Aug. 10, 1937. W. W. CARPENTER 2,089,921

DIAL TELEPHONE SYSTEM

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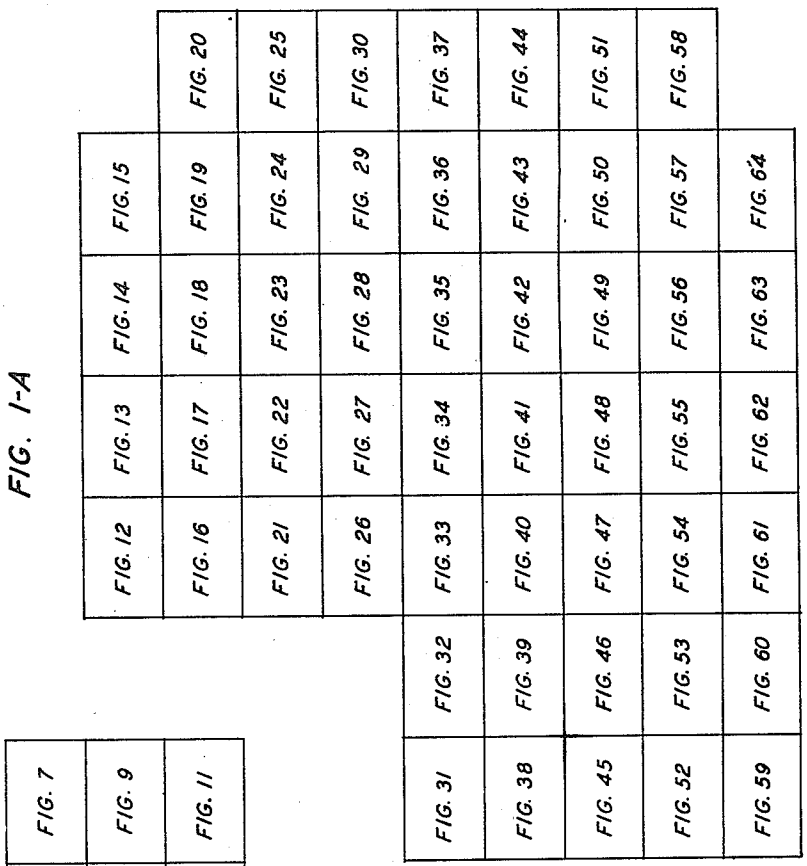

FIG. 1-A

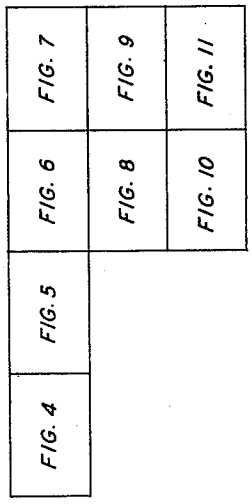

FIG. 1

INVENTOR
W. W. CARPENTER
BY P. C. Smith
ATTORNEY

Aug. 10, 1937. W. W. CARPENTER 2,089,921

DIAL TELEPHONE SYSTEM

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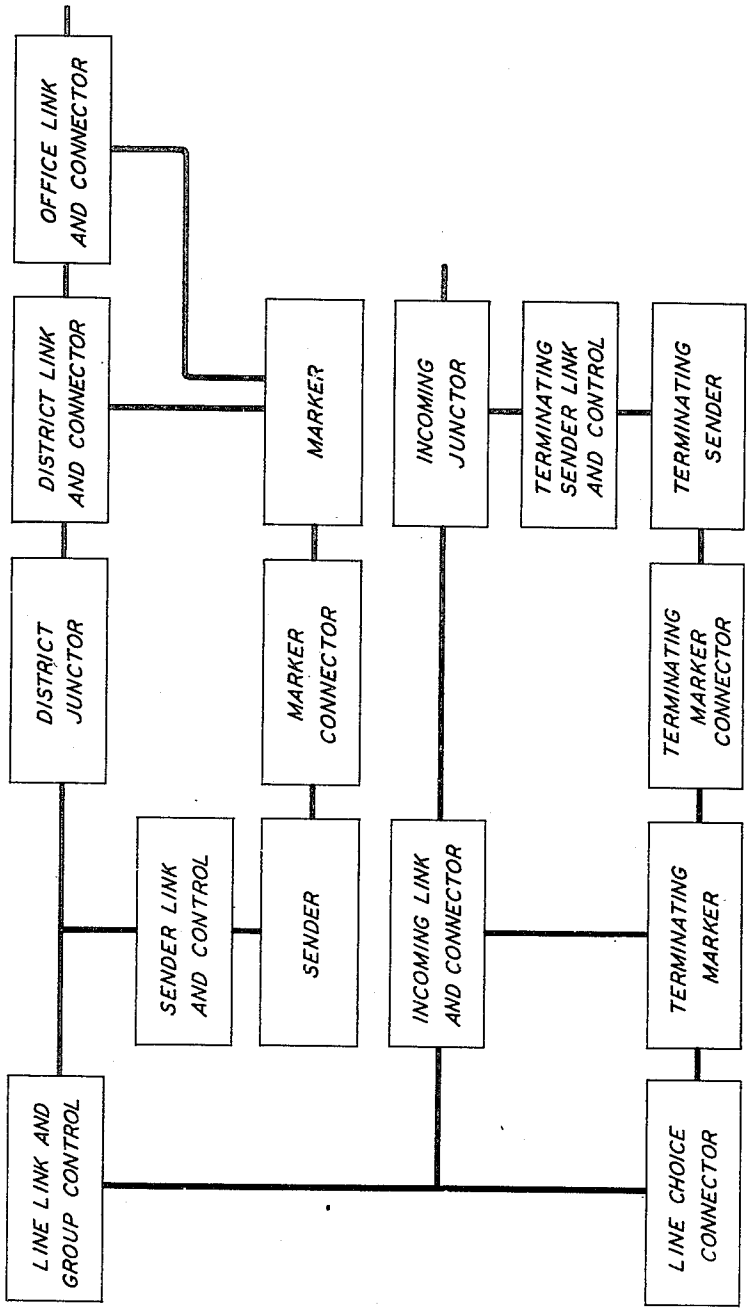

FIG. 2

INVENTOR
W. W. CARPENTER
BY P. C. Smith
ATTORNEY

Aug. 10, 1937. W. W. CARPENTER 2,089,921

DIAL TELEPHONE SYSTEM

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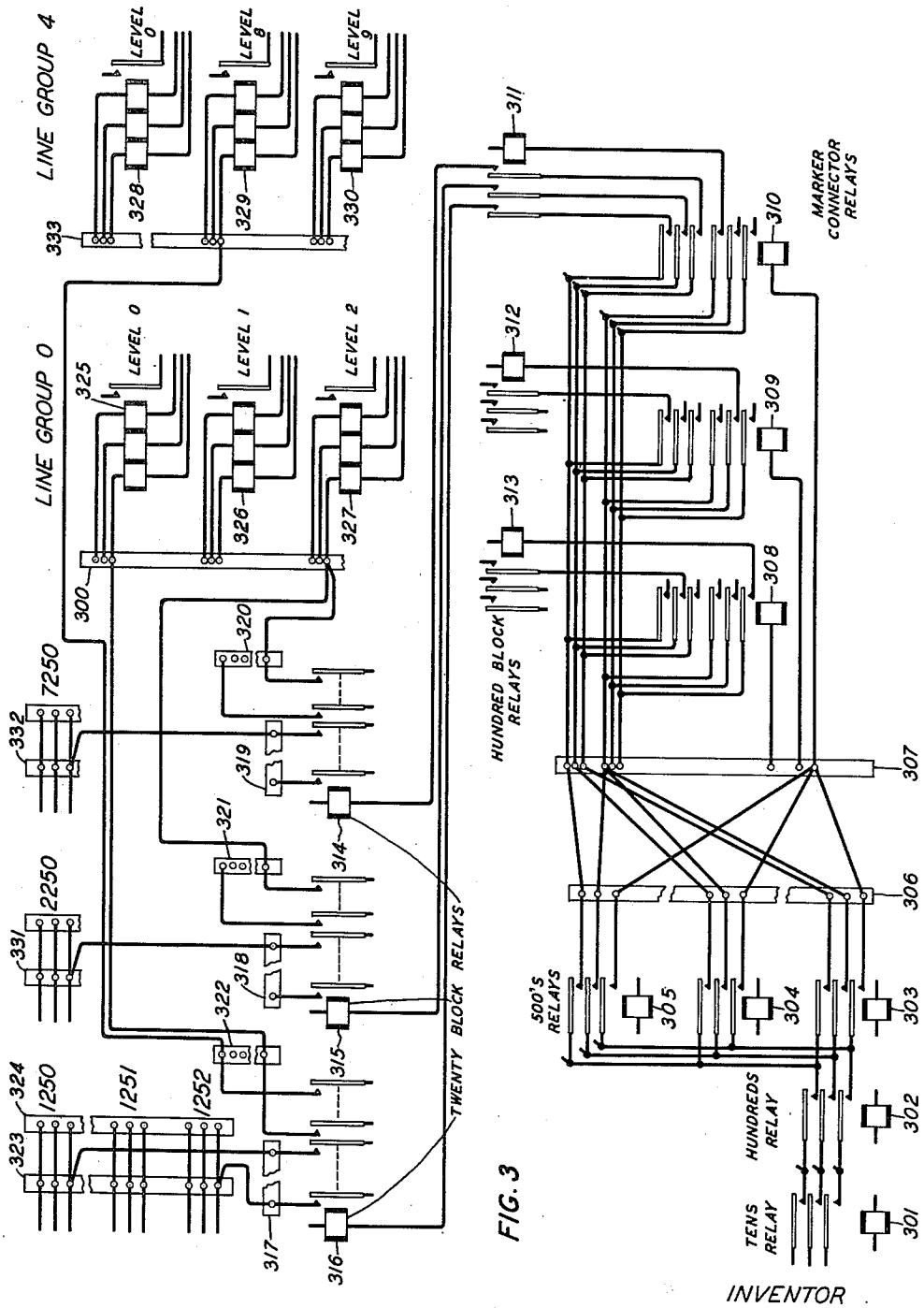

FIG. 3

INVENTOR
W. W. CARPENTER
BY
P. C. Smith
ATTORNEY

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DIAL TELEPHONE SYSTEM

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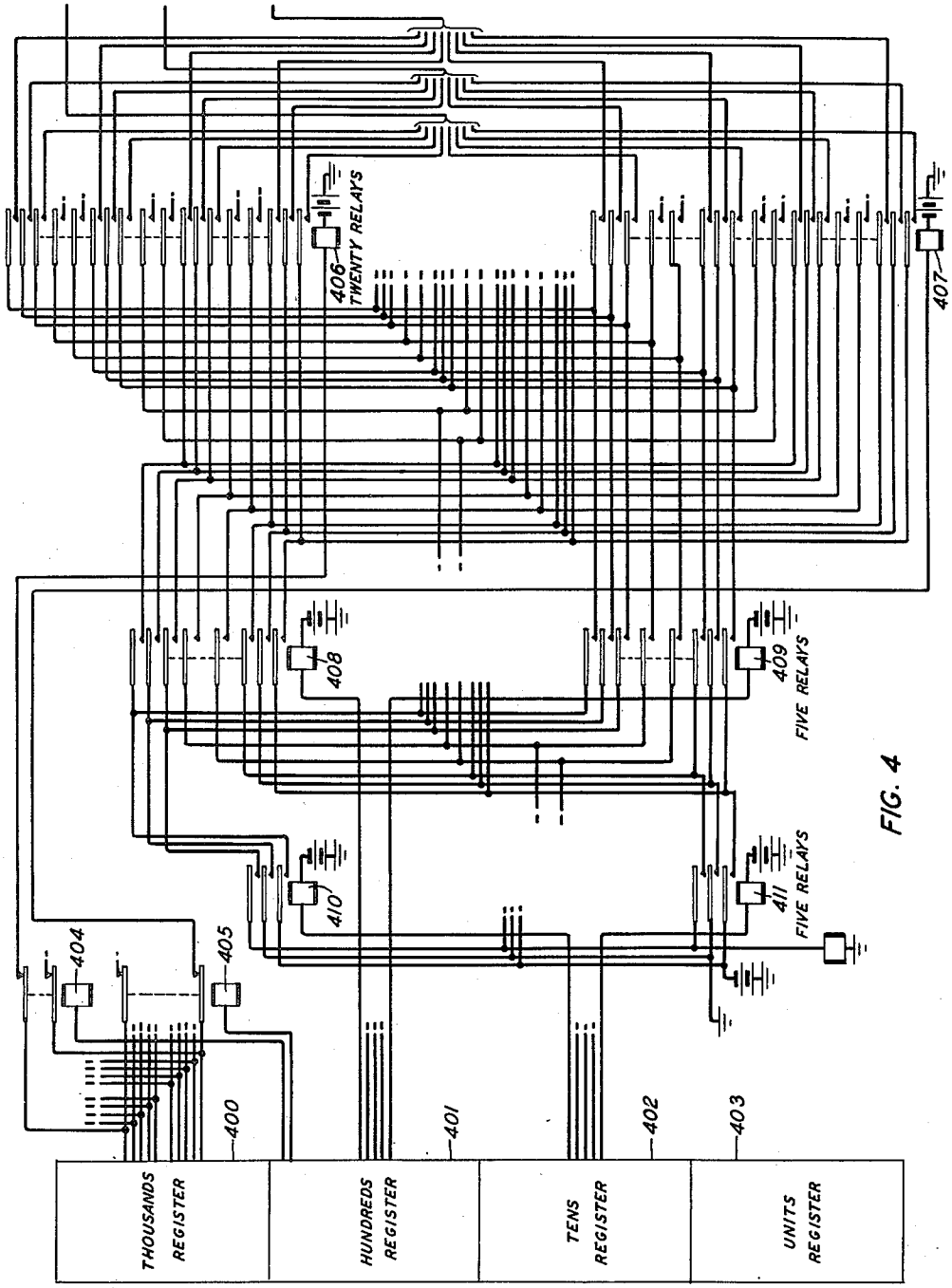

FIG. 4

INVENTOR
W. W. CARPENTER
BY
P. C. Smith
ATTORNEY

Aug. 10, 1937. W. W. CARPENTER 2,089,921

DIAL TELEPHONE SYSTEM

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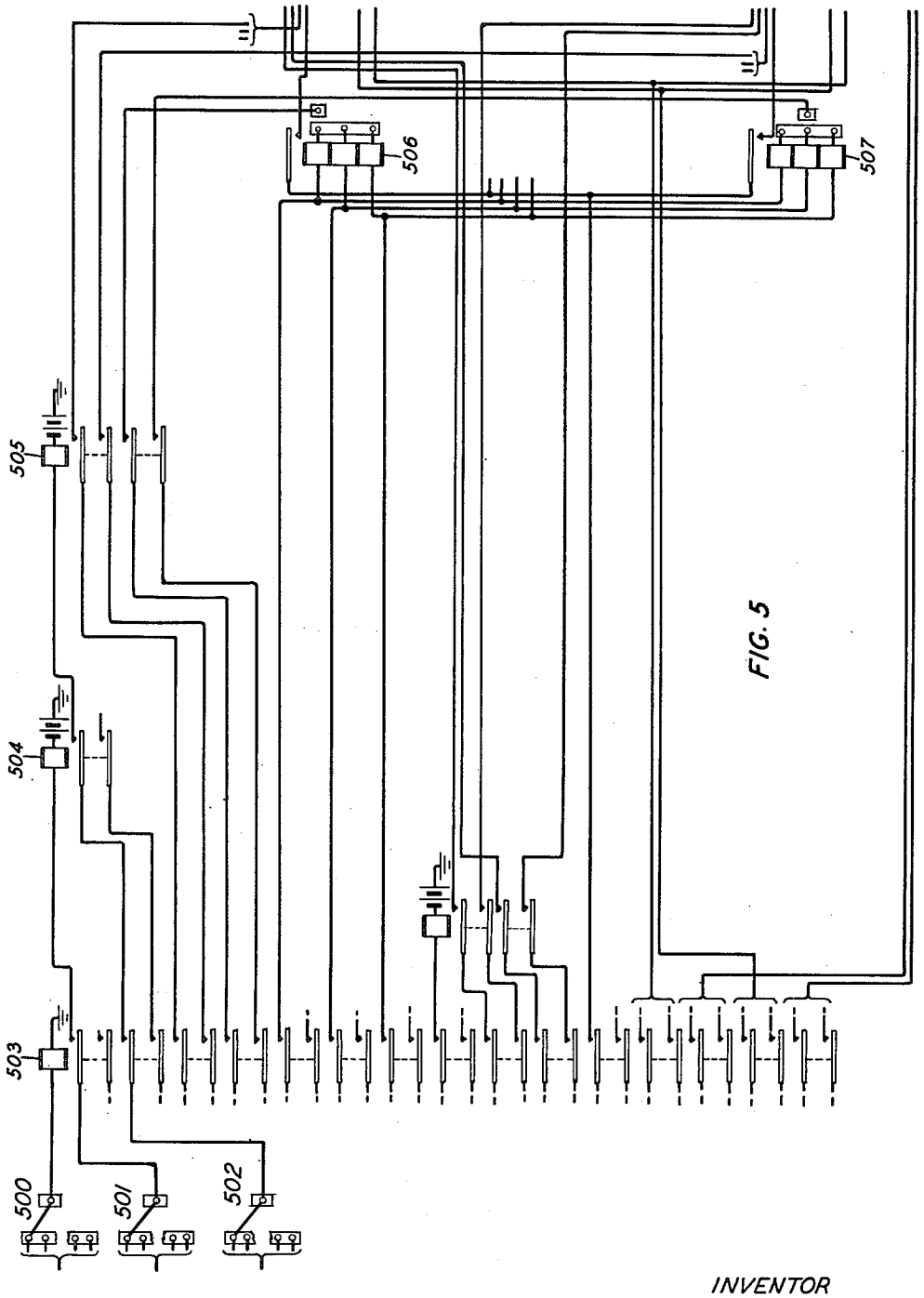

FIG. 5

INVENTOR
W. W. CARPENTER
BY
P. C. Smith
ATTORNEY

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DIAL TELEPHONE SYSTEM

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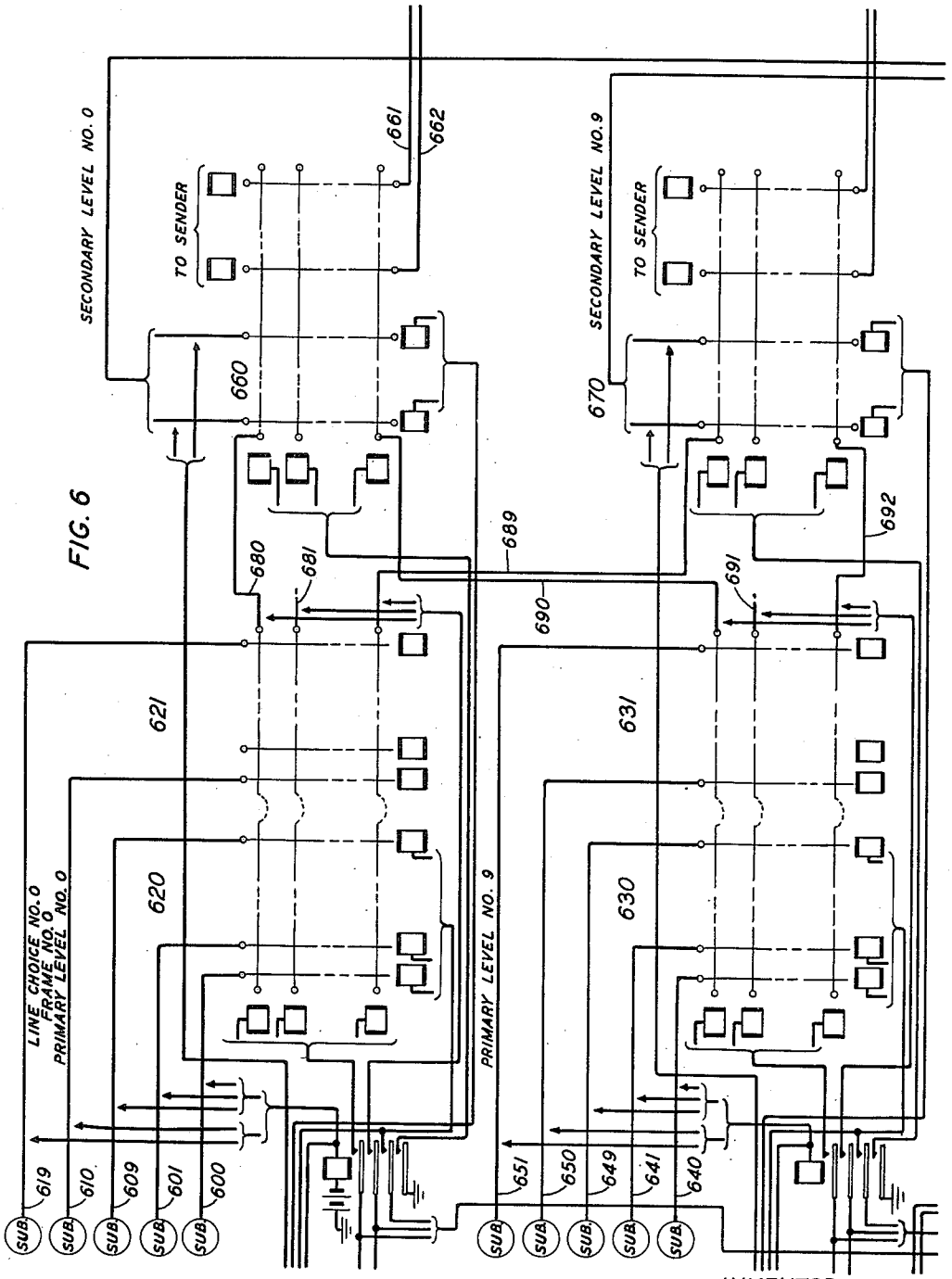

FIG. 6

INVENTOR
W. W. CARPENTER
BY
P. C. Smith
ATTORNEY

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DIAL TELEPHONE SYSTEM

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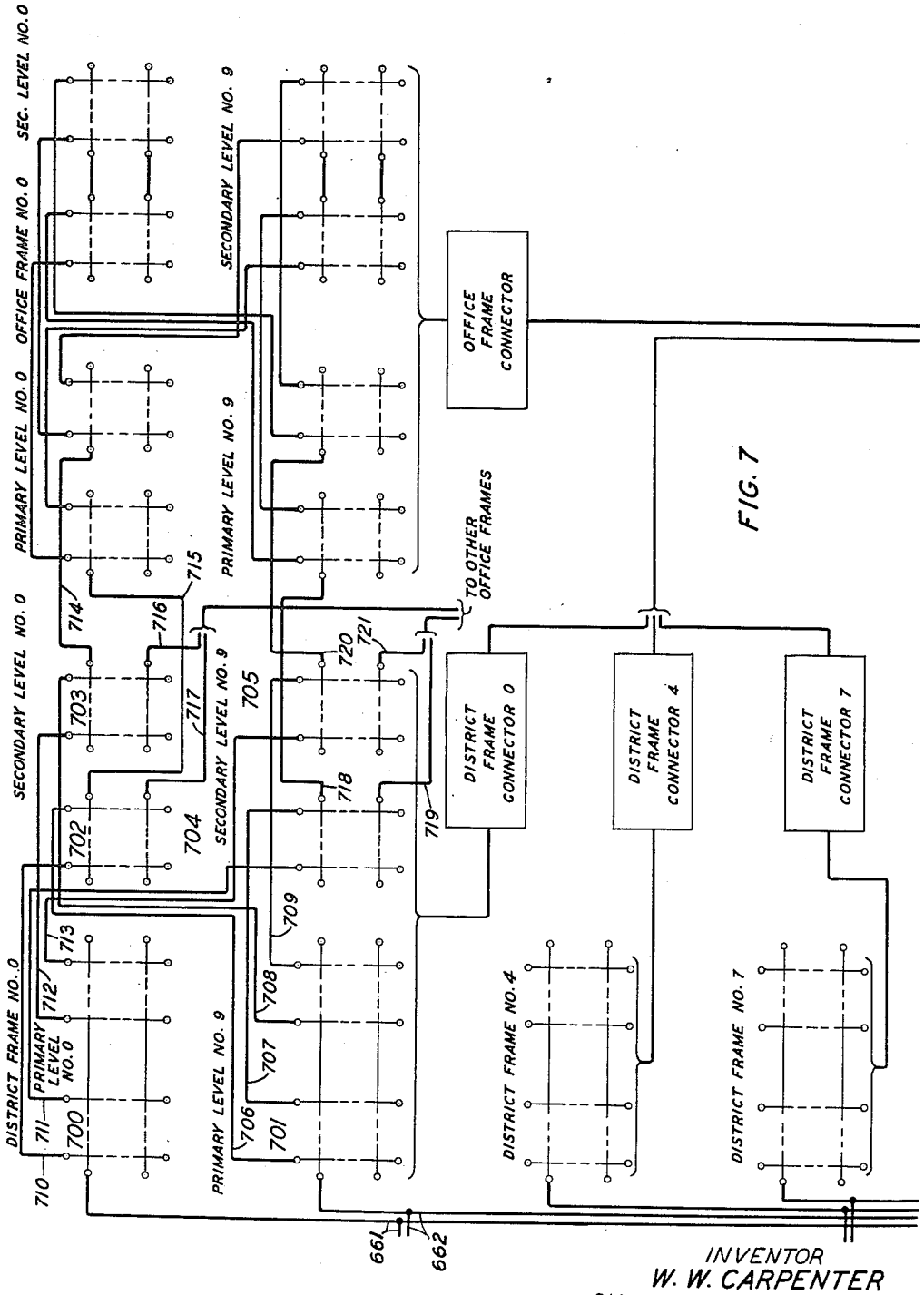

FIG. 7

INVENTOR
W. W. CARPENTER
BY
P. C. Smith
ATTORNEY

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DIAL TELEPHONE SYSTEM

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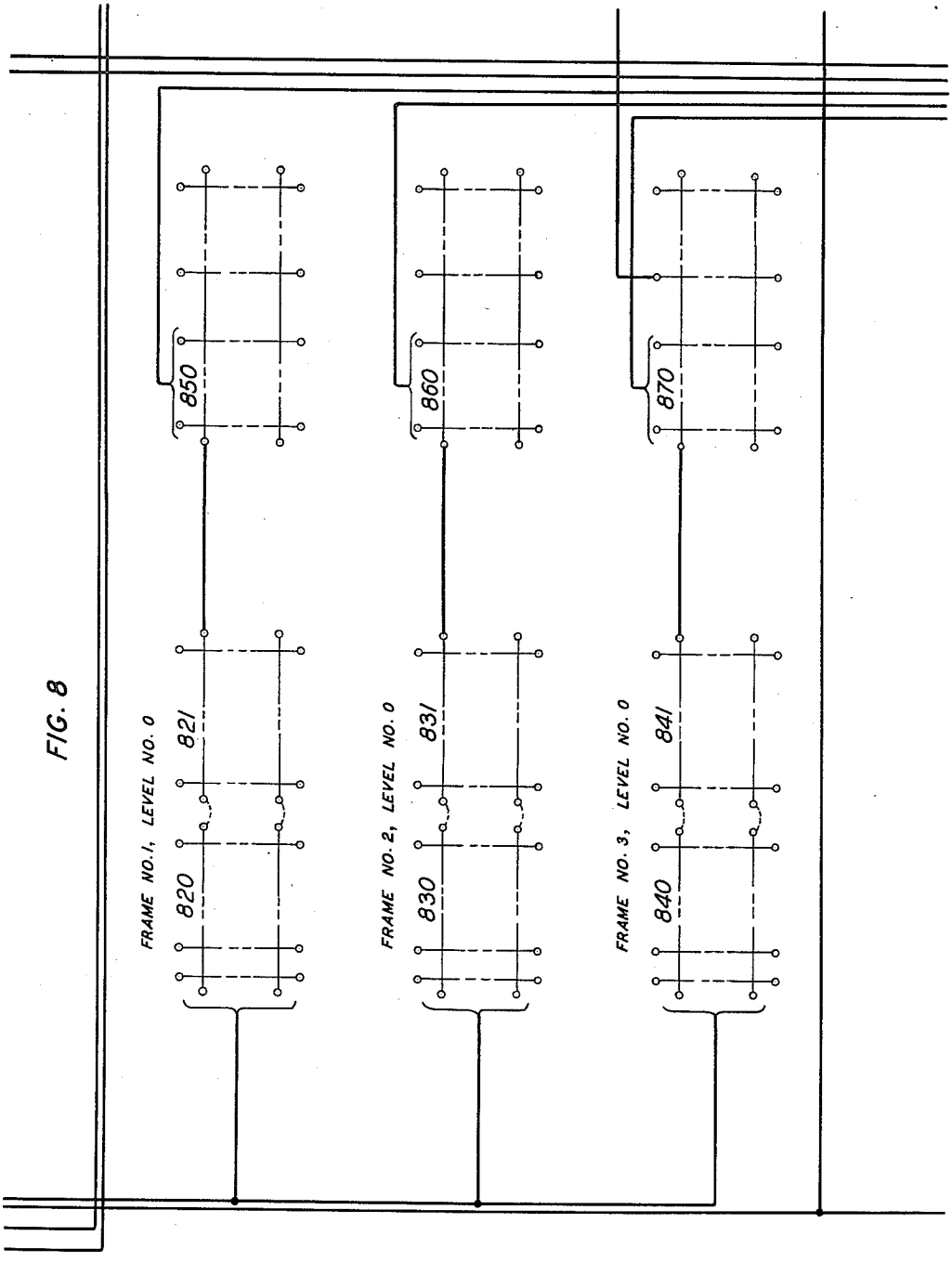

FIG. 8

INVENTOR
W. W. CARPENTER
BY P. C. Smith
ATTORNEY

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DIAL TELEPHONE SYSTEM

Filed March 11, 1936 64 Sheets-Sheet 9

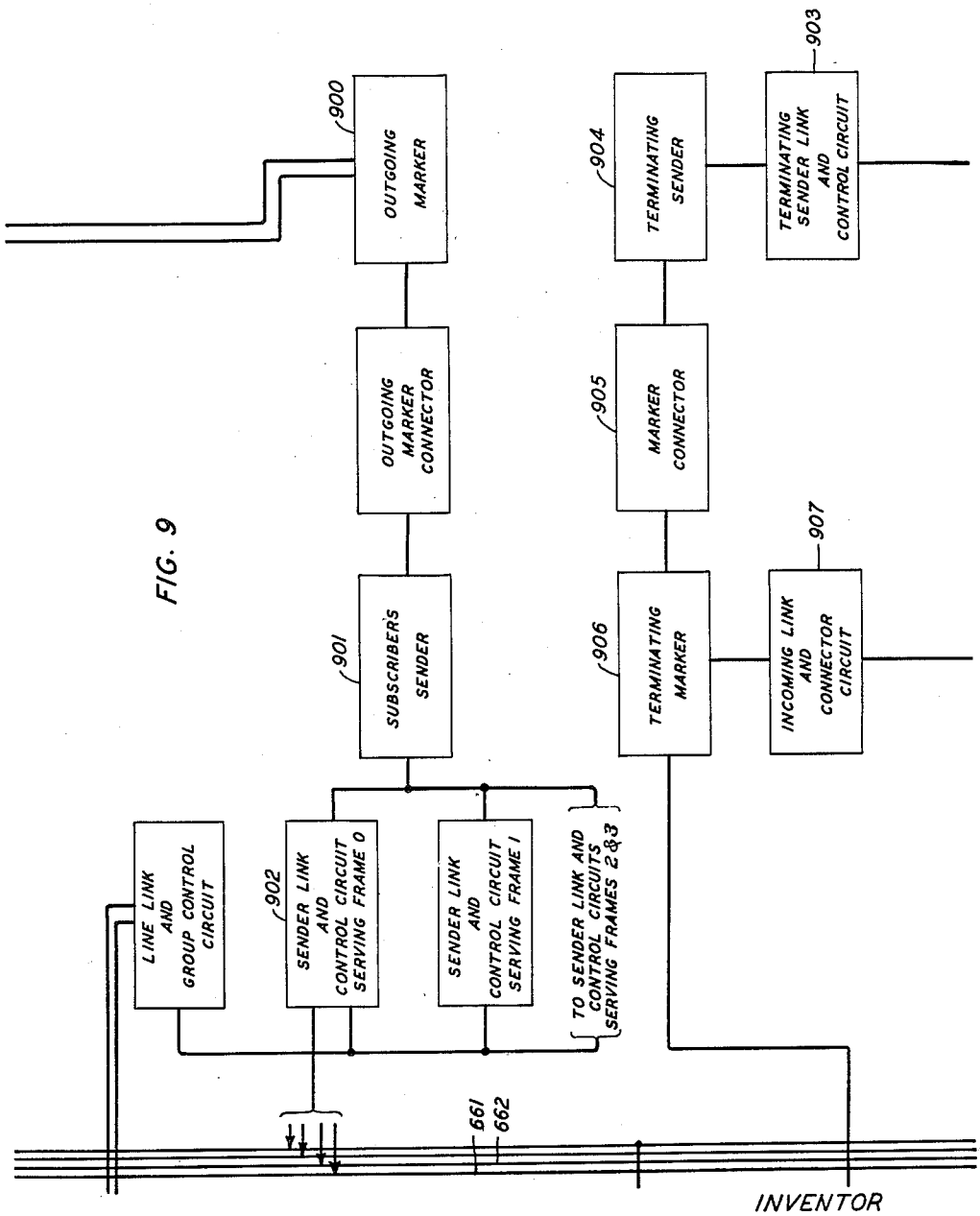

FIG. 9

INVENTOR
W. W. CARPENTER
BY P. C. Smith
ATTORNEY

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DIAL TELEPHONE SYSTEM

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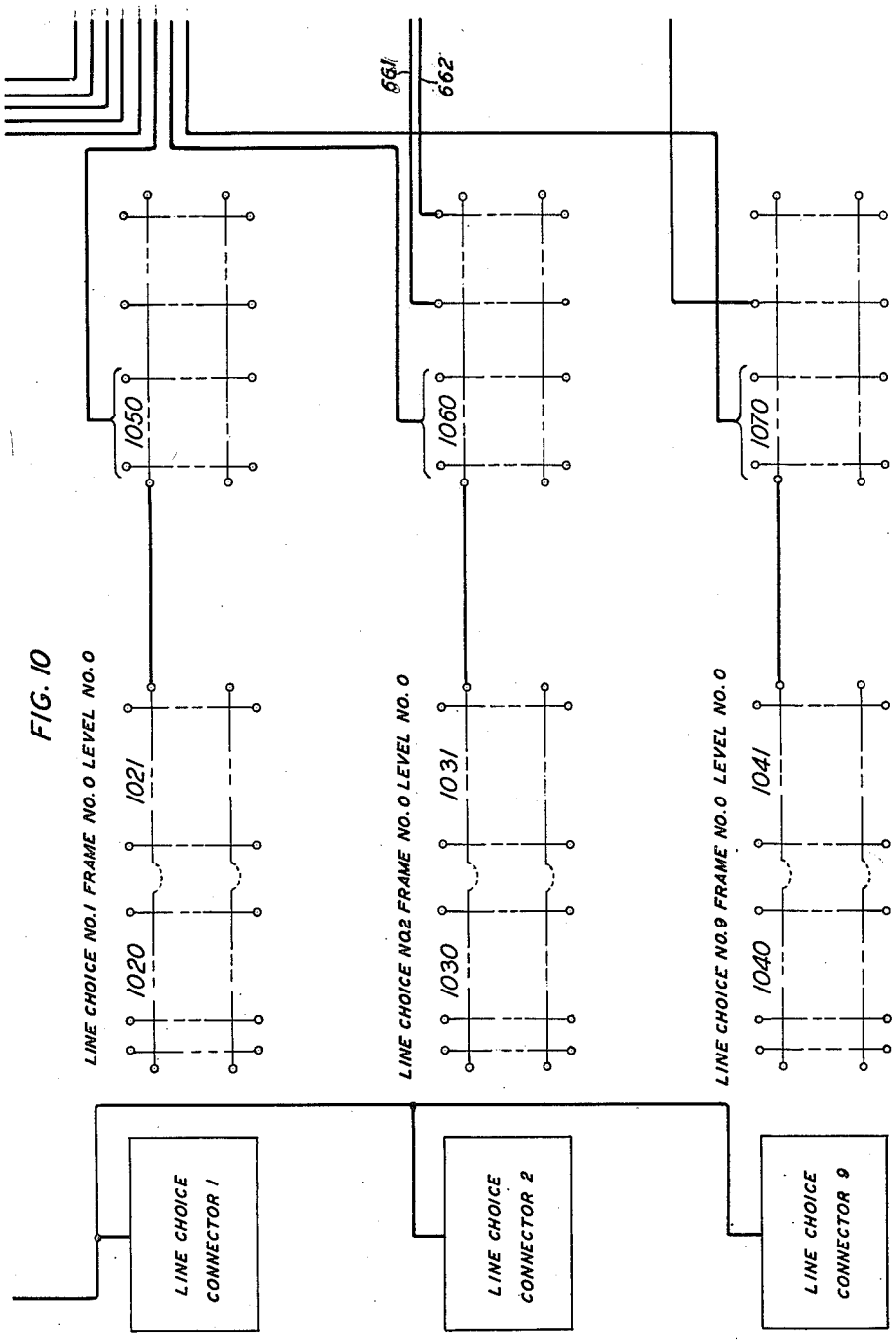

