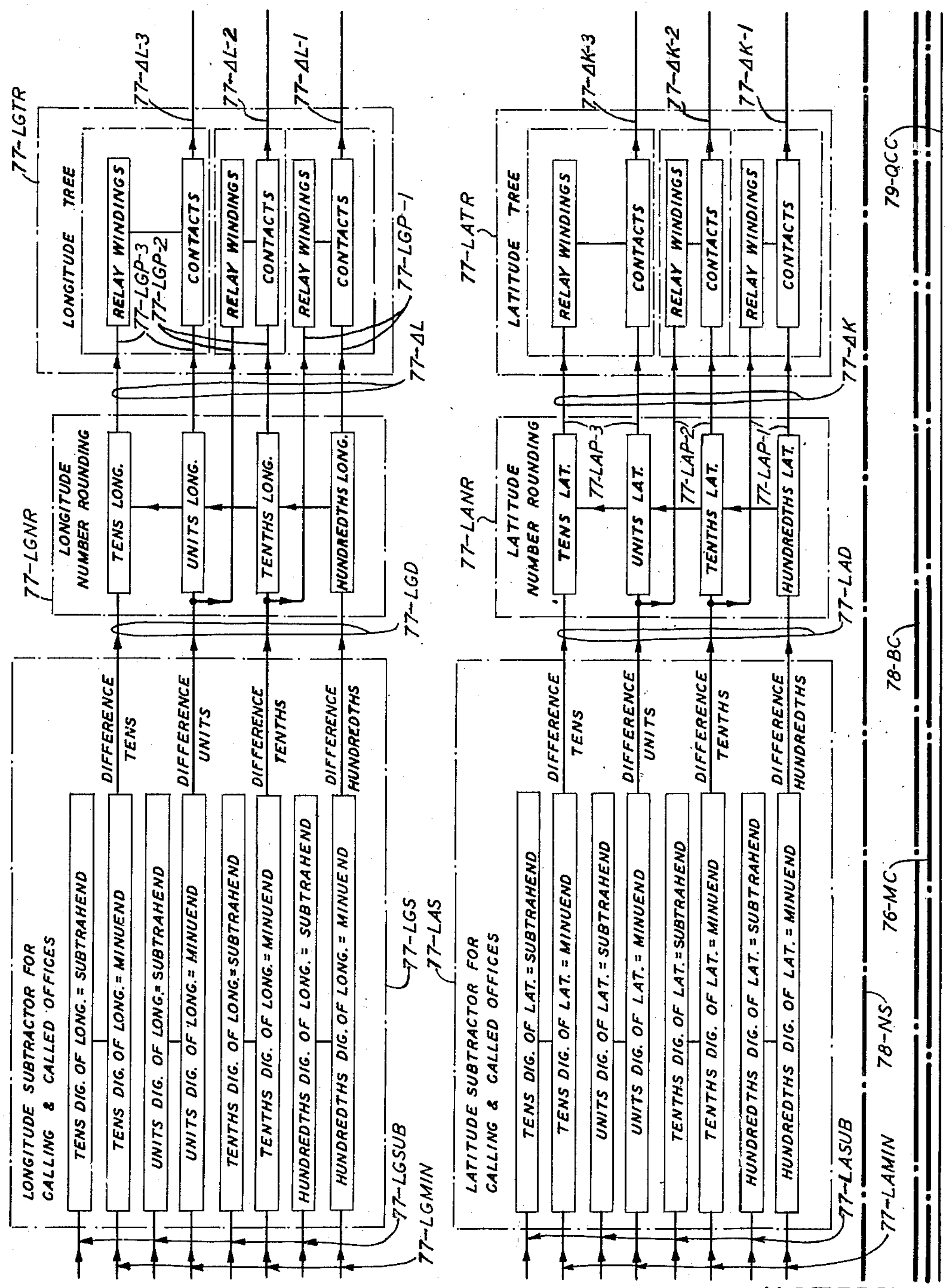

FIG. 77

INVENTORS N. S. TERRY
E. VROOM

BY

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May 16, 1961 N. S. TERRY ET AL 2,984,704

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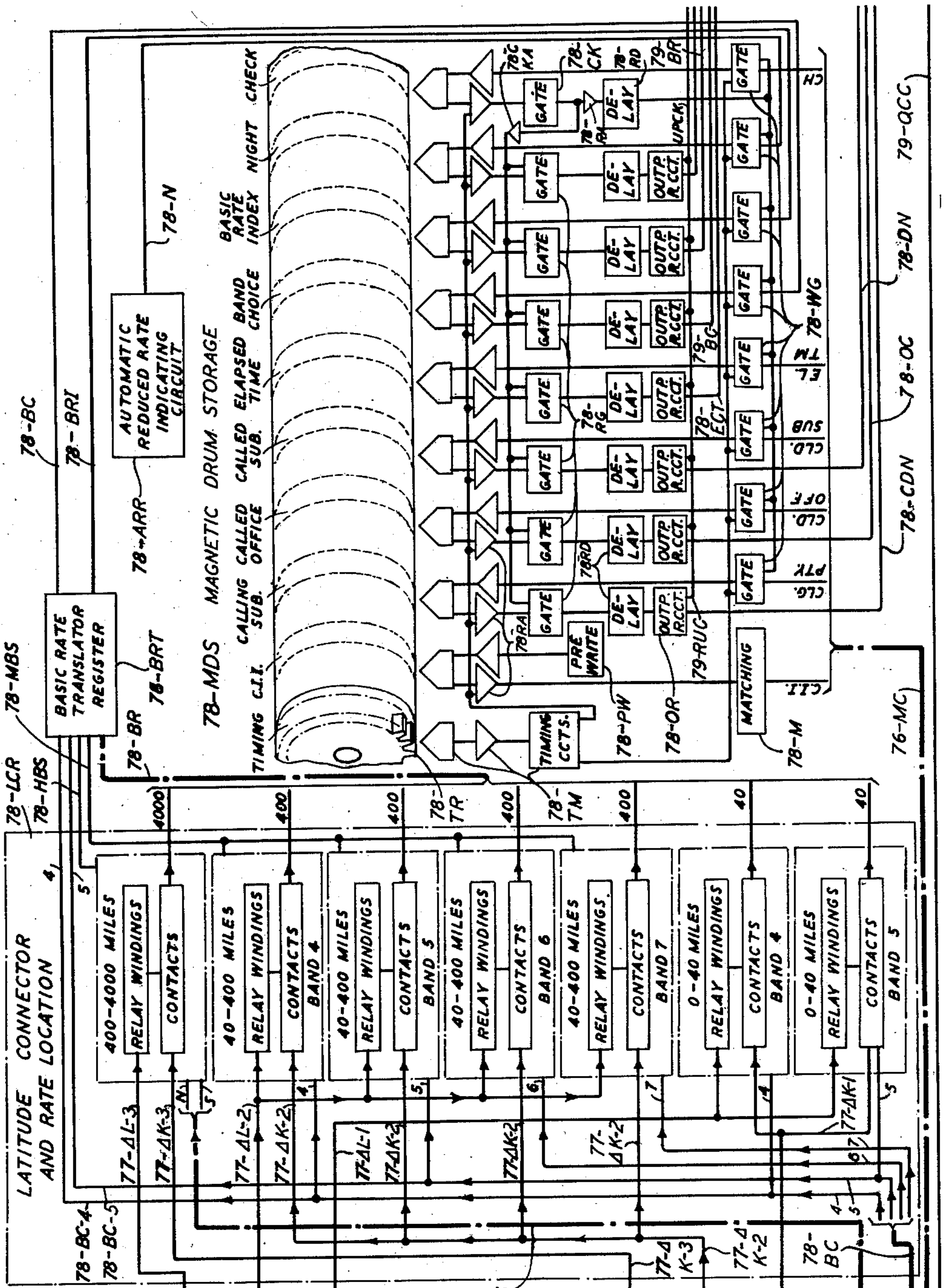

FIG. 78

INVENTORS N.S.TERRY
E.VROOM

BY [signature]

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AUTOMATIC DETERMINATION OF TOLL CALL CHARGES

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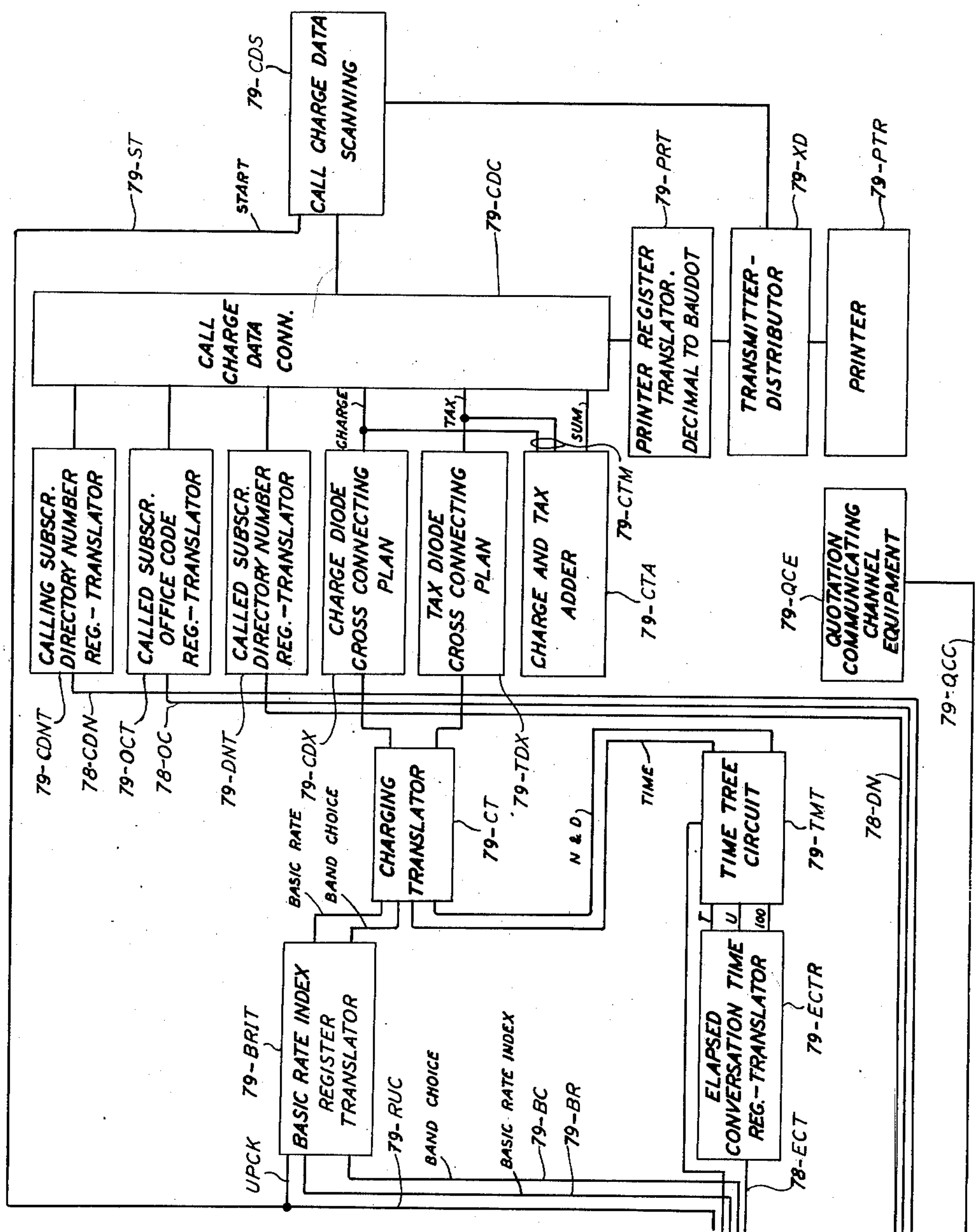

FIG. 79

INVENTORS N. S. TERRY
E. VROOM

BY [signature]

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AUTOMATIC DETERMINATION OF TOLL CALL CHARGES

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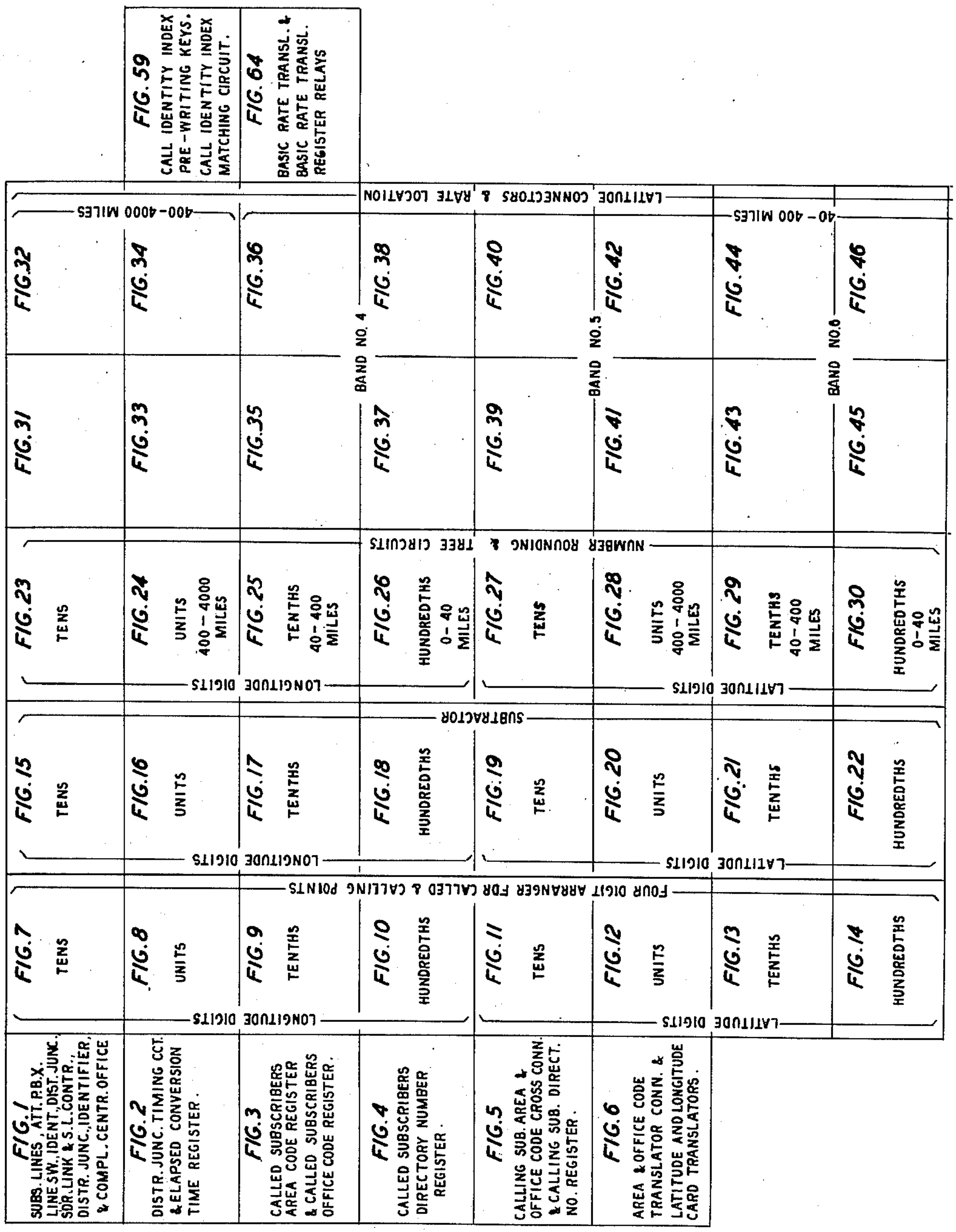

FIG. 80

INVENTORS N. S. TERRY
E. VROOM
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AUTOMATIC DETERMINATION OF TOLL CALL CHARGES

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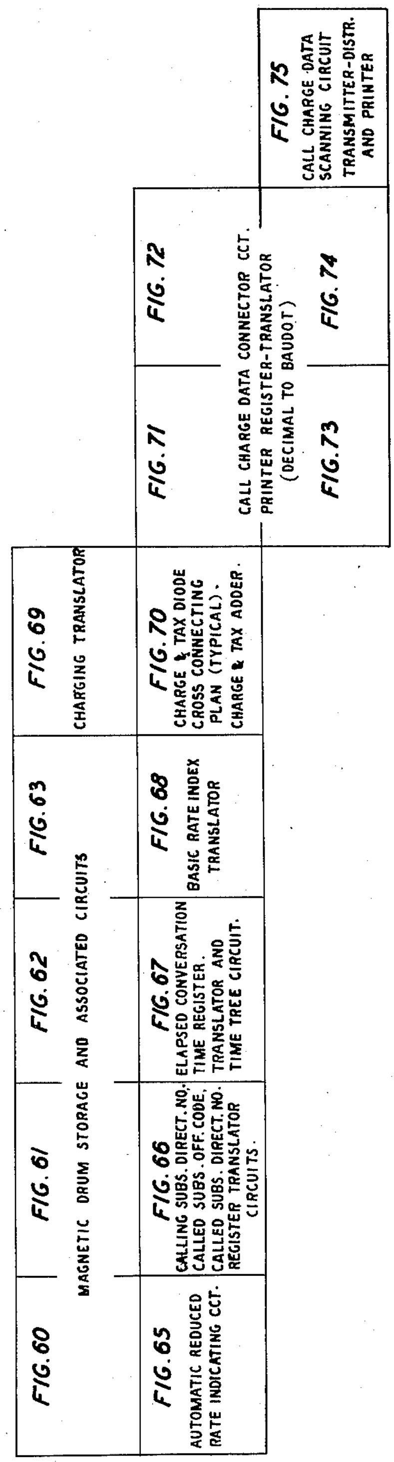

FIG. 81

INVENTORS N.S. TERRY
E. VROOM
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AUTOMATIC DETERMINATION OF TOLL CALL CHARGES

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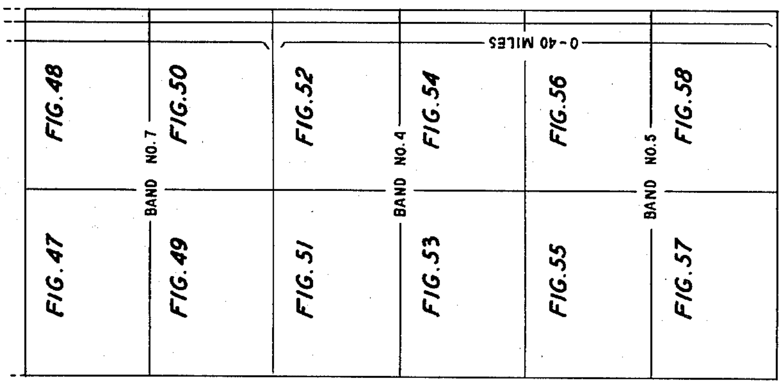

FIG. 82

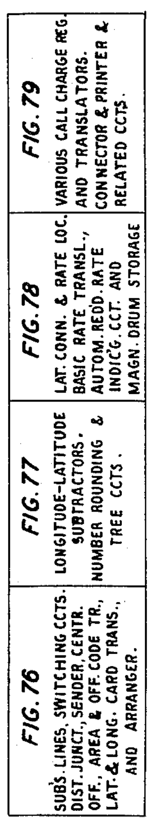

FIG. 83

INVENTORS N.S. TERRY
E. VROOM
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FIG. 84

1	2	3	4		5	6	
K-TOLL INDICES (HUNDREDTHS OF DEGREES OF LATITUDE)	SERVING LATITUDES IN DEGREES NORTH	LATITUDES MINUEND WILL CAUSE GROUNDING OF BAND CHOICE LEAD NO.	WILL OPERATE CONNECTOR RELAY IN RELAY TABLE NO. 40MILE	400MILE	CALLING OFFICE EQUIPPED WITH 4000 MILE TABLE NO.	COVERS BAND WIDTH IN DEGREES	MILES
5000-5099 4900-4999	50-51 49-50	B-9 NOT SHOWN ON DWG.	49	409	4027 4026	2	140.2
4800-4899 4700-4799	48-49 47-48	B-8 NOT SHOWN ON DWG.	48	408	4025 4024	2	140.2
4600-4699 4500-4599	46-47 45-46	11-B-7	47	407	4023 4022	2	140.2
4400-4499 4300-4399	44-45 43-44	11-B-6	46	406	4021 4020	2	140.2
4200-4299 4100-4199 4000-4099	42-43 41-42 40-41	11-B-5	45	405	4019 4018 4017	3	210.3
3900-3999 3800-3899 3700-3799	39-40 38-39 37-38	11-B-4	44	404	4016 4015 4014	3	210.3
3600-3699 3500-3599 3400-3499 3300-3399	36-37 35-36 34-35 33-34	B-3 NOT SHOWN ON DWG.	43	403	4013 4012 4011 4010	4	280.4
3200-3299 3100-3199 3000-3099 2900-2999	32-33 31-32 30-31 29-30	B-2 NOT SHOWN ON DWG.	42	402	4009 4008 4007 4006	4	280.4
2800-2899 2700-2799 2600-2699 2500-2599 2400-2499	28-29 27-28 26-27 25-26 24-25	B-1 NOT SHOWN ON DWG.	41	401	4005 4004 4003 4002 4001	5	350.5

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E. VROOM
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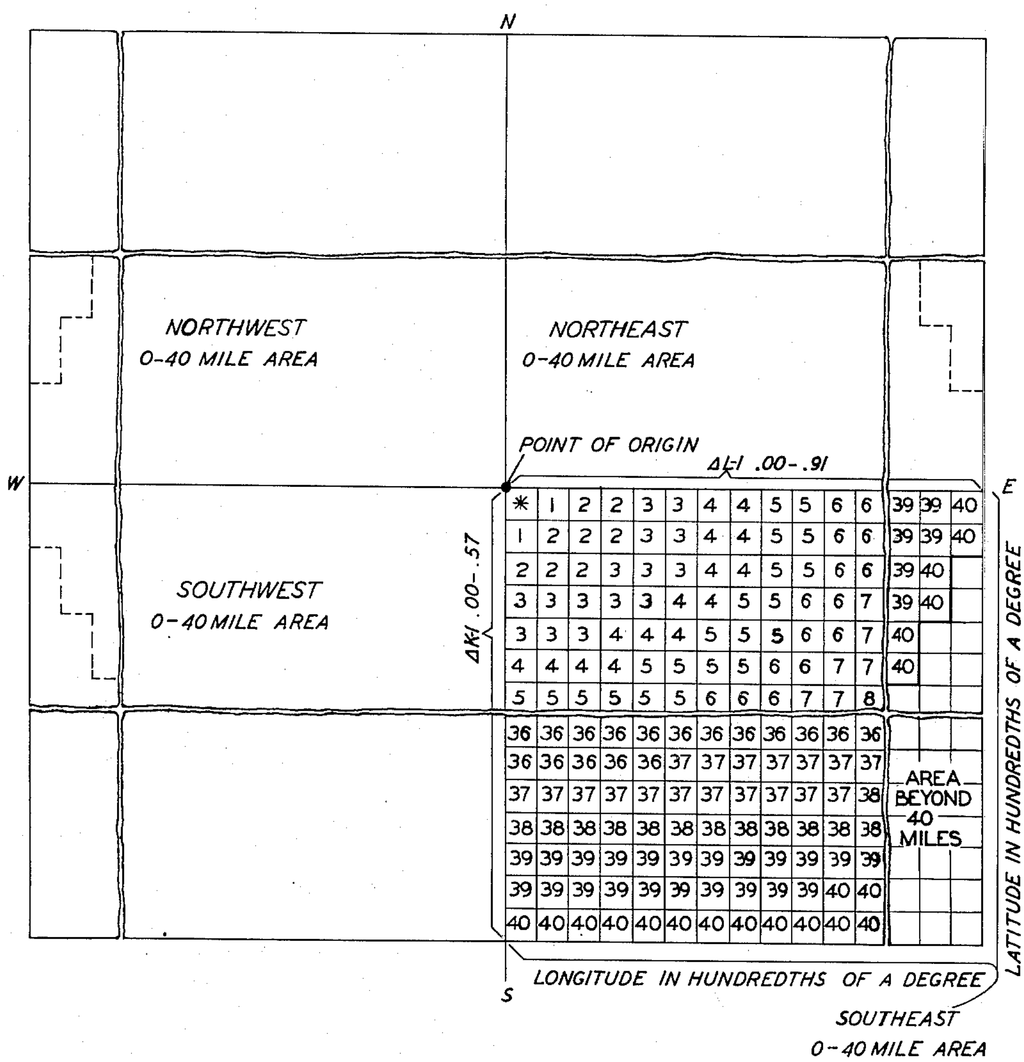
FIG.85

FOUR ADJACENT 0-40 MILE AREAS

INCREMENTAL AREAS BOUNDED BY .01° OF LATITUDE AND .01° OF LONGITUDE



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E. VROOM
BY
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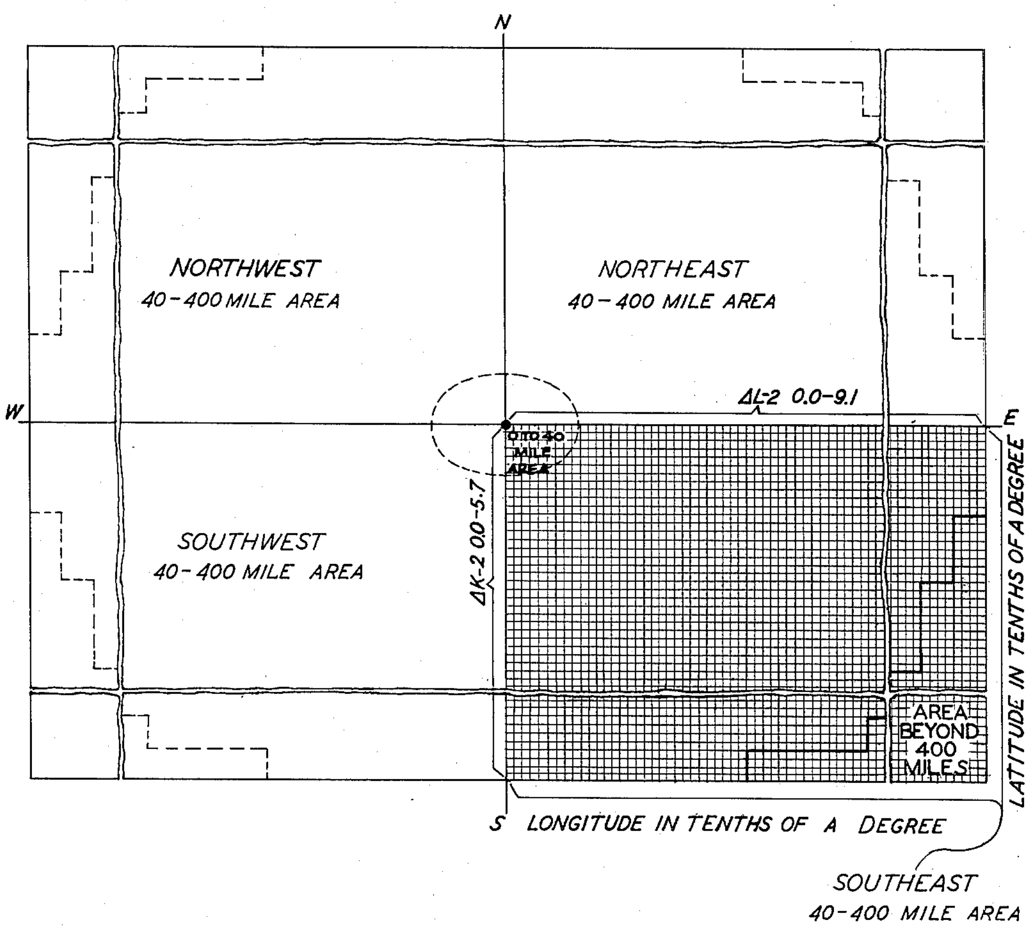
FIG. 86

FOUR ADJACENT 40-400 MILE AREAS

INCREMENTAL AREAS BOUNDED BY .1° OF LATITUDE AND .1° OF LONGITUDE



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E. VROOM
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FIG. 87

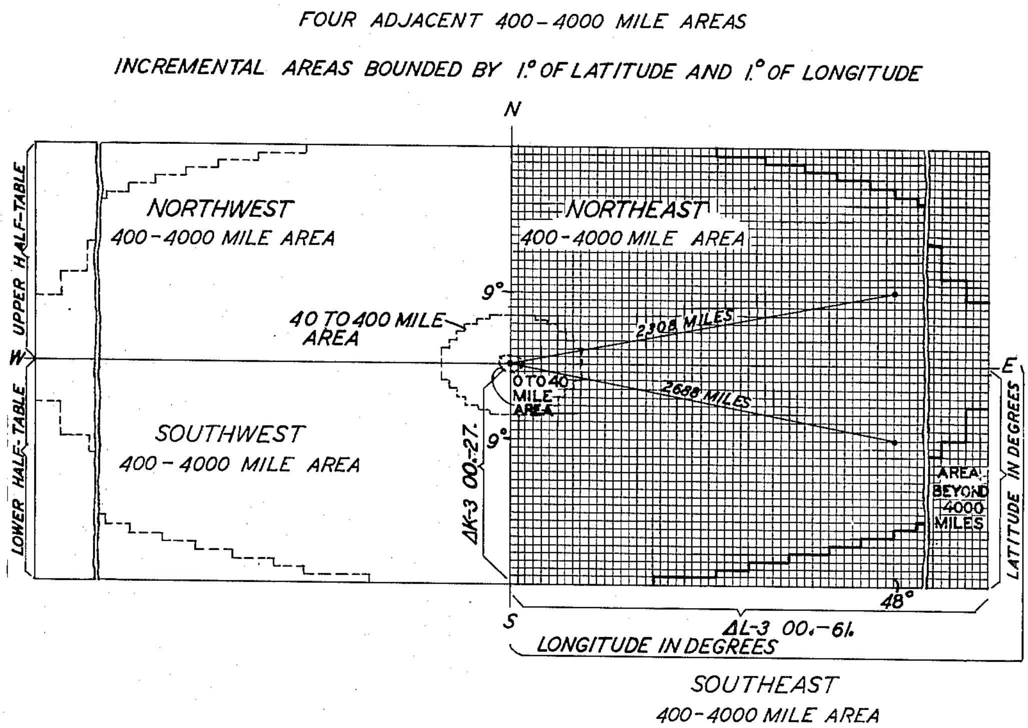
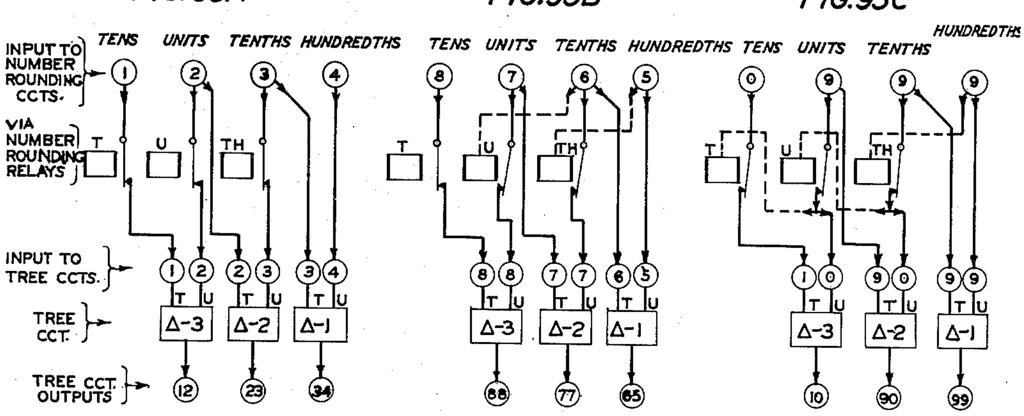


FIG. 95A FIG. 95B FIG. 95C



INVENTORS N. S. TERRY
E. VROOM
BY
ATTORNEY

FIG. 88

Latitude Separation (dK) in Hundredths of Degrees	Longitude Separation (dL) in Hundredths of Degrees																																									
	00	01	02	03	04	05	06	07	08	09	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41
00	*	1	2	2	3	3	4	4	5	5	6	6	7	7	8	8	9	9	10	10	11	11	12	12	13	13	14	14	15	15	16	17	17	18	18	19	19	20	20	21	21	22
01	1	2	2	2	3	3	4	4	5	5	6	6	7	7	8	8	9	9	10	10	11	11	12	12	13	13	14	14	15	15	16	17	17	18	18	19	19	20	20	21	21	22
02	2	2	2	3	3	3	4	4	5	5	6	6	7	7	8	8	9	9	10	10	11	11	12	12	13	13	14	15	15	16	16	17	17	18	18	19	19	20	20	21	21	22
03	3	3	3	3	3	4	4	5	5	6	6	7	7	8	8	9	9	10	10	11	11	12	12	13	13	14	14	15	15	16	16	17	17	18	18	19	19	20	20	21	21	22
04	3	3	3	4	4	4	5	5	5	6	6	7	7	8	8	9	9	10	10	11	11	12	12	13	13	14	14	15	15	16	16	17	17	18	18	19	19	20	20	21	21	22
05	4	4	4	4	5	5	5	5	6	6	7	7	8	8	9	9	9	10	10	11	11	12	12	13	13	14	14	15	15	16	16	17	17	18	18	19	19	20	20	21	21	22
06	5	5	5	5	5	5	6	6	6	7	7	8	8	8	9	9	10	10	11	11	12	12	13	13	14	14	15	15	16	16	17	17	18	18	19	19	20	20	21	21	22	22
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10	7	7	7	8	8	8	8	8	9	9	9	9	10	10	11	11	11	12	12	13	13	13	14	14	15	15	16	16	17	17	17	18	18	19	19	20	20	21	21	22	22	23
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57	40	40	40	40	40	40	40	40	40	40	40	40	40	40																												

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AUTOMATIC DETERMINATION OF TOLL CALL CHARGES

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FIG. 89

<table>
<tr><th rowspan="3">CONDITION</th><th>COL. 1</th><th>COL. 2</th><th>COL. 3</th><th>COL. 4</th><th>COL. 5</th><th>COL. 6</th><th>COL. 7</th><th>COL. 8</th><th>COL. 9</th><th>COL. 10</th><th>COL. 11</th><th>COL. 12</th><th>COL. 13</th></tr>
<tr><th colspan="2">N. LATITUDE °</th><th colspan="2">LATITUDE DIFFERENCE IN HUNDREDTHS, TENTHS & UNITS DEGREES</th><th rowspan="2">SOUTH TO NORTH DISTANCE IN MILES (APPROX.)</th><th colspan="2">LONGITUDE °</th><th colspan="2">LONGITUDE DIFFERENCE IN HUNDREDTHS, TENTHS & UNITS DEGREES</th><th rowspan="2">EAST TO WEST DISTANCE IN MILES</th><th colspan="3">RELAY TABLE NO.</th></tr>
<tr><th>CALLING OFFICE</th><th>CALLED OFFICE</th><th>FROM SUB-TRACTOR</th><th>FROM NUMBER ROUNDING</th><th>CALLING OFFICE</th><th>CALLED OFFICE</th><th>FROM SUB-TRACTOR</th><th>FROM NUMBER ROUNDING</th><th>0 TO 40 MILES</th><th>40 TO 400 MILES</th><th>400 TO 4000 MILES</th></tr>
<tr><td>1</td><td>39.50
MINUEND</td><td>39.00</td><td>0050
ΔK-3 ΔK-1
ΔK-2</td><td>ΔK-1 50 (H)
ΔK-2 05 (T)
ΔK-3 01 (U)</td><td>35
35
70</td><td>70.35
MINUEND</td><td>70.00</td><td>0035
ΔL-3 ΔL-1
ΔL-2</td><td>ΔL-1 35 (H)
ΔL-2 04 (T)
ΔL-3 00 (U)</td><td rowspan="5">VARIES WITH LATITUDE</td><td>44</td><td>404
ANS.</td><td>4016</td></tr>
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ΔK-2</td><td>ΔK-1 50 (H)
ΔK-2 05 (T)
ΔK-3 01 (U)</td><td>35
35
70</td><td>70.35
MINUEND</td><td>70.00</td><td>0035
ΔL-3 ΔL-1
ΔL-2</td><td>ΔL-1 35 (H)
ΔL-2 04 (T)
ΔL-3 00 (U)</td><td>45
ANS.</td><td>405</td><td>4017</td></tr>
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MINUEND</td><td>39.50</td><td>0450
ΔK-3 ΔK-1
ΔK-2</td><td>ΔK-1 50 (H)
ΔK-2 45 (T)
ΔK-3 05 (U)</td><td>35
315
350</td><td>70.35
MINUEND</td><td>70.00</td><td>0035
ΔL-3 ΔL-1
ΔL-2</td><td>ΔL-1 35 (H)
ΔL-2 04 (T)
ΔL-3 00 (U)</td><td>46</td><td>406
ANS.</td><td>4021</td></tr>
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ΔK-2 55 (T)
ΔK-3 06 (U)</td><td>35
386
420</td><td>70.35
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ΔL-3 ΔL-1
ΔL-2</td><td>ΔL-1 35 (H)
ΔL-2 04 (T)
ΔL-3 00 (U)</td><td>47</td><td>407</td><td>4022
ANS.</td></tr>
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ΔK-3 ΔK-1
ΔK-2</td><td>ΔK-1 50 (H)
ΔK-2 65 (T)
ΔK-3 07 (U)</td><td>35
456
490</td><td>70.35
MINUEND</td><td>70.00</td><td>0035
ΔL-3 ΔL-1
ΔL-2</td><td>ΔL-1 35 (H)
ΔL-2 04 (T)
ΔL-3 00 (U)</td><td>47</td><td>407</td><td>4023
ANS.</td></tr>
</table>

FIG. 90

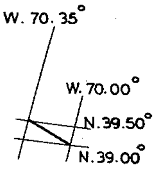

FIG. 91

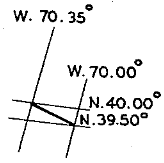

FIG. 92

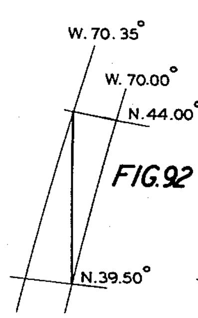

FIG. 93

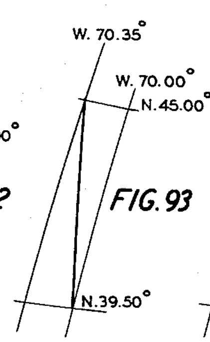

FIG. 94

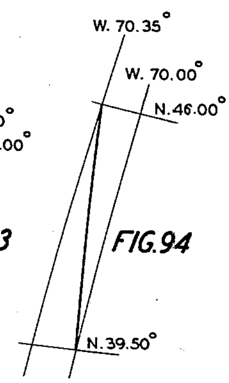

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FIG. 96

STATION TO STATION

RATE TABLE

MILEAGES AND CORRESPONDING RATES

	BASIC RATE INDEX NUMBER	RATE MILEAGE	DAY, NIGHT SUNDAY & HOLIDAY			
			INITIAL 3 MIN.	ADD'L MIN.		
1 TO 40 MILES	1	1-8	.10	.05		
	2	9-13	.15	.05		
	3	14-18	.20	.05		
	4	19-24	.25	.05		
	5	25-30	.30	.05		
	6	31-40	.35	.10		
			DAY (EXCEPT SUNDAY) & HOLIDAY		NIGHT SUNDAY & HOLIDAY	
			INITIAL 3 MIN.	ADD'L MIN.	INITIAL 3 MIN.	ADD'L MIN.
41 TO 400 MILES	1	41-55	.40	.10	.35	.10
	2	56-70	.45	.10	.35	.10
	3	71-85	.50	.10	.35	.10
	4	86-100	.55	.15	.35	.10
	5	101-124	.60	.15	.40	.10
	6	125-148	.65	.15	.40	.10
	7	149-172	.70	.15	.45	.10
	8	173-196	.75	.20	.45	.10
	9	197-220	.80	.20	.50	.10
	10	221-244	.85	.20	.55	.15
	11	245-268	.90	.20	.60	.15
	12	269-292	.95	.25	.60	.15
	13	293-316	1.00	.25	.65	.15
	14	317-354	1.05	.25	.70	.15
	15	355-400	1.10	.25	.75	.20
401 TO 4000 MILES	1	401-446	1.15	.30	.75	.20
	2	447-492	1.20	.30	.80	.20
	3	493-538	1.25	.30	.85	.20
	4	539-584	1.30	.30	.90	.20
	5	585-652	1.35	.35	.95	.25
	6	653-743	1.40	.35	1.00	.25
	7	744-894	1.50	.35	1.10	.25
	8	895-1045	1.60	.40	1.20	.30
	9	1046-1196	1.70	.40	1.30	.30
	10	1197-1347	1.80	.45	1.40	.35
	11	1348-1603	1.90	.45	1.50	.35
	12	1604-1964	2.05	.50	1.65	.40
	13	1965-2430	2.20	.55	1.75	.45
	14	2431-3006	2.35	.60	1.85	.45
	15	3007-4000	2.50	.60	2.00	.50

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United States Patent Office 2,984,704 Patented May 16, 1961

2,984,704

AUTOMATIC DETERMINATION OF TOLL CALL CHARGES

Noah S. Terry, Freeport, N.Y., and Edward Vroom, Brooklyn, Conn., assignors to Bell Telephone Laboratories, Incorporated, New York, N.Y., a corporation of New York

Filed Dec. 7, 1956, Ser. No. 626,848

30 Claims. (Cl. 179—7.1)

This invention relates to telephone systems, and particularly to those systems which are provided with facilities to record items of information appertaining to the identification and billing of established telephone connections. The invention especially relates to a new and novel arrangement of apparatus and associated circuitry for a telephone central office by which such items are obtained and automatically processed at the office itself into an individual record for each connection, the record containing, among other indicia, the identity of the calling and called stations and the monetary charge for the connection.

In telephone systems arranged for automatic message accounting (AMA), a record is made at the central office of items of information pertaining to each call placed therefrom. These items, included in three "entries" which make up the record for each call, are recorded on a continuous tape. During a period of light load (usually around 3 a.m.) the tape with the recorded items is severed from the tape roll and taken to an automatic message accounting center where suitable computing, sorting and tabulating equipment process the entries into a separate record for each subscriber. This record is subsequently used in making up the subscriber's monthly statement.

This arrangement is, of course, perfectly suitable regardless of whether the established calls are local or toll, the recording and computing equipment operating automatically in all cases to obtain the necessary data, and to process the same into the involved charges.

However, in the case of direct distance calls which are placed from stations in large P.B.X exchanges, for instance a P.B.X exchange serving a hotel, the automatic message accounting equipment provides no facilities for computing the charges for an established call immediately after the call is terminated. A guest in a New York hotel, for instance, making a call to a subscriber in San Francisco, would have to wait for the regular billing period before the charge for the call would be determined. On the other hand, he might have to check out within the hour, or at all events before the statement becomes available. For this reason P.B.X exchanges falling in the above category, are presently denied service with automatic message accounting equipment. Long distance calls originating at a P.B.X exchange for which the charge is to be made known at the termination of the call are routed through toll operators who will time and ticket such calls according to established manual practice, and communicate the charges to the P.B.X operator or to the calling subscriber soon after the termination of the calls.

In order to extend the benefit of Direct Distance Dialing to all subscribers, and particularly to those who may be obliged to pay for the service immediately after it is rendered, it is desirable to provide in the central office apparatus which will automatically compute the cost of the call upon its termination.

Accordingly, it is the broad object of the present invention to provide means at the central office of an automatic telephone system which, in response to the establishment and the timing of a long distance call, operates to compute the charge therefor and make a record of the same.

Another object of this invention is the provision of means for determining the distance in great circle miles between a calling and a called central office, said means comprising a novel subtractor circuit which ascertains the difference between the latitudes and the difference between the longitudes of the calling and the called central offices;

Still another object of this invention is to obtain from suitable central office apparatus appropriate indicia representing, respectively, the geographical position of a calling and a called central office expressed in terms of their respective latitudes and longitudes;

According to another object of this invention the indicia representing the difference in latitude and the difference in longitude between the calling and the called central office is utilized in conjunction with an appropriate relay mileage table to determine the distance in great circle miles between the calling and the called central office;

According to another object of this invention, each of a plurality of items of indicia pertinent to the identification, distance and duration of a call in progress is stored in a magnetic drum as it becomes available until the conclusion of the call, after which it is withdrawn from storage and utilized to operate suitable computing and visual display devices to provide the monetary charges for the completed call together with data indicating the identity of the calling and called subscribers;

Still another object of the invention is to provide circuits, apparatus and method for translating a plurality of sets of indicia, respectively representing basic rate, a band-choice (or table use determining) data, elapsed conversation time data, and data respectively indicating that the regular (or day) rate, or that the reduced (or "night") rate should be employed, into a single integrated index number representing the charging rate to be employed in the determination of the monetary charges for a completed telephone call;

Still another object of the invention is to obtain, from indicia previously stored in a translating device the identity of the called office in terms of its geographical position expressed in degrees of latitude and longitude or fractions thereof;

Still another object of the invention is to provide circuits for comparing the magnitudes of the longitudes of the calling and called offices, and so arranging them that the larger and the smaller of the two quantities are respectively presented to the longitude subtractor circuit as the minuend and the subtrahend thereof;

Still another object of the invention is to provide circuits for comparing the magnitudes of the latitudes of the calling and called offices, and so arranging them that the larger and the smaller of the two quantities are respectively presented to the latitude subtractor circuit as the minuend and the subtrahend thereof;

Still another object of the invention is to provide a band-choice circuit controlled by central office latitude indicia values presented thereto, to effect the choice of one band of a plurality of mileage bands, the band so chosen determining which set of a plurality of sets of relay tables is to be used, each said set of relay tables having precomputed mileage data pre-stored therein peculiarly appropriate to one range of latitude indicia values presented to said band-choice circuit;

Still another object of the invention is to provide circuits, controlled by latitude indicia values representing the positions of a calling and a called central office, to determine whether the called central office location is north or south of that of the calling central office;

Still another object of the invention is to provide a number-rounding circuit receptive to and controllable by potential inputs that represent a number expressed in four denominational orders, said number-rounding circuit being so arranged that when the numerical value of the input to any of the three lower denominational orders lies between five and nine, the numerical value of the output of the next higher denominational order will be raised in numerical value by one;

Still another object of the invention is the provision of circuits connected in a "tree" pattern or the equivalent thereof for translating a four denominational order input number expressed in decimal code and representing geographical position difference data, into an output expressed over a single electrically activated conductor in one or more of three groups of conductors, each said group of conductors being connected as an input to a relay mileage table germane to a specific range of mileage values, and each of said output conductors being significant of one of a large plurality of discrete values of positional difference input data to said table;

According to another object of the invention the decimal input indicia representing a basic rate number is applied to a basic rate translator circuit wherein under control of the accompanying mileage band-choice input and an "over" or "under" four hundred mile indication input, said indicia is translated into the corresponding basic rate index number which applies to a sub-group of mileage values. Simultaneously with the translation of the indicia to said basic rate index, one of three band-choice conductors is energized by the basic rate translator circuit to indicate which mileage band-choice is to be utilized in conjunction with said basic rate index;

According to another object of the invention the basic rate index, expressed in a binary code, is applied to a basic rate index translator wherein, under control of a selected mileage band-choice input, said index is translated into an output expressed by a single activated lead in one of three groups of output leads, each group of leads being germane to a specified range of mileage values, and each of said output leads being significant of one of a plurality of basic charging rates. Simultaneously with the activation of said output lead, one of three mileage band-choice conductors is energized by the basic rate index translator to indicate which mileage band-choice is to be utilized in establishing the charge for a call in conjunction with said activated output lead;

According to another object of the invention the several registers wherein have been registered the directory numbers of the calling and the called subscribers' stations, the called central office code, and the monetary charges for a completed call between said stations, are progressively connected on a digit-by-digit and item-by-item basis, to the printing equipment employed in producing a visual record of said call between said stations and of the monetary charges for said call;

These and other objects and features of the invention will be more apparent from the description which follows, the appended claims, and the drawings, in which:

Fig. 1 shows the calling and called subscribers' lines, an attended P.B.X, a line switch, an identifier, a district junctor, a district junctor identifier, a sender link and sender link controller, a completing central office, and quotation communicating channel equipment;

Fig. 2 shows a district junctor timing circuit and an elapsed conversation time register;

Fig. 3 shows the called subscriber's area code register and the called subscriber's office code register;

Fig. 4 shows the called subscriber's directory number register;

Fig. 5 shows the calling subscriber's area code cross-connections and the calling subscriber's directory number register;

Fig. 6 shows the area and office code translator-connectors and the latitude and longitude card translators required to produce by translation the latitude and longitude corresponding to the latitude and longitude of the called office;

Figs. 1 to 6, inclusive, disclose, in general, those circuits used in establishing a conversation path between the calling and called subscriber, furnishing the latitude and longitude of the calling and called offices, furnishing the identification of the calling and called subscribers and the district junctor employed to time the duration of the conversation and to supply all of the above data to the associated circuits employed in computing the charge for a completed call;

Figs. 7 to 14, inclusive, in general, show the four digit arranger circuits;

Figs. 7, 8, 9 and 10, respectively, show the tens, units, tenths and hundredths digits for the longitude arranger circuits;

Figs. 11, 12, 13 and 14, respectively, show the tens, units, tenths and hundredths digits for the latitude arranger circuits;

Figs. 15 to 22, inclusive, in general, show the four digit subtractor circuits;

Figs. 15, 16, 17 and 18, respectively, show the tens, units, tenths and hundredths digits for the longitude subtractor;

Figs. 19, 20, 21 and 22, respectively, show the tens, units, tenths and hundredths digits for the latitude subtractor;

Figs. 23 to 30, inclusive, in general, show the four digit number rounding and tree circuits;

Figs. 23, 24, 25 and 26, respectively, show the tens, units, tenths and hundredths digits of the adjusted longitude number rounding circuits and also, in Figs. 24, 25 and 26, respectively, in the right-hand portion are shown the 400 to 4000 mile, the 40 to 400 mile and the 0 to 40 mile bands of the tree circuits;

Figs. 27, 28, 29 and 30, respectively show the tens, units, tenths and hundredth digits of the latitude number rounding circuits and also, in Figs. 28, 29 and 30, respectively, in the right-hand portion are shown the 400 to 4000 mile, the 40 to 400 mile and the 0 to 40 mile bands of the tree circuits;

Figs. 31 to 58, inclusive, in general, show the latitude connectors and rate location circuits which are divided into the following bands;

Figs. 31 to 34, inclusive, show the 400 to 4000 mile band circuits;

Figs. 35 to 50, inclusive, show a plurality of 40 to 400 mile band circuits identified as bands numbered 4, 5, 6 and 7;

Figs. 35 to 38, inclusive, show band number 4;

Figs. 39 to 42, inclusive, show band number 5;

Figs. 43 to 46, inclusive, show band number 6;

Figs. 47 to 50, inclusive, show band number 7;

Figs. 51 to 58, inclusive, show a pluraity of 0 to 40 mile band circuits identified as bands numbered 4 and 5;

Figs. 51 to 54, inclusive, show band number 4;

Figs. 55 to 58, inclusive, show band number 5;

Fig. 59 shows the call identity index prewriting keys and the call identity index matching circuits;

Figs. 60 to 63, inclusive, show the magnetic drum storage circuit and the amplifiers and gate circuits operatively associated therewith;

Fig. 64 shows the basic rate translator and basic rate translator-register relay circuits;

Fig. 65 shows the automatic reduced rate indicating circuit;

Fig. 66 shows the calling subscriber's directory number register-translator circuit, the called subscriber's office code register-translator circuit and the called subscriber's directory number register-translator circuit;

Fig. 67 shows the elapsed conversation time register-translator and time tree circuit;

Fig. 68 shows the basic rate index register-translator circuit;

Fig. 69 shows the charging translator circuit;

Fig. 70 shows a typical plan for cross connecting diodes to a set of multiple paths to indicate the charge and tax for a completed call;

Figs. 71 to 74, inclusive, in general, show the call charge data connector circuits and the printer register-translator circuits;

Figs. 73 and 74, on their lower portions, show the printer register-translator circuit;

Fig. 75 shows the call charge data scanning circuit, the transmitter distributor circuit and the printer;

Figs. 76 to 79, inclusive, in general, disclose in block diagram form the organization of the circuits comprising an exemplary form of the inventon;

Fig. 76 indicates the calling and called subscribers' lines, an attended P.B.X, a line switch, a line identifier, an identifier connector, a district junctor, a district junctor identifier, a district junctor timing circuit, an elapsed conversation time register, a sender, a completing central office, an area code translator-connector, an office code translator connector, a latitude and longitude card translator, longitude and latitude arranger circuits, and quotation communicating channel equipment;

Fig. 77 indicates the longitude and latitude subtractor circuits; the longitude and latitude number rounding circuits and the longitude and latitude tree circuits;

Fig. 78 indicates the latitude connectors and rate location circuits, the basic rate translator register circuit, the automatic reduced rate indicating circuit and the magnetic drum storage circuits;

Fig. 79 indicates the basic rate index translator circuit, the elapsed conversation time translator-register, the time tree circuit, the charging translator circuit, the calling subscriber's directory number register-translator, the called subscriber's office code register-translator, a typical cross-connecting plan for the diodes employed in the charge and tax plan circuits, a charge and tax adder circuit, the call charge data connector circuit, the printer register-translator circuit, the transmitter-distributor circuit, a printer, the call charge data scanning circuit, and quotation communicating channel equipment;

Figs. 80, 81 and 82 illustrate the relative arrangement of the Figs. 1 to 75, inclusive, to completely disclose the invention; and

Fig. 83 illustrates the relative arrangement of Figs. 76 to 79, inclusive, to disclose the invention in block diagram form.

Fig. 84 is a table showing the corelation of toll indices, latitudes, band choices and band widths in degrees of latitude and in equivalent distances in miles south to north.

Fig. 85 is a diagrammatic illustration of the development of a 0 to 40 mile table.

Fig. 86 is a diagrammatic illustration of the development of a 40 to 400 mile table with the area served by the 0 to 40 mile table superimposed thereon in dotted outline.

Fig. 87 is a diagrammatic illustration of the development of a 400 to 4000 mile table, showing the resolution of the table into north and south half-tables, with the areas served by the 0 to 40 mile and the 40 to 400 mile tables superimposed thereon in dotted outlines.

Fig. 88 is a table showing, in part, the precomputed data for a typical 0 to 40 mile table of great circle mileages.

Fig. 89 is a table showing several combinations of assumed latitudes and longitudes for the calling and the called central offices and their corelation with the differences in latitude and longitude and the several band choices.

Figs. 90 to 94, inclusive, are diagrammatic illustrations of the several combinations of latitude and longitude indicated in Fig. 89. Figs 95–A, 95–B and 95–C are diagrammatic illustrations of several assumed values of longitude or latitude difference and show the derivation, from a four digit input number, of three pairs of two digit output leads.

Fig. 96 is a rate mileage table adapted for use in the present invention and shows the basic rates applicable to the several rate mileage zones.

In order to facilitate the tracing of circuit operations, each relay or other item of apparatus appearing in Figs. 1 to 79 is designated by a functional designation, consisting primarily of letters, which is preceded by the number of the figure in which said item appears. Thus, a relay or other item mentioned in the text may readily be found in the drawings by reference to the figure number included in the designation of said item. For example, the relay designated **1–ANS** will be found in Fig. 1.

For a complete and clear understanding of the invention, we will first describe the general organization of the circuits and their particular functions. We will then describe, in general terms, the overall operation of an exemplary telephone system embodying the present invention as shown in the block diagram for Figs. 76 to 79, inclusive. Finally, the detailed operations of the circuits incident to computing and printing the monetary charge and the tax thereon for a completed call will be described.

General description of the circuits

The principal circuits employed in the present embodiment of the invention and their relation to one another is indicated in the block diagram of Figs. 76 to 79, arranged as shown in Fig. 83. The originating circuits comprising the calling subscriber and attended P.B.X, indicated on Fig. 76 and shown in greater detail on Fig. 1, are, in general, similar to the corresponding circuits disclosed in the patent to A. J. Busch, No. 2,585,904 of February 19, 1952. Other originating circuits comprising the line switch, district junctor, district junctor identifier, sender link and sender link controller, and sender, including called subscriber's XOX area code register **76**–ACR, called subscriber's office ABC code register **76**–OCR, called subscriber's directory number (or numerical) register **76**–DN, indicated on Fig. 76 and shown in greater detail on Figs. 1, 3, 4 and 5, are, in general, similar to the corresponding circuits disclosed in the patent to W. W. Carpenter et al., No. 2,688,658 of September 7, 1954. In the present invention, however, the district junctor is modified to include a district junctor timing circuit **76**–DJT and an elapsed conversation time register **76**–ECT, indicated on Fig. 76 and shown in greater detail on Fig. 2, which, acting conjointly, serve to measure and record the conversation time.

Also, the sender **76**–S is modified to include a circuit **76**–CC, indicated on Fig. 76 and shown in detail on Fig. 5, designated calling subscriber's area and office code cross-connections which supplies indicia relative to the geographical location of the calling office in terms of latitude and longitude. The identifier **76**–I and identifier connector **76**–IC, indicated on Fig. 76 and shown in greater detail on Fig. 1, are, in general, similar to the corresponding circuits disclosed in the patent to H. D. Cahill and W. W. Carpenter, No. 2,599,358 of June 3, 1952. The area code translator-connector **76**–AT and the office code translator-connector **76**–OT indicated on Fig. 76 and shown in greater detail on Fig. 6, are adapted to receive data from the called subscriber's area code register **76**–ACR and the called subscriber's office code register **76**–OCR. By a "tree" circuit pattern in said connectors the operation of the latitude and longitude card translator **76**–CT is effected. This translator is also indicated on Fig. 76 and shown in greater detail on Fig. 6. Other modifications are made in the originating circuits to adapt them for the purposes of distance and call charge determination and for the production of a suitable record thereof.

Since the terminating office equipment **76–CCO** indicated on Fig. 76 performs no new functions in respect to the present invention, it is not herein disclosed in detail. Reference may be had, however, to the patent to W. W. Carpenter, No. 2,089,921, August 10, 1937, for a description of the construction and operation of suitable terminating equipment.