FIG. 10

INVENTOR
W. W. CARPENTER
BY
P. C. Smith
ATTORNEY

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DIAL TELEPHONE SYSTEM

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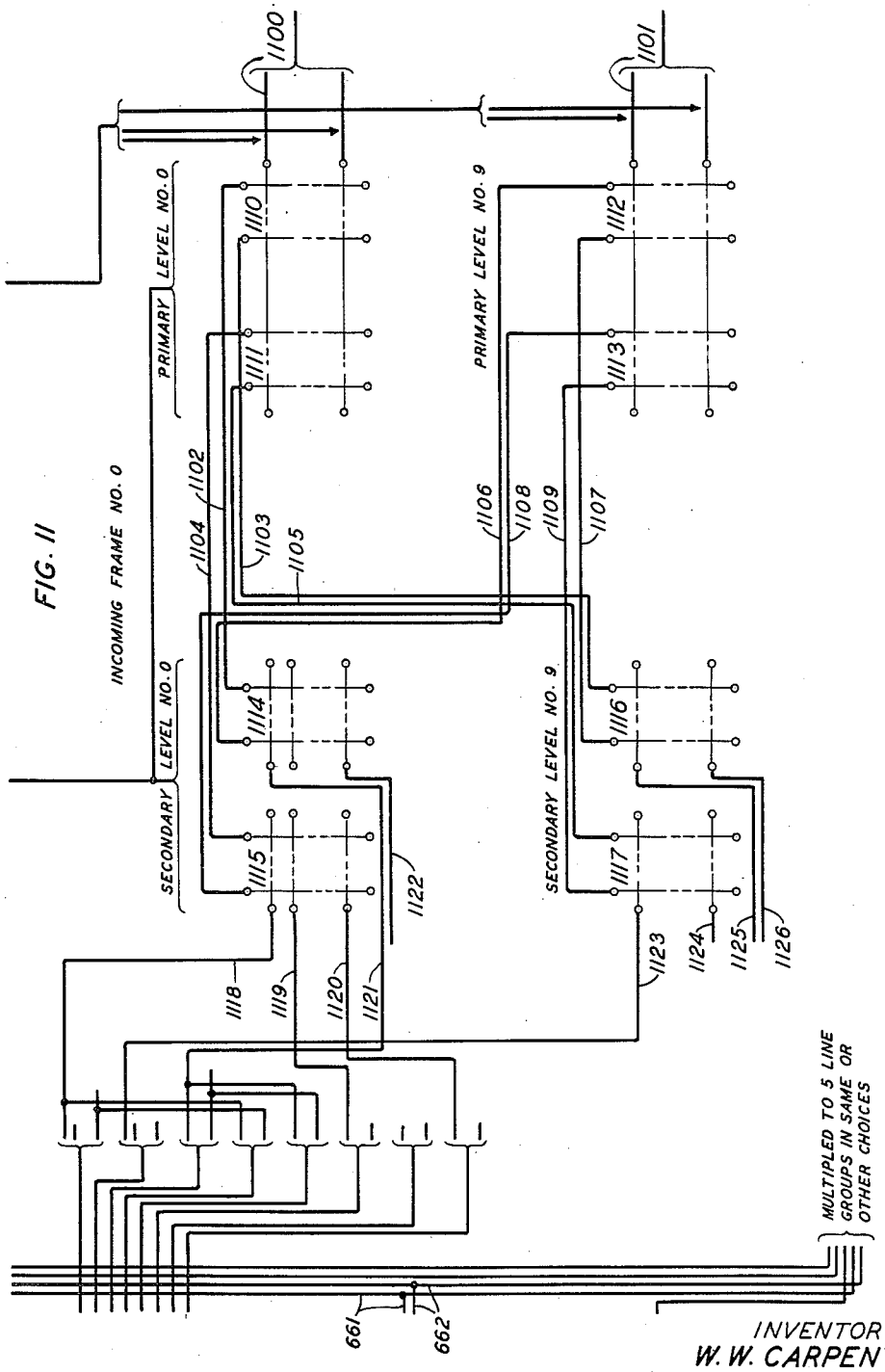

FIG. 11

INVENTOR
W. W. CARPENTER
BY
P. C. Smith
ATTORNEY

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DIAL TELEPHONE SYSTEM

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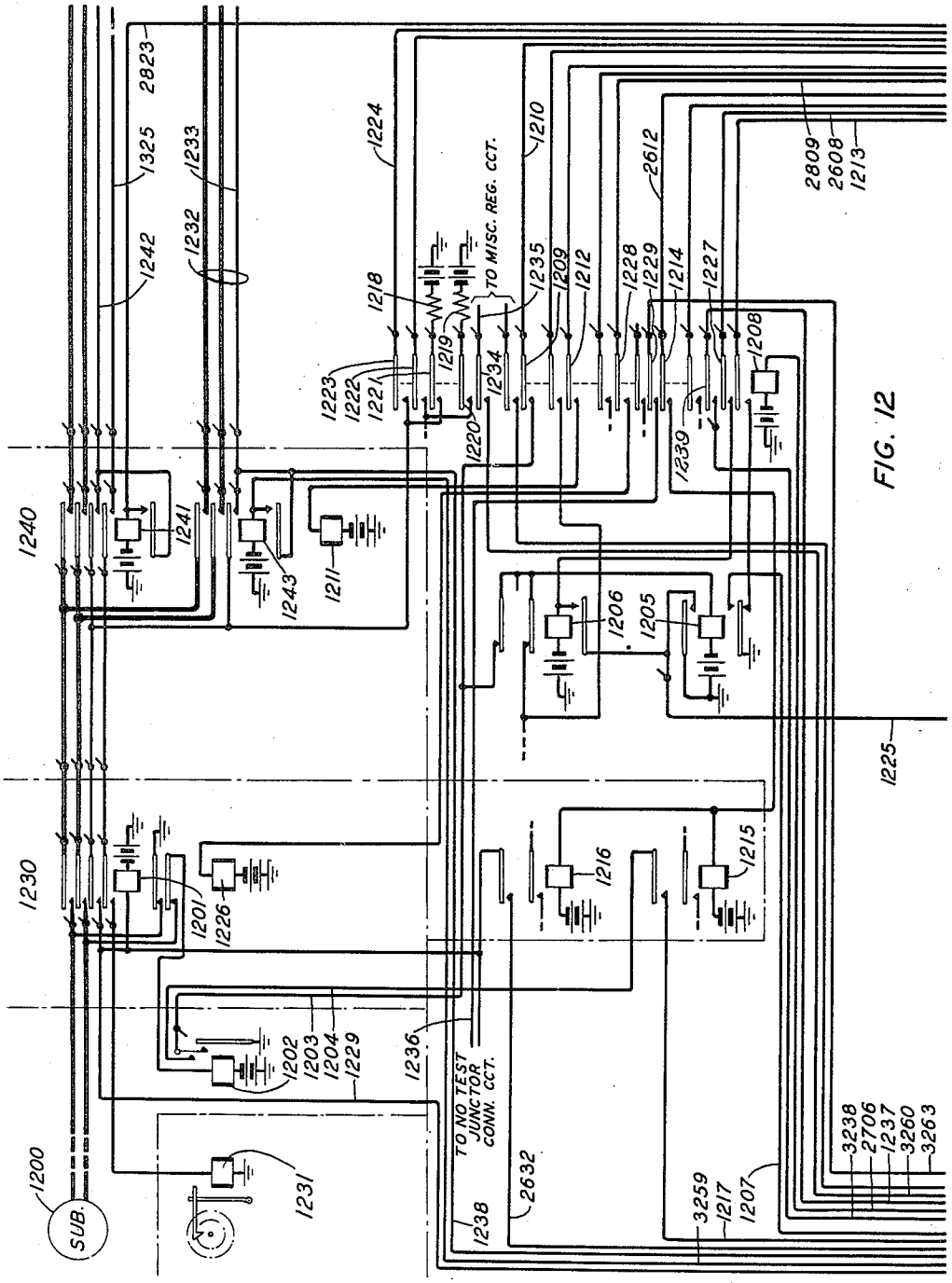

FIG. 12

INVENTOR
W. W. CARPENTER
BY
P. C. Smith
ATTORNEY

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DIAL TELEPHONE SYSTEM

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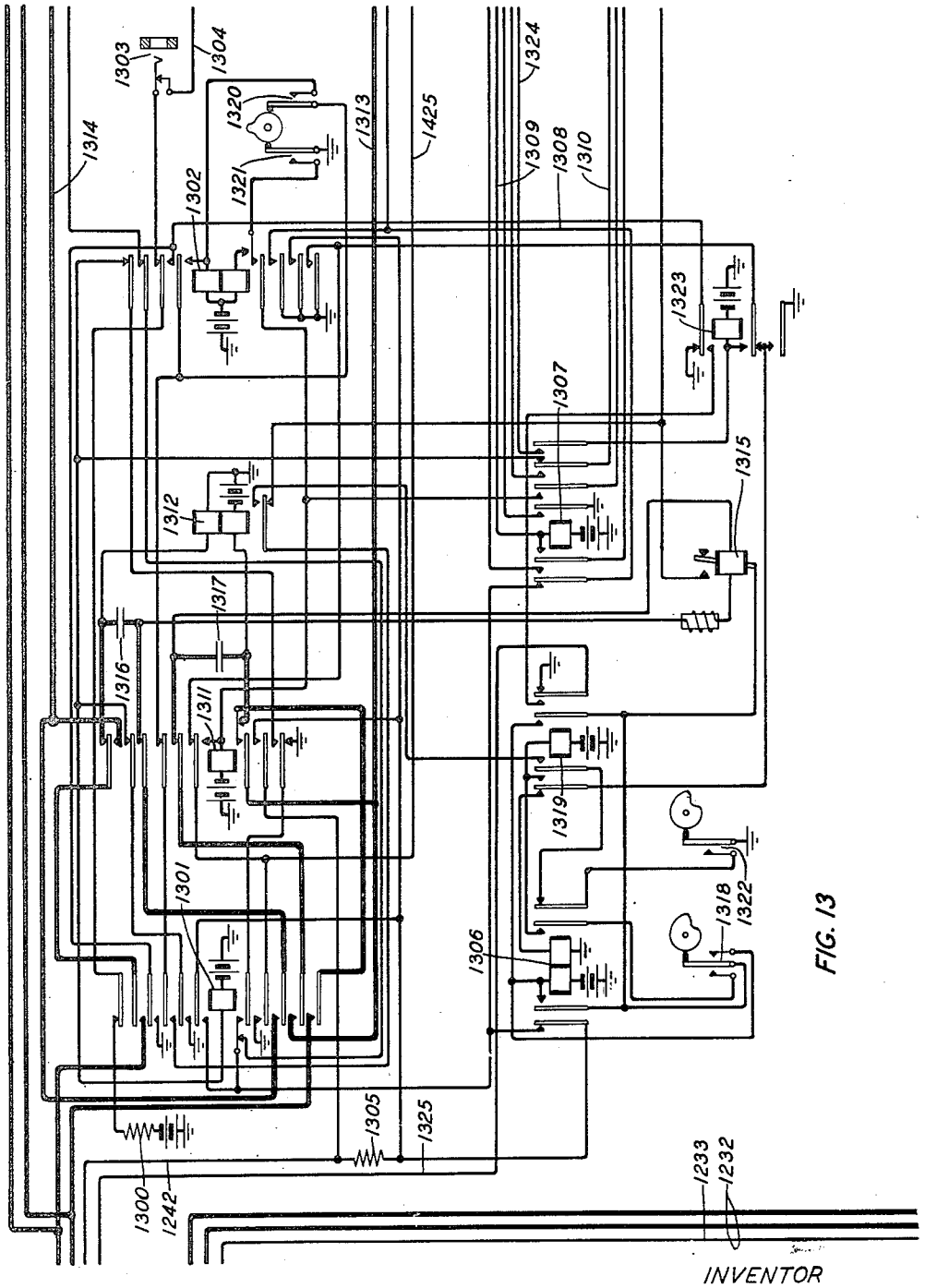

FIG. 13

INVENTOR
W. W. CARPENTER
BY P. C. Smith
ATTORNEY

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DIAL TELEPHONE SYSTEM

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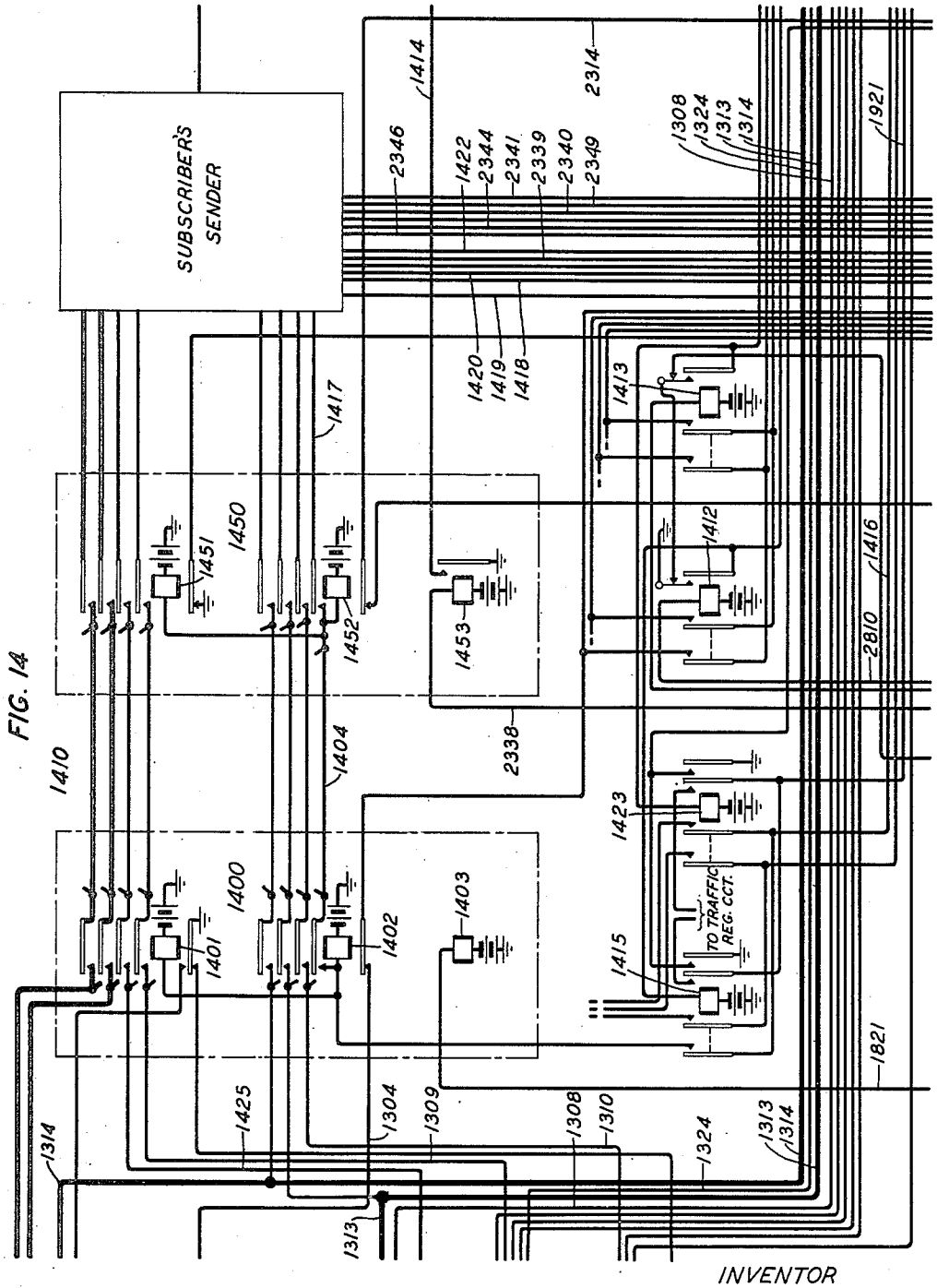

FIG. 14

INVENTOR
W. W. CARPENTER
BY
P. C. Smith
ATTORNEY

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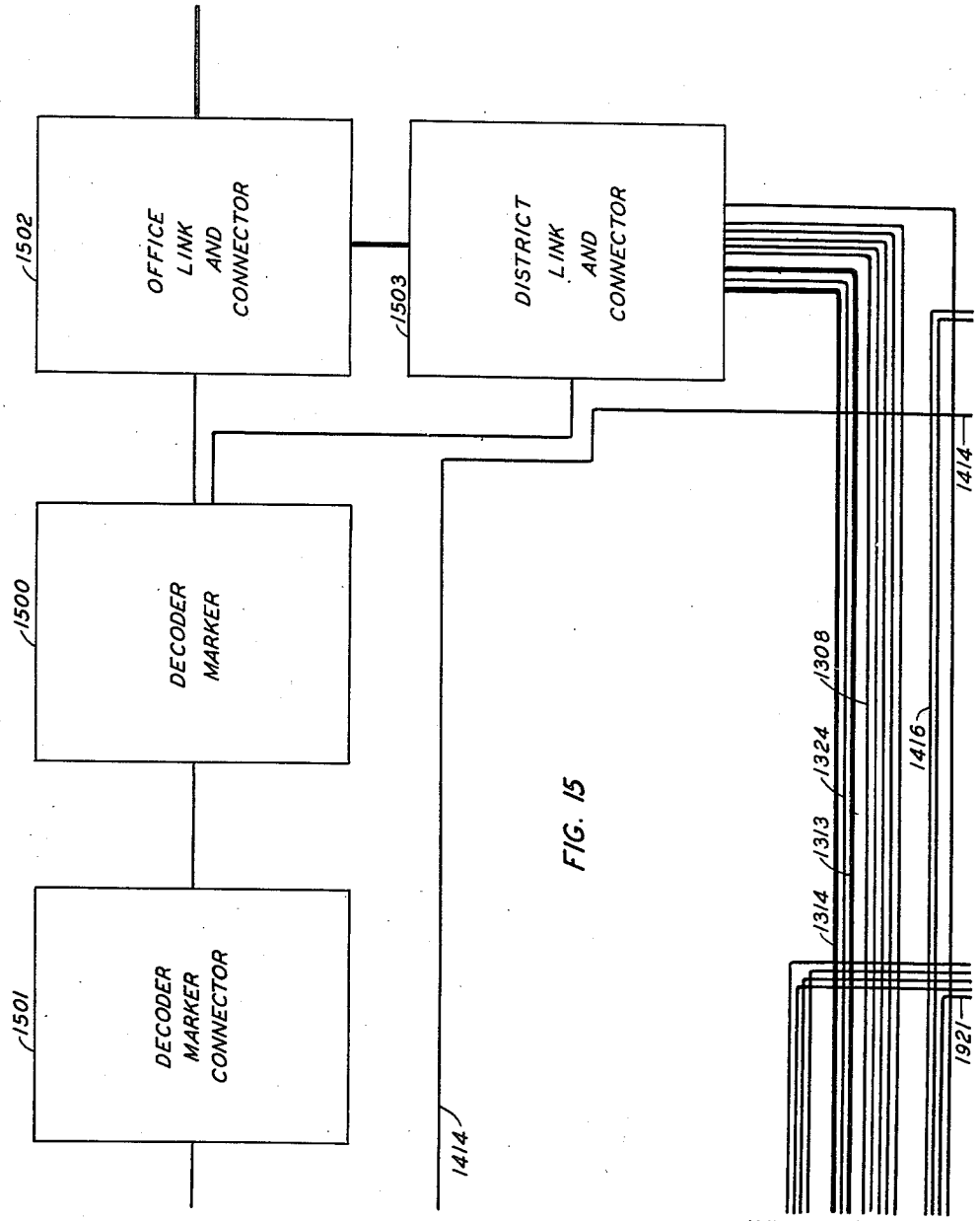

FIG. 15

INVENTOR
W. W. CARPENTER
BY
P. C. Smith
ATTORNEY

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DIAL TELEPHONE SYSTEM

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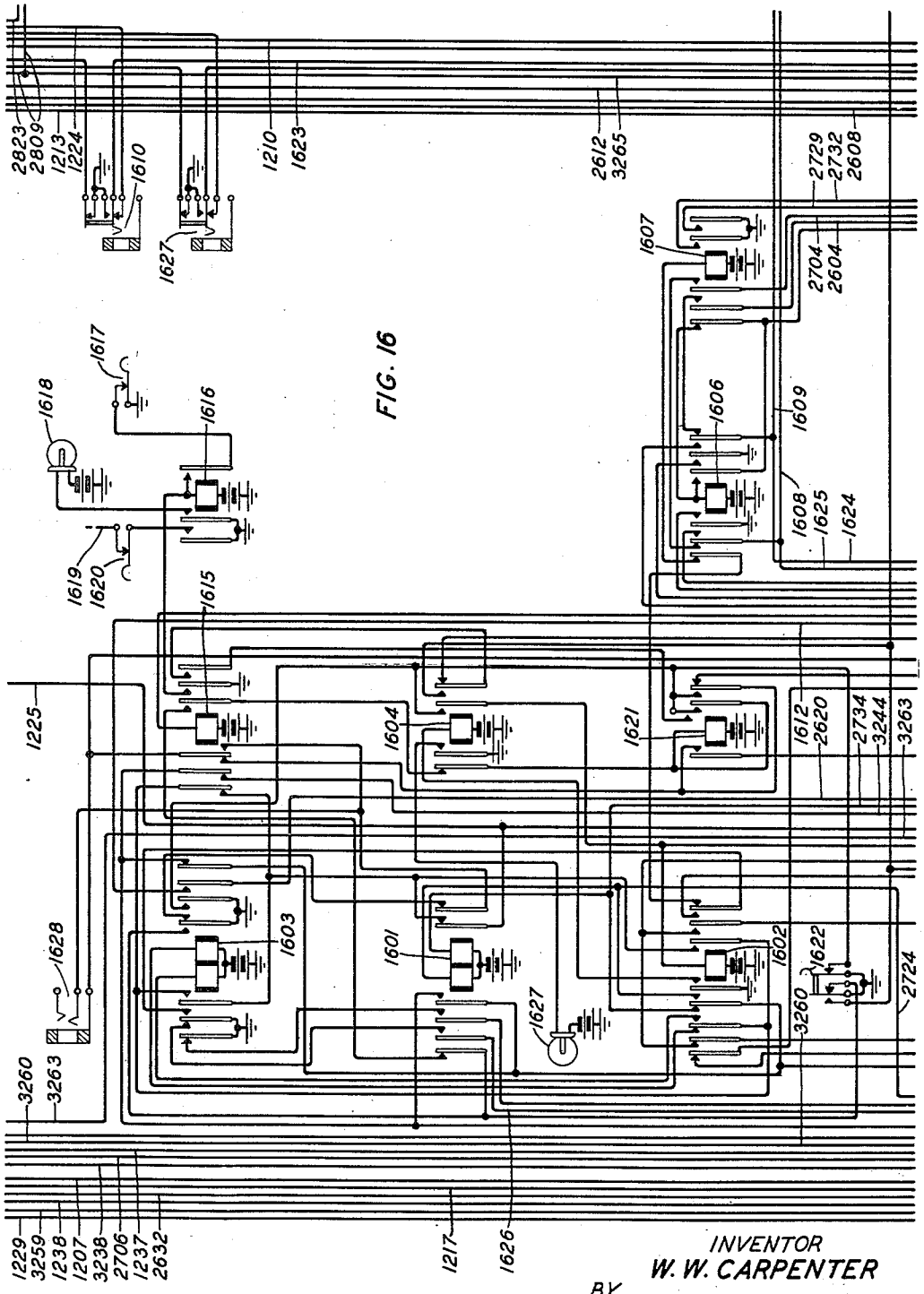

FIG. 16

INVENTOR
W. W. CARPENTER
BY
P. C. Smith
ATTORNEY

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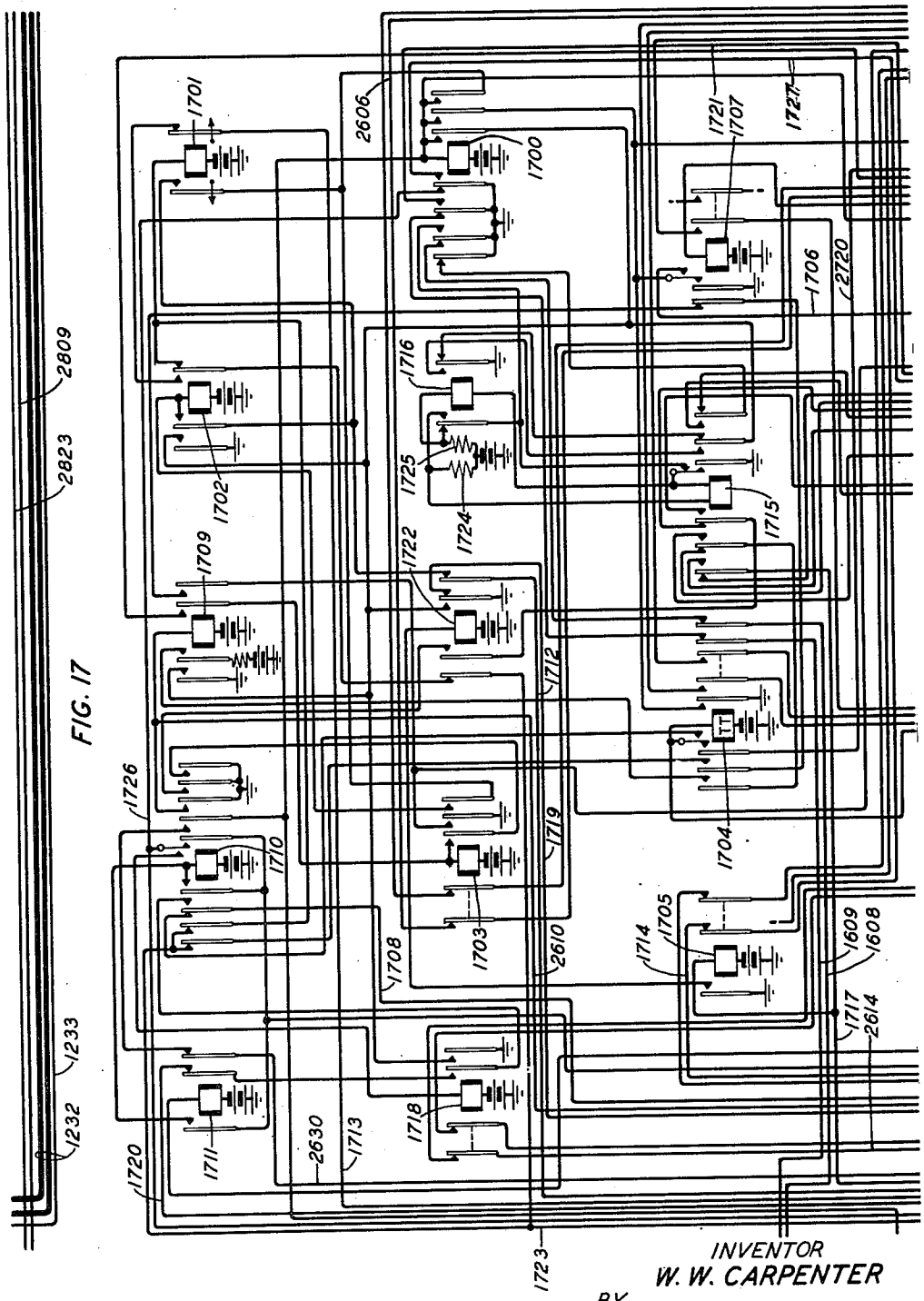

FIG. 17

INVENTOR
W. W. CARPENTER
BY
P. C. Smith
ATTORNEY

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DIAL TELEPHONE SYSTEM

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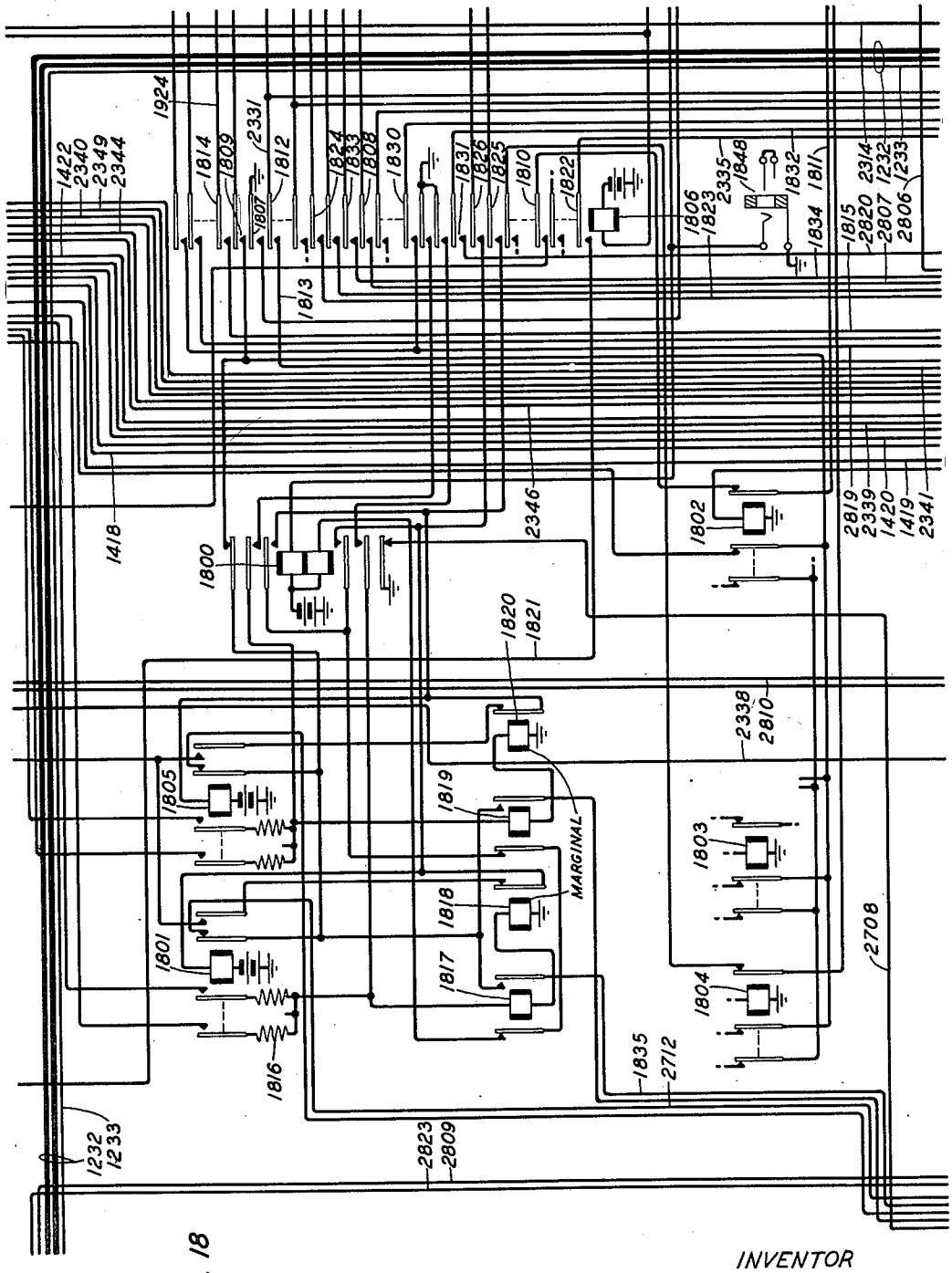

FIG. 18

INVENTOR
W. W. CARPENTER
BY P. C. Smith
ATTORNEY

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DIAL TELEPHONE SYSTEM

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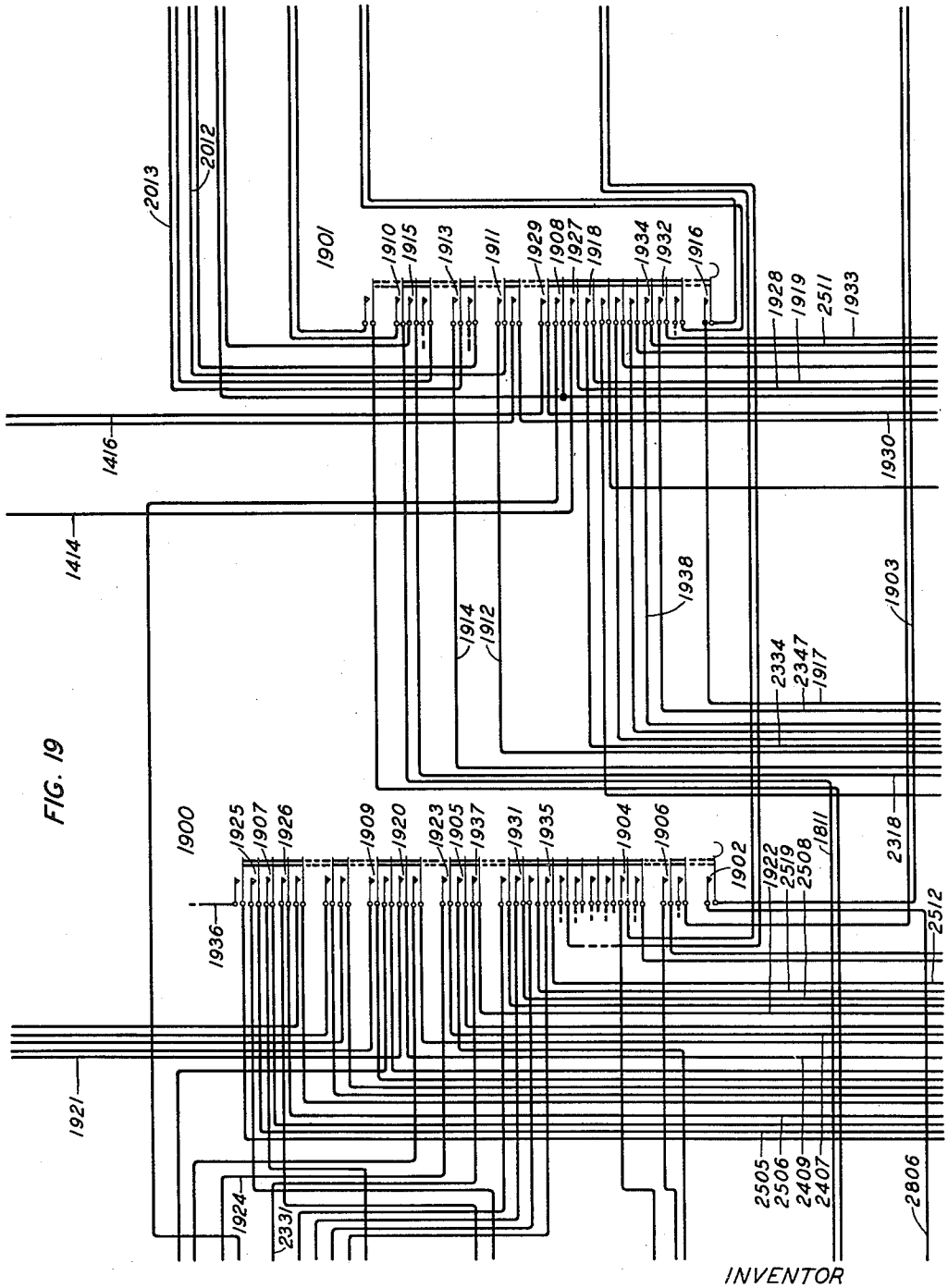