The quotation communicating channel equipment, **76–QCE** and **79–QCE**, respectively, indicated on Figs. 76 and 79, and also on Figs. 1 and 75, may comprise any suitable means for receiving, either orally or visually, information as to the identity of the originator of a completed call and the monetary charge therefor. For example, a simple telephone set may be employed.

The longitude arranger **76–LGA** indicated on Fig. 76 and shown in greater detail on Figs. 7 to 10, inclusive, compares the magnitude of the longitudes, as expressed in degrees and decimal parts thereof, representative of the geographical locations of the calling and called offices, determines which of the two quantities is the larger, and applies the larger and smaller quantities, respectively, over the minuend and subtrahend leads **77–LGMIN** and **77–LGSUB**, respectively, to the longitude subtractor **77–LGS**. The latitude arranger **76–LAA**, also indicated on Fig. 76 and shown in greater detail on Figs. 11 to 14, inclusive, compares the magnitudes of the latitudes, as expressed in degrees and decimal parts thereof, representative of the geographical locations of the calling and called offices, determines which of the two quantities is the larger, and applies the larger and smaller quantities, respectively, over the minuend and subtrahend leads **77–LAMIN** and **77–LASUB**, respectively, to the latitude subtractor **77–LAS**. In addition, the latitude arranger also performs a discriminating function relative to mileage band choice and applies the resultant data over the leads **78–BC** to the latitude connector and rate location circuit **78–LCR**. The band choice leads **78–BC–4** and **78–BC–5** are also extended to the basic rate translator register circuit **78–BRT**. The latitude arranger also, for use under certain condition, furnishes indicia via leads **78–NS**, to the latitude connector and rate location circuit as to whether the called office latitude is north or south of that of the calling office.

The longitude subtractor **77–LGS**, indicated on Fig. 77 and shown in greater detail on Figs. 15 to 18, inclusive, determines the difference in magnitude, as expressed in tens, units, tenths and hundreths of degrees, between the longitudes of the calling and called offices and applies said difference over the leads **77–LGD** to the longitude number rounding circuit **77–LGNR**.

The latitude subtractor **77–LAS**, also indicated on Fig. 77 and shown in greater detail on Figs. 19 to 22, inclusive, similarly determines the difference in magnitude, as expressed in tens, units, tenths and hundreths of degrees, between the latitudes of the calling and called offices and applies said difference over the leads **77–LAD** to the latitude number rounding circuit **77–LANR**.

The longitude number rounding circuit **77–LGNR**, indicated on Fig. 77 and shown in greater detail on Figs. 23 to 26, inclusive, will, upon receipt of an input consisting of four denominational orders, designated tens, units, tenths and hundreths, respectively, when the value of any of the three lower denominational orders is between 5 and 9, cause a shift relay to operate and raise by one the value of the next higher denominational order. The resultant values will be applied as pairs of adjacent digits comprising tens with units, units with tenths, and tenths with hundredths, over the leads **77–ΔL** to the adjusted longitude tree circuit **77–LGTR**.

The latitude number rounding circuit **77–LANR** also indicated on Fig. 77 and shown in greater detail on Figs.

27 to 30, inclusive, is constructed and operates in identically the same manner as the above-mentioned longitude number rounding circuit **77–LGNR** and will, in a similar manner, apply the resultant values over pairs of adjacent digital leads to the latitude tree circuit **77–LATR**.

The longitude tree circuit **77–LGTR**, indicated on Fig. 77 and shown in greater detail on Figs. 23 to 26, inclusive, is a form of circuit well known in the prior art and, in this invention, will cause each pair of digital input leads such as **77–LGP–1**, **77–LGP–2** and **77–LGP–3** to control a translation, in accordance with a predetermined pattern, to effect the grounding in each of three groups of leads such as **77–ΔL–1**, **77–ΔL–2** and **77–ΔL–3** of a corresponding single lead significant of one of a large plurality of discrete values of difference in longitude between the calling and called offices, each group of leads being related to a different mileage band. Said grounded leads, one for each band, will cause the energization of a relay winding in each of their respective bands in the latitude connector and rate location circuit corresponding to these values of longitude difference.

The latitude tree circuit **77–LATR**, indicated on Fig. 77 and shown in greater detail on Figs. 27 to 30, inclusive, is similar in construction and operation to the longitude tree circuit and will effect the grounding in each of three groups of leads such as **77–ΔK–1**, **77–ΔK–2** and **77–ΔK–3** of a corresponding single lead significant of one of a large plurality of discrete values of difference in latitude between the calling and called offices, each group of leads being related to a different mileage band. Said grounded leads, one for each band, will effect the grounding of a relay contact in each of their respective bands in the latitude connector and rate location circuit corresponding to those values of latitude difference.

The latitude connector and rate location circuit **78–LCR** indicated on Fig. 78 and shown in greater detail on Figs. 31 to 58, inclusive, consist of relays interconnected in such a pattern as to constitute a plurality of tables. The tables are resolved into three principal groups identified as the 400 to 4000 mile range, shown on Figs. 31 to 34, inclusive, the 40 to 400 mile range, shown on Figs. 35 to 50, inclusive, and the 0 to 40 mile range, shown on Figs. 51 to 58, inclusive. Each such principal group is subdivided into a plurality of bands. Different bands will be assigned to distinguish the several geographical areas served. The determination as to which of the above-mentioned bands is to be employed in a given instance, resides in the operation of a particular band choice relay. The operation of the band choice relays is under the control of band selection leads, hereinbefore mentioned, from the latitude arranger circuit **76–LAA**.

The longitude difference data, ΔL, and the latitude difference data, ΔK, furnished by the longitude tree and the latitude tree circuits, respectively, are applied to the tables as the horizontal and vertical input ordinates, respectively, to obtain, by translation, the basic rate applicable to a given call. The basic rate indicia, as obtained by the operation of the latitude connector and rate location circuit (expressed by one or more terminals strapped together) will be applied over the leads in the cable **78–BR** to the basic rate translator register circuit **78–BRT**. A further determination will be made by the latitude connector and rate location circuit **78–LCR** as to whether the calling and called offices are separated from each other by a distance of more or less than 400 miles, and the resultant indicia will be applied over the "below 400 miles" leads to the basic rate translator register circuit **78–BRT**.

The basic rate translator register circuit **78–BRT**, indicated on Fig. 78 and shown in greater detail on Fig. 64, consists of a network including relays and diodes. It is resolved into three parts identified as the 400 to 4000 mile band, the 40 to 400 mile band, and the 0 to 40 mile band. The determination as to which of the bands is to be selected for use on a given call will be under the joint control of the band selection leads, hereinbefore mentioned, from the latitude arranger circuit 76–LAA and the "below 400 miles" leads from the latitude connector and rate location circuit 78–LCR. A particular basic rate, as determined by the latitude connector and rate location circuit, will effect the grounding of one lead to each of the three above-mentioned bands, and upon the selection of one of the bands will, by means of the translation function inherent in the cross-connection pattern of the diodes, extend ground over the basic rate index leads to the magnetic drum storage circuit 78–MDS. The selection of a particular band within the basic rate translator will also extend other grounds, indicative of said band selection, to said magnetic drum storage circuit.

The automatic reduced rate indicating circuit 78–ARR, indicated on Fig. 78 and shown in greater detail on Fig. 65, is a clock controlled arrangement for automatically causing the grounding of a control or "night" lead to the magnetic drum storage circuit 78–MDS as a signal that for calls originating at night or on Sundays or holidays, the reduced, or night, rate will apply. The means for recognizing Sundays and holidays, as they occur, comprises a translator employing a plurality of varistors, flexibly cross-connectable in a coordinate pattern to simulate a calendar. Cooperable therewith are day and week progress switches, also clock controlled, which apply from day to day and week to week the appropriate charging signal to the above-mentioned control lead to the magnetic drum storage circuit.

The magnetic drum storage equipment 78–MDS, indicated on Fig. 78 and shown in greater detail on Figs. 60 to 63, inclusive, is an information storage device wherein all of the several items of data essential to the charging of the call, such as the identity of the calling and called subscribers' numbers, the basic rate, the band choice and the reduced rate indicia, may be stored to await the conclusion of the call and the elapsed period of conversation time.

When all of the items of data requisite to the computation of the charge for a call have been stored in the magnetic drum storage circuit 78–MDS, the stored data is transferred to the several circuits which, in their turn, will supply data to the printer 79–PTR via the latter's associated translator and distributor circuits 79–PTR and 79–XD, respectively.

The magnetic drum storage circuit includes devices and circuit arrangements similar in construction and operation to those shown in the prior art.

The magnetic drum; reading, writing and timing heads; the timing impulse reading amplifier circuit, the reading control (or gate) circuit, the check reading gate circuit and the amplifier circuits associated with the outputs thereof are similar to those shown in the patent to C. E. Brooks, C. A. Lovell, J. H. McGuigan, O. J. Murphy, and D. B. Parkinson, No. 2,764,634 of September 25, 1956.

The writing amplifier, the single cycle multivibrator, the address combine, the tens and units matching, the writing time gate, and prewrite key and relay circuits are, in general, similar to those shown in a patent application of H. A. Henning, E. Jacobitti, B. F. Lewis, entitled "Magnetic Drum Translator for Automatic Toll Switching Center," Serial No. 418,508, filed March 25, 1954.

The functions of the reading amplifier circuits, together with those of the pulse generator, power amplifier and delay and power amplifier circuits associated with the timing pulse, are similar to those of comparable equipment shown in the patent to W. A. Cornell, J. H. McGuigan, O. J. Murphy, No. 2,845,610 of July 29, 1958.

The delay network circuits, respectively associated with the restoring function of the single cycle multivibrator and with the output of the check reading gate circuits, may be of any suitable type known in the art that will introduce a delay of a few milliseconds.

The basic rate index register-translator circuit 79–BRIT, indicated on Fig. 79 and shown in greater detail on Fig. 68, is an arrangement whereby basic rate indicia (which are on a binary basis) and band choice indicia which have been stored in the magnetic drum storage circuit 78–MDS, will effect the conversion of said basic rate indicia to a plurality of rate indicia expressed on a decimal basis. Said rate indicia will be directed, via band choice relays selectably operated under control of said band choice indicia, to the appropriate band paths in the charging translator circuit 79–CT.

The elapsed conversation time register-translator circuit 79–ECTR, indicated on Fig. 79 and shown in greater detail on Fig. 67, is an arrangement which combines the functions of registration and translation. When the elapsed conversation time, expressed in minutes for example, has been stored in the magnetic drum storage circuit on a two-out-of-five code basis it will be reregistered on a two-out-of-five code basis in the register-translator and translated to a three digit decimal code basis for application to the time tree circuit 79–TMT.

The time tree circuit 79–TMT, indicated on Fig. 79 and shown in greater detail on Fig. 67, is a translating device which causes the elapsed conversation time data as supplied by the elapsed conversation time-register translator on a three digit decimal code basis to effect the grounding of a single lead out of a group of one hundred leads, each lead being expressive of a definite time quantity in minutes to be applied to the charging translator circuit 79–CT.

The time tree circuit 79–TMT also includes a relay operable from the magnetic drum storage circuit to register when the night (or reduced) rate shall apply, and to cause the data corresponding thereto to be conveyed to the charging translator circuit 79–CT.

The charging translator circuit 79–CT, indicated on Fig. 79 and shown in greater detail on Fig. 69 is a coordinate arrangement of relays and contacts which translates and integrates the indicia supplied by the basic rate index translator circuit 79–BRIT expressive of the distance category by which the calling and called offices are separated, the band choice data also supplied by the basic rate index translator, and the indicia supplied by the time tree circuit 79–TMT expressive of the number of minutes of elapsed conversation for which the call should be charged for at the reduced (or "night") rate, into charging indicia on certain output leads which are flexibly cross-connectable to the charge and tax diode cross-connecting plan circuit 79–CDX and 79–TDX.

The charge and tax diode cross-connecting plan circuits 79–CDX and 79–TDX indicated on Fig. 79 and shown in greater detail on Fig. 70, are coordinate arrangements which convert charging indicia supplied via charging indicia leads from the charging translator circuit 79–CT to data expressive of the monetary charge for a completed call and the tax chargeable thereon. Said charge and tax data are respectively applied over the charge and tax output multiple leads to the charge and tax adder circuit 79–CTA and to the call charge data connector circuit 79–CDC.

The charge and tax adder circuit 79–CTA, indicated on Fig. 79 and also on Fig. 70, at the completion of a call, adds the monetary charge for a call and the tax thereupon as supplied by the charge and tax cross-connecting plan circuits, respectively, and applies the sum of the charge and tax to the call charge data connector circuit 79–CDC.

The above-mentioned charge and tax adder may be similar in construction and operation to that disclosed in the patent to E. W. Flint and A. E. Joel, No. 2,572,804 of October 23, 1951.

The calling subscriber's directory number register-translator 79–CDNT, indicated on Fig. 79 and shown in greater detail on Fig. 66, is an arrangement which combines the functions of registration and translation. When the calling subscriber's directory number, expressed in a four digit code on a two-out-of-five code basis, has been stored in the magnetic drum storage circuit, said number is registered on a two-out-of-five code basis and translated to a decimal code basis. As translated the digits of the number are applied over the leads to the call charge data connector circuit **79–CDC**.

The called subscriber's office code register-translator **79–OCT**, indicated on Fig. 79 and shown in greater detail on Fig. 66, is an arrangement which registers and translates the called subscriber's office code. When this code, expressed as a three digit code on a two-out-of-five code basis has been stored in the magnetic drum storage circuit **78–MDS**, it is reregistered on a two-out-of-five code basis and translated to a decimal code basis. Thereafter it is applied over the leads to the call charge data connector circuit **79–CDC**.

The called subscriber's directory number register-translator **79–DNT**, indicated on Fig. 79 and shown in greater detail on Fig. 66, does for the above number what circuit **79–CDNT** does for the calling subscriber's directory number. The translated data is applied over the leads to the call charge data connector circuit **79–CDC**.

The call charge data connector circuit **79–CDC**, indicated on Fig. 79 and shown in greater detail on Figs. 71 to 74, inclusive, is an arrangement whereby the data pertinent to recording the identity and the monetary charges for a completed call and obtained as above briefly indicated are each progressively and in a predetermined order connected digit by digit and item by item to the printer register-translator circuit **79–PRT**.

The printer register-translator circuit **79–PRT**, indicated on Fig. 79 and shown in greater detail on Figs. 73 and 74, is an arrangement which performs the functions of registering and translating all of the items of data pertinent to the identification and charge for a given completed call. As each digit and item is received from the call charge data connector circuit **79–CDC** on a decimal code basis, it is reregistered and translated to a Baudot code basis for application to the transmitter-distributor circuit **79–XD**.

The transmitter-distributor circuit **79–XD**, indicated on Fig. 79 and shown in greater detail on Fig. 75, receives the Baudot code data as supplied by the printer register-translator circuit and distributes the Baudot code pulses on a time division basis to the printer circuit **79–PTR**. The transmitter-distributor is well known in the prior art and may be similar in construction and operation to that disclosed in the patent to R. K. McAlpine et al., No. 2,44,202 of June 29, 1948, and also the patent to W. B. Bacon et al., No. 2,495,682 of January 31, 1950.

The printer **79–PTR**, indicated on Fig. 79 and also on Fig. 75, receives the Baudot code pulses from the transmitter-distributor circuit and prints the equivalent numerals representing the identification of the calling and called subscribers, the monetary charge, and the tax assessed against a given completed call. The printer is well known in the prior art and may be similar in construction and operation to that disclosed in the patent to S. Morton et al., No. 1,745,633 of February 4, 1930.

The call charge data scanning circuit **79–CDS**, indicated on Fig. 79 and shown in greater detail on Fig. 75, employs a rotary stepping switch, the bank terminals of which are connected in a manner to effect the successive operation in a predetermined sequence of the several connector relays of the call charge data connector circuit **79–CDC**.

General system description

Subscriber's station **76–SO** and subscriber's line **76–LO** are representative of a plurality of such lines served by the attended private branch exchange **76–P.B.X.** This exchange, by way of example, may be located at a hotel from which a large volume of toll cards may be normally expected to originate.

When a toll call is originated by a transient guest at a hotel, it is necessary that the amount of the toll charge therefor be rapidly made known to the hotel billing clerk in order that the same may be immediately entered on the guest bill.

Accordingly, when a call is placed at telephone **76–LO**, the call is answered over line **76–LO** by the operator at the attended P.B.X in the ordinary manner. The operator orally obtains, by means of her operator's set **76–OS**, the office name and directory number of the called subscriber from the calling subscriber.

The P.B.X operator, recognizing the call as a toll call, proceeds to dial the called subscriber **76–SC** via the P.B.X line **76–L1**, district junctor **76–DJ**, the toll completing path **76–T**, the completing central office **76–CCO**, and the called subscriber's line **76–LC**. Since, in dialing the called office code for an office in a foreign area, the office code must be preceded by the area code of the area in which the called office is located, the digits dialed by the P.B.X operator are resolved into three groups consisting of the area, or XOX, code, the office, or ABC, code, and the numerical, or the thousands, hundreds, tens and units digits of the called subscriber's directory number.

The dial impulses, in a manner well known to the prior art, cause the called subscriber's area code register **76–ACR**, the called subscriber's office code register **76–OCR**, and the called subscriber's directory number register **76–DN** (all of which are part of the sender **76–S**) to assume settings respectively in accordance therewith.

The settings assumed by the registers of the sender cause the actuation of the switching mechanisms to effect the connection to, and ringing of the called subscriber **76–SC** in a manner well known to the prior art.

The called subscriber's office code register **76–OCR** and the called subscriber's directory number register **76–DN** have embodied therein suitable circuit modifications which adapt them to transmit, via multiple conductors **76–MC**, the data expressed by their settings to the writing amplifier gate circuits **78–WG** of the magnetic drum storage circuit **78–MDS**. This data is stored in the drum until the call is completed, after which it is used as part of the call identifying data.

The called subscriber's area code register **76–ACR** and the called subscriber's office code register **76–OCR** have embodied therein suitable circuitry which enable the registers to transmit, via conductors **76–CD**, the coded data stored therein to the area and office code translator-connector **76–AT** and **76–OT**, respectively.

The area and office code translator-connector circuits **76–AT** and **76–OT**, respectively, when operating in response to received coded data, will, by means of a "tree" circuit arrangement well known to the prior art, effect the selection of one of a plurality of card translator circuits such as **76–CT**, for example, and cause the selection therein of a card having a pattern of apertures which represent the latitude and longitude of the called office. These apertures control the operation of a plurality of contacts, the closure of which applies grounds in a code pattern indicative of the latitude and longitude of the called office. The latitude indicia is conveyed to the latitude arranger circuit **76–LAA** via multiple conductors **76–CLAT**, while longitude indicia is conveyed to the longitude arranger circuit **76–LGA** via multiple conductors **76–CLON**.

The sender **76–S** is modified to include a calling subscriber's area and office code cross-connection circuit **76–CC**, the purpose of which is to indicate the latitude and longitude of said calling office. The latitude indicia is conveyed to the latitude arranger circuit **76–LAA** via multiple conductors **76–LAT**, while the longitude indicia is conveyed to the longitude arranger circuit **76–LGA** via multiple conductors **76–LON**.

The latitude arranger circuit **76–LAA** compares the magnitudes of the latitudes of the calling and called offices, and causes the larger and the smaller of the two quantities to be entered into the latitude subtractor circuit **77–LAS** as the minuend and subtrahend, respectively, via conductors **77–LASUB** and **77–LAMIN**, respectively.

The latitude arranger circuit **76–LAA** also performs the additional functions of discriminating as to which of the several "mileage bands" is to be used in computing the charges for the call, for closing a circuit to a lead indicative of the appropriate mileage band, and of conveying the indicia thereof to the latitude connector and rate location circuit **78–LCR** and also to the basic rate translator register circuit **78–BRT**.

The latitude arranger circuit **76–LAA** also performs the further functions of discriminating as to whether, in the particular call in progress, the geographical position of the called office is north or south of the geographical position of the calling office, of closing a circuit to a lead indicative of such relative position, and of conveying the indicia thereof to the latitude connector and rate location circuit **78–LCR**.

The latitude subtractor circuit **77–LAS** determines the difference in magnitude between the latitudes of the calling and called offices and applies said differences as the input to the latitude number rounding circuit **77–LANR** via conductors **77–LAD**.

The latitude number rounding circuit **77–LANR**, on receiving the latitude difference as a four digit input when the value of any of the three lowest denominational orders of the difference lies between 5 and 9, causes a shift operation by which the value of the next higher denominational order is raised by "1." The resultant values are applied over leads 77–ΔK to the latitude tree circuit as three pairs of adjacent digits comprising tens with units, units with tenths and tenths with hundredths.

The latitude tree circuit **77–LATR** causes each of the pairs of digital input leads **77–LAP–1**, **77–LAP–2** and **77–LAP–3** to effect, by translation, the grounding of a particular single lead expressive of a discrete value of latitude difference in each of the three groups of leads **77–ΔK–1**, **77–ΔK–2** and **77–ΔK–3**, to the contacts of a relay in the latitude connector and rate location circuit **78–LCR**, each of said groups of leads being related to a different mileage band.

The longitude arranger circuit **76–LGA**, in a manner similar to that described for the latitude arranger **76–LAA**, compares the magnitude of the longitudes of the calling and called offices and causes the larger and smaller of the two quantities to be entered into the longitude subtractor circuit **76–LGS** as the minuend and subtrahend, respectively, via conductors **77–LGSUB** and **77–LGMIN**, respectively.

The longitude subtractor circuit **77–LGS** determines the difference in magnitude between the longitudes of the calling and called offices and applies said difference as the input to the longitude number rounding circuit **77–LGNR** via conductors **77–LGD**.

The longitude number rounding circuit **77–LGNR**, in a similar manner to the latitude number rounding circuit, applies the resultant values over pairs of adjacent digital leads **77–ΔL** to the input of the longitude tree circuit **77–LTGR**.

The longitude tree circuit **77–LGTR**, in a manner similar to the latitude tree circuit **77–LATR**, causes each of the pairs of digital input leads **77–LGP–1**, **77–LGP–2** and **77–LGP–3** to effect, by translation, the grounding of a particular single lead expressive of a discrete value of longitude difference in each of the three groups of leads **77–ΔL–1**, **77–ΔL–2** and **77–ΔL–3**, to the windings of relays in the latitude connector and rate location **78–LCR**, each of said groups of leads being related to a different mileage band.

The latitude connector and rate location circuit **78–LCR** is responsive to the indicia received from the latitude arranger circuit **76–LAA** and the latitude and longitude tree circuits **77–LATR** and **77–LGTR**, respectively. When the indicia is received, it operates to select from the "tables" incorporated therein the appropriate mileage band, the appropriate circuit paths which determine the charges according to the indication as to whether the geographical position of the called office is north or south of the geographical position of the calling office, and the appropriate table within which will be found the basic rate (expressed by one or more terminals connected to a common output) applicable to a given call. The latitude connector and rate location circuit **78–LCR** also performs the discriminating function of determining wether the calling and called offices are separated from each other by a distance more or less than 400 miles, furnishing an indication thereof via leads **78–HBS** and **78–MBS** to the basic rate translator register circuit **78–BRT**. The indicia relative to the applicable basic rate is conveyed to the basic rate translator circuit **78–BRT** via conductors **78–BR**.

The basic rate translator register circuit **78–BRT** responding to the band selection indicia received from the latitude arranger circuit **76–LAA** via leads **78–BC–4** and **78–BC–5**, and the data indicative of whether the calling and called offices are separated from each other by a distance more or less than 400 miles received from the latitude connector and rate location circuit **78–LCR** via leads **78–HBS** and **78–MBS**, selects the appropriate mileage band and, from within said band and responsive to the data indicative of the applicable basic rate received from the latitude connector and rate location circuit **78–LCR**, evolves by translation a basic rate index number, and also energizes one of a plurality of conductors indicative of the mileage band to be employed. The basic rate index number indicia and the mileage band indicia are then conveyed to the magnetic drum storage circuit **78–MDS** via conductors **78–BRI** and **78–BC**, respectively.

The automatic reduced rate indicating circuit **78–ARR**, under control of clock actuated contacts and in connection with flexibly cross-connectable progress circuits, causes from day to day and week to week the closure of a circuit over conductor **78–N** to the magnetic drum storage circuit **78–MDS** indicative of the "night" or reduced rate which is applicable in determining the charges for the call, the data for which is currently being stored therein.

The magnetic drum storage circuit **78–MDS** receives, via the several writing gate and amplifier circuits the calling subscriber's directory number from register circuit **76–CDN**, the called subscriber's office code from register circuit **76–OCR**, the called subscriber's directory number from register circuit **76–DN**, the basic rate from translator circuit **78–BRT**, and the automatic reduced rate from indicating circuit **78–ARR**, storing the indicia as received.

Each of the several above-identified groups of indicia is received simultaneously with a call identity index number which, by means of the matching circuits **78–M**, assures that the said indicia will be stored only in that slot of the drum which has been previously identified by means of the pre-writing circuit **78–PW**, with that particular call identity index number. The entry of the several groups of indicia into the appropriate slot of the magnetic drum storage circuit **78–MDS** is synchronously effected by means of the toothed timing rotor **78–TR** in conjunction with its associated reading head and timing circuits **78–TM**.

The check signal is the last item of indicia to become available, and will, when received by the magnetic drum storage circuit, indicate that all of the indicia essential to identify a call and to compute the monetary charge therefor have been stored in the magnetic drum. The check signal, after having been thus registered in the drum, is read, in consequence of which it transmits an impulse via the associated gate circuit **78–CK** and amplifier circuit **78–CKA** to one of the two input reading gate circuits **78–RG**.

The reading amplifiers 78–RA are activated under control of the timing pulse circuits 78–TM, and when thus activated will impress impulses, in accordance with the coded indicia, upon the other of the two inputs to the reading gate circuits 78–RG. The simultaneous application of an impulse to each of the two inputs to the reading gate circuits, permits an impulse to be transmitted therefrom to the reading delay circuits 78–RD. The reading delay circuits, after a short delay interval, transmit pulses in conformity to the coded data to the output relay circuits 78–OR which are then energized and locked up.

The impulse delivered to the check reading gate circuit 78–CK is also applied to amplifier 78–RA the outoutput of which will be transmitted via delay network circuit 78–RD over one of the "write zero" or erase input leads to the writing gate circuits 78–WG. The delay network circuit 78–RD delays the application of the "write zero" or erase pulse to the writing gate circuits 78–WG by a time interval, of sufficient duration to insure the operation of the output relay circuits 78–OR before the operating pulses therefor shall have been erased from the drum. The erasure operation will, obviously, clear those areas of the drum so that they may be subsequently re-used.

The several groups of output relays 78–OR, having been energized in accordance with the coded indicia stored in the magnetic drum 78–MDS, are locked up, transmitting the indicia registered therein severally to the calling subscriber's directory number register-translator circuit 79–CDNT via conductor 78–CDN; the called subscriber's office code register-translator circuit 79–OCT via conductor 78–OC; the called subscriber's directory number register-translator 79–DNT via conductors 78–DN; the elapsed conversation time register-translator 79–ECTR via conductors 78–ECT; and the basic rate index translator 79–BRIT via conductors 79–BR and 79–BC, all of which register circuits will lock up.

The basic rate index translator circuit 79–BRIT, upon being operated, completes an up-check path to lead 79–RUC, and closes a circuit to effect the unlocking of all of the output relays 78–OR, thus making them available for reuse. The above-mentioned up-check circuit also completes a circuit to effect the starting of the call charge data scanning circuit 79–CDS via conductor 79–ST.

The basic rate index translator circuit 79–BRIT receives from the magnetic drum storage circuit 78–MDS the basic rate indicia on a binary basis and the band choice indicia stored therein, and translates the basic rate indicia to a decimal basis. Under control of the band choice indicia, it directs the basic rate indicia to the appropriate band paths in the charging translator circuit 79–CT.

The elapsed conversation time register-translator circuit 79–ECTR receives from the magnetic drum storage circuit 78–MDS the elapsed conversation time values stored therein on a two-out-of-five code basis, and translates the same to a three digit decimal code basis and conveys the translated values to the time tree circuit 79–TMT.

The time tree circuit 79–TMT will, translating the elapsed conversation time values as received from the elapsed conversation time register-translator circuit 79–ECTR on a three digit decimal code basis, effect the energization of a single lead out of a group of one hundred leads to the charging translator circuit 79–CT, each lead being expressive of a definite time quantity in minutes. The time tree circuit 79–TMT also receives from the magnetic drum storage circuit 78–MDS an indication as to when the night (or reduced) rate shall apply, and conveys the data corresponding thereto to the charging translator circuit 79–CT.

The charging translator circuit 79–CT translates and integrates the basic rate indicia supplied by the basic rate index translator circuit 79–BRIT, the band choice data, also supplied by the basic rate index translator, and the elapsed conversation time indicia supplied by the time tree circuit 79–TMT into charging indicia which is transmitted to the charge diode cross-connecting plan circuit 79–CDX and to the tax diode cross-connecting plan circuit 79–TDX.

The calling subscriber's directory number register-translator circuit 79–CDNT, the called subscriber's office code register-translator circuit 79–OCT, and the called subscriber's directory number register-translator circuit 79–DNT, via leads 78–CDN, 78–OC and 78–DN, respectively, receive from the magnetic drum storage circuit 78–MDS, the indicia stored therein on a two-out-of-five code basis, translate said indicia to a decimal code basis, and convey it to the call charge data connector circuit 79–CDC.

The charge and tax diode cross-connecting plan circuits 79–CDX and 79–TDX, respectively, receive from the charging translator circuit 79–CT charging indicia expressive of the integrated factors of distance, time, and standard or reduced rate and, by suitable cross-connections, convert said integrated indicia into data expressive of the monetary charge and the tax thereon for a completed call, and will convey said charge and tax data to the call charge data connector circuit 79–CDC and to the charge and tax adder circuit 79–CTA via multiple leads 79–CTM.

The charge and tax adder circuit 79–CTA receives from the charge and tax diode cross-connecting circuits 79–CDX and 79–TDX, respectively, the data indicative of the monetary charge and the tax thereon for a completed call, adds the charge and the tax, and conveys the data expressive of the sum of the charge and tax to the call charge data connector circuit 79–CDC.

The call charge data connector circuit 79–CDC, on a digit by digit and item by item basis and in a predetermined order, successively connects the data pertinent to recording the identity and monetary charge for a given completed call, to the printer register-translator circuit 79–PRT.

The printer register-translator circuit 79–PRT, also on a digit by digit and item by item basis, receives the data pertinent to recording the identity and monetary charges for a given completed call, and will record the received data on a decimal code basis, translate said data to a Baudot code basis and convey the Baudot code data to the transmitter-distributor circuit 79–XD.

The transmitter-distributor circuit 79–XD receives the Baudot code data from the printer register translator circuit 79–PRT and distributes the Baudot code pulses on a time division basis to the printer circuit 79–PTR.

The call charge data scanning circuit 79–CDS will, in a predetermined sequence, effect the progressive and successive operation of the connectors in the call charge data connector circuit 79–CDC.

The quotation communicating channel equipment 79–QCE and 76–QCE, connected by the quotation communication channel 79–QCC, afford a means whereby the monetary charges for a previously identified completed call as recorded by the call charge printer 79–PTR, may be transmitted from the central office to the premises of the originating private branch exchange 76–PBX.

Detailed description

We will now describe in detail an exemplary embodiment of the invention, having particular reference to Figs. 1 through 30.

When a call is originated by calling subscriber 1–SO, it is answered via line 1–L by the operator at the attended P.B.X, 1–PBX. Over the telephone set 1–OS the operator orally obtains from the calling subscriber the name of the city or town, the state, the office name and directory number of the called subscriber 1–SC. Since the present invention relates to the determination of toll charges, it will be assumed that the called subscriber 1–

SC is located at such a distance that a toll charge will be required.

The P.B.X operator then connects her telephone set **1**–OS to the P.B.X line **1**–L**1**. The line switch **1**–LS, district junctor **1**–DJ–**99**, and sender link and sender link controller **1**–SLC effect a connection to the sender **3**–S in a manner well known to the prior art. The sender **3**–S will supply dial tone via the above-mentioned path to the P.B.X operator's telephone set. It will be assumed, for example, that the P.B.X line **1**–L**1** is identified by the directory number 1234. It will also be assumed that the called subscriber's office designation is HU–7 and his directory number is 8951.

The P.B.X operator, having been apprised that the call is for an office in a distant city, to call which a foreign area code must be dialed preceding the office code, will have consulted her directory to obtain the appropriate foreign area code of the area in which the called office is located. It will be further assumed, for example, that the foreign area code number "203" is listed as the one to be dialed for the required called office destination. The operator, upon hearing dial tone, then proceeds to dial "203" for the called office area (or XOX) code, "HU–7" for the called office (or ABC) code and "8951" for the called subscriber's directory number.

The dial impulses, in a manner well known and understood in the prior art, cause the called subscriber's area code register **3**–ACR, the called subscriber's office code register **3**–OCR, and the called subscriber's director number register **4**–DN, all of which registers are a part of the sender **3**–S, to assume settings in accordance therewith.

The above-mentioned registers are of the two-out-of-five code type, each comprising five relays numbered 0, 1, 2, 4 and 7, wherein any value from 1 to 9, inclusive, may be expressed by the simultaneous operation of two relays, the sum of whose numbers is equal to that value. The zero value is expressed by the simultaneous operation of the relays 4 and 7, which is an arbitrary code assignment.

The settings assumed by the sender registers in accordance with the received dial impulses control other instrumentalities, not shown but well known to the prior art, which causes the selection of a suitable route or toll switching path, indicated at **1**–TS, over which the calling subscriber **1**–SO and the called subscriber **1**–SC are interconnected via line **1**–**1**L, PBX, **1**–PBX, line **1**–L**1**, line switch **1**–LS, district junctor **1**–DJ–**99**, completing central office **1**–CCO and line **1**–SL.

The called subscriber's office code register **3**–OCR and the called subscriber's directory number register **4**–DN have embodied therein suitable circuitry to enable them to transmit via the cables **3**–WRIC, **3**WROC, **3**–OCRC **4**–WRIC, **4**–WROC, **4**–DNC and **10**–CHGD to the writing amplifier gate circuits **61**–WG–**32** through **62**–WG–**71**, (of which **61**–WG–**33** through **61**–WG–**35**; **61**–WG–**38** through **61**–WG–**40**; **61**–WG–**43** through **61**–WG–**45**; **62**–WG–**48** through **62**–WG–**50**; **62**–WG–**53** through **62**–WG–**55**; **62**–WG–**58** through **62**–WG–**60**; **62**–WG–**63** through **62**–WG–**65**; and **62**–WG–**68** through **62**–WG–**70** are not shown), the data implicit in their settings to the magnetic drum storage circuit, therein to be stored until the completion of the call, and then to be used as a part of the call identifying data.

In the present invention the geographical distances in miles between the calling and called offices are obtained from a plurality of tables into which are built precomputed mileage values. The mileage values will have been computed on a Great Circle basis in accordance with the theory and practices developed by the American Telephone and Telegraph engineers, and described in the American Telephone and Telegraph Company pamphlet copyrighted February 26, 1952, entitled "Geographical Mileages, Their Use for Rate Purposes." Included in the above-mentioned pamphlet is a table typical of the 0–40 mile ranges which has been reproduced and appears as Fig. 88 of this disclosure.

In conventional maps, longitudes are given in degrees east or west of the Greenwich, or zero, meridian. The exemplary disclosure of the present invention contemplates the application of the system herein described to the determination of mileages within the geographical area embraced by a longitude span extending from 52 degrees west of Greenwich to 140 degrees west of Greenwich, and a latitude span extending from 24 degrees north latitude to 51 degrees north latitude.

In spherical trigonometry computations, wherein longitude is reckoned from the Greenwich, or zero, meridian to points west, negative values will be encountered after passing 90 degrees west longitude. To avoid the complication inherent in dealing with negative quantities, the true, or map, longitude values are "adjusted" by subtracting 52 degrees from the true or map value. Thus, it will be seen that the Greenwich, or zero, meridian of longitude will have been supplanted as the reference meridian by the 52-degree west longitude meridian, which is the most easterly longitude that defines the geographical area with relation to which the present invention is described. Therefore all of the points located within the said area will be defined in terms of their "adjusted longitude" or their distance west of 52 degrees west longitude. Hereinafter, when referring to longitudinal data it is to be understood that the values will be expressed in terms of "adjusted" longitude.

In the present invention, the arranger circuits employed to facilitate the obtaining from the precomputed tables the geographical distances in miles by which the calling and called offices are separated must be supplied with grounds, corresponding to coded data, to control their operation. The coded control data indicates the respective geographical positions of the calling and called offices expressed in tens, units, tenths and hundredths of degrees of latitude and "adjusted longitude."

The called subscriber's area code (or XOX) register **3**–ACR embodies a circuit modification whereby the three digits registered therein responsive to the dialing of a particular area code will, upon the operation of the corresponding relays, ground one of the leads numbered two to nine in the H or hundreds digit group; will ground the zero lead in the T or tens digit; and will ground one of the ten leads in the U or units digit group. The grounds representing the digits registered in the H, T and U digital registers will be respectively transmitted via cable **3**–AH to the windings of relays **6**–AT–**2** to **6**–AT–**9** inclusive (of which **6**–AT–**5** to **6**–AT–**8**, inclusive, are not shown); via conductor **3**–AT to the armatures of relays **6**–AT–**2** to **6**–AT–**9** inclusive; and via cable **3**–AU to the armatures of relays **6**–AT–**20**, **6**–AT–**30**, **6**–AT–**40**, **6**–AT–**50**, **6**–AT–**60**, **6**–AT–**70**, **6**–AT–**80** and **6**–AT–**90** (of which **6**–AT–**50**, **6**–AT–**60**, **6**–AT–**70**, and **6**–AT–**80** are not shown) of the area code translator-connector circuit **6**–AT.

The absence of the digits 0 and 1 in the H digit register and the absence of the digits 1 to 9 in the T digit register is due to the fact that the type of telephone switching system with which the present exemplary disclosure of the invention is adapted to function is so designed that the first or H digit of the area code must not be a 1 or a 0, and the second or T digit must be a 0. However, modifications of the invention to use the omitted digits in each of the three denominational orders will readily occur to those skilled in the art.

The called subscriber's office code (or ABC) register **3**–OCR embodies a circuit modification whereby the three digits registered therein responsive to the dialing of a particular office code, upon the operation of the corresponding relays, grounds two leads in each group of five leads comprising the A, B and C digit groups. The grounds representing in the two-out-of-five code the digits registered in the A, B and C registers, are transmitted via cables 3–OA, 3–OB and 3–OC, respectively, to the A, B and C groups of armatures of the relays of the office code translator-connector circuit **6–OT**. Relays **6–OT–203** and **6–OT–903** are representative of a large plurality of such relays, the A, B and C armatures of which are respectively multipled together.

To illustrate the operation of the area code translator-connector circuit **6–AT** and the office code translator-connector circuit **6–OT**, let us assume that relays **3–AH–0**, **3–AH–2**, **3–AT–4**, **3–AT–7**, **3–AU–1** and **3–AU–2** in the called subscriber's area code register **3–ACR** have been energized to register the area code "203." As a result, grounds are applied to leads "2," "0" and "3" in the H, T and U digit groups, respectively. Grounds on these leads are extended via cable **3–AH**, conductor **3–AT** and cable **3–AU**, respectively, to the winding of the **6–AT–2** relay, causing it to operate; to the multipled armatures of relays **6–AT–2** to **6–AT–9**, inclusive, (**6–AT–5** through **6–AT–8** are not shown); and to the No. 3 multipled armatures of the relays **6–AT–20**, **6–AT–30**, **6–AT–40**, (**6–AT–50**, **6–AT–60**, **6–AT–70**, **6–AT–80**, are not shown), and **6–AT–90**, respectively, of the area code translator-connector circuit **6–AT**.

Since relay **6–AT–2** is operated, a circuit is completed for relay **6–AT–20** of the area code translator-connector, said circuit extending from ground traced to lead **3–AT**, contacts of relay **6–AT–2**, winding of relay **6–AT–20** to battery. Relay **6–AT–20** operates and completes a circuit for relay **6–OT–203** from ground previously traced to the No. 3 contact of relay **6–AT–20**, winding of relay **6–OT–203**, to battery, operating said latter relay. The operation of relay **6–OT–203** indicates that the particular called office is located in the area identified by the area code "203," and extends the multipled conductors of cables **3–OA**, **3–OB** and **3–OC** through its contacts to the selecting magnets of a latitude and longitude card translator **6–CT–203**. These magnets are energized in the two-out-of-five code in accordance with the number registered in the called subscriber's office code register **3–OCR**.

A latitude and longitude card translator, of which one kind is shown in the patent to C. B. Brown, L. N. Hampton, F. A. Thiel, Jr., No. 2,774,821 of December 18, 1956, is provided for each foreign area, such as, for example, translator **6–CT–203** for the area 203, a group of such translators being indicated by the designation **6–CT**, and may be selectively chosen in response to a predetermined one of a plurality of area codes. Each translator is equipped with a plurality of cards, one card for each office in the area, and is selectable in response to a particular called office code. Each card is perforated with a different pattern or arrangement of apertures representing the latitude and longitude of a particular called office, and is designed to effect the simultaneous closure of one contact each in the tens, units, tenths and hundredths digits for the latitude contact group, and similarly one contact each in the tens, units, tenths and hundredths digits for the longitude contact group. The translator card thus selected will express in tens, units, tenths and hundredths of degrees, the latitude and longitude of the called office.

To illustrate the operation of the latitude and longitude card translator **6–CT–203** (as an example for all the others) let us assume that relays **3–OA–0**, **3–OA–4**, **3–OB–1**, **3–OB–7**, **3–OC–0** and **3–OC–7** in the called subscriber's office code register **3–OCR** have been energized to register the office code "487." As a result, grounds are applied to leads "0" and "4" in the A digit group; to leads "1" and "7" in the B digit group; and to leads "0" and "7" in the C digit group. Grounds on the leads in the A, B and C digit groups are extended via the cables **3–OA**, **3–OB** and **3–OC**, respectively, to the multipled A, B and C armatures, respectively, of the relays **6–OT–203** and **6–OT–903** of the office code translator-connector **6–OT**.

Selecting magnets **6–203–A–0**, **6–203–A–4**, **6–203–B–1**, **6–203–B–7**, **6–203–C–0** and **6–203–C–7** of the latitude and longitude card translator **6–CT–203** operate in circuits which may be traced from battery through their windings, through contacts and armatures of relay **6–OT–203** numbered "0" and "4" of the A digit group; "1" and "7" of the B digit group, and "0" and "7" of the C digit group, respectively, thence, via cables **3–OA**, **3–OB** and **3–OC**, respectively, to ground on leads "0" and "4" of the A digit group; "1" and "7" of the B digit group; and "0" and "7" of the C digit group of the called subscriber's office code register circuit **3–OCR**.

The operation of the selecting magnets of the latitude and longitude card translator **6–CT–203** causes the actuation of the selecting mechanism thereof to effect the selection of one of a plurality of translator cards.

Let us assume, for example, that the translator card selected in response to the office code "487" has a perforation pattern therein designed to close contacts "3," "9," "0" and "0" in the tens, units, tenths and hundredths digits, respectively, of the latitude group, and contacts "7," "0," "0," and "0" in the tens, units, tenths and hundredths digits, respectively, of the longitude group. The above-described pattern of contact closures will indicate to the latitude and longitude arranger circuits the geographical position of the called office as defined by latitude 39.00 degrees and longitude 70.00 degrees.

Therefore to indicate the latitude of the called office, grounds are extended from the tens, units, tenths and hundredths contacts of the latitude and longitude card translators **6–CT–203** and **6–CT–903**, representing the No. 1 and No. 80 card translators, respectively, (and also from the contacts of the card translators intermediate thereto, but not shown), via multiple cable **6–LA** and thence, respectively, via cables **11–CDT**, **12–CDU**, **13–CDTH** and **14–CDH** to the tens, units, tenths and hundredths inputs of the called office latitude arranger circuit.

Similarly, to indicate the longitude of the called office, grounds are extended from the tens, units, tenths and hundredths contacts of the latitude and longitude card translators **6–CT–203** and **6–CT–903** (and also from the contacts of the card translators intermediate thereto, but not shown), via multiple cable **6–LG** and thence, respectively, via cables **7–CDT**, **8–CDU**, **9–CDTH** and **10–CDH** to the tens, units, tenths and hundredths inputs of the called office longitude arranger circuit. In the same manner, if the call is for a subscriber in an office located within another foreign area, for example the area 903, then translator **6–CT–903** individual to the area would be chosen, the card individual to the called office therein would be selected, and conductors in cable **6–LA** would be selectively grounded to express the latitude and longitude of the office.

The sender **3–S** also includes a calling subscriber's area and office code cross-connection circuit **5–CC**, on which certain terminals are permanently grounded to express the latitude and longitude designation of the calling office. When the sender **3–S** has been seized and has operated in the usual manner incident to the placing of a call, the off-normal relay **5–ON** operates and causes the longitude-latitude relay **5–LL** to operate and apply ground to terminals **5–LAT** and **5–LON**. Terminals **5–LAT** are cross-connected to the terminals below in a pattern indicative of the latitude of the calling office, expressed in tens, units, tenths and hundredths of degrees, so that ground from certain of the contacts of relay **5–LL** is applied to one lead in each group of ten leads in the tens, units, tenths and hundredths digits of the latitude group. Likewise, terminals **5–LON** are cross-connected to the terminals below in a pattern indicative of the longitude of the calling office, expressed in tens, units, tenths and hundredths of degrees; so that ground from certain other contacts of relay 5–LL is applied to one lead in each group of ten leads in the tens, units, tenths and hundredths digits of the longitude group. Let us, for example, assume that the calling office is positionally identified by latitude 39.50 degrees and longitude 70.35 degrees. The latitude of the calling office is then represented by connecting one of each of the 5–LAT terminals to the terminals "three," "nine," "five" and "zero" terminals of the tens, units, tenths and hundredths digits, respectively, of the latitude group. Similarly, the longitude of the calling office is expressed by connecting one of each of the 5–LON terminals to the number "seven," "zero," "three" and "five" terminals of the tens, units, tenths and hundredths digits, respectively, of the longitude group. The connections, or straps, are placed at the time the central office equipment is installed.

Therefore, to indicate the longitude of the calling office, ground is extended from the longitude tens, units, tenths and hundredths terminals via cable 5–LG and thence, respectively, via cables 7–CGT, 8–CGU, 9–CGTH and 10–CGH to the input of the longitude arranger circuit. Similarly, to indicate the latitude of the calling office, ground is extended from the latitude tens, units, tenths and hundredths leads, via cable 5–LA and thence, respectively, via cables 11–CGT, 12–CGU, 13–CGTH and 14–CGH to the input of the latitude arranger circuit.

As has been previously stated, one of the principal objects of the present invention is to automatically determine the distance in "great circle" miles between the calling and the called central offices. The circuits for implementing the practices set forth in the previously mentioned American Telephone and Telegraph Company pamphlet for the determination of such distances are designed to accomplish a series of arithmetical operations to be performed in steps and in a predetermined order.

The first arithmetical step required to be performed is that of comparing the relative magnitudes of the longitudes of the calling and called offices, and so arranging their values that the larger and the smaller of the two magnitudes shall be respectively presented to the longitude subtractor circuit shown on Figs. 15 to 18, inclusive, as the minuend and the subtrahend thereof.

Concurrently with the comparison of the magnitudes of the longitudes will be performed the operation of comparing the relative magnitudes of the latitudes of the calling and called offices, and so arranging their values that the larger and the smaller of the two magnitudes shall be respectively presented to the latitude subtractor circuit, shown on Figs. 19 to 22, inclusive, as the minuend and the subtrahend thereof.

The above-mentioned operations will be performed by the longitude arranger circuit shown on Figs. 7 to 10, inclusive; and the latitude arranger circuit shown on Figs. 11 to 14, inclusive.

We have previously described the circuit means whereby grounds, corresponding to the indicia representative of the longitudes and the latitudes of the calling and the called central offices, are extended to their respective terminations in the longitude and the latitude arranger circuits. Now when the four-digit numbers, respectively representative of the longitudes (or latitudes) of a calling and a called office are presented to the arranger circuit, and if the number representative of the longitude (or latitude) of the calling office is equal to or greater than that of the longitude (or latitude) of the called office, the grounded leads indicative of the longitudes (or latitudes) of the calling and called offices will be connected through the back contacts of the switching relays (such as 7–SW–1, 8–SW–2, etc.) of the arranger circuits to the subtractor circuit; the leads indicative of the identity of the calling office will be connected as the minuend, and the leads indicative of the identity of the called office will be connected as the subtrahend. Should the number representative of the longitude (or latitude) of the called office be greater than the number representative of the longitude (or latitude) of the calling office, the circuits of the highest denominational order in which such greater value is present will cause the operation of the switching relays (such as 7–SW–1, 8–SW–2, etc.) and connect the grounded leads, indicative of the longitudes (or latitudes) of the called and calling offices, through the front contacts of the switching relays of the arranger circuits to the subtractor circuits; the leads indicative of the identity of the called office will be connected as the minuend, and the leads indicative of the identity of the calling office will be connected as the subtrahend.

In the exemplary disclosure, we have assumed that the longitudes of the calling and called offices are W.70.35° and W.70.00°, respectively. To represent the longitude of the calling office, leads 7–CGT–7, 8–CGU–0, 9–CGTH–3 and 10–CGH–5 are grounded by the operation of the previously described calling subscriber's area and office code cross-connecting circuit 5–CC, via cable 5–LG, and thence via cables 7–CGT, 8–CGU, 9–CGTH and 10–CGH, respectively. To represent the longitude of the called office, leads 7–CDT–7, 8–CDU–0, 9–CDTH–0 and 10–CDH–0 are grounded by the operation of the previously described latitude and longitude card and translator circuit 6–CT–203, via cable 6–LG, and thence, via cables 7–CDT, 8–CDU, 9–CDTH and 10–CDH, respectively.

The function of the longitude arranger circuit is to determine, as is that of the latitude arranger circuit, which of the two multi-digit quantities presented thereto is the larger and to transmit the larger and smaller of these two quantities as the minuend and subtrahend, respectively, to the subtractor circuit.

In the example given and presently described, the quantity 70.35, representing the longitude of the calling office is greater than the quantity 70.00, representative of the longitude of the called office. Since the calling and called office quantities are the same in the tens and units digits, it is evident that the comparison of magnitudes must be in the next, or tenths, digit where the calling and called office values are "3" and "0," respectively.

Relays 7–CDT–7, 8–CDU–0 and 9–CDTH–0 operate in circuits from battery, through their respective windings to grounded leads 7–CDT–7, 8–CDU–0 and 9–CDTH–0, respectively. The operation of these relays does not perform any useful function at this time for the particular tens and units values presented thereto. Relay 9–CDTH–0, however, completes a circuit for operating relay 9–CO–3 over a path extending from negative battery, through its winding, conductor 9–CC–1, through diode 9–D–3, and number 3 contact of relay 9–CDTH–0, to the grounded lead 9–CGTH–3.

The operation of relay 9–CO–3 disables the operating circuit of relay 10–SW–4. This prevents the hundredths digit from having any control over the comparison of the longitude magnitudes, should the hundredths digit value for the called office exceed the hundredths digit value for the calling office. This safeguard is necessary since the determination of the larger magnitude of the two longitudes will have been accomplished by the "tenths" digit circuit.

Relays 7–SW–1, 8–SW–2, 9–SW–3 and 10–SW–4 remain unoperated, no operating circuits having been completed therefor by the above-described circuit operations.

Since the calling office longitude of 70.35 degrees is larger than the called office longitude of 70.00 degrees, the grounded leads indicating their respective values are connected directly through the back contacts of the switching relays 7–SW–1, 8–SW–2, 9–SW–3 and 10–SW–4 as the minuend and subtrahend, respectively, for the subtractor circuit.

Since the tens digit of the number representing the longitude of the calling office is 7, and the tens digit of the number representing the longitude of the called office is also 7, the two tens digits, are equal in value. Hence the grounded lead 7–CGT–7 indicative of the tens digit value of the longitude of the calling office will be connected through the No. 18 back contacts of relay 7–SW–1, via lead **15–LOSM–7** (longitude subtractor minuend 7) of the tens digit input minuend leads of the longitude subtractor circuit. Similarly the grounded lead 7–CDT–7, indicative of the tens digit value of the longitude of the called office, will be connected through the No. 8 back contacts of relays 7–SW–1, via lead **15–LOSS–7** (longitude subtractor subtrahend 7), of the input subtrahend leads of the adjusted longitude subtractor circuit.

Also, since the units digits of the two numbers respectively representing the longitudes of the calling and the called offices are both zero they, too, are equal. Hence the grounded lead **8–CGU–0**, indicative of the units digit values of the longitude of the calling office, will be connected through the No. 11 back contacts of relay **8–SW–2**, via lead **16–LOSM–0**, of the units digit input minuend leads of the adjusted longitude subtractor circuit. Similarly, the grounded lead **8–CDU–0**, indicative of the units digit value of the longitude of the called office, will be connected through the No. 1 back contacts of relay **8–SW–2**, via lead **16–LOSS–0**, to the units digit input subtrahend leads of the longitude subtractor circuit.

The tenths digit of the number representing the longitude of the calling office is assumed to be a "3," and is obviously larger than the tenths digit of the number representing the longitude of the called office which is assumed to be a "0." Hence the grounded lead **9–CGTH–3**, indicative of the tenths digit value of the longitude of the calling office, will be connected through the No. 14 back contacts of relay **9–SW–3**, via lead **17–LOSM–3**, to the tenths digit of the minuend of the longitude subtractor circuit. Similarly, the grounded lead **9–CDTH–0**, indicative of the tenths digit value of the longitude of the called office, will be connected through the No. 1 back contacts of relay **9–SW–3**, via lead **17–LOSS–0**, to the tenths digit of the subtrahend of the longitude subtractor circuit.

The hundredths digit of the number representing the longitude of the calling office is assumed to be a "5," and is obviously larger than the hundredths digit of the number representing the longitude of the called office which is assumed to be "0." Hence the grounded lead **10–CGH–5** indicative of the hundredths digit value of the longitude of the calling office will be connected through the No. 16 back contacts of relay **10–SW–4**, via lead **18–LOSM–5**, to the hundredths digit of the minuend of the longitude subtractor circuit. Similarly, the grounded lead **10–CDH–0**, indicative of the hundredths digit value of the longitude of the called office will be connected through the No. 1 back contacts of relay **10–SW–4**, via lead **18–LOSS–0**, to the hundredths digit of the subtrahend of the longitude subtractor circuit.

Thus far the detailed circuit description has been confined to a discussion of the operation of those portions of the exemplary disclosure of the arranger circuits which are involved in the comparison of the magnitudes of the numbers representing the longitudes of the calling and the called central offices.

In order that the functioning of the latitude arranger circuits may be fully understood, let us first assume that the latitude of the calling office is N.40.00 degrees and that the latitude of the called office is N.30.00 degrees. To represent the latitude of the calling office, leads **11–CGT–4**, **12–CGU–0**, **13–CGTH–0** and **14–CGH–0** will have been grounded by the operation of the previously described calling subscriber's area and office code cross-connecting circuit 5–CC, via cable 5–LA, and thence via cables **11–CGT**, **12–CGU**, **13–CGTH** and **14–CGH**, respectively. To represent the latitude of the called office, leads **11–CDT–3**, **12–CDU–0**, **13–CDTH–0** and **14–CDH–0** will have been grounded by the operation of the previously described latitude and "adjusted longitude" card translator circuit **6–CT–203**, via cable 6–LA, and, thence, via cables **11–CDT**, **12–CDU**, **13–CDTH** and **14–CDH**, respectively.

Since, as previously stated, the purpose of the latitude arranger circuits is, in part, to determine which of two numbers presented thereto is the larger, it follows that if the tens digit of the first of two multi-digit numbers presented to the arranger is larger than the tens digit of the second multi-digit number, the whole first multi-digit number is the larger, and will be presented to the subtractor circuit as the minuend.

Relays **11–CDT–3**, **12–CDU–0** and **13–CDTH–0** will operate in circuits from battery through their respective windings, to grounded leads **11–CDT–3**, **12–CDU–0** and **13–CDTH–0** respectively. The operation of relays **12–CDU–0** and **13–CDTH–0** performs no useful function when the number representing the latitude of the calling office is represented by a zero in the units and tenths denominational orders, as in the particular example above assumed. Relay **11–CDT–3**, on operating, completes circuits for energizing relays **11–CO–1**, **12–CO–2** and **13–CO–3**. Relay **11–CO–1** operates in a circuit from negative battery through its winding, via common conductor **11–CC–1**, through diode **11–D–4**, No. 4 contacts of relay **11–CD–3**, to the grounded lead **11–CGT–4**. Relay **12–CO–2** operates in a circuit from negative battery through its winding, via common conductor **12–CC–1**, through diode **11–D–10**, via common conductor **11–CC–1**, through diode **11–D–4**, the No. 4 contacts of relay **11–CDT–3** to grounded lead **1–CGT–4**. Relay **13–CO–3** operates in a circuit from negative battery through its winding, common conductor **13–CC–1**, through diode **12–D–10**, via common conductor **12–CC–1**, through diode **11–D–10** and thence to ground via common conductor **11–CC–1**, as previously described.

The operation of relays **11–CO–1**, **12–CO–2** and **13–CO–3** disables the operating circuits for relays **12–SW–2**, **13–SW–3** and **14–SW–4**. The normal condition of the latter relays prevents the units, tenths and hundredths digits from having any control over the comparison of the latitude magnitudes, should any of those digits have larger values in the subtrahend than in the minuend. This safeguard is necessary since the determination of the relative magnitudes of the two latitudes will have been accomplished by the tens digit circuit.

The diodes depicted herein, such as **11–D–4**, **11–D–10** and **12–D–10**, for example, are of substantially unilateral conductivity and permit the flow of currents therethrough sufficient to operate relays when their respective cathodes are supplied with a potential which is negative with respect to the anodes.