FIG. 19

INVENTOR
W. W. CARPENTER
BY P. C. Smith
ATTORNEY

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DIAL TELEPHONE SYSTEM

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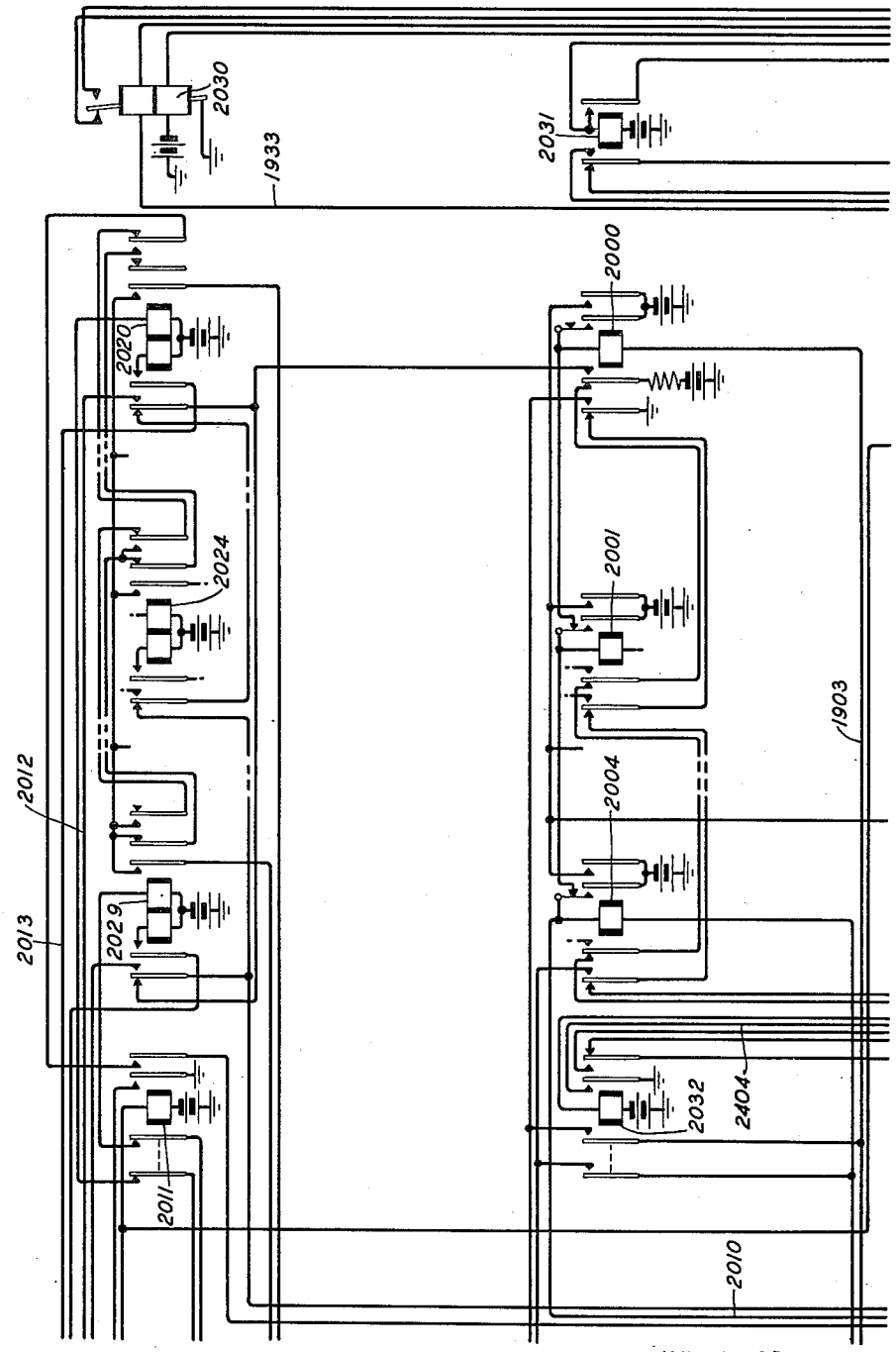

FIG. 20

INVENTOR
W. W. CARPENTER
BY
R. C. Smith
ATTORNEY

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DIAL TELEPHONE SYSTEM

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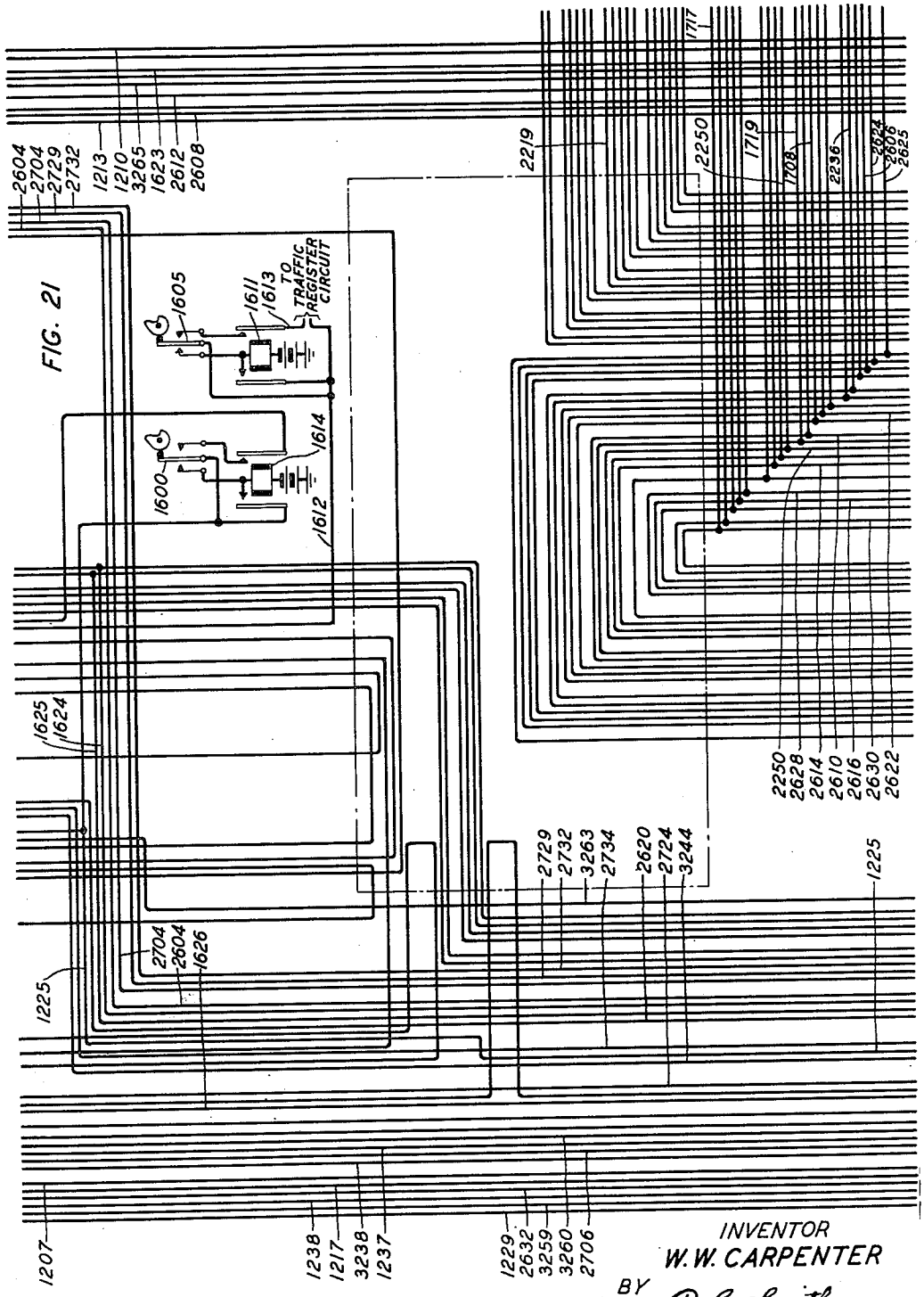

INVENTOR
W. W. CARPENTER
BY
P. C. Smith
ATTORNEY

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DIAL TELEPHONE SYSTEM

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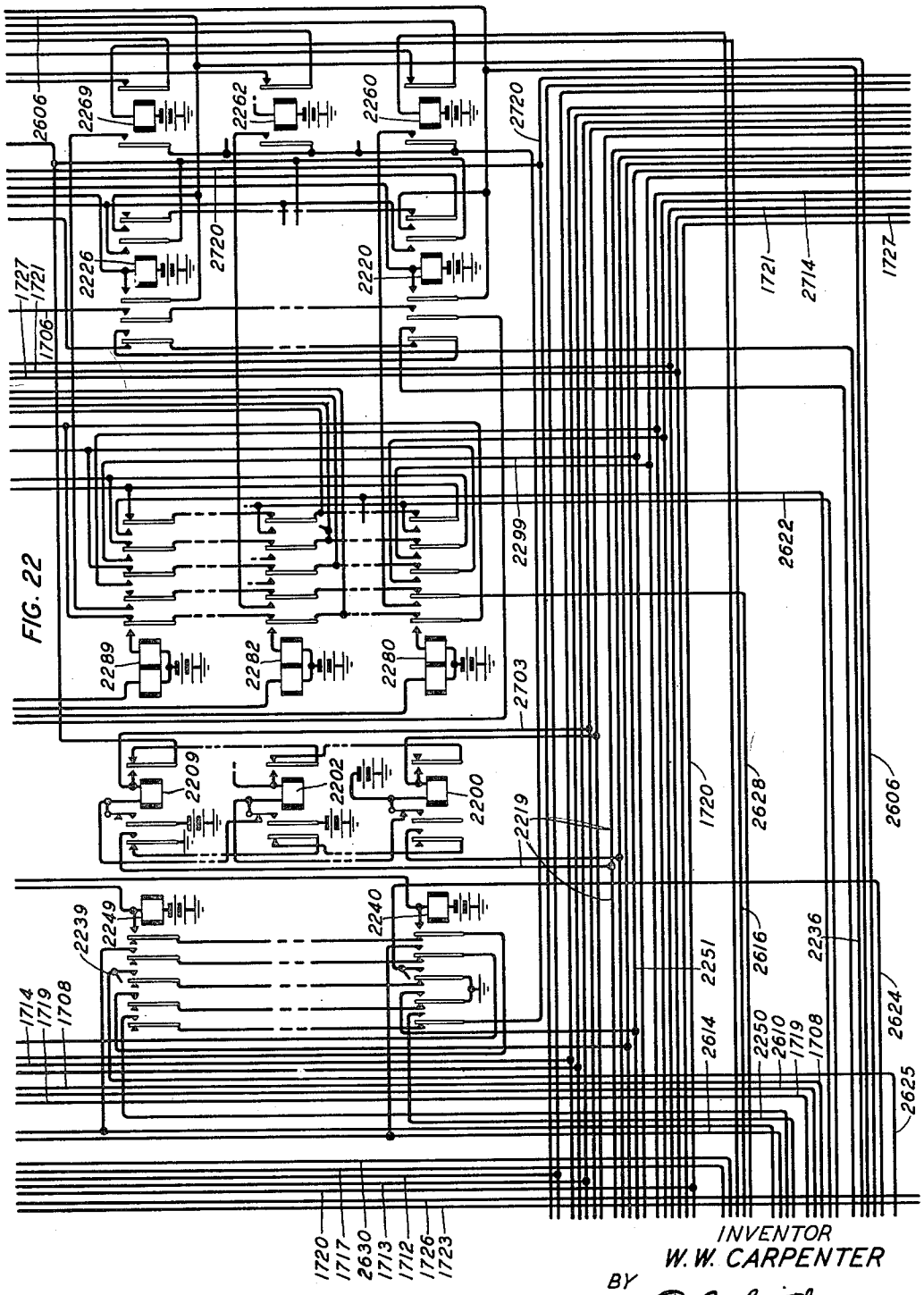

FIG. 22

INVENTOR
W. W. CARPENTER
BY
P. C. Smith
ATTORNEY

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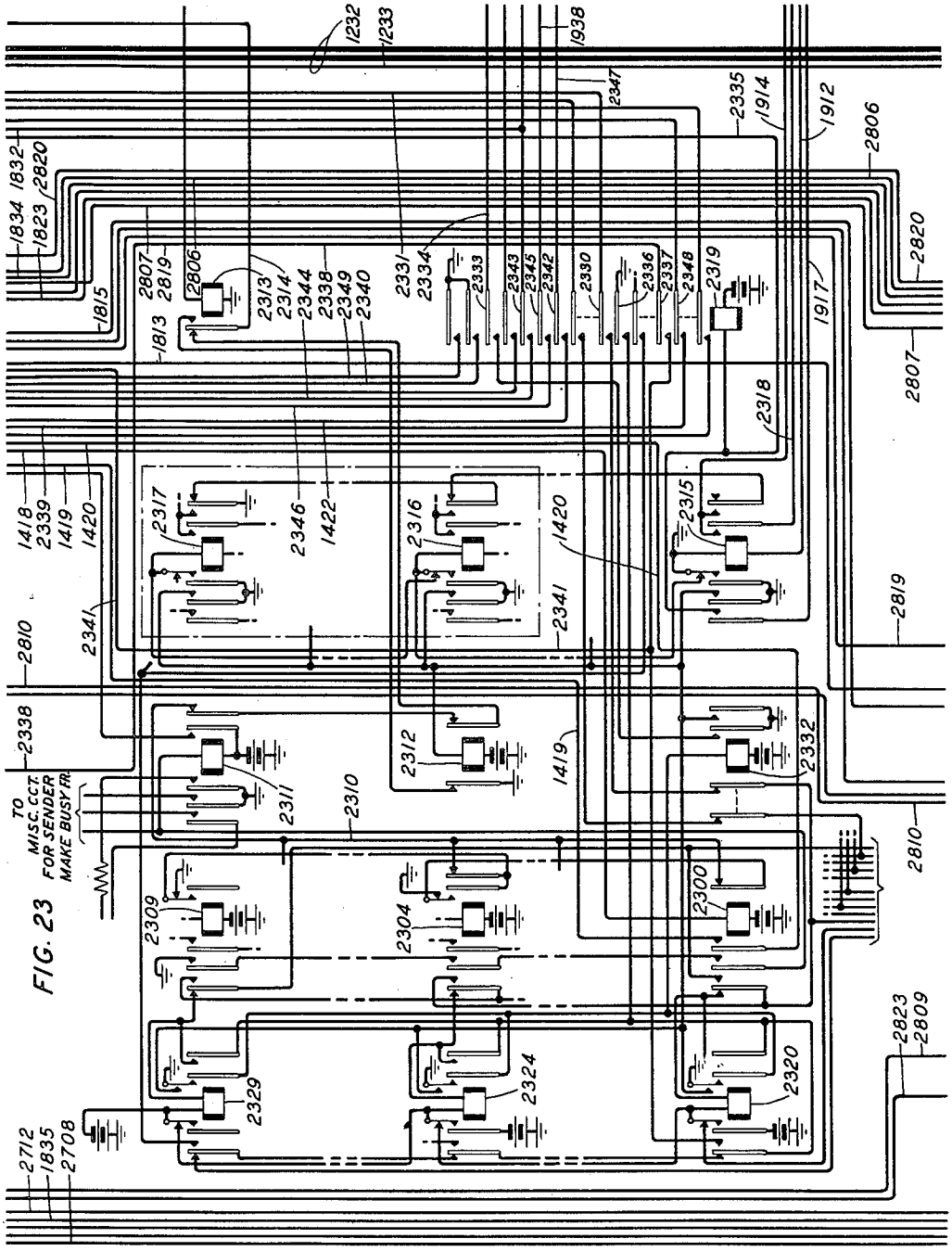

FIG. 23

INVENTOR
W. W. CARPENTER
BY P. C. Smith
ATTORNEY

Aug. 10, 1937. W. W. CARPENTER 2,089,921

DIAL TELEPHONE SYSTEM

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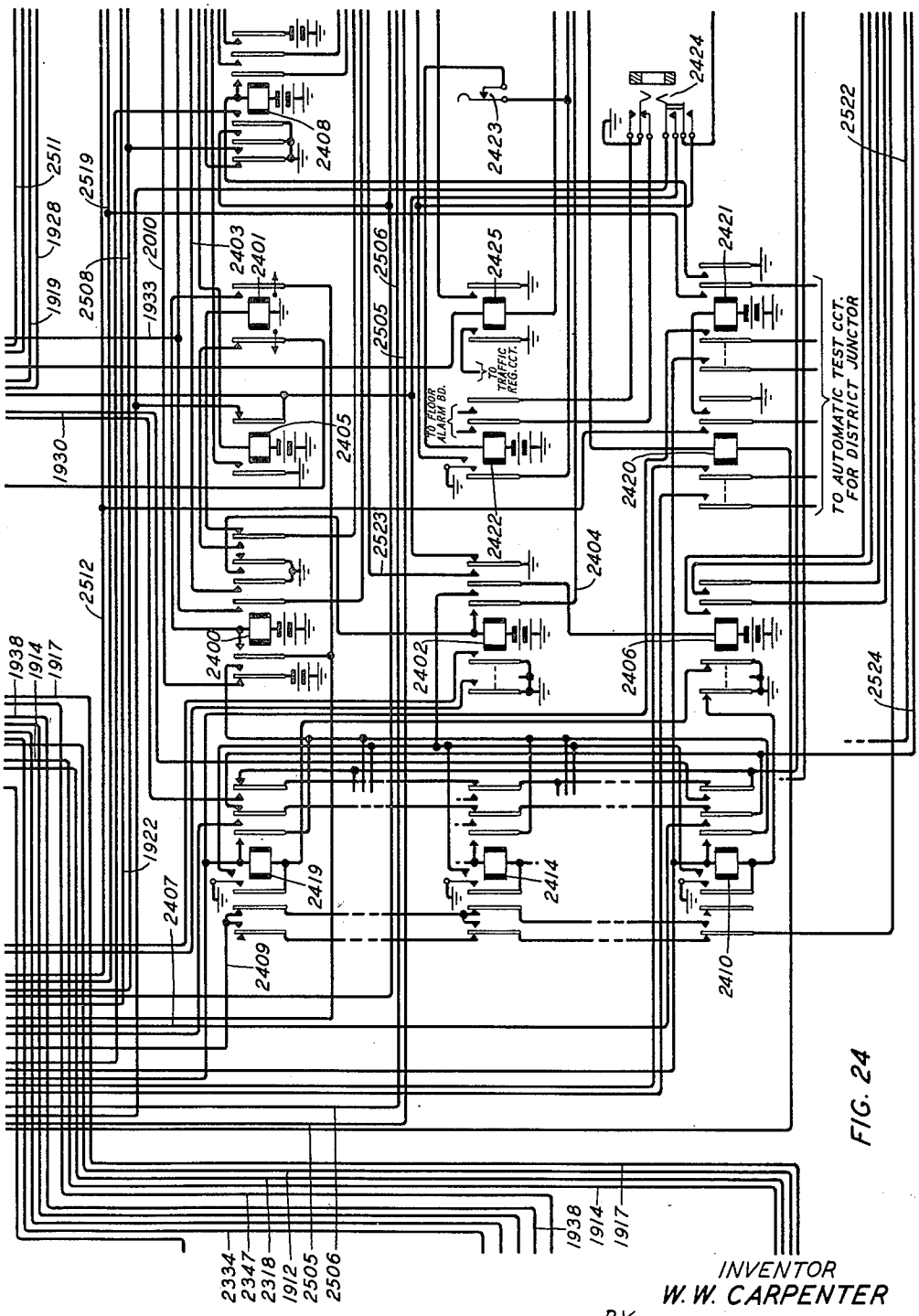

FIG. 24

INVENTOR
W. W. CARPENTER
BY
P. C. Smith
ATTORNEY

Aug. 10, 1937. W. W. CARPENTER 2,089,921

DIAL TELEPHONE SYSTEM

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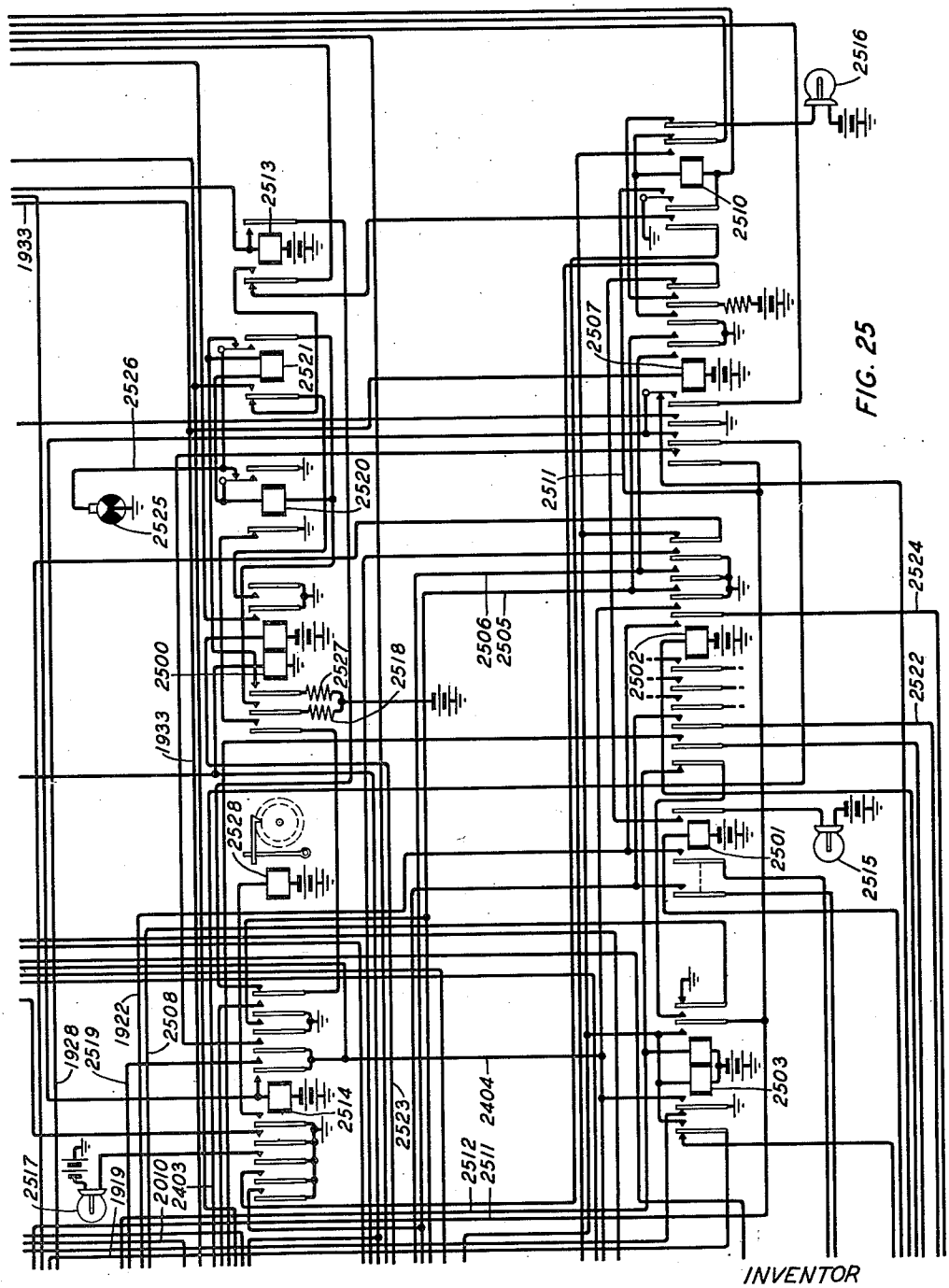

FIG. 25

INVENTOR
W. W. CARPENTER
BY P. C. Smith
ATTORNEY

Aug. 10, 1937. W. W. CARPENTER 2,089,921

DIAL TELEPHONE SYSTEM

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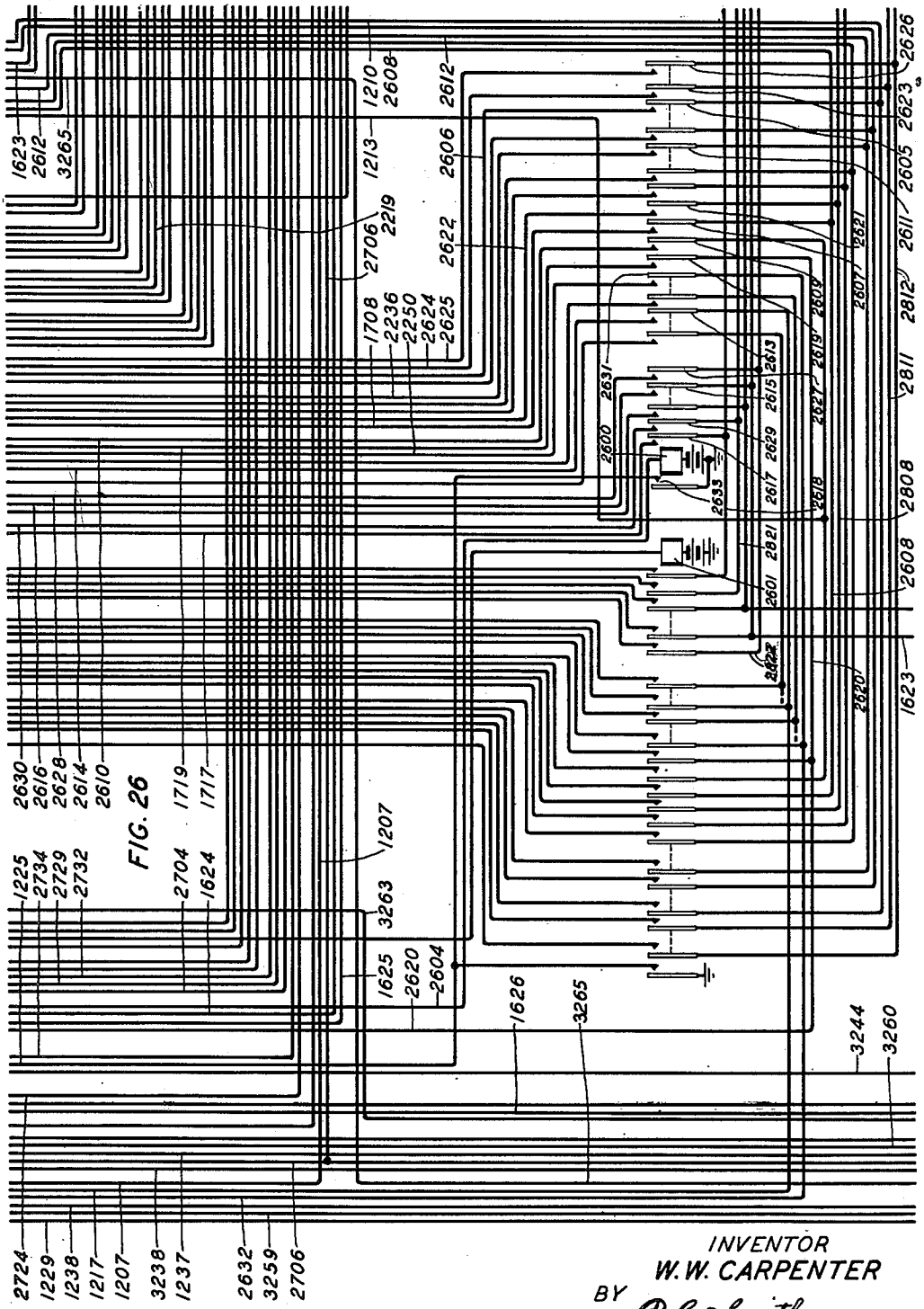

FIG. 26

INVENTOR
W. W. CARPENTER
BY P. C. Smith
ATTORNEY

Aug. 10, 1937. W. W. CARPENTER 2,089,921

DIAL TELEPHONE SYSTEM

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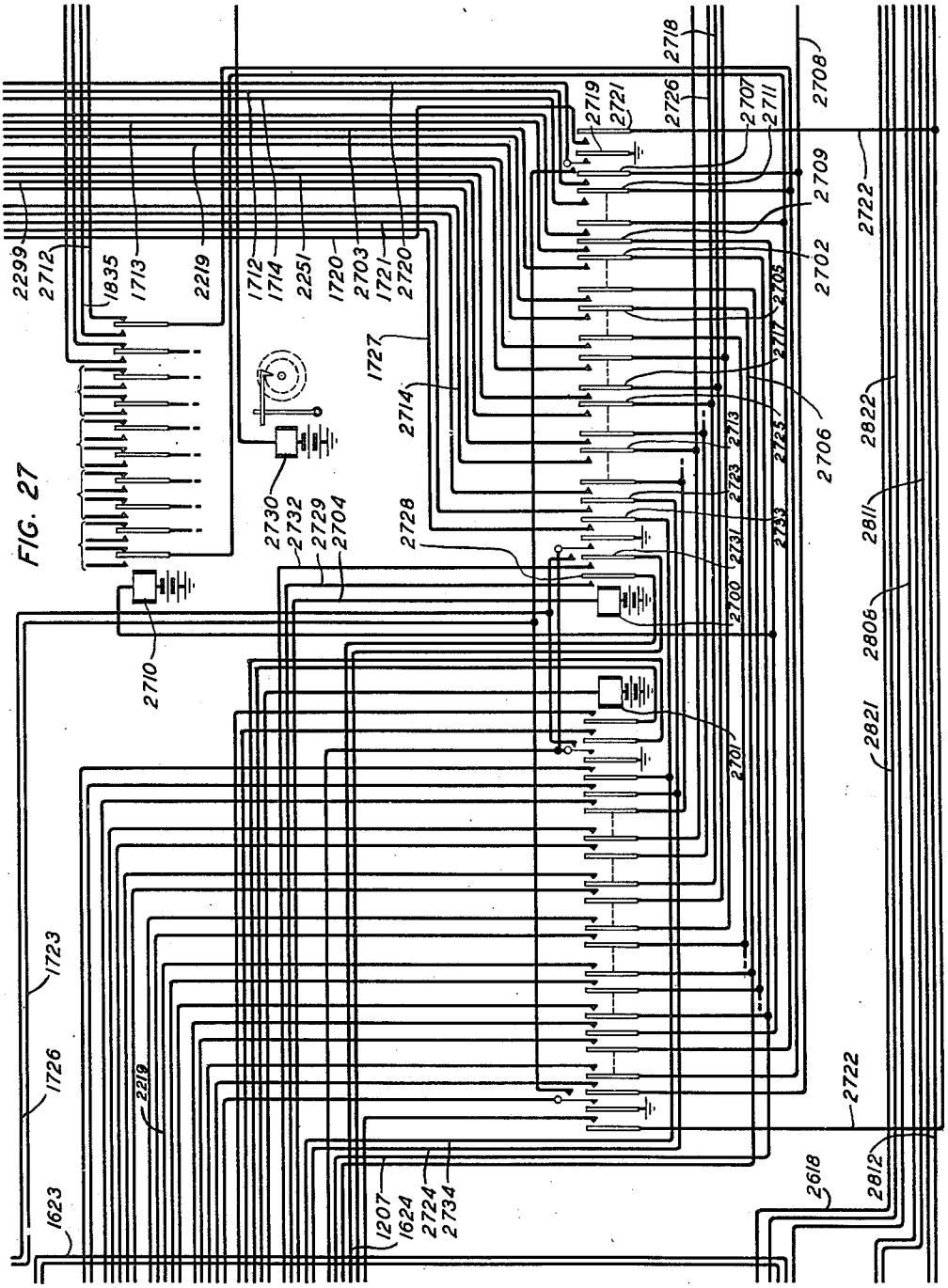

FIG. 27

INVENTOR
W. W. CARPENTER
BY P. C. Smith
ATTORNEY

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DIAL TELEPHONE SYSTEM

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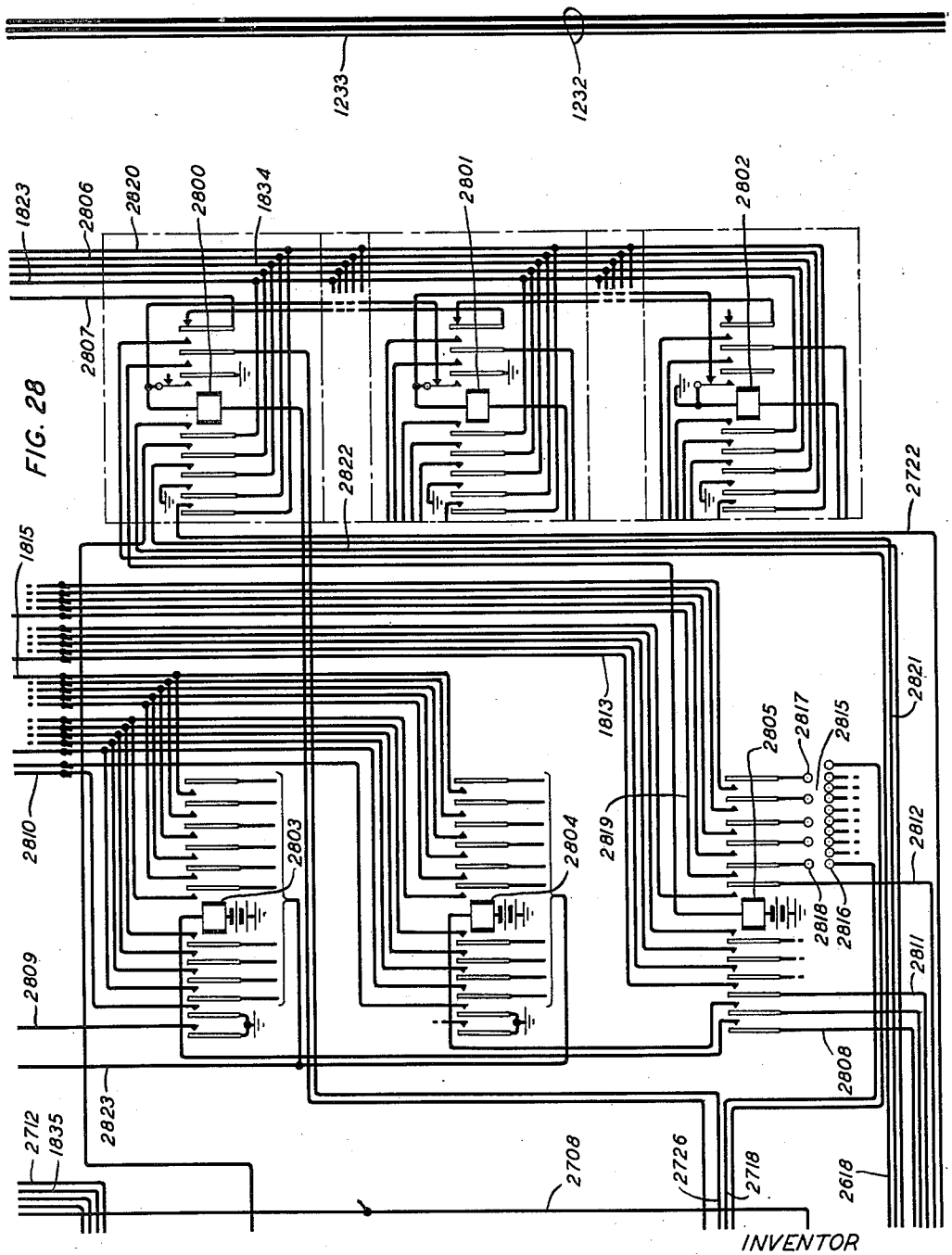