Relays **11–SW–1**, **12–SW–2**, **13–SW–3** and **14–SW–4** will remain unoperated, no operating circuits having been completed therefor by the above-described circuit operations.

Since the tens digit of the number representing the latitude of the calling office is assumed to be a "4," and the tens digit of the number representing the latitude of the called office is assumed to be a "3," the grounded lead **11–CGT–4** indicating larger of the two tens digits will be connected through the No. 15 back contacts of relay **11–SW–1**, via lead **19–LASM–4**, to the tens digit of the minuend of the latitude subtractor circuit. Similarly, the grounded lead **11–CDT–3** indicating the smaller of the two tens digits, will be connected through the No. 4 back contacts of relay **11–SW–1**, via lead **19–LASS–3**, to the tens digit of the subtrahend of the latitude subtractor circuit.

The grounded lead **12–CGU–0** indicating the units digit value of the latitude of the calling office is connected through the No. 11 back contacts of relay **12–SW–2**, via lead **20–LASM–0**, to the units digit of the minuend of the latitude subtractor. Similarly, the grounded lead **12–CDU–0** indicating the units digit value of the latitude of the called office, is connected through the No. 1 back contacts of relay **12–SW–2**, via lead **20–**

LASS–0, to the units digit of the subtrahend of the latitude subtractor circuit.

The grounded lead **13–CGTH–0** indicating the tenths digit value of the latitude of the calling office is connected through No. 11 back contacts of relay **13–SW–3**, via lead **21–LASM–0**, to the tenths digit of the minuend of the latitude subtractor circuit. Similarly, the grounded lead **13–CDTH–0**, indicating the tenths digit value of the latitude of the called office is connected through the No. 1 back contacts of relay **13–SW–3**, via lead **21–LASS–0**, to the tenths digit of the subtrahend of the latitude subtractor circuit.

The grounded lead **14–CGH–0** indicating the hundredths digit value of the latitude of the calling office is connected through No. 11 back contacts of relay **14–SW–4**, via lead **22–LASM–0**, to the hundredths digit of the minuend of the latitude subtractor circuit. Similarly, the grounded lead **14–CDH–0** indicating the hundredths digit value of the latitude of the called office is connected through No. 1 back contacts of relay **14–SW–4**, via lead **22–LASS–0**, to the hundredths digit of the subtrahend of the latitude subtractor circuit.

From the foregoing description it is apparent that the grounds representing a calling office latitude of 40.00 degrees and a called office latitude of 30.00 degrees will be applied to the latitude subtractor circuit as the minuend and the subtrahend, respectively.

Let us now assume that values of the latitudes of the calling and called offices in the preceding example are reversed. The latitudes of the calling and called offices are now N.30.00 degrees and N.40.00 degrees, respectively. To represent the latitude of the calling office, leads **11–CGT–3**, **12–CGU–0**, **13–CGTH–0** and **14–CGH–0** are grounded by operation of the previously described subscriber's area and office code cross-connecting circuit **5–CC** via the previously described paths. To represent the latitude of the called office, leads **11–CDT–4**, **12–CDU–0**, **13–CDTH–0** and **14–CDH–0** are grounded by the operation of the previously described latitude and adjusted longitude card translator circuit **6–CT–203** via the previously described paths.

Relays **11–CDT–4**, **12–CDU–0** and **13–CDTH–0** now operate in circuits from battery, through their respective windings to the grounded leads **11–CDT–4**, **12–CDU–0** and **13–CDTH–0**, respectively. The operation of relays **12–CDU–0** and **13–CDTH–0** does not perform any useful function when the number of the latitude of the calling office is represented by a zero in the units and tenths denominational orders, as in the particular example above described.

Relay **11–SW–1** now operates in a circuit from negative battery through its winding, via common conductor **11–CC–2**, through diode **11–D–14**, through the No. 3 contacts of relay **11–CDT–4** to the grounded lead **11–CGT–3**. Relay **12–SW–2** operates in a circuit from negative battery through its winding, via common conductor **12–CC–2**, through diode **11–D–20**, via common conductor **11–CC–2**, through diode **11–D–14**, through the No. 3 contacts of relay **11–CDT–4**, to the grounded lead **11–CGT–3**. Relay **13–SW–3** also operates in a circuit from negative battery through its winding, via common conductor **13–CC–2**, through diode **12–D–20**, via common conductor **12–CC–2**, to ground through the previously described path, on the lead **11–CGT–3**. Relay **14–SW–4** also operates in a circuit from negative battery through its winding, via common conductor **14–CC–2**, through diode **13–D–20**, via common conductor **13–CC–2**, through diode **12–D–20**, via common conductor **12–CC–2**, to ground through the previously described path on the lead **11–CGT–3**.

Relays **11–SW–1**, **12–SW–2**, **13–SW–3** and **14–SW–4**, when operated, switch the two sets of grounded leads representing the latitudes of the calling and called offices.

Since the tens digit of the latitude of the calling office is now assumed to be a "3" and the tens digit of the latitude of the called office is now assumed to be a "4," the grounded lead **11–CDT–4** indicating the larger of the two tens digit numbers, is connected through the No. 15 front contacts of relay **11–SW–1**, via lead **19–LASM–4** to the tens digit of the minuend of the latitude subtractor. Similarly, the grounded lead **11–CGT–3** indicating the smaller of the two tens digit numbers, is connected through No. 4 front contacts of relay **11–SW–1**, via lead **19–LASS–3** to the tens digit of the subtrahend of the latitude subtractor.

The grounded lead **12–CGU–0**, indicating the units digit value of the latitude of the calling office is connected through the No. 1 front contacts of relay **12–SW–2**, via lead **20–LASS–0**, to the units digit of the subtrahend of the latitude subtractor. Similarly, the grounded lead **12–CDU–0**, indicating the units digit value of the latitude of the called office is connected through the No. 11 front contacts of relay **12–SW–2**, via lead **20–LASM–0**, to the units digit of the minuend of the latitude subtractor.

The grounded lead **13–CGTH–0** indicating the tenths digit value of the latitude of the calling office is connected through the No. 1 front contacts of relay **13–SW–3**, via lead **21–LASS–0**, to the tenths digit of the subtrahend of the latitude subtractor. Similarly, the grounded lead **13–CDTH–0** indicating the tenths digit value of the latitude of the called office is connected through the No. 11 front contacts of relay **13–SW–3**, via lead **21–LASM–0**, to the tenths digit of the minuend of the latitude subtractor.

The grounded lead **14–CGH–0** indicating the hundredths digit value of the latitude of the calling office is connected through the No. 1 front contacts of relay **14–SW–4**, via lead **22–LASS–0**, to the hundredths digit of the subtrahend of the latitude subtractor. Similarly, the grounded lead **14–CDH–0** indicating the hundredths digit value of the latitude of the called office is connected through the No. 11 front contacts of relay **14–SW–4**, via lead **22–LASM–0**, to the hundredths digit of the minuend of the latitude subtractor.

From the foregoing description it is apparent that the grounds representing a calling office latitude of N.30.00 degrees and a called office latitude of N.40.00 degrees will be applied, by virtue of the switching function of relays **11–SW–1**, **12–SW–2**, **13–SW–3** and **14–SW–4**, to the latitude subtractor circuit as the subtrahend and the minuend, respectively.

Relays **7–SW–1**, **8–SW–2**, **9–SW–3** and **10–SW–4**, in the longitude arranger circuit operate in a manner similar to that of relays **11–SW–1**, **12–SW–2**, **13–SW–3** and **14–SW–4** to perform the function of switching the grounded input leads representing longitudes of the calling and called offices so that the larger and the smaller of the two numbers will be presented to the longitude subtractor circuit as the minuend and the subtrahend, respectively.

In the exemplary disclosure of the present invention, certain values of latitudes and longitudes for the calling and called offices have been assumed for illustrative purposes. The calling subscriber's area and office code cross-connecting circuit **5–CC** show the terminals **5–LAT** cross-connected to represent a latitude of N.39.50 degrees and the terminals **5–LON** cross-connected to represent a longitude of W.70.35 degrees for the calling office. The latitude and longitude card translator **6–CT–203**, it is assumed, will have selected a card which is perforated with a pattern that effects the closure of contacts therein representing a latitude of N.39.00 degrees and a longitude of W.70.00 degrees for the called office, as illustrated in Fig. 6.

Assuming, then, that the latitude of the calling office is N.39.50 degrees, leads **11–CGT–3**, **12–CGU–9**, **13–CGTH–5** and **14–CGH–0** will have grounds applied thereto from the contacts of relay **5–LL**, via cross-connections of terminals **5–LAT**, to the latitude tens, units, tenths and hundredths leads, via cable 5–LA, and thence, respectively, via cables **11–CGT**, **12–CGU**, **13–CGTH** and **14–CGH**.

Assuming, also, that the latitude of the called office is N. 39.00 degrees, leads **11–CDT–3**, **12–CDU–9**, **13–CDTH–9** and **14–CDH–0** will have grounds applied thereto from the contacts of card translator **6–CT–203** to the tens, units tenths and hundredths leads, via cable **6**-LA, and thence respectively, via cables **11–CDT**, **12–CDU**, **13–CDTH** and **14–CDH**.

Relays **11–CDT–3**, **12–CDU–9** and **13–CDTH–0** will operate in circuits through their respective windings to the grounded leads **11–CDT–3**, **12–CDU–9** and **13–CDTH–0**, respectively. Relay **13–CDTH–0**, in operating, completes a circuit for energizing relay **13–CO–3** over a circuit from negative battery through its winding, via common conductor **13–CC–1**, diode **13–D–5**, the No. 5 contacts of relay **13–CDTH–0** to the grounded lead **13–CGTH–5**. The operation of relay **13–CO–3** disables the operating circuit for relay **14–SW–4**, and prevents the hundredths digit from having any control over the comparison of the latitude magnitudes, as previously explained.

The grounded lead **11–CGT–3** indicating the tens digit value of the latitude of the calling office is connected through the No. 14 back contacts of relay **11–SW–1**, via lead **19–LASM–3** to the tens digit of the minuend of the latitude subtractor circuit. Similarly, the grounded lead **11–CDT–3** indicating the tens digit value of the latitude of the called office is connected through the No. 4 back contacts of relay **11–SW–1**, via lead **19–LASS–3**, to the tens digit of the subtrahend of the latitude subtractor circuit.

The grounded lead **12–CGU–9** indicating the units digit value of the latitude of the calling office is connected through the No. 20 back contacts of relay **12–SW–2**, via lead **20–LASM–9**, to the units digit of the minuend of the latitude subtractor circuit. Similarly the grounded lead **12–CDU–9** indicating the units digit value of the latitude of the called office is connected through the No. 10 back contacts of relay **12–SW–2**, via lead **20–LASS–9**, to the units digit of the subtrahend of the latitude subtractor circuit.

The grounded lead **13–CGTH–5** indicating the tenths digit value of the latitude of the calling office is connected through the No. 16 back contacts of relay **13–SW–3**, via lead **21–LASM–5**, to the tenths digit of the minuend of the latitude subtractor circuit. Similarly the grounded lead **13–CDTH–0** indicating the tenths digit value of the latitude of the called office is connected through the No. 1 back contacts of relay **13–SW–3**, via lead **21–LASS–0**, to the tenths digit of the subtrahend of the latitude subtractor circuit.

The grounded lead **14–CGH–0** indicating the hundredths digit value of the latitude of the calling office is connected through the No. 11 back contacts of relay **14–SW–4**, via lead **22–LASM–0**, to the hundredths digit of the minuend of the latitude subtractor circuit. Similarly the grounded lead **14–CDH–0** indicating the hundredths digit value of the latitude of the called office is connected through the No. 1 back contacts of relay **14–SW–4**, via lead **22–LASS–0**, to the hundredths digit of the subtrahend of the latitude subtractor.

It will be noted in the above-described example that since the value of the calling latitude number (N.39.50) is greater than that of the called latitude number (N.39.00), the switching, or value-reversing relays **11–SW–1**, **12–SW–2**, **13–SW–3** and **14–SW–4**, are not required to be operated. The larger and the smaller of the two latitude numbers are directly applied to the latitude subtractor circuit as the minuend and subtrahend, respectively.

It will be obvious that for latitudes north of the equator, given two numbers representative of two different latitudes, the larger of the two numbers will represent the more northerly of the two offices respectively identified thereby. In relation to this fact, particular attention is directed to relay **14–SW–4**, the operating circuits for which have been previously described. Relay **14–SW–4** will operate only under those conditions where the magnitude of the latitude of the called office is greater than, and hence the more northerly, than that of calling office. From which it follows that the latitude values must be respectively reversed in order to present the larger and smaller values of the latitude subtractor circuit as the minuend and the subtrahend, respectively. Hence with relay **14–SW–4** normal, as will be the case when the number expressive of the latitude of the calling office is the larger number, ground furnished responsive to the seizure of the sender will be applied over its No. 21 back contacts to lead **14–N**, and thence through the winding of north latitude connector relay **31–NLAC** to negative battery. When operated, relay **14–SW–4** will apply the above ground through its No. 21 front contacts to lead **14–S**, and thence through the winding of south latitude connector relay **33–SLAC** to negative battery. Relay **31–NLAC** or **33–SLAC** in the latitude connector and rate location circuit will operate in the above-described circuits, the former completing the connections required for the condition where the latitude of the calling office is north of the latitude of the called office, the latter completing the connections required for the condition where the latitude of the calling office is south of the latitude of the called office.

The exemplary disclosure of the present invention contemplates a system designed to serve an area bounded on the south by latitude N.24.00 degrees and on the north by N.51.00 degrees. The easterly and westerly boundaries will be 0.00 degrees and 88.00 degrees, respectively, "adjusted" longitude. This area embraces all of the United States, the southern portion of Canada and the northern part of Mexico.

The present invention envisages the interconnection of any two of the large plurality of central offices provided to serve the United States and portions of the contiguous land areas. Every central office will have its geographical position defined by degrees, or decimal parts thereof, of latitude and longitude.

Let it be assumed that the above-described service area is represented on a spherical section map on which the respective positions of all of the central offices are indicated. Let it be further assumed that the map be inscribed with lines parallel to the equator and spaced one hundredth of a degree of latitude apart. The map will then consist of a large plurality of horizontal strips one hundredth of a degree in width. Each horizontal strip will be respectively identified by its own "toll index number." Each central office lying within the confines of a given horizontal strip, irrespective of its longitude, is defined by the same lower toll index number. As illustrated in the table shown in Fig. 84, column 2, the 27 degrees of latitude (the difference between N.24.00 and N.51.00) encompassed by the service area are each divided into hundredths of degrees, each of the latter being identified by its corresponding toll index number. Thus the one degree span bounded by latitude N.24.00 degrees and N.25.00 degrees includes toll index numbers from 2400 to 2499 (see Fig. 84, column 1).

The geographical north-to-south distance between parallels of latitude is substantially uniform (about 70.1 miles) over the entire range of latitudes spanned by N.24.00 degrees to N.51.00 degrees. It is obvious, however, that because of the convergence of the meridians of longitude at the poles, the east-to-west geographical distances measured along the several parallels of latitude will decrease as the assumed positions of the calling or called offices are moved northward.

As particular examples, let us consider the variations in mileages encountered in measuring east-to-west distances along the most southerly latitude (N.24.00 degrees) and the most northerly latitude (N.51.00 degrees) contemplated in the present disclosure. One degree of longitude at latitude N.24.00 degrees will span an east-to-west distance of approximately 61 miles, while one degree of longitude at N.51.00 degrees will span an east-to-west distance of approximately 44 miles. It will be apparent that a table computed to give extremely close approximations to true mileages for a calling office having an assumed latitude of N.24.00 degrees would introduce an undesirably large percentage of error if used for a calling office having an assumed latitude of N.51.00 degrees. Likewise, a table computed to give close approximations to true mileages at a calling office having an assumed latitude of N.51.00 degrees would be unsatisfactory for a calling office having an assumed latitude of N.24.00 degrees.

In the exemplary disclosure of the present invention, the distance in "great circle" miles between the calling and the called offices will be determined by consulting, at the calling office, the appropriate one of a plurality of "relay tables." The use of three sets of tables, respectively covering mileage ranges of 0 to 40 miles, 40 to 400 miles, and 400 to 4,000 miles, is contemplated.

Let it also be assumed that the previously mentioned spherical section map be inscribed with longitudinal lines dividing each degree of longitude into hundredths of degrees. The spherical section map will now consist of a large number of trapezoids, each bounded by .01 degree of latitude and .01 degree of longitude, as indicated in the southeast quadrant of Fig. 85. One degree of latitude being equal to 70.1 miles; .57 degree of latitude equals approximately 40 miles north to south distance. One degree of longitude at N.51.00 degrees, the most northerly latitude on our spherical section map, being equal to approximately 44 miles; .91 degree of longitude equals approximately 40 miles east to west distance. The trapezoids defined by the hundredth degree divisions of latitude and longitude are referred to as "incremental areas." Fig. 88 discloses, in part, a typical one of a series of precomputed 40-mile tables for determining, from the difference in latitude and the difference in longitude between a calling and a called central office, the distance in "great circle" miles between the calling and the called central office, each of which may be in different incremental areas of the entire spherical section map of the area being served by this invention. It will be evident, of course, and as shown in Figs. 85, 86 and 87 that one of the two offices will be in a given 40-mile table, which table may be, in turn, contained with the much larger 400-mile table, and the latter, in turn, may be contained in the 4000-mile table.

Referring again to the table of Fig. 88, the column at the left, designated *d*K, shows the difference in latitude in increments of .01 degree, while the horizontal row of figures at the top, designated *d*L, shows the difference in longitude in increments of .01 degree. Given the difference in latitude and the difference in longitude, the great circle mileage distance between the calling and the called central offices in the 40-mile zone will be found at the intersection of the designated vertical column and designated horizontal row. The table particularly shown in Fig. 88 is useful for distances up to 40 miles, and applies only to central offices identified by toll index numbers lying between 4000 and 4299, which is referred to in Fig. 84, column 4, as 40-mile table number 45. Other 40-mile tables, generally similar to the one shown in Fig. 88 and applicable to central offices identified by toll index numbers 2400 to 2899, 2900 to 3299, 3300 to 3699, 3700 to 3999, 4300 to 4499, 4500 to 4699, 4700 to 4899, and 4900 to 5099, are referred to in Fig. 84, column 4, as 40-mile table numbers 41, 42, 43, 44, 46, 47, 48 and 49, respectively.

Fig. 85 shows four adjacent 0 to 40-mile areas, the southeast areas disclosing the pattern of output terminal strapping to be employed, and is in accordance with the precomputed data set forth in Fig. 88, which is a typical one of such precomputed tables. The southeast area is roughly in the shape of a quarter ellipse. The southwest area, indictaed in dotted outline, would be a mirror image of the southeast quadrant and would be served by the same precomputed data table. The northeast area, indicated in dotted outline, due to errors inherent in computing distances from the point of origin to a point in a higher latitude, would differ substantially from an inverted image of the southeast quadrant. The northwest quadrant indicated in dotted outline, would be a mirror image of the northeast quadrant and could be served by the same precomputed table serving the northeast area. At the left side of the southeast area the bracket ΔK–1 refers to the ΔK–1 values or horizontal coordinates set forth in Fig. 88.

The ΔK–1 values in Figs. 85 and 88 represent increments of .01 degree of latitude and are equivalent to .701 mile. The complete set of ΔK–1 values will span a south-to-north distance of approximately 40 miles. The several latitude bands, each to be served by a separate table as specified in the previously mentioned American Telephone and Telegraph Company pamphlet will always be two or more degrees of latitude in width. Therefore, more than one 0 to 40-mile table will be required at a calling office only if the latitude of the calling office is within .56 degree of the upper limit of application of the normally specified table for that band of latitudes (or toll indices).

In Fig. 85, at the top of the southeast area, the bracket ΔL–1 refers to the ΔL–1 values or vertical coordinates set forth in Fig. 88. The ΔL–1 values in Figs. 85 and 88 represent increments of .01 degree of longitude and will have equivalent mileage values varying with latitude. At the southernmost limit of the area to be served .01 degree of longitude is equivalent to .615 mile and at the northernmost limit of the area .01 degree of longitude is equivalent to .439 mile.

The 0 to 40-mile table shown in part in Fig. 88 is applicable to any central office whose toll index numbers lie between 4000 and 4299. The horizontal or ΔK–1 coordinate entries are shown for the full range of values to be employed. The ΔL–1 or vertical coordinate entries are incomplete. In practice, the ΔL–1 values will be .00 degree to .91 degree.

The 40 to 400 mile tables are computed between geographical incremental areas bounded by .1° of latitude and .1° of longitude as shown on Fig. 86. Every 40 to 400 mile table embraces a north to south span of 5.79° of latitude. In Fig. 86, the dotted ellipsoidal area at the center represents the area served by the 0 to 40 mile table, shown in Fig. 85, superimposed thereon. In Fig. 86, the southeast area will embrace an area in the shape of a quarter ellipse and the southwest area will be a mirror image thereof. The northeast area will also embrace a quarter ellipse having a different minor axis length and the northwest area will be a mirror image thereof. At the left and top sides of the southeast area are respectively shown brackets ΔK–2 and ΔL–2 which refer, respectively, to the horizontal and vertical coordinate entries thereto.

The ΔK–2 values in Fig. 86 represent increments of .1° of latitude and are equivalent to 7.01 miles. The complete set of ΔK–2 values will span a south to north distance of approximately 400 miles. More than one 40 to 400 mile table will be required at a calling office only if the latitude of the calling office is within 1.78° of the upper limit of application of the normally specified table for that band of latitudes (or toll indices).

The 400 to 4000 mile tables are computed between geographical incremental areas bounded by 1.° of latitude and 1.° of longitude as shown by the four adjacent such areas on Fig. 87. A separate 400 to 4000 mile table will be computed for each degree of latitude, and will serve a south to north span of 1.° of latitude, or 70.1

miles. Each 400 to 4000 mile table actually consists of two half-tables. The lower half-table serving adjacent southeast and southwest areas is designed to determine great circle distances when the latitude of the called office is south of the latitude of the calling office. The upper half-table serving the adjacent northeast and northwest areas is designed to determine great circle distances when the latitude of the called office is north of the latitude of the calling office. The southeast areas is roughly in the shape of a quarter ellipse, and the southwest area will be a mirror image thereof. The northeast area will also be similar in shape to the southeast area, but will not be a true inverted image thereof. The northwest area will be a mirror image of the northeast area. The use of two half-tables, each comprising a compilation of a different set of precomputed mileage values, is necessary because the distance in miles between meridians of longitude will be greater at the southern limiting latitude of the service area, and diminishing because of the convergence of the meridians of longitude at the poles, as the assumed latitude values become more northerly. At the left and bottom sides of the southeast area are respectively shown brackets ΔK–3 and ΔL–3 which refer, respectively, to the horizontal and vertical coordinate entries thereto. The employment of either the south or the north half-table will be controlled by the latitude arranger circuit which will have determined whether the latitude of the called office is north or south of the latitude of the calling office and will, accordingly, cause the ΔK–3 factors to be applied to the appropriate half-table. In Fig. 87, the areas served by the 0 to 40 mile table and the 40 to 400 mile table are indicated by the two concentric ellipsoids superimposed thereon and indicated in dotted outline.

The ΔK–1, ΔK–2 and ΔK–3 values are latitude difference indicia and the ΔL–1, ΔL–2 and ΔL–3 values are longitude difference indicia supplied by the tree circuits under control of data supplied by the subtractor circuits via the rounding circuits in a manner which will later be described in detail.

In order that acceptably accurate mileage determinations may be obtained with the employment of the minimum number of precomputed tables, a compromise assignment of a given mileage table to a limited band of latitudes has been devised, as set forth in the table shown on Fig. 84.

Data, precalculated by the traffic engineers, included in the previously mentioned American Telephone and Telegraph Company pamphlet by way of example, specifies which of a plurality of precomputed tables shall be applicable to a central office the toll index number of which lies within a prescribed block of toll index numbers. Let us again assume, for example, that the latitude of the calling office is N.39.50 degrees. If we consult Fig. 84, which shows in tabulated form the correlated data set forth in the above-mentioned pamphlet, we will find that latitude N.39.50° (the assumed latitude of the calling office) lies between N.39.00° and N.40.00° (see ranges of latitudes as set forth in Fig. 84, column 2); and lies within a narrow horizontal strip or area which is 1/10 of a degree in width, and which, in accordance with the previous explanation, is identified by toll index number 3950 (see Fig. 84, column 1). We will also find that central offices whose toll index numbers lie between 3700 and 3999 (see Fig. 84, column 1) are encompassed by a latitude span of three degrees, from N.37.00° to N.40.00°, and covering a north to south distance of 210.3 miles; see Fig. 84, column 6. We will further find that central offices whose toll index numbers lie between 3700 and 3999 are to be served either by the 0 to 40 mile table number 44; the 40 to 400 mile table number 404 (see Fig. 84, column 4) or one of the three 400 to 4000 mile tables 4014, 4015 or 4016 (see Fig. 84, column 5). The number, in any instance, of the particular 400 to 4000 mile tables to be furnished at a calling office must correspond to the numbers of the two parallels of latitude between which the calling office is located. The latitude arranger circuit will, as previously described, compare the magnitudes of the two numbers respectively representative of the latitudes of the calling and called offices, and will connect the larger and the smaller of the two numbers to the minuend and the subtrahend, respectively, of the latitude subtractor circuit. The tens and units conductors from the latitude arranger circuit are also connected to a plurality of relays constituting a band choice circuit. The band choice circuit functions in a manner later described in detail to apply grounds to the "band choice" leads (see Fig. 84, column 3) to effect the choice of the appropriate relay tables.

Each relay table comprises a plurality of multi-contact relays in which all of the armatures of each level are respectively multipled together and to an input conductor. A ground supplied by the tree circuit, indicative of a particular one of a plurality of possible latitude difference, or ΔK, values, is applied to the corresponding input conductor as the horizontal input coordinate to the relay tables. Also, a ground supplied by the tree circuit, indicative of a particular one of a plurality of possible longitude or ΔL, values, is applied to the corresponding multi-contact relay winding as the vertical input coordinate to the relay table. The conjoint effect of the simultaneous application of an input ground to one of each of the horizontal and vertical input coordinates is to extend ground to a terminal, or a plurality of terminals strapped together, the pattern of interconnection being expressive of, and in accordance with, a corresponding table of precomputed great circle mileage data.

A relay table comprising a plurality of relays electrically interconnected in a pattern simulative of the precomputed data listed in the 0 to 40 table of Fig. 88, is shown on Figs. 55, 56, 57 and 58.

A relay table comprising a plurality of relays electrically interconnected in a pattern simulative of the precomputed data listed in one of the 40 to 400 mile tables is shown on Figs. 39, 40, 41 and 42.

A relay table comprising a plurality of relays electrically interconnected in a pattern simulative of the precomputed data listed in one of the 400 to 4000 mile tables, is shown on Figs. 31, 32, 33 and 34.

Assume, for example, that the latitudes of the calling and called offices are respectively N.39.50 degrees and N.39.00 degrees, and that the longitudes of the calling and called offices are respectively W.70.35 degrees and W.70.00 degrees, as diagrammatically illustrated in Fig. 90 and also indicated in the table shown in Fig. 89, condition 1. The table in Fig. 84, column 2, shows the latitude band; column 1 shows that the corresponding toll index number is 3950; column 4 shows that the 0 to 40 mile table number 44, and the 40 to 400 mile table number 404 will be required; column 5 shows that the 400 to 4000 mile table number 4016 will be required, and column 6 shows that the latitude band is 3 degrees in width. We will find that the upper limit of application of the 0 to 40 mile table number 44 is N.40.00 degrees, and since the latitude of the calling office is N.39.50 degrees and hence within only .50 degrees of the upper limit of application, we must provide an additional 0 to 40 mile table, which will be the number 45, the next highest numbered 0 to 40 mile band.

In the table shown in Fig. 89 are listed a number of hypothetical combinations of latitude and longitude; each combination positionally defining a calling and a called office. Fig. 89 also correlates, in tabular form, certain operational relationships, as will hereinafter be described.

In Fig. 89, columns 1 and 2, for a first example, indicate a first condition, as illustrated in Fig. 90, where the latitudes of the calling and called offices are, respectively, 39.50 degrees and 39.00 degrees. Column 1 shows the calling latitude of 39.50 degrees underscored, with the legend "minuend" placed thereunder; indicating that the latitude arranger circuit will have determined the number representative of the calling latitude to be the larger and thus to be presented to the latitude subtractor circuit as the minuend. Column 3 shows the difference between the calling and called office latitudes, as will have been obtained by the latitude subtractor circuit to be 00.50, and also shows the resolution of the difference into the factors ΔK–1, ΔK–2 and ΔK–3, to be applied to the number rounding circuits. Column 4 shows the ΔK–1, ΔK–2 and ΔK–3 values after having been "rounded off" to be applied to the relay tables as the horizontal coordinate inputs. Column 5 shows the south to north distance in miles equivalent to the rounded latitude differences shown in column 4. Columns 6 and 7 indicate, as an example, a condition where the longitudes of the calling and called offices are respectively 70.35 degrees and 70.00 degrees. Column 6 shows the calling longitude of 70.35 degrees underscored, with the legend "minuend" placed thereunder, indicating that the longitude arranger circuit will have determined the number representative of the calling adjusted longitude to be the larger and thus to be presented to the longitude subtractor circuit as the minuend. Column 8 shows the difference between the calling and called office longitudes as will have been obtained by the adjusted longitude subtractor circuit, and also the resolution of the difference into the factors ΔL–1, ΔL–2 and ΔL–3 to be applied to the number rounding circuits. Column 9 shows the ΔL–1, ΔL–2 and ΔL–3 values after having been "rounded off" to be applied to the relay tables as the vertical coordinate inputs. Columns 11, 12 and 13 show that relay tables numbered 44, 404 and 4016 will function in condition 1 to be described. In column 12, table number 404 is underscored, with the legend "ans" placed thereunder; indicating that the answer, in the condition 1 to be described, will be obtained from the 40 to 400 mile table number 404.

Fig. 89, columns 1 and 2, for a second example (condition 2) indicate a second condition as illustrated in Fig. 91, where the latitudes of the calling and called offices are, respectively, N.40.00 degrees and N.39.50 degrees. Column 1 shows the calling latitude of N.40.00 degrees underscored, with the legend "minuend" placed thereunder, indicating that the latitude arranger circuit will have determined the number representative of the calling latitude to be the larger and thus to be presented to the latitude subtractor circuit as the minuend. Column 3 shows the difference between the calling and called office latitudes to be 00.50 as will have been obtained by the latitude subtractor circuit, and also shows the resolution of the difference into the factors ΔK–1, ΔK–2 and ΔK–3, to be applied to the number rounding circuits. Column 4 shows the ΔK–1, ΔK–2 and ΔK–3 values after having been "rounded off" to be applied to the relay tables as the horizontal coordinate inputs. Columns 5, 6, 7, 8 and 9 are functionally the same as in the first condition (1) and need not be again described. Columns 11, 12 and 13 show that relay tables numbered 45, 405 and 4017 will function in the second condition to be described. In column 11, table number 45 is underscored, with the legend "ans" placed thereunder, indicating that the answer in the second condition to be described will be obtained from the 0 to 40 mile table number 45.

Fig. 89, columns 1 and 2, for a third example, indicate a third condition (3) as illustrated in Fig. 92, where the latitudes of the calling and called offices are, respectively, N.44.00 degrees and N.39.50 degrees. Column 1 shows the calling latitude of N.44.00 underscored with the legend "minuend" placed thereunder, indicating that the latitude arranger circuit will have determined the number representative of the calling latitude to be the larger and thus to be presented to the latitude subtractor circuit as the minuend. Column 3 shows the difference between the calling and called office latitudes to be 04.50 as will have been determined by the latitude subtractor circuit, and also shows the resolution of the difference into the factors ΔK–1, ΔK–2 and ΔK–3, to be applied to the number rounding circuits. Column 4 shows the ΔK–1, ΔK–2 and ΔK–3 values after having been "rounded off" to be applied to the relay tables as the horizontal coordinate inputs. Columns 5, 6, 7, 8 and 9 functionally are as previously described. Columns 12 and 13 show that relay tables numbered 406 and 4021 will function in the third condition (3) to be described. In column 12, table number 406 is underscored, with the legend "ans" placed thereunder, indicating that the answer, in the third condition (3) to be described will be obtained from the 40 to 400 mile table number 406.

Fig. 89, columns 1 and 2, for a fourth example, indicate a fourth condition (4) as illustrated in Fig. 93 when the latitudes of the calling and called offices are, respectively, N.45.00 degrees and N.39.50 degrees. Column 1 shows the calling office latitude of N.45.00 degrees underscored, with the legend "minuend" placed thereunder, indicating that the latitude arranger circuit will have determined the number representative of the called latitude to be the larger and thus to be presented to the latitude subtractor circuit as the minuend. Column 3 shows the difference between the calling and called office latitudes to be 0550, as will have been determined by the latitude subtractor circuit, and also shows the resolution of the difference into the factors ΔK–1, ΔK–2 and ΔK–3, to be applied to the number rounding circuits. Column 4 shows the ΔK–1, ΔK–2 and ΔK–3 values after having been "rounded off" to be applied to the relay tables as the horizontal coordinate inputs. Columns 5, 6, 7, 8 and 9 functionally are as previously described. Columns 12 and 13 show that relay tables numbered 407 and 4022 will function in the fourth condition to be described. In column 13 table number 4022 is underscored, with the legend "ans" placed thereunder, indicating that the answer, in the fourth condition to be described, will be obtained from the 400 to 4000 mile table number 4022.

Fig. 89, columns 1 and 2, for a fifth, and last, example, indicates a fifth condition (5) as illustrated in Fig. 94, where the latitudes of the calling and called offices are, respectively, N.46.00 degrees and N.39.50 degrees. Column 1 shows the calling office latitude of N.46.00 degrees underscored, with the legend "minuend" placed thereunder, indicating that the latitude arranger circuit will have determined the number representative of the calling latitude to be the larger and thus to be presented to the latitude subtractor circuit as the minuend. Column 3 shows the difference between the calling and called latitudes to be 06.50 as will have been determined by the latitude subtractor circuit, and also shows the resolution of the difference into the factors ΔK–1, ΔK–2 and ΔK–3 to be applied to the number rounding circuits. Column 4 shows the ΔK–1, ΔK–2 and ΔK–3 values, after having been "rounded off," to be applied to the relay tables as the horizontal coordinate inputs. Columns 5, 6, 7, 8 and 9 are as previously described. Columns 12 and 13 show that relay tables numbered 407 and 4023 will function in the fifth condition (5) to be described. In column 13, table number 4023 is underscored, with the legend "ans" placed thereunder, indicating that the answer in the fifth condition to be described will be obtained from the 400 to 4000 mile table number 4023.

It should be remembered that only one 400 to 4000 mile relay table will be furnished at each central office. The particular table required for a given calling central office will be determined by a latitude band one band degree wide within which said calling central office is located. However, to facilitate the understanding of the invention we have assumed as examples conditions 1 to 5 (as indicated in Fig. 89) which are illustrative of a plurality of hypothetical calling central office locations, each of which requires thereat the use of a different 400 to 4000 mile table, as shown in Fig. 89, column 13.

In the determination of the mileage between the calling and any called office, the three pairs of coordinate inputs; namely ΔK–1 with ΔL–1; ΔK–2 with ΔL–2 and ΔK–3 with ΔL–3 will be simultaneously presented to the 0 to 40 mile, the 40 to 400 mile, and the 400 to 4000 mile tables, respectively. The answer will be sought, first in the 400 to 4000 mile table. If not found in this table the answer will then be sought in the 40 to 400 mile table, and if not found in the latter table finally will be sought in the 0 to 40 mile table. The search for the answer will be terminated at the first table in which the answer may be found.

We will now describe the operation of the band selection circuit whereby grounds indicative of latitude values and applied to the leads connecting the tens and units digits output of the latitude arranger circuit to the tens and units digits, respectively, of the minuend input of the latitude subtractor circuit, control the extension of a ground to determine which relay table, or tables, of a plurality of such tables furnished at the calling office will be required to determine the distance in great circle miles for a particular call.

As a first example, let us consider condition 1 as illustrated in Fig. 90 and as indicated in the table in Fig. 89, columns 1 and 2. The latitude of the calling office is N.39.50 degrees and, being the larger, is presented to the latitude subtractor circuit as the minuend. Band choice relay **11–BC–3** operates in a circuit from negative battery through its winding, to ground on lead **19–LASM–3** of the tens digit of the minuend of the latitude subtractor circuit. Ground on lead **20–LASM–9** is applied via diode **20–D–39**, thence via common conductor **20–C–4**, through the front contact of relay **11–BC–3** to lead **11–B–4** (see Fig. 84, column 3) extending to the winding of latitude connector relays **51–LAC–44** for the 0 to 40 mile table No. 44, and to the winding of relay **35–LAC–404** for the 40 to 400 mile table No. 404 in parallel, and also through the back contacts of relay **64–B–5** through the winding of relay **64–B–4** in the basic rate translator circuit to negative battery. Relays **51–LAC–44** and **35–LAC–404** operate and close a plurality of contacts to connect the ΔK–**1** and ΔK–**2** coordinate input factor leads to the 0 to 40 and to the 40 to 400 mile relay tables, Nos. 44 and 404, respectively. Relay **64–B–4** operates and performs a function that will be described later in detail. Since the calling office latitude is north of the called office latitude, relay **14–SW–4** remains unoperated, and ground from the sender off normal SON is applied through its No. 21 back contacts, lead **14–N**, the winding of latitude connector relay **31–NLAC**, to battery, operating said relay. In operating, its closes a plurality of contacts to connect the ΔK–3 coordinate input factor leads to the north half of the 400 to 4000 mile relay table which, for condition 1, would be table No. 4016.

To summarize: a 3 and a 9 respectively presented to the tens and units digits of the latitude subtractor minuend input causes the application of ground to band choice lead **11–B–4** (see Fig. 84, column 3), which operates the latitude connector relays **51–LAC–44** and **35–LAC–404**, connecting the 0 to 40 mile table No. 44, and the 40 to 400 mile relay table No. 404 to the ΔK–**1** and ΔK–**2** outputs, respectively, of the latitude tree circuit. The non-operation of relay **14–SW–4**, indicating that the latitude of the calling office is the more northerly, effects the operation of relay **31–NLAC** to cause the north half of the table, assumed in this example to be table 4016, to be connected to the ΔK–3 output of the latitude tree circuit.

Fig. 89, column 3, shows that the subtractor output difference in latitude between the calling and called office is .50 degree. Column 8 shows that the subtractor output difference in longitude between the calling and the called office is .35 degree. These latitude and longitude differences are respectively applied to the inputs of the latitude and the longitude number rounding circuits (to be explained later) which furnish, respectively, the three sets of ΔK– and ΔL– values as shown in columns 4 and 9, respectively. The latitude difference of .50 degree is "rounded" by the latitude number rounding circuit to values ΔK–1=.50 degree, ΔK–2=.05 degree, and ΔK–3=.01 degree, respectively equivalent to 35, 35 and 70 miles in a south to north direction as shown in column 5. The derivation of these mileages will be apparent from a study of Figs. 85, 86 and 87 wherein the south to north mileage dimensions of the incremental areas are equivalent to .7, 7. and 70 miles, respectively. The longitude difference of .35 degree is "rounded" by the longitude number rounding circuit to values of ΔL–1=.35 degree, ΔL–2=.04 degree, and ΔL–3=.00 degree, the respective east to west mileages of which will vary with latitude. The ΔK–**1** and ΔL–**1**; ΔK–**2** and ΔL–**2**; and ΔK–3 and ΔL–3 values are respectively applied to the inputs of tables Nos. 44, 404 and 4016 and the answer, being just beyond the scope of the 0 to 40 mile relay table, is obtained from the 40 to 400 mile table number 404, as indicated in column 12.

As a second example of the operation of the band selection circuit let us consider condition 2 as illustrated in Fig. 91 and as indicated in Fig. 89, columns 1 and 2. The assumed latitude of the calling office is N.40.00 degrees and the latitude of the called office is assumed as being N.39.50 degrees. The latitude of the calling office, being N.40.00 degrees is the larger and will be presented to the latitude subtractor circuit as the minuend. Band choice relay **11–BC–4** in this case operates in a circuit from negative battery through its winding, to ground on lead **19–LASM–4** of the tens digit of the minuend of the latitude subtractor circuit. Ground on lead **20–LASM–0** is applied, via diode **20–D–40**, thence via common conductor **20–C–5**, through front contact No. 1 of relay **11–BC–4** to lead **11–B–5** (see Fig. 84, column 3) extending to the windings of latitude connector relays **55–LAC–45** (for the 40 mile table No. 45) and **39–LAC–405** (for the 400 mile table No. 405) in parallel, and also through the back contact of relay **64–B–4** through the winding of relay **64–B–5** in the basic rate translator circuit, to negative battery. Relays **55–LAC–45** and **39–LAC–405** operate and close a plurality of contacts to connect the ΔK–**1** and ΔK–**2** factor input leads to the 0 to 40 and 40 to 400 mile tables, Nos. 45 and 405, respectively. Relay **64–B–5** operates to perform a circuit function which will later be described in detail. Since the calling office latitude is north of the called office, relay **14–SW–4** remains unoperated, and ground from the sender off normal SON is applied through its No. 21 back contacts, lead **14–N**, the winding of latitude connector relay **31–NLAC**, to battery, operating said relay. In operating, relay **31–NLAC** closes a plurality of contacts to connect the ΔK–3 coordinate input factor leads to the north half of the 400 to 4000 mile relay table which, for condition 2, would be No. 4017.

To summarize: a 4 and 0, respectively presented to the tens and units digits of the latitude subtractor minuend input, causes the application to ground to band choice lead No. **11–B–5** (see Fig. 84, column 3) which operates the latitude connector relays **55–LAC–45** and **39–LAC–405**, connecting the 40 mile relay table No. 45 and the 400 mile relay table No. 405 to the output of the latitude tree circuit. The non-operation of relay **14–SW–4**, indicating that the latitude of the calling office is the more northerly, effects the operation of relay **31–NLAC** to cause the north half of the table, assumed in this example to be table No. 4017, to be connected to the ΔK–3 output of the latitude tree circuit.

In Fig. 89 it will be evident that for condition 2 all of the data in columns 3 to 9, inclusive, are identical with the corresponding data for condition 1, previously described. In column 1, however, the latitude of the calling office is N.40.00. The latitude difference is the same as in condition 1, but since the latitude of the calling office is further north than in condition 1 described in the preceding example, and because of the convergence of the meridians of longitude, the distance, in miles, equivalent to the rounded longitude difference shown in column 9, will be smaller than in condition 1. Therefore, the answer in great circle miles lies just within the range of, and is obtained from, the 0 to 40 mile relay table No. 45; as shown in column 11.

As a third example of the operation of the band selection circuit let us consider condition 3 as illustrated in Fig. 92 and indicated in Fig. 89, columns 1 and 2. The assumed latitude of the calling office is N.44.00 degrees and the latitude of the called office N.39.50 degrees. The latitude of the calling office, being N.44.00 degrees is the larger and is therefore presented to the latitude subtractor circuit as the minuend. Band choice relay **11–BC–4** operates, as previously described, responsive to a 4 in the tens digit of the latitude subtractor minuend input. Ground on lead **20–LASM–4** is applied via diode **20–D–44**, thence via common conductor **20–C–6**, the No. 2 contacts of relay **11–BC–4** to lead **11–B–6** (see Fig. 84, column 3) extending to the winding of latitude connector relay **43–LAC–406** (for the 40 to 400 mile table No. 406). Relay **43–LAC–406** operates and closes a plurality of contacts to connect the ΔK–**2** factor input leads to the 40 to 400 mile relay table No. 406.

Since, as in the preceding example, the calling office is north of the called office, the relay **14–SW–4** remains unoperated and the relay **31–NLAC** operates in circuits as previously described to connect the ΔK–**3** coordinate input factor leads to the north half of the 400 to 4000 mile relay table which, for condition 3, would be No. 4021.

To summarize: a 4 and a 4, respectively presented to the tens and units digits of the latitude subtractor minuend input, causes the application of ground to band choice lead number **11–B–6** (see Fig. 84, column 3) which operates the latitude connector relay **43–LAC–406**, connecting the 40 to 400 mile relay table No. 406 to the output of the latitude tree circuit. The non-operation of relay **14–SW–4**, indicating that the latitude of the calling office is the more northerly, effects the operation of relay **31–NLAC** to cause the north half of the table, assumed in this example to be table No. 4021, to be connected to the ΔK–**3** output of the latitude tree circuit.

Fig. 89, column 3, shows that the subtractor output difference in latitude between the calling and called office is N.04.50 degrees, which is applied to the input of the latitude number rounding circuit. The latitude number rounding circuit furnishes the "rounded" values of ΔK–**1**=.50 degree, ΔK–**2**=.45 degree, and ΔK–**3**=.05 degree, respectively equivalent to 35, 315 and 350 miles in a south to north direction, as shown in column 5. In Fig. 89 it will be evident that for condition 3 all of the data in columns 6, 7, 8 and 9 are identical with the corresponding data for conditions 1 and 2, previously described. In column 1, however, the latitude of the calling office is N.44.00 degrees. The ΔK–**1** and ΔL–**1**; ΔK–**2** and ΔL–**2**; and ΔK–**3** and ΔL–**3** values are respectively applied to the inputs of the tables numbered 46, 406 and 4021, and the answer is obtained from the 40 to 400 mile relay table number 406, as indicated in column 12.

As a fourth example of the operation of the band selection circuit, let us consider condition 4 as illustrated in Fig. 93 and indicated in Fig. 89, columns 1 and 2. The assumed latitude of the calling office is N.45.00 degrees and the latitude of the called office is N.39.50 degrees. The latitude of the calling office, being 45.00 degrees, is the larger and will be presented in the latitude subtractor circuit as the minuend. Band choice relay **11–BC–4** then operates as previously described, responsive to a 4 in the tens digit of the latitude subtractor minuend input. Ground on lead **20–LASM–5** is applied via diode **20–D–45**, thence via common conductor **20–C–7**, through the No. 3 front contacts of relay **11–BC–4**, to lead **11–B–7** (see Fig. 84, column 3) extending to the winding and battery of latitude connector relay **47–LAC–407** (for the 40 to 400 mile relay table No. 407). Relay **47–LAC–407** operates and closes a plurality of contacts to connect the ΔK–**2** factor input leads to the 40 to 400 mile relay table No. 407. Since, as in the preceding example, the calling office is north of the called office, relay **14–SW–4** remains unoperated and relay **31–NLAC** will operate in a circuit as previously described to connect the ΔK–**3** coordinate input factor leads to the north half of the 400 to 4000 mile relay table which, for condition 4, would be table No. 4022.

To summarize: a 4 and a 5, respectively presented to the tens and units digits of the latitude subtractor minuend input, causes the application of ground to band choice lead No. **11–B–7** (see Fig. 84, column 3) which operates the latitude connector relay **47–LAC–407**, connecting the 40 to 400 mile relay table No. 407 to the output of the latitude tree circuit. The non-operation of relay **14–SW–4**, indicating that the latitude of the calling office is the more northerly, effects the operation of relay **31–NLAC** to cause the north half of the table, assumed in this example to be table No. 4022, to be connected to the ΔK–**3** output of the latitude tree circuit.

Fig. 89, column 3, shows that the subtractor output difference in latitude between the calling and the called offices is N.05.50 degrees, which is applied to the input of the latitude number rounding circuit. The latitude number rounding circuit furnishes the "rounded" values of ΔK–**1**=.50 degree, ΔK–**2**=.55 degree, and ΔK–**3**=.06 degree, respectively equivalent to 35, 386 and 420 miles in a south to north direction as shown in column 5. In Fig. 89, it will be evident that for condition 4 all of the data in columns 6, 7, 8 and 9 are identical with the corresponding data for conditions 1, 2 and 3, previously described. In column 1, however, the latitude of the calling office is N.45.00 degrees. The ΔK–**1** and ΔL–**1**; ΔK–**2** and ΔL–**2**; and the ΔK–**3** and ΔL–**3** values are respectively applied to the inputs of the tables numbered 47, 407 and 4022, and the answer is obtained from the 400 to 4000 mile table number 4022, as indicated in column 13.

As a fifth and last example of the operation of the band circuit, let us consider condition 5 as illustrated in Fig. 94 and indicated in Fig. 89, columns 1 and 2. The assumed latitude of the calling office is 46.00 degrees and the latitude of the called office is N.39.50 degrees. The latitude of the calling office being 46.00 degrees is the larger and will be presented to the latitude subtractor circuit as the minuend. Band choice relay **11–BC–4** will operate, as previously described, responsive to a 4 in the tens digit of the latitude subtractor minuend input. Ground on lead **20–LASM–6** is then applied via diode **20–D–46**, thence via common conductor **20–C–7**, through front contact No. 3 of relay **11–BC–4** to lead **11–B–7** (see Fig. 84, column 3) extending to the winding and battery of latitude connector relay **47–LAC–407** (for the 40 to 400 mile relay table No. 407). Relay **47–LAC–407** operates to connect the ΔK–**2** factor input leads to the 40 to 400 mile relay table No. 407. Since, as in the preceding example, the calling office is north of the called office, the relay **14–SW–4** remains unoperated and the relay **31–NLAC** will operate in circuits as previously described. Relay **31–NLAC** will, as previously described, connect the ΔK–**3** coordinate input factor leads to the north half of the 400 to 4000 mile relay table which, for condition 5, would be table No. 4023.

To summarize: a 4 and a 6, respectively presented to the tens and units digits of the latitude subtractor minuend input, causes the application of ground to band choice lead number **11–B–7** (see Fig. 84, column 3) which operates the latitude connector relay **47–LAC–407**, connecting the 40 to 400 mile relay table No. 407 to the output of the latitude tree circuit. The non-operation of relay **14–SW–4**, indicating that the latitude of the calling office is the more northerly, as previously described, effects the operation of relay **31–NLAC** to cause the north half of the table, assumed in this example to be table No. 4023, to be connected to the ΔK–3 output of the latitude tree circuit.

Fig. 89, column 3, shows that the subtractor output difference in latitude between the calling and the called office is N.06.50 degrees which is applied to the input of the latitude number rounding circuit. The latitude number rounding circuit furnishes the "rounded" values of ΔK–1=.50 degree, ΔK–2=.65 degree, and ΔK–3=.07 degree, respectively equivalent to 35, 456 and 490 miles in a south to north direction as shown in column 5. In Fig. 89 it will be evident that for condition 5 all of the data in columns 6, 7, 8 and 9 are identical with the corresponding data for conditions 1 to 4, previously described. In column 1, however, the latitude of the calling office is N.46.00 degrees. The ΔK–1 and ΔL–1; ΔK–2 and ΔL–2; and ΔK–3 and ΔL–3 values are respectively applied to the inputs of the tables numbered 47, 407 and 4023, and the answer is obtained from the 400 to 4000 mile table number 4023, as indicated in column 13.

From the above description of the several examples of the operation of the band selection circuit it will be apparent that the tens digit of the larger of the two values of latitude presented to the latitude arranger circuit will extend a ground, via the latitude arranger circuit to cause the operation of the assigned band choice relay. It is also apparent that the units digit of the larger of the two values of latitude presented to the latitude arranger circuit will extend a ground, via the latitude arranger circuit, via a diode, and through a contact on the operated band choice relay to an assigned band choice lead, which is determined by the value of the tens and units digits of the larger of the two values of latitude presented to the latitude arranger circuit, as indicated in Fig. 84, column 3.

We have, in the preceding pages, described a plurality of hypothetical conditions each representative of a calling and a called central office positionally defined by a different combination of latitudes and longitudes, and have stated, in general terms, the resulting outputs derived from the subtractor and number rounding circuits.

The second arithmetical step required to be performed in determing the distance in great circle miles between a calling and a called central office, which we will now describe in detail, is that of subtracting the smaller from the larger of the two numbers respectively representative of the longitudes of the calling and the called central offices, and, concurrently therewith, subtracting the smaller from the larger of the two numbers respectively representative of the latitudes of the calling and the called central offices.

The above-mentioned operations are performed by the longitude subtractor circuit shown on Figs. 15 to 18, inclusive; and the latitude subtractor circuit shown on Figs. 19 to 22, inclusive.

We have traced, in the previous description relating to the longitude arranger circuit and the latitude arranger circuit, the circuit operations by which grounds representative of the longitudes and the latitudes of the calling and the called central offices, will be extended to their respective terminations in the longitude and the latitude subtractor circuits.

The minuend and subtrahend input leads of the longitude subtractor circuit will have grounds applied thereto as a result of the functioning of the longitude arranger circuit, which grounded leads are respectively representative of the larger and the smaller of the two numbers expressive of the longitudes of the calling and the called central offices. Likewise, the minuend and subtrahend input leads of the latitude subtractor circuit will have grounds applied thereto as a result of the functioning of the latitude arranger circuit, which grounded leads are respectively representative of the larger and the smaller of the two numbers expressive of the latitudes of the calling and the called central offices.

In the exemplary disclosure we have assumed that the longitudes of the calling and called central offices are W.70.35 degrees and W.70.00 degrees respectively. The longitude arranger circuit, having determined that 70.35 degrees and 70.00 degrees are, respectively, the larger and the smaller of the two numbers, will have caused ground to be extended to leads 15–LOSM–7, 16–LOSM–0, 17–LOSM–3 and 18–LOSM–5 to express the calling central office longitude number 70.35 degrees; and will have caused grounds to be extended to leads 15–LOSS–7, 16–LOSS–0, 17–LOSS–0 and 18–LOSS–0 to express the called central office adjusted longitude number 70.00 degrees.

The function of the longitude subtractor circuit is to determine the difference, expressed in tens, units, tenths and hundredths of degrees, between the adjusted longitudes of the calling and the called central offices.

Relays 15–LOSS–7, 16–LOSS–0, 17–LOSS–0 and 18–LOSS–0 will operate in circuits from battery through their respective windings, to grounded leads 15–LOSS–7, 16–LOSS–0, 17–LOSS–0 and 18–LOSS–0, respectively. Ground on leads 15–LOSM–7, 16–LOSM–0, 17–LOSM–3 and 18–LOSM–5, will be extended through front contacts respectively numbered 0, 0, 3 and 5, of operated relays 15–LOSS–7, 16–LOSS–0, 17–LOSS–0 and 18–LOSS–0, respectively, to leads 15–LOTD–0, 16–LOUD–0, 17–LOTHD–3 and 18–LOHD–5, respectively.

With relays 15–LOTS, 16–LOUS and 17–LOTHS normal, grounds on leads 15–LOTD–0, 16–LOUD–0 and 17–LOTHD–3 are extended through back contacts on armatures respectively numbered 0, 0, and 3 on relays 15–LOTS, 16–LOUS and 17–LOTHS, respectively, to leads 23–LOTD–0, 24–LOUD–0 and 25–LOTHD–3 to the input to the longitude number rounding circuit. Lead 18–LOHD–5 is directly connected to the number rounding circuit. Grounds presented to the number rounding circuit via the above-mentioned four leads indicate longitude tens difference 0, longitude units difference 0, longitude tenths difference 3 and longitude hundredths difference 5, respectively; provided that in the subtrahend no digit thereof has a value exceeding the value of the corresponding digit in the minuend, as illustrated in the example below.

$$\begin{array}{r} 70.35 \\ -70.00 \\ \hline 00.35 \end{array}$$

The relays 15–LOTS, 16–LOUS and 17–LOTHS, signifying longitude tens shift, longitude units shift, and longitude tenths shift, respectively, function as "borrow" relays when the value of the units, tenths or hundredths digits in the subtrahend exceeds the value of the corresponding digit in the minuend.

To illustrate the "borrow" function of the relays 15–LOTS, 16–LOUS and 17–LOTHS let us, as before, assume that the longitude value of 70.35 degrees is presented to the longitude subtractor circuit as the minuend, and that grounds are present on leads 15–LOSM–7, 16–LOSM–0, 17–LOSM–3 and 18–LOSM–5. Let us now assume that the value of the longitude to be presented to the longitude subtractor circuit is 69.99, and that grounds are present on leads 15–LOSS–6, 16–LOSS–9, 17–LOSS–9 and 18–LOSS–9. Relays 15–LOSS–6, 16–LOSS–9, 17–LOSS–9 and 18–LOSS–9 now operate in circuits from battery through their respective windings, to grounded leads 15–LOSS–6, 16–LOSS–9, 17–LOSS–9 and 18–LOSS–9, respectively. Ground on leads 15–LOSM–7, 16–LOSM–0, 17–LOSM–3 and 18–LOSM–5 will then be extended through front contacts respectively numbered 1, 1, 4 and 6 of operated relays 15–LOSS–6, 16–LOSS–9, 17–LOSS–9 and 18–LOSS–9, respectively, to leads 15–LOTD–1, 16–LOUD–1, 17–LOTHD–4 and 18–LOHD–6, respectively, and will indicate that the difference, undiminished by borrowing, between the minuend and the subtrahend tens, units, tenths and hundredths digits is, respectively 1, 1, 4 and 6; as illustrated in the example below.

Tens	Units	Tenths	Hundredths
7 −6	0 −9	3 −9	5 −9
1	1	4	6

Since the units, tenths and hundredths digits of the subtrahend have values exceeding the corresponding digits of the minuend, a borrowing operation is required. Continuing with the above assumed values of longitude we will now describe the functioning of the borrowing circuits.

Ground on lead 18–LOSM–5, is extended through diode 18–D–59, via common conductor 18–CC–9, through the No. 10 contacts on relay 18–LOSS–9, via conductor 17–LOTHS, through the winding of relay 17–LOTHS to negative battery. Relay 17–LOTHS operates in this circuit and transfers the leads 25–LOTHD–0 to 25–LOTHD–9, inclusive, connected to the armatures thereof from the normal, or back contacts to the front contacts. Ground on lead 17–LOTHD–4, normally connected through the No. 4 back contacts of relay 17–LOTHS to lead 25–LOTHD–3 and indicative of a difference of 4 in the tenths digit, is connected through the No. 3 front contacts to the lead 25–LOTHD–3, indicative of a difference of 3, having been diminished in value by one. Ground on lead 17–LOSM–3 is extended through diode 17–D–39 via common conductor 17–CC–9, through the No. 10 contacts of relay 17–LOSS–9, via conductor 16–LOUS, through the winding of relay 16–LOUS to negative battery. Relay 16–LOUS operates in this circuit and transfers leads 24–LOUD–0 to 24–LOUD–9, inclusive, connected to the armatures thereof from the normal, or back, contacts to the front contacts. Ground on lead 16–LOUD–1, normally connected through the No. 1 back contacts of relay 16–LOUS to lead 24–LOUD–1 and indicative of a difference of 1 in the units digit, is now connected through the No. 0 contacts of relay 16–LOUS to the lead 24–LOUD–0, indicative of a difference of 0, having been diminished in value by one.