FIG. 28

INVENTOR
W. W. CARPENTER
BY
P. C. Smith
ATTORNEY

Aug. 10, 1937. W. W. CARPENTER 2,089,921

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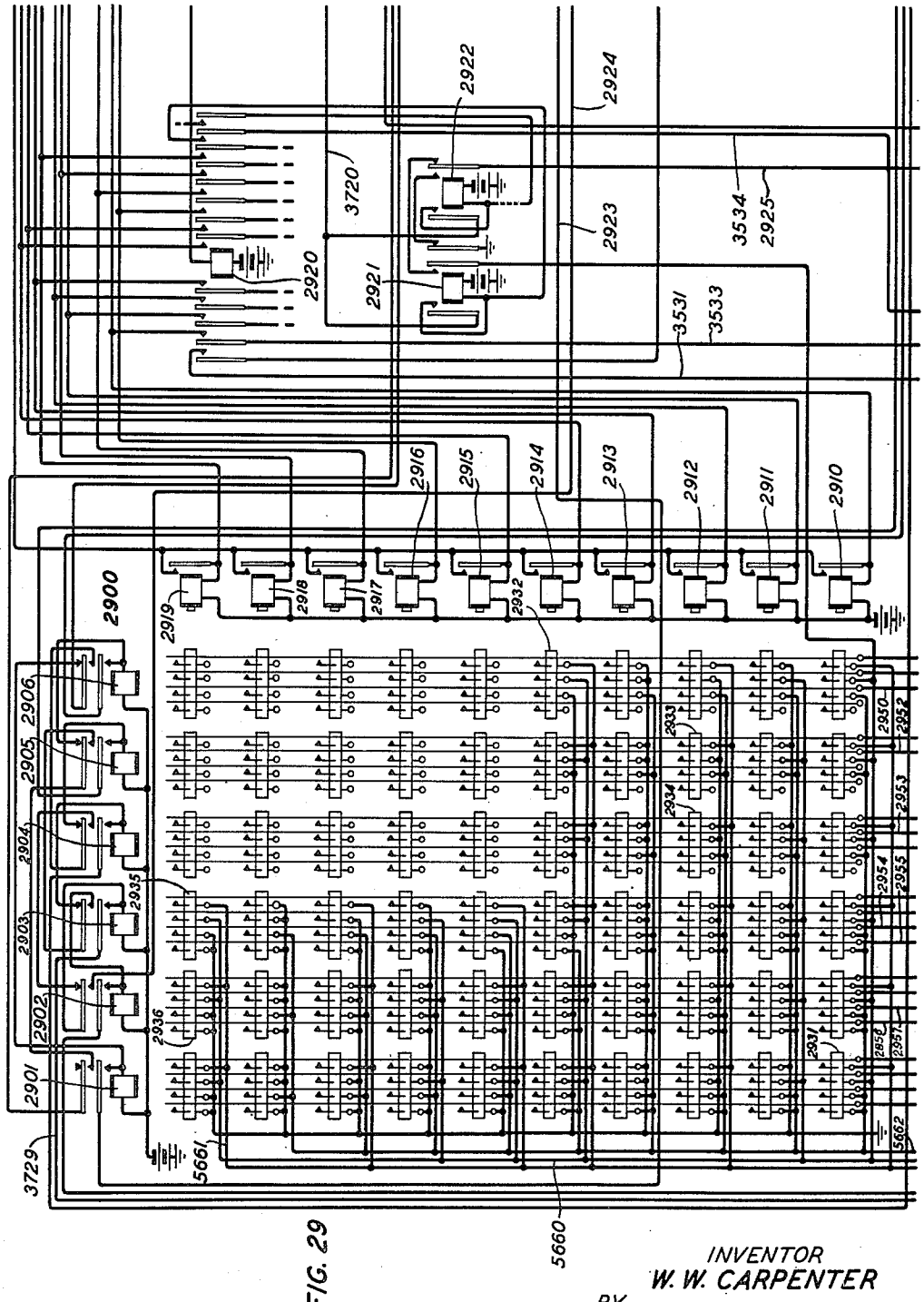

FIG. 29

INVENTOR
W. W. CARPENTER
BY P. C. Smith
ATTORNEY

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DIAL TELEPHONE SYSTEM

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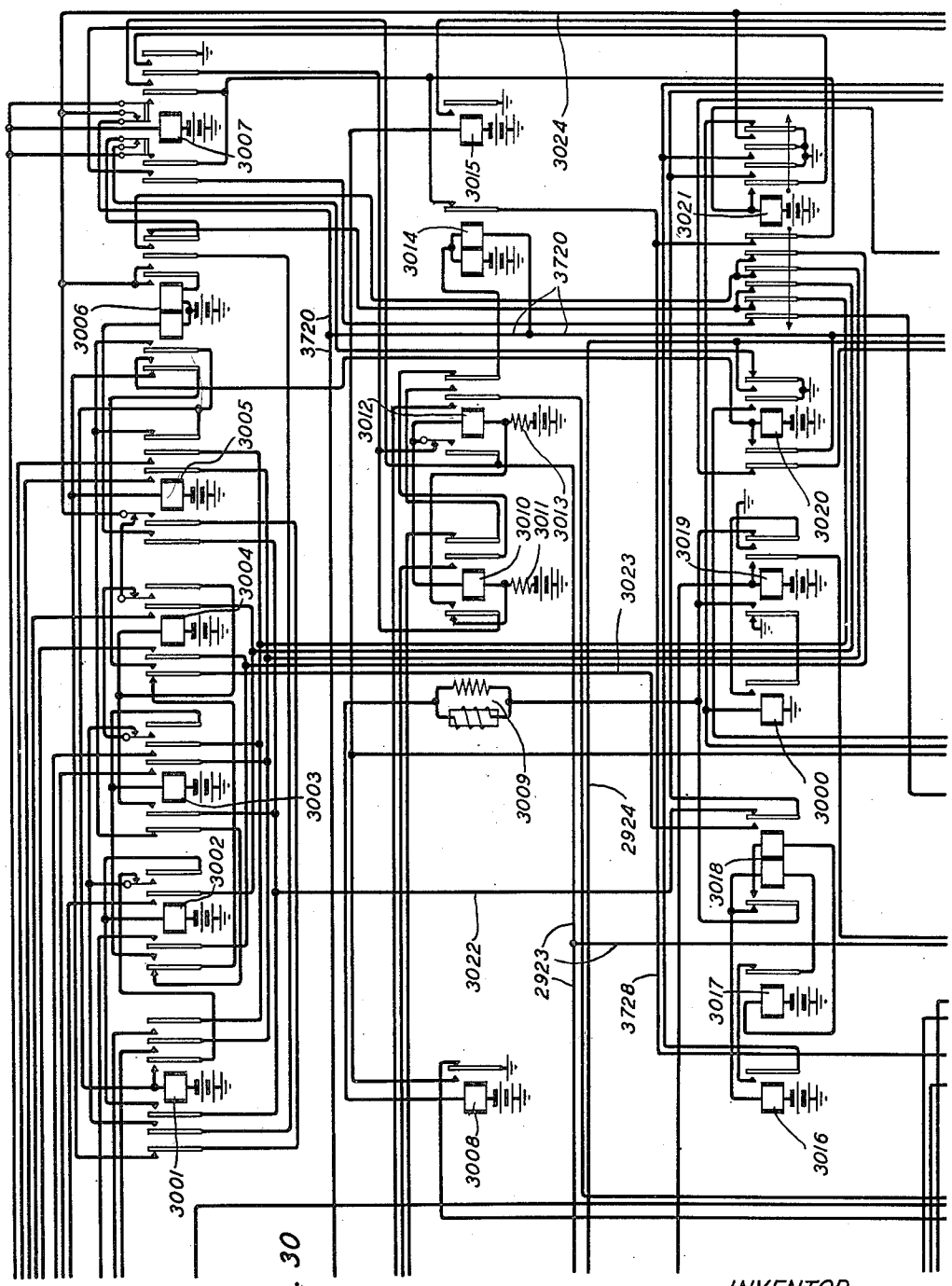

FIG. 30

INVENTOR
W. W. CARPENTER
BY
P. C. Smith
ATTORNEY

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DIAL TELEPHONE SYSTEM

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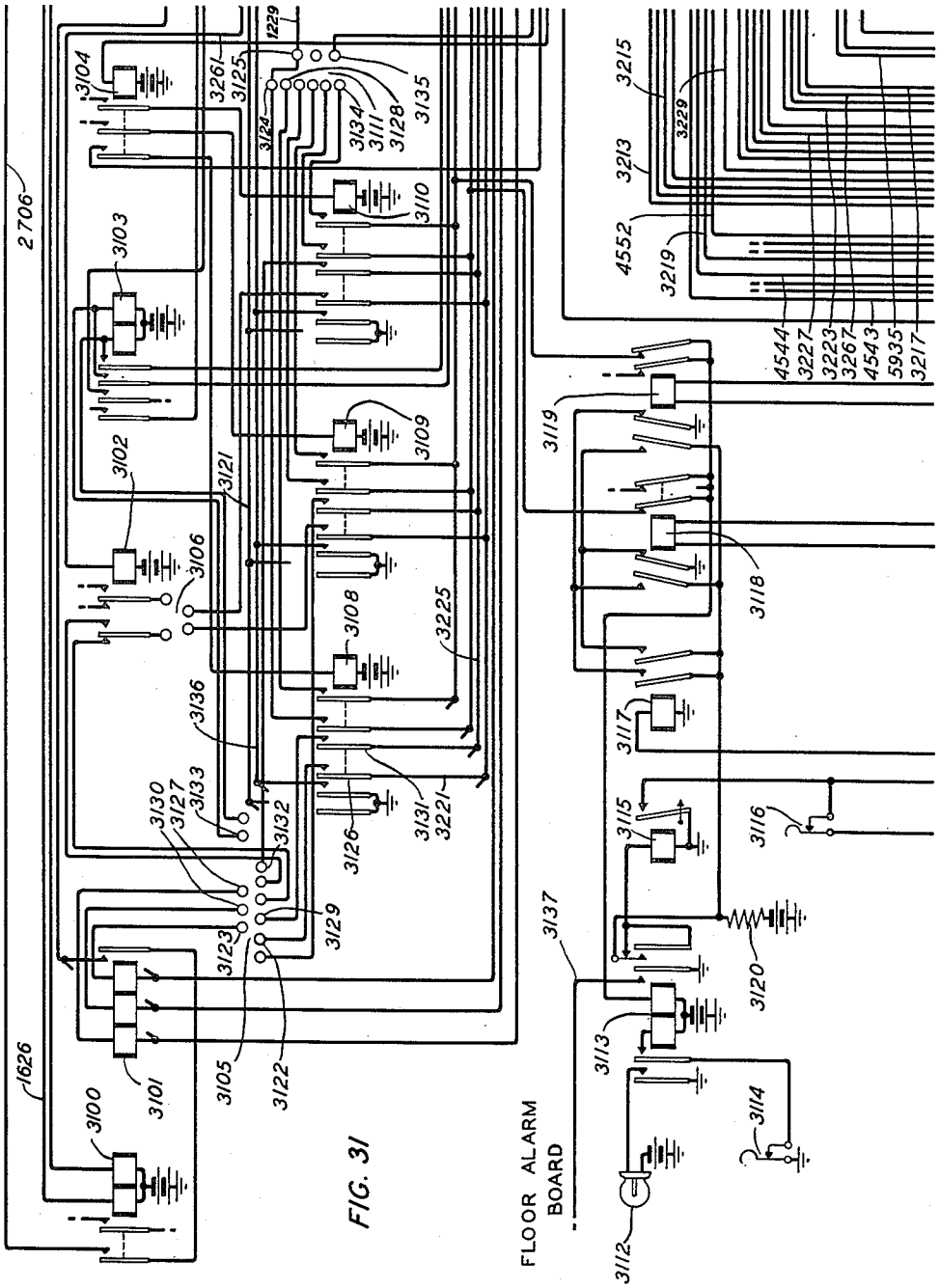

FIG. 31

INVENTOR
W. W. CARPENTER
BY P. C. Smith
ATTORNEY

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DIAL TELEPHONE SYSTEM

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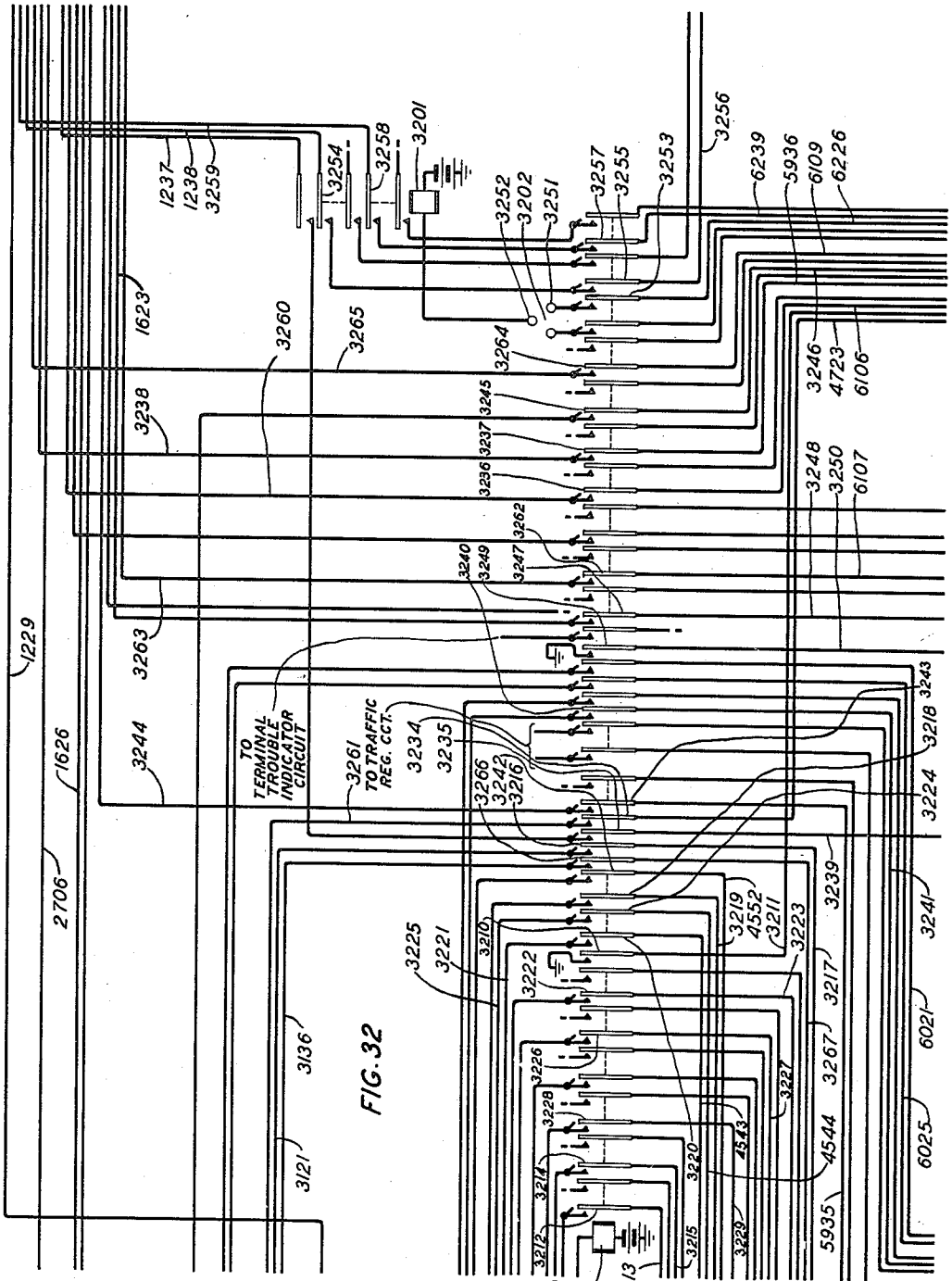

INVENTOR
W. W. CARPENTER
BY
P. C. Smith
ATTORNEY

Aug. 10, 1937. W. W. CARPENTER 2,089,921

DIAL TELEPHONE SYSTEM

Filed March 11, 1936 64 Sheets-Sheet 33

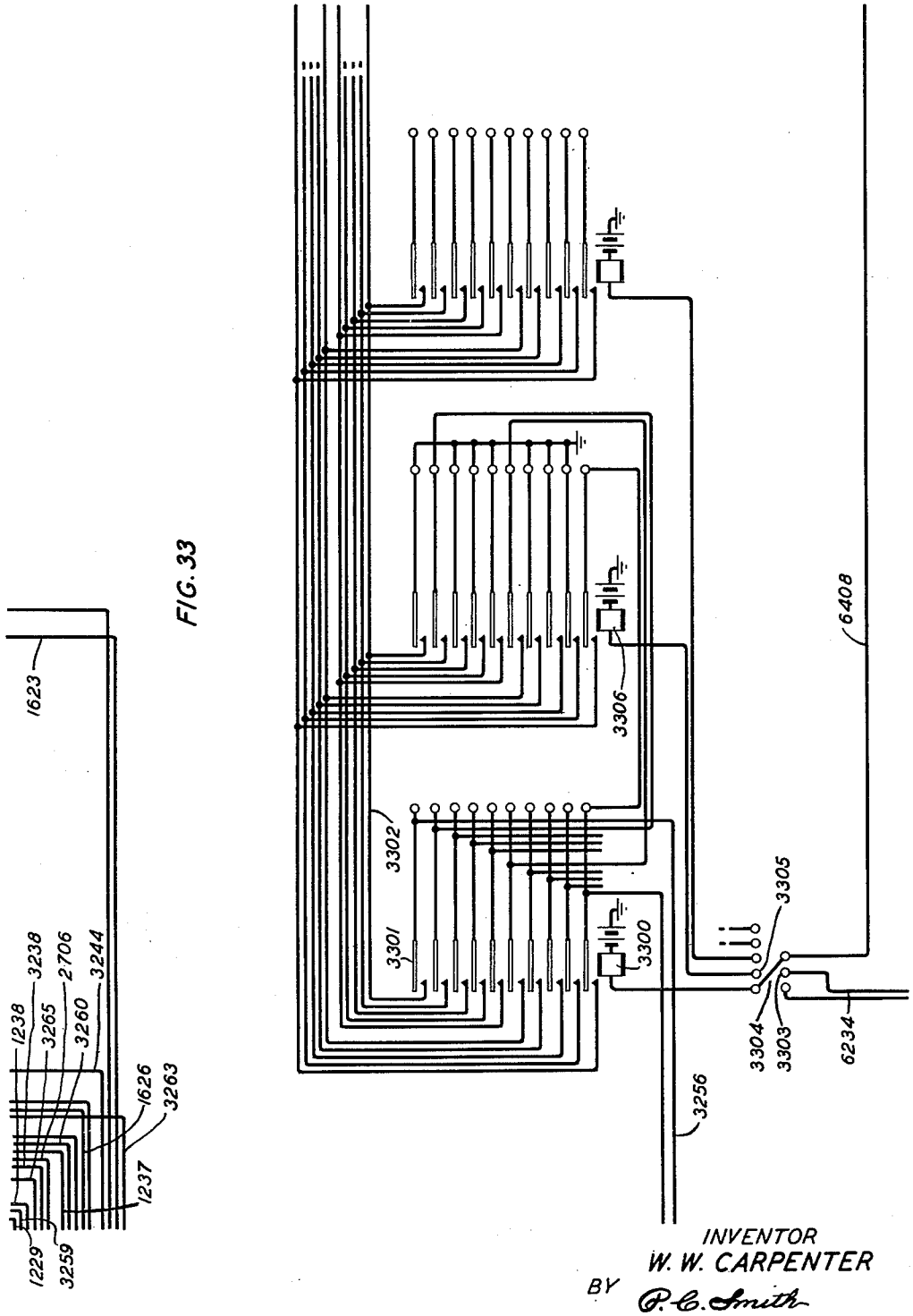

FIG. 33

INVENTOR
W. W. CARPENTER
BY P. C. Smith
ATTORNEY

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DIAL TELEPHONE SYSTEM

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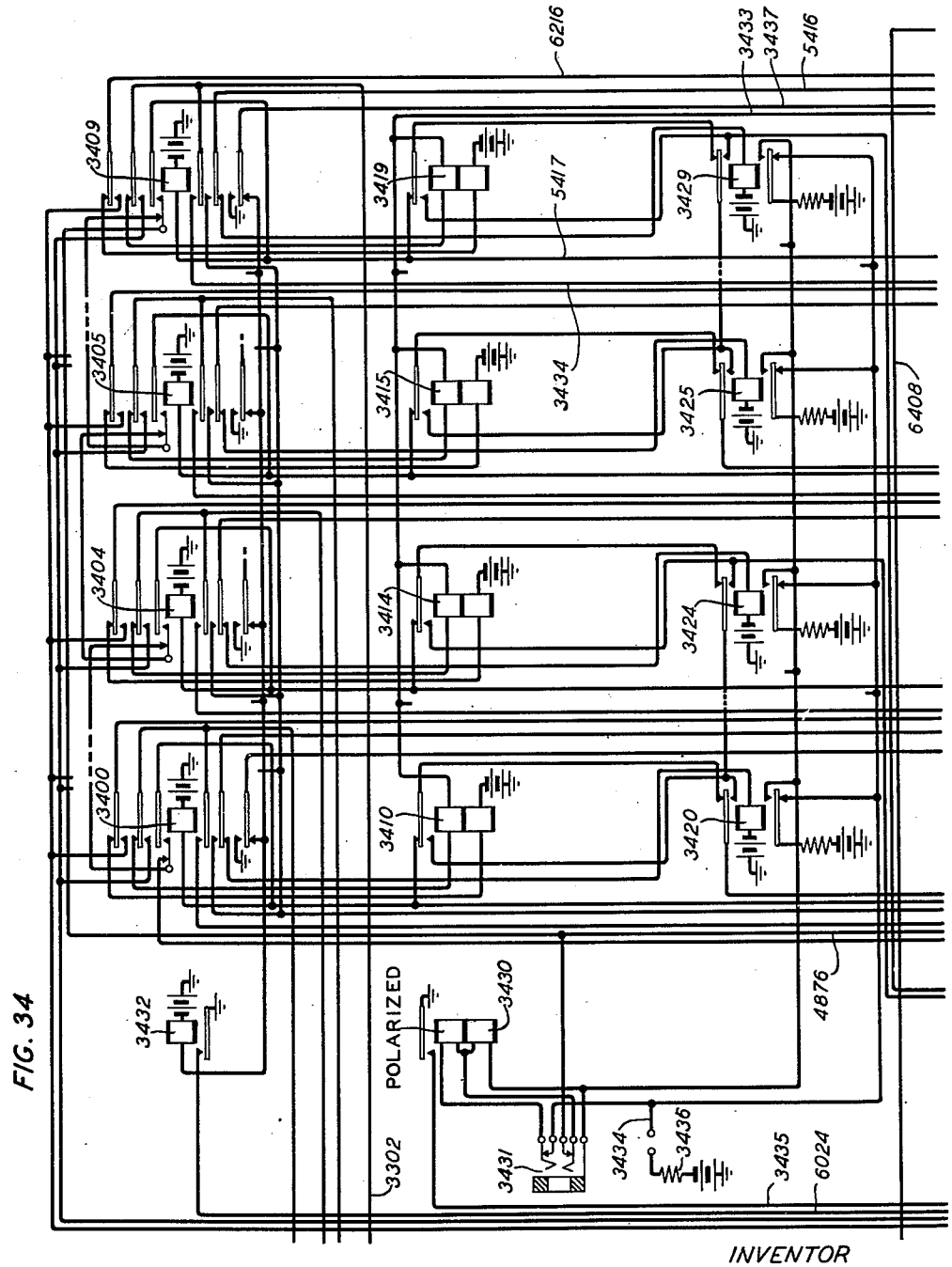

FIG. 34

INVENTOR
W. W. CARPENTER
BY
P. C. Smith
ATTORNEY

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DIAL TELEPHONE SYSTEM

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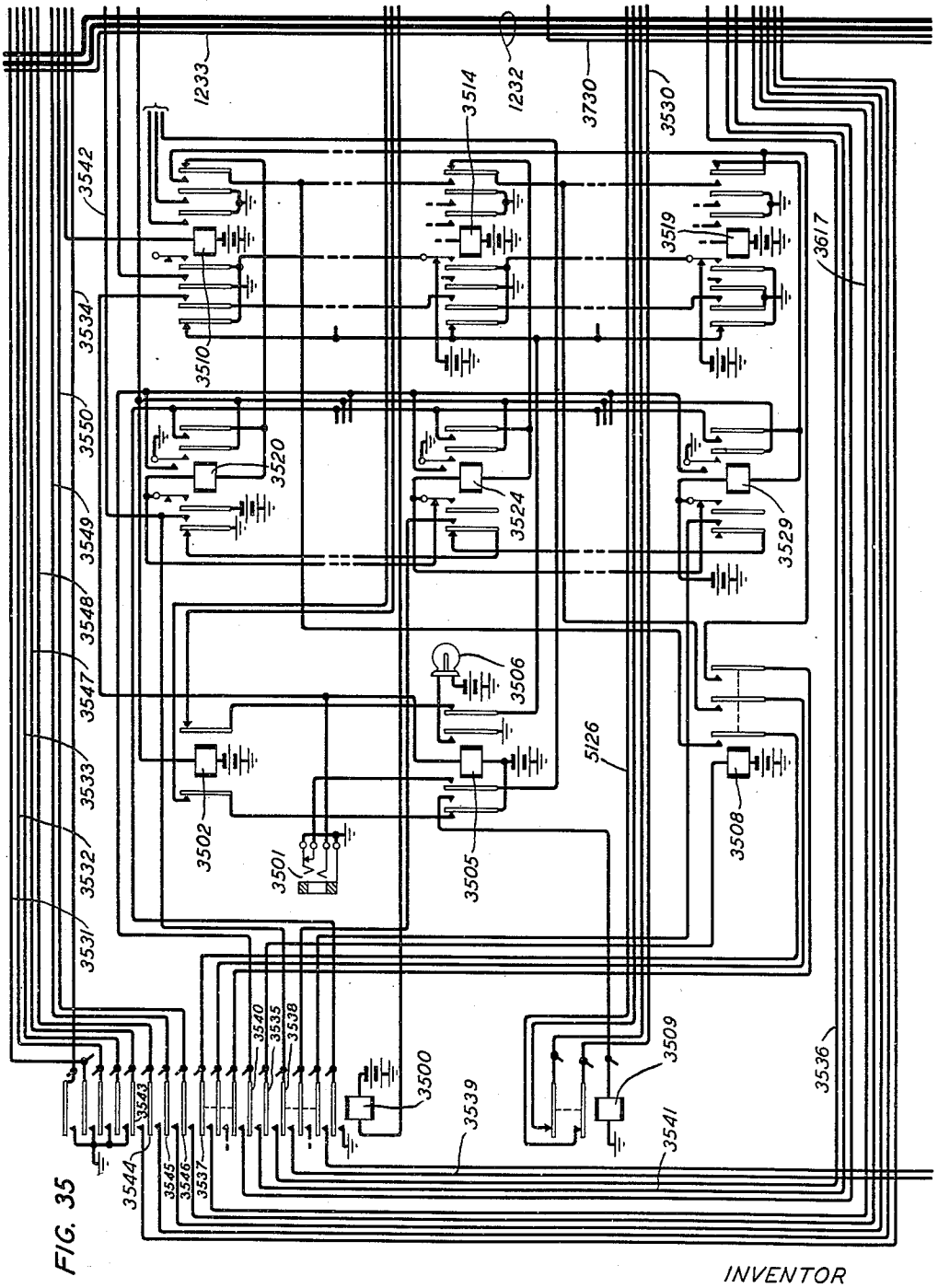

FIG. 35

INVENTOR
W. W. CARPENTER
BY
P. C. Smith
ATTORNEY

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DIAL TELEPHONE SYSTEM

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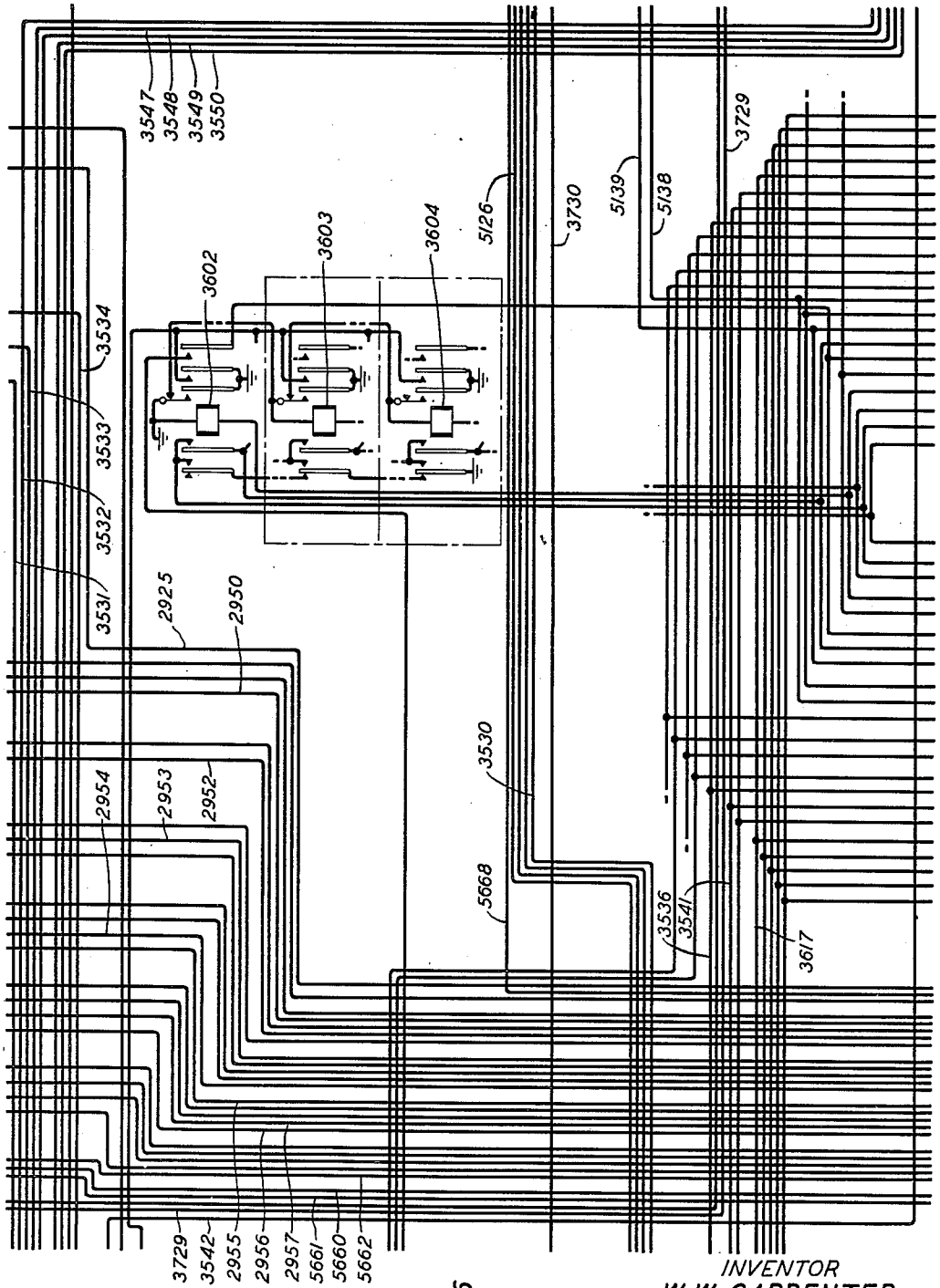

FIG. 36

INVENTOR
W. W. CARPENTER
BY
P. C. Smith
ATTORNEY

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DIAL TELEPHONE SYSTEM

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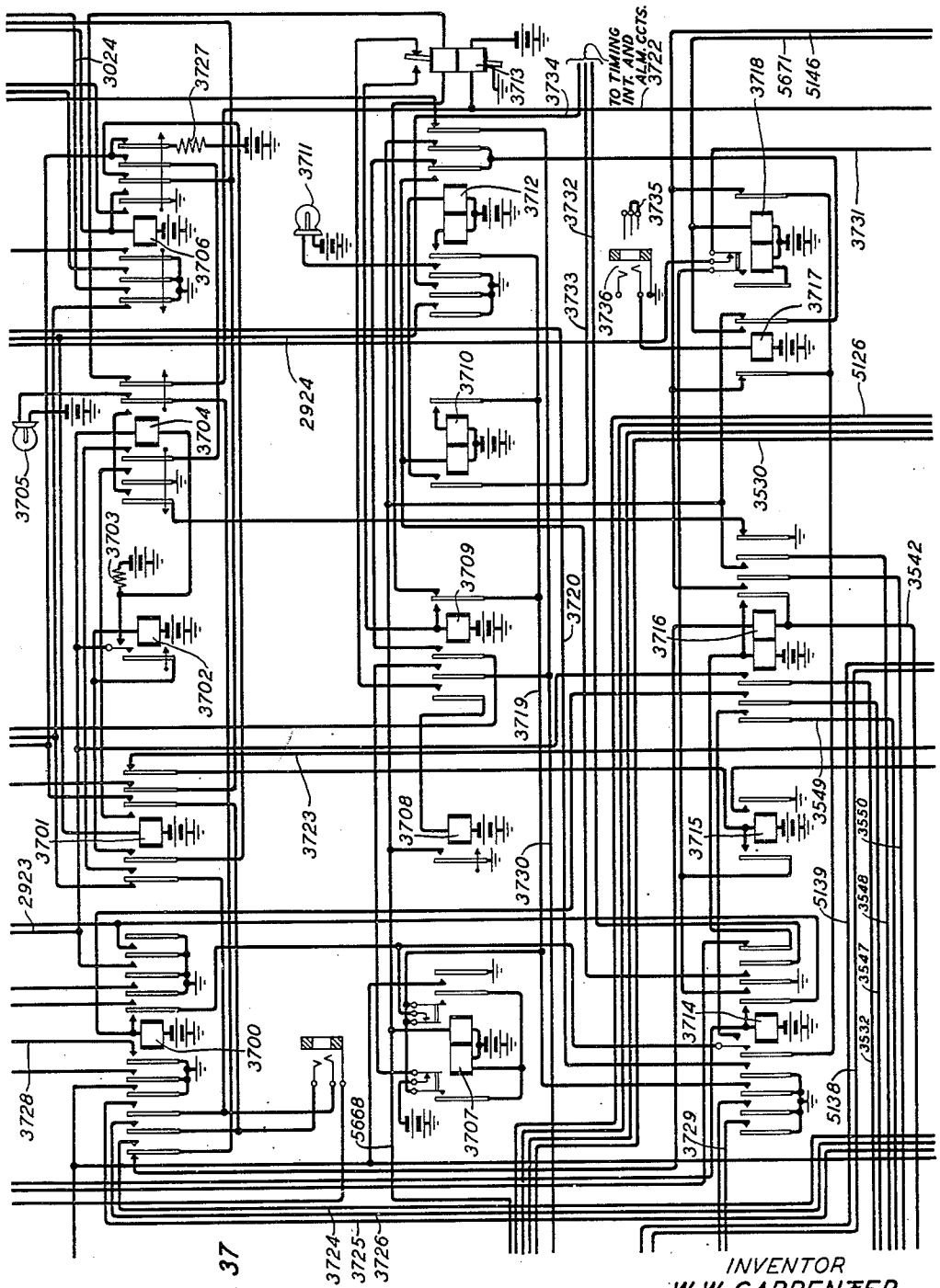

FIG. 37

INVENTOR
W. W. CARPENTER
BY
P. C. Smith
ATTORNEY

Aug. 10, 1937. W. W. CARPENTER 2,089,921

DIAL TELEPHONE SYSTEM

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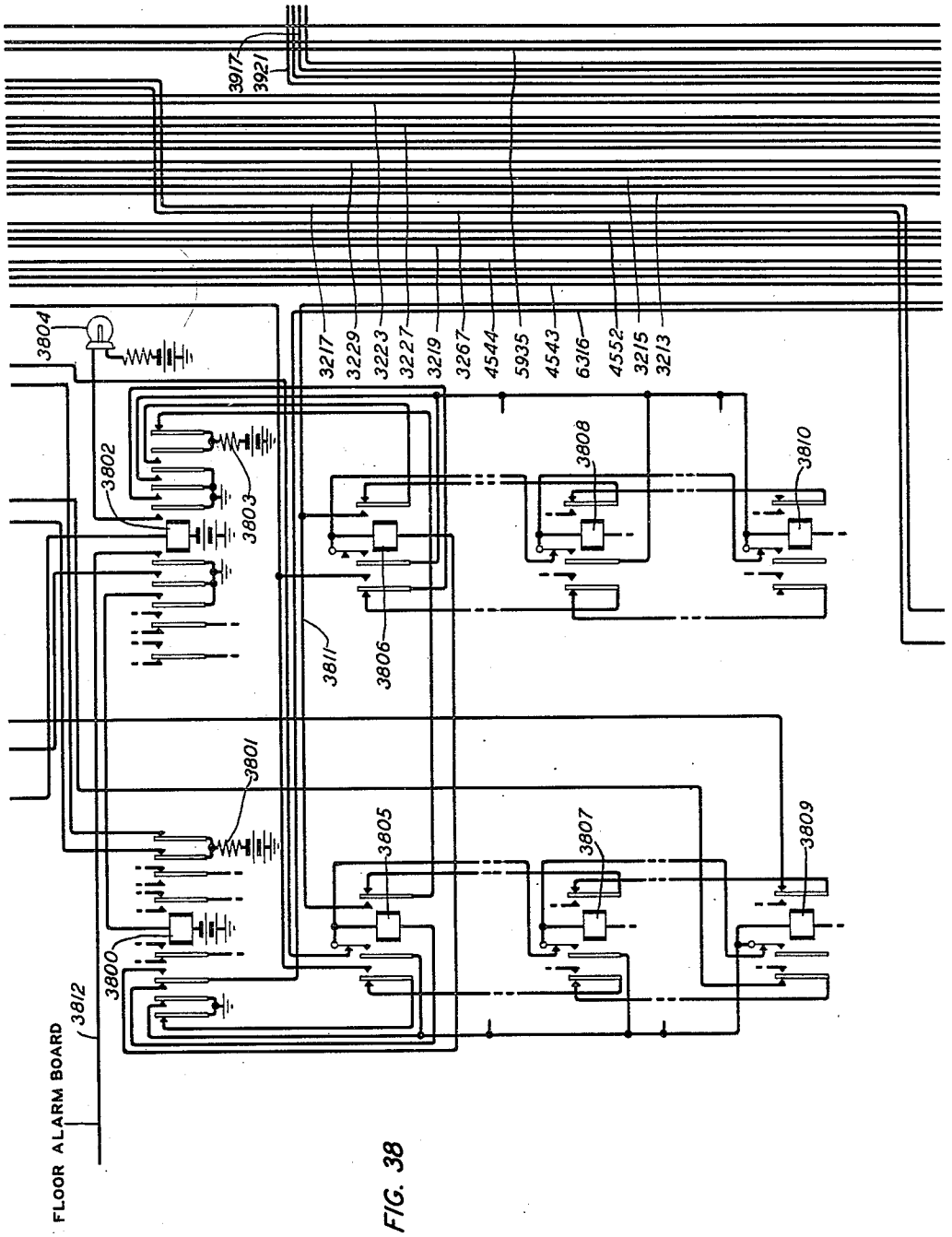

FIG. 38

INVENTOR
W.W. CARPENTER
BY P. C. Smith
ATTORNEY

Aug. 10, 1937. W. W. CARPENTER 2,089,921

DIAL TELEPHONE SYSTEM

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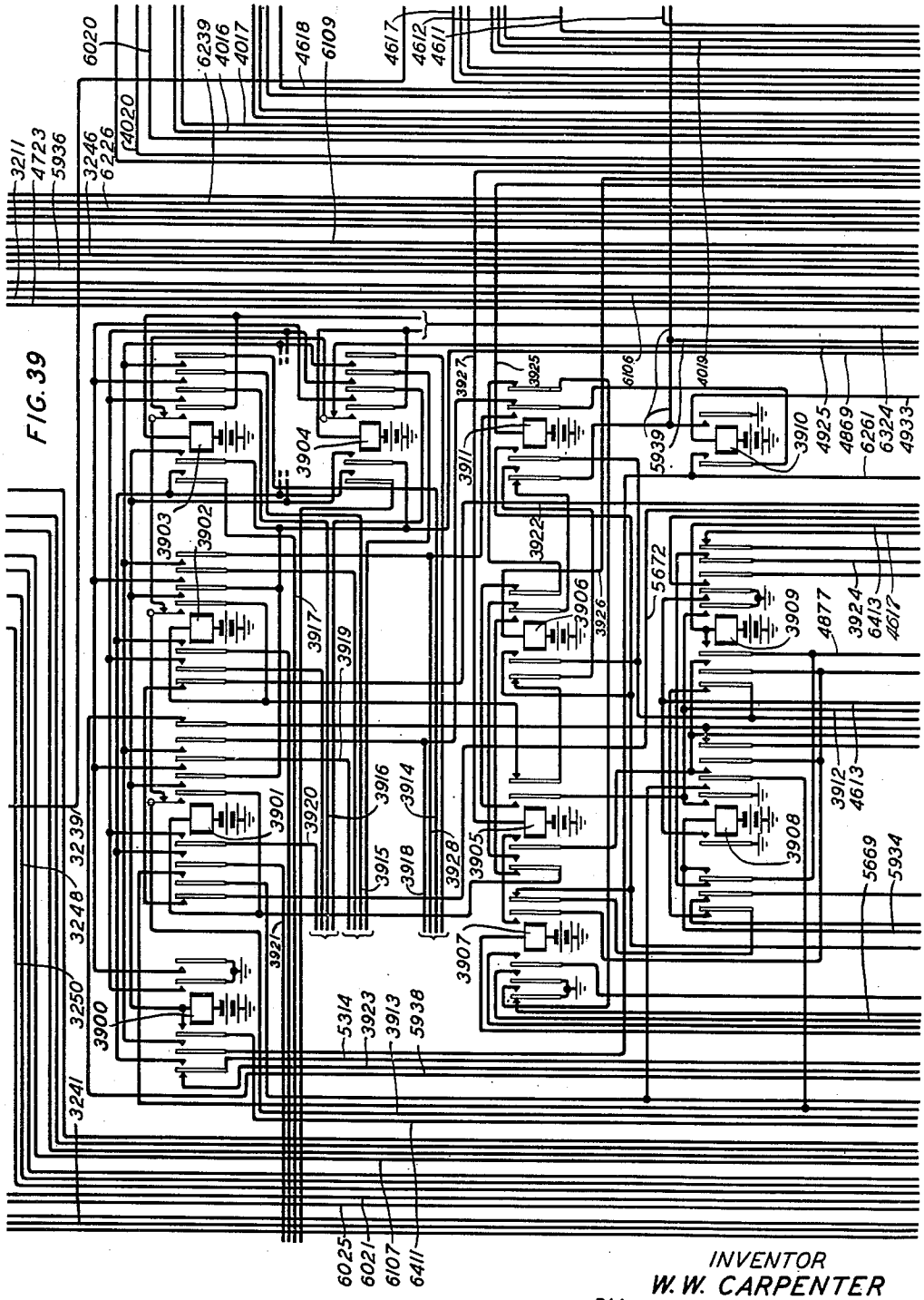

FIG. 39

INVENTOR
W. W. CARPENTER
BY
P. C. Smith
ATTORNEY

Aug. 10, 1937. W. W. CARPENTER 2,089,921

DIAL TELEPHONE SYSTEM

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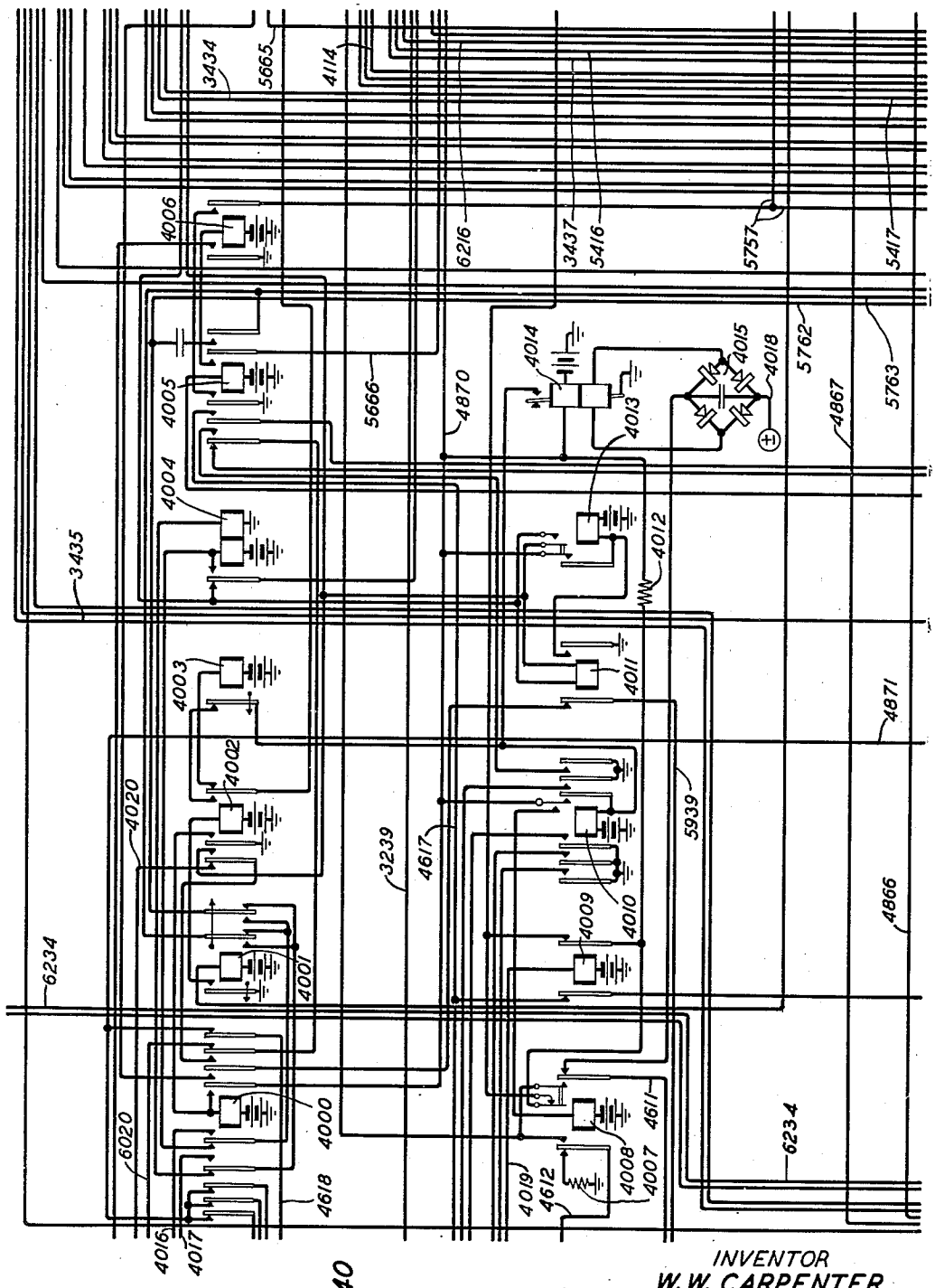

FIG. 40

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Aug. 10, 1937. W. W. CARPENTER 2,089,921

DIAL TELEPHONE SYSTEM

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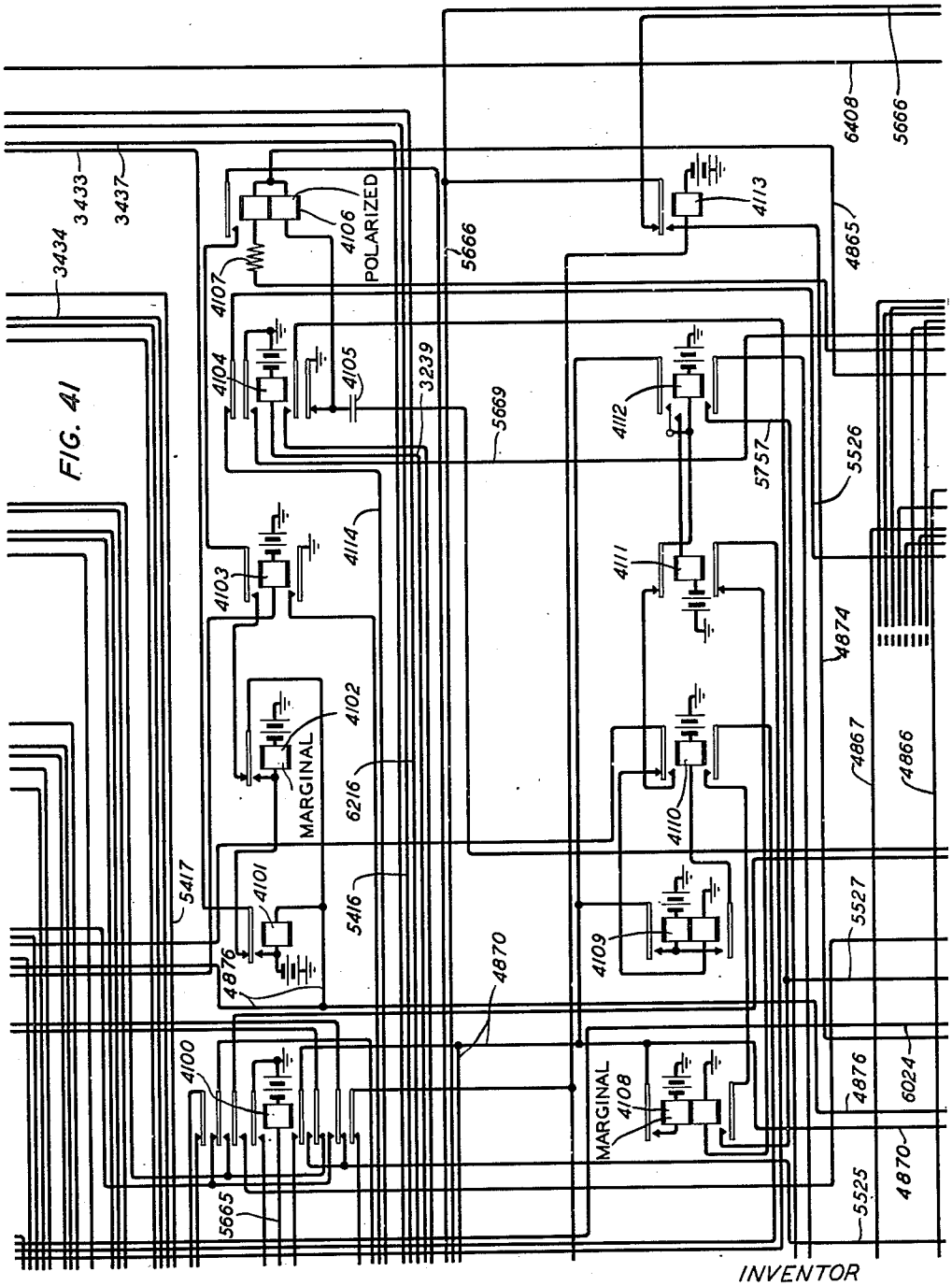