Ground on lead 16–LOSM–0 is extended through diode 16–D–09, via common conductor 16–CC–9, through the No. 10 contacts of relay 16–LOSS–9, via conductor 15–LOTS, through the winding of relay 15–LOTS, to negative battery. Relay 15–LOTS operates in this circuit and transfers the leads 23–LOTD–0 to 23–LOTD–9, inclusive, connected to the armatures thereof from the normal, or back, contacts to the front contacts. Ground on lead 15–LOTD–1 normally connected through the No. 1 back contacts of relay 15–LOTS to lead 23–LOTD–1 and indicative of a difference of 1 in the tens digit, is extended through the No. 0 contacts of relay 15–LOTS to the lead 23–LOTD–0, indicative of a difference of 0, having been diminished in value by one. As a result of the operation of the relays 15–LOTS, 16–LOUS and 17–LOTHS, grounds are applied to leads 23–LOTD–0, 24–LOUD–0, 25–LOTHD–3 and 18–LOHD–6 to indicate that the longitude number rounding circuit is being presented with a longitude difference in the tens, units, tenths and hundredths digits of 0, 0, 3 and 6, respectively, as illustrated below.

$$\begin{array}{r} 70.35 \\ -69.99 \\ \hline 00.36 \end{array}$$

In the exemplary disclosure we have assumed that the latitudes of the calling and called central offices are N.39.50 degrees and N.39.00 degrees, respectively. The latitude arranger circuit, having determined that 39.50 degrees and 39.00 degrees are, respectively, the larger and the smaller of the two numbers, will have caused ground to be extended to leads 19–LASM–3, 20–LASM–9, 21–LASM–5 and 22–LASM–0 to express the calling central office latitude number 39.50 degrees; and will have caused grounds to be extended to leads 19–LASS–3, 20–LASS–9, 21–LASS–0 and 22–LASS–0 to express the called central office latitude No. N.39.00 degrees.

The function of the latitude subtractor circuit is to determine the difference, expressed in tens, units, tenths and hundredths of degrees, between the latitudes of the calling and the called central offices.

Relays 19–LASS–3, 20–LASS–9, 21–LASS–0 and 22–LASS–0 operate in circuits from negative battery through their respective windings, to grounded leads 19–LASS–3, 20–LASS–9, 21–LASS–0 and 22–LASS–0, respectively. Ground on leads 19–LASM–3, 20–LASM–9, 21–LASM–5 and 22–LASM–0, is extended through front contacts respectively numbered 0, 0, 5 and 0, of operated relays 19–LASS–3, 20–LASS–9, 21–LASS–0 and 22–LASS–0, respectively, to leads 19–LATD–0, 20–LAUD–0, 21–LATHD–5 and 22–LAHD–0, respectively.

With relays 19–LATS, 20–LAUS and 21–LATHS normal, grounds on leads 19–LATD–0, 20–LAUD–0 and 21–LATHD–5 are connected through back contacts on armatures respectively numbered 0, 0 and 5 on relays 19–LATS, 20–LAUS and 21–LATHS, respectively, to leads 27–LATD–0, 28–LAUD–0 and 29–LATHD–5 to the input to the latitude number rounding circuit. Lead 22–LAHD–0 connected directly to the number rounding circuit. Grounds presented to the number rounding circuit via the above-mentioned four leads, indicate latitude differences of 0, 0, 5 and 0 in the tens, units, tenths and hundredths digits, respectively, provided that in the subtrahend no digit thereof has a value exceeding the value of the corresponding digit in the minuend, as illustrated in the example below.

$$\begin{array}{r} 39.50 \\ -39.00 \\ \hline 00.50 \end{array}$$

The relays 19–LATS, 20–LAUS and 21–LATHS, signifying latitude tens shift, latitude units shift and latitude tenths shift, respectively, function as "borrow" relays when the value of the units, tenths or hundredths digits in the subtrahend exceed the value of the corresponding digit in the minuend. The above relays functionally correspond to relays 15–LOTS, 16–LOUS and 17–LOTHS, respectively, as described and illustrated in the circuit description relating to the longitude subtractor circuit.

The third arithmetical step required to be performed in determining the distance in great circle miles between the calling and the called central offices is accomplished by the longitude and the latitude number rounding circuits. The purpose of these circuits is to receive, from the longitude and the latitude subtractor circuits respectively indicia representative of the difference in the longitude and the difference in the latitude between the calling and the called central offices, respectively, each expressed as a four digit number, and to transmit each digit, either as received or rounded to the next higher value, to the longitude and the latitude tree circuits.

The longitude number rounding circuit and the latitude number rounding circuit input leads have grounds applied thereto by the longitude subtractor circuit and the latitude subtractor circuit, respectively, indicative of the difference in longitude and the difference in latitude between the calling and the called central offices, and expressed in tens, units, tenths and hundredths of degrees. A further purpose of the longitude number rounding circuit and the latitude number rounding circuit is to extend the input grounds, presented to the tens, units, tenths and hundredths digits thereof, over three pairs of leads to the longitude tree circuit and the latitude tree circuit. Thus, a four digit number presented to the input of the number rounding circuit will be translated into three two digit numbers; each two digit number to be applied as a coordinate input to a corresponding tree circuit. The longitude number rounding circuit and the latitude number rounding circuit are identical in construction and operation.

The fourth arithmetical step in determining the distance in great circle miles between the calling and the called central offices is the utilization by the longitude and the latitude tree circuits of the Δ–K and Δ–L input grounds presented thereto for controlling the selective grounding of Δ–K and Δ–L output leads which are employed as the controlling inputs to the several relay tables. There are three longitude tree circuits, respectively designated ΔL–1, ΔL–2 and ΔL–3. The purpose of each of the tree circuits is to receive decimal coordinate input indicia from its respectively related number rounding circuit, consisting of ground extended to one of a possible ten units digit leads, and ground extended to one of a possible ten tens digit leads and, responsive to the received indicia, to extend ground over one of a possible 100 leads, each lead representing a discrete value of longitude (or latitude) difference, to the respectively related relay table circuit. The several tree circuits are alike in principle and operation but vary in the range of input values applicable thereto in conformity to the range of input indicia required by the respectively related relay table circuits, as will hereinafter be described. In the several examples which follow, the operation of the tree circuits will be described in conjunction with the description of the operation of the circuits of Figs. 95–A, 95–B and 95–C.

Figs. 95–A, 95–B and 95–C are condensed diagrammatic versions of Figs. 23 to 26 (longitude number rounding) or Figs. 27 to 30 (latitude number rounding) and should be read in conjunction therewith. The encircled numbers in the upper part of Figs. 95–A, 95–B and 95–C indicate three exemplary values of longitude or latitude difference as the assumed inputs to the longitude or latitude number rounding circuit, respectively, typifying three different hypothetical conditions. In the upper part of Figs. 95–B and 95–C, the conductors represented by dotted lines indicate the operating paths for the number rounding relays and are illustrative of the dependency of the number rounding action on the numerical value of the input to the preceding lower digit. The encircled numbers in the central part of the figures indicate the values of three two-digit numbers produced under control of the number rounding relays and constitute the coordinate inputs to the Δ–1, Δ–2 and Δ–3 tree circuits. The encircled numbers in the lower part of the figures each indicate the numerical identity of a single output conductor from each of the Δ–1, Δ–2 and Δ–3 tree circuits energized responsive to the illustrated input. The Δ–1, Δ–2 and Δ–3 conductors from the tree circuits are respectively employed as the Δ–1, Δ–2 and Δ–3 inputs to the relay tables.

Fig. 95–A shows an assumed difference value of 12.34, indicated by the encircled numbers in the upper part of the figure as the input to the number rounding and tree circuits (Figs. 23 to 26 or Figs. 27 to 30). For illustrative purposes we will assume that the difference value represents a longitude difference. Accordingly, the description will be predicated on the assumption that the preceding circuits (that is, the subtractor circuits) will have extended ground to leads **23–LOTD–1**, **24–LOUD–2**, **25–LOTHD–3** and **18–LOHD–4**. The set of leads **18–LOHD–0** to **18–LOHD–9**, inclusive, signifying "longitude hundredths difference" is connected to the ΔL–1 tree circuit as the "units" input thereto (contacts of its relays) and is paired with (pair ΔL–1) the set of leads **25–LOTHD–0** to **25–LOTHD–9**, inclusive, signifying "longitude tenths difference," which is connected to the ΔL–1 tree circuit as the tens input thereto (windings of its relays). The hundredths and tenths digit difference values will always be transmitted unchanged to the ΔL–1 tree circuit to furnish, respectively, the units and tens coordinate inputs thereto. The ground assumed to be applied to lead **18–LOHD–4**, significant of a longitude difference value of 4 in the hundredths digit, does not affect the operation of the number rounding relay **25–LOTHR** of the succeeding higher digit. The ground assumed to be applied to lead **25–LOTHD–3**, indicative of a longitude difference value of 3 in the tenths digit as determined by the longitude subtractor circuit, is extended through the No. 3 back contacts of relay **25–LOTHR** to lead **25–TH–3–U**, representing the tenths digit input value of 3 unrounded by virtue of the non-operation of relay **25–LOTHR**. The set of leads **25–TH–0–U** to **25–TH–9–U**, inclusive, signifying the longitude difference tenths digit values, in this example unaltered by virtue of the non-operation of relay **25–LOTHR**, is connected to the ΔL–2 tree circuit as the units input thereto (the contacts of relays **25–2–LO–0** to **25–2–LO–9**, inclusive, of which **25–2–LO–4** through **25–2–LO–8** are not shown), and is paired with (pair ΔL–2) the group of leads **24–LOUD–0** to **24–LOUD–9**, inclusive, signifying the longitude difference units digit values as determined by the longitude subtractor circuit. These leads are connected to the windings of ΔL–2 tree circuit relays as the tens input thereto. The ground applied to lead **25–LOTHD–3** does not affect the operation of the number rounding relay **24–LOUR** of the succeeding higher digit. The ground applied to lead **24–LOUD–2** is extended through the No. 2 back contacts of relay **24–LOUR** to lead **24–U–2–U**, representing the units digit input of 2, unrounded by virtue of the non-operation of relay **24–LOUR**.

The set of leads **24–U–0–U** to **24–U–9–U**, inclusive, signifying the longitude difference unit digit values, in this example unaltered by virtue of the non-operation of relay **24–LOUR**, is connected to the ΔL–3 tree circuit as the units input thereto (contacts of its relays) and is paired with (pair ΔL–3) the set of leads **23–T–0–T** to **23–T–9–T**, inclusive, signifying the longitude difference tens digit values as controlled by the number rounding circuit (condition of relay **23–LOTR**) which is connected to the ΔL–3 tree circuit as the tens input thereto (windings of its relays). The ground applied to lead **24–LOUD–2** does not affect the operation of the number rounding relay **23–LOTR** of the succeeding higher digit. The ground applied to lead **23–LOTD–1** is extended, through the No. 1 back contacts of relay **23–LOTR** to lead **23–T–1–T**, representing the tens digit input of 1 unrounded by virtue of the non-operation of relay **23–LOTR**. Since, in the specific illustration, the input value in any digit is not in excess of 4, no number rounding operation is called for. The input valve of 12.34, therefore, will have been resolved by the number rounding circuit into ΔL–1, ΔL–2 and ΔL–3 values of .34, 2.3 and 12., respectively, as the inputs to the correspondingly designated tree circuits.

The ground assumed to be applied to lead **25–LOTHD–3** is also extended through the winding of relay **26–1–LO–3** to negative battery, causing it to operate and extend ground, assumed to be applied to lead **18–LOHD–4**, through its No. 4 contacts to the No. 34 lead of the ΔL–1 conductors.

The ground assumed to be applied to lead **24–LOUD–2** is also extended through the winding of relay **25–2–LO–2** to negative battery causing it to operate and extend ground, assumed to be applied to lead **25–TH–3–U** by virtue of the non-operation of relay **25–LOTHR**, through the No. 3 contacts of relay **25–2–LO–2** to the No. 23 lead of the ΔL–2 conductors.

The ground assumed to be applied to lead **23–T–1–T** by virtue of the non-operation of relay **23–LOTR**, is extended through the winding of relay **24–3–LO–1** to negative battery causing it to operate and extend ground, assumed to be applied to lead **24–U–2–U** by virtue of the non-operation of relay **24–LOUR**, through the No. 2 contacts of relay **24–3–LO–1** to the No. 12 lead of the ΔL–3 conductors.

Fig. 95–B shows an assumed difference value of 87.65,

indicated by the encircled numbers in the upper part of the figure, as the input to the number rounding and tree circuits (Figs. 23 to 26 or Figs. 27 to 30). For illustrative purposes we will assume that the difference value represents a longitude difference. Accordingly, the description will be predicated on the assumption that the preceding circuits (that is, the substractor circuits) will have extended ground on to leads 23–LOTD–8, 24–LOUD–7, 25–LOTHD–6 and 18–LOHD–5. The same paired grouping of input digital leads to the ΔL–1, ΔL–2 and ΔL–3 tree circuits obtains as in the preceding description relating to Fig. 95–A. Ground assumed to be applied to lead 18–LOHD–5 is extended through diode 26–D–5 via lead 25–LOTHR, through the winding of relay 25–LOTHR to negative battery, causing it to operate. Ground assumed to be applied to lead 25–LOTHD–6 is extended through the number 6 front contacts of relay 25–LOTHR to lead 25–TH–7–U; representing the tenths digit input value of 6 rounded to the next higher value 7. Ground assumed to be applied to lead 25–LOTHD–6 is extended through diode 25–D–6, via lead 24–LOUR, through the winding of relay 24–LOUR to negative battery, causing it to operate. Ground assumed to be applied to lead 24–LOUD–7 is extended through the number 7 front contacts of relay 24–LOUR, to lead 24–U–8–U; representing the units digit input value of 7 rounded to the next higher value 8. Since in the specific illustration there is not a 9 in the tens digit input the number rounding relay 23–LOTR of the succeeding higher digit will not be operated. Ground assumed to be applied to lead 23–LOTD–8 is extended through the number 8 back contacts of relay 23–LOTR, to lead 23–T–8–T; representing the tens digit input of 8, unrounded. The input of 87.65, therefore, will have been resolved by the number rounding circuit into ΔL–1, ΔL–2 and ΔL–3 values of .65, 7.7 and 88., respectively, as the inputs to the correspondingly designated tree circuits.

Ground assumed to be applied to lead 25–LOTHD–6 is also extended through the winding of relay 26–1–LO–6 (not shown) to negative battery, causing it to operate and extend ground, assumed to be applied to lead 18–LOHD–5, through its No. 5 contacts to the No. 65 lead (not shown) of the ΔL–1 conductors.

Ground assumed to be applied to lead 24–LOUD–7 is also extended through the winding of relay 25–2–LO–7 (not shown) to negative battery, causing it to operate and extend ground, assumed to be applied to lead 25–TH–7–U as a result of the operation of relay 25–LOTHR, through the No. 7 contacts of relay 25–2–LO–7 (not shown) to the No. 77 lead (not shown) of the ΔL–2 conductors.

Ground assumed to be applied to lead 23–T–8–T by virtue of the non-operation of relay 23–LOTR, is extended through the winding of relay 24–3–LO–8 (not shown) to negative battery, causing it to operate and extend ground, assumed to be applied to lead 24–U–8–U as a result of the operation of relay 24–LOUR, through the No. 8 contacts of relay 24–3–LO–8 (not shown) to the No. 88 lead (not shown) of the ΔL–3 conductors.

Fig. 95–C shows an assumed difference value of 09.99, indicated by the encircled numbers in the upper part of the figure, as the input to the number rounding and tree circuits (Figs. 23 to 26 or Figs. 27 to 30). For illustrative purposes we will assume that the difference value represents a longitude difference. Accordingly, the description will be predicated on the assumption that the preceding circuits (that is, the subtractor circuits) will have extended ground to leads 23–LOTD–0, 24–LOUD–9, 25–LOTHD–9 and 18–LOHD–9. The same paired grouping of input digital leads to the ΔL–1, ΔL–2 and ΔL–3 tree circuits obtains as in the preceding description relating to Figs. 95–A and 95–B. Ground assumed to be applied to lead 18–LOHD–9 is extended through diode 26–D–9, via lead 25–LOTHR, through the winding of relay 25–LOTHR to negative battery, causing it to operate. Ground assumed to be applied to lead 25–LOTHD–9 is also extended through the No. 9 front contacts of relay 25–LOTHR, to lead 25–C–90, through diode 25–D–90, to lead 25–TH–0–U; representing the tenths digit input value of 9, rounded to the next higher value 10. Ground assumed to be applied to lead 25–C–90 will also be extended through diode 25–DNR-9 via lead 24–LOUR, through the winding of relay 24–LOUR to negative battery, causing it to operate. Ground assumed to be applied to lead 24–LOUD–9 is extended through the number 9 front contacts of relay 24–LOUR to lead 24–C–90, through diode 24–D–90, to lead 24–U–0–U representing the units digit input of 9 rounded to the next higher value 10. Ground assumed to be applied to lead 24–C–90 is also extended through diode 24–DNR, via lead 23–LOTR, through the winding of relay 23–LOTR to negative battery, causing it to operate. Ground assumed to be applied to lead 23–LOTD–0 is extended through the No. 0 front contacts of relay 23–LOTR, to lead 23–T–1–T; representing the tens digit input value of 0 rounded to the next higher value 1. The input of 09.99 will have, therefore, been resolved by the number rounding circuit into ΔL–1, ΔL–2 and ΔL–3 values of .99, 9.0 and 10., respectively, as the inputs to the correspondingly designated tree circuits.

Ground assumed to be applied to lead 25–LOTHD–9 is also extended through the winding of relay 26–1–LO–9 to negative battery, causing it to operate and extend ground, assumed to be applied to lead 18–LOHD–9, through its No. 9 contacts to the No. 99 lead of the ΔL–1 conductors.

Ground assumed to be applied to lead 24–LOUD–9 is also extended through the winding of relay 25–2–LO–9 to negative battery, causing it to operate and extend ground, assumed to be applied via the No. 9 front contacts of relay 25–LOTHR and diode 25–D–90 to lead 25–TH–0–U, through the No. 0 contacts of realy 25–2–LO–9 to the No. 90 lead of the ΔL–2 conductors.

Ground assumed to be applied to lead 23–T–1–T as a result of the operation of realy 23–LOTR, is extended through the winding of relay 24–3–LO–1 to negative battery, causing it to operate and extend ground, assumed to be applied via the No. 9 front contacts of relay 24–LOUR and diode 24–D–90 to lead 24–U–0–U, through the No. 0 contacts of relay 24–3–LO–1 to the No. 10 lead of the ΔL–3 conductors.

The primary purpose of the number rounding circuits is to convert the four-digit numbers representing the output of the longitude or the latitude subtractor circuits into three two-digit numbers comprising the inputs to the tree circuits. The specific embodiment of the number rounding circuits as disclosed in the left-hand portions of Figs. 23 to 30 is productive of values which, when applied as the inputs to the tree circuits shown in the right-hand portion of Figs. 24, 25, 26, 28, 29 and 30, are conducive to a smooth transition between the 0 to 40 and the 40 to 400-mile tables, and also between the 40 to 400-mile and the 400 to 4000-mile tables.

In the exemplary disclosure of the present invention it is assumed that the longitudes of the calling and the called central offices are, respectively, W.70.35° and W.70.00°. As a result of the operation of the longitude subtractor circuit, grounds indicative of a longitude difference of 00.35 are extended to leads 23–LOTD–0, 24–LOUD–0, 25–LOTHD–3 and 18–LOHD–5. Therefore, ground on lead 18–LOHD–5 is extended through diode 26–D–5, via lead 25–LOTHR, through the winding of relay 25–LOTHR to negative battery, causing its operation. Ground on lead 25–LOTHD–3 is extended through the No. 3 front contacts of relay 25–LOTHR to lead 25–TH–4–U, representing the tenths digit input value of 3, rounded to the next higher value 4. The ground on lead 25–LOTHR–3 does not affect the operation of the number rounding relay 24–LOUR in the succeeding higher digit. In the same manner, ground on lead 24-LOUD-0 is extended through the No. 0 back contacts of relay 24-LOUR to lead 24-U-0-U, representing the units digit input value of 0, unrounded. Ground on lead 24-LOUD-0 does not affect the operation of the number rounding relay 23-LOTR in the succeeding higher digit.

Ground on lead 23-LOTD-0 is extended through the No. 0 back contacts of relay 23-LOTR to lead 23-T-0-T, representing the tens digit input value of 0, unrounded. Accordingly, the input of 00.35 is resolved by the number rounding circuit into ΔL-1, ΔL-2 and ΔL-3 values of .35, 0.4 and 00., respectively, as the inputs to the correspondingly designated tree circuits.

Thus far the detailed description of the number rounding circuits has been directed more particularly to the longitude number rounding circuit. We will now describe the operation of the latitude number rounding circuit. In the exemplary disclosure of the present invention it is assumed that the latitudes of the calling and the called central offices are, respectively, N.39.50° and N.39.00°. As a result of the operation of the latitude subtractor circuit, ground indicative of a latitude difference of 00.50°, is extended to leads 27-LATD-0, 28-LAUD-0, 29-LATHD-5 and 22-LAHD-0. The set of leads 22-LAHD-0 to 22-LAHD-9, inclusive, and signifying "latitude hundredths difference," is connected to the ΔK-1 tree circuit as the units input thereto, and is paired with (pair ΔK-1) the set of leads 29-LATHD-0 to 29-LATHD-9, inclusive, signifying "latitude tenths difference," which is connected to the ΔK-1 tree circuit as the tens input thereto. The hundredths and tenths latitude difference values are always transmitted unchanged to the ΔK-1 tree circuit to furnish, respectively, the units and tens coordinate inputs thereto. Since in the hundredths digit input the difference value is 0, the number rounding relay 29-LATHR in the succeeding higher digit will not be operated. Ground on lead 29-LATHD-5 is extended through the No. 5 back contacts of relay 29-LATHR to lead 29-TH-5-U, representing the tenths digit input value of 5, unrounded. The set of leads 29-TH-0-U to 29-TH-9-U, inclusive, and signifying "latitude difference tenth" values as controlled by the number rounding circuit, is connected to the ΔK-2 tree circuit as the units coordinate input thereto, and is paired with (pair ΔK-2) the group of leads 28-LAUD-0 to 28-LAUD-9, inclusive, and signifying the "latitude difference unit" values as determined by the latitude subtractor circuit, which is connected to the ΔK-2 tree circuit as the tens coordinate input thereto. The ground on lead 29-LATHD-5 is extended through diode 29-D-5, via lead 28-LAUR, through the winding of relay 28-LAUR to negative battery, causing it to operate. Ground on lead 28-LAUD-0 is extended through the No. 0 front contacts of relay 28-LAUR to lead 28-U-1-U, representing the units digit input value of 0 rounded to the next higher value 1. Ground on lead 28-LAUD-0 does not affect the operation of the number rounding relay 27-LATR in the succeeding higher digit. The set of leads 28-U-0-U to 28-U-9-U, inclusive, signifying the latitude difference unit digit values as controlled by the number rounding circuit, is connected to the ΔK-3 tree circuit as the units coordinate input thereto, and is paired with (pair ΔK-3) the set of leads 27-T-0-T to 27-T-9-T, inclusive, signifying the latitude difference tens digit values as controlled by the number rounding circuit, which is connected to the ΔK-3 tree circuit as the tens coordinate input thereto. Ground on lead 27-LATD-0 is extended through the No. 0 back contacts of relay 27-LATR to lead 27-T-0-T, representing the tens digit input value of 0, unrounded. Therefore the input of 00.50 is resolved by the number rounding circuit into ΔK-1, ΔK-2 and ΔK-3 values of .50, 0.5 and 01., respectively, as the inputs to the correspondingly designated tree circuits.

The description which follows relates specifically to the operation of the tree circuits, that is, the fourth arithmetical step previously discussed with reference to Figs. 95-A, 95-B and 95-C.

We will assume that as a result of the operation of the previously described number rounding circuits in determining the longitude difference between longitude W.70.35° for the calling office and longitude W.70.00° for the called office (the difference being 00.35), ground is extended to leads 23-T-0-T, 24-U-0-U, 24-LOUD-0, 25-TH-4-U, 25-LOTHD-3 and 18-LOHD-5 indicative of the rounded values of said difference. The set of leads 23-T-0-T to 23-T-9-T, inclusive, conveys the indicia determinative of the value of the tens digit of the number identifying the output leads from the ΔL-3 tree circuit. The set of leads 24-U-0-U to 24-U-9-U, inclusive, conveys the indicia determinative of the value of units digit of the number identifying the output leads from the ΔL-3 tree circuit. The ΔL-3 tree circuit grounds one of 62 leads supplying indicia representative of a particular value of longitude difference, expressed in degrees, to the 400 to 4000 mile relay table, because the 400 to 4000 mile relay table has 62 vertical ordinates or points of entry. Accordingly, the ΔL-3 tree circuit comprises seven relays, designated 24-3-LO-0 to 24-3-LO-6, inclusive (of which 24-3-LO-4 and 24-3-LO-5 are not shown), which will accommodate indica representative of the tens digits of numbers from 00 to 69. Hence the leads 23-T-7-T, 23-T-8-T and 23-T-9-T are not required to be connected. Ground on lead 23-T-0-T is extended through the winding of relay 24-3-LO-0 to negative battery, causing it to operate. Ground on lead 24-U-0-U is extended through the front contacts No. 0 of relay 24-3-LO-0 to the ΔL-3-00 lead "00" in the ΔL-3 cable to the vertical or longitude difference coordinate input to the 400 to 4000 mile relay table. On relay 24-3-LO-6 the armatures numbered 2 to 9, inclusive, are respectively connected to leads 62 to 69, inclusive, which, because of the requirements of the 400 to 4000 mile relay table, are spares and are not connected through.

The set of leads 24-LOUD-0 to 24-LOUD-9, inclusive, conveys the indicia determinative of the value of the tens digit of the numbers identifying the output leads from the ΔL-2 tree circuit. The set of leads 25-TH-0-U to 25-TH-9-U, inclusive, conveys the indicia determinative of the value of the units digit of the numbers identifying the output leads from the ΔL-2 tree circuit. The ΔL-2 tree circuit grounds one of 92 leads supplying indicia representative of a particular value of longitude difference expressed in tenths of a degree to the 40 to 400 mile relay tables because the 40 to 400 mile relay table has 92 vertical ordinates or points of entry. Accordingly, the ΔL-2 tree circuit comprises the nine relays designated 25-2-LO-0 to 25-2-LO-9, inclusive (of which 25-2-LO-4 to 25-2-LO-8, inclusive are not shown), which accommodate indicia representative of the tens digits of numbers from 00 to 99. Ground on lead 24-LOUD-0 is extended through the winding of relay 25-2-LO-0 to negative battery, causing it to operate. Ground on lead 25-TH-4-U, is extended through the No. 4 contacts of relay 25-2-LO-0 to the ΔL-2-04 lead ("04") in the ΔL-2 cable to the vertical or longitude difference coordinate inputs to the 40 to 400 mile relay tables Nos. 404, 405, 406 and 407, shown on Figs. 35 to 38; 39 to 42; 43 to 46; and 47 to 50, respectively. On relay 25-2-LO-9 the armatures numbered 2 to 9, inclusive, are respectively connected to leads 92 to 99, inclusive, which, because of the requirements of the 40 to 400 mile relay table, are spares and are not connected through.

The set of leads 25-LOTHD-0 to 25-LOTHD-9, inclusive, conveys the indicia determinative of the value of the tens digits of the numbers identifying the output leads from the ΔL-1 tree circuit. The set of leads 18-LOHD-0 to 18-LOHD-9, inclusive, conveys the indicia determinative of the value of the units digits of the numbers identifying the output leads from the ΔL–1 tree circuit. The ΔL–1 tree circuit grounds one of 92 leads supplying indicia representative of a particular value of longitude difference, expressed in hundredths of a degree, to the 0 to 40 mile relay tables Nos. 44 and 45, shown on Figs. 51 to 54; and 55 to 58, respectively, because the 0 to 40 mile relay tables have 92 vertical ordinates or points of entry.

Accordingly the ΔL–1 tree circuit comprises the nine relays designated **26–1–LO–0** to **26–1–LO–9**, inclusive (of which **26–1–LO–4** to **26–1–LO–8**, inclusive, are not shown), which accommodate indicia representative of the tens digits of numbers from 00 to 99. Ground on lead **25–LOTHD–3** is extended through the winding of relay **26–1–LO–3** to negative battery, causing it to operate. Ground on lead **18–LOHD–5** is extended through the contacts No. 5 of relay **26–1–LO–3** to the ΔL–1–35 lead ("35") in the ΔL–1 cable to the vertical or longitude difference coordinate input to the 0 to 40 mile relay table. On relay **26–1–LO–9** the armatures numbered 2 to 9, inclusive, are respectively connected to leads 92 to 99, inclusive, which, because of the requirements of the 0 to 40 mile relay table, are spares and are not connected through.

Thus far the detailed description of the tree circuits has been directed more particularly to the longitude tree circuits. We will now describe the operation of the latitude tree circuits. We will assume that as a result of the previously described latitude subtractor and latitude number rounding circuits in determining the latitude difference between latitude N.39.50° for the calling office and latitude N.39.00° for the called office (the difference being 00.50), ground is extended to leads **27–T–0–T**, **28–U–1–U**, **28–LAUD–0**, **29–TH–5–U**, **29–LATHD–5** and **22–LAHD–0**, indicative of the rounded values of said difference. The set of leads **27–T–0–T** to **27–T–9–T**, inclusive, conveys the indicia determinative of the value of the tens digit of the number identifying the output leads from the ΔK–3 tree circuit. The set of leads **28–U–0–U** to **28–U–9–U**, inclusive, conveys the indicia determinative of the value of the units digit of the number identifying the output leads from the ΔK–3 tree circuit. The ΔK–3 tree circuit grounds one of 28 leads supplying indicia representative of a particular value of latitude difference, expressed in degrees to the 400 to 4000 mile relay table, because the 400 to 4000 mile relay table has 28 horizontal ordinates or points of entry. Accordingly the ΔK–3 tree circuit comprises three relays designated **28–3–LA–0**, **28–3–LA–1** and **28–3–LA–2** which will accommodate indicia representative of the tens digits of numbers 00 to 29. Hence leads **27–T–3–T** to **27–T–9–T**, inclusive, are not required to be connected. Ground on lead **27–T–0–T**, is extended through the winding of relay **28–3–LA–0** to negative battery, causing it to operate. Ground, on lead **28–U–1–U**, is extended through the No. 1 contacts of relay **28–3–LA–0** to the **ΔK–3–01** lead ("01") in the ΔK–3 cable to the horizontal or latitude difference coordinate input to the 400 to 4000 mile relay table Nos. 4016, 4017, 4021, 4022, or 4023, shown as Figs. 31 to 34. On relay **28–3–LA–2** the armatures numbered 8 and 9 are respectively connected to leads 28 and 29, which, because of the requirements of the 400 to 4000 mile relay table, are spares and are not connected through.

The set of leads **28–LAUD–0** to **28–LAUD–9**, inclusive, conveys the indicia determinative of the value of the tenths digit of the numbers identifying the output leads from the ΔK–2 tree circuit. The set of leads **29–TH–0–U** to **29–TH–9–U**, inclusive, conveys the indicia determinative of the value of the units digit of the numbers identifying the output leads from the ΔK–2 tree circuit. The ΔK–2 tree circuit grounds one of 58 leads supplying indicia representative of a particular value of latitude difference, expressed in tenths of a degree, to the 40 to 400 mile relay tables Nos. 404, 405, 406 and 407, shown on Figs. 35 to 38; 39 to 42; 43 to 46; and 47 to 50, respectively, because the 40 to 400 mile relay table has 58 horizontal ordinates or points of entry. Accordingly, the ΔK–2 tree circuit comprises six relays designated **29–2–LA–0** to **29–2–LA–5**, inclusive, which will accommodate indicia representative of the tens digits of numbers from 00 to 59. Ground on lead **28–LAUD–0** is extended through the winding of relay **29–2–LA–0** to negative battery, causing it to operate. Ground on lead **29–TH–5–U** is extended through the contacts No. 5 of relay **29–2–LA–0** to the **ΔK–2–05** lead ("05") in the ΔK–2 cable to the horizontal or latitude difference coordinate input to the 40 to 400 mile relay table. On relay **29–2–LA–5** the armatures numbered 8 and 9 are respectively connected to leads 58 and 59 which, because of the requirements of the 40 to 400 mile relay table, are spares and are not connected through.

The set of leads **29–LATHD–0** to **29–LATHD–9**, inclusive, conveys the indicia determinative of the value of the tens digits of the numbers identifying the output leads from the ΔK–1 tree circuit. The set of leads **22–LAHD–0** to **22–LAHD–9**, inclusive, conveys the indicia determinative of the value of the units digits of the numbers identifying the output leads from the ΔK–1 tree circuit. The ΔK–1 tree circuit grounds one of 58 leads supplying indicia representative of a particular value of latitude difference, expressed in hundredths of a degree, to the 0 to 40 mile relay tables, Nos. 44 and 45, shown on Figs. 51 to 54; and 55 to 58, respectively, because the 0 to 40 mile relay tables have 58 horizontal ordinates or points of entry. Accordingly the ΔK–1 tree circuit comprises six relays, designated **30–1–LA–0** to **30–1–LA–5**, inclusive, which will accommodate indicia representative of the tens digits of numbers from 00 to 59. Ground on lead **29–LATHD–5** is extended through the winding of relay **30–1–LA–5** to negative battery, causing it to operate. Ground on lead **22–LAHD–0** is extended through the contacts No. 0 of relay **30–1–LA–5** to the **ΔK–1–50** lead ("50") in the ΔK–1 cable to the horizontal or latitude difference coordinate input to the 0 to 40 mile relay table. On relay **30–1–LA–5** the armatures 8 and 9 are respectively connected to leads 58 and 59, which, because of the requirements of the 0 to 40 mile relay table, are spares and are not connected through.

Recapitulating the previously described operations: The longitude and latitude arranger circuits determine which of two numbers presented to each is the larger, transmitting the larger and the smaller, respectively, as the minuend and the subtrahend of the corresponding subtractor. The latitude arranger circuits also determine which band choice conductor is to be energized to control the connection of the relay table appropriate to the latitude of the calling office. The longitude and latitude substractor circuits then determine the difference between the two input values presented to each and transmit the resultant difference to the longitude and latitude number rounding circuits, respectively. The longitude and latitude number rounding circuits produce rounded-off values, the grounds expressive of which are transmitted to the longitude and latitude tree circuits, which tree circuits, in turn, ground selected conductors in the sets of conductors which extend to the 0 to 40, the 40 to 400, and the 400 to 4000 mile relay tables. The choice of which table, or tables, shall be used is then determined by the band choice conductor which is energized by the latitude arranger circuits.

The fifth step in determining the distance in great circle miles between the calling and called central offices is the operation of the latitude connector and rate location circuits shown in Figs. 31 to 58, inclusive, from the grounds supplied by the longitude (or vertical coordinate) input ΔL–1 and the latitude (or horizontal coordinate) input ΔK–1, whereby certain output leads are activated which are expressive of the basic mileage applicable to a given call, and of the basic rate applicable for that call. The latitude connector and rate location circuits comprise one 400 to 4000 mile, four 40 to 400 mile, two 00 to 40 mile relay tables, and the connector relays respectively associated therewith. Each of the several relay tables is arranged to receive vertical coordinate input indicia from the respectively related longitude tree circuits, which indicia is indicative of the difference in longitude between the calling and the called central offices. In a like manner, each of the several relay tables is also arranged to receive horizontal coordinate input indicia from the respectively related latitude tree circuits, which indicia is indicative of the difference in latitude between the calling and the called central offices.

In order that the functioning of the several relay tables may be fully understood, we will continue with the assumption that the longitudes of the calling and the called central offices are W.70.35° and W.70.00°, respectively. As previously stated, the longitude subtractor circuit determines the difference in longitude between the calling and the called central offices to be 00.35°. The longitude number rounding circuit then resolves this value into rounded ΔL–**1**, ΔL–**2** and ΔL–**3** values of .35, 0.4 and 00., respectively, as the inputs to the correspondingly designated tree circuits. Responsive to the above-described inputs, the tree circuits ΔL–**1**, ΔL–**2** and ΔL–**3** cause ground to be extended to conductor 35 in the ΔL–**1** cable, conductor 04 in the ΔL–**2** cable, and conductor 00 in the ΔL–**3** cable, respectively.

Ground on the No. 5 armature of relay **26–1**–LO–**3** is extended via lead ΔL–**1–35** in cable ΔL–**1** to lead ΔL–**1–35** in Figs. 51 and 55 in multiple, and through the respective windings of relays **51**–LO–**35** and **55**–LO–**35** to battery, which relays will operate in the circuits just traced.

Ground on the No. 4 armature of relay **25–2**–LO–**0** is extended via lead ΔL–**2–04** in cable ΔL–**2** to the ΔL–**2–04** leads in Figs. 35, 39, 43 and 47 in multiple, and through the respective windings of relays **35**–LO–**04**, **39**–LO–**04**, **43**–LO–**04** and **47**–LO–**04** to battery, which relays operate in the circuits just traced.

Ground on the No. 0 armature of relay **24–3**–LO–**0** is extended via lead ΔL–**3–00** in cable ΔL–**3** to the ΔL–**3–00** lead in Fig. 31 and through the winding of relay **31**–LO–**00** to battery, causing it to operate.

As earlier stated and described with reference to Fig. 84, a plurality of 0 to 40, and 40 to 400 mile tables are furnished at each central office. The particular 0 to 40, and 40 to 400 mile table to be employed for any call is determined by the latitude of the calling central office. Fig. 88 is a partial disclosure of a 0 to 40 mile table, pre-computed for use at a central office lying between latitudes N.40.00° and N.43.00°, the data therein corresponding to the pattern of connections in the 0 to 40 mile relay table No. 45 (Figs. 55 to 58). The 0 to 40 mile table No. 45 is effectuated under control of the band choice conductor **11**–B–**5**, as earlier described with reference to Fig. 84.

To illustrate a hypothetical condition of latitude which requires the use of relay table No. 45 as described with reference to Fig. 89, condition 2, it will now be assumed, for example, that the latitudes of the calling and the called central offices, instead of being 39.50° and 39.00° as previously described are, respectively, N.40.00° and N.39.50°. The latitude subtractor circuit determines the difference in latitude between the calling and the called central offices to be 00.50°, which value the latitude number rounding circuit resolves into rounded ΔK–**1**, ΔK–**2** and ΔK–**3** values of .50, 0.5 and 01., respectively, as the inputs to the correspondingly designated tree circuits. Responsive to the above-described inputs, the tree circuits ΔK–**1**, ΔK–**2** and ΔK–**3** extend ground to lead ΔK–**1–50** in the ΔK–**1** cable, lead ΔK–**2–05** in the ΔK–**2** cable, and lead ΔK–**3–01** in the ΔK–**3** cable. Ground on the No. 0 armature of relay **30–1**–LA–**5** is extended via lead ΔK–**1–50** in cable ΔK–**1** to the ΔK–**1–50** leads in Figs. 53 and 57 in multiple. Ground on the No. 5 armature of relay **29–2**–LA–**0** is extended via lead ΔK–**2–05** in cable ΔK–**2** to the ΔK–**2–05** leads in Figs. 35, 39, 43 and 47 in multiple. Ground on the No. 1 armature of relay **28–3**–LA–**0** is extended via lead ΔK–**3–01** in cable ΔK–**3** to the ΔK–**3–01** leads in Figs. 31 and 33.

The 400 to 4000 mile relay table (in this example table No. 4016 and shown on Figs. 31 to 34, inclusive) comprises a plurality of multicontact relays designated **31**–LO–**00** to **31**–LO–**07**, inclusive (of which **32**–LO–**10** to **32**–LO–**60**, inclusive, are not shown) and **32**–LO–**08** to **32**–LO–**61**, inclusive. Each multicontact relay is operable by a ground extended from the longitude tree circuit indicative of a discrete value of difference in longitude between the calling and the called central offices, expressed in degrees. As previously explained in connection with Fig. 87, the 400 to 4000 mile relay table actually consists of two half tables, the upper half being employed when the calling central office is north of the called central office and the lower half-table when the calling central office is south of the called central office. Since in the example presently being described the calling central office is north of the called central office, relay **31**–NLAC is operated as previously described. Ground extending from the latitude tree circuit and indicative of the discrete value of difference in latitude between the calling and the called central offices expressed in degrees is applied to the upper half-table via the front contacts of latitude connector relay **31**–NLAC. Ground on lead ΔK–**3–01** is extended through the No. 01 contacts of relay **31**–NLAC, via lead **31**–NLA–**01**, No. 01 contacts of relay **31**–LO–**00** to terminal **31–00–01**–HBS, thence via conductor **31**–HBS through the winding of relay **64**–HBS to battery, causing this relay to operate. Each of the horizontal coordinate input indicia leads **31**–NLA–**00** to **31**–NLA–**27**, inclusive, represents latitude difference indicia in increments of 1.° where the calling central office is north of the called central office.

Each of the horizontal coordinate input indicia leads **33**–SLA–**00** to **33**–SLA–**27**, inclusive, represents latitude difference indicia in increments of one degree where the calling central office is south of the called central office. Since one degree of latitude spans a south to north distance of approximately 70 miles, the ground extended to terminal **31–00–01**–HBS indicates that the calling and called central offices are separated by a distance which exceeds 70 miles but is less than 400 miles and is therefore within the range of a 40- to 400-mile relay table. If due to the operation of the latitude tree and preceding circuits in response to other values of latitudes for the calling and the called central offices, terminal **31–01–05**–HBS, for example, were to have ground extended thereto for a five degrees difference in latitude, or approximately 350 miles south to north, the ground on said lead **31**–HBS would indicate that the distance between the two offices is less than 400 miles but more than 70. Lead **31**–HBS is connected to all the terminals HBS, the ground extended thereto indicating that the mileage between the calling and the called central offices is less than 400 miles, which means that the answer sought (the mileage distance between the two offices) will not be found in the 400- to 4000-mile relay table.

It will be remembered that earlier in the description it was stated that the system embodying the present invention is designed to serve an area embracing a south to north span bounded by latitudes N.24.00° and N.51.00°, that is to say 27 degrees of latitude. This area is divided into latitudinal or east to west strips, each strip having a south to north width of 1 degree of latitude such, for example, as the latitudinal strip bounded by latitudes N.40.00° and N.41.00° (see Fig. 84). A plurality of 400- to 4000-mile tables will be available, a separate table having been precomputed for each such one degree latitudinal strip. The precomputed data in each such table is applicable to all of the central offices lying within the north to south confines of the one degree latitudinal strip, irrespective of the longitude, or east to west, position of the central office. There are, therefore, twenty-seven such precomputed tables available of which, however, one, and one only, will be furnished at a given central office. The latitude of the central office is, in any instance, determinative of which table is to be furnished. In the description and drawings, several hypothetical combinations of latitude and longitude illustrative of several exemplary locations of calling and called central offices, have been disclosed (see Figs. 89–94). It has been advantageous for illustrative purposes to predicate the description on the assumption that for each hypothetical calling office latitude the appropriate 400- to 4000-mile table, precomputed for the latitude of said calling office, is furnished.

In each of the 400- to 4000-mile relay tables numbered 4016, 4017, 4021, 4022 and 4023 there is a large field of terminals (a maximum of 1860 as shown in Figs. 31–34) each terminal being numbered in accordance with a table of precomputed data pertinent to that particular degree of latitude (and each of which tables is generally similar to the table shown on Fig. 88) to indicate when ground is extended thereto, a distance lying between 400 and 4000 miles being in accordance with the input data presented to said table.

To facilitate the conversion of the distances in miles into basic rate indicia as obtained from numbered terminals of the field, a plurality of terminals (each terminal of mileage value lying within a predetermined range of miles) are strapped together and, in turn, to a common terminal, such as terminals representative of mileage values between 401 miles to 446 miles which, in accordance with the table below, are connected to terminal **34–T–1**.

The terminals comprising the field shown in a 400-mile relay table such as table No. 4016 for example, are connected as follows:

BASIC RATE MILEAGE ZONES FOR 100 TO 4000 MILES

Field Terminals Indicating Miles	Connect to Terminal
-401 to -446	34-T-1
-447 to -492	34-T-2
-493 to -538	34-T-3
-539 to -584	34-T-4
-585 to -652	34-T-5
-653 to -743	34-T-6
-744 to -894	34-T-7
-895 to -1045	34-T-8
-1046 to -1196	34-T-9
-1197 to -1347	34-T-10
-1348 to -1603	34-T-11
-1604 to -1964	34-T-12
-1965 to -2430	34-T-13
-2431 to -3006	34-T-14
-3007 to -4000	34-T-15

Terminals **34–T–1** to **34–T–15**, inclusive (of which **34–T–3** to **34–T–14**, inclusive are not shown), are respectively connected to terminals **64**–BT–**1** to **64**–BT–**15**, inclusive, in the basic rate translator circuit via cable **34–C–4000**. Each of the latter terminals represents a basic rate which applies to the particular range of miles represented by the terminal in the group **34–T–1**—**34–T–15** to which it is connected as further explained below.

We have previously described the operation of the band choice circuits whereby in response to the latitudes of the calling and the called central offices being N.40.00° and N.39.50°, respectively, as indicated in Fig. 84, columns 2, 3 and 4, band choice lead **11–B–5** is grounded, causing the operation of the latitude connector relay **39**–LAC–**405** in the 40- to 400-mile relay table No. 405 and the latitude connector relay **55–LAC–45** in the 0- to 40-mile relay table No. 45.

The 40- to 400-mile relay table No. 405 shown on Figs. 39 to 42, inclusive, comprises a plurality of multi-contact relays designated **39**–LO–**00** to **39**–LO–**07**, inclusive, and **40**–LO–**08** to **40**–LO–**91**, inclusive (of which **40–LO–13** to **40**–LO–**18**, inclusive, are not shown). Each multi-contact relay is operable by a ground extended from the longitude tree circuit indicative of the difference in longitude between the calling and the called central offices expressed in tenths of a degree, and constituting the vertical coordinate input indicia thereto as diagrammatically illustrated in Fig. 86. In the specific example where the longitude difference between the calling and called ffices is .35 degree, it will be recalled that ground was applied to conductor ΔL–**2–04** to result in the operation of relay **39–LO–04**. Ground extended from the latitude tree circuit indicative of the difference in latitude between the calling and the called central offices expressed in tenths of a degree and constituting the horizontal co-ordinate input indicia thereto is applied to the 40- to 400-mile relay table No. 405 via the front contacts of latitude connector relay **39–LAC–405**. Specifically, ground on lead ΔK–**2–05**, is extended through the No. 05 contacts of relay **39–LAC–405**, via lead **39–LA–05**, the No. 05 contacts of relay **39–LO–04** to terminal **39–04–05**–MBS, thence via conductor **35**–MBS, through the winding of relay **64**–MBS to battery, causing the latter relay to operate.

Now each of the horizontal coordinate input indicia leads **39**–LA–**00** to **41–LA–57**, inclusive, represents latitude difference indicia in increments of 0.1 degree, which is equal to approximately seven miles. Since lead **35**–MBS is multipled to other terminals of the 40- to 400-mile table No. 405, ground on any one of which would indicate that the answer in miles sought for is not to be found in the 40- to 400-mile table, it follows that when the ground is extended to lead **35**–MBS and relay **64**–MBS operates in consequence thereof, the operation of said relay indicates that the 40- to 400-mile table is not to be used in obtaining the mileage distance between the calling and called office. If, due to the operation of the latitude tree and preceding circuits in response to other values of latitude for the calling and the called central offices, one of the terminals designated **39–01–00**–MBS, **39–01–01**–MBS or **39–01–05**–MBS, for example, were to have ground extended thereto respectively to indicate a difference in latitude of .1 degree, .2 degree or .5 degree, or approximately within a distance of 7, 14 or 35 miles south to north, the lead **35**–MBS would still receive ground therefrom, indicating that the distance between the calling and the called central offices is less than 40 miles, and consequently not within the 40- to 400-mile table. In the 40- to 400-mile relay table No. 405 (as in the 400- to 4000-mile table previously discussed) there is a large field of terminals, each terminal numbered in accordance with a table of precomputed data pertinent to the band of latitudes, and is generally similar to the table shown in Fig. 88 to indicate when ground is extended thereto, some distance lying between 40 and 400 miles.

To facilitate the conversion into basic rate indicia of the distances in miles as obtained from the equivalent numbered terminals of the field of a 40- to 400-mile table; for example, table No. 405, terminals numbered to indicate like distances are strapped together into sets. A plurality of such sets of terminals is connected together and to one of a pluarity of terminals **42–T–1** to **42**–T–**15**, inclusive; (of which **42–T–2** to **42–T–14**, inclusive, are not shown) each of the latter terminals representing a rate mileage zone to which a particular basic rate applies. The terminals comprising the field of terminals shown in relay table No. 405 are connected as follows:

BASIC RATE MILEAGE ZONES FOR 40 TO 400 MILES

Field Terminals Indicating Miles	Connect to Terminal
-41 to -55	42-T-1
-56 to -70	42-T-2
-71 to -85	42-T-3
-86 to -100	42-T-4
-101 to -124	42-T-5
-125 to -148	42-T-6
-149 to -172	42-T-7
-173 to -196	42-T-8
-197 to -220	42-T-9
-221 to -244	42-T-10
-245 to -268	42-T-11
-269 to -292	42-T-12
-293 to -316	42-T-13
-317 to -354	42-T-14
-355 to -400	42-T-15

Thus for example, all the terminals numbered -41 to -55, inclusive, indicative of distance of 41 to 55 miles, are respectively strapped together into sets, and all of the sets of terminals are connected together and to the terminal **42-T-1**, representing the rate mileage zone to which the basic rate for those mileages is applicable, as indicated in the 40- to 400-mile section of the rate mileage table shown in Fig. 96.

Terminals **42-T-1** to **42-T-15**, inclusive (**42-T-2** to **42-T-14** are not shown), are respectively connected to terminals **64-AT-1** to **64-AT-15**, inclusive, in the basic rate translator circuit via cable **50-C-400**.

The same arrangement and disposition of conductors is made for the 0- to 40-mile relay table, for example, table No. 45 shown on Figs. 55 to 58, inclusive. This particular table comprises a plurality of multicontact relays designated **55-LO-00** to **55-LO-35**, inclusive (of which **55-LO-04** to **55-LO-32**, inclusive, are not shown) and **56-LO-36** to **56-LO-91**, inclusive (of which **56-LO-42** to **56-LO-90**, inclusive, are not shown). Each multicontact relay is operable by a ground extended from the longitude tree circuit indicative of the difference in longitude between the calling and the called central offices, expressed in hundredths of a degree and constituting the vertical coordinate input indicia thereto, as diagrammatically illustrated in Fig. 85. Specifically for the difference of longitude of .35 degree between the calling and called office, ground is extended from the longitude tree circuit over lead **ΔL-1-35** to the winding of relay **55-LO-35**, causing this relay to operate. Ground extended from the latitude tree circuit indicative of the difference in latitude between the calling and the called central offices expressed in hundredths of a degree and constituting the horizontal coordinate input indicia thereto is applied to the 0- to 40-mile relay table No. 45 via cable **ΔK-1** and the front contacts of latitude connector relay **55-LAC-45**. Specifically for the difference of latitude of .50 degree between the calling and called offices, ground is extended on lead **ΔK-1-50**, through the No. 50 contacts of latitude connector relay **55-LAC-45**, lead **57-LA-50**, through the No. 50 contacts of relay **55-LO-35**, to terminal **57-40**.

Consulting the table shown in Fig. 88, which discloses in part the assignment of equivalent distances in miles for the 0- to 40-mile relay table shown in Figs. 55 to 58, inclusive, it is found that the conjoint effect of the application of a **ΔL-1** input of .35 degree and a **ΔK-1** input of a .50 degree corresponds to a distance of approximately 40 miles, which is the distance represented by terminal 57-40 and grounded as above described. In other words, 40 miles is the distance between the calling and called offices. An inspection of the table shown in Fig. 88 shows that other combinations of **ΔL-1** and **ΔK-1** input values will also cause ground to be extended to other terminals which indicate a distance of 40 miles.

In the 0- to 40-mile relay table 45 (as in the 40- to 400-mile table previously discussed) there is a large field of terminals, each terminal numbered in accordance with a table of precomputed data pertinent to the band of latitudes (and each of which tables is generally similar to the table in Fig. 88) to indicate when ground is extended thereto, some distance between 0 and 40 miles. To facilitate the conversion into basic rate indicia of the distances in miles as obtained from the equivalent numbered terminals of the field of a 0- to 40-mile table, for example table No. 45, terminals numbered to indicate like distances are strapped together in sets. A plurality of such sets of terminals are connected together and to one of a plurality of terminals **58-T-1** to **58-T-6**, inclusive. These terminals represent a rate mileage zone to which a particular basic rate is applicable. The terminals comprising the field of terminals shown in relay table No. 45 are connected as follows:

BASIC RATE MILEAGE ZONES FOR 0 TO 40 MILES

Field Terminals Indicating Miles	Connect to Terminal
-1 to -8	58-T-1
-9 to -13	58-T-2
-14 to -18	58-T-3
-19 to -24	58-T-4
-25 to -30	58-T-5
-31 to -40	58-T-6

For example, all of the field terminals -31 to -40, inclusive, indicating a distance of 31 to 40 miles, are respectively strapped together in sets and all of the sets are connected together and to the terminal **58-T-6**. The latter represents the rate mileage zone to which the basic rate for mileage lying between 31 to 40 miles is applicable. The basic rates for mileages lying between 1 and 40 miles are shown in the 0- to 40-mile section of the rate mileage table shown in Fig. 96.

Terminals **58-T-1** to **58-T-6**, inclusive, are respectively connected to terminals **64-T-1** to **64-T-6**, inclusive, in the basic rate translator circuit via cable **58-C-40**.

The operation of the circuits responsive to an assumed set of values as set forth in the table in Fig. 89, condition 1, will now be described, wherein the latitudes of the calling and the called central offices are N.39.50° and N.39.00°, respectively, and the longitudes of the calling and called central offices are 70.35° and 70.00°, respectively.

Since in the example presently being described the calling central office is north of the called central office, relay **31-NLAC** will have operated under the control of relay **14-SW-4**, as previously described. Ground extended from the longitude tree circuit indicative of the difference in longitude between the calling and the called central offices is applied to lead **ΔL-3-00** and through the winding of relay **31-LO-00** to battery, causing its operation as previously described. Ground, extended from latitude tree circuit, and indicative of the difference in latitude between the calling and the called central offices, is applied to the upper half-table (in this example table No. 4016) via the front contacts of latitude connector relay **31-NLAC**. Ground on lead **ΔK-3-01** indicative of the difference in latitude between the calling and the called central offices is extended through the No. 01 contacts of relay **31-NLAC**, via lead **31-NLA-01**, through the No. 01 contacts of relay **31-LO-00** to terminal **31-00-01-HBS** and connected to the previously described conductor **31-HBS**, indicating that the distance between the calling and the called central offices is less than 400 miles.

The latitude and longitude differences, as will have been determined by the subtractor circuits, are the same as for the previous description relative to condition 2 of the table of Fig. 89. The band choice circuits, as previously described, responsive to an assumed condition wherein the latitudes of the calling and the called central offices are N.39.50° and N.39.00°, respectively, as indicated in Fig. 84, columns 2, 3 and 4, cause the band choice lead **11–B–4** to be grounded. Ground on lead **11–B–4** causes the operation of the latitude connector relay **35–LAC–404** in the 40- to 400-mile relay table No. 404 and the latitude connector relay **51–LAC–44** in the 0- to 40-mile relay table No. 44.

The 0- to 40-mile relay table No. 44 shown on Figs. 51 to 54, inclusive, is identical in construction and operation with the previously described 0- to 40- mile relay table No. 45. The assignments of mileage values to the coordinate intersection terminals are, of course, different from table No. 45 since relay table No. 44 is associated with a more southerly latitude than the previously described 0– to 40-mile relay table No. 45. Ground extended from the longitude tree circuit indicative of the difference in longitude between the calling and the called central offices is applied to lead **ΔL–1–35** and through the winding of relay **51–LO–35** to battery, causing its operation as previously described. Ground on lead **ΔK–1–50**, indicative of the difference in latitude between the calling and the called central offices, is extended through the No. 50 contacts of latitude connector relay **51–LAC–44**, via lead **53–LA–50**, through contacts No. 50 of relay **51–LO–35** to unassigned terminal **53–TNA** which, structurally, exactly corresponds with the terminal 57–40 connected to armature No. 50 of relay **55–LO–35** in table 45 to which is assigned a mileage value of 40. Due to the divergence of the meridians of longitude as the assumed point of reference approaches the equator, and assuming the same coordinate input indicia of **ΔL–1–35** and **ΔK–1–50** as in the previous description relating to relay table No. 45, the terminal **53–TNA** will represent a distance in excess of 40 miles (not assigned) and therefore will not be connected to the basic rate translator circuit. The answer being just in excess of the scope of the 0–40 mile relay table No. 44, will therefore be found in the 40–400 mile relay table No. 404, which is activated by the same said choice conductor **11–B–4** as activated the 0–40 mile table No. 44.