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DIAL TELEPHONE SYSTEM

Filed March 11, 1936 64 Sheets-Sheet 42

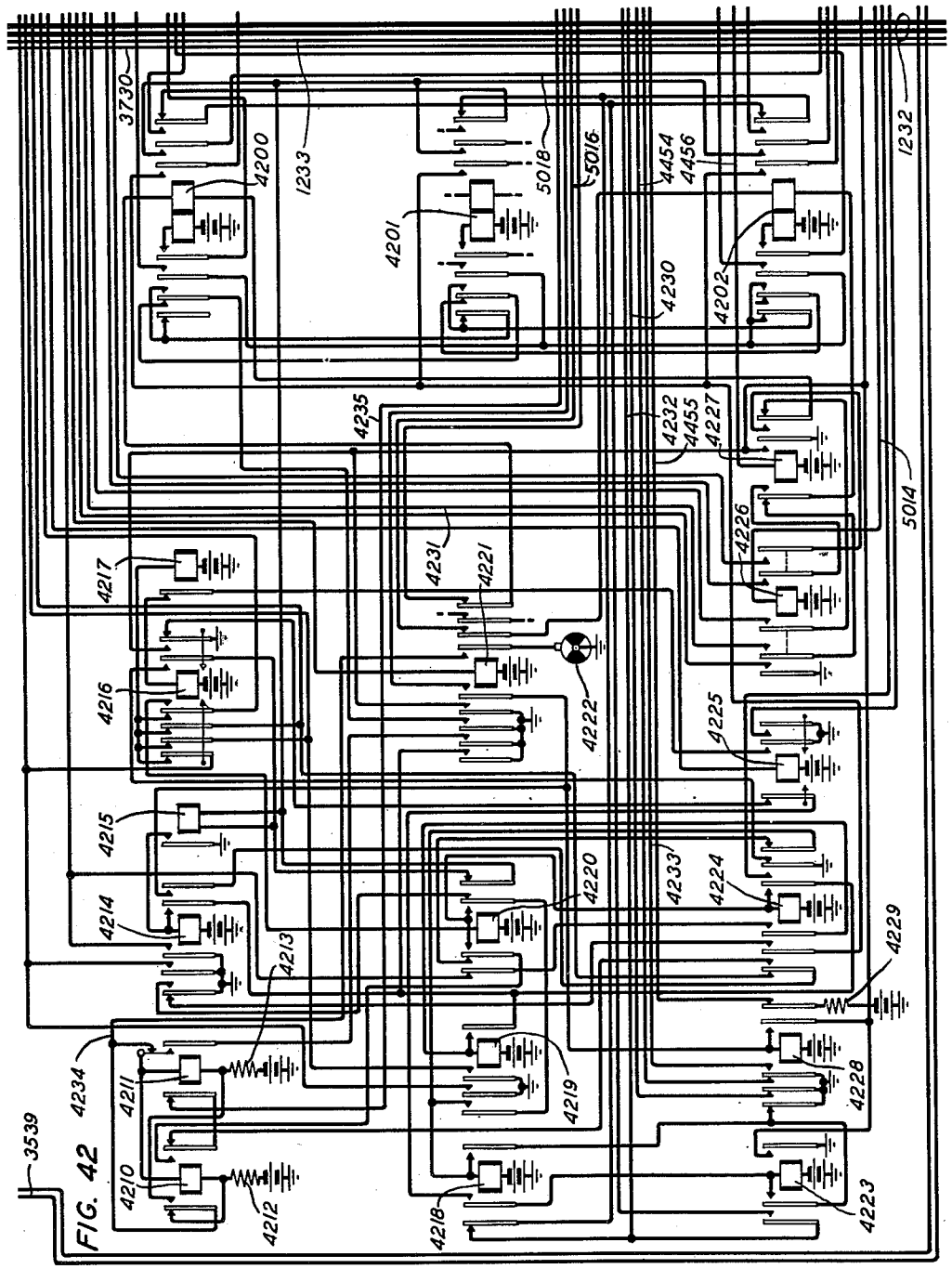

FIG. 42

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DIAL TELEPHONE SYSTEM

Filed March 11, 1936 64 Sheets-Sheet 43

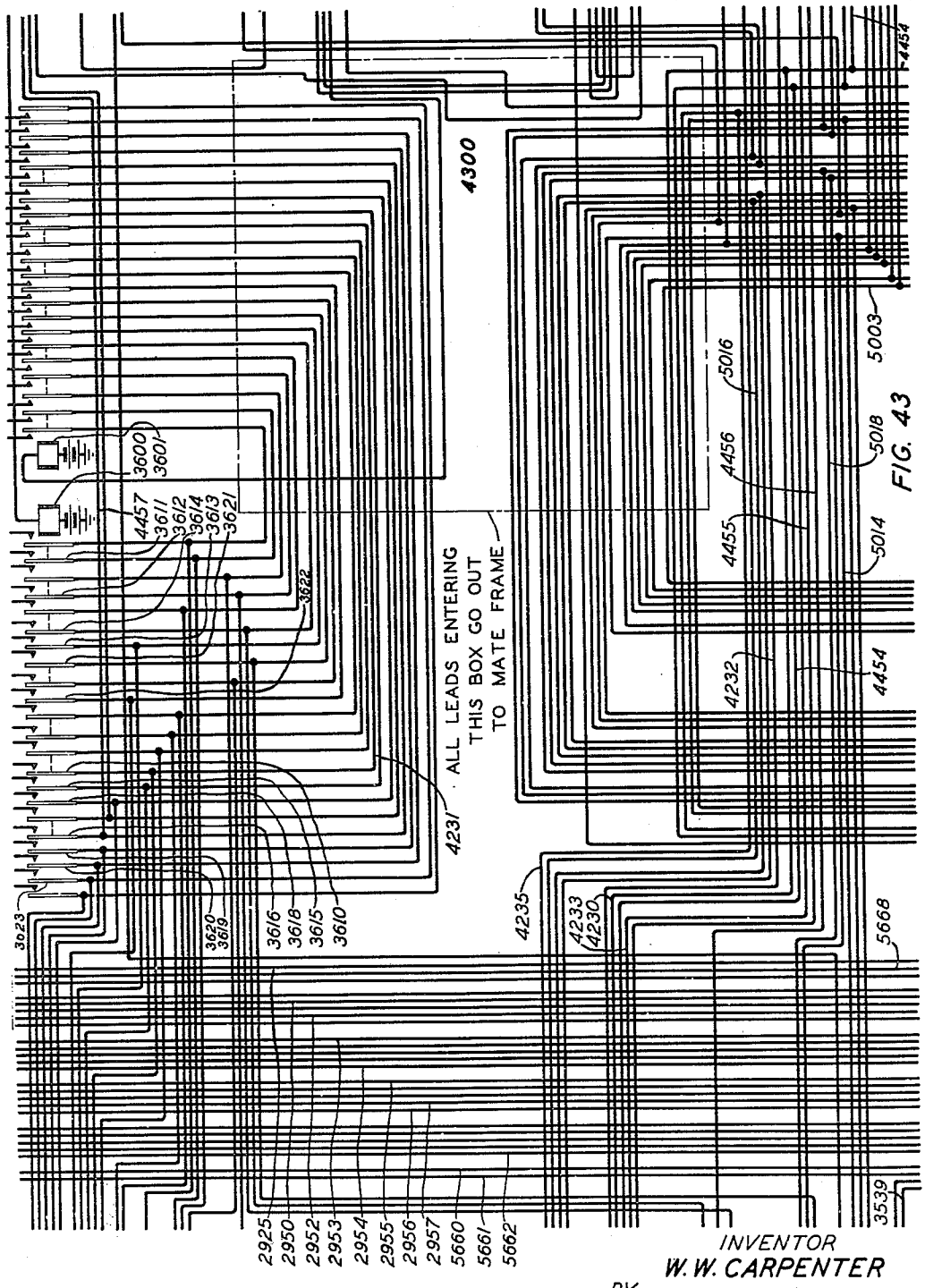

FIG. 43

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DIAL TELEPHONE SYSTEM

Filed March 11, 1936 64 Sheets-Sheet 44

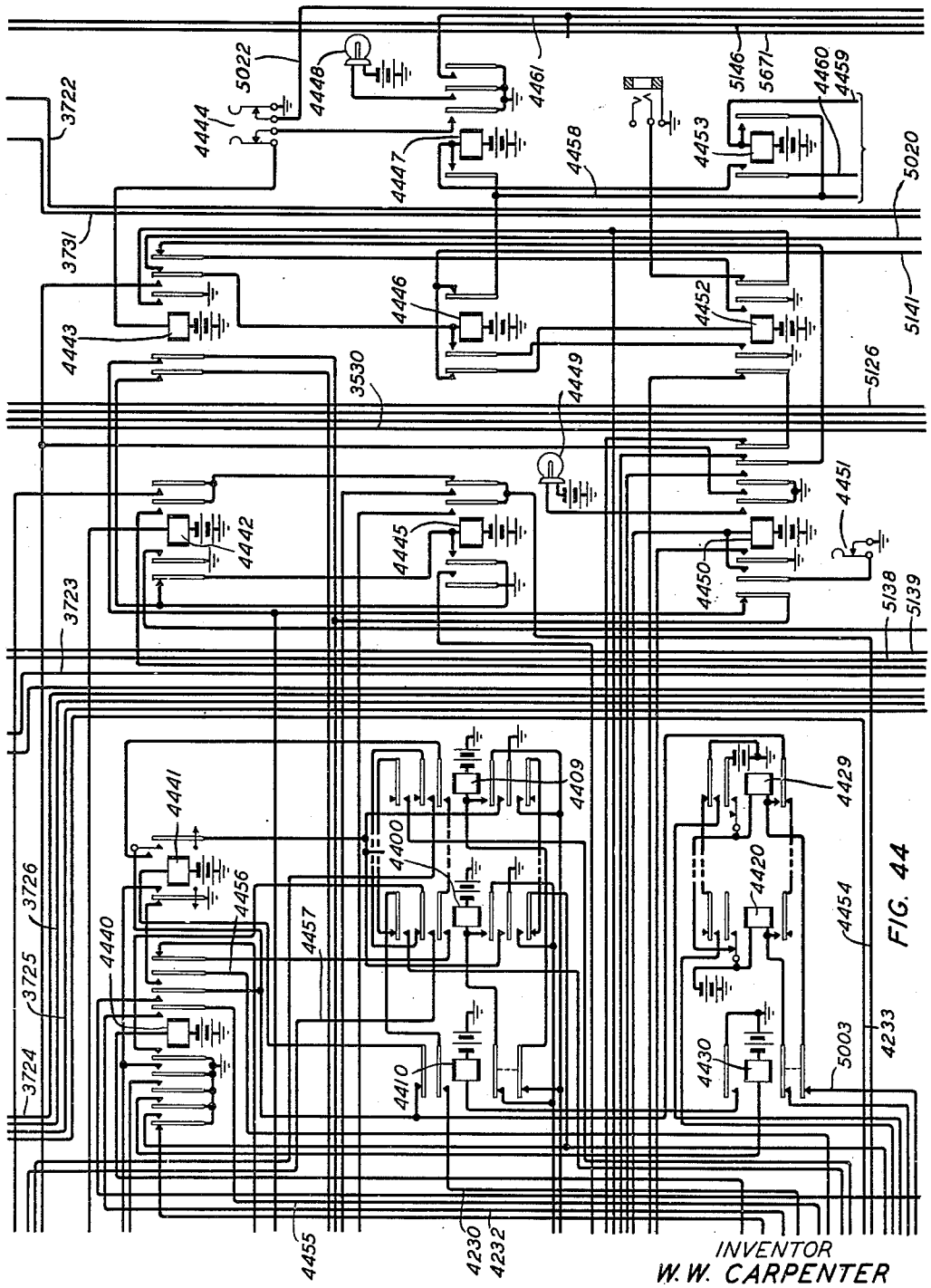

FIG. 44

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DIAL TELEPHONE SYSTEM

Filed March 11, 1936 64 Sheets-Sheet 45

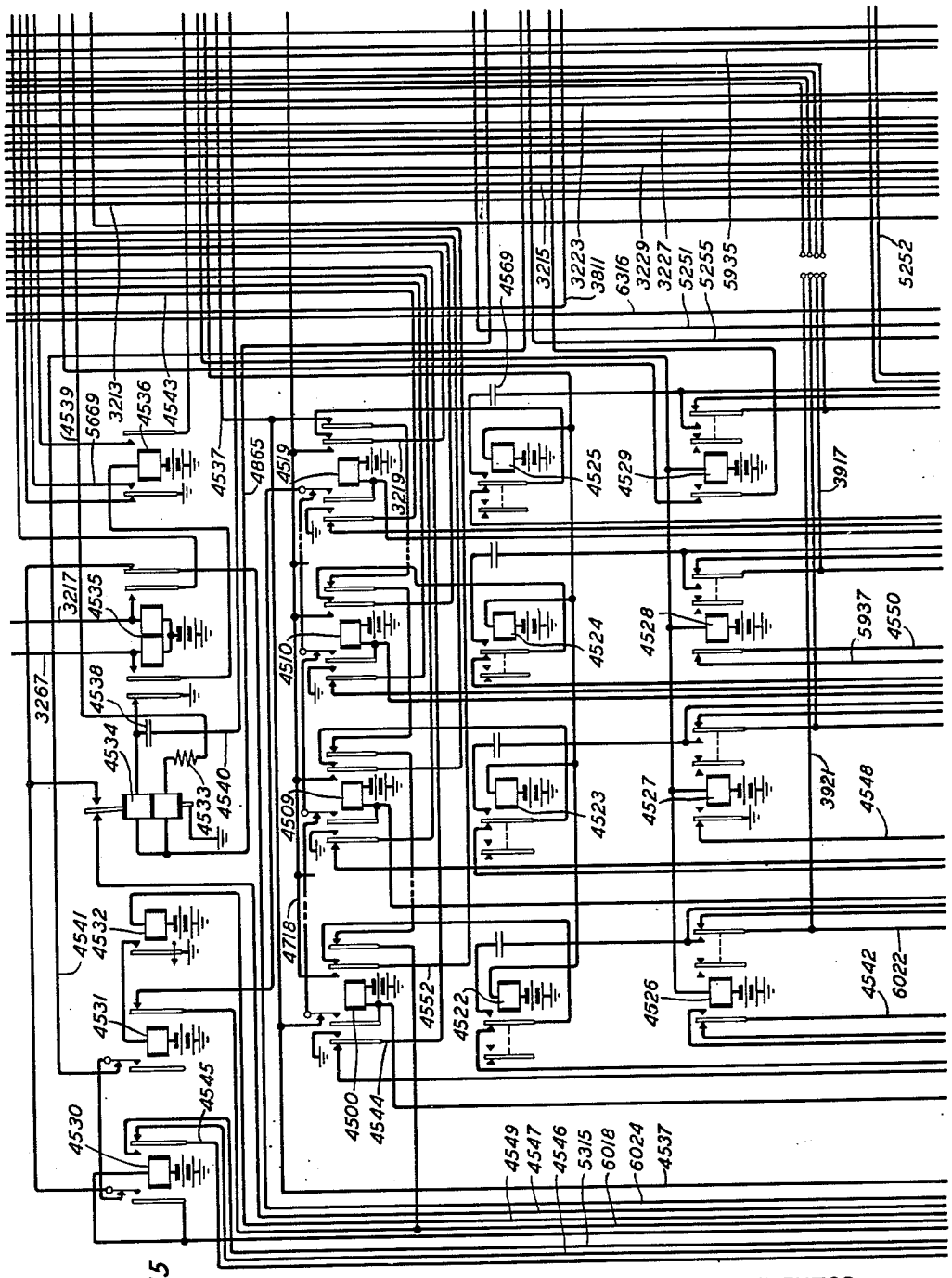

FIG. 45

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DIAL TELEPHONE SYSTEM

Filed March 11, 1936 64 Sheets-Sheet 46

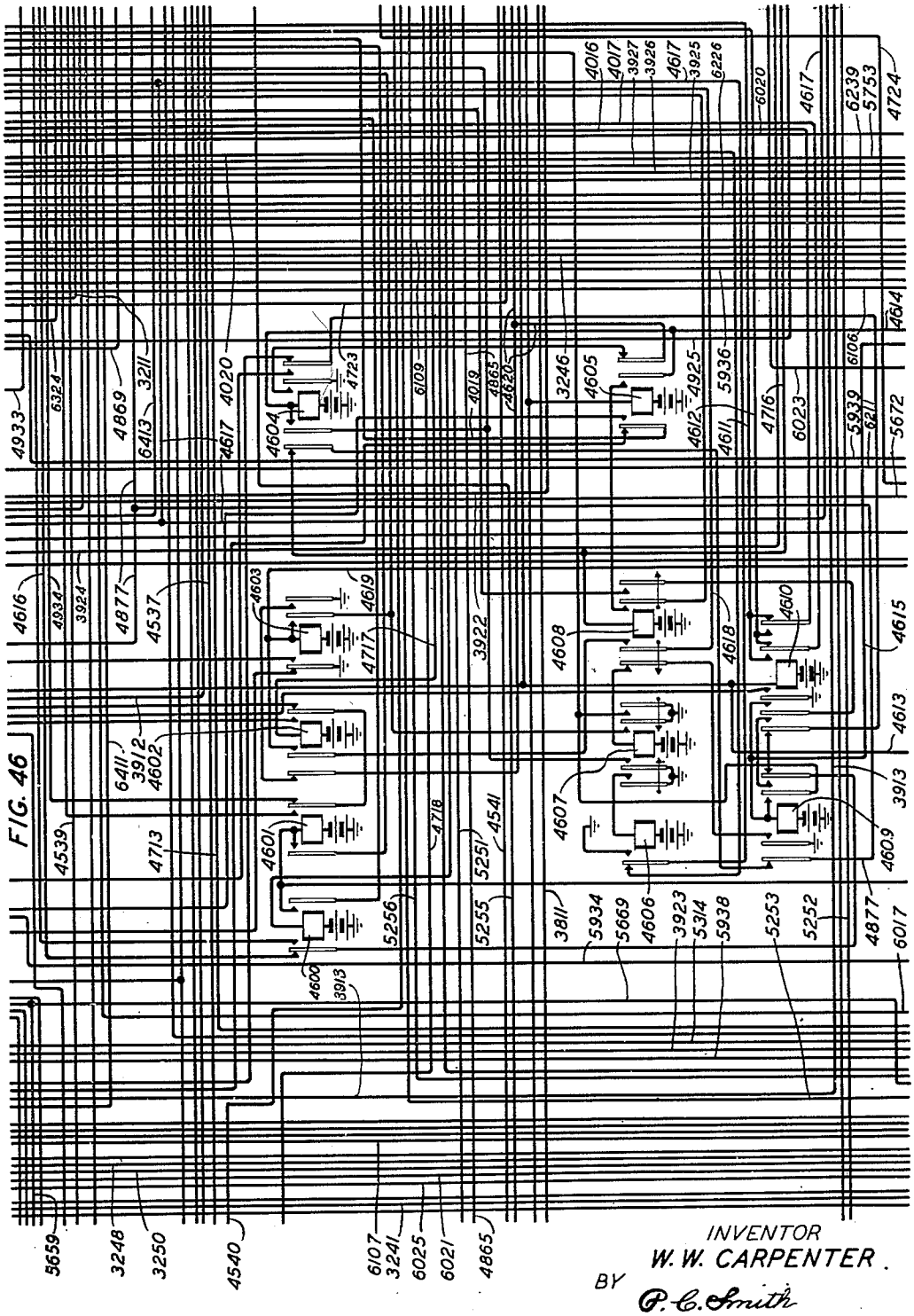

FIG. 46

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DIAL TELEPHONE SYSTEM

Filed March 11, 1936 64 Sheets-Sheet 47

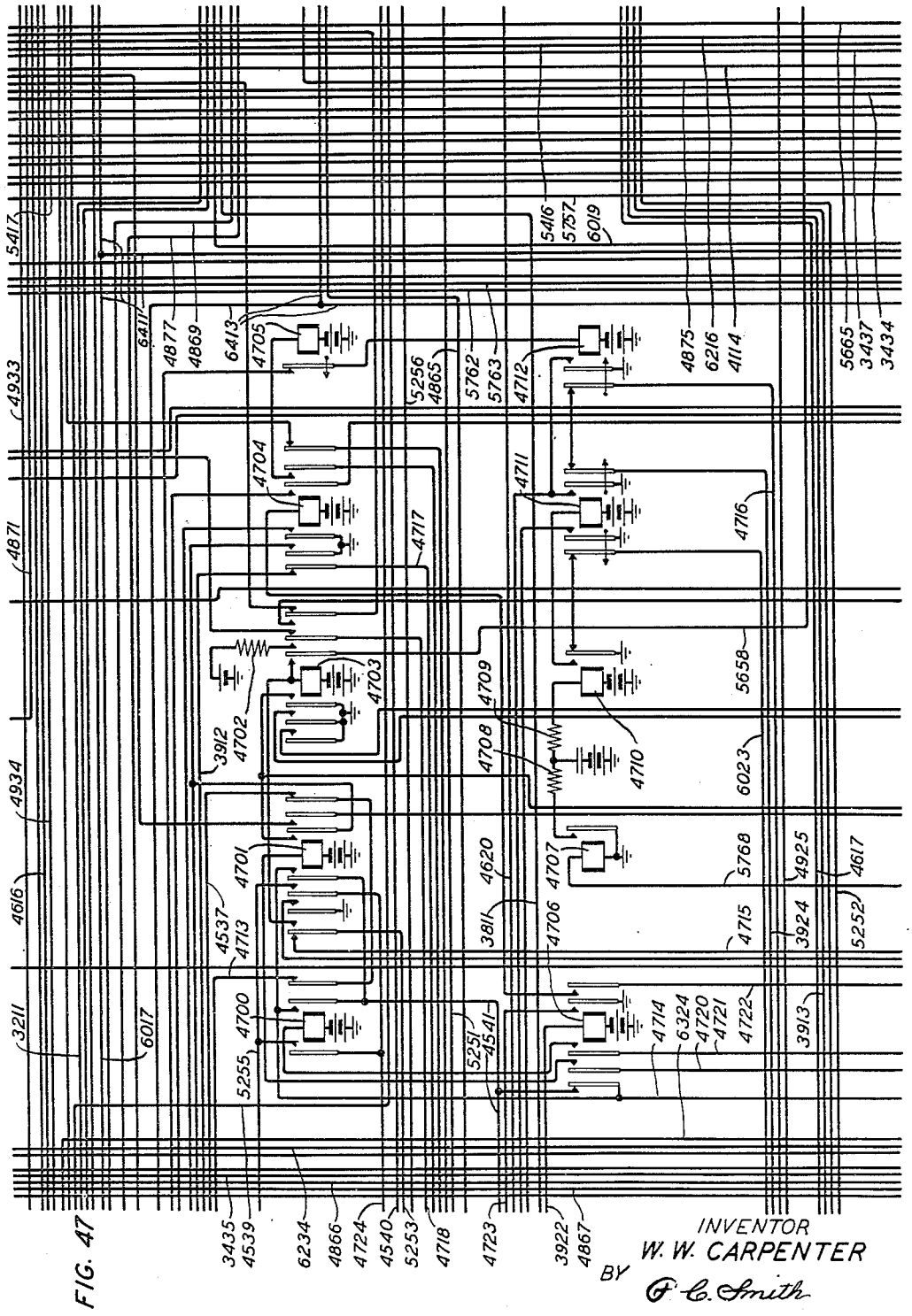

FIG. 47

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DIAL TELEPHONE SYSTEM

Filed March 11, 1936 64 Sheets-Sheet 48

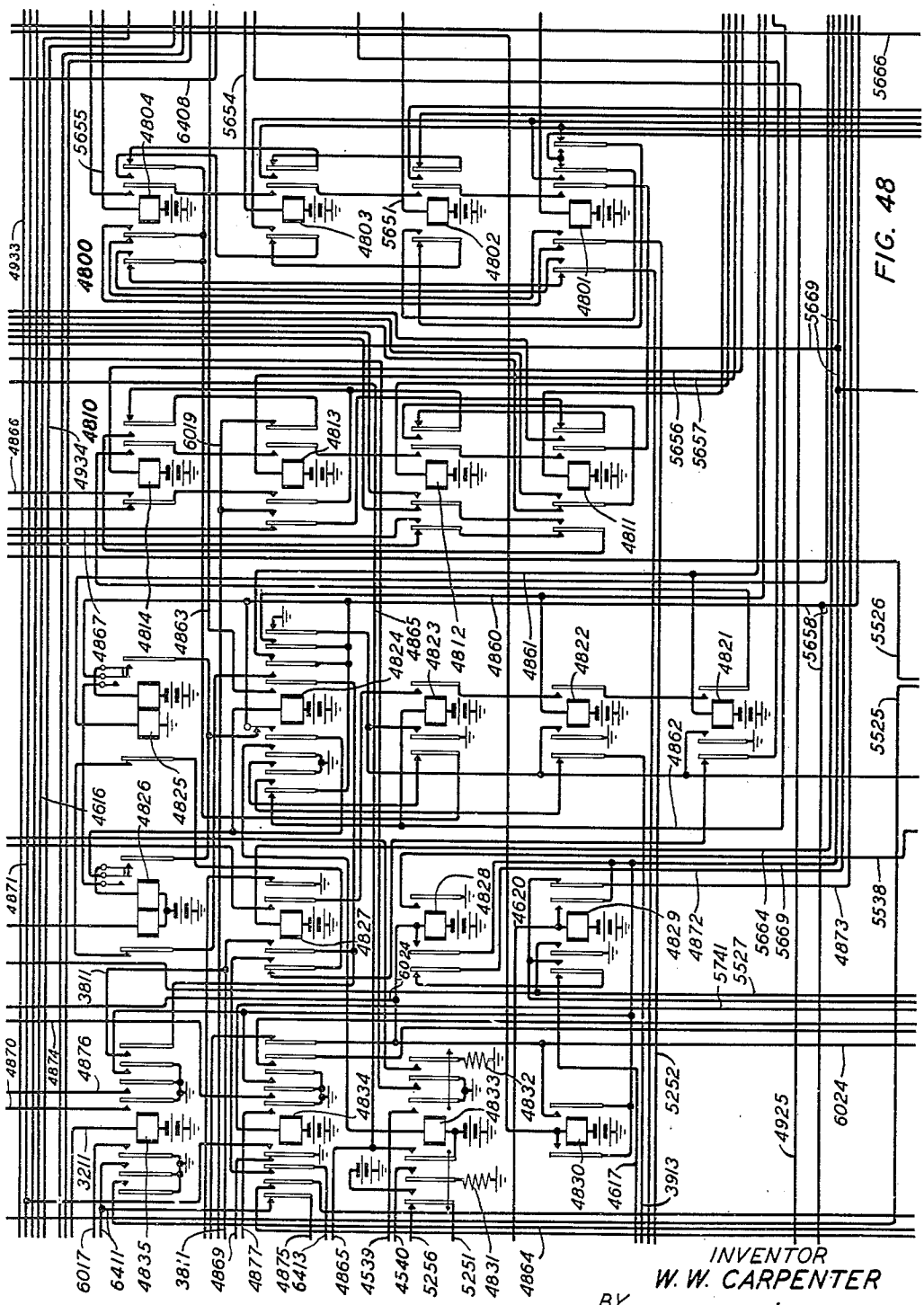

FIG. 48

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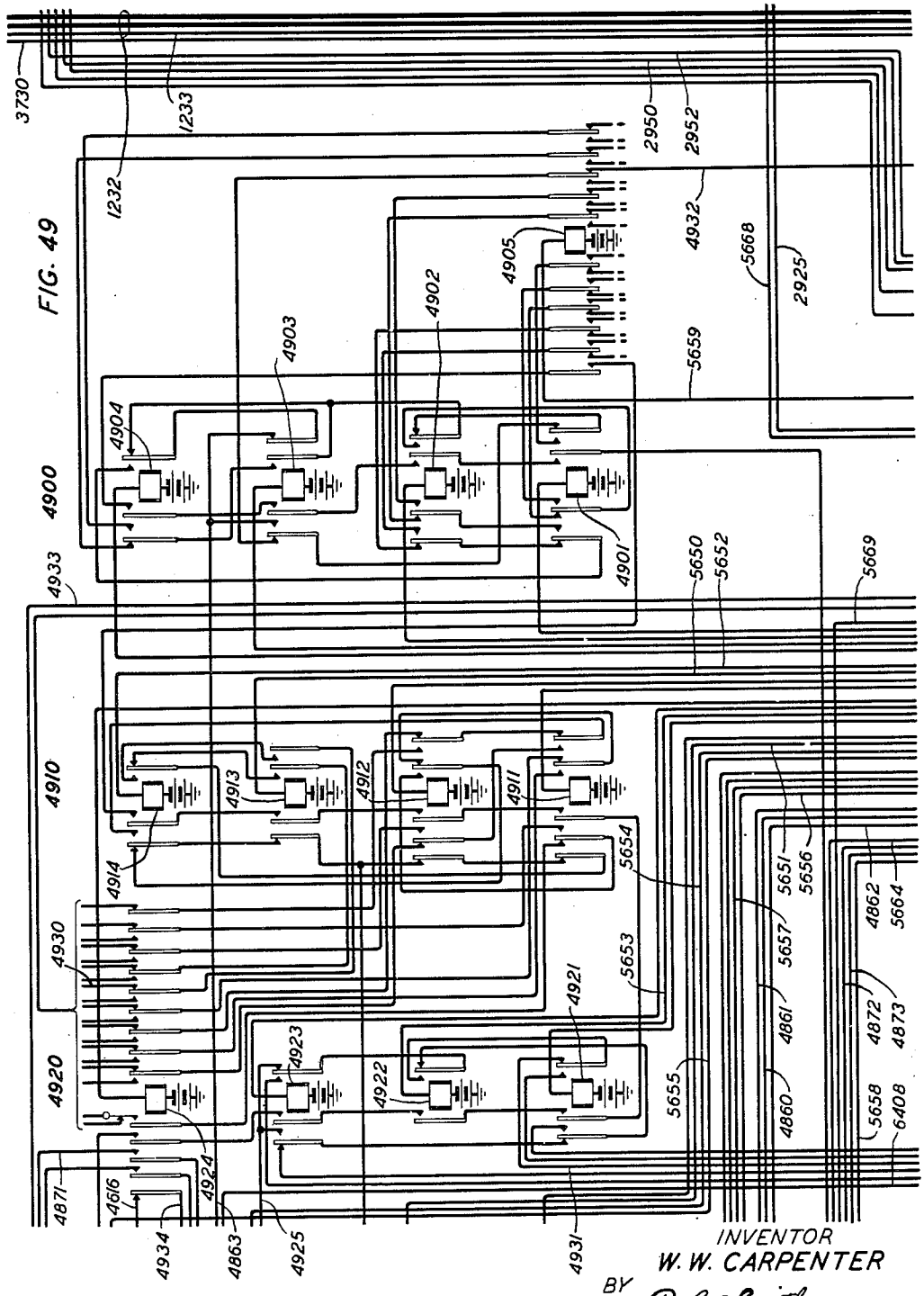
DIAL TELEPHONE SYSTEM

Filed March 11, 1936 64 Sheets-Sheet 49



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DIAL TELEPHONE SYSTEM

Filed March 11, 1936 64 Sheets-Sheet 50

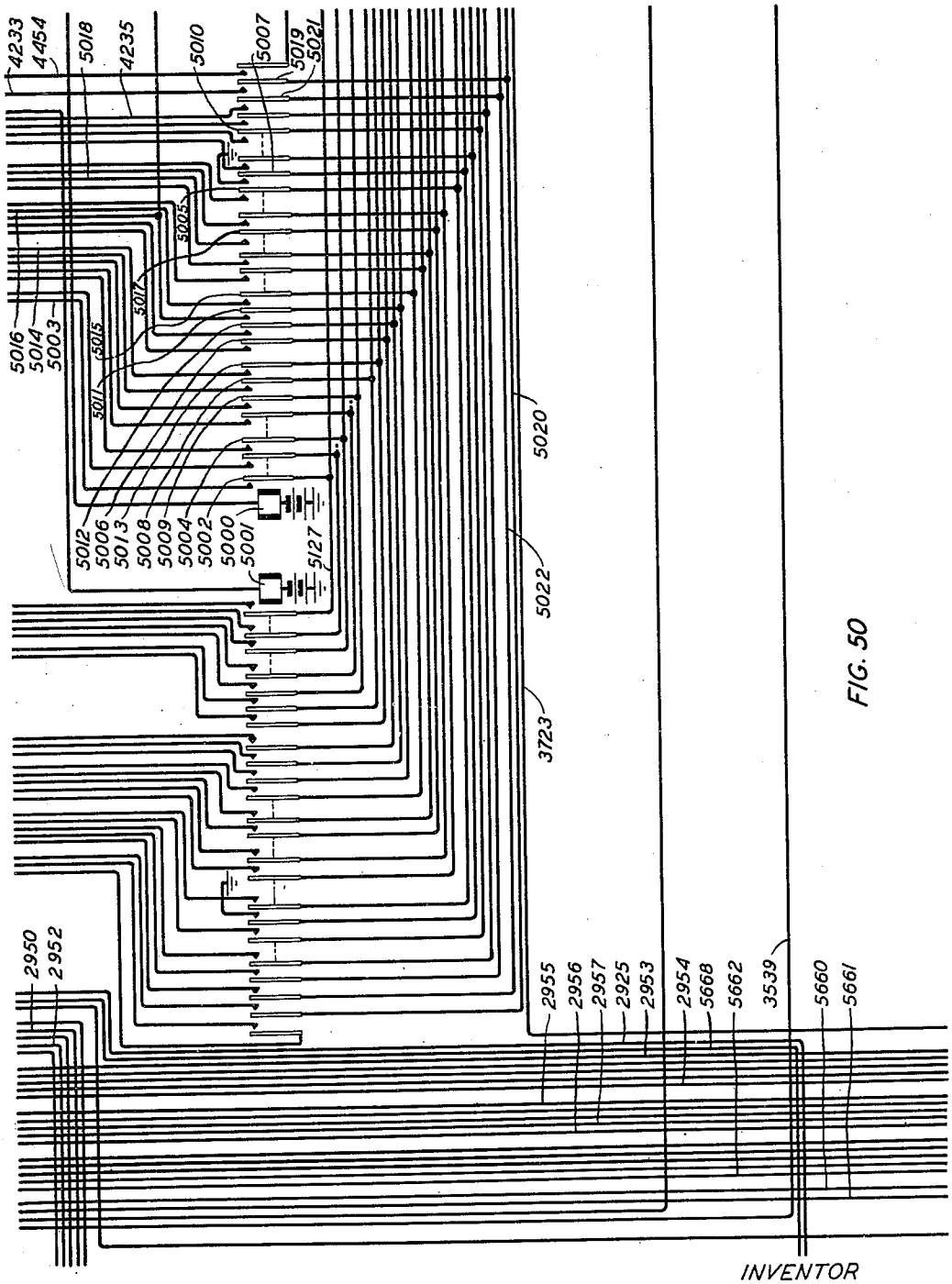

FIG. 50

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DIAL TELEPHONE SYSTEM

Filed March 11, 1936 64 Sheets-Sheet 51

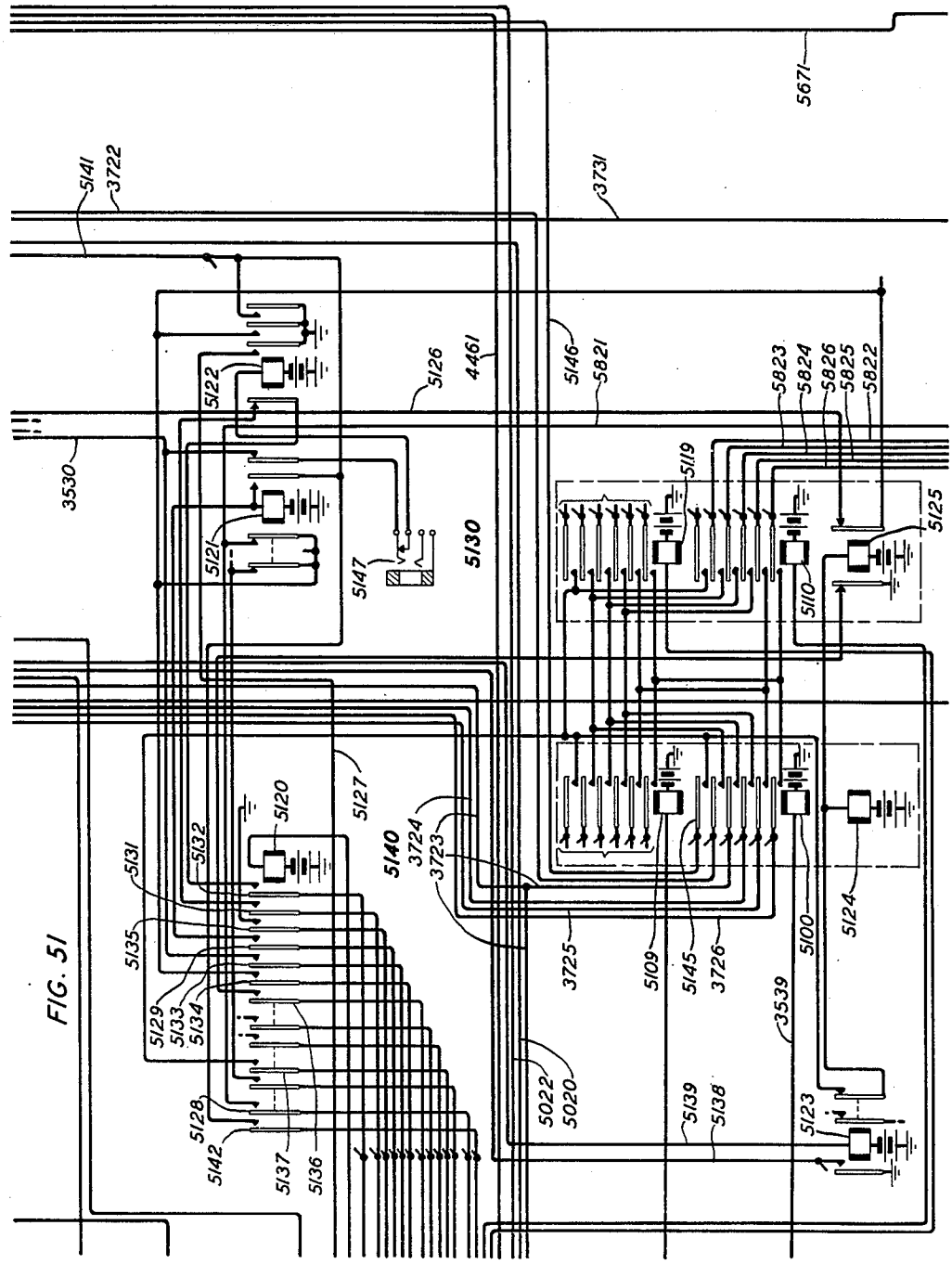

FIG. 51

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DIAL TELEPHONE SYSTEM

Filed March 11, 1936 64 Sheets-Sheet 52

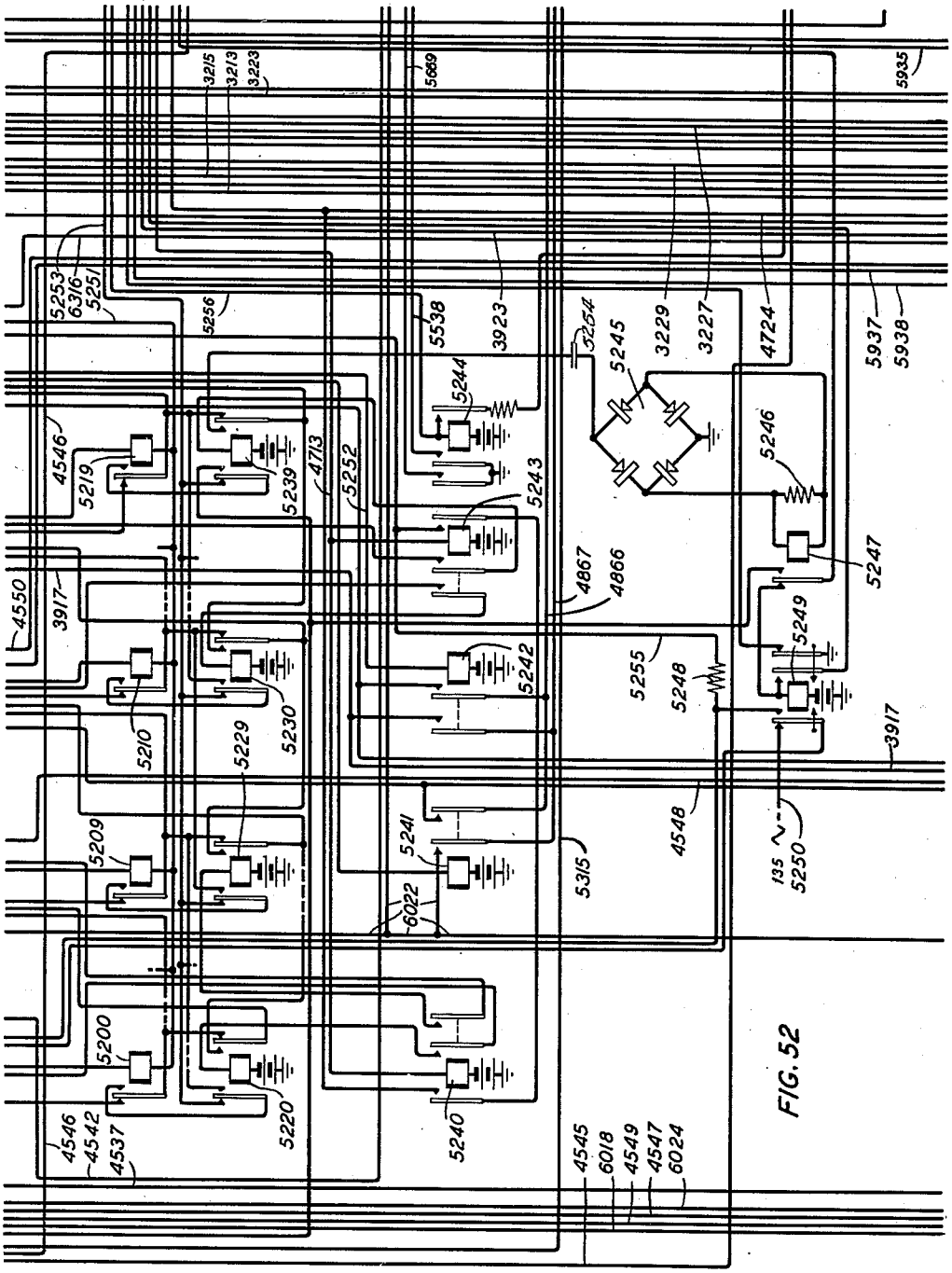

FIG. 52

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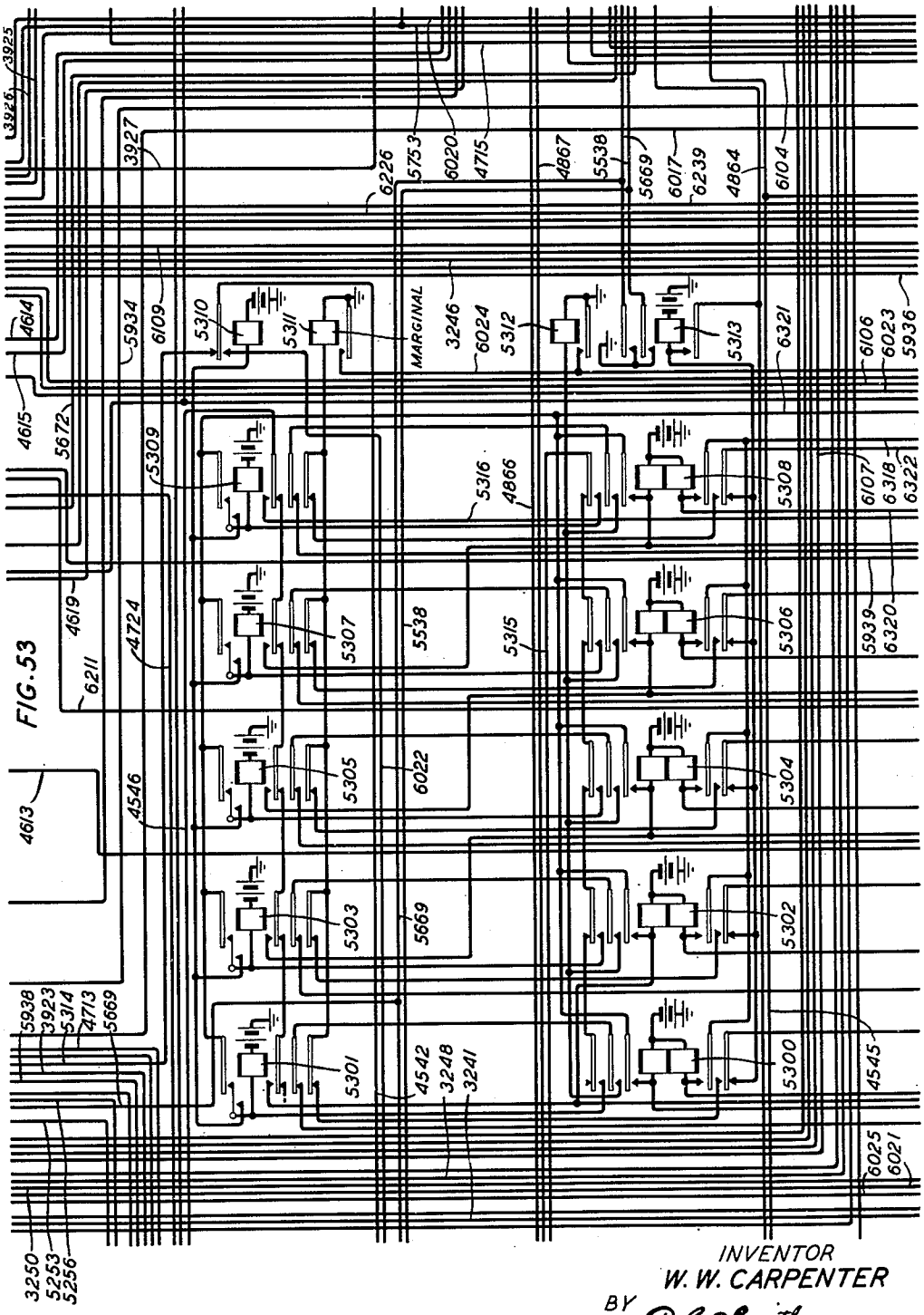
DIAL TELEPHONE SYSTEM

Filed March 11, 1936 64 Sheets-Sheet 53



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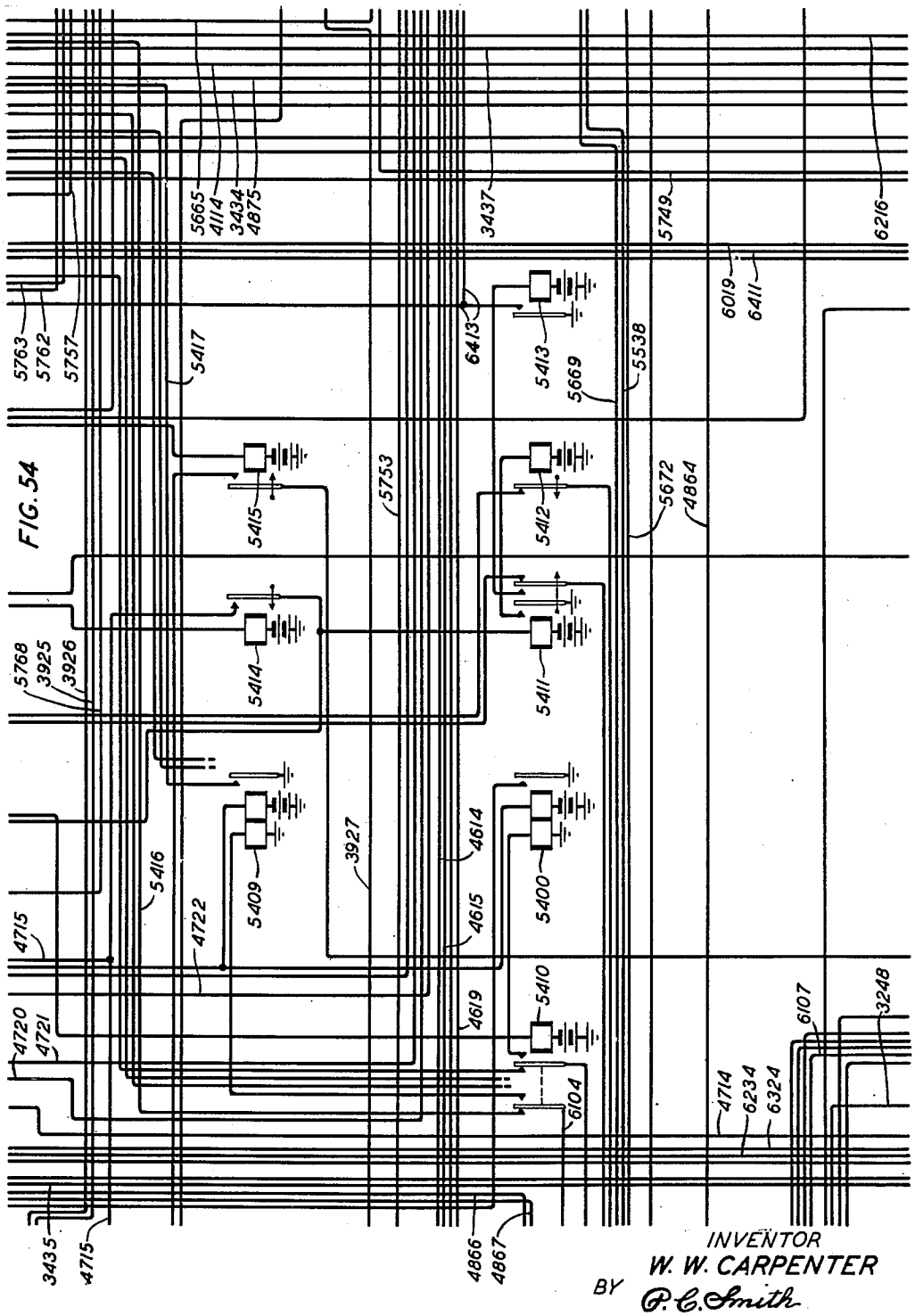
DIAL TELEPHONE SYSTEM

Filed March 11, 1936 64 Sheets-Sheet 54



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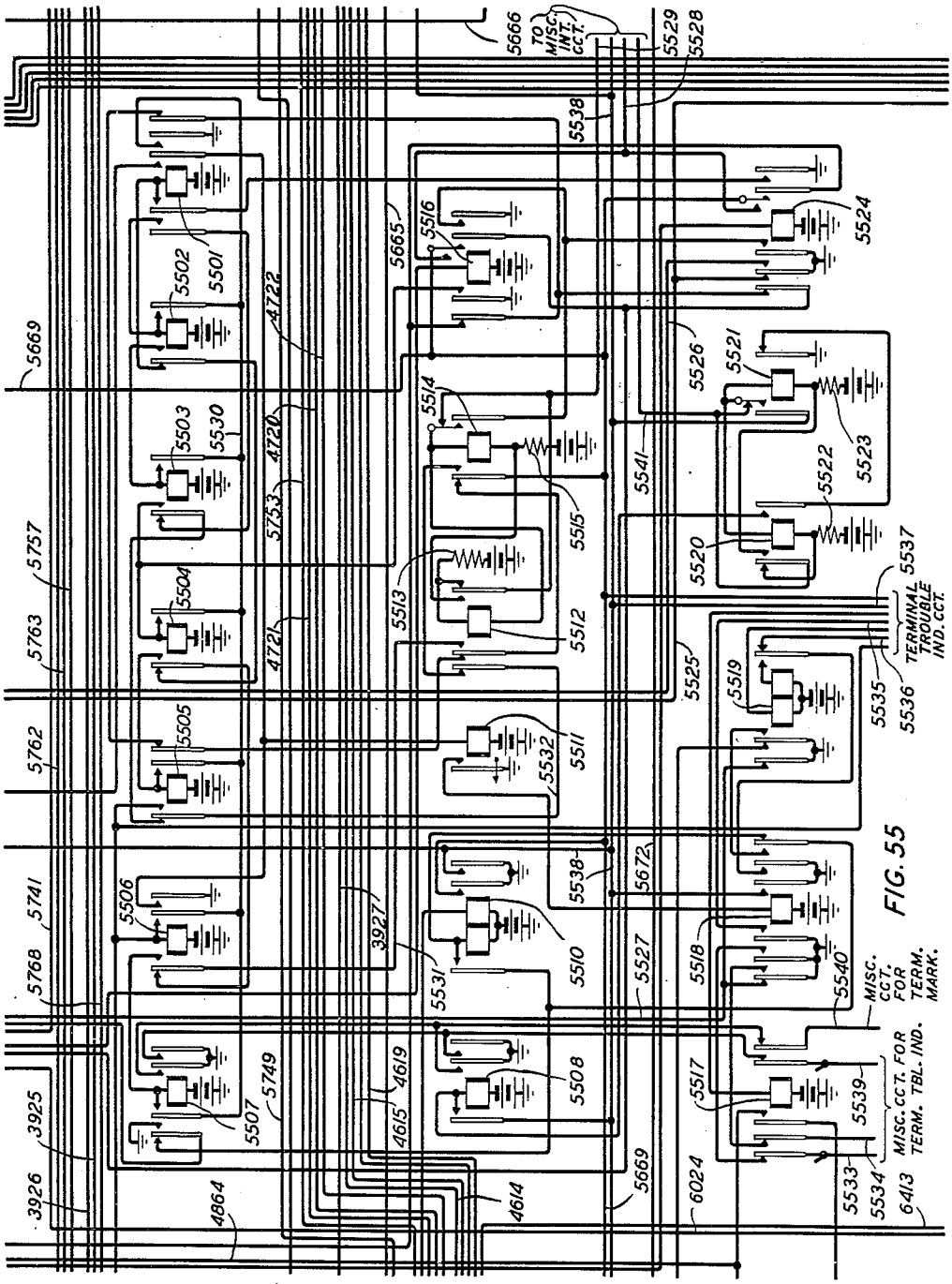
DIAL TELEPHONE SYSTEM