To return to relay table No. 44, and to facilitate the conversion into basic rate indicia of the distances in miles as obtained from the equivalent numbered terminals of the field, terminals numbered to indicate like distances are strapped together in sets. A plurality of such sets of terminals is connected together and to one of a plurality of terminals **54–T–1** to **54–T–6**, inclusive; each of the latter terminals representing a rate mileage zone to which a particular basic rate applies. The terminals comprising the field of terminals shown in relay table No. 44 are connected as follows:

BASIC RATE MILEAGE ZONES FOR 0 TO 40 MILES

Field Terminals Indicating Miles	Connect to Terminal
-1 to -8	54-T-1
-9 to -13	54-T-2
-14 to -18	54-T-3
-19 to -24	54-T-4
-25 to -30	54-T-5
-31 to -40	54-T-6

Thus for example, all the terminals numbered **–1** to **–8**, inclusive, indicative of distances of 1 to 8 miles, are respectively strapped together into sets, and all of the sets of terminals are connected together and to the terminal **54–T–1** represening the rate mileage zone to which the basic rate for these mileages is applicable, as indicated in the 0 to 40 mile section of the rate mileage table shown in Fig. 96. Terminals **54–T–1** to **54–T–6**, inclusive, are respectively connected to terminals **64–T–1** to **64–T–6**, inclusive, in the basic rate translator circuit via cable **58–C–40**.

The 40- to 400-mile relay table No. 404 shown on Figs. 35 to 38, inclusive, is identical in construction and operation with the previously described 40- to 400-mile relay table No. 405. In the 40- to 400-mile relay table relay table No. 404 the terminals comprising the field of terminals are numbered in accordance with a table of precomputed data pertinent to the band of latitudes (and the table is generally similar to the table shown in Fig. 88) to indicate when ground is extended thereto, some distance lying between 40 and 400 miles. The assignments of equivalent mileage values to the coordinate intersection terminals are, of course, different from those of relay table No. 405 since relay table No. 404 is associated with a more southerly latitude. Ground extended from the longitude tree circuit indicative of the difference in longitude between the calling and the called central offices is applied to lead **ΔL–2–04** and through the winding of relay **35–LO–04** to battery, causing its operation as previously described. Ground on lead **ΔK–2–05**, indicative of the difference in latitude between the calling and the called central offices, is extended through the No. 05 contacts of latitude connector relay **35–LAC–404**, via lead **35–LA–05**, through the No. 05 contacts of relay **35–LO–04** to terminal 35–41 which is indicative of a precomputed distance of 41 miles between the calling and the called central offices. In relay table No. 404, to facilitate the conversion into basic rate indicia of the distances in miles as obtained from the equivalent numbered terminals of the field, terminals numbered to indicate like distances are strapped together in sets.

A plurality of such sets of terminals is connected together and to one of a plurality of terminals **38–T–1** to **38–T–15**, inclusive (of which **38–T–2** to **38–T–14**, inclusive, are not shown); each of the later terminals representing a rate mileage zone to which a particular rate applies. The terminals comprising the field of terminals shown in relay table No. 404 are connected as follows:

BLOCKS OF DISTANCES IN MILES FOR 40 TO 400 MILES

Field Terminals Indicating Miles	Connect to Terminal
-41 to -55	38-T-1
-56 to -70	38-T-2
-71 to -85	38-T-3
-86 to -100	38-T-4
-101 to -124	38-T-5
-125 to -148	38-T-6
-149 to -172	38-T-7
-173 to -196	38-T-8
-197 to -220	38-T-9
-221 to -244	38-T-10
-245 to -268	38-T-11
-269 to -292	38-T-12
-293 to -316	38-T-13
-317 to -354	38-T-14
-355 to -400	38-T-15

For example, all of the field terminals –41 to –55, inclusive, indicative of distances of 41 to 55 miles, are respectively strapped together in sets, all of the sets of terminals –41 to –55 being connected together, and to the terminal **38–T–1**, and represent the rate mileage zone to which the basic rate for mileages lying between 41 and 55 miles is applicable. The basic rate for mileages lying between 41 and 400 miles are shown in the 40 to 400 mile section of the rate mileage table shown in Fig. 96.

Terminals **38–T–1** to **38–T–15**, inclusive (**38–T–2** to **38–T–14**, inclusive, are not shown), are respectively connected to terminals **64–AT–1** to **64–AT–15**, inclusive, in the basic rate translator circuit via conductors in cable **50–C–400**.

We will now describe the operation of the circuits responsive to an assumed set of values as set forth in the table in Fig. 89, condition 3, wherein the latitudes of the calling and the called central offices are N.44.00° and N.39.50°, respectively, and the longitudes of the calling and the called central offices are 70.35° and 70.00°, respectively.

Since in the example presently being described the calling central office is north of the called central office, relay **31**–NLAC will have operated under the control of relay **14**–SW–**4**, as previously described, to apply the latitude difference values, as determined by the latitude tree circuit, to the upper half-table of the 400- to 4000-mile relay table, in this example relay table No. 4021, shown in Figs. 31 to 34, inclusive. Ground extended from the longitude tree circuit indicative of the difference in longitude between the calling and the called central offices is applied to lead ΔL–**3**–**00** and through the winding of relay **31**–LO–**00** to battery, causing its operation as previously described. Ground on lead ΔK–**3**–**05**, indicative of the difference in latitude between the calling and the called central offices, is extended through the No. 05 contacts of relay **31**–NLAC, via lead **31**–NLA–**05** through the No. 05 contacts of relay **31**–LO–**00** to terminal **31**–**00**–**05**–HBS and connected to the previously described conductor **31**–HBS, indicating that the distance between the calling and the called central offices is less than 400 miles.

We have previously described the operation of the band choice circuits whereby, responsive to an assumed condition wherein the latitudes of the calling and the called central offices are N.44.00° and N.39.50°, respectively, as indicated in Fig. 84, columns 2, 3 and 4, the band choice lead **11**–B–**6** is grounded, causing the operation of the latitude connector relay **43**–LAC–**406** in the 40- to 400-mile relay table No. 406.

The 40- to 400-mile relay table No. 406 shown on Figs. 43 to 46, inclusive, is identical in construction and operation with the previously described 40- to 400-mile relay table No. 405. The assignments of equivalent mileage values to the coordinate intersection terminals are, of course, different from table No. 405 since relay table No. 406 is associated with a latitude more northerly than are relay tables numbered 404 and 405. Ground extended from the longitude tree circuit indicative of the difference in longitude between the calling and the called central offices is applied to lead ΔL–**2**–**04** and through the winding of relay **43**–LO–**04** to battery, causing its operation as previously described. Ground on lead ΔK–**2**–**45**, indicative of the difference in latitude between the calling and the called central offices, is extended through the No. 45 contacts of latitude connector relay **43**–LAC–**406**, via lead **45**–LA–**45**, through contacts No. 45 of relay **43**–LO–**04** to terminal 45–323 which is indicative of a precomputed distance of 323 miles between the calling and the called central offices. In relay table No. 406, as in the other relay tables, each terminal in the field of terminals is numbered in accordance with a table of precomputed data pertinent to the band of latitudes (and the table is generally similar to the table shown in Fig. 88) to indicate when ground is extended thereto, some distance lying between 40 and 400 miles.

In relay table No. 406, to facilitate the conversion into basic rate indicia of the distances in miles as obtained from the equivalent numbered terminals of the field, terminals numbered to indicate like distances are strapped together in sets. A plurality of such sets of terminals is connected together and to one of a plurality of terminals **46**–T–**1** to **46**–T–**15**, inclusive, (of which **46**–T–**2** to **46**–T–**13**, inclusive, are not shown); each of the latter terminals representing a rate mileage zone to which a particular basic rate applies. The terminals comprising the field of terminals shown in relay table No. 406 are connected as follows:

BASIC RATE MILEAGE ZONES FOR 40 TO 400 MILES

Field Terminals Indicating Miles	Connect to Terminal
–41 to –55	46–T–1
–56 to –70	46–T–2
–71 to –85	46–T–3
–86 to –100	46–T–4
–101 to –124	46–T–5
–125 to –148	46–T–6
–149 to –172	46–T–7
–173 to –196	46–T–8
–197 to –220	46–T–9
–221 to –244	46–T–10
–245 to –268	46–T–11
–269 to –292	46–T–12
–293 to –316	46–T–13
–317 to –354	46–T–14
–355 to –400	46–T–15

For example, all of the field terminals –317 to –354, inclusive, indicative of distances of 317 to 354 miles, are respectively strapped together in sets, and all of the sets of terminals –317 to –354 are connected together and to terminal **46**–T–**14** and represent the rate mileage zone to which the basic rate for mileages lying between 317 and 354 miles is applicable. The basic rates for mileages lying between 41 and 400 miles are shown in the 40 to 400 mile section of the rate mileage table shown in Fig. 96.

Terminals **46**–T–**1** to **46**–T–**15**, inclusive, (**46**–T–**2** to **46**–T–**13**, inclusive, are not shown) are respectively connected to terminals **64**–AT–**1** to **64**–AT–**15**, inclusive, in the basic rate translator circuit via cable **50**–C–**400**.

We will now describe the operation of the circuits responsive to an assumed set of values as set forth in the table in Fig. 89, condition **4**, wherein the latitudes of the calling and the called central offices are N.45.00° and N.39.50°, respectively, and the longitudes of the calling and called central offices are 70.35° and 70.00°, respectively.

Since in the example presently being described, the calling central office is north of the called central office relay **31**–NLAC will have operated, under the control of relay **14**–SW–**4**, as previously described, to apply the latitude difference values, as determined by the latitude tree circuit, to the upper half-table of the 400- to 4000-relay table, in this example No. 4022, shown in Figs. 31 to 34, inclusive. Ground extended from the longitude tree circuit indicative of the difference in longitude between the calling and the called central offices is applied to lead ΔL–**3**–**00** and through the winding of relay **31**–LO–**00** to battery, causing its operation as previously described. Ground on lead ΔK–**3**–**06** indicative of the difference in latitude between the calling and the called central offices, is extended through the No. 06 contacts of relay **31**–NLAC, via lead **31**–NLA–**06**, through the No. 06 contacts of relay **31**–LO–**00** to terminal 31–421 which is indicative of a precomputed distance of 421 miles between the calling and the called central offices.

Consulting the table of basic rate mileage zones for 400 to 4000 miles, previously described in relation to a condition wherein the latitudes of the calling and called offices are respectively, N.40.00° and N.39.50° and the longitudes of the calling and the called central offices are 70.35° and 70.00°, respectively, it will be found, for example, that all of the field terminals numbered –401 to –446, inclusive, indicative of distances of 401 to 446 miles are respectively strapped together in sets and all of the sets of terminals –401 to –446 are connected together and to terminal **34**–T–**1** and represent the rate mileage zone to which the basic rate for mileages lying between 401 and 446 miles is applicable as indicated in the 400 to 4000 mile section of the rate mileage table shown in Fig. 96.

We have previously described the operation of the band choice circuits whereby, responsive to an assumed condition wherein the latitudes of the calling and the called central offices are N.45.00° and N.39.50°, respectively, as indicated in Fig. 84, columns 2, 3, and 4, the band choice lead **11–B–7** is grounded, causing the operation of the latitude connector relay **47–LAC–407** in the 40- to 400-mile relay table No. 407.

The 40- to 400-mile relay table No. 407 shown in Figs. 47 to 50, inclusive, is identical in construction and operation with the previously described 40- to 400-mile relay tables numbered 404, 405 and 406. The assignments of equivalent mileage values to the coordinate intersection terminals are, of course, different from tables numbered 404, 405 and 406 because of the fact that relay table No. 407 is associated with a latitude more northerly than are the previously described 40- to 400-mile relay tables. Ground extended from the longitude tree circuit indicative of the difference in longitude between the calling and the called central offices is applied to lead Δ**L–2–04** and through the winding of relay **47–LO–04** to battery, causing its operation as previously described. Ground on lead Δ**K–2–55**, indicative of the difference in latitude between the calling and the called central offices, is extended through the No. 55 contacts of latitude connector relay **47–LAC–407**, via lead **49–LA–55**, through contacts No. 55 of relay **47–LO–04** to terminal 49–386 which is indicative of a precomputed distance of 386 miles between the calling and the called central offices. From the foregoing description it is apparent that under certain conditions two different distances are indicated one by the 400- to 4000-mile relay table and the other by the 40- to 400-mile relay table just described. This double reading will, however, cause no difficulty as the reading from the higher mileage band table will always be used under such circumstances. In relay table No. 407, as in the other relay tables, each terminal in the field of terminals is numbered in accordance with a table of precomputed data pertinent to the band of latitudes and the table is generally similar to the table shown in Fig. 88 to indicate when ground is extended thereto, some distance lying between 40 and 400 miles.

In relay table No. 407, to facilitate the conversion into basic rate indicia of the distances in miles as obtained from the equivalent numbered terminals of the field, terminals numbered to indicate like distances are strapped together in sets. A plurality of such sets of terminals is connected together and to one of a plurality of terminals **50–T–1** to **50–T–15**, inclusive (**50–T–2** to **50–T–14**, inclusive, are not shown); each of the latter terminals representing a rate mileage zone to which a particular rate applies. The terminals comprising the field of terminals shown in relay table No. 407 are connected as follows:

BASIC RATE MILEAGE ZONES FOR 40 TO 400 MILES

Field Terminals Indicating Miles	Connect to Terminal
–41 to –55	50–T–1
–56 to –70	50–T–2
–71 to –85	50–T–3
–86 to –100	50–T–4
–101 to –124	50–T–5
–125 to –148	50–T–6
–149 to –172	50–T–7
–173 to –196	50–T–8
–197 to –220	50–T–9
–221 to –244	50–T–10
–245 to –268	50–T–11
–269 to –292	50–T–12
–293 to –316	50–T–13
–317 to –354	50–T–14
–355 to –400	50–T–15

For example, all of the terminals numbered –355 to –400, inclusive, indicative of distances of 355 to 400 miles are respectively strapped together in sets and all of the sets of terminals are connected together and to the terminal **50–T–15** and represent the rate mileage zone to which the basic rate for those mileages is applicable as indicated in the 40 to 400 mile section of the rate mileage table shown in Fig. 96.

Terminals **50–T–1** to **50–T–15**, inclusive (of which **50–T–2** to **50–T–14**, inclusive, are not shown), are respectively connected to terminals **64–AT–1** to **64–AT–15**, inclusive, in the basic rate translator circuit via cable **58–C–400**.

We will now describe the operation of the circuits responsive to an assumed set of values as set forth in the table in Fig. 89, condition 5, wherein the latitudes of the calling and the called central offices are N.46.00° and N.39.50°, respectively, and the longitudes of the calling and the called central offices are 70.35° and 70.00°, respectively.

Since in the example presently being described the calling central office is north of the called central office, relay **31–NLAC** will have operated, under the control of relay **14–SW–4**, as previously described, to apply the latitude difference values, as determined by the latitude tree circuit, to the upper half-table of the 400- to 4000-mile relay table, in this example No. 4023, shown in Figs. 31 to 34, inclusive. Ground extended from the longitude tree circuit indicative of the difference in longitude between the calling and the called central offices is applied to lead Δ**L–3–00** and through the winding of relay **31–LO–00** to battery, causing its operation as previously described. Ground on lead Δ**K–3–07** indicative of the difference in latitude between the calling and the called central offices is extended through the No. 07 contacts of relay **31–NLAC**, via lead **31–NLA–07**, through the contacts No. 07 of relay **31–LO–00** to terminal 31–491 which is indicative of a precomputed distance of 491 miles between the calling and the called central offices.

Again, consulting the previously described table of "basic rate mileage zones for 400 to 4000 miles," it will be found that all of the field terminals numbered –477 to –492, inclusive, indicative of distances of 447 to 492 miles are respectively strapped together in sets and all of the sets of terminals are connected together and to terminal **34–T–2** and represent the rate mileage zone to which the basic rate for mileages lying between 447 and 492 is applicable.

Responsive to the previously described condition, band choice lead **11–B–7** is again grounded causing the operation of latitude connector relay **47–LAC–407** in the 40- to 400-mile relay table No. 407. The operation of the relay table No. 407 as previously described, effects the extension of ground to a field terminal to which, however, no equivalent mileage value has been assigned because the distance exceeds 400 miles and the answer will be found in the 400- to 4000-mile relay table.

In the 40- to 400-mile relay tables numbered 404, 406, and 407 (shown on Figs. 35 through 38; 43 through 46; and 47 through 50, respectively), the terminals such as **35–00–00–MBS**, **35–06–02–MBS**, **43–00–00–MBS**, **43–06–02–MBS**, **47–00–00–MBS** and **47–06–02–MBS**, respectively; each indicating, when grounded, that the calling and the called central offices are separated by a distance of less than 40 miles; are each respectively strapped to the other MBS terminals in the same relay table and connected to the conductor **35–MBS**, and function in the manner described with reference to the terminals such as **39–01–00–MBS**, **39–01–01–MBS**; **39–01–05–MBS**, and **39–04–05–MBS**, in relay table No. 405 (shown on Figs. 39 through 42).

In the preceding description we have described the manner in which the several relay tables comprising the rate location circuit, operating in conjunction with related circuits, have translated the several sets of indicia expressive of a plurality of hypothetical combinations of latitude and longitude of the calling and called central offices into distances in miles there-between.

We will now describe the operation of the basic rate translator which translates the indicia in miles furnished by the operation relay tables, into the appropriate basic rate index for the call in progress.

We will first assume that the longitudes of the calling and the called central offices are W.70.35° and W.70.00°, respectively, and that the latitudes of the calling and the called central offices are N.40.00° and N.39.50°, respectively, as indicated in Fig. 89, condition 2. Responsive to the above described condition, grounds are extended to terminals **33–00–01–HBS**, **33–04–05–MBS** and **57–40** as previously described. Ground on terminals **33–00–01–HBS** and **39–04–05–MBS** operate relays **64–HBS** and **64–MBS**, respectively; also as previously described. Relay **64–B–5** operates from ground on lead **11–B–5** as previously described, causing ground to be extended through its number 1 contacts and lead **64–1**, the front contacts of relay **64–HBS**, lead **64–2**, the front contacts of relay **64–MBS**, lead **64–3**, the winding of the relay **64–40**, to negative battery, causing the latter relay to operate, indicating that the distance in miles between the calling and the called central offices is obtained from a 0 to 40 mile relay table.

The operation of relay **64–HBS** indicates that the distance in miles between the calling and the called central offices is not within the range of the 400 to 4000 mile relay table, and disables the operating circuit for relay **64–4000**. The operation of relay **64–MBS**, on the other hand, indicates that the distance in miles is not to be obtained from the 40 to 400 mile relay tables, and disables the operating circuit for relay **64–400**. Ground on terminal **57–40** in 0 to 40 mile relay table number 45, indicative of a distance of 40 miles, is extended to terminal **58–T–6**, thence via conductor **58–6** in cable **58–C–40** to terminal **64–T–6** in the basic rate translator circuit, thence through the number 6 contacts of relay **64–40**, via conductor **64–40–C–6** to the anodes of diodes **64–40–D–62** and **64–40–D–64** in parallel; then from the cathode of diode **64–40–D–62**, via common conductor **64–C–2** in cable **64–C**, through the winding of relay **64–BRT–2** to negative battery; also from the cathode of diode **64–40–D–64**, via common conductor **64–C–4** in cable **64–C** through the winding of relay **64–BRT–4** to negative battery causing relays **64–BRT–2** and **64–BRT–4** in the basic rate translator register to operate and register on a binary basis the basic rate index number 6 which, in a manner to be later described, is transmitted to and recorded in the magnetic drum storage circuit. Relay **64–40**, in operating, shifts positive battery from its No. 7 back contact to the No. 7 armature front contacts, thus causing to be recorded, in the magnetic drum storage circuit, and in a manner to be later described, the indication that the basic rate index number 6 was obtained from the 0 to 40 mile band choice.

We will now assume that the longitudes of the calling and the called central offices are W.70.35° and W.70.00° respectively, as before, and that the latitudes of the calling and the called central offices are N.39.50° and N.39.00°, respectively, as indicated in Fig. 89, condition 1. Responsive to the above-described condition grounds are extended to terminals **31–HBS** and **35–41** as previously described. Relay **64–HBS** operates from ground on the **31–HBS** lead as previously described. Relay **64–B–4** operates from ground on the band-choice lead **11–B–4** as previously described, causing ground to be extended through No. 1 contacts, lead **64–1**, the armature and front contact of **64–HBS**, lead **64–2**, the armature and back contact of relay **64–MBS**, lead **64–4**, through the winding of relay **64–400**, to negative battery, causing it to operate, indicating that the distance in miles between the calling and the called central offices is obtained from a 40 to 400 mile relay table. Ground on terminal **35–41** in the 40 to 400 mile relay table number 404, indicative of a distance of 41 miles, is extended to terminal **38–T–1**, thence via conductor 50–1 in cable **50–C–400** to terminal **64–AT–1** in the basic rate translator circuit, thence through the No. 1 contacts of relay **64–400**, via conductor **64–400–C–1** to the anode of diode **64–400–D–1**, and from the cathode thereof via common conductor **64–C–1** in cable **64–C**, through the winding of relay **64–BRT–1** to negative battery, causing it to operate and register, on a binary basis, the basic rate index number 1 which, in a manner to be later described, is transmitted to and recorded in the magnetic drum storage circuit. Relay **64–400**, in operating, shifts positive battery from its No. 16 back contact to its No. 16 front contacts. As will be shown, this battery will cause an indication that the basic rate index number 1 was obtained from the 40 to 400 mile band choice to be recorded in the magnetic drum storage circuit.

We will now assume as before that the longitudes of the calling and the called central offices are W.70.35° and W.70.00°, respectively, and that the latitudes of the calling and the called central offices are N.44.00° and N.39.50°, respectively, as indicated in Fig. 89, condition 3. Responsive to the above-described condition grounds are extended to terminals **33–00–05–HBS** and **45–323** as previously described. Relay **64–HBS** operates from ground on the **31–HBS** lead. Relay **64–B–6** operates from ground on lead **11–B–6** as previously described, causing ground to be extended through its No. 1 contacts, lead **64–1**, the armature and front contacts of relay **64–HBS**, lead **64–2**, the armature and back contact of relay **64–MBS**, lead **64–4**, through the winding of relay **64–400** to negative battery, causing it to operate, indicating that the distance in miles between the calling and the called central offices is obtained from a 40 to 400 mile relay table. Ground on terminal **45–323** in the 40 to 400 mile relay table number 406, indicative of a distance of 323 miles, is extended to terminal **46–T–14**, thence via conductor **46–14** in cable **50–C–400** to terminal **64–AT–14** in the basic rate translator circuit, thence through the number 14 contacts of relay **64–400**, via conductor **64–400–C–14** to the anodes of diodes **64–400–D–142**, **64–400–D–144** and **64–400–D–148** in parallel; from the cathode of diode **64–400–D–142**, via common conductor **64–C–2** in cable **64–C**, through the winding of relay **64–BRT–2** to negative battery; from the cathode of diode **64–400–D–144**, via common conductor **64–C–4** in cable **64–C**, through the winding of relay **64–BRT–4** to negative battery; from the cathode of diode **64–400–D–148**, via common conductor **64–C–8** in cable **64–C**, through the winding of relay **64–BRT–8** to negative battery. Relays **64–BRT–2**, **64–BRT–4** and **64–BRT–8** in the basic rate translator register circuit will operate in the circuits just traced and register, on a binary basis, the basic rate index number 14 the digits of which, in a manner to be later described, are transmitted to and recorded in the magnetic drum storage circuit. Relay **64–400**, in operating, shifts positive battery from its back to the front contact of its number 16 armature, thus causing to be recorded in the magnetic drum storage circuit the indication that the basic rate index number 14 was obtained from the 40 to 400 mile band choice, as will later be described.

We will now assume as before that the longitudes of the calling and the called central offices are W.70.35° and W.70.00°, respectively, and that the latitudes of the calling and the called central offices are N.45.00° and N.39.50°, respectively, as indicated in Fig. 89, condition 4. Responsive to the above-described condition ground is extended to terminals **31–421** and **49–386** as previously described. Relay **64–B–7** operates from ground on the band choice lead **11–B–7** as previously described, causing ground to be extended through its No. 1 contacts, lead **64–1**, back contacts of relay **64–HBS**, lead **64–6**, the winding of relay **64–4000**, to negative battery, causing said relay to operate, indicating that the distance in miles between the calling and the called central offices is obtained from the 400 to 4000 mile relay table. Ground on terminal **49–386** in the 40 to 400 mile relay table number 407, indicative of a distance of 386 miles, is extended to terminal **50–T–15**, thence via conductor **50–15** in cable **50–C–400** to terminal **64–AT–15** in the basic rate translator circuit where, due to the non-operated condition of relay **64–400**, the path to the diodes of the basic rate translator circuit is open. Ground applied to terminal **31–421** in the 400 to 4000 mile relay table number 4016, indicative of a distance of 421 miles, is extended to terminal **34–T–1**, thence via conductor **34–1** in cable **34–C–4000** to terminal **64–BT–1** in the basic rate translator circuit, thence through the number 1 contacts of relay **64–4000**, via conductor **64–4000–C–1**, to the anode of diode **64–4000–D–1** and from the cathode thereof via common conductor **64–C–1** in cable **64–C**, through the winding of relay **64–BRT–1** to negative battery, causing it to operate and register thereby, on a binary basis, the basic rate index number 1 which, in a manner to be later described, is transmitted to and recorded in the magnetic drum storage circuit. Relay **64–4000**, in operating, shifts positive battery from the back to the front contact of its number 16 armature thus causing to be recorded, in a manner to be later described, in the magnetic drum storage circuit, the indication that the basic rate index number 1 was obtained from the 400 to 4000 mile band choice. Under the assumed condition above described it will be noted that indications of distance in miles are simultaneously furnished by the 40 to 400 mile relay table number 407 and by the 400 to 4000 mile relay table number 4016. The distance indication from the higher, or 400 to 4000 mile, relay table will be presented to the basic rate translator and the distance indication from the lower, or 40 to 400 mile, relay tables will not be presented to the basic rate translator because of the steering function performed by the relays **64–HBS** and **64–MBS**.

We will now assume that the longitudes of the calling and the called central offices are W.70.35° and W.70.00°, respectively, as before, and that the latitudes of the calling and called central offices are N.46.00° and N.39.50°, respectively, as indicated in Fig. 89, condition 5. Responsive to the above described condition ground is extended to terminal **31–491** as previously described. Relay **64–B–7** operates from ground on lead **11–B–7** as previously decribed and causes ground to be extended through its number 1 contacts, lead **64–1** through the armature and back contact of relay **64–HBS**, via lead **64–6**, through the winding of relay **64–4000** to negative battery, causing said relay to operate and indicate that the distance in miles between the calling and the called central offices is obtained from the 400 to 4000 mile relay table. Ground on terminal **31–491** in 400 to 4000 mile relay table, in this example number 4023 indicative of a distance of 491 miles, is extended to terminal **34–T–2** thence via conductor **34–2** in cable **34–C–4000** to terminal **64–BT–2** in the basic rate translator circuit, thence through the number 2 contacts of relay **64–4000**, via conductor **64–4000–C–2**, to the anode of diode **64–4000–D–2**, and from the cathode thereof via common conductor **64–C–2** in cable **64–C**, through the winding of relay **64–BRT–2** to negative battery, causing it to operate and register, on a binary basis, the basic rate index number 2 which, in a manner to be later described, is transmitted to and recorded in the magnetic drum storage circuit. Relay **64–4000**, in operating, shifts positive battery from the back to the front contact of its number **16** armature, thus causing to be recorded, in a manner to be later described, in the magnetic drum storage circuit, the indication that the basic rate index number 2 was obtained from the 400 to 4000 mile band choice.

Band choice relays **64–B–4** and **64–B–5** are respectively operable by ground extended via the **11–B–4** or **11–B–5** leads and are mutually exclusive. If, for example, ground is applied by the band selection circuit to band choice lead **11–B–4**, an operating path for relay **64–B–4** will be completed through the number 2 contacts of relay **64–B–5** unoperated. Similarly, if ground is applied to band choice lead **11–B–5**, relay **64–B–5** may be energized only if relay **64–B–4** is not operated. This circuit arrangement precludes the simultaneous presentation of grounds, indicative of distance in miles, to the basic rate translator circuit from relay tables associated with band choices 4 and 5. Band choice relays **64–B–6** and **64–B–7** are respectively operable by ground extended via the **11–B–6** or **11–B–7** band choice leads and, similar to relays **64–B–4** and **64–B–5**, are mutually exclusive. This circuit arrangement precludes the simultaneous presentation of grounds to the basic rate translator circuit from relay tables associated with band choices 6 and 7.

The basic rate translator register circuit **64–BRTR**, consisting of relays **64–BRT–1**, **64–BRT–2**, **64–BRT–4** and **64–BRT–8**, employs a binary code well known in the art. Any number from 1 to 15 may be stored therein, and the output, expressed as a potential change, transmitted to and recorded in the magnetic drum storage circuit.

The table below shows the register relays to be operated to express any numerical value from 1 to 15:

1=**64–BRT–1**
2=**64–BRT–2**
3=**64–BRT–1** and **64–BRT–2**
4=**64–BRT–4**
5=**64–BRT–1** and **64–BRT–4**
6=**64–BRT–2** and **64–BRT–4**
7=**64–BRT–1**, **64–BRT–2** and **64–BRT–4**
8=**64–BRT–8**
9=**64–BRT–1** and **64–BRT–8**
10=**64–BRT–2** and **64–BRT–8**
11=**64–BRT–1**, **64–BRT–2** and **64–BRT–8**
12=**64–BRT–4** and **64–BRT–8**
13=**64–BRT–1**, **64–BRT–4** and **64–BRT–8**
14=**64–BRT–2**, **64–BRT–4** and **64–BRT–8**
15=**64–BRT–1**, **64–BRT–2**, **64–BRT–4** and **64–BRT–8**

District junctor circuits and associated timing circuits

The originating central office is served by a group of one hundred district junctors consecutively numbered from 00 to 99, inclusive, and indicated as **1–DJ–00** and **1–DJ–99**, respectively. In telephone systems wherein the customer billing charges are automatically computed and recorded, it is the practice to employ the number designation of the particular district junctor used to complete a given call as the means of associating the several items of indicia pertaining to the call. The said numerical designation of the district junctor is known as the call identity index and will be hereinafter so referred to. A district junctor identifier circuit **1–DJI** serves as the means common to a group of 100 district junctors for associating, via conductors in cables **1–TC**, **1–UC**, and **1–CIIM** and conductors **1–00** to **1–99**, the call identity index number of a junctor over which a connection is being established or has been established with the item of record information to be recorded in the magnetic drum circuit.

Each of the district junctors, for the purpose of determining the elapsed conversation time for a completed call, has associated therewith a district junctor timing circuit **2–DJT**, and an elapsed conversation time register circuit **2–ECT**. The operation of the district junctor timing circuit may be traced as follows; assume that a call is currently in progress via district junctor circuit **1–DJ–99**. Relay **1–ANS** operates as disclosed in the prior art responsive to the answer by the called party, completing an obvious circuit to energize relay **1–TM** which operates and remains operated for the duration of the conversation connection between the calling and called subscribers.

A clock-controlled interrupter **1–INT**, arranged to close its contacts at six second intervals, common to all of the district junctor circuits, applies interrupted ground to the district junctors via lead 1–IG. Stepping magnet 2–STP–1 operates over a circuit extending from battery through the winding of said stepping magnet, lead 1–DJ–1, No. 1 contacts of relay 1–TM, lead 1–IG, and contacts of interrupter 1–INT to ground upon the closure of said interrupter.

Stepping magnet 2–STP–1 releases when its operating circuit is broken by the opening of the contacts of interrupter 1–INT and causes the selector switch arms to advance one step to the number two terminal. Successive operations of the interrupter 1–INT cause the 2–STP–1 selector arms to continue to advance. When the selector switch 2–STP–1 has advanced its selector switch arms to the No. 11 terminals a circuit will be closed from ground on its No. 2 arm, No. 2 bank, No. 11 terminal to battery through the winding of the 2–STP–2 stepping magnet which will operate.

Stepping magnet 2–STP–1 will release under control of the interrupter 1–INT, causing its selector switch arms to advance, removing ground from its No. 2 bank, No. 11 terminal, to open the operating circuit for stepping magnet 2–STP–2 which will release. The release of stepping magnet 2–STP–2 will cause its selector arms to advance one step to its No. 2 terminals. Further operations of the interrupter 1–INT will cause stepping magnet 2–STP–1 to continue to advance its selector switch arms. When the selector 2–STP–1 has advanced its selector switch arms to the No. 21 terminals a circuit will be closed from ground on the No. 2 arm, No. 2 bank, No. 21 terminal, to battery through the winding of the 2–STP–2 stepping magnet which will again operate.

Stepping magnet 2–STP–1 will again release, under control of the interrupter 1–INT, causing its selector switch arms to advance to its No. 22 terminals, removing ground from the No. 2 bank, No. 21 terminal to open the circuit for stepping magnet 2–STP–2 which will again release. The release of the stepping magnet 2–STP–2 will cause its selector arms to advance one step to its No. 3 terminals.

When the selector 2–STP–1 has advanced its selector switch arms to its No. 22 terminals a circuit will be closed from ground on the No. 3 arm, No. 3 bank, No. 22 terminal, armature and back contact on the 2–STP–1 stepping magnet to battery through the winding of the 2–STP–1 stepping magnet which will operate and in so doing open its own operating circuit and release. The selector switch arms of selector 2–STP–1 will step to its No. 1 terminals.

The 2–STP–1 stepping magnet will continue to be energized and deenergized under control of the interrupter 1–INT, thus causing the continued stepping of its selector switch arms in the manner above described, for the duration of the conversation connection.

Selector switch 2–STP–2 will, as above described, continue to step once for each tenth step of selector switch 2–STP–1, until its selector switch arms have advanced to its No. 11 terminals. When the selector switch 2–STP–2 has advanced its selector switch arms to its No. 11 terminals a circuit will be closed from ground on its No. 4 arm, No. 4 bank, No. 11 terminal, to battery through the winding of the 2–STP–3 stepping magnet which will operate.

Selector switch 2–STP–2 will continue to step, as previously described, removing ground from its No. 4 bank, No. 11 terminal to open the operating circuit for stepping magnet 2–STP–3 which will release. The release of stepping magnet 2–STP–3 will cause its selector switch arms to advance on a step to its No. 2 terminals.

Selector switch 2–STP–2 will continue to be stepped, as previously described, until its selector switch arms have advanced to its No. 21 terminals when a circuit will be closed from ground on its No. 4 arm, No. 4 bank, No. 21 terminal, to battery through the winding of the 2–STP–3 stepping magnet which will again operate.

Stepping magnet 2–STP–2 will again release as previously described, and will advance its selector switch arms to its No. 22 terminals, removing ground from the No. 4 bank, No. 21 terminal to open the circuit for stepping magnet 2–STP–3 which will release. The release of the stepping magnet 2–STP–3 will cause its selector arms to advance one step to its No. 3 terminals.

When the selector 2–STP–2 has advanced its selector switch arms to its No. 22 terminals a circuit will be closed from ground on its No. 6 arm, No. 6 bank, No. 22 terminal, armature and back contact on the 2–STP–2 stepping magnet which will operate and in so doing open its own operating circuit and release. The selector switch arms of selector 2–STP–2 will step to its No. 1 terminals.

Selector switch 2–STP–3 will, as above described, continue to step once for each tenth step of selector switch 2–STP–2 until its selector switch arms have advanced to its No. 11 terminal. When the selector switch 2–STP–3 has advanced its selector switch arms to its No. 11 terminals a circuit will be closed from ground on its No. 3 arm, No. 3 bank, No. 11 terminal, to battery through the winding of relay 2–100 which will operate.

Selector switch 2–STP–3 will, as previously described, release and advance its selector switch arms removing ground from its No. 3 bank, No. 11 terminal to open the operating circuit for relay 2–100 which will release.

Selector switch 2–STP–3 will, as above described, continue to step until its selector switch arms have advanced to its No. 21 terminals when a circuit will be closed from ground on its No. 3 arm, No. 3 bank, No. 21 terminal, to battery through the winding of relay 2–100 which will again operate.

Stepping magnet 2–STP–3 will again release, as previously described, and will advance its selector switch arm to its No. 22 terminals, removing ground from its No. 3 bank, No. 21 terminals to again open the operating circuit for relay 2–100 which will again release.

When the selector switch 2–STP–3 has advanced its selector switch arms to its No. 22 terminals a circuit will be closed from ground on its No. 5 arm, No. 5 bank, No. 22 terminal, armature and back contact on the 2–STP–3 stepping magnet to battery through the winding of the 2–STP–3 stepping magnet which will operate and in so doing open its own operating circuit and release. The selector switch arms of selector 2–STP–3 will step to its No. 1 terminals.

Thus it will be apparent that selector switch 2–STP–1 will step once for each interrupter cycle or once every six seconds.

It will also be apparent, that since every ten steps of selector switch 2–STP–1 will cause selector switch 2–STP–2 to step once, that selector switch 2–STP–2 will step once for every ten interrupter cycles or once every minute.

It will also be further apparent, that since every ten steps of selector switch 2–STP–2 will cause selector switch 2–STP–3 to step once, that selector switch 2–STP–3 will step once for every hundred interrupter cycles or once every ten minutes.

From the foregoing description it will also be apparent, that since every ten steps of selector switch 2–STP–3 will close the operating circuit for relay 2–100, that relay 2–100 will operate once for every thousand interrupter cycles or once for every 100 minutes of elapsed conversation time.

From the foregoing description it will be seen that the positions assumed by the selector switch arms 1 and 2 of selector switch 2–STP–2 will indicate elapsed conversation time in minutes; the positions of selector switch arms 1 and 2 of selector switch 2–STP–3 will indicate elapsed conversation time in tens of minutes and the operated condition of relay 2–100 indicating an elapsed conversation time of 100 minutes.

When, at the conclusion of a call, either subscriber hangs up his instrument and the district junctor identifier is again associated with the district junctor, and if it is assumed that the call has been established over trunk No. 99, relays **1–T–9** and **1–U–9** of the identifier operate and complete a circuit for relays **2–TA** and **2–RA** in parallel over a path extending from battery through the windings of said relays, conductor **1–99**, No. 10 contacts of relay **1–T–9** and No. 1 contacts of relay **1–U–9**, to ground.

It is assumed that the identifier operates in the known manner to hold the trunk busy after conversation terminates until the recording functions to be described will have been completed.

Relay **2–TA**, upon operating, supplies grounds to the Nos. 1 and 2 selector switch arms of selector switches **2–STP–2** and **2–STP–3**, and also to the armature of relay **2–100**.

The relay windings of the elapsed conversation time register **2–ECT**, comprising relay **2–100–H** representative of 100 minutes of elapsed conversation time, relays **2–TR–0**, **2–TR–1**, **2–TR–2**, **2–TR–4** and **2–TR–7** representative of tens of minutes of conversation time (of which only **2–TR–0** and **2–TR–7** are shown) and relays **2–UR–0**, **2–UR–1**, **2–UR–2**, **2–UR–4** and **2–UR–7** representative of minutes of conversation time (of which only **2–UR–0** and **2–UR–7** are shown) are energized in accordance with the settings assumed by the selector switch arms of the district junctor timing circuit. The elapsed conversation time register is capable of taking settings expressive of elapsed conversation times of from 0 to 100 minutes, the units and tens denominational orders being constructed on the two-out-of-five code basis and hence requiring the operation of two relays in each order to express a value, the **2–100–H** relay being operated only for the maximum value of 100 minutes.

Included in the elapsed conversation time register is a register check relay **2–RCK** which operates to indicate the operation of the elapsed conversation time register relays responsive to valid combinations of the two-out-of-five code.

Relay **2–RA**, upon operating, supplies battery to all of the armatures of the digital relays and to the armature of the check relay **2–RCK** of the elapsed conversation time register.

Each of the plurality of elapsed conversation time registers will, in its turn, apply its output via the multiple conductors in cables **2–ECTM**, **2–ITM**, and **10–CHGD**, to the magnetic drum storage circuit to record the elpased time for the completed call whose data is currently being processed.

When at the conclusion of a call relay **1–TM** has released, a circuit is completed from ground, its No. 2 back contacts, conductor **1–TRL**, through delay circuit **1–DL**, conductor **1–TRLD** to selector switch arm No. 4 of selector switch **2–STP–3**, selector switch arm No. 5 of selector switch **2–STP–2**, and to selector switch arm No. 4 of selector switch **2–STP–1**, any one of which selector switch arms in an off-normal position will complete a ground connection through its respective strapped Nos. 2 to 22 terminals, armature and back contact and winding of its respective stepping magnet, to battery, causing their respective selector switch arms to be stepped to their No. 1 terminals where they will come to rest to await their next use in timing a call. The delay circuit **1–DL** (which may be of any suitable construction) delays the application of ground to conductor **1–TRLD** to delay the release of the stepping switches in the district junctor timing circuit until the elapsed conversation time register **2–ECT** will have transmitted the coded information of elapsed conversation time to the magnetic drum storage circuit.

Automatic reduced rate indicating circuit

In telephone systems it is the general practice to charge for toll calls originating during the usual business hours of week days at the standard day rate and to charge for toll calls originating on Sundays, holidays and certain other hours at a reduced or night rate. It is the purpose of the Automatic Reduced Rate Indicating Circuit, shown on Fig. 65, to automatically apply a potential condition to the magnetic drum storage circuit indicating that the call charging indicia then being recorded in that particular slot is to be charged for at the night rate.

The operation of the Automatic Reduced Rate Indicating Circuit is as follows. A clock motor **65–CM**, which, for example, may be of the usual 60-cycle synchronously driven type, continuously drives through a suitable reduction gear train **65–RG** the cams **65–N** and **65–DA** at the rate of 1 revolution in 24 hours. The cam **65–N** is shown in that portion of its rotational cycle wherein the night contacts **65–NC** are open. The cam **65–N** is cut in such a manner that from the hours of 6 p.m. to 6 a.m. the contact **65–NC** will be closed, during which time ground will be extended through the contacts **65–NC**, through the diode **65–DN–1**, through the winding of relay **65–NR** to negative battery. Relay **65–NR** operates in the circuit just traced and, in operating, transfers positive battery from its back to its front contact, thereby causing an indication to be transmitted to and recorded in the magnetic drum storage circuit that the night rate should apply to the call charge indicia then being recorded in the same slot. At the same time ground through contacts **65–NC** causes the night pilot lamp **65–NP** to be lighted as an indication to the attendant that the call charging indicia currently being recorded is chargeable at the night rate.

The means for recognizing Sundays or holidays as they occur and for applying the reduced or night rate to calls then being originated operates as follows. The cam **65–DA**, which completes one revolution in each 24 hours, causes, at midnight, contacts **65–DAC** to close and extend ground through the winding of slow operating relay **65–SLO**, to battery. Ground from contacts **65–DAC**, when relay **65–SLO** operates, is extended through the make-before-break contacts thereof, through the winding of stepping switch magnet **65–STPA**, to battery. The momentary energization of magnet **65–STPA** causes the arm of stepping switch **65–SWA** to be advanced from its number 1 terminal, or rest position, to its number 2 terminal. At the expiration of 24 hours when cam **65–DA** again closes contacts **65–DAC**, the circuit through stepping switch magnet **65–STPA** is again closed, causing switch arm **65–SWA** to advance to its number 3 terminal. Manually operated keys **65–MSA**, **65–MRA**, **65–KBS** and **65–KBR** are provided for administrative and maintenance purposes whereby the attendant may, at will, cause the stepping switches **65–SWA** or **65–SWB** to be advanced or released. Since the calendar period depicted in the exemplary disclosure begins on Tuesday, January first (see Fig. 65A) it will be assumed in this instance that the switch arm **65–SWA** is resting on the terminal number 1, to which position it will have been returned by the energization of its release magnet **65–RLA**. The attendant momentarily operates manual stepping key **65–MSA** causing the day stepping switch arm **65–SWA** to advance to its number 2 terminal. The attendant again momentarily operates key **65–MSA**, advancing the arm **65–SWA** to terminal number 3 which represents Tuesday, January first, the beginning of the calendar period illustrated in Fig. 65–A. With day stepping switch arm **65–SWA** resting on its number 3 terminal, ground is extended via day multiple conductor **65–DM3**, through the pilot lamp **65–D–3** to negative battery. Pilot lamp **65–D–3** lights to indicate to the attendant that the day stepping switch arm **65–SWA** is in its position indicative of a Tuesday. Week stepping switch arms **65–SWB–1** and **65–SWB–2** will be assumed to be resting on their number 1 terminals, to which position they will have been returned by the energization of release magnet **65–RLB**.

With switch arm 65–SWA resting on its number 3 terminal ground is extended, via conductor 65–DM3, through the varistor 65–V–1 indicative that Tuesday, January first is a holiday, via week multiple conductor 65–WM–1 to the number 1 terminal of stepping switch 65–SWB–1, through the switch arm, via conductor 65–SH, through diode 65–SH, through the winding of relay 65–NR causing it to operate and transfer positive battery from its back to its front contact to cause an indication to be transmitted to and recorded in the magnetic drum storage circuit that the night rate should apply to the call charge indicia then being recorded in the same slot. At the same time ground on lead 65–SH is extended through the Sunday-holiday pilot lamp 65–SH, causing it to be lighted as an indication to the attendant that the call charging indicia currently being recorded is for a Sunday or a holiday. The stepping switch arm 65–SWB–1 is shown in contact with its number 1 terminal, which represents the first week of a pre-set calendar period. The stepping switch arm 65–SWB–2 is shown in contact with its number 1 terminal and ground supplied thereto causes the lamp 65–W–1, indicative of the first week of a pre-set calendar period, to be lighted as an indication that the call charge indicia currently being recorded is for the first week of a pre-set calendar period. The other lamps, 65–W–2 to 65–W–10, inclusive, respectively connected to terminals 2 to 10, inclusive, of stepping switch 65–SWB–2, respectively indicate the remaining 9 weeks of the calendar period. Successive operations of stepping switch arm 65–SWA successively extend ground via the day multiple conductors 65–DM–4 to 65–DM–7 to successively cause the lighting of the day pilot lamps 65–D–4 to 65–D–7. Stepping switch arm 65–SWA continues to be advanced one step for each elapsed twenty-four hour interval until the switch arm is in contact with its terminal number 8, when ground will be extended, via conductor 65–C–1, to the anodes of diodes 65–DSB and 65–DR in parallel. Ground is extended from the anode of diode 65–DSB via conductor 65–S–1 through the winding of stepping switch magnet 65–STPB to negative battery. Simultaneously therewith ground is also extended from the anode of diode 65–DR, through the release magnet 65–RLA, to negative battery. The energization of release magnet 65–RLA causes the arm of stepping switch 65–SWA to release and return to its number 1 terminal which represents a Sunday. The other terminals 2 to 7, inclusive, respectively represent Monday to Saturday, inclusive. Stepping switch magnet 65–STPB is energized over the circuit previously traced and causes stepping switch arms 65–SWB–1 and 65–SWB–2 to be advanced to the number 2 terminals. With day stepping switch arm 65–SWA resting on its number 1 terminal and week stepping switch arms 65–SWB–2 and 65–SWB–1 resting on the number 2 terminals, ground will be extended through the switch arm 65–SWA, via day multiple conductor 65–DM–1, through varistor 65–V–2, indicative that January sixth is a Sundary, via week multiple conductor 65–WM–2 to the number 2 terminal of switch 65–SWB–1, through the switch arm, via conductor 65–SH to light lamp 65–SH and through diode 65–SH to operate the relay 65–NR as previously described. Lamp 65–W–2 will be lighted from ground on switch arm 65–SWB–2. Lamp 65–D–1 will be lighted from ground on the switch arm 65–SWA.

Stepping switch arm 65–SWA will continue to be advanced one step for each elapsed twenty-four hour interval and will, each time that it has completed a circuit through its No. 8 terminal, cause stepping switch arms 65–SWB–1 and 65–SWB–2 to be advanced one step and energize the release magnet 65–RLA as previously described. When stepping switch arm 65–SWA has been advanced to its number 5 terminal, and stepping switch arms 65–SWB–1 and 65–SWB–2 have been advanced to their number 9 terminals; conjointly indicative of Thursday, February 28th, the end of the calendar period for which varistor connections representative thereof have been set up, the attendant will operate release keys 65–MRA and 65–KBR which, respectively, will cause the release magnets 65–RLA and 65–RLB to be energized and cause all of the stepping switch arms to be returned to their number 1 terminals. The attendant will then change the pattern of connections for the varistors to represent the next succeeding calendar period and reset the day stepping switch to the appropriate start position therefor.

The terminal banks of stepping switch 65–SWB in the exemplary disclosure have ten terminals and are capable of accommodating a calendar period of ten weeks. It is obvious that if it were desired to extend the calendar period it could be readily accomplished by substituting a stepping switch having a greater number of terminals in its terminal banks. The stepping switches 65–SWA and 65–SWB are of a type well known in the communications switching art. Each switch comprises one or more terminal banks each including a plurality of arcuately disposed terminals and a switch arm having electrical access thereto, a stepping magnet and a release magnet. The stepping magnet, upon the momentary energization thereof, will cause the switch arm or arms, to advance from the start position, one terminal at a time and be held in such position until the stepping magnet is again momentarily energized causing the switch arms to advance another step. Thus, the switch arms will continue to be advanced with each successive energization of the stepping magnet until the last, or stop position has been reached, or until the release magnet is momentarily energized to permit a spring action to return the switch arm to the start position.

The translator comprises a day multiple consisting of a plurality of parallel conductors 65–DM–1 to 65–DM–7, inclusive, lying in the same plane, and a week multiple consisting of a plurality of parallel conductors 65–WM–1 to 65–WM–10, inclusive, lying in a plane parallel to, but slightly separated from the plane of the day multiple. At each of the points where the conductors of the day multiple and the week multiple cross or intersect each other, a quickly attachable or detachable means is provided for effecting an electrical connection therebetween by means of a varistor or other unilaterally conductive device. Thus a unilaterally conductive circuit, indicative of a Sunday or a holiday, may be flexibly established between any conductor or conductors of the week multiple and any conductor or conductors of the day multiple. Fig. 65–A shows a sample calendar for the nine-week period of 1952 beginning January first and ending February 28, wherein each number enclosed in a double outline is representative of a Sunday or holiday. Each Sunday or holiday will be electrically simulated by a varistor connected in accordance with the pattern illustrated in Fig. 65–A, to the conductors of the day and week multiples.

Magnetic drum storage and related input circuits

We have in the foregoing pages described the several circuits which function during the origination and completion of a toll call, including a means for identifying the trunk being utilized, a means for measuring and registering the elapsed conversation time therefor, and a means for registering the directory numbers of the calling and the called subscribers. We have also described in detail those circuits particularly germane to the present invention and by means of which the distance between the calling and the called central offices and the basic charging rate appropriate thereto are determined.

We will now describe the magnetic drum storage arrangement by means of which are associated and recorded all of the indicia essential to identify the two subscribers between whom a conversation is in progress, to record the elapsed time therefor, and, at the conclusion of the call, to transmit the indicia to the call charge computing and printing circuits.

The drum comprises a cylinder of magnetic material or other material having a surface layer of magnetic material thereon having so-called hard magnetic characteristics, i.e., permanent magnet characteristics in which the magnetic condition impressed thereon persists until changed by other magnetic fields, forces or phenomena. The shaft upon which the drum is supported may be driven by an electric motor or other suitable means.

The speed of rotation of the drum need not be synchronous with any of the other circuits. Instead, a timing wheel 60–TW is mounted on the same supporting shaft and employed to control the various drum circuits as described hereinafter.

A plurality of coils comprising one or more windings on a ferromagnetic core structure are located adjacent the periphery of the magnetic drum and employed to apply a magnetic field to the magnetic material of the drum for changing its magnetic condition, thereby to record or write indicia therein, and also for responding to the magnetic field or condition of the drum, thereby to read the indicia previously stored therein.

The coil and core structure is so oriented with respect to the drum, in an exemplary embodiment of this invention, that the magnetic field produced by the cores and responded to by the cores or coils is in the direction of rotation of the drum or opposed thereto depending upon the polarity of the energizing current flowing through the windings of the core structure.

The circumferential area of the drum which passes immediately beneath the pole tips such as 60–PT of a given coil is defined as a "channel." The elemental part of the surface of the drum comprising an elemental portion of a channel or track, as defined above, which is directly under or immediately adjacent the recording coil when a pulse of writing current is applied to the winding of the coil is frequently called a "cell" or elemental area and is employed for recording a single pulse in or on the drum. Where a multiplicity of recording heads are employed, as in the exemplary embodiment set forth herein, the aggregate of cells or elemental areas which are under several recording heads at one instant of time is frequently called a slot. It has been assumed that the "slot," both in Fig. 78 and in Figs. 60 to 63, comprises a small band or ribbon area on the surface of the drum parallel to the axis thereof. In an actual structure the slots are not embraced in such a rectangular area but may comprise any complex pattern of the areas on the surface of the drum depending upon the relative locations of the various combined recording and pick-up coils adjacent to the surface of the drum. It may be desirable to stagger the heads or coils in which case the slot may be in the form of a helix, a saw-tooth pattern, or any other discontinuous broken pattern or configuration.

Since an originating call may seize and be served by the first idle one of a group of one hundred district junctor circuits, the magnetic drum must have a minimum of one hundred slots around its periphery in order to provide one slot identifiable, by means of the call identity index number, with each district junctor circuit. Each district junctor circuit while in use for the completion of a call will, by means of the district junctor identifier circuit, cause a two-digit number, expressed in a two-out-of-five code to be transmitted in conjunction with other coded call charging indicia to the magnetic drum storage circuit via the control circuits associated therewith. The call identity index number permits the item, or items, of call charging indicia simultaneously transmitted therewith to be recorded in the slot of the magnetic drum which has had prerecorded therein a call identity index number which exactly matches therewith.

In Figs. 60 to 63 are indicated a timing pick-up head 60–TP–1 and a plurality of combined recording and pick-up heads 60–RP–2 to 63–RP–91, inclusive (of which

60–RP–8 through 60–RP–10; 60–RP–13 through 60–RP–15; 61–RP–18 through 61–RP–20; 61–RP–23 through 61–RP–25; 61–RP–28 through 61–RP–30; 61–RP–33 through 61–RP–35; 61–RP–38 through 61–RP–40; 61–RP–43 through 61–RP–45; 62–RP–48 through 62–RP–50; 62–RP–53 through 62–RP–55; 62–RP–58 through 62–RP–60; 62–RP–63 through 62–RP–65; 62–RP–68 through 62–RP–70; 63–RP–74 through 63–RP–76; and 63–RP–79 through 63–RP–81 are not shown). Each combined recording and pick-up head is equipped with two coils, one coil for recording or writing indicia in or on the drum, and the other coil for reading the indicia recorded in or on the drum. Each slot will have stored therein a plurality of items of indicia essential to the determination of the toll charge for a call in progress, the several items of which are identified, by means of the call identity index number prerecorded therein, with the particular district junctor serving that call.

As shown in Fig. 60 and indicated in Figs. 60 to 63, each of the combined recording and pick-up heads or coils is provided with two amplifiers, a recording or writing amplifier such as 60–WA–2, and a reading amplifier such as 60–RA–2.

In Fig. 60, a section of the drum consisting of ten channels, and the combined recording and pick-up heads 60–RP–2 to 60–RP–11, inclusive (of which 60–RP–8 through 60–RP–10 are not shown), associated therewith are employed, in conjunction with related control circuits, to pre-record and subsequently read and recognize the call identity index numbers.

Toothed wheel, pick-up coil and amplifier

The pick-up coil 60–TP–1 is provided for generating synchronizing pulses. As shown in the drawing the coil is located adjacent the periphery of the timing wheel 60–TW which is shown to be in the form of a gear wheel having a plurality of substantially uniformly spaced teeth or poles. Each of the teeth or poles of the wheel adjacent coil 60–TP–1 generates a pulse which is employed to control the recording of signals in the drum as will be described hereinafter. The output of coil 60–TP–1 is amplified by amplifier 60–TA. Output of coil 60–TP–1 and amplifier 60–TA are so designed that a high positive output pulse is obtained for each tooth of gear wheel which passes under the pole pieces of coil 60–TP–1. The amplifier 60–TA contains the necessary pulse forming, pulse shaping means, and means for otherwise controlling pulse characteristics as required. In an exemplary embodiment of this invention, the pulse output from amplifier 60–TA for each of the teeth of the gear wheel under coil 60–TP–1 has a duration of approximately one tenth the time required for a cell of the magnetic surface of the drum as defined above to pass under a pick-up coil. This pulse duration is not critical and satisfactory results may be obtained with pulses of such a duration.

The pulses from the amplifier 60–TA are applied to the various gate circuits and other controlling circuits to accurately time the operation of those circuits relative to the angular position of the drum.

Means for producing a series of "read-synchronizing" pulses and a series of "write-synchronizing" pulses of suitable amplitude and duration and of suitable time relationship one to the other

A series of suitably spaced (timing) impulses are transmitted from amplifier 60–TA and applied through capacitor 59–1 to the grid of trigger tube 59–TRO. When the input signal applied to the grid of tube 59–TRO becomes sufficiently positive to overcome the negative bias applied thereto through resistor 59–2, an increasing current will flow through winding 59–W1, included in the plate circuit of tube 59–TRO.

Tube 59–BO constitutes, in combination with the coils 59–BC–2, a normally quiescent blocking oscillator circuit and tube 59–BO is normally biased to cut off. When, however, the plate current of tube 59–TRO flows in winding 59–W1 a positive voltage is induced in winding 59–W2 of coil 59–BC2, and this positive voltage is applied to the control grid of tube 59–BO, thereby initiating a flow of plate current in the blocking oscillator tube 59–BO. Since the plate circuit of tube 59–BO includes winding 59–W3 of the blocking oscillator coils 59–BC2, the flow of plate current through winding 59–W3 will induce a more positive voltage in winding 59–W2, thus tending further to increase the plate current in tube 59–BO. This regenerative process results in large voltages being induced in winding 59–W2 which will drive the control grid of tube 59–BO far positive and which, in so doing, will charge capacitor 59–3. As saturation current in tube 59–BO is approached, the rate of increase of current with time will diminish, and with it, the induced voltage in winding 59–W2. When the induced voltage is no longer sufficient to make the plate current increase further, an abrupt reversal of action occurs, the current drops quickly back to zero, and the control grid of the tube 59–BO is driven far negative by induced voltage of the opposite sign. During and after this portion of the action, capacitor 59–3 discharges, thereby restoring the control grid of tube 59–BO to its initial potential. This surge of plate current in tube 59–BO will produce a corresponding change in the potential drop across load resistor 59–4 so that the potential applied through resistor 59–5 to point 59–P1 will tend to rise from ground potential to a positive value and then return to ground potential. However, the peak value which may be reached at point 59–P1 is limited by means of varistor 59–6 which is connected to a point on the potential divider comprising resistors 59–7 and 59–8 the latter of which is shunted by capacitor 59–9. Thus varistor 59–6 and its associated elements serve an amplitude-limiting and pulse-shaping function.