Filed March 11, 1936 64 Sheets-Sheet 55



F/G. 55

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DIAL TELEPHONE SYSTEM

Filed March 11, 1936 64 Sheets-Sheet 56

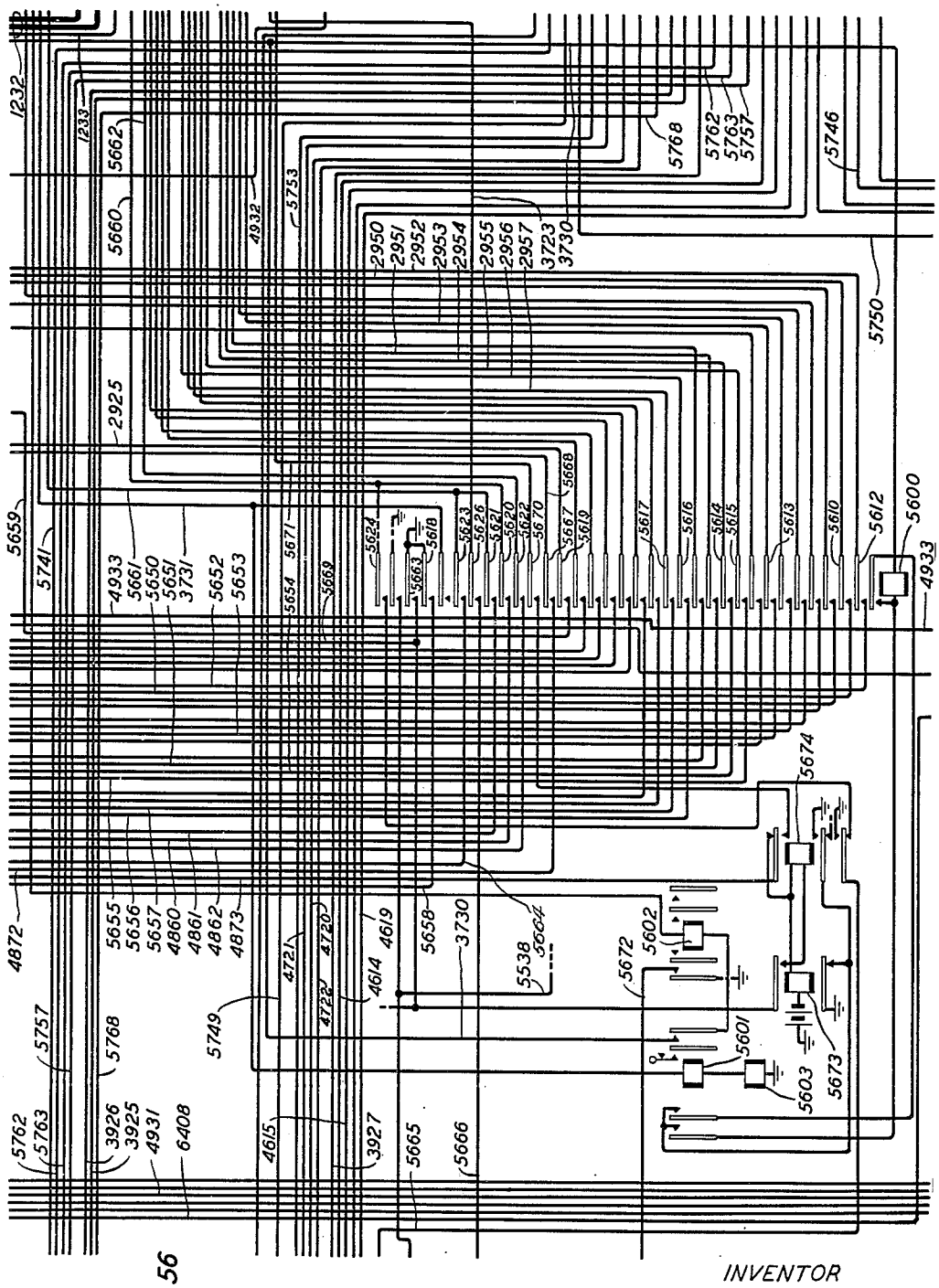

FIG. 56

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DIAL TELEPHONE SYSTEM

Filed March 11, 1936 64 Sheets-Sheet 57

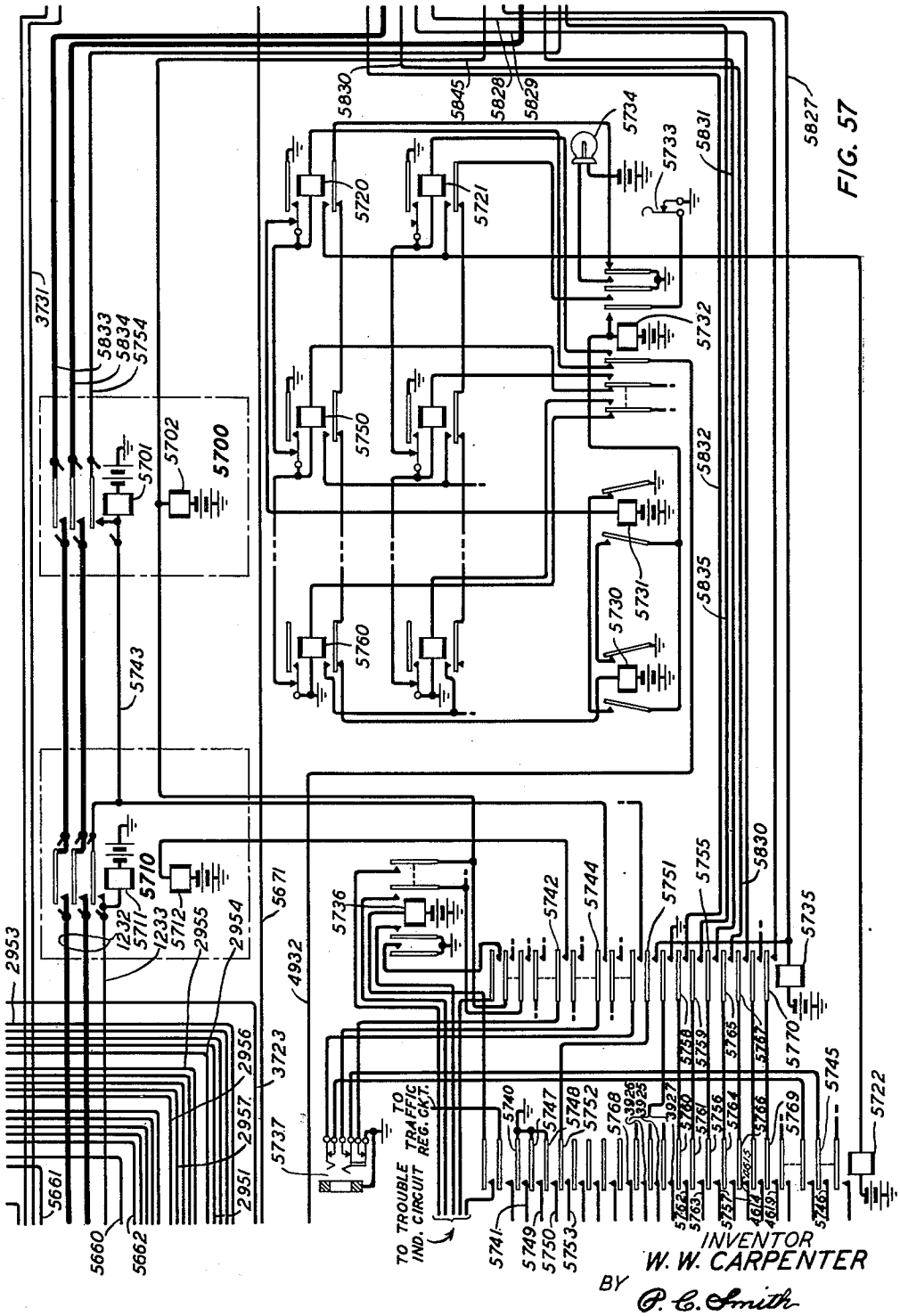

FIG. 57

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DIAL TELEPHONE SYSTEM

Filed March 11, 1936 64 Sheets-Sheet 58

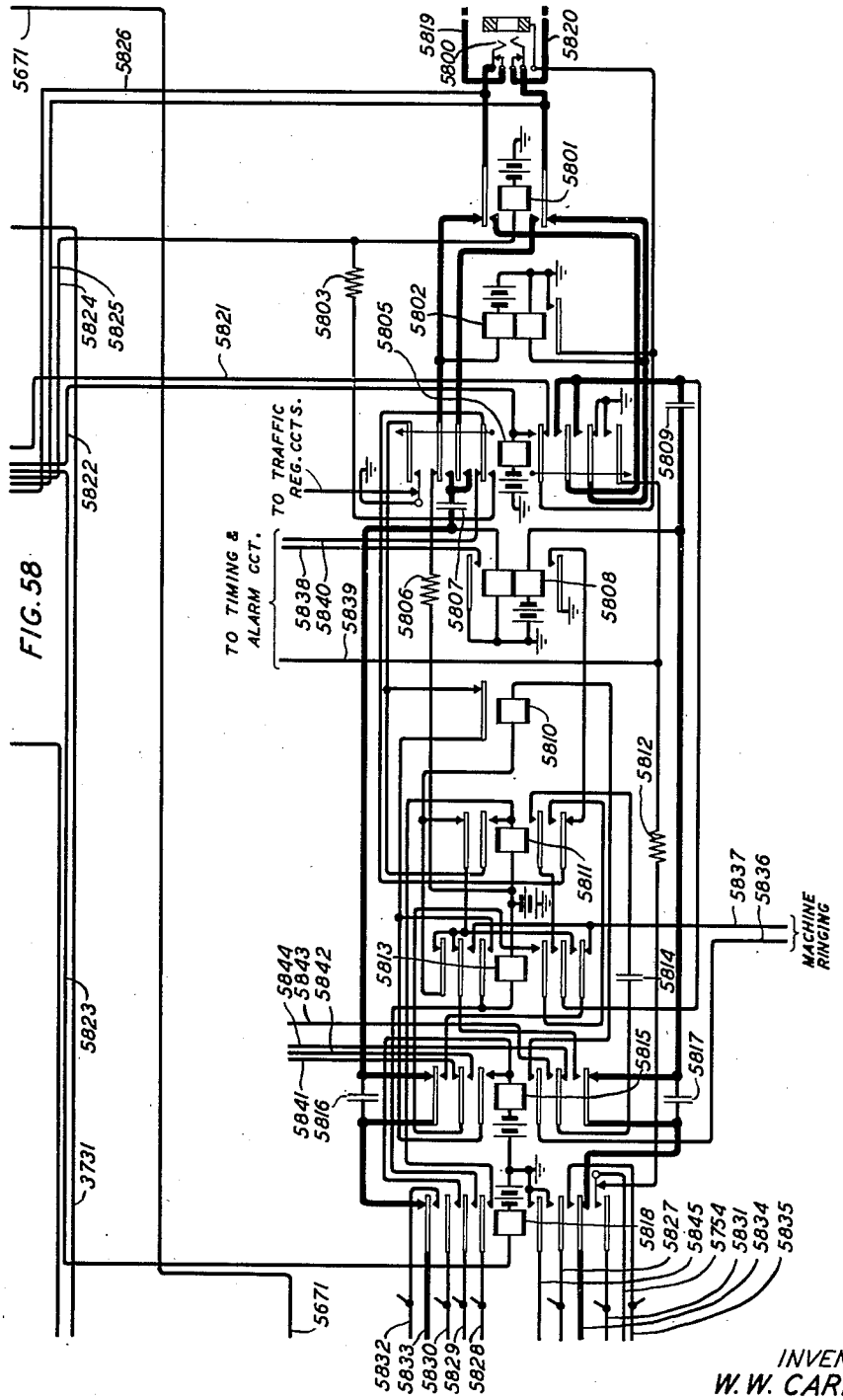

FIG. 58

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DIAL TELEPHONE SYSTEM

Filed March 11, 1936 64 Sheets-Sheet 59

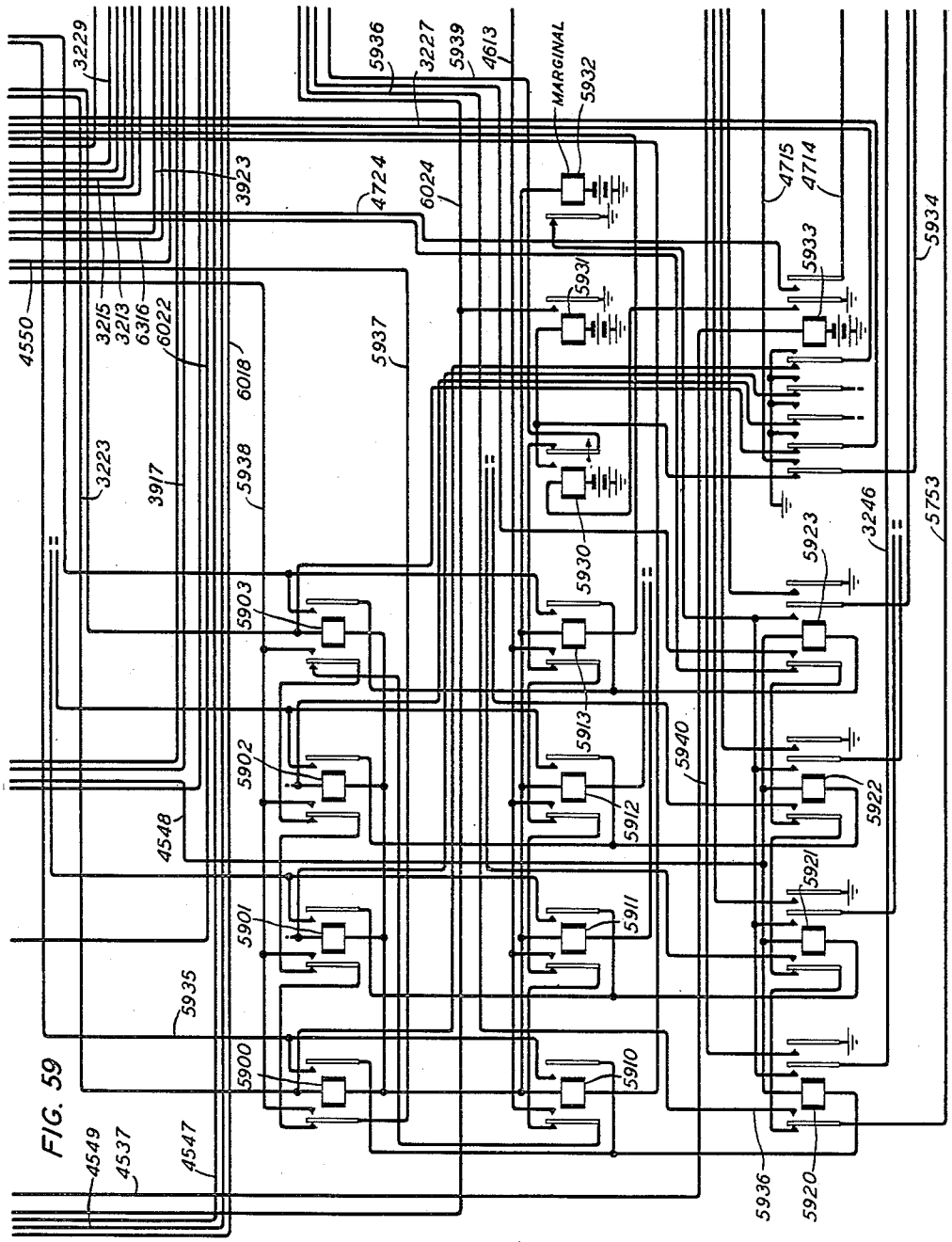

FIG. 59

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DIAL TELEPHONE SYSTEM

Filed March 11, 1936 64 Sheets-Sheet 60

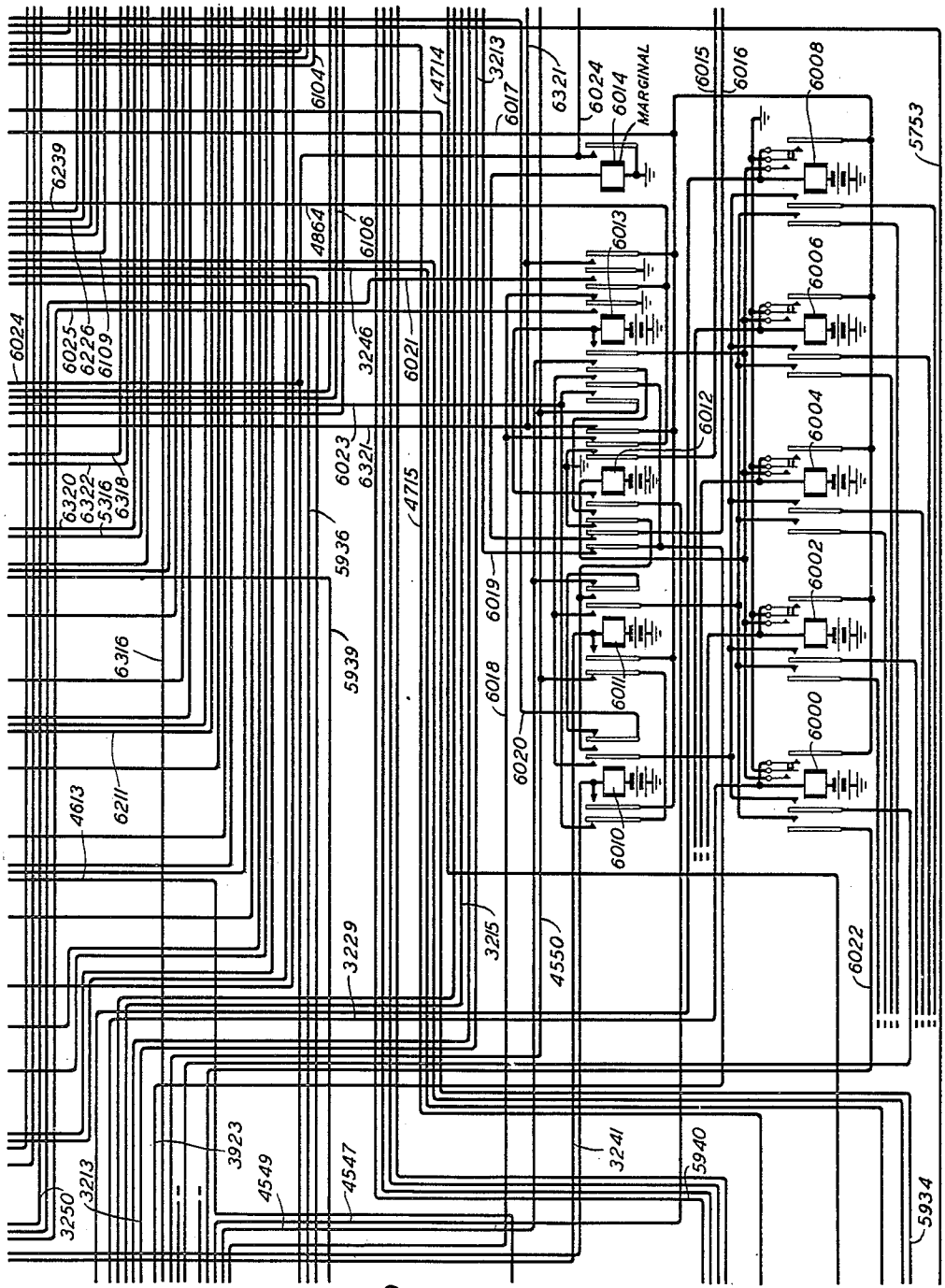

FIG. 60

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DIAL TELEPHONE SYSTEM

Filed March 11, 1936 64 Sheets-Sheet 61

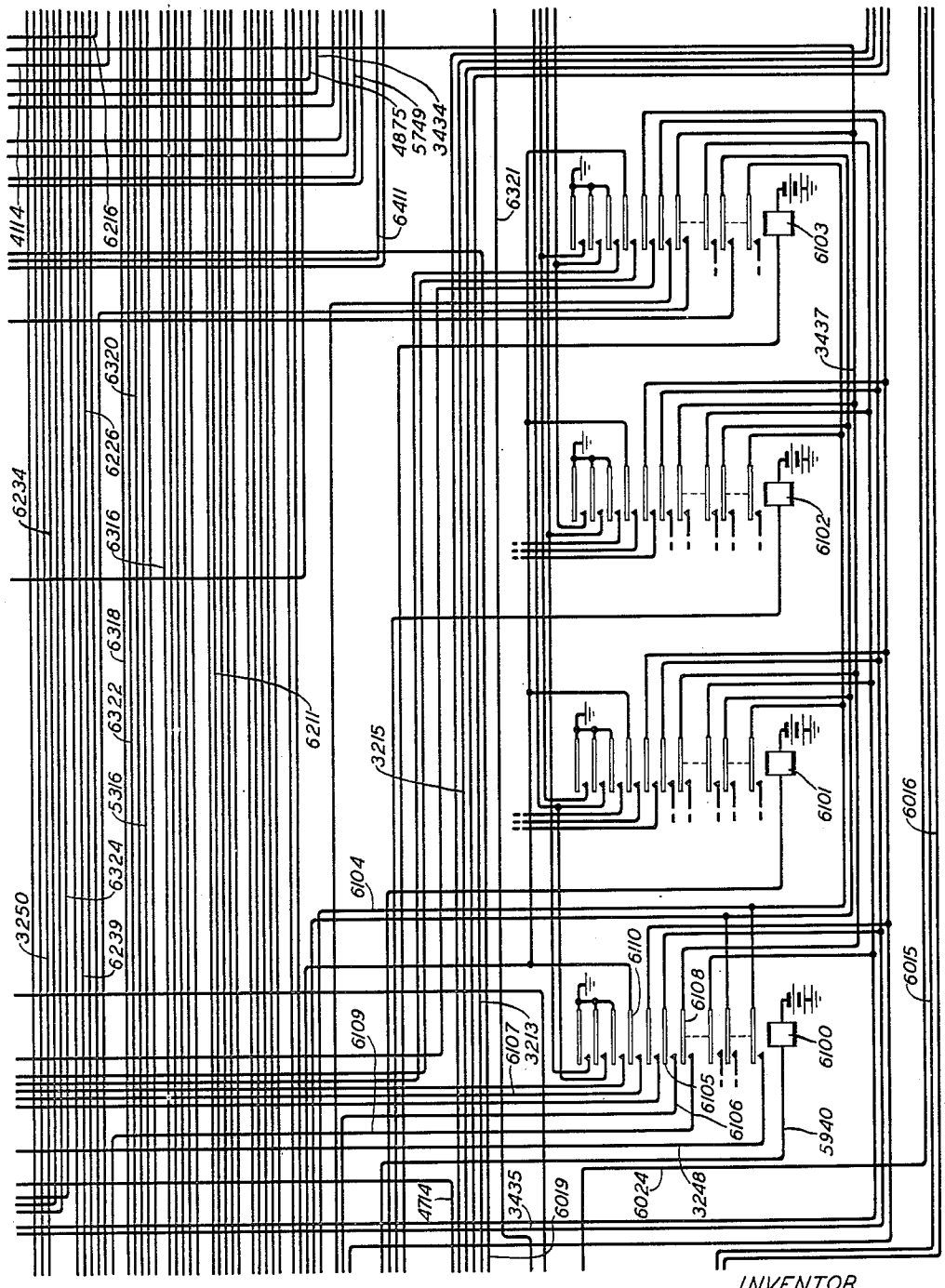

FIG. 61

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DIAL TELEPHONE SYSTEM

Filed March 11, 1936 64 Sheets-Sheet 62

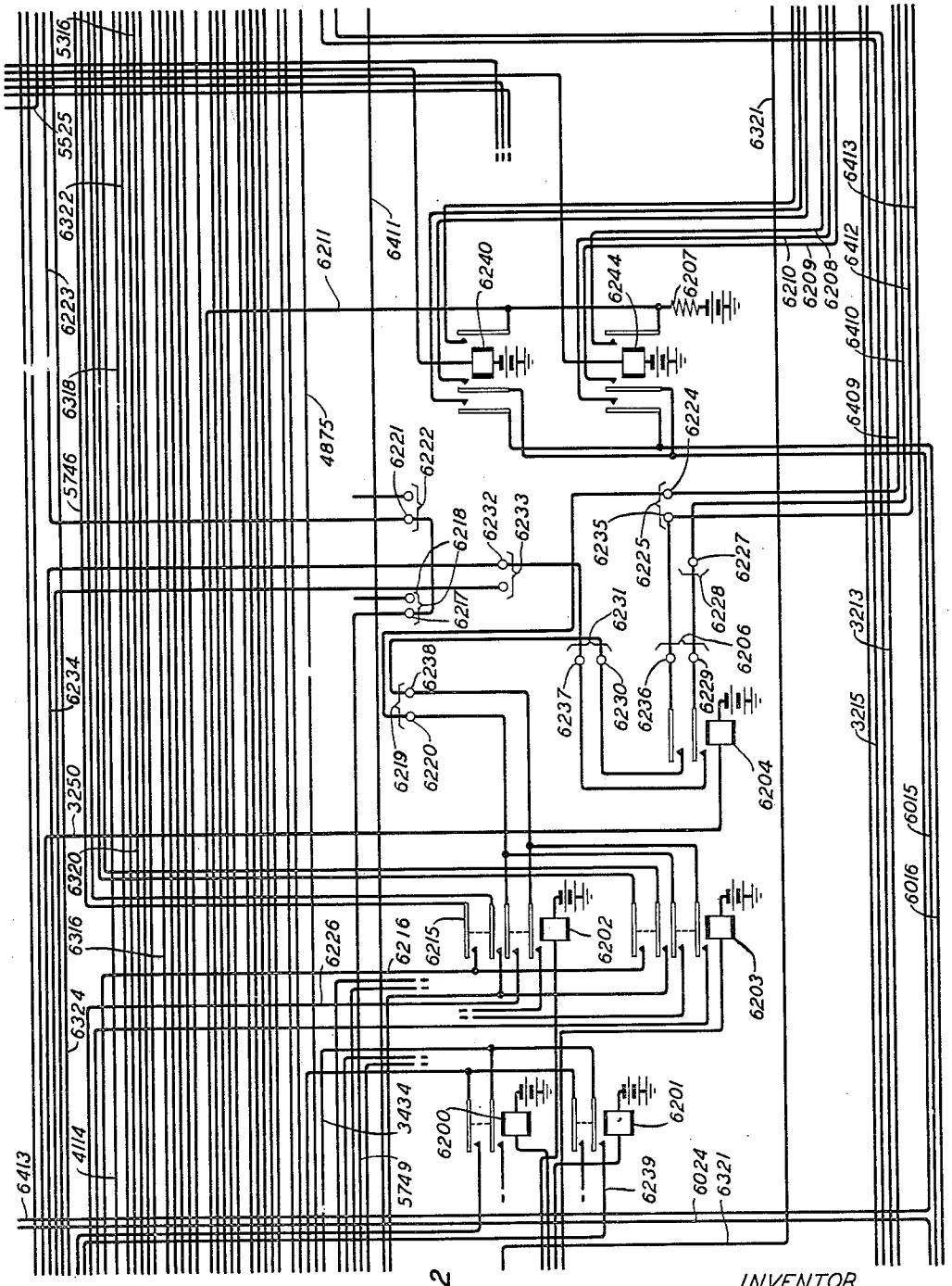

FIG. 62

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DIAL TELEPHONE SYSTEM

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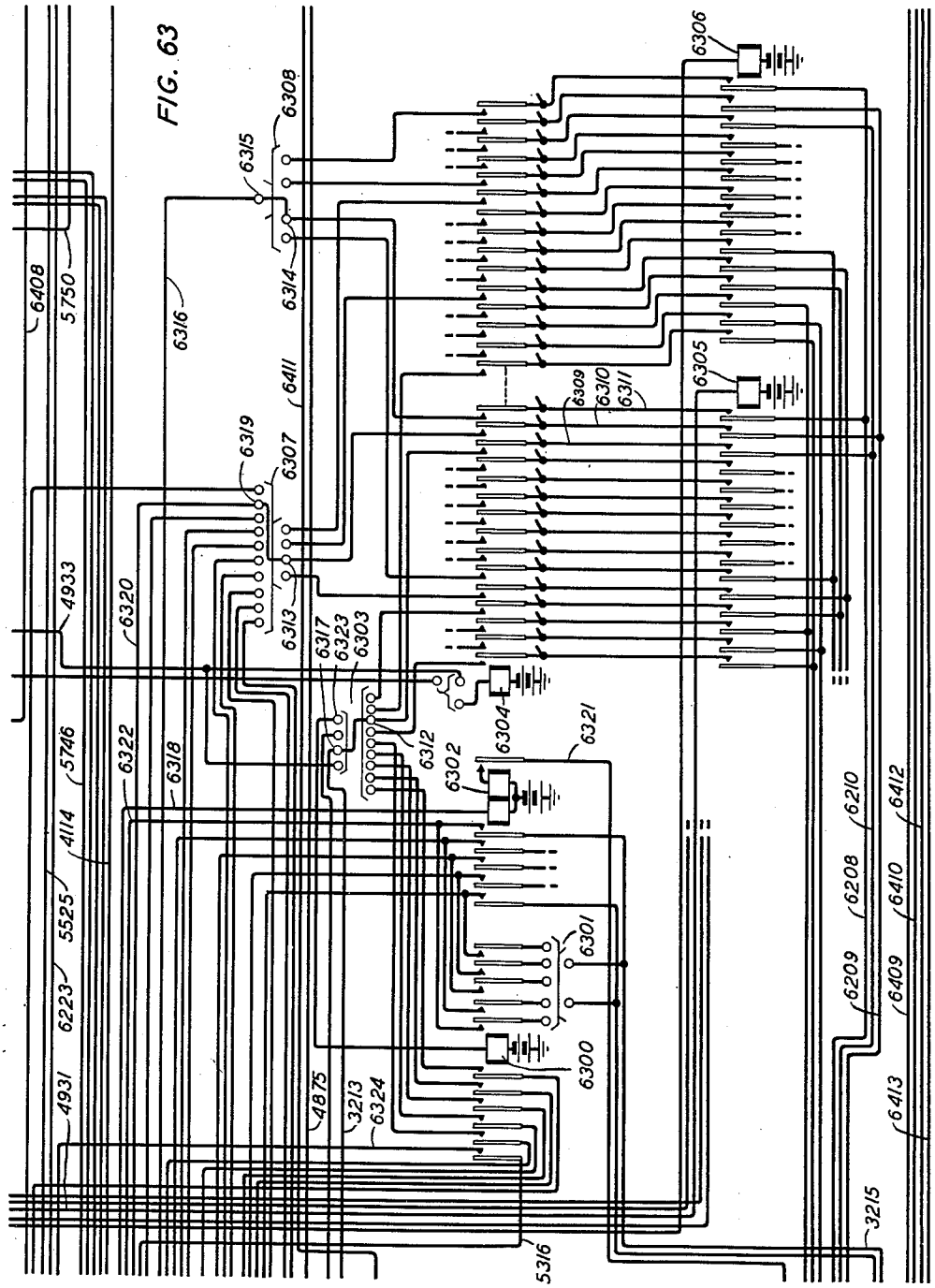
FIG. 63



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DIAL TELEPHONE SYSTEM

Filed March 11, 1936 64 Sheets-Sheet 64

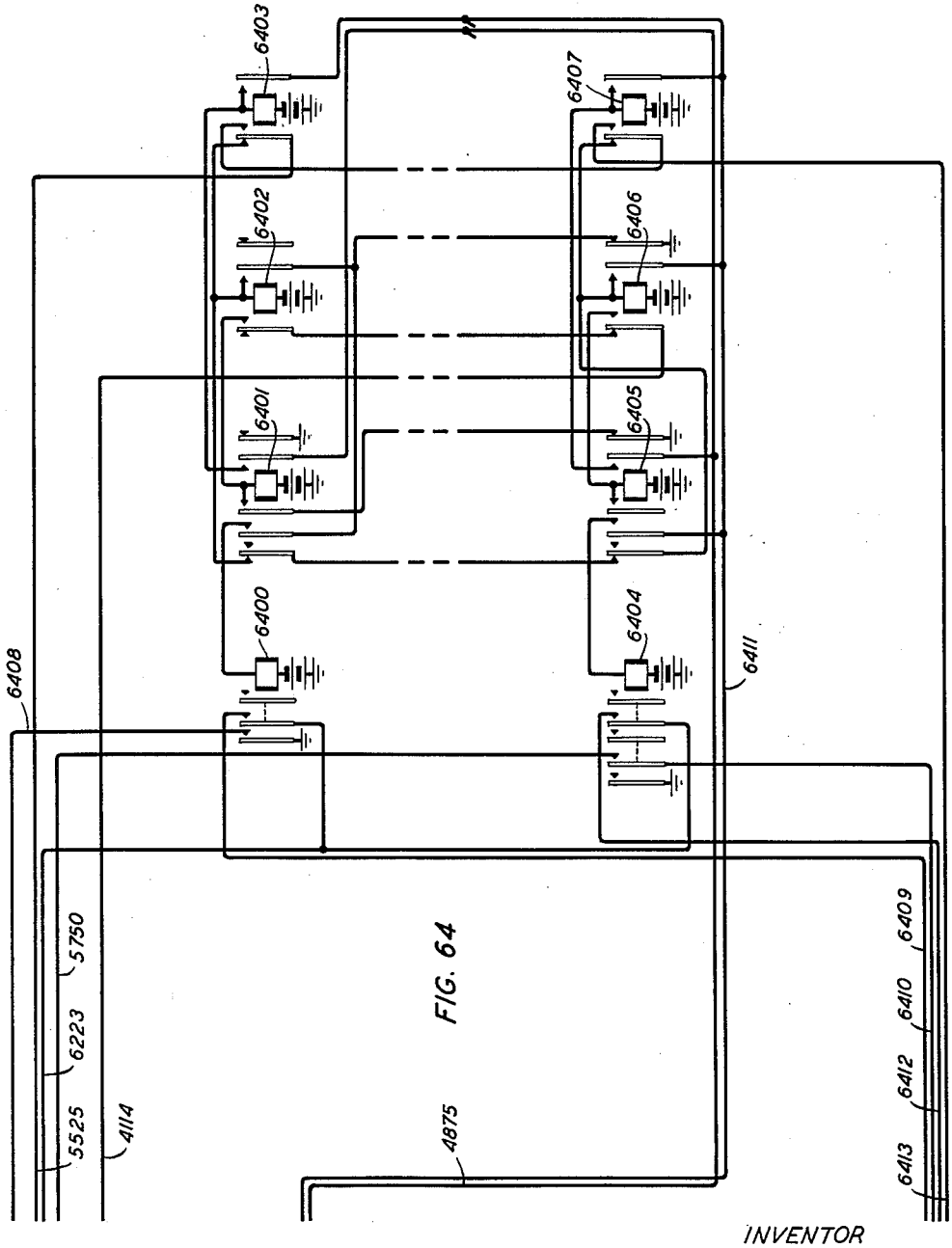

FIG. 64

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Patented Aug. 10, 1937 2,089,921

UNITED STATES PATENT OFFICE

2,089,921

DIAL TELEPHONE SYSTEM

Warren W. Carpenter, Garden City, N. Y., assignor to Bell Telephone Laboratories, Incorporated, New York, N. Y., a corporation of New York

Application March 11, 1936, Serial No. 68,262

42 Claims. (Cl. 179—18)

This invention relates to telephone systems and particularly to systems of the kind in which automatic switching equipment is used wholly or in part for the establishment of connections.

The objects of the invention are to improve telephone systems of this character by the use of simple, reliable and efficient switching and connecting devices; to provide a more flexible arrangement of the lines, trunks and other connecting circuits involved in setting up connections; to secure an efficient use of common switching squipment for both originating and terminating calls; to make use of a novel grouping of lines and division of the switching equipment with respect to the common controlling apparatus; to uniformly distribute the traffic loads over the several groups or units of equipment without expensive wiring changes and without changing directory numbers; to secure greater latitude and flexibility in the enlargement or rearrangement of private branch exchange groups; to effect improvements in the testing of both direct lines and private branch lines; and to otherwise improve and increase generally the efficiency and serviceability of such systems.

The invention relates, in general, to automatic or dial telephone systems designed for use in large areas, and the numerous features to be described and claimed herein are illustrated in a system employing the cross-bar switch as the switching medium, together with central office register senders for registering the designations of wanted lines and common markers cooperating with said senders and with the selective switches to establish the desired connections.

A feature of the present invention is a system in which a plurality of cross-bar switches serve the subscribers' lines both as line switches for outward calls from said lines and as final selectors for inward calls to said lines, the lines and switches being divided into line groups, a plurality of these line groups comprising a larger group or line choice, in which each line group is provided with a line control circuit for controlling the switches thereof on an outward call, and in which a marker is provided which serves all the line groups of a choice for controlling the switches in any of said line groups to complete an inward call to one of the lines therein.

Another feature is a system in which each of the line control circuits of a choice is provided with means to prevent the marker from associating itself with the corresponding group while an outward call is in progress, and in which said marker is also provided with means to render any one of the line control circuits of the choice ineffective while the marker is engaged with the corresponding line group on an inward call.

Another feature of the invention is a system in which the switch structures combining the functions of both line switches and final selectors consist of primary and secondary cross-bar switches, the lines appearing in the primary switches, and the primary and secondary switches being interconnected by links over which both originating and terminating calls are completed, together with one testing means for testing these line links for an idle one when an originating call is made and other testing means for testing them for an idle one when a terminating call is being completed.

Another feature relates to a system of this nature in which said line links are connectable through the secondary line switches to district trunks or junctors for extending a call outgoing from one of the lines, and said line links are accessible through the secondary line switches to other trunks known as line junctors for the purpose of completing incoming calls to said lines, and wherein testing means is provided for testing said line links in conjunction with the district junctors for outward calls and for testing said line links in conjunction with the line junctors for inward calls.

According to another feature, the several line groups have access each to a plurality of groups of district junctors, and any particular line group prefers to place its calls in one or the other of two of the junctor groups to which it has access, the choice between the preferred two groups alternating between them from call to call. In case all junctors in both preferred groups are busy, then the line group will place its calls in the first succeeding junctor group that offers an idle one. The purpose of this feature is to confine the outgoing calls as much as possible to a certain few of the line links in the line group, thus leaving the remaining links free for selection and use on incoming calls for lines in the same group. The reason for this will appear more clearly in the following description.

Also in accordance with the last-mentioned feature the district junctor groups may be multiplied to several line groups in which case means is provided whereby each line group will have a different pair of district groups in which it prefers to place its calls.

According to a further feature, the selection of an individual district junctor from the chosen

group will depend on the location of the calling line in the primary line switch. The subscribers' lines appear in the vertical rows of contacts of the primary cross-bar line switches, and each such line occupies a full vertical row of contacts in one and only one of these switches. A convenient size for these switches is ten vertical rows of contacts or ten subscribers' lines per switch, and it is the vertical location of the calling line in its switch that determines which district junctor in a group is preferred for the call.

Another feature of the invention is a system wherein the equipment comprising the switches and circuits that carry traffic to and from the subscribers' lines is divided into a number of groups or units, the amount of equipment, including switches, trunks and links, in each unit remaining fixed, and in which the variations in traffic loads that occur in the several units are met not by adding more equipment but by a simple and novel distributing means whereby lines individually or in groups may be shifted from one location to another within a unit or to other units without the necessity of changes in the telephone directory.

According to the feature last-mentioned, a subscriber's line may be located anywhere in a line choice. A line choice consists of a plurality of line groups, four, for example, and each group comprises ten horizontal groups or levels of primary line switches and ten secondary line switches. The marker on receiving the number of the called line first connects itself to the proper choice of lines, operates a relay, associated with the choice, that is individual to a block of twenty lines containing the called line. The marker next closes a circuit through this relay to a lead that is individual to the called line. This lead, in common with similar leads for all other lines in the same horizontal level, operates a horizontal level relay, there being one of these relays for each of the forty horizontal levels in the choice. The purpose of these relays is to cause the connection of the marker to the line links of the horizontal level containing the called line. It is, therefore, possible to shift a line to any location in the choice by connecting its individual lead to the proper horizontal level relay, and it is unnecessary to make any change in the marker. This means that the physical location of the lines in one choice regardless of their directory numbers need not bear any relation to the physical location of the lines of any other choice. Accordingly, lines may be moved singly or in blocks of twenty from one level to another or from one group to another in the choice without changing the marker or the directory numbers of the lines.

Another feature and one related to the feature last-mentioned is an arrangement whereby one or more blocks of twenty lines each may be shifted from one line choice to another. To this end, a cross-connecting rack is provided between the translator of the marker and the connectors for the several line choices. To shift a block of twenty lines to a new choice it is only necessary to disconnect the leads on the translator for that block from the old choice and connect them to the line choice connector of the new choice. When one of these lines is called, its number being the same as before, the marker connects itself to the new choice where the line is now located and also operates the proper relay for the block of twenty and the proper horizontal level relay.