Cathode follower tube 59–CF1 is normally biased by means of voltage divider resistors 59–10 and 59–11 and the load resistor 59–12 to a point where it is conducting. Due to the potential drop across load resistor 59–12 a positive potential of substantial amplitude is normally applied to output conductor 59–RS1. When point 59–P1 rises in potential due to the previously described blocking oscillator action, this rise in potential will be applied through capacitor 59–13 to the control grid of tube 59–CF1, driving the grid to a higher value of potential, increasing the plate current in tube 59–CF1, increasing the potential drop across the load resistor 59–12, and thereby causing an increased potential to be applied to output conductor 59–RS1. When the potential at point 59–P1 falls in value the conduction in tube 59–CF1 will be reduced whereby the output potential on conductor 59–RS1 will restore to its initial value. In this fashion a positive going pulse is applied to conductor 59–RS1 at each operation of the blocking oscillator circuit comprising tube 59–BO. The output pulses on conductor 59–RS1 are approximately square topped in form.

Concurrently with the above-described operation of cathode follower 59–CF1, the rise in potential at point 59–P1 is applied through capacitor 59–14 to the control grid of the left-hand section of tube 59–MP1. Tube 59–MP1 comprises that which may logically be labeled a "monopulser," and is a conventional form of the so-called "single shot multivibrator," i.e., it is a device, which when triggered, will complete one cycle of operation. The monopulser comprising tube 59–MP1 is so biased that normally the left-hand section is conducting and the right-hand section is below cut off. Upon the application of the leading edge of the positive-going pulse through capacitor 59–14 to the control grid of the left-hand section of tube 59–MP1, capacitor 59–14 will charge but no change of state will occur since that section is already at grid conduction. However, at the trailing edge of that pulse the control grid of the left-hand section of tube 59–MP1 will be driven to a negative potential, cutting off conduction in the left-hand section of tube 59–MP1. Due to the action of the cross-coupling networks comprising resistor 59–15 and capacitor 59–16, and capacitor 59–17, a potential will be applied to the control grid of the right-hand section of tube 59–MP1 which will cause that section to become conductive. After a period of time, determined primarily by the time constant of the network elements capacitor 59–17 and resistor 59–18, the tube 59–MP1 will restore to its initial condition wherein the left-hand section is conducting and the right-hand section is cut off.

As a result of this cycle of operations and due to the potential drop across load resistor 59–19, a positive-going essentially square wave pulse will be applied from the anode of the left-hand section of tube 59–MP1 through capacitor 59–20 to the control grid of cathode follower 59–CF2, the nature and operation of which is identical to that of cathode follower 59–CF1, as hereinbefore described. Consequently, a positive-going wave pulse will be applied to conductor 59–21 in response to each operation of the blocking oscillator comprising tube 59–BO. Since the pulse on output conductor 59–RS1 is produced as a result of a rise in potential at point 69–P1, and since the output pulse on conductor 59–21 is produced as a result of a fall in potential at point 59–P1, each pulse on conductor 59–21 will immediately follow, in point of time, but not overlap the corresponding pulse on conductor 59–RS1.

The pulses on conductor 59–21 constitute the "write-synchronizing" pulses. The pulses on conductor 59–RS1 constitute the "read-synchronizing" pulses.

Utilization of "read-synchronizing" pulses

The voltages induced in the coils of the reading heads appear across winding 60–C2 of transformer 60–T1 (in the amplifiers respectively associated therewith). Windings 60–C1 and 60–C2 of autotransformer 60–T1, with winding 60–C1 having, in the preferred embodiment of the invention, about twice as many turns as in winding 60–C2. Consequently, the voltage appearing between the grounded terminal of winding 60–C2 and the upper terminal of winding 60–C1 is about three times the voltage appearing across winding 60–C2 alone. The voltage appearing across windings 60–C1 and 60–C2 of autotransformer 60–T1 is applied, via conductor 60–1, to the input of the reading amplifier comprising tubes 60–A1 to 60–A4, inclusive.

The peak-to-peak voltage appearing on conductor 60–1 as the result of the reading of a recorded "1," may be, for example, approximately 0.1 volt, while the peak-to-peak voltage appearing on conductor 60–1 as the result of the reading of a recorded "0" may be in the range of 0.01 to 0.03. To provide the requisite output signal with the input signals, the gain of the reading amplifier must be relatively great.

Varistors 60–2 and 60–3, which are unidirectional current conducting devices, serve, in conjunction with resistor 60–4, as a means for limiting the incoming signals. Varistor 60–2 is connected between conductor 60–5 and a point on the voltage divider comprising ground, resistors 60–6 and 60–7 and negative bias battery, so that the lower electrode of varistor 60–2 is held at an approximately negative 2-volt potential. Varistor 60–3 is connected between conductor 60–5 and ground. Each of the varistors 60–2 and 60–3, as all other varistors on the drawings, presents a low impedance to conventional current when the arrow side thereof is positive relative to the other side, and a high impedance to conventional current when the arrow side is negative relative to the other side. It will be seen, therefore, that the voltage on conductor 60–5 cannot become much more negative than a negative two volts due to the action of varistor 60–2, and cannot become much more positive than ground potential due to the action of varistor 60–3. The parameters of the plural direct-current paths from conductor 60–5 to sources of potential are so selected that the direct potential on conductor 60–5 is normally approximately one volt negative with respect to ground.

The signal voltage on conductor 60–5 is applied through isolating resistor 60–8 to the grid of triode 60–A1. The biasing voltage on tube 60–A1 is established by the connection of resistor 60–9 to negative bias battery and by a feedback connection hereinafter to be described. Tube 60–A1 is directly coupled to triode 60–A2, the cathode of which is held at a positive bias potential.

The output of amplifier 60–A2 is applied through a coupling network comprising resistor 60–10 and capacitor 60–11, in parallel, to the grid of triode 60–A3. The aforesaid coupling network substantially improves the high frequency response of the amplifier.

The output of tube 60–A3 is applied both to an output circuit and to a feedback loop. With the particular magnetic surface speeds, pulsing and amplifying arrangements employed it was found that most of the energy in the pulses applied to the input of the reading amplifier was in the frequency range of five kilocycles to 200 to 300 kilocycles per second, although this is a function of the size of the incremental area, the speed of movement of the incremental area past the pole-pieces, and other factors. In this frequency range, high gain amplification is required. However, since the signal to be amplified by the reading amplifier has no direct-current component, no direct-current amplification is required. Therefore, a degenerative feedback circuit may be employed which reduces the over-all gain of the amplifier very little at the upper range of frequencies but which is effective to reduce the gain to only a few decibels as the frequency approaches zero. By providing very little amplifier gain for direct currents, the output drift which is frequently a characteristic of direct coupled amplifiers is largely avoided, and the operating point of tube remains substantially constant.

Since tube 60–A3 is the third stage of amplification, the signal at its anode is of a phase opposite to that of the input signal and negative feedback may, therefore, be obtained by connecting the anode of tube 60–A3 to the control grid of tube 60–A1 through resistors 60–12 and 60–13. The parameters of the grounded network comprising resistors 60–14 and 60–15 and capacitors 60–16 and 60–17 are selected so as to introduce substantially no loss in the feedback loop at low frequencies, e.g., five to ten cycles per second, and progressively to introduce more loss in the feedback loop up to a higher frequency, e.g., 1,500 to 2,000 cycles per second. This value is determined mainly by one pair of elements—say resistor 60–14 and capacitor 60–16. With the experimentally employed parameters, the over-all gain of the amplifier increased between six cycles per second and 1,600 cycles per second by a factor of about 270. The gain of the amplifier for frequencies above 1,500 to 2,000 cycles per second is relatively constant until frequencies of the order of 100,000 cycles per second are reached. In this region elements 60–15 and 60–17 come into play and introduce a little more loss into the feedback path to counteract the tendency of the gain to fall off as the frequency increases. At frequencies well above 100,000 cycles per second, the gain of the amplifier falls off at a substantial rate. The output of tube 60–A3 is also applied via resistor 60–18 and capacitor 60–19 to the grid of triode 60–A4, the cathode of which is grounded and the anode of which is connected through load resistor 60–20 to a source of positive potential.

Tube 60–A4 is effective to transmit an output indication, however, only under certain conditions. The input pulse to it must exceed a certain amplitude and a positive going "read-synchronizing" pulse must be received over conductors 59–RS1.

Under the static conditions, the anode of tube 60–A3 is at a potential of about 100 volts positive. With the application to the grid of tube 60–A3 of a previously amplified negative-going signal, the anode voltage will rise to a more positive value, becoming slightly more positive, to 105 to 110 volts positive for example, if the input signal to the reading amplifier results from the reading of "0," and becoming substantially more positive to 130 to 140 volts or more positive for example, if the input signal to the reading amplifier results from the reading of a "1." This rise in potential to the anode of tube 60–A3 is applied through resistor 60–18 to one terminal of varistor 60–21. If varistor 60–21 presents a low impedance to this signal, substantially no signal will be applied to the grid of tube 60–A4; if, however, varistor 60–21 presents a high impedance to this signal, the signal is applied with little attenuation through capacitor 60–19 to the grid of tube 60–A4.

The impedance conditions of varistor 60–21 are controlled by the presence or absence of the "read-synchronizing" pulse on conductor 59–RS1, which pulse is a substantially square wave pulse having, for example, a 50-volt amplitude above a 100-volt reference line. Thus, when the reading amplifier is in its normal quiescent condition, both terminals of varistor 60–21 are at a potential of about 100 volts positive. If the anode potential of tube 60–A3 rises as the result of the receipt of a signal, varistor 60–21 will present a low impedance path and substantially no pulse will be applied to tube 60–A4. If, however, at any time that the anode of tube 60–A3 is at such high potential, the potential at the upper electrode of varistor 60–21 temporarily rises to 150 volts as a result of the receipt of the "read-synchronizing" pulse, varistor 60–21 will present a high impedance to the less-than-150-volt signal at the anode of tube 60–A3 and a signal will thereby be applied to the grid of tube 60–A4. The "read-synchronizing" pulse occurs and terminates prior to the appearance of a "write-synchronizing" pulse, and a "write-synchronizing" pulse terminates a substantial interval before any succeeding "read-synchronizing" pulse is received.

During the limited period during which a "read-synchronizing" pulse is being received, a positive going pulse will be applied to the grid of output tube 60–A4. This pulse may be indicative either of the reading of an "0" or of the reading of a "1." As above noted, in the former case this pulse will have a maximum amplitude of somewhat less than a predermined voltage and in the latter case it will have a minimum amplitude somewhat greater than that predetermined voltage. To permit the circuits to discriminate between these two conditions, a threshold biasing potential is applied to tube 60–A4 through resistor 60–22. Obviously, this voltage should be negative relative to ground by an amount approximately equal to the difference between the threshold value for the particular tube and circuit conditions and the aforesaid predetermined voltage. Thus, as an example, if the threshold value for tube 60–A4 under a particular set of plate circuit conditions be a negative six volts, and if the predetermined voltage, above which a signal derived from the reading of a "1" always goes and above which a signal derived from the reading of a "0" never goes, be 20 volts positive, then the voltage to be applied through resistor 60–22 should be approximately a negative 26 volts. With the proper threshold bias established, no output signal will be transmitted from tube 60–A4 if a "0" is read, but a negative-going pulse will be transmitted if a "1" is read. The negative going pulses from the reading amplifiers, such as 60–RA–2 to 63–RA–91, inclusive are applied to the various circuits which are adapted to receive and utilize them in a manner later to be described.

There will be a series of "read-synchronizing" pulses spaced one cell length apart, and it is to be understood that these pulses do not define either the beginning, end or center of a cell but actually occur at a time when somewhat less than half of the cell length has passed under the magnetic head. There will be a series of "write-synchronizing" pulses which do not appear until after the corresponding "read-synchronizing" pulses have ended. These "write-synchronizing" pulses occur at a point in time when the center of a cell is approximately under the magnetic head.

Entering a translation item

When a magnetic drum is first received and before it is put into operation it is necessary to enter the call identity index numbers in or on the surface of the magnetic material of the drum. In order to properly enter the call identity index numbers and the other items of call charging indicia identified therewith the surface of the drum is first polarized or magnetized in one or the other of the two directions of magnetization employed in storing the various items of call charging indicia. It is assumed herein that the drum will be polarized or magnetized initially in the same manner as it is magnetized when it is recording zeros, that is, by the application of negative pulses to the recording coils or heads. One way in which the drum is initially polarized is to cause direct current of a suitable magnitude to flow through each of the recording or pick-up coils during one or more revolutions of the drum. With the drum thus polarized in a suitable manner by temporary circuit connections not shown in the drawing, the drum equipment is ready for recording the various items of call charging indicia. The power will be applied to the various circuits, and the drum will be set into rotation by applying power to the electric motor driving it or actuating any other driving means which is provided.

We will assume that for administrative purpose it is desired to record a complete new set of call identity index numbers, one number for each district junctor circuit available for serving toll call connections.

After the drum has been set in the zero condition, that is, all the elemental areas of the surface thereof are magnetized in the zero or negative direction, the attendant operates the various control keys so as to permit the pre-recording or writing in or on the call identity index section of the drum, one at a time, in randomly successive idle or vacant slots, the call identity index numbers.

To effect the writing of the first one of a plurality of call identity index numbers the attendant operates the call identity index writing key 59–CIIW which, over an obvious path, completes a circut to operate relay 59–CII. Relay 59–CII in operating extends positive voltage through its number 13 contacts to the springs of the call identity write and erase keys 59–WTK–0 through 59–WTK–9 (of which 59–WTK–2 through 59–WTK–8 are not shown) and 59–WUK–0 through 59–WUK–9 (of which 59–WUK–2 through 59–WUK–8 are not shown), and the erase keys 59–ET and 59–EU. Relay 59–CII also completes circuits through its armatures numbered 2 through 11 and the front contacts thereon from the springs of call identity index matching keys 59–MTK–0 through 59–MTK–9 (of which 59–WUK–2 through 59–WUK–8 are not shown) and 59–MUK–0 through 59–MUK–9 (of which 59–MUK–2 through 59–MUK–8 are not shown) to the tens and the units match control circuits 59–TCM and 59–UCM, respectively. The attendant then, assuming, for example, that the first call identity index number to be pre-recorded in the drum is 00, operates tens and units call identity number writing keys 59–WTK–0 and 59–WUK–0, respectively. The tens and units call identity matching keys 59–MTK–0 through 59–MTK–9 and 59–MUK–0 through 59–MUK–9, respectively, are employed, in a manner to be later described, to set up, on a two-out-of-five code basis, numbers simulative of call identity index numbers which direct the matching circuits to seek the slot on the drum in which a number corresponding thereto has been pre-recorded. Since the drum has, up to this point, had no indicia recorded therein, and is in that magnetic state representative of zeros in all elemental areas, a condition equivalent to that in the ten call identity index channels is represented by the tens and units call identity matching keys 59–MTK–0 through 59–MTK–9, and 59–MUK–0 through 59–MUK–9 in their unoperated condition. All of the above-mentioned keys are of the locking type and are constructed in a manner well known in the prior art, whereby the operation of any key in a column or "strip" causes the release of any previously operated key in the same column or strip.

The attendant now momentarily operates the start key 59–ST which is non-locking. Ground is extended through start key 59–ST, through the front contact on armature number 1 of relay 59–CII, via lead 59–ST, to the starting control circuit 49–SC. Lead 59ST normally has a negative voltage applied thereto by means of the voltage dividing resistors 59–22 and 59–23. Consequently, capacitor 59–24 normally has a negative voltage with respect to ground on its upper terminal. Likewise, the capacitor 59–25 has a negative voltage connected to its upper terminal. Capacitor 59–25 also has a voltage due to the voltage divider 59–26 connected to its lower terminal. This negative voltage serves as a bias for diode 59–27 so that it will normally have a high impedance and thus prevent the application of negative pulses of appreciable magnitude to the grid of the left-hand section of tube 59–28.

Both sections of tube 59–28 are connected in a single cycle multivibrator circuit in which the right-hand section normally conducts current. In an exemplary embodiment of this invention, the circuits of tube 59–28 are arranged so that when a flow of current is initiated through the left-hand section thereof current will continue to flow through this section, with the right-hand section cut off, for approximately three milliseconds, after which time the right-hand section again starts to conduct current, and interrupts a flow of current through the left-hand section of this tube.

Thus when ground is connected to conductor 59–ST in the manner described above, the voltage of this conductor rises from the negative value determined by the voltage divider resistors 59–22 and 59–23 to substantially ground potential. The capacitor 59–25 has a small electrostatic capacity so that the capacity, together with relatively low resistance of the voltage divider resistors 59–26, form a differentiating circuit and cause, at this time, positive pulses of short duration, which positive pulses overcome the negative bias applied to diode 59–27. As a result, the impedance of diode 59–27 falls to a low value so that it readily transmits the positive pulses to the control grid of the left-hand section of tube 59–28. The diode 59–27 is poled to readily convey the positive voltage or pulses applied from the differentiating capacitor 59–25. The application of the positive voltage to the left-hand section of tube 59–28 at this time in response to the ground applied to the conductor 59–ST causes a flow of current through the lefthand section of tube 58–28 to be initiated which, in turn, interrupts the flow of current through the right-hand section thereof.

The interruption of the flow of current through the right-hand section of tube 59–28 is due to a more negative voltage applied to the grid of the right-hand section from the anode circuit of the left-hand section thereof. The grid of the right-hand section of tube 59–28 is coupled to the grid of the left-hand section of tube 59–29 so that a flow of current through this left-hand section is likewise interrupted or reduced with the result that a positive voltage is applied to the grid of the right-hand section of tube 59–29. The right-hand section operates as a cathode follower so that a correspondingly more positive, or positive-going voltage is applied from the cathode section of tube 59–29 to conductor 59–30 the output lead therefrom.

The next write-synchronizing pulse generated by the synchronizing circuit shown in Figs. 59 and 60 is applied, via conductor 59–31, through delay network circuit **59–32** via conductor **59–33**, to capacitor **59–34** and then to the anode of the left-hand section of tube **59–28**, and also through the coupling capacitor **59–35** to the grid of the right-hand section of tube **59–28**. The positive pulse applied to conductor **59–33** occurs before the end of the three milliseconds after the grounding of the conductor **59**–ST. The application of a positive pulse to the right-hand grid of tube **59–28** at this time again initiates the flow of current through the right-hand section and interrupts a flow of current through the left-hand section thereof.

Due to the positive pulse applied to the control grid of the right-hand section of tube **59–28** and the initiation of conduction through this section, a still more positive voltage is applied to the grid of the right-hand section due to the interruption of a discharge through the left-hand section and the coupling between these two sections. The positive voltage applied to the grid of the right-hand section of tube **58–28** is also applied to the grid of the left-hand section of tube **59–29** which repeats and amplifies this pulse or voltage and applies a negative voltage to the control grid of the right-hand section of tube **59–29**. As a result, the negative voltage or pulse applied to the grid is repeated by the right-hand or cathode follower section of tube **59–28** which negative-going pulse is applied to conductor **59–30** the output lead therefrom.

The application of a positive-going voltage to the conductor **59–30** applies positive voltage to the left-hand terminal of diode **59–36**.

The call identity matching keys **59**–MTK–**0** through **59**–MTK–**9** (of which **59**–MTK–**2** through **59**–MTK–**8** are not shown) and **59**–MUK–**0** through **59**–MUK–**9** (of which **59**–MUK–**2** through **59**–MUK–**8** are not shown) as before stated have all been set in their "all zeros" position. In other words, all their contacts are open. In addition, as pointed out above, all of the elements or elemental areas suitable for recording information on the drum have been set to their "all zeros" position, consequently, match is obtained at all times, between the reading tens and units conductors **60**–RT–**0**, **60**–RT–**1**, **60**–RT–**2**, **60**–RT–**4**, and **60**–RT–**7** (in cable **60**–RT); and **60**–RU–**0**, **60**–RU–**1**, **60**–RU–**2**, **60**–RU–**4**, and **60**–RU–**7** (in cable **60**–RU); respectively applied to the upper inputs of the tens and units matching circuits, and the matching tens and units conductors **59**–MT–**0**, **59**–MT–**1**, **59**–MT–**2**, **59**–MT–**4** and, **59**–MT–**7** (in cable **59**–T) and **59**–MU–**0**, **59**–MU–**1**, **59**–MU–**2**, **59**–MU–**4**, and **59**–MU–**7** (in cable **59**–MU); respectively applied to the lower inputs of the tens and units matching circuits, before the recording of the indicia representative of the first call identity index number in or on the drum.

Upon encountering each match between the conductors **60**–RT–**0**, **60**–RT–**1**, **60**–RT–**2**, **60**–RT–**4**, and **60**–RT–**7**; and **60**–RU–**0**, **60**–RU–**1**, 6O–RU–**2**, **60**–RU–**4**, and **60**–RU–**7**, and the conductors **59**–MT–**0**, **59**–MT–**1**, **59**–MT–**2**, **59**–MT–**4**, and **59**–MT–**7**; and **59**–MU–**0**, **59**–MU–**1**, **59**–MU–**2**, **59**–MU–**4**, and through **59**–MU–**7**, respectively; the tens control match circuit **59**–TCM applies a positive voltage to the output conductor **59–37** and the units control match circuit **59**–UCM applies a positive voltage to the output conductor **59–38**. The output conductors **59–37** and **59–38** apply a positive voltage to the left-hand electrodes of diodes **59–39** and **59–40**, respectively, in the match combine circuit **59**–MC. The units and tens matching circuits **59**–TCM and **59**–UCM, respectively, are constructed and operate in substantially the same manner as the circuits disclosed in the aforementioned United States patent application of H. A. Henning-E. Jacobitti-B. F. Lewis, entitled "Magnetic Drum Translator for Automatic Toll Switching Center." Serial No. 418,508, filed March 25, 1954.

Thus, upon the obtaining of a match between the input signal, in this instance "all zeros," from the call identity matching keys **59**–MTK–**0** through **59**–MTK–**9**, and **59**–MUK–**0** through **59**–MUK–**9**, and the "all zeros" indicia existing in the elemental areas of the drum channels respectively under the combined recording and pick-up heads **60**–RP–**2** through **60**–RP–**11**, upon the momentary operation of start key **59**–STK positive voltages are simultaneously applied to the left-hand sides of diode **59–36**, **59–39** and **59–40**. The simultaneous application of all of these positive voltages to the respective diodes causes a positive voltage to be applied to the grid of tube **59–41** in the match combine circuit. Tube **59–41** operates as a cathode follower and repeats a positive voltage over the output conductor **59–42**. This conductor extends to the left-hand side of diode **59–43** in the writing time gate circuit **59**–WTG.

The application of a positive pulse or voltage, via conductor **59–42**, to diode **59–43** initiates the operation of the time gate circuit. Write synchronizing pulses are applied, via conductor **59–21**, through the voltage divider comprising resistors **59–44** and **59–45** to the control grid of tube **59–46**.

The application of write synchronizing pulses, via conductor **59–21**, through the voltage divider resistors **59–44** and **59–45** to the grid of tube **59–46** normally does not apply positive voltage to the grid of tube **59–46** because these pulses are readily transmitted through the diode **59–43**, via conductor **59–42**, to ground through the cathode resistor **59–47** of tube **59–41**. As a result, the voltage of the grid of tube **59–46** is maintained at or near ground potential so that the tube is substantially non-conducting due to the cathode resistor **59–48**. However, upon the application of a positive voltage to the conductor **59–42** as described above, the impedance of the diode **59–43** then becomes relatively high, so that upon the next application of a write synchronizing pulse over lead **59–21** positive voltage will be applied to the grid of tube **59–46**, which causes this tube to become conductive. As a result, a positive output voltage or pulse is obtained from the cathode of tube **59–46**, since this tube operates as a cathode follower. This positive pulse is applied through the coupling condenser **59–49** to the grid of the left-hand section of tube **59–50**. The left-hand section of tube **59–50** operates as an amplifier tube and repeats the pulse through the upper winding of the coil or transformer **59–51**. The right-hand section of tube **59–50** operates as an over-biased blocking oscillator. When a positive pulse is applied to the grid of the left-hand section of tube **59–50**, the repeated pulse through the upper winding of transformer **59–51** initiates the operation of the right-hand section of tube **59–50** which, in turn, applies a positive pulse to the output conductor **59–31**. The right-hand section of tube **59–50** operates as a power output tube and delivers a pulse of appreciable energy from the low impedance source of its cathode circuit comprising the resistor **59–52**. This pulse will be applied, via conductor **59–31**, to the input of the delay network circuit **59–32**, to the writing gate circuits such as **60**–WG–**12** through **60**–WG–**16** shown on Fig. 60, and to **61**–WG–**17** through **63**–WG–**91** indicated on Figs. 61 through 63, and also through the number 12 armature and front contact of relay **59**–CII, thence via conductor **59–53**, to the writing amplifiers **60**–WA–**2** through **60**–WA–**11** (of which **60**–WA–**8** through **60**–WA–**10** are not shown).

We have assumed, as a first example, that the first call identity index number to be pre-recorded is 00. Call identity index write keys **59**–WTK–**0** and **59**–WUK–**0** will have been operated by the attendant who will have subsequently thereto momentarily operated the start key **59**–STK to cause the numbers 0 and 0, respectively, to be written in the tens and units digits of the call identity index number channels of the drum.

The writing amplifier **60**–WA–**2** is shown and will be described in detail. The writing amplifiers **60**–WA–**3** through **63**–WA–**91** are constructed and will operate in a manner identical with that of amplifier **60**–WA–**2**. The upper or write "1" section of amplifier 60–WA–2 is employed to write ones, while the lower or write "0" section thereof is employed to write zeros. The positive potential applied through armature number 13 and front contact of relay 59–CII to conductors 59–WT–4 and 59–WT–7, by the operation of the call identity write key 59–WTK–0, representing in two out of five code the tens digit of the call identity index number, is extended, via cable 59–WTC, to the upper or write "1" input conductors 59–WT–4 and 59–WT–7, respectively, of the tens amplifiers 60–WA–5 and 60–WA–6, respectively. The positive potential applied to conductors 59–WU–4 and 59–WU–7, by the operation of the call identity write key 59–WUK–0, representing in two out of five code the units digit of the call identity index number, is extended, via cable 59–WUC, to the upper or write "1" input conductors 59–WU–4 and 59–WU–7, respectively, of the units amplifiers 60–WA–10 (not shown) and 60–WA–11, respectively. The positive potential applied to the upper or write "1" input conductors, corresponding to the input conductor 59–WT–0 of amplifier 60–WA–2, for example, is applied to the junction between diodes 60–23 and 60–24, through the voltage divider resistors 60–25. This voltage, however, is ineffective to actuate tube 60–26 because diode 60–24 is normally connected to substantial ground potential over conductor 59–53, through front contact and armature number 12 of relay 59–CII, via conductor 59–31, through the cathode resistor 59–52. With positive potential applied to conductor 59–WT–0 the impedance of the diode 60–24 is low, so that the junction between diodes 60–23 and 60–24 is maintained at a relatively low voltage near ground potential.

However, the application of a positive pulse or voltage to conductor 59–53 in response to the write synchronizing pulse described above, raises the voltage of the lower terminal of diode 60–24 with the result that the voltage of the junction between diodes 60–23 and 60–24, rises to a relatively high positive value, so that a pulse is transmitted through the diode 60–23 and coupling capacitor 60–27 to the grid of tube 60–26. Tube 60–26 is normally biased to be non-conducting by means of the voltage divider 60–28 but on the application of the positive pulse as described above, tube 60–26 becomes conducting and repeats the pulse to the lower winding of the blocking oscillator coil or transformer 60–29. As a result, the over-biased blocking oscillator tube 60–30 is set into operation in response to the pulse from tube 60–26 with the result that a writing pulse of large magnitude flows in the output circuit of tube 60–30 and through the coupling transformer 60–31. The output winding of transformer 60–31 is connected to output conductor 60–W–32. The outputs of amplifiers 60–WA–3 through 60–WA–11 are similarly connected to output conductors 60–W–33 through 60–W–41, respectively. As a result of the application of a positive potential to conductors 59–WT–4, 59–WT–7, 59–WU–4 and 59–WU–7 and, simultaneously therewith, the application of a positive going pulse to the conductor 59–53 as described above, the amplifiers 60–WA–5, 60–WA–6, 60–WA–10 (not shown) and 60–WA–11 will function in the manner above described in detail, with reference to amplifier 60–WA–2, and will transmit a writing pulse, via the leads 60–W–35, 60–W–36, 60–W–40, and 60–W–41 to the combined recording and pick-up heads 60–RP–5, 60–RP–6, 60–RP–10 (not shown) and 60–RP–11, respectively; causing a "one" to be written in channels 5, 6, 10 and 11. It should be noted that this particular slot has been effectively selected at random in being the first idle slot to pass under the pick-up coils or heads and having all zeros in the call identity index number section after the first write synchronizing pulse following the momentary operation of the start key 59–STK.

Since all of the elemental areas of the drum had been magnetized to a condition representing all zeros, and since zeroes are to be written or remain written in channels 2, 3, 4, 7, 8 and 9 of the call identity index number section, the call identity write keys 59–WTK–0 and 59–WUK–0 will not affect the lower or zero writing section of any of the ten call identity writing amplifiers 60–WA–2 through 60–WA–11.

We will now assume, for example, that the next call identity index number to be pre-recorded is 01. Call identity index write keys 59–WTK–0 and 59–WUK–1 are operated by the attendant to write the numbers 0 and 1, respectively, in the tens and units digits of the call identity index number channels of the drum.

The positive potential applied to conductor 59–WT–4 and 59–WT–7 and 59–WU–0 and 59–WU–1 by the operation of the call identity index write keys 59–WTK–0 and 59–WUK–1 is extended, via cable 59–WTC and 59–WUC, respectively, to the upper or write "1" input conductors 59–WT–4 and 59–WT–7 of the tens amplifiers 60–WA–5 and 60–WA–6 and to the upper or write "1" input conductors 59–WU–0 and 59–WU–1 of the units amplifiers 60–WA–7 and 60–WA–8. Amplifiers 60–WA–8, 60–WA–9, 60–WA–10 are not shown. The positive potentials applied to the upper or write "1" input conductors of the amplifiers cause the amplifiers to operate in the manner described with reference to amplifier 60–WA–2. The attendant, again, momentarily operates the start key 59–STK.

The application of a positive potential to the upper or write "1" input conductors 59–WT–4 and 59–WT–7 of amplifiers 60–WA–5 and 60–WA–6, respectively, and to the upper or write "1" input conductors 59–WU–0 and 59–WU–1 of amplifiers 60–WA–7 and 60–WA–8, respectively, and, simultaneously therewith, the application of a positive going pulse to the conductor 59–53, as described above, the amplifiers 60–WA–5, 60–WA–6, 60–WA–7 and 60–WA–8 function in the manner above described in detail, with reference to amplifier 60–WA–2, and will transmit a writing pulse, via the leads 60–W–35, 60–W–36, 60–W–37, and 60–W–38 (not shown) to the combined recording and pick-up heads 60–RP–5, 60–RP–6, 60–RP–7 and 60–RP–8 (not shown) respectively, causing an "A" or a "1" to be written in channels 5, 6, 7 and 8. It should be noted that this particular slot has also been effectively selected at random in being the first idle slot to pass under the pick-up coils or heads and having all zeros in the call identity index number section after the first synchronizing pulse following the second momentary operation of the start key 59–STK.

Thus, the attendant by successively operating the call identity write keys in appropriate combinations, may successively, and in any desired numerical order, cause to be pre-recorded in the drum a number representative of each of the district junctors employed in completing toll calls in that office. The attendant, at the conclusion of recording a set of call identity index numbers, will release key 59–CIIW and relay 59–CII will release. All other keys will also be restored to normal.

We will now assume that it is desired, for administrative purposes, to erase some particular call identity index number previously recorded in the drum. We will assume, for example, that it is desired to erase the call identity index number 21. The attendant operates the call identity match keys 59–MTK–2 (not shown) and 59–MUK–1. Ground is extended through the contact springs of key 59–MTK–2 to conductors 59–MT–0 and 59–MT–2, representing in two out of five code the tens digit of the call identity index number, via cable 59–MTC, to the front contacts on the armatures numbered 2 and 4, respectively, of relay 59–CII, thence, via cable 59–T, to the lower inputs of the tens control match circuit 59–TCM. Ground is extended through the contact springs of key 59–MUK–1 to conductors 59–MU–0 and 59–MU–1, representing in two of the five code the units digit of the call identity index number, via cable 59–MUC, to the front contacts on the armatures numbered 7 and

8, respectively, of relay 59–CII, thence, via cable 59–U, to the lower inputs of the units control match circuit 59–UCM.

Upon encountering a match between the conductors 60–RT–0 and 60–RT–2 applied to the upper inputs, and conductors 59–MT–0 and 59–MT–2 applied to the lower inputs, the tens control match circuit 59–TCM applies a positive voltage to the output conductor 59–37. Upon encountering a match betwen the conductors 60–RU–0 and 60–RU–1 applied to the upper inputs, and conductors 59–MU–0 and 59–MU–1 applied to the lower inputs, the units control match circuit 59–UCM applies a positive voltage to the output conductor 59–38. The output conductors 59–37 and 59–38 again, as previously described, apply positive voltage to the left-hand electrodes of diodes 59–39 and 59–40, respectively, in the match combine circuit 59–MC.

Thus upon the obtaining of a match between the input signal, in this instance a tens digit of 2 and a units digit of 1 from the call identity tens and units matching keys 59–MTK–2 (not shown) and 59–MUK–1, respectively, and the presence of a magnetic state representative of a one in the drum channels under the combined recording and pick-up heads 60–RT–0, 60–RT–2, 60–RU–0 and 60–RU–1, representing the call identity index number 21, and upon the momentary operation of start key 59–STK positive voltages are simultaneously applied to the left-hand side of diodes 59–36, 59–39 and 59–40. The simultaneous application of all of these positive voltages to the respective diodes causes a positive voltage to be applied to the grid of tube 59–41 in the match combine circuit. Tube 59–41 operates as a cathode follower and repeats a positive voltage over the output conductor 59–42. This conductor extends to the left-hand side of diode 59–43 in the writing time-gate circuit 59–WTG.

The writing time-gate circuit functions in the manner previously described to apply a positive pulse, via the output conductor 59–31, to the input of the delay network circuit 59–32, and to the writing gate circuits such as 60–WG–12 through 60–WG–16 shown on Fig. 60 and to 61–WG–17 through 63–WG–91 indicated on Figs. 61 through 63; and also through the number 12 armature and front contact of relay 59–CII, thence, via conductor 59–53, to the writing amplifiers 60–WA–2 through 60–WA–11.

We have assumed, as an example, that the pre-recorded call identity index number 21 is to be erased. Call identity index matching keys 59–MTK–2 (not shown) and 59–MUK–1 will have been operated, resulting in the operations above described. The attendant will, also, have operated the call identity index erase keys 59–ET and 59–EU to cause the erasure of the call identity index number 21 from the call identity index number channels of the drum.

It will be remembered that in the initial preparation of the magnetic surface of the drum for recording, all the elemental areas thereof were magnetized to their negative or "all zeros" state. The subsequent recording of a number thereon requires the reversal of the magnetic state in those elemental areas wherein the indicia significant of a number are to be recorded. A recorded number will, therefore, consist of a slot comprising a plurality of elemental areas some of which are in a negative and some in a positive magnetic state. The erasure of a previously recorded number will, therefore, require the reversal of the magnetic state of those elemental areas having a positive magnetic condition, thus returning all of the elemental areas of a particular designated slot to the negative or all zeros condition.

The positive potential applied through the armature number 13 and front contact of relay 59–CII to conductors 59–ET–0, 59–ET–1, 59–ET–2, 59–ET–4 and 59–ET–7, by the operation of call identity erase tens key 59–ET, is extended, via cable 59–ETC, to the lower or write "0" input conductors 59–ET–0, 59–ET–1, 59–ET–2, 59–ET–4 and 59–ET–7, respectively, of the tens amplifiers 60–WA–2 through 60–WA–6, respectively. The positive potential applied to conductors 59–EU–0, 59–EU–1, 59–EU–2, 59–EU–4 and 59–EU–7, by the operation of call identity erase units key 59–EU, is extended, via cable 59–EUC, to the lower or write "0" input conductors of the units amplifiers 60–WA–7 through 60–WA–11, respectively.

The lower or write "0" sections of amplifiers 60–WA–2 through 60–WA–11, to be employed in writing 0's, are electrically identical with the upper or write "1" sections thereof and operate in the manner described above with reference to amplifier 60–WA–2. To write 0's the output pulse employed will be of a polarity opposite to that employed when writing "1's"; and the writing of "0's" is accomplished by a reversal of phase in the output transformer 60–31 in amplifier 60–WA–2 and the transformers corresponding thereto in amplifiers 60–WA–3 through 60–WA–11. The phase reversal is due to the fact that the windings connected to tubes 60–30 and 60–33 are opposite in phase, similar to a push-pull output transformer. Consequently, when tube 60–30 conducts, an output pulse of one polarity is induced in the output winding of transformer 60–31 while, when tube 60–33 conducts, an output pulse of the opposite polarity is induced in the output winding of the transformer 60–31.

The positive potential applied to all of the lower or write "0" input conductors of amplifiers 60–WA–2 through 60–WA–11 cause the lower or write "0" section of the amplifiers to operate in the manner described with reference to the upper or write "1" section of amplifier 60–WA–2. The attendant again, momentarily operates the start key 59–STK.

The application of a positive potential to the lower or write "0" input conductors of all of the amplifiers 60–WA–2 through 60–WA–11 and, simultaneously therewith, the application of a positive-going pulse to the conductor 59–53, as described above, causes the amplifiers 60–WA–2 through 60–WA–11 to function in the manner above described in detail, with reference to amplifier 60–WA–2, and transmits writing pulses, via the leads 60–W–32 through 60–W–41, respectively, to the combined recording and pick-up heads 60–RP–2 through 60–RP–11, respectively, causing a "0" to be written in channels 2 through 11. In this particular example, "0's" will be present in the elemental areas of channels 3, 5, 6, 9, 10 and 11 for this particular slot and "0's" will be superimposed thereon, with no resulting change of magnetic state. "1's" will be present in the elemental areas of channels 2, 4, 7 and 8 for this particular slot and "0's" will be superimposed thereon and will effect a reversal of the magnetic state, so that all of the elemental areas of this particular slot will be in an "all zeros" condition. It should be noted that, in this example, this is not a random selection. The selection is the result of a match between a pre-recorded call identity index number read from the drum and a number corresponding thereto, set up by the operation of the call identity match keys, applied to the tens and units match control circuits in conjunction with the operation of the start key 59–STK.

Thus the attendant, by the operation of the call identity match keys and the call identity erase keys, may erase any number pre-recorded in the drum. A number which has been erased will leave an idle or all zeros slot into which may be entered, by means above described, any number to be substituted for the one erased.

The attendant, having recorded in the drum all of the call identity index numbers, now releases the call identity index write key 59–CIIW. The magnetic drum storage and associated circuits are now ready to receive call charging indicia from the central office circuits designed to furnish such indicia.

We will assume that the particular toll call now in progress is being served by district junctor circuit 1–DJ–99. District junctor circuit 1–DJ–99 is identified by call identity index number 99, obtained from the district junctor identifier circuit 1–DJI. The directory number of the calling subscriber will have been ascertained by the subscriber's number identifier circuit 1–NI, and grounds expressive thereof, in two out of five code, are extended through connector 1–CON via cable 1–IDC, to the calling subscriber's directory number register circuit 5–CGN and registered therein. The P.B.X attendant will have dialed the called party area code, called office code and called subscriber's directory number. The called subscriber's office code will have been registered in the called subscriber's office code register circuit 3–OCR and the called subscriber's directory number will have been registered in the called subscriber's directory number register circuit 4–DN. The basic rate translator register relays 64–BRT–1, 64–BRT–2, 64–BRT–4 and 64–BRT–8 will have been energized either singly or in combination as previously described, to register the appropriate basic rate index number and will close an up-check circuit in so doing. When all of the above-named registers have been validly operated, ground is extended through an up-check path in the calling subscriber's directory number register circuit 5–CGN, thence, via up-check conductor 5–CKI through the upper or check contacts of relay 5–LL in the calling subscriber's area and office code cross-connection circuit 5–CC, thence via up-check conductor 5–CK, to the called subscriber's directory number register circuit 4–DN, and through the up-check path therein, thence, via up-check conductor 4–CK, to the called subscriber's office code register circuit 3–OCR and through the up-check path therein, thence, via up-check conductor 3–CK, to the district junctor identifier circuit 1–DJI, and through the up-check path therein to the up-check conductor 1–CK, thence, via cables 1-CIIM and 2–ITM and then via cable 10–CHGD, to the basic rate translator register relay circuit 64–BRTR, and through the up-check path therein to the up-check conductor 64–CK, thence through the back contact and number 1 armature of relay 59–CII, via conductor 59–ST, to the previously described start control circuit 59–SC. Ground extended through the above-described up-check path is an indication that the sender registers contain therein the data essential to the identification of the calling and the called subscribers and the district junctor serving the call, and that the basic rate translator register circuit 64–BRTR contains the basic rate index number for the call. The availability of the essential identity indicia permits the transfer from the several register circuits to the magnetic drum the indicia, as controlled by the call identity index number transmitted simultaneously therewith. Ground extended through the up-check path, when applied via lead 59–ST to the start control circuit 59–SC, causes the start control circuit to function in the same manner as described above with reference to the operation of the start key 59–STK.

Simultaneously with the extension of ground over the above-described up-check paths to the start control circuit via lead 59–ST, each of the several above-mentioned circuits comprising a link in the up-check causes a potential condition to be applied to the plurality of conductors extending therefrom to the magnetic drum storage circuits, expressing the indicia stored therein in a two out of five code. The district junctor identifier circuit 1–DJI applies ground to the tens conductors 1–TC–2 and 1–TC–7 and to the units conductors 1–UC–2 and 1–UC–7, via cables 1–TC and 1–UC, respectively, and thence via cables 1–CIIM and 2–ITM and then via 10–CHGD, through the back contacts and the number 4, 6, 9 and 11 armatures, respectively, of relay 59–CII, via the tens and units cables 59–T and 59–U, respectively, to the lower input conductors of the tens and units control match circuits 59–TCM and 59–UCM, respectively.

The called subscriber's office code register circuit 3–OCR was assumed, for example, to have had registered therein the office code number 487. The called subscriber's directory number register 4–DN was assumed, for example, to have had registered therein the directory number 89512, the last digit of the number being significant of the party designation. The calling subscriber's directory number register 5–CGN was assumed, for example, to have had registered therein the directory number 1234. The relays comprising the three above-named registers will, in their normal or unoperated condition, cause ground to be applied through resistors individual to each of the code output conductors emanating therefrom. When a sender is seized for use in completing a call registration, the activating relay, such as relay 3–ACT in the called subscriber's office code register 3–OCR, for example, will be operated by means well known in the prior art. The activating relay, in operating, extends a positive potential to the lower armature springs of the register relays, and through the back contacts of such relays as are unoperated, to superimpose positive potential on the code output conductors therefrom.

As a result of the seizure of called subscriber's office code register circuit 3–OCR and the registration therein of the number 487, the "write 1" conductors H–0, H–4, T–1, T–7, U–0 and U–7, and the "write 0" conductors H–1, H–2, H–7, T–0, T–2, T–4, U–1, U–2 and U–4 emanating therefrom will have a positive potential superimposed thereon.

As a result of the seizure of the called subscriber's directory number register circuit 4–DN and the registration therein of the number 89512, the "write 1" conductors TH–1, TH–7, H–2, H–7, T–1, T–4, U–0, U–1, STA–0, STA–2 and the "write 0" conductors TH–0, TH–2, TH–4, H–0, H–1, H–4, T–0, T–2, T–7, U–2, U–4, U–7, STA–1, STA–4 and STA–7 emanating therefrom will have a positive potential superimposed thereon.

As a result of the seizure of the calling subscriber's directory number register circuit 5–CGN and the registration thereon of the number 1234 the "write 1" conductors TH–0, TH–1, H–0, H–2, T–1, T–2, U–0, U–4, and the "write 0" conductors TH–2, TH–4, TH–7, H–1, H–4, H–7, T–0, T–4, T–7, U–1, U–2 and U–7 emanating therefrom will have a positive potential superimposed thereon.

The positive potential applied by the operation of relay 3–ACT to the code output conductors of the called subscriber's office code register circuit is extended, via cables 3–WR1C, 3–WR0C, and 3–OCRC, thence, via cable 10–CHGD, to the input conductors of the writing gate circuits 61–WG–32 through 61–WG–46 for the called office channels on the drum.

The positive potential applied by the operation of relay 4–ACT to the code output conductors of the called subscriber's directory number register circuit 4–DN is extended via cables 4–WR1C and 4–WR0C, via cable 4–DNC, thence, via cable 10–CHGD, to the input conductors of the wiring gate circuits 62–WG–47 through 62–WG–71 for the called subscriber's directory number channels on the drum.

The positive potential applied by the operation of relay 5–ACT to the code output conductors of the calling subscriber's directory number register circuit 5–CGN is extended, via cables 5–WR1C and 5–WR0C, via cable 5–CGNC, thence, via cable 10–CHGD, to the input conductors of the writing gate circuits 60–WG–12 through 60–WG–16 and 61–WG–17 through 61–WG–31 for the calling subscriber's directory number channels on the drum.

The recording or storing in the magnetic drum of the several above-named items of numerical call charging indicia is contingent upon a match being encountered between a pre-recorded call identity index number and the call identity index number furnished by the district junctor identifier, and transmitted concurrently with the call charging indicia from the registers to the gate circuits.

The combined recording and pick-up heads **60–RP–2** through **60–RP–11**, and the reading amplifiers **60–RA–2** through **60–RA–11**, respectively cooperative therewith, transmit the call identity index number indicia, as read, to the upper inputs of the tens and units control match circuits **59–TCM** and **59–UCM** in the same manner as previously described. The tens and units control match circuits **59–TCM** and **59–UCM**, respectively, operate in the manner previously described.

Upon encountering a match between the upper and lower input conductors, the tens control match circuit **59–TCM** applies a positive voltage to the output conductor **59–37** and the units control match circuit **59–UCM** applies a positive voltage to the output conductor **59–38**. The output conductors **59–37** and **59–38** apply a positive voltage to the left-hand electrodes of diodes **59–39** and **59–40**, respectively, in the match combine circuit **59–MC**.

Thus upon obtaining a match between the input signal, in this instance the number 99 received from the district junctor identifier circuit **1–DJI**, and the call identity index 99 pre-recorded in the call identity index number channels of the drum, and upon the application of ground, via the up-check path, to the start conductor **59–ST** of the start control circuit **59–SC**, positive voltages are simultaneously applied to the left-hand sides of diodes **59–36**, **59–39** and **59–40**. The simultaneous application of all of these positive voltages to the respective diodes causes a positive voltage to be applied to the grid of tube **59–41** in the match combine circuit. Tube **59–41** operates as a cathode follower and repeats a positive voltage over the output conductor **59–42**. This conductor extends to the left-hand side of diode **59–43** in the writing time-gate circuit **59–WTG**.

The application of a positive pulse or voltage via conductor **59–42** to diode **59–43** initiates the operation of the time gate circuit. Write synchronizing pulses are applied via conductor **59–21** through the voltage divider comprising resistors **59–44** and **59–45** to the control grid of the tube **59–46** of the write time-gate circuit **59–WTG**.

The write time-gate circuit functions under the conjoint effect of a positive pulse, via conductor **59–42**, and a write synchronizing pulse, via conductor **59–21**, to apply a positive pulse to the output conductor **59–31**, as previously described. This pulse is applied, via conductor **59–31**, to the input of the delay network circuit **59–32** and to the writing gate circuits such as **60–WG–12** through **60–WG–16**, **61–WG–17** through **61–WG–46**, **62–WG–47** through **62–WG–72** and **63–WG–73** through **63–WG–91**, and also to the center or write synchronizing conductor of writing amplifiers **60–WA–12** through **63–WA–91**.

We have assumed that, for example, the toll call in progress, the charging indicia for which is to be stored in the magnetic drum, is served by district junctor number 99 which is identified by call identity index number 99. The potential conditions, expressive of the numerical indicia in two out of five code, representative of the calling subscriber's directory number, the called office code, the called subscriber's directory number and the basic rate index number will have been extended, concurrently with the call identity index number indicia, to the write "1" and write "0" input conductors of the writing gate circuits **60–WG–12** through **60–WG–16**, **61–WG–17** through **61–WG–46**, **62–WG–47** through **62–WG–71** and **63–WG–86** through **63–WG–89**.

Concurrently with the transmission of the above-named call charging indicia, the basic rate translator circuit **64–BRT**, the basic rate translator register circuit **64–BRTR**, and the automatic reduced rate indicating circuit shown on Fig. 65 cause potential conditions to be applied to the respective output conductors therefrom and extended to the magnetic drum storage circuit to store therein other items of indicia pertinent to the determination of the toll charge for the call in progress. The relays controlling the call charging indicia outputs from the above-named registers, will, in their normal or unoperated condition, cause ground potential to be applied through resistors individual to each of the write "1" code output conductors and will also cause a positive potential to be applied to each of the write "0" code output conductors emanating therefrom. Any of these relays, upon being operated will cause a reversal of the potential condition on the write "1" and write "0" code output conductors connected, respectively, to its front and back contacts.

In the basic rate translator circuit **64–BRT**, the band relays **64–40**, **64–400** and **64–4000** are, respectively, operable, one at a time, in response to the selection of a band comprising one or more, but no more than three relay tables, and not more than one each in the 0–40 mile, the 40–400 mile or the 400–4000 mile range. We will assume, for example, that the relay **64–40** has been operated. A positive potential is extended through the number 7 armature and front contact of relay **64–40** to the code output conductor **64–40–WR1**. Ground, through resistance, is extended to code output conductor **64–40–WR0**. Code output conductors **64–40–WR1**, **64–400–WR1**, **64–4000–WR1**, **64–40–WR0**, **64–400–WR0** and **64–4000–WR0** are connected, via cable **64–BN**, thence, via cable **60–CHGD**, to the input conductors of the writing gate circuits **63–WG–83**, **63–WG–84** and **63–WG–85** for the band number channels on the drum.

In the basic rate translator register circuit **64–BRTR**, the register relays **64–BRT–1**, **64–BRT–2**, **64–BRT–4** and **64–BRT–8** are operable, either singly or in combinations of two or more, to transmit indicia, on a binary code basis, expressive of a number lying between one and fifteen and indicative of the basic rate index number to be employed in the determination of the charge for a toll call in progress. We will assume that, as previously described, terminal **64–T–6** has had ground extended thereto indicative of a distance of 40 miles, and as a result thereof relays **64–BRT–2** and **64–BRT–4** have been operated to indicate a call identity index number 6. A positive potential is extended through the respective armatures and front contacts of relays **64–BRT–2** and **64–BRT–4** to the code output conductors **64–2–WR1** and **64–4–WR1**, respectively. Ground, through resistance, is extended to code output conductors **64–2–WR0** and **64–4–WR0**. Code output conductors **64–1–WR1**, **64–2–WR1**, **64–4–WR1**, **64–8–WR1**, **64–1–WR0**, **64–2–WR0**, **64–4–WR0** and **64–8–WR0** are connected, via cable **64–BRI**, thence, via cable **60–CHGD**, to the input conductors of the writing gate circuits **63–WG–86** through **63–WG–89** for the basic rate index number channels on the drum.

In the automatic reduced rate indicating circuit shown in Fig. 65, the relay **65–NR** in its normal or unoperated position will indicate, as previously described, that the call in progress will be chargeable at the day rate. When relay **65–NR** is operated it will, conversely, indicate that the night or reduced rate is to be applied. We will assume that the relay **65–NR** has been operated and that, therefore, the night rate is applicable. A positive potential is extended through the front contact of relay **65–NR** to the indicia output conductor **65–N–WR1**. Ground, through resistance, is extended to the indicia lead **65–N–WR0**. Indicia output conductors **65–N–WR1** and **65–N–WR0** are connected, via cables **60–CHGD** and **65N**, to the input conductors of the writing gate circuit **63–WG–90** for the "NITE" channel on the drum.

The writing gate circuits **60–WG–12** through **62–WG–71** and **63–WG–83** through **63–WG–90** have had applied to the input conductors thereof, as above described, potential conditions representative of the several items of coded indicia essential to the determination of the monetary charge for a toll call in progress, with the exception of the elapsed conversation time indicia which will not be available until either the calling or the called subscriber has hung up.

The writing gate circuits **60–WG–12** through **63–WG–91** are identical in construction and operation. We will now describe in detail the operation of the writing gate circuit **60–WG–12** which is shown in detail. The midpoint between diodes **60–34** and **60–35** is connected to a source of write synchronizing pulses, via lead **59–31**, such as described herein. Output conductor **60–36** is connected to the write "1" input conductor of the writing amplifier **60–WA–12** which causes the amplifier to transmit a write "1" pulse, via conductor **60–W–42**, to the combined recording and pick-up head **60–RP–12**. Output conductor **60–37** is connected to the write "0" input conductor of the writing amplifier **60–WA–12** which causes the amplifier to transmit a write "0" pulse, via conductor **60–W–42**, to the combined recording and pick-up head **60–RP–12**.

The input conductor **5–WR1–0** of the writing gate circuit **60–WG–12** receives a positive potential applied thereto, as above described, for causing the recording of a "1" condition on the drum. The input conductor **5–WR0–0** of the writing gate circuit **60–WG–12** receives a positive potential applied thereto, as above described, for causing the recording of a "0" condition on the drum. When a pulse of positive polarity is applied to the input conductor **5–WR1–0** and, simultaneously therewith, a positive write synchronizing pulse is applied to the midpoint between diodes **60–34** and **60–35**, a positive output pulse is repeated, via conductor **60–36**, to the WR1 input conductor of writing amplifier **60–WA–12**. However, in the absence of either of the two positive input pulses no output pulse will be applied to the output conductor **60–36** because the impedance of the input circuits connected to ground or to a small positive voltage is low in the absence of a positive voltage applied to them and, in effect, shunts the positive voltage pulses applied to the other input terminal, so that substantially none of the voltage of the other pulse appears on the output conductor **60–36**. Diodes **60–39** and **60–40** are arranged so that when a pulse of positive polarity is applied, via input conductor **5–WR0–0**, to the diode **60–40** or, via conductor **63–ER**, to the diode **60–39** and, simultaneously therewith, a positive write synchronizing pulse is applied to the midpoint between diodes **60–34** and **60–35**, a positive output pulse will be repeated, via conductor **60–37**, to the WR0 input conductor of writing amplifier **60–WA–12**. It is to be understood that the polarity of diodes **60–39** and **60–40** is reversed relative to the polarity of diode **60–41** and that an additional diode **60–42** is interposed between diodes **60–40** and **60–35**. Here, positive voltage applied to either conductor **5–WR0–0** or **63–ER**, is repeated through the diode respectively connected thereto and, when positive potential is applied, via lead **59–31**, is repeated to output conductor **60–37**.

The writing amplifiers **60–WA–12** through **63–WA–91** are constructed in and operate in the same manner as the previously described writing amplifier **60–WA–2**. The application of write "1" or write "0" pulses to the input conductor of the above-described writing gate circuits, and the simultaneous application thereto, and to the writing amplifiers, of a write synchronizing pulse cause these indicia, when accompanied by a set of call identity index indicia, to be stored in the magnetic drum storage circuit there to await the completion of the call and the concomitant availability of the elapsed conversation time and check indicia. The writing gate circuits, such as **60–WG–12** above described, are disclosed in the patent to C. E. Brooks, J. H. McGuigan, O. J. Murphy and N. D. Newby, No. 2,700,148 of January 18, 1955.

When, at the conclusion of the call, either the calling subscriber, the called subscriber, or both shall have hung up, the relays **1–ANS** and **1–TM** release. Ground is extended through the number 3 armature and back contact of relay **1–TM**, via lead **3–CK**, to the district junctor identifier circuit **1–DJI** and through the up-check circuit therein to the conductor **1-CK**. The district junctor identifier relays are so designed as to remain operated for a few seconds after hang-up to permit the indicia stored therein to be used in identifying the district junctor number with the elapsed time indicia. The conductor **1–CK** is connected via cables **1-CIIM** and **2–IIM**, and thence via cable **10–CHGD**, to the basic rate translator register relay circuit **64–BRTR** and through the up-check path therein to the up-check conductor **64–CK**, thence through the back contact and number 1 armature of relay **59–CII**, via conductor **59–ST**, to the previously described start control circuit **59–SC**. Ground, extended through the above-described up-check path, is an indication that the services of the start control circuit **59–SC** are again required, in this instance, to facilitate the matching of the slot in the drum containing call charging indicia with the elapsed conversation time related thereto by means of the common call identity index number. The availability of the elapsed time indicia permits the transfer from the elapsed conversation time register circuit **2–ECT** to the magnetic drum of the elapsed conversation time indicia as controlled by the call identity index number transmitted simultaneously therewith. Ground, originating in the district junctor and extended through the above-described up-check path, when applied, via lead **59–ST**, to the start control circuit **59–SC** causes the start control circuit to function in the same manner as described above with reference to the operation of the start key **59–STK**.

Simultaneously with the extension of ground over the above-described up-check paths to the start control circuit via lead **59–ST**, the district junctor identifier circuit **1–DJI** and the elapsed conversation time register **2–ECT** cause a potential condition to be applied to the coded indicia output conductors extending therefrom to the magnetic drum storage circuit, expressing the call identity index number identifiable with a call in progress and the elapsed conversation time chargeable thereto, together with an indication to the magnetic drum storage circuit that the final item of indicia essential to the determination of the monetary charge for a toll call has been applied to the magnetic drum. The district junctor identifier circuit **1–DJI** again applies ground to the tens conductors **1–TC–2** and **1–TC–7** and to the units conductors **1–UC–2** and **1–UC–7**, via cables **1–TC** and **1–UC**, respectively, and thence, via cables **1–CIIM**, **2–ITM**, and **10–CHGD**, through the back contacts and the number 4, 6, 9 and 11 armatures, respectively, of relay **59–CII**, via the tens and units cables **59–T** and **59–U**, respectively, to the lower input conductors of the tens and units control match circuits **59–TCM** and **59–UCM**, respectively. The call identity index number, transmitted over the circuit just traced, facilitates the recording of the concurrently transmitted elapsed time indicia in the appropriate slot.

The relay **1–TM** in the district junctor circuit **1–DJ–99**, in releasing, extends ground through its number 4 armature and back contact, via lead **1–TMA**, to the parallel connected number 1 armatures of of relays **1–U–0** through **1–U–9**. Since the district junctor number 99 is assumed to be serving the call in progress, ground supplied via lead **1–TMA** is extended through the armature and front contact of relay **1–U–9**, via lead **1–UA–9**, to the parallel connected number 10 armatures of relays **1–T–0** through **1–T–9** and through the front contact on the number 10 armature of relay **1–T–9**, via lead **1–99**, through the winding of timer-activating relay **2–TA** to battery.

The district junctor timing circuit **2–DJT** will have been, in the meantime, counting and accumulating a record of elapsed conversation time. The positions to which the stepping arms **2–T–1** and **2–T–2** of the tens, and **2–U–1** and **2–U–2** of the units stepping switches will have been advanced during the progress of a call are determined by the elapsed conversation time of the call. The terminals of the number 1 and number 2 banks of the tens and units switches are connected to the minutes tens and minutes units conductors, respectively. The minutes tens conductors **2–MT–0**, **2–MT–1**, **2–MT–2**, **2–MT–4** and **2–MT–7** and the minutes units conductors **2–MU–0**, **2–MU–1**, **2–MU–2**, **2–MU–4** and **2–MU–7** are, respectively connected to the tens and units banks in a pattern to express, when grounds are extended thereto, the elapsed conversation time as a two-digit number, in two out of five code.

Relay **2–TA**, when operated, extends ground through its armatures 2, 3, 4 and 5 and the front contacts thereof to the stepping switch arms **2–T–1**, **2–T–2**, **2–U–1** and **2–U–2**, respectively, and thence, through the bank terminals, and via the minutes tens and minutes units conductors, respectively, through the windings of the elapsed conversation time register relays, such as **2–TR–0**, **2–TR–7**, **2–UR–0** and **2–UR–7**, to battery. Relay **2–TA**, when operated, also extends ground through its number 1 armature and front contact to the armature of relay **2–100**. Relay **2–100** will operate only when the elapsed conversation time is 100 minutes as accumulated by the timing circuit, as previously described. When relay **2–100** is operated, ground will be extended through its armature and front contact, via lead **2–M–100**, through the winding of relay **2–100–H**, of the elapsed conversation time register, to battery.

The register relays **2–100–H**, **2–TR–0**, **2–TR–1**, **2–TR–2**, **2–TR–4**, **2TR–7**, **2–UR–0**, **2–UR–1**, **2–UR–2**, **2–UR–4** and **2–UR–7**, and the check relay **2–RCK** comprising the elapsed conversation time register circuit **2–ECT** will, in their normal or unoperated condition, cause ground to be applied through resistors individual to each of the code output conductors emanating therefrom. When either the 100 minutes relay **2–100–H** or the minutes tens and minutes units relays such as **2–TR–0**, **2–TR–7**, **2–UR–0** and **2–UR–7** have been operated to represent a valid combination expressive of an elapsed time interval in minutes, a local up-check circuit, not shown in detail, is closed and completes an operating circuit for check relay **2–RCK**, through its winding, to battery. Relay **2–RCK**, by its operation, indicates that valid elapsed time indicia have been made available to the magnetic drum storage circuits. The register activating relay **2–RA** will have been energized and will have operated in parallel to the timer activating relay **2–TA** from the ground extended, as above described, via lead **1–99**. The register-activating relay **2–RA**, in operating, extends a positive potential to the lower armature springs of the elapsed conversation time register relays, and through the back contacts of such relays as are unoperated, to superimpose a positive potential on the code output conductors therefrom. The code output conductors **2–CK–WR1**, **2–CK–WR0**, **2–ET–100–WR1**, **2–ETT–0–WR1**, (**2–ETT–1–WR1**, **2–ETT–2–WR1**, **2–ETT–4–WR1** not shown), **2–ETT–7–WR1**, **2–ETU–0–WR1**, (**2–ETU–1–WR1**, **2–ETU–2–WR1**, **2–ETU–4–WR1** not shown), **2–ETU–7–WR1**, **2–ETT–0–WR0**, (**2–ETT–1–WR0**, **2–ETT–2–WR0**, **2–ETT–4–WR0** not shown), **2–ETT–7–WR0**, **2–ETU–0–WR0**, (**2–ETU–1WR–0**, **2–ETU–2–WR0**, **2–ETU–4–WR0** not shown), and **2–ETU–7–WR0** extend the potential conditions applied thereto, via cables **2–WR1C**, **2–WR0C**, and **2–ECTM**, thence via cable **10–CHGD**, to the input conductors of the writing gate circuits **62–WG–72**, **63–WG–73** through **63–WG–82** and **63–WG–91** for the elapsed conversation time and check channels on the drum.

The recording or storing in the magnetic drum of the indicia representative of the elapsed conversation time and the check signal is contingent upon a match being encountered between a pre-recorded call identity index number and the call identity index number furnished by the district junctor identifier at the conclusion of a call, and transmitted concurrently with the elapsed conversation time and check indicia from the elapsed conversation time register circuit to the gate circuits.

The combined recording and pick-up heads **60–RP–2** through **60–RP–11** (**60–RP–8** through **60–RP–10**, not shown) and the reading amplifiers **60–RA–2** through **60–RA–11** (**60–RA–8** through **60–RA–10**, not shown), respectively cooperative therewith, transmit the call identity index number indicia, as read, to the upper inputs of the tens and units control match circuits **59–TCM** and **59–UCM** in the same manner as previously described. The tens and units control match circuits **59–TCM** and **59–UCM**, respectively, operate in the manner previously described.

Upon encountering a match between the upper and lower input conductors, the tens control match circuit **59–TCM** applies a positive voltage to the output conductor **59–37**, and the units control match circuit **59–UCM** applies a positive voltage to the output conductor **59–38**. The output conductors **59–37** and **59–38** apply a positive voltage to the left-hand electrodes of diodes **59–39** and **59–40**, respectively, in the match combine circuit **59–MC**.

Thus upon the obtaining of a match between the input signal, in this instance the number 99 received from the district junctor identifier circuit **1–DJI**, at the conclusion of a call, and the call identity index number 99 prerecorded in the call identity index number channels of the drum, and upon the application of ground, from the number 3 armature and back contact of relay **1–TM** in the district junctor, via lead **3–CK**, and through the up-check path in the district junctor identifier circuit **1–DJI**, via the up-check path therein and conductor **1–CK**, via cables **1–CIIM** and **2–ITM**, and thence, via cable **10–CHGD**, to the basic rate translator register relay circuit **64–BRTR** and through the up-check path therein to the up-check conductor **64–CK**, thence through the back contact and number 1 armature of relay **59–CII**, via conductor **59–ST**, to the start conductor of the start control circuit **59–SC**, and positive voltages are simultaneously applied to the left-hand sides of diodes **59–36**, **59–39** and **59–40**. The simultaneous application of all of the these positive voltages to the respective diodes causes a positive voltage to be applied to the grid of tube **59–41** in the match combine circuit. Tube **59–41** operates as a cathode follower and repeats a positive voltage over the output conductor **59–42**. This conductor extends to the left-hand side of diode **59–43** in the writing time-gate circuit **59–WTG**.

The application of a positive pulse or voltage, via conductor **59–42** to diode **59–43** initiates the operation of the time-gate circuit. Write synchronizing pulses are applied, via conductor **59–21**, through the voltage divider comprising resistors **59–44** and **59–45** to the control grid of the tube **59–46** of the write time-gate circuit **59–WTG**.

The write time-gate circuit functions, under the conjoint effect of a positive pulse, via conductor **59–42**, and a write synchronizing pulse, via conductor **59–21**, to apply a positive pulse to the output conductor **59–31**, as previously described. This pulse is applied, via conductor **59–31**, to the input of the delay network circuit **59–32**, and to the writing gate circuits **62–WG–72**, **63–WG–73** through **63–WG–82** and **63–WG–91**, and also to the center or write synchronizing conductor of writing amplifiers **62–WA–72**, **63–WA–73** through **63–WA–82** and **63–WA–91** of the channels on the drum used for the elapsed conversation time and the check signal.

We have assumed that, for example, in the toll call in progress the charging indicia, the last item of which is the elapsed conversation time, is to be stored in the magnetic drum; is served by district junctor number 99 which is identified by call identity index number 99. The potential conditions, expressive of the elapsed conversation time numerical indicia in two out of five code, and the accompanying check signal, will have been extended, concurrently with the call identity index number indicia, to the write "1" and write "0" input conductors of the writing gate circuits 62–WG–72, 63–WG–73 through 63–WG–82 and 63–WG–91.

The writing gate circuits 62–WG–72, 63–WG–73 through 63–WG–82 and 63–WG–91 are identical in construction and operation with writing gate circuit 60–WG–12, previously described in detail. The write "1" or the write "0" input conductors of the writing gate circuits 62–WG–72, 63–WG–73 through 63–WG–82 receive a combination of negative or positive potentials applied thereto, as above described, expressive, in two out of five code, of the numerical value of the elapsed time indicia. When a positive pulse is applied to the write "1" or to the write "0" leads and simultaneously therewith, a positive write-synchronizing pulse is applied to the upper center or write-synchronizing conductors thereof, via conductor 59–31, a positive output pulse is repeated, via the output conductors to the write "1" or to the write "0" input conductors of writing amplifiers 62–WA–72 and 63–WA–73 through 63–WA–82 as above described.

The writing amplifiers 62–WA–72 and 63–WA–73 through 63–WA–82 are constructed and will operate in the same manner as the previously described writing amplifier 60–WA–2. The application of write "1" or write "0" pulses to the input conductors of the above-described writing gate circuits, and the simultaneous application thereto, and to the writing amplifiers, of a write-synchronizing pulse, cause the elapsed conversation time indicia, when accompanied by a set of call identity index indicia, to be stored in the magnetic drum storage circuit.

The writing gate circuit 63–WG–91 will have a positive potential applied to the write "1" input conductor 2–CK–WR1 when the check relay 2–RCK in the elapsed conversation time register circuit 2–ECT has operated as previously described. The writing gate circuit 63–WG–91 operates as above described and applies a positive pulse to the write "1" input conductor of writing amplifier 63–WA–91, causing a write "1" or positive pulse to be transmitted, via conductor 63–CK, to the combined recording and pick-up head 63–RP–91, to record a write "1" or positive condition in the check channel of the magnetic drum.

The several register circuits employed to supply indicia to the magnetic drum storage circuit release as soon as the indicia registered therein has been transferred to the magnetic drum. The drum now has stored therein all of the several items of indicia which are essential to the identification of the calling and the called subscribers and the determination of the monetary charge for a toll call.

Magnetic drum storage and related output registers

We will now describe the circuits and their operation, by means of which the magnetic state of the several elemental areas comprising a slot in the magnetic drum, identified by a pre-recorded call identity index number, may be read and the indicia stored therein transferred to a plurality of output registers. The transfer of the indicia from the magnetic drum to the output registers is contingent upon the receptivity of the registers as evidenced by the continuity of a down-check circuit extending in series through the several output registers to the check signal reading gate circuit 63–RG–91, which check circuit will be traced as follows. Positive potential is extended, via conductor 66–DN–CK, through the down-check circuit comprising the armatures and back contacts of the calling subscriber's directory number register-translator circuit 66–CGSRT, via down-check conductor 66–1, through the down-check circuit comprising the armatures and back contacts of the called subscriber's office code register-translator circuit 66–CDORT, via down-check conductor 66–2, through the down-check circuit comprising the armatures and back contacts of called subscriber's directory number register-translator circuit 66–CDSRT, via down-check conductor 66–3, through the down-check circuit comprising the back contacts and armatures of the basic rate index translator circuit binary relays 68–8, 68–4, 68–2 and 68–1, via down-check conductor 68–10, through the down-check circuit comprising the back contacts and armatures of band register relays 68–40, 68–400 and 68–4000, via conductor 68–DN–CK, through the down-check circuit comprising upper number 3 back contact and armature of relay 67–N, through the down-check circuit comprising the back contacts and armatures of the tens relays of the time tree circuit 67–TT, via conductor 67–1, through the down-check circuit comprising upper number 3 armature and back contact of relay 67–100 and the down-check circuit of the relays comprising the tens and units digits of the elapsed conversation time register-translator circuit 67–ECTR, via conductor 67–DN–CK, to the upper left-hand input conductor of the reading gate circuit 63–RG–91.

The check channel of the magnetic drum comprises an annularly disposed plurality of elemental areas, said annulus having a width of one elemental area. Each elemental area in the check channel will, in turn, pass beneath the combined recording and pick-up head 63–RP–91. On the next revolution of the magnetic drum following the recording of a check signal in an elemental area thereof, when the elemental area of the check channel in which has been recorded a write "1" or positive signal, passes beneath the combined recording and pick-up head 63–RP–91, a positive potential is applied from the combined recording and pick-up head 63–RP–91, via conductor 63–CKR, to the right-hand input conductor of reading amplifier 63–RA–91. The reading amplifier 63–RA–91 is identical in construction and operation with reading amplifier 60–RA–2 previously described in detail. The application of a positive potential to the right-hand input conductor 63–CKR and, simultaneously therewith, the application of a read-synchronizing or positive pulse, via conductor 59–RS1, to the left-hand input conductor of the reading amplifier 63–RA–91 causes a positive potential to be applied, via conductor 63–CKG, to the right-hand input conductor of the reading gate circuit 63–RG–91.

The reading gate circuit 63–RG–91 is identical in construction and operation with the reading gate circuits 60–RG–12 through 60–RG–16, 61–RG–17 through 61–RG–46, 62–RG–47 through 62–RG–72 and 63–RG–73 through 63–RG–90. Reading gate circuit 60–RG–12, which we will describe in detail, is of a type known as an "and" circuit and is disclosed in the aforementioned patent to C. E. Brooks, C. A. Lovell, J. H. McQuigan, O. J. Murphy and D. B. Parkinson, No. 2,764,634 of September 25, 1956. The application of a positive input pulse, via the upper right-hand conductor 60–48 to the upper electrode of the right-hand diode 60–44, and simultaneously therewith the application of a positive input potential, via the upper left-hand conductor 63–CRS, to the upper electrode of the left-hand diode 60–43, causes a positive output pulse to be repeated, via the lower or output conductor 60–45, to the delay gate amplifier 60–DGA–12.

The application of a positive input pulse, via the conductor 63–CKG, to the upper right-hand conductor of the reading gate circuit 63–RG–91, and simultaneously therewith the application of a positive potential, via the down-check conductor 67–DN–CK, to the upper left-hand conductor of the reading gate circuit 63–RG–91, causes a positive output pulse to be repeated, via conductor 63–GA, to the inputs of the amplifiers 63–1 and 63–2.

The amplifiers 63–1 and 63–2 are similar in construction and are designed to repeat a positive output pulse of high amplitude and of greater duration than the positive input pulse applied thereto, by the reading gate circuit 63–RG–91 via conductor 63–GA, but of shorter duration than the time required for an elemental area to pass under the pick-up head. The amplifiers 63–1 and 63–2 contain the necessary pulse forming, pulse shaping means, and means for otherwise controlling the output pulse characteristics therefrom as required. The amplifier 63–1 repeats a positive output pulse, via the common read-synchronizing conductor 63–CRS, to the upper left-hand input conductors of all the reading gate circuits 60–RG–12 through 63–RG–90. Each of the reading gate circuits 60–RG–12 through 63–RG–90, when a positive input pulse is applied to the upper right-hand input conductor thereof, as the result of a positive or "1" signal having been read from the magnetic drum, and simultaneously therewith a positive input pulse is applied to the upper left-hand input conductor thereof, respectively repeats a positive output pulse, via the lower or output conductor, to the respectively related delay gate amplifier circuit.

The amplifier 63–2 repeats a positive output pulse, via conductor 63–3, to the erase delay network 63–EDL which will, after a few milliseconds have elapsed, repeat a positive pulse to the erase conductor 63–ER.

The delay gate amplifiers 60–DGA–12 through 60–DGA–16, 61–DGA–17 through 61–DGA–46, 62–DGA–47 through 62–DGA–72 and 63–DGA–73 through 63–DGA–90 are identical in construction and operation. Delay gate amplifier 60–DGA–12, which we will describe in detail, is disclosed in the aforementioned patent application of H. A. Henning, E. Jacobitti and B. F. Lewis, entitled "Magnetic Drum Translator For Automatic Toll Switching Center," Serial No. 418,508, filed March 25, 1954.

A positive voltage is extended through the armature and back contact of the output erase relay 63–OE, via the common output relay erase conductor 63–ORE, through a resistor and the winding of output relay 60–OR–12 to the anode of tube 60–46, thus energizing tube 60–46. Tube 60–46 however, does not conduct at this time because of the negative potential applied to its grid from the voltage divider connected to the grid of the upper section of tube 60–47.

As above described, a positive pulse is repeated from the reading gate circuit 60–RG–12, via conductor 60–45, and applied to the delay gate amplifier 60–DGA–12 through the coupling capacitor 60–49 and the diode 60–50 to the upper grid of tube 60–47. It is to be noted that, inasmuch as the right-hand terminal of diode 60–51 is connected to a source of positive voltage, the diode 60–51 will have a high resistance to positive pulses and will not materially prevent the application of the positive pulse to the grid of the upper section of tube 60–47.

Tube 60–47 has its two sections connected in a single cycle multivibrator circuit and is arranged so that a pulse of relatively short duration of the order of several microseconds will be sufficient to initiate the operation of the circuits of this tube, and thereafter the circuits will remain in their actuated condition for a much longer interval of time of sufficient duration to operate a relay, such as relay 60–OR–12 in the manner now to be described.

Tube 60–47 is arranged so that the lower section is normally conducting current. Upon the application of a positive pulse to the upper grid of tube 60–47, the flow of current through the upper section is initiated which, in turn, due to the cross-coupling arrangement, interrupts the current flowing through the lower section. The current then continues to flow through the upper section for a period of time equal to approximately fifteen milliseconds in an exemplary embodiment of this invention. During the time that current does not flow through the lower section of tube 60–47, the grid of the upper section is at a relatively high positive potential. Consequently, current continues to flow through the upper section. In addition, the grid of the upper section is connected to the grid of amplifier tube 60–46 and as a result, during the time that the grid of the upper section of tube 60–47 is positive, the grid of tube 60–46 is also positive. Consequently, current flows in the anode cathode circuit of tube 60–46 during this time. The circuit path for the anode current of tube 60–46 extends from battery through

the armature and back contact of relay 63–OE, via conductor 63–ORE, through the resistor 60–52, through the winding of relay 60–OR–12 to the anode of tube 60–46 and then through a resistor to the grounded cathode of tube 60–46. As a result, relay 60–OR–12 operates and in operating completes a circuit for maintaining it in its operated condition independently of tube 60–46, from ground through its armature and left-hand front contact, through resistor 60–53, through its winding and through resistor 60–52, via conductor 63–ORE, through the back contact and armature of relay 63–OE to battery.

The delay network circuit 63–EDL delivers a delayed positive output pulse, via conductor 63–ER, to the lower center input conductors of all of the writing gate circuits 60–WG–12 through 63–WG–91. We will describe in detail the operation of writing gate circuit 60–WG–12 in response to the application to its lower center conductor of a positive input pulse via conductor 63–ER; it is to be understood that the other writing gate circuits will operate in an identical manner. The application of a positive pulse, via conductor 63–ER to the diode 60–39 will have exactly the same effect as the previously described application of a write "0" or positive pulse to the diode 60–40 and will cause a write "0" or positive pulse to be applied, via conductor 60–37, to the write "0" input conductor of writing amplifier 60–WA–12. Writing amplifier 60–WA–12 will operate, as previously described, to repeat a write "0" pulse to the combined recording and pick-up head 60–RP–12, causing a write "0" condition to be written over or superimposed on the existing signal or condition in that elemental area included in the slot identified by call identity index number 99. In brief, the function of the delayed positive pulse from the delay network circuit 63–EDL, via conductor 63–ER, is to apply an erase or clearing out pulse to all of the elemental areas of the slot identified by call identity index number 99, after a time interval of a duration sufficient to assure the reading and utilization of the call charging indicia stored therein.

Relay 60–OR–12, in operating, also extends ground, via conductor 60–CGS–TH–0 in cable 61–CGS, through the winding of relay 66–TH–0 to a negative battery. The relay 66–TH–0 will operate in the circuit just traced, to register one of the elements of a two out of five code indicative of the thousands digit of the calling subscriber's directory number.

The calling subscriber's directory number register-translator circuit 66–CGSRT, the called subscriber's office code register-translator circuit 66–CDORT, the called subscriber's directory number register-translator circuit 66–CDSRT, and the tens and units digits of the elapsed conversation time register circuit 67–ECTR comprise relay means for respectively registering, on a two out of five code basis, the call charging indicia stored in and read from the correspondingly designated channels of the magnetic drum, in the same manner as described in detail with reference to relay 66–TH–0.

The relay 67–100 in the elapsed conversation time register circuit 67–ECTR, responsive to the reading of a positive or write "1" condition from an elemental area in channel 100 in a slot identified by the appropriate matching of call identity index numbers, in this instance number 99, is operated in the same manner as described in detail with reference to relay 66–TH–0 to register an elapsed time of 100 minutes.

One of the band register relays 68–40, 68–400 and 68–4000, employed to register the number of the mileage band required in conjunction with a call in progress, in the basic rate index register-translator circuit shown on Fig. 68, is operated responsive to the reading of a positive or write "1" condition from an elemental area in a correspondingly designated channel in the drum included in the slot identified by the call identity index number 99.

The relays 68–1, 68–2, 68–4 and 68–8 in the basic rate index register-translator circuit shown on Fig. 68 are operated either singly or in combinations of two, three or four, responsive to the reading of the indicia from the elemental areas in the correspondingly designated channels in the drum included in the slot identified by the call identity index number 99, to register on a binary code basis the basic rate index number required in conjunction with a call in progress.

The relay **67**–N in the time tree circuit **67**–TT, responsive to the reading of a positive or write "1" condition from an elemental area in the channel designated "NITE," in a slot identified by the appropriate matching of call identity index numbers, is operated in the same manner as described in detail with reference to relay **66**–TH–**0** to register the information that the night or reduced rate should be applied in the determination of the monetary charge for the call in progress.

All of the several items of call charging indicia stored in that slot of the magnetic drum identified by the call identity index number 99 will have been read and will have caused the operation of selected combinations of the output relays **60**–OR–**12** through **60**–OR–**16**, **61**–OR–**17** through **61**–OR–**46**, **62**–OR–**47** through **62**–OR–**72** and **63**–OR–**73** through **63**–OR–**90** representative of the indicia as read. The output relays, so operated, will lock themselves in their operated condition, as described in detail with reference to relay **60**–OR–**12**.

The register relays, such as relay **66**–TH–**0** previously described in detail, will have operated under control of their respectively related output relays to register the call charging indicia as read from the magnetic drum. The output relays, such as **60**–OR–**12**, will have now transferred their indicia to their respectively related register relays, such as **66**–TH–**0**, and may now be released to serve another call. The unlocking and releasing of the output relays, such as **60**–OR–**12**, is contingent upon the registration in the several output registers, as operated under control of the output relays, of a full complement of call charging indicia expressed by valid combinations of operated relays, as evidenced by the continuity of an up-check circuit extending in series through the several output registers to the output erase relay **63**–OE, which will be traced as follows:

Ground is extended via conductor **66**–UP–CK through the two out of five up-check circuits of the thousands, hundreds, tens and units digits of the calling subscriber's directory number register-translator **66**–CGSRT, via up-check conductor **66**–**4**, through the two out of five up-check circuits of the hundreds, tens, and units digits of the called subscriber's office code register-translator **66**–CDORT, via up-check conductor **66**–**5**, through the thousands digit up-check circuit **66**–TH–UP–CK, or alternatively, through the upper number 2 armatures and back contacts in series of the thousands digit, via conductor **66**–**7**, through the hundreds, tens, units and stations digits of the called subscriber's directory number register-translator **66**–CDSRT, via up-check conductor **66**–**6**, through the up-check circuit of the time tree circuit **67**–TT, via conductor **67**–**3**, through the upper number 2 armature and front contact of relay **67**–N, via conductor **67**–**2**, through the upper number 2 armature and front contact of relay **67**–**100**, or alternatively, through the up-check circuit of the relays comprising the tens and units digits of the elapsed conversation time register-translator circuit **67**–ECTR, via conductor **67**–UP–CK, through the binary up-check circuit of the relays **68**–**8**, **68**–**4**, **68**–**2** and **68**–**1** of the basic rate index register-translator circuit shown on Fig. 68, via up-check conductor **68**–**11**, through the one out of three up-check circuit of relays **68**–**40**, **68**–**400** and **68**–**4000** of the basic rate index register-translator circuit, via up-check conductor **68**–UP–CK, through the winding of erase relay **63**–OE to battery. Relay **63**–OE operates from ground via the up-check circuit just described. Relay **63**–OE, in operating, disconnects the source of voltage from conductor **63**–ORE, which causes the release of all of the operated output relays, such as **60**–OR–**12**.

The relays comprising the several output registers are locked in their operated positions under control of ground extended through the armatures and back contacts of relay **66**–UL and will remain locked until released at the completion of the printing of the computed toll call charge and the accompanying identifying data.

Translating registered data into call charges

We will now describe the circuit operations by which the indicia stored in the magnetic drum and subsequently transferred to and registered in the several register-translator circuits is utilized to identify the calling and the called subscribers and to compute the monetary charges for the call.

To establish the identity of the call, the directory number of the calling subscriber, the called subscriber's office code number and the directory number of the called subscriber will have been determined, stored in the magnetic drum and, as above described, transfered to the corresponding register-translator circuits which will, respectively, have operated to assume settings appropriate thereto and will have been locked in their operated condition under control of ground through the back contacts of relay **66**–UL. The registration of the above call identifying numbers will have been accomplished on a two out of five code basis. The outputs, however, from the registers will be on a decimal basis and will be later described in detail.

The geographical area to be served by the telephone toll call charging system of the present invention is, as previously described, resolved into three mileage bands or ranges. When a call is in progress, the previously-described circuit means will have caused band number indicia to be stored in the magnetic drum as an indication that the distance in miles between the calling and the called central offices lies either in the 40, the 400 or the 4000 mile band. The indicia stored in the "band" channels of the magnetic drum will have been read out, in the manner previously described, and will have caused one of the relays **68**–**40**, **68**–**400** or **68**–**4000** in the basic rate index register-translator circuit to operate in correspondence therewith and to lock in its operated condition under control of ground through the back contact and armature number 4 of relay **66**–UL.

A call wherein the distance does not exceed 40 miles is chargeable at a basic rate which will be selected from a group of basic rates numbered 1 through 6, as illustrated, in the 1 to 40 mile section of the rate table shown in Fig. 96.

A call wherein the distance is in excess of 40 miles and does not exceed 400 miles is chargeable at a basic rate which will be selected from a group of basic rates numbered 1 through 15, as illustrated, in the 41 to 400 mile section of the rate table shown in Fig. 96.

A call wherein the distance is in excess of 400 miles lies between 401 and does not exceed 4000 miles is chargeable at a basic rate which will be selected from a group of basic rates numbered 1 through 15, as illustrated, in the 401 to 4000 mile section of the rate table shown in Fig. 96.

A call originating between the hours of 6 a.m. and 6 p.m., except on a Sunday or a holiday, employs the rates shown in the "day (except Sunday or holiday)" column of the rate table, whereas a call originating between the hours of 6 p.m. and 6 a.m. employs the reduced rates shown in the "night, Sunday and holiday" column, except for calls wherein the distance between the calling and the called central offices lies between 1 and 40 miles and to which the reduced rates are not applicable and, therefore, will employ the rates shown in the "day (except Sunday or holiday)" column of the rate table shown in Fig. 96.

The basic rate index number indicia, representing a number between one and fifteen, stored in the basic rate index channels in the magnetic drum, will have been read out in the manner previously described, and will have caused one of, or a combination of, the relays **68–1**, **68–2**, **68–4** and **68–8** to operate in correspondence therewith and to lock in the operated condition under control of ground through the back contact and armature number 4 of relay **66–UL**.

The operation of the relays **68–1**, **68–2**, **68–4** and **68–8**, either singly or in appropriate combinations, in a manner to be described later in detail, causes ground to be extended through a right-hand front contact and an armature of one of the relays **68–40**, **68–400** or **68–4000**, via cables **68–C–40**, **68–C–400** or **68–C–4000**, respectively, thence, via cable **68–BRI**, to the charging translator circuit shown in Fig. 69. The operation of one of the relays **68–40**, **68–400** or **68–4000** extends negative battery, through resistance and its front contact and left-hand number 1 armature, via either the conductor **68–BN–40**, **68–BN–400** or **68–BN–4000**, respectively, to the 40, 400 or 4000 mile band relays shown in Fig. 69.

An item of indicia stored in the "nite" channel of the magnetic drum indicating that the night or reduced rate is to be employed in computing the monetary charge for a call in progress will, in a manner previously described, cause the operation of the night relay **67–N**. Relay **67–N**, when operated, locks under control of ground through the back contact and armature number 4 of relay **66–UL**. Relay **67–N** in its normal or unoperated condition extends ground through its lower number 1 armature and back contact, via conductor **67–DR**, through the winding of day relay **69–D** to battery. Relay **69–D** therefore, will be in a normally operated condition through the circuit just traced. Relay **67–N**, in operating, opens the circuit of relay **69–D** which releases. Relay **67–N**, when operated, extends ground through its lower number 1 armature and front contact, via conductor **67–NR**, through the winding of night relay **69–N** to battery. Relay **69–N** operates in the circuit just traced.

The elapsed conversation time indicia, representing a value of elapsed conversation time lying between 1 and 100 minutes, stored in the "elapsed time" channels of the magnetic drum, will have been read out in the manner previously described, and cause the operation, either of suitable combinations of relays of the tens and units digits or, of the relay **67–100** in the elapsed conversation time register-translator circuit **67–ECTR**. The operated relays of the elapsed conversation time register-translator circuit lock in their operated condition under control of ground through the number 4 armature and back contact of relay **66–UL**. The operation of a suitable combination of two of the tens digit relays **67–TR–0**, **67–TR–1**, **67–TR–2**, **67–TR–4** and **67–TR–7**, representative of a minutes tens digit value lying between 0 and 9, causes ground to be extended via one of ten conductors to complete an operating circuit through the winding of one of the ten relays **67–MT–0** through **67–MT–9** to battery. The operated one of the relays **67–MT–0** through **67–MT–9** locks up in its operated condition under control of ground through the number 4 armature and back contact of relay **66–UL**. The operation of a suitable combination of two of the units digit relays **67–UR–0**, **67–UR–1**, **67–UR–2**, **67–UR4** and **67–UR–7**, representative of a minutes units digit value lying between 0 and 9, causes ground to be extended, via cable **67–MU**, the correspondingly numbered one of a plurality of conductors extending horizontally and connected in multiple to the front contacts of the lower armatures of the relays **67–MT–0** through **67–MT–9** of the time tree circuit **67–TT**.

The simultaneous extension of a ground from the tens and units digits of the elapsed conversation time register-translator circuits **67–ECTR**, respectively causing the operation of one of the ten relays **67–MT–0** through **67–MT–9** of the time tree circuit **67–TT** and the extension of ground through a front contact and lower armature of the relay so operated, causes ground to be applied to one conductor of the plurality of conductors numbered 01 through 99 extending from the lower armatures of relays **67–MT–0** through **67–MT–9**. The relay **67–100** operates only when the elapsed conversation time is 100 minutes and, therefore, beyond the range of values expressible by the tens and units digit relays of the elapsed conversation time register-translator circuit **67–ECTR**. The relay **67–100**, when operated, extends ground through its lower armature and front contact to the conductor 100. The conductors 01 through 100 are extended via cable **67–ECT** to the correspondingly numbered multiple conductors in the charging translator circuit shown in Fig. 69.

In the charging translator circuit shown in Fig. 69, each of the conductors in cable **67–ECT** numbered 01 through 100, indicative of the elapsed conversation time in minutes, is respectively multipled to the three relays employed in computing the monetary charges for calls wherein the distance between the calling and the called central offices is, respectively, in the 40, 400 or 4000 mile bands.

In order that the operation of the charging translator circuit shown in Fig. 69 may be more clearly understood, we will assume, for a first example, that a call is being processed wherein the distance between the calling and the called central offices lies between 1 and 40 miles, as illustrated in Fig. 89, condition 2, and is, therefore, within the 40 mile band. Relay **68–40** operates under control of the indicia read out from the 40 mile channel on the magnetic drum, as previously described. Relay **68–40**, in operating, extends battery, through a resistance and its left number 1 contacts, via conductor **68–BN–40**, to the charging translator circuit where conductor **68–BN–40** is connected in multiple to the lower end of the windings of all of the relays **69–40–01** through **69–40–100**. It is to be understood that, in practice, there actually will be 100 such relays for the system herein disclosed.

For the data as set forth in Fig. 89, condition 2, the distance between the calling and the called central offices will have been determined to be 40 miles; causing the basic rate index number 6 representative thereof to be stored in the magnetic drum and read out into the basic rate index register-translator circuit as previously described. The relays **68–4** and **68–2** will operate and lock up in the manner previously described to record and express on a binary code basis the basic rate index number 6. Ground is extended through the lower number 1 armature and back contact of relay **68–1**, through the lower number 2 armature and front contact of relay **68–2**, through the lower number 4 armature and front contact of relay **68–4**, through the lower number 7 armature and back contact of relay **68–8** to conductor **68–BR–6** which is connected in multiple to the front contacts of the right-hand number 6 armatures of relays **68–40**, **68–400** and **68–4000**. Ground is further extended through the right-hand number 6 armature of relay **68–40**, via conductor **68–40–6** in cable **68–C–40**, thence via cable **68–BRI**, to the conductor **68–40–6** in Fig. 69 which is connected in multiple to the front contacts of the number 6 armatures of all of the relays **69–40–01** through **69–40–100** in the charging translator circuit shown in Fig. 69. The extension of ground to any one of the six conductors respectively connected in multiple to the six front contacts of relays **69–40–01** through **69–40–100** is determinative that the rate at which the call is to be charged will be one of the 600 rates based upon the rate table shown in the 1 to 40 mile section of Fig. 96. The extension of ground to the above-mentioned conductor **68–40–6** connected in multiple to the number 6 front contacts is determinative that the rate to be employed will be one of the 100 rates based upon the basic rate index number 6 shown in the 1 to 40 mile section of the rate table shown in Fig. 96.

We will further assume, for example, that the elapsed conversation time will have been determined to be five minutes, that is to say, an initial period of three minutes plus two additional minutes of overtime, causing the indicia representative thereof to be stored in the magnetic drum and read out into the elapsed conversation time register-translator circuit **67–ECTR**. The relays **67–TR–4** and **67–TR–7** operate and lock up, in the manner previously described, to register on a two out of five code basis and express an output, on a decimal basis, of a zero in the tens digit. The relays **67–UR–1** and **67–UR–4** operate and lock up, in the manner previously described, to register on a two out of five code basis and express an output, on a decimal basis, of a five in the units digit.

Ground is extended through the lower number **4** armature and front contact of relay **67–TR–4**, through the lower number **4** armature and front contact of relay **67–TR–7**, via conductor **67–MT–0**, through the winding of relay **67–MT–0** to battery. Relay **67–MT–0** operates in the circuit just traced. Ground is extended through the lower number 2 armature and front contact of relay **67–UR–1**, through the lower number 2 armature and front contact of relay **67–UR–4**, via conductor **67–MU–5** in cable **67–MU**, to the multiple connected front contacts of the number five armatures of the relays **67–MT–0** through **67–MT–9**. Ground is further extended through the lower number **5** armature of the operated relay **67–MT–0**, via conductor number 05 in cable **67–ECT**, to the upper end of the windings of relays **69–40–05**, **69–400–05** and **69–4000–05** connected in multiple. The extension of ground via any one of the 100 conductors in cable **67–ECT** will be respectively determinative of some value of elapsed time but alone will convey no indication as to which relay is to be employed. The extension of ground via conductor number 05 in cable **67–ECT** will be determinative that the total elapsed conversation time is five minutes. Ground extended via conductor number 05 meets battery potential supplied via conductor **68–BN–40** through the winding of relay **69–40–05**, causing it to operate.

Ground extended via conductor **68–40–6** in cable **68–C–40** is further extended through the number 6 armature of relay **69–40–05** to rate terminal **69–40–30** associated therewith. Terminal **69–40–30** is one of 600 charging plan terminals associated with the 40 mile band and is indicative of a call wherein the distance between the calling and the called central office lies between 31 and 40 miles and is selectable only under the conjoint control of a basic rate index number 6, a band indication of 40, and an elapsed conversation time indication of 05 minutes. Ground from rate terminal **69–40–30** is further extended, via charging plan conductor **69–P–1**, to the charge and tax diode cross-connecting plan circuit shown in Fig. 70.

The charge and tax diode cross-connecting plan circuit in Fig. 70 is a means for converting incoming charging indicia, expressed by ground extended via one of a plurality of incoming charging indicia conductors at a time, into the monetary charge for a call and the tax assessable thereon. It cimprises a four-digit "charge" multiple **70–CHG** and a "tax" multiple **70–TX**; each multiple being cross-connectable, through a plurality of diodes, to the incoming charging indicia conductors in a pattern suitably arranged to implement the rates set forth in the table in Fig. 96. Since, as above described, the ground extended to terminal **69–40–30** is indicative of a call distance lying between 31 and 40 miles and the total elapsed conversation time is five minutes, we will find in the 1 to 40 mile section of the table in Fig. 96 that for a call whose distance is 31 to 40 miles that the basic rate for that distance is thirty-five cents for the initial three minutes. The remaining two minutes will be chargeable at ten cents for each additional minute. The total charge for the call will therefore, be fifty-five cents without tax. Assuming a tax rate of twenty-five percent, the tax will be fourteen cents. Ground extended from terminal **69–40–30**, via conductor **69–P–1**, is extended through multiple-connected diodes **70–T–01**, **70–U–01**, **70–T–51** and **70–U–51** to the dollars tens conductor 0, the dollars units conductor 0, the cents tens conductor 5 and the cents units conductor 5, respectively, in the charge multiple **70–CHG**, thus expressing a call charge of fifty-five cents. The conductor **69–P–1** also extends ground through the multiple-connected diodes **70–T–04**, **70–U–04**, **70–T–11** and **70–U–41** to the dollars tens conductor 0, the dollars units conductor 0, the cents-tens conductor 1 and the cents-units conductor 4, respectively, in the tax multiple **70–TX**, thus expressing a tax of fourteen cents.

In order to further facilitate the understanding of the charging translator circuit, we will assume, for a second example, that a call is being processed wherein the distance between the calling and the called central offices lies between 41 and 400 miles, as illustrated in Fig. 89 condition 3, and is, therefore, within the 400 mile band. Relay **68–400** will be operated under control of the indicia read out from the 400 mile channel on the magnetic drum, as previously described. Relay **68–400**, in operating, extends battery, through resistance, through the front contact on its number 1 left-hand armature, via conductor **68–BN–400**, to the charging translator circuit where conductor **68–BN–400** is connected in multiple to the lower end of the windings of all of the relays **69–400–01** through **69–400–100**.

For the data as set forth in Fig. 89, condition 3, the distance between the calling and the called central offices will have been determined to be 323 miles, causing the basic rate index number 14 representative thereof to be stored in the magnetic drum and read out into the basic rate index register-translator circuit as previously described. The relays **68–8**, **68–4** and **68–2** operate and lock up in the manner previously described to record and express on a binary code basis the basic rate index number 14. Ground is extended through the lower number 1 armature and back contact of relay **68–1**, through the lower number 2 armature and front contact of relay **68–2**, through the lower number 4 armature and front contact of relay **68–4**, through the lower number 7 armature and front contact of relay **68–8** to conductor **68–BR–14** which is connected in multiple to the front contacts of the right-hand number 14 armatures of relays **68–400** and **68–4000**. Ground is further extended through the right-hand number 14 armature of relay **68–400**, via conductor **68–400–14** in cable **68–C–400** thence via cable **68–BRI** to the conductor **68–40–14** in Fig. 69 which is connected in multiple to the front contacts on the number 14 armatures of relays **69–D** and **69–N**. Relay **69–D** is normally operated from ground through the lower armature and back contact of relay **67–N**, via conductor **67–DR**, through the winding of **69–D** to battery. Ground from conductor **68–400–14** in cable **68–C–400** is extended through the front contact and number 14 armature of relay **69–D** to the conductor **69–400–14** which is connected in multiple to the front contacts of the "day" number 14 armatures of all of the relays **69–400–01** through **69–400–100** in the charging translator circuit. The extension of ground to any one of the fifteen conductors respectively connected in multiple to the fifteen "day" front contacts of relays **69–400–01** through **69–400–100** is determinative that the rate at which the call is to be charged will be one of the 1500 rates based upon the rate table shown in the "day" column of the 41 to 400 mile section of Fig. 96. The extension of ground to the above-mentioned conductor **69–400–14** connected in multiple to the "day" number 14 front contacts is determinative that the rate to be employed will be one of the 100 rates based upon the basic rate index number 14 shown in the "day" column of the 41 to 400 mile section of the rate table shown in Fig. 96.

We will again assume, for example, that the elapsed conversation time will have been determined to be five minutes, that is to say an initial period of three minutes plus two additional minutes of overtime, causing the tens and units relays of the elapsed conversation time register-translator circuit 67–ECTR and the relay 67–MT–0 of the time tree circuit 67–TT to be operated as previously described. Ground is extended through the lower number 5 armature of the operated relay 67–MT–0, via conductor number 05 in cable 67–ECT, to the upper end of the windings of relays 69–40–05, 69–400–05 and 69–4000–05 connected in multiple. Ground extended via conductor number 05 will meet battery potential supplied via conductor 68–BN–400 through the winding of relay 69–400–05, causing it to operate. Ground extended to the conductor 69–400–14 is further extended through the "day" number 14 armature of relay 69–400–05 to rate terminal 69–400–74–D associated therewith. Terminal 69–400–74–D is one of 1500 charging plan terminals associated with the 400 mile band for "day" calls and is indicative of a call wherein the distance between the calling and the called central offices lies between 317 and 354 miles and is selectable only under the conjoint control of a basic rate index number 14, a band indication of 400, an elapsed conversation time indication of 05 minutes and an indication that the call is to be chargeable at day rates. Ground from rate terminal 69–400–74–D is further extended, via charging plan conductor 69–P–2, to the charge and tax diode cross-connecting plan circuit in Fig. 70.

Since, as above described, the ground extended to terminal 69–400–14–D is indicative of a call distance lying between 317 and 354 miles, that the total elapsed conversation time is five minutes, and that the call is to be charged at "day" rates, we will find in the "day" column of the 41 to 400 mile section of the table in Fig. 96 that for a call whose distance is 317 to 354 miles that the basic rate for that distance is one dollar five cents for the initial three minutes. The remaining two minutes will be chargeable at twenty-five cents for each additional minute. The total charge for the call will, therefore, be one dollar fifty-five cents without tax. The tax, at twenty-five per cent, will be thrity-nine cents. Ground extended from terminal 69–400–74–D, via conductor 69–P–2, is extended through multiple connected diodes 70–T–02, 70–U–12, 70–T–52 and 70–U–52 to the dollars tens conductor 0, the dollars units conductor 1, the cents-tens conductor 5 and the cents-units conductor 5, respectively, in the charge multiple 70–CHG, thus expressing a call charge of one dollar fifty-five cents. The conductor 69–P–2 will, also, extend ground through the multiple connected diodes 70–T–05, 70–U–05, 70–T–32 and 70–U–92 to the dollars tens conductor 0, the dollars units conductor 0, the cents-tens conductor 3 and the cents-units conductor 9, respectively, in the tax multiple 70–TX, thus expressing a tax of thirty-nine cents.

In order to still further facilitate the understanding of the charging translator, particularly where the call is to be chargeable at the "night " or reduced rate, we will assume, for a third example, that a call is being processed wherein the distance between the calling and the called central offices lies between 400 and 4000 miles, as illustrated in Fig. 89, condition 5, and is, therefore, within the 4000 mile band. Relay 68–4000 will be operated under control of the indicia read out from the 4000 mile channel on the magnetic drum, as previously described. Relay 68–4000, in operating, extends battery, through resistance, through the front contact on its number 1 left-hand armature, via conductor 68–BN–4000, to the charging translator circuit where conductor 68–BN–4000 is connected in multiple to the lower end of the windings of all of the relays 69–4000–01 through 69–4000–100.

For the data as set forth in Fig. 89, condition 5, the distance between the calling and the called central offices will have been determined to be 491 miles, causing the basic rate index number 2 representative thereof to be stored in the magnetic drum and read out into the basic rate index register-translator circuit, as previously described. The relay 68–2 operates and locks up in the manner previously described to record and express on a binary code basis the basic rate index number 2. Ground is extended through the lower number 1 armature and back contact of relay 68–1, through the lower number 2 armature and front contact of relay 68–2, through the lower number 4 armature and back contact of relay 68–4, through the lower number 8 armature and back contact of relay 68–8 to conductor 68–BR–2 which is connected in multiple to the front contacts of the right-hand number 2 armatures of relays 68–40, 68–400 and 68–4000. Ground is further extended through the right-hand number 2 armature of relay 68–4000, via conductor 68–4000–2 in cable 68–C–4000, thence via cable 68–BRI, to the conductor 68–4000–2 in Fig. 69 which is connected in multiple to the front contacts on the number 2 armatures of relays 69–D and 69–N. Since the call is assumed to have originated between the hours of 6 p.m. and 6 a.m., the relay 67–N will be operated under control of indicia stored in the "NITE" channel of the magnetic drum and read out in the manner previously described. Ground is extended through the lower armature and front contact of relay 67–N, via conductor 67–NR, through the winding of relay 69–N to battery, causing it to operate. The circuit for relay 69–D will have been opened, causing it to release. Ground from conductor 68–4000–2 in cable 68–C–4000 is extended through the front contact and number 2 armature of relay 69–N to the conductor 69–4000–2 which is connected in multiple to the front contacts of the "night" number 2 armatures of all of the relays 69–4000–01 through 69–4000–100 in the charging translator circuit. The extension of ground to any one of the fifteen conductors respectively connected in multiple to the fifteen "night" front contacts of relays 69–4000–01 through 69–4000–100 is determinative that the rate at which the call is to be charged will be one of 1500 rates based upon the rate table shown in the night column of the 401 to 4000 mile section of Fig. 96. The extension of ground to the above-mentioned conductor 69–4000–2 connected in multiple to the "night" number 2 contacts is determinative that the rate to be employed will be one of 100 rates based upon the basic rate index number 2 shown in the "night" column of the 401 to 4000 mile section of the rate table shown in Fig. 96.

We will, in this instance, assume, for example, that the elapsed conversation time will have been determined to be 100 minutes, that is to say an initial period of three minutes plus 97 additional minutes of overtime, causing the relay 67–100 to be operated under control of indicia stored in the magnetic drum and read out in the manner previously described. Ground is extended through the lower armature and front contact of relay 67–100, via conductor number 100 in cable 67–ECT, to the upper end of windings of relays 69–40–100, 69–400–100 and 69–4000–100 connected in multiple. Ground extended via conductor number 100 in cable 67–ECT meets battery potential supplied via conductor 68–BN–4000 through the winding of relay 69–4000–100 causing it to operate. Ground extended to the conductor 69–4000–2 is further extended through the "night" number 2 armature of relay 69–4000–100 to rate terminal 69–4000–1487–N associated therewith. Terminal 69–4000–1487–N is one of 1500 charging plan terminals associated with the 4000 mile band for "night" calls and is indicative of a call wherein the distance between the calling and the called central offices lies between 447 and 492 miles and is selectable only under the conjoint control of a basic rate index number 2, a band indication of 4000, an elapsed conversation time indication of 100 minutes and an indication that the call is to be charged at "NITE" rates. Ground from rate terminal 69–4000–1487–N is further extended, via charging plan conductor 69–P–3, to the charge and tax diode cross-connecting plan circuit in Fig. 70.

Since, as above described, the ground extended to terminal **69–4000–1487**–N is indicative of a call distance lying between 447 and 492 miles, that the total elapsed conversation time is 100 minutes and that the call is to be charged at "night" rates, we will find in the "night" column of the 401 to 4000 mile section of the table in Fig. 96 that for a call whose distance is 447 to 492 miles that the basic rate for that distance is eighty cents for the initial three minutes. The remaining 97 minutes will be chargeable at twenty cents for each additional minute. The total charge for the call will, therefore, be twenty dollars twenty cents without tax. The tax at twenty-five percent, will be five dollars five cents. Ground extended from terminal **69–4000–1487**–N, via conductor **69**–P–**3**, is extended through multiple connected diodes **70**–T–**23**, **70**–U–**03**, **70**–T–**24** and **70**–U–**04** to the dollars-tens conductor 2, the dollars-units conductor 0, the cents-tens conductor 2 and the cents-units conductor 0, respectively, in the charge multiple 70–CHG, thus expressing a call charge of twenty dollars twenty cents. The conductor **69**–P–**3** also extends ground through the multiple connected diodes **70**–T–**06**, **70**–U–**53**, **70**–T–**03** and **70**–U–**53** to the dollars-tens conductor 0, dollars-units conductor 5, the cents-tens conductor 0 and the cents-units conductor 5, respectively, in the tax multiple **70**–TX, thus expressing a tax of five dollars five cents.

It is to be understood that whereas only three of the rate terminals in Fig. 69, designated **69–40–30**, **69–400–74**–D and **69–4000–1487**–N, have been shown connected to the charge and tax diode cross-connecting plan circuit in Fig. 70, the connections shown are respectively chosen merely as typical illustrations of three possible conditions to be enconutered. To fully implement the charging plans set forth in the table in Fig. 96 several thousand of such connections will be required and may readily be accomplished, by one skilled in the art, by reference to the preceding description and the table in Fig. 96.

Sequentially reading out, translating and printing the call identifying and monetary charge data from registers

We have, in the foregoing description, by several exemplary illustrations delineated the operations by which the identity of the calling subscriber, the called subscriber and the called central office will have been registered and the monetary charge for the call ascertained.

We will now describe the operations by which the several items of call identifying and charging data previously registered will be translated into a decimal code, then translated into Baudot code and printed.

It will be assumed, for example, that the calling subscriber's directory number is 1234 and it has been registered in the calling subscriber's directory number register circuit **5**–CGN. The potential conditions indicative of the number 1234 in two out of five code will have been transmitted, via the conductors in cable **5**–CGNC and via cable **10**–CHGD, to the magnetic drum storage circuit shown in Figs. 60 and 61 and recorded in the calling subscriber's directory number channels thereof as previously described.

It will also be assumed, for example, that the called subscriber's office code number is 487 and that it has been registered in the called subscriber's office code register circuit 3–OCR. The potential conditions indicative of the number 487 in two out of five code will have been transmitted, via the conductors in cable 3–OCRC and via cable **10**–CHGD, to the magnetic drum storage circuit shown in Fig. 61, and recorded in the called office channels thereof as previously described.

It will be assumed, for example, that the called subscriber's directory number is 89512, the extreme right-hand digit "2" being significant of the station or party designation, and that it has been registered in the called subscriber's directory number register circuit 4–DN. The potential conditions indicative of the number 89512 will have been transmitted, via the conductors in the cable 4–DNC and via cable **10**–CHGD, to the magnetic drum storage circuit shown in Fig. 62 and recorded in the called subscriber's directory number channels thereof as previously described.

The indicia representative of the calling subscriber's directory number, the called office code and the called subscriber's directory number will have been read out of the magnetic drum and into the register-translator circuits respectively corresponding thereto in the manner previously described.

The calling subscriber's directory number register-translator circuit **66**–CGSRT, the called subscriber's office code register-translator circuit **66**–CDORT and the called subscriber's directory number register-translator circuit **66**–CDSRT will have been operated from the two out of five input code respectively corresponding thereto but the outputs from the registers are on a decimal code basis.

The calling subscriber's directory number register-translator circuit **66**–CGSRT in operating will have extended ground to the conductors **66**–CGN–TH–**1**, **66**CGN–H–**2**, **66**–CGN–T–**3** and **66**–CGN–U–**4** representative of the calling subscriber's directory number 1234 expressed on a decimal code basis.

The called subscriber's office code register-translator circuit **66**–CDORT, in operating, will have extended ground to the conductors **66**–CDO–A–**4**, **66**–CDO–B–**8** and **66**–CDO–C–**7**, representative of the called subscriber's office code number 487 expressed on a decimal code basis.

The called subscriber's directory number register-translator circuit **66**–CDSRT, in operating, will have extended ground to the conductors **66**–CDN–TH–**8**, **66**–CDN–H–**9**, **66**–CDN–T–**5**, **66**–CDN–U–**1** and **66**–CDN–ST–**2**, representative of the called subscriber's directory number 89512 expressed on a decimal code basis.

When no "stations" designation is required for the called subscriber, the called subscriber's directory number will consist of only four digits which will, respectively, be registered in the four digital registers of the subscriber's directory number register translator designated H, T, U and STA, leaving the extreme left-hand or TH digital register unoccupied. With the left-hand or TH digital register unoccupied, a ground, expressive of a "0" in the TH digital register, is automatically extended through the armatures and back contacts in series of the 0, 1, 2, 4 and 7 relays of the TH digital register, via conductor **66**–CDN–TH–**0**, to satisfy the TH digit of the printer register-translator circuit shown on Fig. 73.

It will also be assumed, for example, that the monetary charges for the call are $1.55 plus a tax of $0.39, as described with reference to condition 3 as set forth in the table in Fig. 89. The conductors **70**–CHG–$T–**0**, **70**–CHG–$U–**1**, **70**–CHG–¢T–**5** and **70**–CHG–¢U–**5** will have had ground extended thereto from conductor **69**–P–**2**, and via the diodes as previously described to express, on a decimal basis, the charge of $01.55. The conductors **70**–TX–$T–**0**, **70**–TX–$U–**0**, **70**–TX–¢T–**3** and **70**–TX–¢U–**9** will have had ground extended thereto from conductor **69**–P–**2**, and via the diodes as previously described to express, on a decimal basis, the tax of $00.39.

The charge and tax multiple conductors are connected, via cables **70**–CGC and **70**–TXC, respectively, to the augend and the addend circuits of the charge and tax adder circuit **70**–CTA. The charge and tax adder circuit add the amount of the tax to the call charge and cause ground to be extended to the conductors **70**–S–$H–**0**, **70**–S–$T–**0**, **70**–S–$U–**1**, **70**–S–¢T–**9** and **70**–S–¢U–**4** expressing, on a decimal code basis, the sum of the call charge and the tax thereon which, for the example chosen, is $1.94. The charge and tax adder circuit **70**–CTA may be similar in construction and operation to that disclosed in the patent to E. W. Flint and A. E. Joel, Jr., No. 2,752,804 of October 23, 1951.

Ground, extended through the up-check circuit of the register-translator circuits and via conductor **68–UP–CK** to the winding of relay 63–OE, evidencing the registration of a full complement of call identifying data and the computation of the related call charge, is also extended via a branch of conductor 68–UP–CK, through the winding of the start relay 75–ST to battery, causing it to operate.

Printing thousands digit of calling subscriber's directory number

Relay 75–ST in operating extends ground through its left-hand armature and front contact, through the stepping switch arm 75–S–1, through the number 1 terminal on selector bank 75–B–1, via conductor 75–1, through the winding of calling subscriber thousands connector relay 71–CGSTH to battery, causing it to operate. Ground, originating in the thousands digit of the calling subscriber's directory number register-translator circuit 66–CGSRT, is extended, via conductor 66–CGN–TH–1 in cable 66–CGS and cable 66–CI, through the front contact and number 1 armature of relay 71–CGSTH, through the back contacts and number 1 armatures in series of relays 71–CDOA, 71–CDSTH, 73–C$H, 73–T$H, through the winding of printer register-translator relay 73–RA–1 to battery, causing it to operate. Ground is extended through the number 5 armature and front contact of relay 73–RA–1, via distributor start conductor 73–DS, through the winding of relay 75–DS to battery, causing it to operate and remove ground from the back contact of its transfer armature, thus opening the "marking" circuit which is normally closed through the stop segment of the commutator 75–CM, through the brush 75–BR, through the continuous ring 75–CR of the commutator, via conductor 75–P, through the winding of the printer selector magnet 75–PS to battery, causing magnet 75–PS to deenergize and release the mechanism associated therewith (not shown) from its normally operated or "marking" condition and to assume its released or "spacing" condition. Relay 75–DS, in operating, extends ground through the front contact of its transfer armature, through the winding of the clutch magnet 75–CL to battery, causing it to operate. Clutch magnet withdraws the detent 75–DT from the stop cam 75–SC. The motor 75–M; through the action of friction clutch 75–FC, worm gear 75–W and pinion gear 75–PN; drives the shaft 75–S carrying the brush arm 75–BA in a clockwise direction. Relay 73–RA–1 in operating also extends ground, via Baudot code multiple conductors 73–BC–1, 73–BC–2, 73–BC–3 and 73–BC–5, representative of the number 1 expressed in Baudot code, to the number 1, 2, 3 and 5 segments, respectively, of commutator 75–CM. The brush 75–BR in traversing the commutator 75–CM, in sequence transmits ground or no ground (or marking and spacing) pulses, via printer conductor 75–P, through the winding of the printer selector magnet 75–PS to battery. The tape printer 75–PR, in a manner well known in the printing telegraphic art, in response to the received pulses, causes the permutative selection and operation of the printing mechanism to print the numeral "1" on that portion of the output tape designated "calling subscriber's directory number."

The transmitter-distributor circuit, shown on Fig. 75, may be similar to that disclosed in the patent to R. K. McAlpine et al., No. 2,444,202 of June 29, 1948, and also the patent to W. B. Bacon et al., No. 2,495,682 of January 31, 1950.

The printer, shown on Fig. 75, may be similar to that disclosed in the patent to S. Morton et al., No. 1,745,633 of February 4, 1930.

The start relay 75–ST, in operating, also completes a circuit whereby ground is extended through contacts 75–SA controlled by step advance cam 75–SAC, via conductor 75–S, through the right-hand armature and front contact of relay 75–ST, via conductor 75–SM, through the winding of stepping magnet 75–SMG to battery, causing it to operate and remain energized until the brush arm 75–BA has almost completed one rotative cycle, when the contacts 75–SA momentarily open its operating circuit under control of the low portion of the cam 75–SAC. Upon the opening of its operating circuit, stepping magnet 75–SMG momentarily releases, thus causing the stepping switch arms of selector switch 75–SSW to rotate one step in a counter-clockwise direction. The selector switch 75–SSW, in stepping, removes ground from the number 1 terminal of bank 75–B–1 thus opening the operating circuit for relay 71–CGSTH, causing it to release and open the operating circuit for relay 73–RA–1 causing it to release. Relay 73–RA–1, in releasing, removes ground from conductor 73–DS, thus opening the operating circuit for relay 75–DS, causing it to release and remove ground from the winding of the clutch magnet 75–CL, causing it to release, thus permitting the detent 75–DT to be re-engaged with the stop cam 75–SC. The brush arm 75–BA thus is halted at the end of a single rotation, with the brush 75–BR again in contact with the stop segment. The relay 73–RA–1, in releasing, also removes ground from the Baudot code multiple conductors 73–BC–1, 73–BC–2, 73–BC–3 and 73–BC–5 connected to the number 1, 2, 3 and 5 segments, respectively, of the commutator 75–CM. Relay 75–DS, in releasing, extends ground, via its transfer armature and back contact, through the stop segment, through the brush 75–BR and the continuous ring of the commutator, via conductor 75–P, through the winding of the printer selector magnet 75–PS to battery, thus re-establishing the normal "marking" circuit.

Printing hundreds digit of calling subscriber's directory number

The start relay 75–ST remains in its operated condition under control of ground supplied, via conductor 68–UP–CK, from the previously described up-check circuit. Ground is extended through the left-hand armature and front contact of relay 75–ST, through the stepping switch arm 75–S–1, through the number 2 terminal on selector bank 75–B–1, via conductor 75–2, through the winding of calling subscriber hundreds connector relay 72–CGSH to battery, causing it to operate. Ground, originating in the hundreds digit of the calling subscriber's directory number register-translator circuit 66–CGSRT, is extended, via conductor 66–CGN–H–2 in cable 66–CGS and cable 66–CI, through the front contact and number 2 armature of relay 72–CGSH, through the back contacts and number 2 armatures in series of relays 72–CDOB, 72–CDSH, 74–C$T, 74–T$T and 74–S$T, through the winding of the printer register-translator relay 74–RB–2, not shown, to battery. The front contacts of the printer register-translator relays 74–RB–0 through 74–RB–9, of which only the first and last are shown, are connected to the Baudot code multiple conductors 73–BC–1 through 73–BC–5 and to the distributor start conductor 73–DS in a pattern identical with that shown for relays 73–RA–0 through 73–RA–9. Relay 74–RB–2, not shown, operates in the above-described circuit. Ground is extended through the number 4 armature and front contact of relay 74–RB–2, via distributor start conductor 73–DS, through the winding of relay 75–DS to battery, causing it to operate and initiate another rotative or printing cycle, as above described. Relay 74–RB–2, in operating, also extends ground, via Baudot code multiple conductors 73–BC–1, 73–BC–2 and 73–BC–5, representative of the number 2 expressed in Baudot code, to the number 1, 2 and 5 segments, respectively, of commutator 75–CM. The distributor and printer circuits function, as above described, to cause the numeral "2" to be printed on that portion of the output tape designated "calling subscriber's directory number."

When the brush arm 75–BA has, again, almost completed its rotative cycle, the contacts 75–SA open momentarily under control of the low portion of cam 75–

SAC, thus opening the operating circuit for the stepping magnet 75–SMG. Upon the opening of its operating circuit, stepping magnet 75–SMG momentarily releases, thus causing the stepping switch arms of selector switch 75–SSW to rotate one step in a counter-clockwise direction. The selector switch 75–SSW, in stepping, removes ground from the number 2 terminal of bank 75–B–1, thus opening the operating circuit for relay 72–CGSH, causing it to release and open the operating circuit for relay 74–RB–2, not shown. Relay 74–RB–2, in releasing, removes ground from conductor 73–DS, thus opening the operating circuit for relay 75–DS, causing it to release and thus, as above described, halt the rotation of the distributor brush arm, and re-establish the normal marking circuit through the printer selector magnet. Relay 74–RB–2, in releasing, also has removed ground from the Baudot code multiple conductors 73–BC–1, 73–BC–2 and 73–BC–5.

Printing tens digit of calling subscriber's directory number

The start relay 75–ST remains in its operated condition under control of ground supplied via conductor 68–UP–CK as above described. Ground is extended through the left-hand armature and front contact of relay 75–ST, through the stepping switch arm 75–S–1, through the number 3 terminal on selector bank 75–B–1, via conductor 75–3, through the winding of calling subscriber tens connector relay 72–CGST to battery, causing it to operate. Ground, originating in the tens digit of the calling subscriber's directory number register-translator circuit 66–CGSRT, is extended, via conductor 66–CGN–T–3 in cable 66–CGS and cable 66–CI, through the front contact and number 3 armature of relay 72–CGST, through the back contacts and number 3 armatures in series of relays 72–CDOC, 72–CDST, 74–C$U, 74–T$U and 74–S$U, through the winding of the printer register-translator relay 74–RC–3, not shown, to battery. The front contacts of the printer register-translator relays 74–RC–0 through 74–RC–9, of which only the first and last are shown, are connected to the Baudot code multiple conductors 73–BC–1 through 73–BC–5 and to the distributor start conductor 73–DS in a pattern identical with that shown for relays 73–RA–0 through 73–RA–9. Relay 74–RC–3 operates in the above-described circuit. Ground is extended through the number 2 armature and front contact of relay 74–RC–3, via distributor start conductor 73–DS, through the winding of relay 75–DS to battery. Relay 75–DS operates in the circuit just traced and, in operating, initiates another rotative or printing cycle as above described. Relay 74–RC–3, in operating, also extends ground, via Baudot code multiple conductor 73–BC–1, representative of the number 3 expressed in Baudot code, to the number 1 segment of commutator 75–CM. The distributor and printer circuits function, as above described, causing the numeral "3" to be printed on that portion of the output tape designated "calling subscriber's directory number."

When the brush arm 75–BA has, again, almost completed its rotative cycle, the contacts 75–SA open momentarily under control of the low portion of cam 75–SAC, thus opening the operating circuit for the stepping magnet 75–SMG. Upon the opening of its operating circuit, stepping magnet 75–SMG momentarily releases, thus causing the stepping switch arms of selector switch 75–SSW to rotate one step in a counter-clockwise direction. The selector switch 75–SSW, in stepping, removes ground from the number 3 terminal of bank 75–B–1, thus opening the operating circuit for relay 72–CGST, causing it to release and open the operating circuit for relay 74–RC–3. Relay 74–RC–3, in releasing, removes ground from conductor 73–DS, thus opening the operating circuit for relay 75–DS, causing it to release and thus, as above described, halt the rotation of the distributor brush arm and re-establish the normal marking circuit through the printer selector magnet 75–PS. Relay 74–RC–3, in releasing, also has removed ground from the Baudot code multiple conductor 73–BC–1.

Printing units digit of calling subscriber's directory number

The start relay 75–ST remains in its operated condition under control of ground supplied via conductor 68–UP–CK as above described. Ground is extended through the left-hand armature and front contact of relay 75–ST, through the stepping switch arm 75–S–1, through the number 4 terminal on selector bank 75–B–1, via conductor 75–4, through the winding of calling subscriber units connector relay 72–CGSU to battery, causing it to operate. Ground, originating in the units digit of the calling subscriber's directory number register-translator circuit 66–CGSRT, is extended, via conductor 66–CGN–U–4 in cable 66–CGS and cable 66–CI, through the front contact and number 4 armature of relay 72–CGSU, through the back contacts and number 4 armatures in series of relays 72–CDC–1, 72–CDSU, 74–C¢T, 74—T¢T and 74–S¢T, through the winding of the printer register-translator relay 74–RD–4, not shown, to battery. The front contacts of the printer register-translator relays 74–RD–0 through 74–RD–9, of which only the first and last are shown, are connected to the Baudot code multiple conductors 73–BC–1 through 73–BC–5 and to the distributor start conductor 73–DS in a pattern identical with that shown for relays 73–RA–0 through 73–RA–9. Relay 74–RD–4 operates in the above-described circuit. Ground is extended through the number 3 armature and front contact of relay 74–RD–4, via distributor start conductor 73–DS, through the winding of relay 75–DS to battery, causing it to operate and initiate another rotative or printing cycle as above described. Relay 74–RD–4, in operating, also extends ground, via Baudot code multiple conductors 73–BC–2 and 73–BC–4, representative of the number 4 expressed in Baudot code, to the number 2 and 4 segments, respectively, of commutator 75–CM. The distributor and printer circuits will function, as above described, to cause the numeral "4" to be printed on that portion of the output tape designated "calling subscriber's directory number."

When the brush arm 75–BA has, again, almost completed its rotative cycle, the contacts 75–SA will open momentarily under control of the low portion of cam 75–SAC, thus opening the operating circuit for the stepping magnet 75–SMG. Upon the opening of its operating circuit, stepping magnet 75–SMG momentarily releases, thus causing the stepping switch arms of selector switch 75–SSW to rotate one step in a counter-clockwise direction. The selector switch 75–SSW, in stepping, removes ground from the number 4 terminal of bank 75–B–1, thus opening the operating circuit for relay 72–CGSU, causing it to release and open the operating circuit for relay 74–RD–4, causing it to release and remove ground from conductor 73–DS, thus opening the operating circuit for relay 75–DS. Relay 75–DS releases and thus, as above described, halts the rotation of the distributor brush arm and re-establishes the normal marking circuit through the printer selector magnet 75–PS. Relay 74–RD–4, in releasing, also removes ground from the Baudot code multiple conductors 73–BC–2 and 73–BC–4.

The number 1234 has been read out from the calling subscriber's directory number register-translator circuit 66–CGSRT and has been sequentially printed, one character at a time, on the output tape from the tape printer. To avoid confusion, it is necessary that a space be left between each of the several groups of characters as the printing operation progresses.

Spacing between successive groups of characters

The start relay 75–ST remains in its operated condition under control of ground supplied via conductor

68–UP–CK, as above described. Ground is extended through the left-hand armature and front contact relay 75–ST, through the stepping switch arm 75–S–1 through the number 5 terminal and strapping on selector bank 75–B–1, via conductor 75–5, through the winding of spacing relay 74–SP–1 to battery, causing it to operate and extend ground through its number 2 armature and front contact, via distributor start conductor 73–DS, through the winding of relay 75–DS to battery, causing it to operate and in operating, initiate another rotative or spacing cycle as above described. Relay 74–SP–1, in operating, also extends ground, via Baudot code multiple conductor 73–BC–3, representative of a "space" expressed in Baudot code, to the number 3 segment of commutator 75–CM. The distributor and printer circuits function, as above described, to cause a space to be inserted following the group of characters previously printed on the tape.

When the brush arm 75–BA has, again, almost completed its rotative cycle, the contacts 75–SA open momentarily under control of the low portion of cam 75–SAC, thus opening the operating circuit for the stepping magnet 75–SMG. Upon the opening of its operating circuit, stepping magnet 75–SMG momentarily releases, thus causing the stepping switch arms of selector switch 75–SSW to rotate one step in a counter-clockwise direction. The selector switch 75–SSW, in stepping, removes ground from the number 5 terminal of bank 75–B–1, thus opening the operating circuit for relay 74–SP–1, causing it to release and remove ground from conductor 73–DS, thus opening the operating circuit for relay 75–DS, causing it to release and thus, as above described, halt the rotation of the distributor brush arm and re-establish the normal marking circuit through the printer selector magnet. Relay 74–SP–1, in releasing, also removes ground from the Baudot code multiple conductor 73–BC–3.

A single space will now have been inserted in the printer tape immediately after the number 1234.

Printing hundreds, tens and units digits of called office code number followed by space

In the manner above described, the stepping switch arms of selector switch 75–SSW are stepped, one terminal at a time. As the stepping switch arm 75–S–1 successively applies ground to terminals 6, 7 and 8 of selector bank 75–B–1, ground is successively extended, via conductors 75–6, 75–7 and 75–8, respectively, through the windings of called office connector relays 71–CDOA, 72–CDOB and the parallel-connected windings of relays 72–CDOC and 72–CDC–1, respectively, to battery. Ground, originating in the hundreds, tens and units digits of the called subscriber's office code register-translator circuit 66–CDORT, is extended; via conductors 66–CDO–A–4, 66–CDO–B–8 and 66–CDO–C–7, respectively, in cable 66–CDO and cable 66–CI; to the number 4, 8 and 7 front contacts, respectively, of called office connector relays 71–CDOA, 72–CDOB and 72–CDOC, respectively.

The successive operation of relays 71–CDOA, 72–CDOB and 72–CDOC causes ground to be extended, in the manner previously described, to respectively cause the successive operation of the printer register-translator relays 73–RA–4, 74–RB–8 and 74–RC–7. Relays 74–RB–8 and 74–RC–7 are not shown but have been previously described.

The successive operation of relays 73–RA–4, 74–RB–8 and 74–RC–7, in the manner previously described, successively controls the distributor and printer circuits to cause, respectively, the numerals "4," "8" and "7" to be successively printed on that portion of the output tape designated "called office code."

Immediately following the printing of the numeral "7" as the right-hand digit of the "called office code number," the stepping switch arm 75–S–1 is rotated one step, as previously described. Ground, as previously described, is extended, through the stepping switch arm 75–S–1, through the number 9 terminal and strapping on selector bank 75–B–1, via conductor 75–5, through the winding of spacing relay 74–SP–1 to battery. Relay 74–SP–1 operates in the circuit just traced and controls the distributor and printer circuits, in the manner above described, to cause a space to be inserted following the group of characters previously printed on the tape.

Printing thousands, hundreds, tens, units and stations digits of called subscriber's directory number, followed by space

After the "space" has been inserted, following the printing of the called office code number, the stepping switch arms of selector switch 75–SSW are, again, stepped, one terminal at a time, in the manner above described. As the stepping switch arm 75–S–1 successively applies ground to terminals 10, 11, 12, 13 and 14 of selector bank 75–B–1, ground is successively extended, via conductors 75–10, 75–11, 75–12, 75–13 and 75–14, respectively, through the windings of called subscriber's connector relays 71–CDSTH, 72–CDSH, 72–CDST, 72–CDSU and 72–CDSST, respectively, to battery. Ground, originating in the thousands, hundreds, tens, units and stations digits of the called subscriber's directory number register-translator circuit 66–CDSRT, is extended; via conductors 66–CDN–TH–8, 66–CDN–H–9, 66–CDN–T–5, 66–CDN–U–1 and 66–CDN–ST–2, respectively, in cable 66–CDN and cable 66–CI; to the number 8, 9, 5, 1 and 2 front contacts, respectively, of called subscriber connector relays 71–CDSTH, 72–CDSH, 72–CDST, 72–CDSU and 72–CDSST, respectively.

The successive operation of relays 71–CDSTH, 72–CDSH, 72–CDST, 72–CDSU and 72–CDSST causes ground to be extended, in the manner previously described, to, respectively, cause the successive operation of the printer register-translator relays 73–RA–8, 74–RB–9, 74–RC–5, 74–RD–1 and 74–RE–2. Relays 74–RC–5, 74–RD–1 and 74–RE2 are not shown but have been previously described.

The successive operation of relays 73–RA–8, 74–RB–9, 74–RC–5, 74–RD–1 and 74–RE–2, in the manner previously described, successively control the distributor and printer circuits to cause, respectively, the numerals "8," "9," "5," "1" and "2" to be successively printed on that portion of the output tape designated "called subscriber's directory number."

Immediately following the printing of the numeral "2" as the right-hand digit of the "called subscriber's directory number," the stepping switch arm 75–S–1 is rotated one step, as previously described. Ground, as previously described, is extended, through the stepping switch arm 75–S–1, through the number 15 terminal and strapping on selector switch bank 75–B–1, via conductor 75–5, through the winding of spacing relay 74–SP–1 to battery. Relay 74–SP–1 operates in the circuit just traced and controls the distributor and printer circuits, in the manner above described, to cause a space to be inserted following the group of characters previously printed on the tape.

Printing dollars hundreds, dollars tens, dollars units, cents tens and cents units digits of monetary charge, followed by space

After the "space" has been inserted, following the printing of the calling subscriber's directory number, the stepping switch arms of selector switch 75–SSW are, again, stepped, one terminal at a time, in the manner above described. As the stepping switch arm 75–S–1 successively applies ground to terminals 16, 17, 18 and 19 of selector bank 75–B–1, ground is successively extended, via conductors 75–16, 75–17, 75–18 and 75–19, respectively, through the parallel-connected windings of charge connector relays 73–C$H and 74–C$T, and through the windings of relays 74–C$U, 74–C¢T and 74–C¢U, respectively, to battery. Ground, originating in the basic rate register-translator circuit shown in Fig. 68, is extended, through a previously described circuit and, in this example; via conductor 69–P–2, through the multiple connected diodes 70–T–02, 70–U–12, 70–T–52 and 70–U–52, via the "charge" conductors 70–CHG–$T–0, 70–CHG–$U–1, 70–CHG–¢T–5 and 70–CHG–¢U–5, respectively, via cable 70–CGC; to the number 0, 1, 5 and 5 front contacts, respectively, of charge connector relays 74–C$T, 74–C$U, 74–C¢T and 74–C¢U, respectively.

The successive operation of relays 74–C$T, 74–C$U, 74–C¢T and 74–C¢U causes ground to be extended, in the manner previously described, to, respectively, cause the successive operation of the printer register-translator relays 74–RB–0, 74–RC–1, 74–RD–5 and 74–RE–5. Relays 74–RC–1, 74–RD–5 and 74–RE–5 are not shown but have been previously described.

The successive operation of relays 74–RB–0, 74–RC–1, 74–RD–5 and 74–RE–5, in the manner previously described, successively control the distributor and printer circuits to cause, respectively, the numerals "0," "1," "5" and "5" to be successively printed on that portion of the output tape designated "charge."

Immediately following the printing of the numeral "5" as the right-hand digit of the monetary "charge," the stepping switch arm 75–S–1 is rotated one step, as previously described. Ground, as previously described, is extended, through the stepping switch arm 75–S–1, through the number 20 terminal and strapping on selector switch bank 75–B–1, via conductor 75–5, through the winding of spacing relay 74–SP–1 to battery. Relay 74–SP–1 operates in the circuit just traced and controls the distributor and printer circuits, in the manner above described, to cause a space to be inserted following the group of characters previously printed on the tape.

Printing of dollars ten, dollars units, cents tens and cents units digits of tax, followed by space

After the "space" has been inserted, following the printing of the monetary "charge", the stepping switch arms of selector switch 75—SSW are, again, stepped, one terminal at a time, in the manner above described. The stepping switch arms 75–S–1 and 75–S–2 are angularly displaced with respect to each other by one hundred and eighty degrees, so that immediately after selector switch arm has cleared terminal number 22 on bank 75–B–1 selector switch arm 75–S–2 will make contact with terminal number 23 on bank 75–B–2. As the stepping switch arm 75–S–1 successively applies ground to terminals 21 and 22 of selector bank 75–B–1, and as the stepping switch arm 75–S–2 subsequently and successively applies ground to terminals 23 and 24 of selector bank 75–B–2, ground will successively be extended, via conductors 75–21, 75–22, 75–23 and 75–24, respectively, through the parallel-connected windings of tax connector relays 73–T$H and 74–T$T, and through the windings of relays 74–T$U, 74–T¢T and 74–T¢U, respectively, to battery. Ground, originating in the basic rate register-translator circuit shown in Fig. 68, is extended, through a previously described circuit, and in this example; via conductor 69–P–2, through the multiple-connected diodes 70–T–05, 70–U–05. 70–T–32 and 70–U–92, via the "tax" conductors 70–TX–$T–0, 70–TX–$U–0, 70–TX–¢T–3 and 70–TX–¢U–9, respectively, via cable 70–TXC; to the number 0, 0, 3 and 9 front contacts, respectively, of tax connector relays 74–T$T, 74–T$U, 74–T¢T and 74–T¢U, respectively.

The successive operation of relays 74–T$T, 74–T$U, 74–T¢T and 74–T¢U causes ground to be extended, in the manner previously described, to, respectively, cause the successive operation of the printer register-translator relays 74–RB–0, 74–RC–0, 74–RD–3 and 74–RE–9. Relay 74–RD–3 is not shown but has been previously described.

The successive operation of relays 74–RB–0, 74–RC–0, 74–RD–3 (not shown) and 74–RE–9, in the manner previously described, successively controls the distributor and printer circuits to cause, respectively, the numerals "0," "0," "3" and "9" to be successively printed on that portion of the output tape designated "tax."

Immediately following the printing of the numeral "9" as the right-hand digit of the "tax," the stepping switch arm 75–S–2 is rotated one step, as previously described. Ground, as previously described, is extended, through the stepping switch arm 75–S–2, through the number 25 terminal and strapping on selector switch bank 75–B–2, via conductor 75–5, through the winding of spacing relay 74–SP–1 to battery. Relay 74–SP–1 operates in the circuit just traced and controls the distributor and printer circuits, in the manner above described, to cause a space to be inserted following the group of characters previously printed on the tape.

Printing of dollars hundreds, dollars tens, dollars units, cents tens and cents units digits of sum, followed by triple space

After the "space" has been inserted, following the printing of the "tax," the stepping switch arms of selector switch 75–SSW are, again, stepped, one terminal at a time, in the manner above described. As the stepping switch arm 75–S–2 successively applies ground to terminals 26, 27, 28, 29 and 30 of selector bank 75–B–2, ground is successively extended, via conductors 75–26, 75–27, 75–28, 75–29 and 75–30, respectively, through the windings of sum connector relays 73–S$H, 74–S$T, 74–S$U, 74–S¢T and 74–S¢U, respectively, to battery. Ground, originating in the charge and tax adder circuit 70–CTA, is extended; via the "sum" conductors 70–S–$H–0, 70–S–$T–0, 70–S–$U–1, 70–S–¢T–9 and 70–S–¢U–4, respectively, via cable 70–SC; to the number 0, 0, 1, 9 and 4 front contacts, respectively, of sum connector relays 73–S$H, 74–S$T, 74–S$U, 74–S¢T and 74–S¢U, respectively.

The successive operation of relays 73–S$H, 74–S$T, 74–S$U, 74–S¢T and 74–S¢U causes ground to be extended, in the manner previously described, to respectively, cause the successive operation of the printer register-translator relays 73–RA–0, 74–RB–0, 74–RC–1, 74–RD–9 and 74–RE–4. Relays 74–RC–1 and 74–RE–4 are not shown but have been previously described.

The successive operation of relays 73–RA–0, 74–RB–0, 74–RC–1, 74–RD–9 and 74–RE–4, in the manner previously described, successively controls the distributor and printer circuits to cause, respectively, the numerals "0," "0," "1," "9" and "4" to be successively printed on that portion of the output tape designated "sum."

Obviously, there will be many telephone calls wherein the sum of the monetary call charge and the tax thereon will be less than one dollar. In the example herein described and illustrated, the sum of the monetary charge and the tax is one dollar ninety-four cents, printed as 00194. The call charge data scanning circuit and the transmitter-distributor circuit require that each of the five groups of numerals comprising a toll call charge always shall respectively contain a predetermined number of digits. Hence, when the significant numbers comprising an entry group are expressible in less than five denominational orders, the non-significant denominational orders are filled with zeros. Therefore, the $H, the $T and the $U denominational order register circuits of the charge and tax adder circuit 70–CTA are arranged, when no significant quantity has been registered therein, to always extend ground to their respective zero output conductors to satisfy the corresponding digits of the printer register-translator circuit. The output circuits employed in the $ hundreds, $ tens and $ units denominational order register circuits to extend ground to their respective zero output leads may be similar to the circuit arrangements disclosed in the thousands digit of the called subscriber's directory number register-translator circuit **66**–CDSRT.

Immediately following the printing of the numeral "4" as the right-hand digit of the "sum," the stepping switch arm **75**–S–**2** is rotated one step, as previously described. Ground, as previously described, is extended, through the stepping switch arm **75**–S–**2**, through the number 31 terminal on selector switch bank **75**–B–**2**, via conductor **75**–**5**, through the winding of spacing relay **74**–SP–**1** to battery, causing it to operate, and will control the distributor and printer circuits, in the manner above described, to cause a space to be inserted following the group of characters indicative of the "sum," previously printed on the tape.

After the "space" has been inserted, following the printing of the "sum," the stepping switch arms of selector switch **75**–SSW are, again, stepped, one terminal at a time, in the manner above described. As the stepping switch arm **75**–S–**2** successively applies ground to terminals **32** and **33** of selector bank **75**–B–**2**, ground is successively extended, via conductors **75**–**32** and **75**–**33**, respectively, through the windings of spacing relays **74**–SP–**2** and **74**–SP–**3**, respectively, to battery.

The successive operation of relays **74**–SP–**2** and **74**–SP–**3**, in the manner previously described, successively control the distributor and printer circuits to cause, respectively, a second and a third space to be inserted following the first space inserted after the group of characters indicative of the "sum," printed on the tape.

The plurality of spaces inserted after the "sum" is for the purpose of isolating successive groups of call charge characters from each other. It is obvious that, with a simple circuit change, the insertion of additional spaces may be provided for.

A complete visual record of the calling subscriber's directory number, the called office code, the called subscriber's directory number, the monetary charge for the call, the tax assessable against the call and the sum of the charge and the tax have been printed on the tape, therefore, the registers from which the charging data was obtained may be dismissed.

Release of registers and return of circuits to normal

As the third space is being inserted, following the printing of the "sum," ground on stepping switch arm **75**–S–**4** is extended through the number 33 terminal on selector switch bank **75**–B–**4**, via register release conductor **75**–RR, through the winding of register unlocking relay **66**–UL, causing it to operate momentarily and open its number 1, 2, 3 and 4 back contacts. The opening of the back contacts of relay **66**–UL opens the locking circuits and causes the release of the calling subscriber's directory number register-translator circuit **66**–CGSRT, the called office code register-translator circuit **66**–CDORT, the called subscriber's directory number register-translator circuit **66**–CDSRT, the elapsed time register-translator circuit **67**–ECTR, the time tree circuit **67**–TT and the basic rate index register-translator circuit shown on Fig. 68; which register-translator circuits, in releasing, open the up-check circuit extending therethrough and removes ground from conductor **68**–UP–CK. Upon the removal of ground from conductor **68**–UP–CK, the relays **63**–OE and **75**–ST release. The relay **63**–OE, in releasing, restores battery, via conductor **63**–ORE, to the output relays **60**–OR–**12** through **63**–OR–**90**. The relay **75**–ST, in releasing, opens the operating circuit for stepping magnet **75**–SMG which deenergizes.

Stepping switch arm **75**–S–**4** now steps to terminal number 34. Ground is now extended through stepping switch arm **75**–S–**4**, through terminal number 34 and the strapping on selector bank **75**–B–**4**, via conductor **75**–SR, through the armature and back contact of stepping magnet **75**–SMG to battery, to complete a self-interrupting stepping circuit. The stepping switch **75**–SSW, under control of the self-interrupting circuit, rapidly steps the stepping switch arms until stepper switch arm **75**–S–**4**, clears terminal number 44 on selector bank **75**–B–**4** at which time stepper switch arm **75**–S–**1** is again in contact with terminal number 1 on selector bank **75**–B–**1**.

The various circuits now have been returned to normal and are in readiness to begin the processing of another call.

The attendant at the central office now reads from the tape the call charge data printed thereon and communicates the data by means of the quotation communicating channel equipment **75**–QCE, via quotation communication channel **75**–QCC, to the quotation communicating channel equipment **1**–QCE at the attended P.B.X.

The quotation communicating equipment may comprise a telephone circuit or, where a permanent visual record is required, a printing telegraph circuit, or any other suitable means of communication.

While we have illustrated the invention in its exemplary application to a particular telephone system, it should be understood that it is not limited to such exemplary application nor to the specific arrangements and instrumentalities herein disclosed. It will be apparent to one skilled in the art that various other applications, modifications, and arrangements other than disclosed herein, are within the spirit and scope of the invention as defined by the claims appended hereto.

What is claimed is:

1. In a telephone system, means for automatically pricing a telephone call which comprises in combination means for automatically determining the difference in latitude and the difference in longitude between a calling and a called central office, means responsive to the operation of said latitude and longitude difference determining means for automatically converting said differences into the equivalent great circle miles between said central offices, means under control of said converting means for automatically determining the rate for said miles for a predetermined period of conversation time, and means responsive to the operation of said last-mentioned means for automatically determining the total price and the tax for said conversation time.

2. In a telephone system, means for automatically pricing a telephone call which comprises in combination means for automatically determining the difference in latitude and the difference in longitude between a calling and a called central office, means responsive to the operation of said latitude and longitude difference determining means for automatically converting said differences into the equivalent great circle miles between said central offices, means effective incident to the completion of said call for automatically determining the total elapsed conversation time over said miles, means under control of said converting means for automatically determining the rate for a predetermined period of conversation time over said miles, means responsive to the operation of said last two means for automatically determining the charge and tax for said total elapsed conversation time, and means responsive to the operation of said last-mentioned means for automatically determining the sum of said charge and tax.

3. In a telephone system, means for automatically pricing a telephone call, comprising in combination means for ascertaining the identity of the calling and the called subscriber statious and for producing call identifying indicia therefrom, means for automatically ascertaining the latitude and the longitude of the calling and the called central offices in which said stations respectively terminate, means responsive to the operation of said latitude and longitude ascertaining means for determining the difference in latitude and the difference in longitude between said calling and said called central offices, means for translating said differences into the equivalent great circle mileage therebetween, means for determining a basic

rate index for a predetermined period of conversation time over said mileage, means for determining the total elapsed conversation time between said two stations and for producing an elapsed time index therefor, means for associating and storing said call items of indicia appertaining to said call and for subsequently withdrawing said items from storage, means jointly responsive to the operation of said basic rate index determining means and to the withdrawal of said call items of indicia from storage for determining the charge and tax for said call over said great circle mileage for said elapsed conversation time, means responsive to operation of said last-mentioned means for determining the sum of said charge and said tax, means for producing a visual record of the identity of said calling and called subscriber stations, the said charge, the said tax and sum thereof, and means for communicating the information contained in said visual record to said calling subscriber.

4. In a dial telephone system, in combination, a calling office identified by an office code and located in an area identified by an area code, a calling subscriber's line terminating in said calling office, a called office identified by an office code and located in an area identified by an area code, a called subscriber's line terminating in said called office, means in said calling office responsive to pulses from said calling line indicative of the called office code and of the called office area code for automatically translating said pulses into indicia of the latitude and longitude positionally defining the location of said called office, and means controlled by said translating means in accordance with said indicia for effectuating a determination of charges pertaining to telephone service between said calling and called lines.

5. In a dial telephone system, in combination, a calling office, a calling subscriber's line terminating in said office, means responsive to a calling condition on said line for automatically producing indicia representative of the latitude and longitude positionally defining the location of said calling office, and means controlled by said producing means in accordance with said indicia for effectuating a determination of charges pertaining to telephone service supplied to said calling line in response to said calling condition thereon.

6. In an automatic telephone toll call pricing system, a clock mechanism and a first switching means controlled thereby for successively giving a first indication of the completion of each consecutive 24-hour interval, a second switching means, means responsive to said first indication to identify each said consecutive 24-hour interval with a consecutive day of the week including means for automatically identifying the seventh said consecutive 24-hour interval as the last day of a week and for giving a second indication to said second switching means, means associated with said second switching means to identify each said second indication with a consecutive week in a calendar period, means comprising nonlinear conductors connected to the contacts of said first switching means and said second switching means in a pattern simulative of a calendar for effecting the electrical recognition of Sundays and holidays as they occur, a third indication conjointly given by the positions progressively assumed by said first switching means and said second switching means in cooperation with said nonlinear conductors connected therebetween, thereby to indicate that a reduced rate is to be effective for calls originating on Sundays and holidays.

7. In an automatic telephone toll call-pricing system, in combination, a calling office, a calling line in said office, a called office, a called line in said office, means in said calling office for identifying a call in progress and for furnishing a call identity index represented by a first set of indicia, means for identifying said calling and called subscriber lines and said called office, means for determining the distance in miles between said calling and called offices for said call, means for determining the basic charging rate applicable to said call, over said distance and for furnishing items of data represented by a second set of indicia, means for measuring the elapsed conversation time of said call and for furnishing a number therefor represented by a third set of indicia, a storage means having prerecorded call identifying indicia stored therein, an indicia matching and control means, means for simultaneously transmitting said first and said second sets of indicia to said storage means under control of said indicia matching and control means for storing said second set of indicia in said storage means when said prerecorded call identifying indicia matches said first set of indicia, and means operative at the conclusion of said call for simultaneously transmitting said first and said third sets of indicia to said storage means under control of said indicia matching and control means, and for storing said third set of indicia in said storage means when said prerecorded call identifying indicia matches said first set of indicia.

8. In an automatic telephone toll call-pricing system, a register having registered therein a plurality of items of call charging indicia, said items comprising a basic rate index, a band choice index designating the more northerly latitude defining the location of either the calling office or the called office, elapsed conversation time and reduced rate indicia; and means responsive to the operation of said register in registering all of said indicia for integrating said indicia into a single item of indicia representing the particular predetermined monetary charge for the call in progress.

9. In a telephone call-pricing system, in combination, a plurality of leads, means for selectively applying potential conditions thereon to translate charging indicia into a monetary charge expressed on a multidigit basis, and a plurality of diodes cross-connected to said leads in a plurality of patterns, each of said patterns being arranged to express a different one of a plurality of predetermined monetary charges and the tax assessable thereon.

10. In a system for automatically determining the monetary charge for the use of a facility, a plurality of terminal offices served by said facility, a service route between any two of said plurality of terminal offices, means for automatically ascertaining the great circle distance between said two terminal offices, and means controlled by said distance ascertaining means for automatically obtaining the monetary charge applicable to said use of said facility over said great circle distance.

11. A system for automatically ascertaining charges applicable to customer uses of chargeable facilities extending over a plurality of geographical locations comprising, a facility used to supply to customers one of a plurality of classes of service between any two locations, means for automatically designating one of such classes of service to be supplied, means for ascertaining the great circle distance between said two locations, means controlled by said distance ascertaining means for automatically prescribing a basic charge rate applicable to each such customer use of said facility over said distance, and means jointly controlled by said basic charge rate prescribing means and by said class of service designating means for deriving a charge applicable to each such use of such facility.

12. In a dial telephone system, in combination, a calling office, a calling subscriber's line terminating in said office, a called office identified by an individual office code and located in an area identified by a dialed area code, a first means in said calling office responsive to a calling condition on said calling subscriber's line for automatically producing indicia representative of the latitude and longitude positionally defining the location of said calling office, a second means in said calling office responsive to pulses from said calling subscriber's line indicative of said called office code and said dialed area code for automatically translating said pulses into indicia of the latitude and longitude positionally defining the

location of said called office, means controlled by said first and said second means for determining indicia expressive of the difference in latitude and the difference in longitude between said calling office and said called office, and means controlled by said indicia determining means in accordance with said indicia for automatically effectuating a determination of charges pertaining to telephone service between said calling and called lines.

13. In a system for automatically pricing telephone calls, in combination with means in a calling office for ascertaining the respective latitudes and longitudes of said calling office and a called office, of an arranger device comprising means responsive to the operation of said latitude and longitude ascertaining means for detecting an inequality in the magnitudes of the two latitudes and the magnitudes of the two longitudes, means responsive to the operation of said detecting means when an inequality is detected between the magnitudes of said two latitudes for always storing the larger magnitude in a first predetermined latitude register and the smaller magnitude in a second predetermined latitude register, and means responsive to the operation of said detecting means when an inequality is detected between the magnitudes of said two longitudes for always storing the larger magnitude in a first predetermined longitude register and the smaller magnitude in a second predetermined longitude register.

14. In an automatic telephone call-pricing system, in combination, a calling office and a called office, means in said calling office responsive to a calling condition on a line therein for ascertaining the longitude of said calling office, registering means for registering a called office code identifying the called office, means responsive to the operation of said registering means for ascertaining the longitude of said called office, a longitude arranger controlled by the operation of said ascertaining means for comparing the relative magnitudes of said two longitudes, a subtractor, means in said longitude arranger responsive to and controlled by the operation of said longitude comparing means for transmitting said calling and said called longitude magnitudes to said subtractor respectively as the minuend and subtrahend thereof when said magnitudes are equal or when said calling longitude magnitude exceeds the called longitude magnitude, and respectively as subtrahend and minuend when the called longitude magnitude exceeds the calling longitude magnitude, and means for operating said subtractor to obtain a positive difference between said minuend and said subtrahend, whereby said difference denotes the difference in longitude between the calling and the called office.

15. In an automatic telephone call-pricing system, in combination, a calling office and a called office, means in said calling office responsive to a calling condition on a line therein for ascertaining the latitude of said calling office, registering means for registering a called office code identifying the called office, means responsive to the operation of said registering means for ascertaining the latitude of said called office, a latitude arranger controlled by the operation of said ascertaining means for comparing the relative magnitudes of said two latitudes, a subtractor, means in said latitude arranger responsive to and controlled by the operation of said latitude comparing means for transmitting said calling and said called latitude magnitudes to said subtractor respectively as the minuend and subtrahend thereof when said magnitudes are equal or when said calling latitude magnitude exceeds the called latitude magnitude, and respectively as subtrahend and minuend when the called latitude magnitude exceeds the calling latitude magnitude, and means for operating said subtractor to obtain a positive difference between said minuend and said subtrahend, whereby said difference denotes the difference in latitude between the calling and the called office.

16. In an automatic telephone call-pricing system, in combination, a calling office and a called office, means in said calling office responsive to a calling condition on a line therein for ascertaining the latitude of said calling office, a first group of input leads and means controlled by the operation of said calling office latitude ascertaining means for selectively applying to said first group of input leads an input potential expressing the numerical value of the latitude of said calling office as digits of a multidigit number, registering means for registering a called office code dialed from said line for identifying the called office, means responsive to the operation of said registering means for ascertaining the latitude of said called office, a second group of input leads and means controlled by the operation of said called office latitude ascertaining means for selectively applying to said second group of input leads an input potential expressing the numerical value of the latitude of said called office as digits of a multidigit number, a latitude arranger controlled by the operation of said calling and called office latitude ascertaining means comprising a first and second group of output leads, means in said arranger for comparing the numerical values of corresponding digits in said two multidigit numbers and for detecting when the two values are equal or when the multidigit number expressing the calling office latitude is greater or less than the multidigit number expressing the called office latitude, a subtractor having minuend and subtrahend input registers, said registers being connectable to said output leads, and switching means controlled by the operation of said comparing means when said two multidigit numbers are equal or when the multidigit number expressing said calling office latitude is greater than the multidigit number expressing said called office latitude for respectively extending to said first and second groups of output leads the potentials applied to said first and second groups of input leads, or when the multidigit number expressing said calling office latitude is less than the multidigit number expressing said called office latitude for reversing said connections and for respectively extending to said first and second groups of output leads the potentials applied to said second and first groups of input leads, and means for operating said subtractor in response to said potentials on said output leads for determining a positive difference between said minuend and said subtrahend, whereby said difference denotes the difference in latitude between the calling and the called office.

17. In an automatic telephone call-pricing system, in combination, a calling office and a called office, means in said calling office responsive to a calling condition on a line therein for ascertaining the longitude of said calling office, a first group of input leads and means controlled by the operation of said calling office longitude ascertaining means for selectively applying to said first group of input leads an input potential expressing the numerical value of the longitude of said calling office as digits of a mutidigit number, registering means for registering a called office code dialed from said line for identifying the called office, means responsive to the operation of said registering means for ascertaining the longitude of said called office, a second group of input leads and means controlled by the operation of said called office longitude ascertaining means for selectively applying to said second group of input leads an input potential expressing the numerical value of the longitude of said called office as digits of a multidigit number, a longitude arranger controlled by the operation of said calling and called office longitude ascertaining means comprising a first and second group of output leads, means in said arranger for comparing the numerical values of corresponding digits in said two multidigit numbers and for detecting when the two values are equal or when the multidigit number expressing the calling office longitude is greater or less than the multidigit number expressing the called office longitude, a subtractor having minuend and subtrahend input registers, said registers being connectable to said output leads, and switching means controlled by the operation of said comparing

means when said two multidigit numbers are equal or when the multidigit number expressing said calling office longitude is greater than the multidigit number expressing said called office longitude for respectively extending to said first and second groups of output leads the potentials applied to said first and second groups of input leads, or when the multidigit number expressing said calling office longitude is less than the multidigit number expressing said called office longitude for reversing said connections and for respectively extending to said first and second groups of output leads the potentials applied to said second and first groups of input leads, and means for operating said subtractor in response to said potentials on said output leads for determining a positive difference between said minuend and said subtrahend, whereby said difference denotes the difference in longitude between the calling and the called office.

18. In an automatic telephone call-pricing system, in combination, a calling office and a called office, means in said calling office responsive to a calling condition on a line therein for ascertaining the latitude of said calling office and for expressing said latitude as digits of a multidigit number, registering means for registering a called office code dialed from said line for identifying the called office, means responsive to the operation of said registering means for ascertaining the latitude of said called office and for expressing said latitude as digits of a multidigit number, a multidigit subtractor, a multidigit arranger controlled by the operation of said calling and called office latitude ascertaining means, means in said arranger for comparing the numerical values of corresponding digits in said two multidigit numbers and for detecting the highest digit in which the value of the number expressing said calling office latitude exceeds the value of the number expressing said called office latitude, a cut-off means for each digit included in said arranger except for the last digit, a switching means for each digit controlled by said detecting means, means in said arranger responsive to the detection of a condition in any digit except the last wherein the value of the number expressing said calling office latitude exceeds the value of the number expressing said called office latitude for operating said cut-off means in said digit and remaining digits, thereby to prevent the operation of said switching means in any subsequent digit, whereby in said subsequent digits said comparing means is prevented from exercising any control over the comparison of the values of the numbers expressing said latitudes of said calling and called offices, and whereby said switching means is controlled to always transmit respectively the larger and the smaller of said two multidigit numbers to said subtractor as the minuend and subtrahend inputs thereof, and means for operating said subtractor to obtain a positive difference between said minuend and said subtrahend, whereby said difference denotes the difference in latitude between the calling and called office.

19. In an automatic telephone call-pricing system, in combination, a calling office and a called office, means in said calling office responsive to a calling condition on a line therein for ascertaining the longitude of said calling office and for expressing said longitude as digits of a multidigit number, registering means for registering a called office code dialed from said line for identifying the called office, means responsive to the operation of said registering means for ascertaining the longitude of said called office and for expressing said longitude as digits of a multidigit number, a multidigit subtractor, a multidigit arranger controlled by the operation of said calling and called office longitude ascertaining means, means in said arranger for comparing the numerical values of corresponding digits in said two multidigit numbers and for detecting the highest digit in which the value of the number expressing said calling office longitude exceeds the value of the number expressing said called office longitude, a cut-off means for each digit included in said arranger except for the last digit, a switching means for each digit controlled by said detecting means, means in said arranger responsive to the detection of a condition in any digit except the last wherein the value of the number expressing said calling office longitude exceeds the value of the number expressing said called office longitude for operating said cut-off means in said digit and remaining digits, thereby to prevent the operation of said switching means in any subsequent digit, whereby in said subsequent digits said comparing means is prevented from exercising any control over the comparison of the values of the numbers expressing said longitudes of said calling and called offices, and whereby said switching means is controlled to always transmit respectively the larger and the smaller of said two multidigit numbers to said subtractor as the minuend and subtrahend inputs thereof, and means for operating said subtractor to obtain a positive difference between said minuend and said subtrahend, whereby said difference denotes the difference in longitude between the calling and the called office.

20. In an automatic telephone call-pricing system, in combination, a calling office and a called office, means in said calling office responsive to a calling condition on a line therein for ascertaining the latitude of said calling office and for expressing said latitude as digits of a multidigit number, registering means for registering a called office code dialed from said line for identifying the called office, means responsive to the operation of said registering means for ascertaining the latitude of said called office and for expressing said latitude as digits of a multidigit number, a subtractor, an arranger controlled by the operation of said calling and said called office latitude ascertaining means for comparing the numerical values of corresponding digits in said two multidigit numbers and for detecting the highest digit in which the value of the number expressing said called office latitude exceeds the value of the number expressing said calling office latitude, a switching means for each digit controlled by said detecting means, and means included in said comparing means for operating said switching means when in any digit the value of the number expressing said called office latitude exceeds the value of the number expressing said calling office latitude, whereby said switching means in said digit and in each of the subsequent digits are operated to always respectively transmit to said subtractor the numbers expressing the larger and the smaller of said two multidigit numbers as minuend and subtrahend inputs thereof, and means for operating said subtractor to obtain a positive difference between said minuend and said subtrahend, whereby said difference denotes the difference in latitude between the calling and the called office.

21. In an automatic telephone call-pricing system, in combination, a calling office and a called office, means in said calling office responsive to a calling condition on a line therein for ascertaining the longitude of said calling office and for expressing said longitude as digits of a multidigit number, registering means for registering a called office code dialed from said line for identifying the called office, means responsive to the operation of said registering means for ascertaining the longitude of said called office and for expressing said longitude as digits of a multidigit number, a subtractor, an arranger controlled by the operation of said calling and said called office longitude ascertaining means for comparing the numerical values of corresponding digits in said two multidigit numbers and for detecting the highest digit in which the value of the number expressing said called office longitude exceeds the value of the number expressing said calling office longitude, a switching means for each digit controlled by said detecting means, and means included in said comparing means for operating said switching means when in any digit the value of the number expressing said called office longitude exceeds the value of the number expressing said calling office longitude,

whereby said switching means in said digit and in each of the subsequent digits are operated to always respectively transmit to said subtractor the numbers expressing the larger and the smaller of said two multidigit numbers as minuend and subtrahend inputs thereof, and means for operating said subtractor to obtain a positive difference between said minuend and said subtrahend, whereby said difference denotes the difference in longitude between the calling and the called office.

22. In an automatic telephone call-pricing system, in combination, a calling office and a called office, means in said calling office responsive to a calling condition on a line therein for ascertaining the latitude of said calling office and for expresing said latitude as digits of a multidigit number, a first plurality of groups of input leads and means controlled by the operation of said calling office latitude ascertaining means for selectively applying to each group an input potential expressing the numerical value of a digit of said multidigit number expressing the latitude of said calling office, registering means for registering a called office code dialed from said line for identifying the called office, means responsive to the operation of said registering means for ascertaining the latitude of said called office, a second plurality of groups of input leads and means controlled by the operation of said called office latitude ascertaining means for selectively applying to each group an input potential expressing the numerical value of a digit of said multidigit number expressing the latitude of said called office, a latitude arranger controlled by the operation of said calling and called office latitude ascertaining means comprising means for comparing the numerical values of corresponding digits in said two multidigit input numbers and for ascertaining whether said calling office is north or south of said called office, a source of potential, a north-indicating output lead normally activated by said potential, a south-indicating ouput lead, a mileage table circuit divided into a north half and a south half, means controlled by a potential applied to either said north indicating or said south indicating output leads for selectively controlling said north half and said south half of said mileage table circuit, a switching means respectively associated with each of the digits in said arranger circuit and operably controllable by the operation of said comparing means, means for operating said switching means respectively associated with each of the digits when in corresponding digits the numerical value of said multidigit number expressing said called office latitude exceeds the numerical value of said multidigit number expressing said calling office latitude whereby the said comparing means associated with the highest digit in which said excess occurs operates to cause the operation of said switching means respectively associated with all subsequent digits, and means controlled by the operation of said switching means in the lowest digit to remove said potential normally applied to said north-indicating lead and to apply said potential to said south-indicating lead, thereby to activate said south half of said mileage table circuit and indicate that the latitude of said calling office is south of the latitude of said called office.

23. In an automatic telephone call-pricing system, in combination, a calling office and a called office, means in said calling office responsive to a calling condition on a line therein for ascertaining the latitude of said calling office and for expressing said latitude of said calling office as a multidigit number comprising tens and units digits, a first group of tens input leads and a first group of units input leads, means controlled by the operation of said calling office latitude ascertaining means for selectively applying to said first tens group and to said first units group of input leads an input potential respectively expressing the numerical value of the tens and units digits of the number expressing the latitude of said calling office, registering means for registering a called office code dialed from said line for identifying said called office, means responsive to the operation of said registering means for ascertaining the latitude of said called office, a second group of tens input leads and a second group of units input leads, means controlled by the operation of said called office latitude ascertaining means for selectively applying to said second tens group and to said second units group of input leads an input potential respectively expressing the numerical value of the tens and units digits of a number expressing the latitude of said called office, a latitude arranger controlled by the operation of said calling and called office latitude ascertaining means for comparing the numerical values of corresponding digits and for detecting when the two values are equal or when the multidigit number expressing the calling office latitude is greater or less than the multidigit number expressing the called office latitude, a group of tens output leads and a group of units output leads, a switching means for each digit controlled by the operation of said comparing means for connecting to said group of tens output leads and to said group of units output leads the potentials respectively applied to said first group of tens input leads and to said first group of units input leads when said two multidigit numbers are equal or when the multidigit number expressing said calling office latitude is greater than the multidigit number expressing said called office latitude, whereby the potentials applied to said first groups of tens and units input leads are respectively applied to said groups of tens and units output leads, thereby to indicate that the latitude of said calling office is equal to or greater than the latitude of said called office, and for connecting to said group of tens output leads and to said group of units output leads the potentials respectively applied to said second group of tens input leads and to said second group of units input leads when the multidigit number expressing said calling office latitude is less than the multidigit number expressing said called office latitude, whereby the potentials apply to said second groups of tens and units input leads are respectively applied to said groups of tens and units output leads thereby to indicate that the latitude of said called office exceeds the latitude of said calling office, a band choice circuit comprising a plurality of band choice control leads, a plurality of circuit-closing devices electrically associated with said set of tens output leads, each of said circuit-closing devices being arranged to close a plurality of circuit paths, each one of said circuit-closing devices being correspondingly responsive to the potential extended to a particular one of said tens output leads, a plurality of unilaterally conductive devices electrically associated with said sets of units output leads, each one of said unilaterally conductive devices being correspondingly rendered conductive by the potential applied to a particular one of said units output leads, circuit means jointly controlled by the operation of one of said circuit-closing devices and the conductive condition of one of said unilaterally conductive devices to establish a circuit through one of said plurality of circuit paths, thereby to cause a potential to be applied to a particular one of said plurality of band choice control leads, and a plurality of groups of mileage table circuits, each of said groups being defined as a band choice and operatively related to an office or offices located within a specific band of latitudes, each one of said band choices being selectable in response to the potential applied to a particular one of said band choice control leads, the selected band choice being the one controlled by the larger of the two numbers respectively representing the calling and called office latitudes or by the number representing the latitude of the calling office when said two numbers are equal.

24. In an automatic telephone call-pricing system, in combination, a calling office and a called office, means in said calling office responsive to a calling condition on a line therein for ascertaining a geographical ordinate of said calling office, a first plurality of groups of input

leads and means controlled by the operation of said calling office ordinate ascertaining means for selectively applying to each group an input potential indicating the numerical value of a digit of a multidigit number expressing said calling office ordinate, registering means for registering a called office code dialed from said line for identifying the called office, means responsive to the operation of said registering means for ascertaining a geographical ordinate of said called office, a second plurality of groups of input leads and means controlled by the operation of said called office ordinate ascertaining means for selectively applying to each group an input potential indicating the numerical value of a digit of a multidigit number expressing said called office ordinate, a multidigit arranger controlled by the operation of said calling and called office ordinate ascertaining means for comparing the numerical values of corresponding digits in said two multidigit numbers as indicated by the potentials selectively applied to all of said groups of input leads, a multidigit subtractor including a minuend section and a subtrahend section for each digit of said multidigit numbers, means responsive to the operation of said comparing means for storing from the potentials on all of said groups of input leads the larger of the two multidigit numbers in the minuend section of said subtractor and the smaller of the two multidigit numbers in the subtrahend section of said subtractor, and means in said subtractor responsive to the operation of said subtrahend and minuend sections for subtracting said two numbers, thereby to obtain a positive difference which expresses the numerical difference between the ordinate of the calling and the ordinate of the called office.

25. In an automatic telephone call-pricing system, in combination, a calling office and a called office, means in said calling office responsive to a calling condition on a line therein for ascertaining the latitude and longitude of said calling office, a first plurality of groups of input leads and means controlled by the operation of said calling office latitude and longitude ascertaining means for selectively applying a potential to each group of said input leads indicating the numerical values of digits of two multidigit numbers respectively expressing the latitude and longitude of said calling office, registering means for registering a called office code dialed from said line, means responsive to the operation of said registering means for ascertaining the latitude and longitude of said called office, a second plurality of groups of input leads and means controlled by the operation of said called office latitude and longitude ascertaining means for selectively applying a potential to each group of said second plurality of groups of leads indicating the numerical values of digits of two multidigit numbers respectively expressing the latitude and longitude of said called office, a multidigit arranger controlled by the operation of said calling and called office latitude and longitude ascertaining means for respectively comparing the numerical values of corresponding digits in said two multidigit numbers indicating latitudes and respectively comparing the numerical values of corresponding digits in said two multidigit numbers indicating longitudes, a multidigit subtractor comprising a minuend section and a subtrahend section for each digit of said two numbers indicating latitudes and a minuend section and a subtrahend section for each digit of said two numbers indicating longitudes, means operative in response to the potentials on said groups of input leads for storing in the minuend sections of said subtractor the larger of the two multidigit numbers respectively expressing the latitudes of said calling and called offices and for storing in the subtrahend sections of said subtractor the smaller of the two multidigit numbers respectively expressing the longitudes of said calling and called offices, a plurality of groups of final latitude difference and final longitude difference output leads, one group for each digit of each of said numbers, means operative in said subtractor in response to the potentials on all of said groups of input leads to selectively apply a potential to each group of said plurality of groups of final difference output leads, thereby to express for the two latitudes and the two longitudes as digits of a multidigit number the actual numerical difference between said two latitudes and the actual numerical difference between said two longitudes, a multidigit number rounding circuit comprising a plurality of sections, one section for each digit of each of said multidigit numbers respectively expressive of said numerical difference between said two latitudes and said two longitudes, each said section being respectively responsive to potentials applied to the corresponding group of said plurality of groups of final latitude difference output leads and final longitude difference output leads to express each digit of said two multidigit numbers, means operative in response to said potentials for raising by 1 in each number the digital value of each higher order under the control of the value of the next lower order when said value in the two lowest orders lies between 5 and 9, and when the value of the next to highest order is 9, whereby each digit of each of said two multidigit number except the lowest digit is rounded to its next higher numerical value, and a plurality of rounded number output leads selectively activated to express each of said two multidigit numbers in their rounded form.

26. In an automatic telephone call-pricing system in accordance with claim 25, including a plurality of relay mileage tables, a plurality of mileage indicating conductors, and means jointly responsive to the potentials applied to said rounded number output leads for selectively operating one or more of said mileage relay tables, whereby the operation of each of said relay tables energizes one of said plurality of mileage indicating conductors, each of said energized conductors indicating precomputed numerical data expressive of the distance in miles between said calling office and said called office.

27. In an automatic telephone call-pricing system in accordance with claim 26, including means for insuring that the distance in miles indicated by the operation of more than one of said relay mileage tables is obtained from the one of said operated relay mileage tables that embraces the highest range of distances in which said distance in miles between said calling and said called office is indicated.

28. In an automatic telephone call-pricing system in accordance with claim 26, including a band choice circuit comprising a plurality of band choice leads, and a basic rate translator jointly operative in response to the operation of one of said relay mileage tables and the potential applied to one of said band choice leads, whereby the mileage category indicated by the operated one of said relay mileage tables is translated into a basic rate index applicable to said mileage category.

29. In an automatic telephone call-pricing system, in combination, a calling office, a calling line in said calling office, a called office, a called line in said called office, switching means for establishing a conversation path between said calling and said called lines, a common magnetic data storage device, means in said calling office controlled by said switching means for furnishing a first group of call charging indicia when said conversation path is established and for storing said call charging indicia in said common data storage device, means in said calling office responsive to the termination of conversation for producing a second group of call charging indicia including a checking element, means for storing said second group of call charging indicia into said common data storage means, means for simultaneously reading said first and said second groups of call charging indicia out of said common data storage means, a checking means responsive to the presence of said checking element in said common data storage means, and a regis-

ter operative under the control of said checking means for registering said first and said second groups of call charging indicia as they are simultaneously read out of said common data storage means.

30. In an automatic telephone call-pricing system in accordance with claim 26, each of said relay mileage tables including a group identifying output conductor, the operation of each of said relay tables causing a potential to be applied to said group identifying ouput conductor respectively associated therewith, whereby the operation of one of said relay tables activates one of a plurality of mileage indicating output conductors and applies a potential to said group identifying output conductor of said table, thereby to define in which plurality of mileage

output conductors the activated mileage conductor is located.

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