Another feature is a progress circuit in the marker whereby the lines of a private branch exchange group may be tested by the marker in blocks of twenty lines each. The dialed exchange number causes the selection of the choice and the twenty-block relay therein for the block of twenty lines containing the first line of the wanted private branch. If all these lines are found busy, the progress circuit releases that twenty-block relay and operates the one for the next twenty lines of the group, and these are tested for an idle one. This continues until an idle line is found or all have been tested. Since only one directory number needs to be dialed to select the choice and operate the first twenty-block relay, and since the progress circuit automatically causes the operation of succeeding twenty-block relays, it is necessary to utilize only one number in the directory for an entire private branch group.

Another feature is a testing circuit for private branch lines whereby if the first several lines of the group are followed in the same twenty-block by lines not of the group, and there are further lines of the group in some other twenty-block, the test on reaching the last private branch line in the first twenty-block stops at that point and the next twenty-block relay representing the next lines of the group is operated and the test proceeds.

A further feature of the invention is a system in which calls for subscribers' lines are extended to the line choices over incoming frames, each incoming frame having line junctors, usually ten in number extending to the called line group of the choice, but sometimes having one or more full groups of ten and a partial group of less than ten, and in which two or more partial groups coming from different incoming frames to the same line group are collected to form a full unit of ten junctors for testing purposes. Since the marker is arranged preferably to test a full unit of ten junctors on each test and since a call from a particular incoming frame can be served only by line junctors from that frame, it is necessary, when the marker is testing a partial group, to render artificially busy all remaining junctors of the unit of ten which come from other incoming frames. This plan enables a uniform testing operation on the part of the marker whether it is testing a full or a partial group of line junctors and at the same time allows a more efficient use of the junctors where conditions are such that they are not always divisible into even groups of ten.

According to a further feature, if a line group has a plurality of line junctor groups, one or more of which may be full groups of ten and one of which a partial group, the marker is so arranged that it will on successive calls start its testing operation with different groups.

The foregoing and other features will be described more fully hereinafter and will also be set forth in the appended claims.

For a clearer understanding of the invention, the circuits embodying it have been shown in the accompanying drawings in which:

Fig. 1 shows the manner in which Figs. 4 to 11 are to be arranged;

Fig. 1A shows the manner in which Figs. 12 to 64 are to be arranged;

Fig. 2 shows in block form the relationship between the various elements of the system;

Fig. 3 is a detail of the circuit to bring out the flexibility of the line arrangement;

Figs. 4 to 11 make up a diagrammatic showing of the system as a whole; and

Figs. 12 to 64 are the detailed drawings, wherein the circuits shown in block form in Fig. 2 may be identified as follows:

Figs. 12, 16, 17, 21, 22, 26, 27 and 28 show the line link and group control circuit;

Fig. 13 shows the district junctor;

Figs. 14, 18, 19, 20, 23, 24 and 25 show the sender link and control circuit;

Fig. 15 shows in schematic form the decoder marker connector, decoder marker, district link and connector and office link and connector;

Figs. 29, 30 and 37 show the terminating sender;

Figs. 31, 32 and 38 show the line choice connector;

Figs. 33, 34, 39 to 41, 45 to 49, 52 to 55 and 59 to 64 show the terminating marker;

Figs. 35, 36, 42, 43, 44, 50 and 51 show the terminating sender link and control circuit;

Fig. 56 shows the terminating marker connector;

Fig. 57 shows the incoming link and connector; and

Fig. 58 shows the incoming junctor.

It will be noted that certain of these circuits are presented in diagrammatic form. For the details and complete descriptions of the decoder marker and its associated connectors reference may be made to the application of W. W. Carpenter, Serial No. 27,305, filed June 19, 1935. For a description of the sender, reference is made to the application of R. Raymond, Serial No. 27,340, filed June 19, 1935.

Referring first to Fig. 2, the operation of the system is briefly as follows: The subscriber's line on originating calls is connected by means of a line link and group control circuit to a district junctor and to a sender link and control circuit through which it is connected to a sender. With the wanted line number recorded, the sender connects with a marker through a marker connector and the marker in turn connects by means of a district connector with the district link in which the district junctor appears. By means of an office connector it selects and connects with an office link outgoing to an idle trunk to the wanted office. It then controls the establishment of the connection between line and trunk. The marker and associated connectors are then released, but the sender remains effective until after it has transmitted the line designation to the wanted office or controlled the establishment of the connection thereat.

On terminating calls an incoming junctor is seized by the originating office. The incoming junctor connects with a terminating sender through the terminating sender link and control circuit and the originating sender is signaled to transmit the designation. With the record set up in the terminating sender, a terminating marker is seized by means of the terminating marker connector. Under the control of the wanted line designation the marker picks the proper line choice connector and then, by means of an incoming connector, connects with the incoming link in which the incoming junctor appears. The marker proceeds to determine the line link and group control circuit and the wanted line and then controls the establishment of the connection between the incoming trunk and the wanted line. All of the auxiliary equipment is then released and the connection maintained under the control of the subscribers at the district and incoming junctors.

In the cross-bar system as shown in the present disclosure, the unit is a switch having one hundred contact sets which occur at the intersections of ten vertical units and ten horizontal units, or two hundred contact sets in which case there are twenty vertical units. No attempt will be made to describe the structure of the switch in detail, but each horizontal unit is controlled by a select magnet which prepares the contacts in the corresponding horizontal row while each vertical unit is controlled by a hold magnet which completes the corresponding one of the prepared contacts and locks over that contact, remaining operated throughout the duration of the connection.

SCHEMATIC SHOWING

Referring to the schematic drawing including Figs. 4 to 11, inclusive, in the primary line switch **620**, for example, the ten lines **600** and **601** to **609** are connected to the ten vertical units and the ten line links **680** and **681** to **689** to the horizontal units. According to the density of the traffic from one to seven line switches **620**, **621**, etc., may be connected in multiple to one set of ten line links and are arranged side-by-side in one horizontal level of the line frame. Ten sets of line switches **620**, **621**, **630** and **631**, each with its associated lines and ten line links are arranged above one another to make up one line group or frame. Four line groups or frames constitute one line choice, but this latter grouping is used only in connection with terminating calls.

Ten secondary line switches **660**, **670**, etc., are provided for the line group or frame and one line link from each primary line switch is connected to each secondary line switch so that each line has access to each secondary line switch and to each district junctor outgoing therefrom. A given line link is connected to the secondary line switch occupying the same relative position in the group of switches that the link does in the group of links and appears in that switch in the same relative position as that occupied by the primary line switch. Specifically, line link No. 0 from primary level No. 0, viz. link **680**, connects with horizontal unit No. 0 in secondary line switch No. 0, that is switch **660**. Link **689**, which is link No. 9 in level No. 0, connects with horizontal unit No. 0 in secondary line switch **670** which is switch No. 9. Similarly link **690**, which is the No. 0 link in primary level No. 9, appears in horizontal unit No. 9 of switch No. 0, and link **692**, which is the No. 9 link of level No. 9, appears in horizontal unit No. 9 of switch No. 9.

The district junctors **661** and **662**, include a relay circuit such as shown in Fig. 13 and extend to switches **700** and **701** similar in structure to the line switches on a frame called the district frame. From each secondary line switch, the ten district junctors **661**, **662**, etc., are extended to five district frames, two to each frame and from the line group, a group of twenty district junctors extends to each of five district frames. This group of twenty district junctors is multipled to one or more additional line groups, depending on the traffic originated by the line groups.

A district frame comprises ten primary district selectors **700**, **701**, etc., to which come five groups of district junctors. Thus by the multipling above-mentioned, one district frame may handle calls from a large number of subscribers. The primary district selectors **700**, **701** give access to twenty district links **710** to **713** which are dis-

tributed to twenty secondary district selectors 702, 703, 704, 705 and two hundred interframe trunks 714 to 721. In a similar way there is provided an office frame having primary and secondary switches and giving access to outgoing trunks.

The establishment of a connection from a calling line to an outgoing trunk is controlled by an outgoing marker 900 which in turn receives the designation of the wanted office from a subscriber's sender 901. The sender 901 is connected with the line in parallel with the district junctor and the connection is made through primary and secondary sender selectors included in the sender link and control circuit 902. Five of the groups of district junctors appear in the primary sender selectors which have access through the secondary sender selectors to ten groups of ten senders, or one hundred senders. The sender switches are arranged in the same manner as the line switches so that any district junctor has access to any sender. Each group of twenty district junctors appears in the twenty verticals of a two hundred point switch. The ten horizontals of each switch are spread to the verticals of five secondary selectors, which are split so that each secondary switch gives access to twenty senders and only five sender links are available between a given district junctor and sender. Due to the number of conductors required between the district junctor and the sender, the primary and secondary selectors are furnished in duplicate.

In completing a terminating call, the primary and secondary line switches are again used, in connection with primary and secondary incoming selectors. The secondary line switches are provided with two sets of vertical elements, one set leading to the district selectors as previously described and the other shown on the left, leading to the incoming selectors. Incoming calls are received over incoming junctors including relay circuits like those shown in Fig. 58. These junctors 1100 and 1101, for example, appear in the horizontal elements of the primary incoming selectors 1110, 1111, etc., which are two hundred point switches, that is, have twenty vertical elements. An incoming frame includes ten of these primary incoming selectors and twenty, one hundred point secondary selectors 1114, 1115, etc. Two hundred incoming links 1102 to 1109, etc., connect the primary and secondary incoming selectors, appearing in the vertical elements of each switch. Outgoing from each incoming frame are two hundred line junctors 1118 to 1126, etc. These line junctors appear in the horizontal elements of the secondary incoming selectors, ten to each switch.

In order that any incoming call may reach any line, each secondary incoming selector must be connected to each secondary line switch. As indicated above, the lines of the office are divided, first into line choices, the number of choices depending on the density of the traffic. In the schematic, the number has been taken as ten. Each choice is divided into four groups or frames, each frame comprising ten levels and each level having ten points of access. Therefore there are four thousand points of access to the line switches and, assuming ten incoming frames, two thousand points of egress from the incoming selectors and two thousand line junctors. The line junctors, therefore, are connected each to two line switch units. More specifically the secondary incoming selector 1115 appearing on the left in level No. 0 is connected by line junctor 1118 in multiple to the No. 0 vertical element of secondary line switch 660 in frame No. 0 of choice No. 0 and to the similarly located element in frame No. 2 of choice No. 0. Secondary incoming selector 1117 is connected by line junctor 1123 to the No. 0 vertical in level No. 9 of the same frames as is selector 1115. The selectors 1114 and 1116 appearing on the right are connected with the odd numbered frames.

With ten choices and ten incoming frames the distribution of the line junctors is similar to that of the line links, junctors from the No. 0 frame appearing in the No. 0 verticals of the line switches, from the No. 1 frames in the No. 1 verticals, etc., while the No. 0 junctors from each incoming switch extend to the No. 0 choice, the No. 1 junctors to the No. 1 choice, etc.

As set forth above, the location of the lines in the line frames is independent of the directory numbers assigned to them. To control the selection of a wanted line and the establishment of the connection between the incoming junctor and the line, the incoming junctor when seized controls a terminating sender link and control circuit 903 which establishes a connection between the junctor and an idle terminating sender 904. The wanted line number is then recorded in the sender after which, by means of the marker connector 905, the sender associates itself with an idle terminating marker 906, part of which is shown in Fig. 4.

The sender transfers the wanted line designation to the registers 400, 401, 402 and 403 of the marker. These registers then control a set of relays constituting a translator. The thousands register grounds one of ten conductors which, multipled under the control of a zero hundreds relay 404 and a five hundreds relay 405 control one of twenty relays 406, 407, etc. The hundreds register grounds one of five conductors to operate one of five relays 408, 409, etc., while the tens register also grounds one of five leads to operate one of five relays 410, 411, etc. Each of the relays 410, 411, etc., controls three contacts which are multipled before the relays 408, 409, etc., and the contacts of relays 408, 409, etc., are multipled before the relays 406, 407, etc. Therefore, the registration of a designation marks one set out of five hundred sets of contacts in the cross-connecting racks 500, 501 and 502.

Fig. 5 shows part of the line choice connector by which the marker gains access to the line and which is seized after the translation above described takes place. The contact of the marked set in rack 500 operates the relay 503 which cuts through all of the control conductors from the marker to the line choice which may include from 400 to 2800 lines. The contact in rack 501 controls the operation of a relay 504 individual to one hundred lines or five groups of twenty lines while the contact in rack 502 controls the operation of relay 505 which cuts through two groups of leads one the test and hold leads for twenty lines and the other, the conductors to be known as the number control leads for these same lines. The number control leads are cross-connected to windings of relays 506, 507, etc., which are individual to the horizontal levels of the line choice frames, the cross-connections being made according to the location and class of the corresponding line. These relays return to the marker an indication of the location and class of the wanted line.

When the line choice connector has operated,

the marker controls the incoming link and connector circuit 907, tests the line, and if it is idle, tests the line links, line junctors and incoming links to find an idle channel and then establishes the connection which is held under the control of the subscribers at the incoming junctor circuit.

DETAILED DESCRIPTION

Outgoing Call

Seizure of line group and control circuit

When the subscriber at substation 1200 originates a call, he closes a circuit from battery through the winding of line relay 1202, outer lower contact of the combined hold magnet and cut-off relay 1201 belonging to the calling line in primary line switch 1230, over the ring side of the line, through the subset, back over the tip side of the line, inner lower contact of magnet 1201 to ground.

Line relay 1202 in operating identifies the calling line to the line link and group control circuit. This identification includes the identity of the primary line switch 1230 in which the line appears, as indicated by the horizontal and vertical position of the switch in the frame serving the line group, and the position of the line contacts in that line switch. For this purpose relay 1202 connects ground to conductor 1203 which is common to the ten lines appearing in switch 1230 and to conductor 1204 which is individual to line 1200.

Ground on conductor 1203 first identifies the horizontal group to which the primary line switch belongs by operating relay 1205 over the upper back contact of relay 1206. Relay 1205 closes a circuit from ground over its upper contact to conductor 1225 and thence to interrupter 1600 to start the timing apparatus which will be described hereinafter. It also closes a parallel circuit over the inner right back contact of relay 1601, outer left back contact of relay 1615, middle left back contact of relay 1602, right winding of relay 1603 and battery. Relay 1603 at its outer right back contact opens the circuit by which relay 1601 is operated from the terminating marker to prevent the use of the group circuit in connection with a terminating call until the line has been extended to an idle district junctor and sender.

As will appear more fully hereinafter, the control circuit, while normally used by the group of lines appearing on a single frame, is arranged to act as an emergency control circuit for an adjacent or "mate" frame. Therefore, when relay 1603 operates it serves to connect the line group circuits through to a control circuit. Assuming that the home control circuit is working with the home frame alone, the operation of relay 1603 closes a circuit from ground at its outer left front contact, right back contact of relay 1602, outer left back contact of relay 1606, winding of relay 1607 to battery. Relay 1607 opens the operating circuit for relay 1606 to prevent the connection of the control circuit with the mate frame. It also closes a circuit from battery through the winding of relay 2700, conductor 2704, inner left front contact of relay 1607, inner left back contact of relay 1606, conductor 1608, outer right back contact of relay 1704, third left back contact of relay 1700 to ground. A second circuit is closed from battery through the winding of relay 2600, conductor 2604, outer left front contact of relay 1607, right back contact of relay 1606, conductor 1609, inner right back contact of relay 1704 and second left back contact of relay 1700 to ground. Relays 2600 and 2700 connect the group relays to the home control circuit.

Relay 2700 in operating closes holding circuits for relays 2600 and 2700 independent of relays 1704 and 1700. The circuit for relay 2600 may be traced to the right back contact of relay 1606 as for its operating circuit and thence over conductor 1624, armature 2728 of relay 2700, conductor 2729 to ground at the outer right contact of relay 1607. The circuit of relay 2700 extends to the inner left back contact of relay 1606 as previously traced and thence over conductor 1625, armature 2731 of relay 2700, conductor 2732 to ground at the inner right contact of relay 1607.

As soon as relay 2600 closes its contacts, ground is connected from the inner right back contact of relay 1722, conductor 1719, armature 2619 of relay 2600, conductor 2620, outer right front contact of relay 1603 to conductor 16[illegible] and interrupter 1605. The function of this interrupter will also be described hereinafter.

When relay 2700 operates it closes a circuit from battery through the winding of relay 1701, right back contact of relay 1702, left back contact of relay 1722, conductor 1723 to ground at armature 2719 of relay 2700.

Choosing horizontal group

Relay 1205 also closes a circuit from ground over its lower front contact, conductor 1207, armature 2702 of relay 2700, conductor 2703, winding of relay 2209, left normal contacts of the intermediate horizontal group relays, left normal contact of relay 2200 to battery. If two or more lines should be calling simultaneously, the control circuit can serve only one line at a time and now chooses between the lines according to the horizontal group to which they belong. With lines in several horizontal groups calling, the several relays such as relay 1205 belonging to those groups are operated, in turn grounding the windings of the corresponding relays in the group 2200 to 2209. Since the relays receive battery over the normal contacts of lower numbered relays, the lowest numbered relay of the group will operate, disconnecting battery from the higher numbered relays and locking, with the exception of relay 2200, to battery at its left front contact. Assuming that no other line is calling, relay 2209 locks, closing a circuit from ground over its outer left front contact, conductor 2219, armature 2705 of relay 2700, conductor 2706, winding of relay 1208 to battery.

Operating secondary line switch select magnets

Relay 1208 is one of ten relays, each individual to one horizontal level of the line switch frame, in which level may appear from one to seven individual line switches. The line links outgoing from the primary line switches of one level are multipled together so that the entire horizontal group of lines has access to ten line links and over them to one set of terminals in each of ten secondary line switches. Therefore relay 1208 may immediately operate the ten select magnets corresponding to these ten line links. One such circuit may be traced from battery through the winding of select magnet 1211, armature 1212 of relay 1208, top normal contact of jack 1610 to ground. A similar select circuit is closed for each of the ten line links.

Choosing vertical group

Relay 1208 prepares for identifying the vertical group to which the line switch serving line 1200

belongs. It therefore extends the ground connected to conductor 1203, over armature 1209, conductor 1210, armature 2605 of relay 2600, conductor 2606, outer left back contact of relay 1703, winding of relay 2226 to battery. With relay 2226 operated a circuit is closed from battery through the winding of relay 1707, inner right front contact of relay 2226, right front contact of relay 2209 to ground over the operating circuit of that relay.

It will be noted that the upper armatures of relay 1206 are multipled together so that the connection of ground to any one back contact, as for example over conductor 1203, completes circuits similar to the one above traced over all of these back contacts and the front contacts of relay 1208 to operate all of the relays of the set 2220 to 2226. Relays 2220 to 2226 lock temporarily to their operating grounds over their inner left front contacts independent of relay 1703. With relay 1707 operated a circuit is closed over the front contacts of all of these relays, thus testing during the establishment of each call, the continuity of all of the operating circuits for these vertical group relays. This circuit may be traced from battery through the winding of relay 1704, middle left front contacts of relays 2220 to 2226, conductor 1706, innermost left contact of relay 1707 to ground. Relay 1704 at its outer left contact closes a holding circuit for relay 1707 under the control of relay 2226 and a direct holding circuit for relay 2209. Relay 1704 locks over its second left contact and conductor 2720 to ground at armature 2719 of relay 2700. Relay 1704 also completes a circuit from ground on conductor 2720, inner left back contact of relay 1710, conductor 1708, armature 2607 of relay 2600, conductor 2608, armature 1227 of relay 1208, winding of relay 1206 to battery. Relay 1206 extends its operating ground to conductor 1225 to hold relay 1603 operated. It also opens the operating circuit of relay 1205 and by opening its upper back contacts opens the multiple operating circuits for relays 2220 to 2226. However, relay 2226 which was operated directly from relay 1202 remains operated as do any other such relays which correspond to other vertical groups in which a line is calling. These operated relays hold relay 1707 operated.

When relay 1205 closes its back contact, a circuit is completed from ground at that contact, innermost armature of relay 1208, conductor 1213, armature 2609 of relay 2600, conductor 2610, winding of relay 1709 and battery. Relay 1709 closes a circuit from battery through the winding of relay 1703, inner right contact of relay 1709, to the armature of relay 2220. This circuit extends over the back contacts of unoperated relays of the chain and over the front contact of the lowest numbered operated relay to ground over the operating circuit for that relay. Relay 1703 now determines which vertical group shall be served by closing a circuit from ground at its middle right contact to the outer left armature of relay 2220, and thence over the back contacts of unoperated relays and the front contact of the lowest numbered operated relay. Assuming that relay 2226 is the only operated relay, the circuit extends over the back contacts of relay 2220 and the other relays of this group, outer left front contact of relay 2226, conductor 2236, armature 2611 of relay 2600, conductor 2612, armature 1214 of relay 1208 to battery through the windings of relays 1215 and 1216 in parallel. Relay 1216 connects the hold magnet of the ten subscribers' lines appearing in the identified line switch through to the control circuit, while relay 1215 connects the ten individual calling conductors through to the control circuit.

Choosing the line

The operation of relay 1215 identifies the position of the calling line to the control circuit by closing a circuit from grounded conductor 1204, contact of relay 1215, conductor 1217, armature 2613 of relay 2600, conductor 2614, outer left back contact of relay 1718, winding of relay 2240 to battery. Relay 1215 closes similar circuits from the winding of relay 2249 and the other relays of this line identifying group to the individual calling conductors of the other nine lines in this group. If other lines are calling, their individual calling conductors will be grounded and the corresponding relay of the group 2240 to 2249 will be operated.

With relay 2240 operated, a circuit is closed from battery through the winding of relay 1711, over the second front contact of relay 2240 to the operating circuit of relay 2240 and ground. With relay 1711 operated a circuit is closed from battery through the winding of relay 1710, left front contact of relay 1711, innermost front contact of relay 2240 to ground over the operating circuit of that relay. Relay 1710 locks to conductor 1726 which is grounded at the back contact of relay 1700 and the inner front contact of armature 2719 of relay 2700. Relay 1710 extends its locking ground to the winding of relay 1718 which opens the operating circuits of relays 2240 to 2249. Relay 1710 also extends its locking ground to the locking circuit of relay 2240.

It may be noted that the circuits above traced for operating relays 1711 and 1710 and for locking the line test relays extend to the armatures of relay 2240 and are completed thereover since relay 2240 is the lowest numbered relay operated. Were some other relay the lowest operated, the circuits would extend over the back contacts of relay 2240 and the intermediate relays and the front contacts of the operated relay, thus determining which line is to be served.

When relay 1718 opens the operating circuits for relays 2240 to 2249, if more than one relay has been operated, all but the one locked relay will now release. Relay 1710 also closes a holding circuit for relay 1709 at its third right contact and a locking circuit for relay 1703 at its fifth right contact. Therefore, with relay 1710 operated the horizontal group, vertical group and individual identity of the line to be served is complete and locked in under the control of release relay 1700. If the call is abandoned, the control circuit continues to function until the line is connected to the sender which recognizes the abandonment of the call and releases the control circuit. Relay 1703 closes a circuit from battery through the winding of relay 1702, outer right contact of relay 1703, left contact of relay 1701, outer right back contact of relay 1722, conductor 1712, contact 2707 of relay 2700, conductor 2708 to ground at the lower back contacts of the five relays such as relay 1800 of the five sender control circuits to which the line group has access, those relays being released which correspond to groups in which at least one district junctor is idle. Relay 1702 locks over its inner contact, outer right back contact of relay 1722, and thence to ground as traced over its operating circuit and opens the circuit of relay 1701. Relay 1701 is slow-to-release and after an interval closes

its left back contact, completing a circuit from ground at armature 2719 of relay 2700, conductor 1723, left back contact of relay 1722, right front contact of relay 1702, left back contact of relay 1701, conductor 1713, armature 2709 of relay 2700 to the winding of relay 2710 and battery. The function of relay 2710 will appear later.

Selection of district junctor and sender test for presence of idle equipment

In determining to which district junctor the calling line shall be extended it is necessary that an idle line link be available and that the district junctor belong to a group having access to an idle sender. In order to spread traffic as much as possible preference is given to groups of district junctors having more than one idle district junctor and having access to groups of senders including two or more idle ones.

Busy line links have their sleeve conductors connected to ground at the district junctor or sender. When relay 1208 operates, it tests the line links to determine which are idle by connecting test relays 2260 to 2269 over armatures 1222, 1223, etc. to the ten line links extending from primary line switch 1230 to the ten secondary line switches, one of which appears at 1240. At the same time it connects battery through a resistance over armatures 1220, 1221, etc. in parallel with the test relays to reduce interference with established connections. The test circuit for the line link shown may be traced as follows: From the sleeve conductor of the line link, armature 1223 of relay 1208, conductor 1224, lower normal contact of jack 1610, conductor 1623, armature 2615 of relay 2600, conductor 2616, winding of relay 2269 and battery. Only those relays of the group 2260 to 2269 which correspond to busy line links are operated.

As soon as the identity of the primary line switch is established as indicated by the operation of relays 1704 and 1707, a test is made to determine which district groups and sender link circuits can be used. The district junctors to which any line has access are divided into groups of twenty, each served by a different sender link and control circuit and each group including two district junctors from each of the secondary line switches. Therefore, since there are one hundred district junctors outgoing from the secondary line switches, the line group has access to five district groups and five sender control circuits. Each sender link and control circuit serves one hundred district junctors and therefore serves five line groups.

Regular test

For test purposes, each group of twenty district junctors is divided into two groups of ten each. When relays 1704 and 1707 operate they connect the ten group test relays 2280 to 2289 to test ten groups of ten districts. One such test circuit may be traced from battery through the left winding of relay 2289, inner right contact of relay 1707, right back contact of relay 2269, assuming the corresponding line link to be idle, inner right contact of relay 1705, conductor 1714, armature 2711 of relay 2700, outer right back contact of relay 2710, which has not yet operated, conductor 2712, right back contact of relay 1801, outer upper back contact of relay 1800, inner left back contact of relay 1802 to ground at the back contact of the hold magnet 1451 of the secondary sender selector. The relays 1802, 1803, 1804, etc. are sender group busy relays and operate, as will be described later, when all of the corresponding group of senders are busy. The test circuit extends in parallel over the back contacts of these sender group busy relays to the back contacts of hold magnets of the sender links having access to the corresponding group of senders. Relay 1800 operates as soon as the sender link and control circuit is individualized to a line group and is also held operated when there are no district junctors available in the group. A second test circuit extends from the ninth group test relay (not shown) over the back contact of relay 1805 in parallel to the one traced. The other eight test circuits extend to sender control circuits (not shown). The non-operation of the line link test relays 2260 to 2269 as previously described indicate that an idle means of access to the district junctor group exists. Relays 1801 and 1805 are operated as will be described later during each operation of the sender control circuit with this group of district junctors to test whether there are one, two or more idle district junctors in the group. If two or more district junctors are available the relays release with the control circuit. Therefore, the completion of the circuit above traced indicates that there is an idle line link leading to a group of district junctors including at least two idle junctors and that there is at least one idle sender which may be reached over an idle sender link.

Reserve test

If none of the group relays 2280 to 2289 has been operated by the time relay 1701 releases and relay 2710 operates, a reserve test is made, the group test circuits being transferred to the front contacts of relay 2710 and the right armatures of relays 1817 and 1819. In those district groups containing one idle district, relays 1817 and 1819 will be operated and an attempt will be made to complete the connection using one of these junctors. Those relays of the group 2280 to 2289 which find idle equipment as outlined, operate and attempt to lock over their inner right front contacts.

Relays 1715 and 1716 are arranged to operate on alternate calls and change the preference among the groups of district junctors. With relay 1715 unoperated, as shown, the third group of ten or second group of twenty district junctors is given preference as shown by the locking circuit of relay 2282 which may be traced from battery through the right winding and over the inner right front contact of relay 2282, outer left back contact of relay 1715 to conductor 1717 in parallel with the winding of relay 1705. With relay 1715 operated, the first group of ten district junctors is given preference by the closure of the locking circuit of relay 2280 to conductor 1717. In either case, if the group is not available and the corresponding preferred relay is not operated, the next higher numbered group is given preference, the locking circuit of the group relay extending over the back contact of the lower numbered relays. The preference is given to the lower numbered line links for outgoing calls while preference is given to the higher numbered line links for incoming calls in order to prevent, as far as possible, interference between the two kinds of calls. The locking circuit for these group relays is not completed at this time.

District group preference

Each group of district junctors is multipled to a plurality of line groups, the number of groups depending on the density of the traffic originated by the particular group. In order to avoid interference should two line groups having access to the same group of district junctors originate calls simultaneously, in each line link and control circuit there is a relay such as relay **2800** for each group of districts to which it has access, only one being shown in the present disclosure. That is, each line group has five relays such as relay **2800**. The relays belonging to a particular group of district junctors are arranged in a chain so that each group is first choice to a different line group. As shown in Fig. 28, relays **2800**, **2801** and **2802** belong to the group of district junctors including the one shown, relay **2800** belonging to the line group shown, for which this group of district junctors is last choice. Relay **2801** belongs to a line group for which this group is an intermediate choice, while relay **2802** appears at the line group for which it is first choice. If either relay **2802** or **2801** were operated no circuit would be available for relay **2800**. Assuming, however, that group relay **2289** is operated alone and relays **2801** and **2802** are not operated, a circuit is closed from ground over the normal contacts of relays **2802** and **2801**, winding of relay **2800**, armature **2713** of relay **2700**, conductor **2714**, third right front contact of relay **2289**, back contacts of intermediate relays and relay **2282**, middle left back contact of relay **1715**, outer left front contact of relay **1704**, inner left front contact of relay **1709** to battery. Relay **2800** locks to ground at its inner right front contact, locking out the other line groups from this group of district junctors.

Choosing group of district junctors to be served

With relay **2800** operated, a circuit is closed for indicating to the sender control circuit that this group of districts is calling. This circuit may be traced from ground at the fourth left contact of relay **2800**, conductor **2806**, contact **1902** of transfer key **1900** normally operated, conductor **1903**, winding of relay **2000**, normal contacts of relay **2001** to **2004**, conductor **2010** to battery at the left back contact of relay **2400**.

Since each sender control circuit serves five district groups, more than one such group may be attempting to seize the sender control circuit at this time. In that case ground is connected to the windings of other relays of the group **2000** to **2004**. In this chain, preference is given to the highest numbered relay since relay **2004**, for example, in operating locks to battery at its inner right contact and disconnects the operating battery from relays **2001**, **2000**, etc.

Assuming, however, that relay **2000**, corresponding to the group of district junctors shown is the only one operated, it locks to its inner right contact and closes a circuit from battery over its outer right contact to ground through the left winding of relay **2500** and in parallel therewith over the outer right back contact of relay **2400** to ground through the winding of relay **2401**. Relay **2500** starts the timing circuit connected with the sender control circuit which will be discussed hereinafter.

Relay **2000** also closes a circuit from ground at its outer left front contact, key contact **1904**, through the winding of multi contact relay **1806** which is individual to the group of district junctors represented by relay **2000**, thus appropriating the sender control circuit to the one group.

With relays **1806** and **2401** operated, a circuit is closed from battery through the winding of relay **2400**, right contact of relay **2401**, key contact **1905** to ground at armature **1807** of relay **1806**. Relay **2400**, an off-normal relay, locks to its operating ground independent of relay **2401** and in turn operates relay **2402**. It connects battery to the armatures of the district test relays and grounds conductor **2403**. Relay **2402** at its inner left contact closes a circuit from ground over key contact **1906**, upper winding of relay **1800** and battery. It also closes a similar circuit for the four relays in this sender control circuit individual to the other four groups of district junctors. These relays mark this sender control circuit and the corresponding group of district junctors busy to calling line groups.

Had some other group of lines been calling and in operating its group relay, for example relay **2004**, operated some other relay like relay **1806**, the subsequent operation of relay **1800** would open the test leads for the two relays such as relay **2289** whose circuits extended to this sender control circuit and relay **2289** would have released, in turn releasing relay **2800**. If at this time some other relay had also been operated, but being lower in the preference chain had been ineffective, a circuit for some other relay like **2800** would be closed and that relay would have signaled its sender control circuit and attempted to seize it for this line group.

Under the assumption above made, that relay **2289** was the first relay in the preference chain to be operated, it now locks in a circuit from ground over its inner right contact, back contacts of the unoperated relays such as relay **2282**, outer left back contact of relay **1715**, conductor **1717**, armature **2617** of relay **2600**, conductor **2618**, outer right front contact of relay **2800**, conductor **2807**, armature **1808** of relay **1806**, key contact **1907**, back contact of relay **2405**, key contact **1908**, armature **1809** of relay **1806** over the back contacts of relays **1802**, **1803**, **1804**, etc. to ground at the back contacts of the hold magnets of idle secondary selectors. In parallel with this locking circuit relay **1705** is operated, opening the operating circuits for the group test relays **2280** to **2289**. Relay **1705** also closes an obvious circuit for relay **1722** which disconnects ground from interrupter **1605**. It also releases relay **1702**, in turn releasing relay **2710** and canceling the reserve test above mentioned. In addition it opens the circuit of relay **1701** to prevent its reoperation when relay **1702** falls back. Furthermore it closes a circuit from ground at the middle right contact of relay **1710**, left front contact of relay **1722**, inner left back contact of relay **1715**, fourth right back contacts of relay **2282** and the intermediate relays of the chain, fourth right front contact of relay **2289**, conductor **2299**, armature **2725** of relay **2700**, conductor **2726**, middle right front contact of relay **2800**, winding of relay **2805** and battery. Relay **2805** further connects the line control circuit with the sender control circuit. In addition, it closes a circuit from battery through the winding of relay **2803**, outer left contact of relay **2805**, conductor **2808**, armature **2621** of relay **2600**, conductor **2622**, outermost front contact of relay **2289**, back contacts of the intermediate relays to relay **2282**, outer right back contact of relay **1715** to ground at the outer left back contact of relay **1700**. The circuit of relay **2803** extends in parallel to all of the odd numbered re-

lays of the group 2280 to 2289 while the circuit of relay 2804 extends to the even numbered relays, relays 2803 and 2804 therefore distinguishing between the two groups of ten district junctors making up the group of twenty to which the sender control circuit has access.

Operate select magnet of primary line switch

With relay 2803 operated, a circuit is closed from ground at its outer left contact, conductor 2809, armature 1228 of relay 1208, to battery through the winding of select magnet 1226 of the primary line switch 1230. This magnet prepares for the connection of the calling line to the line link shown which has access through the secondary line switches to the selected group of district junctors. Relay 2803 also prepares the operating circuits for the hold magnets of the ten district junctors in the selected group.

Testing for idle district junctor

The sender control circuit now proceeds to determine which district junctor and which sender shall be used. To this end relay 2803 also closes a circuit from ground at its next to outer left contact, conductor 2810, winding of relay 1412 and battery. Relay 1412 closes an obvious circuit for relay 1415. With relay 1412 operated the ten district junctors are tested to determine which ones are idle. The circuit for testing the junctor shown may be traced from battery through resistance 1300, uppermost back contact of relay 1301, inner upper back contact of relay 1302, contact of jack 1303, conductor 1304, lower back contact of magnet 1402, outermost left contact of relay 1412, key contact 1909, winding of relay 2410 to ground at the outer left back contact of relay 2406. Similar test circuits are closed by relay 1412 from the other nine district junctors of the group to relays 2414, 2419, etc. The relays corresponding to idle districts lock between ground at their middle left front contact and battery over their inner right front contacts and the outer left front contact of relay 2400. Each operated relay connects ground over its inner left contact and the middle right front contact of relay 2402 to the winding of relay 2406 and battery, operating relay 2406. Relay 2406 disconnects ground from the windings of these district test relays to prevent the operation of any additional relays should a district junctor become idle. It also prepares circuits for relays 2501 and 2502.

Testing for idle sender group—regular test

When relay 1806 operated it also prepared test circuits for the senders, to determine which groups of senders, available through idle secondary sender selectors contain at least two idle senders. One of these test circuits may be traced from ground at the back contact of relay 2309 over the outer right back contact of the succeeding relay of the chain to conductor 2310. A similar circuit is closed over the back contacts of relay 2304 and the succeeding relay to conductor 2310.

If all the senders of the group are idle, ground is connected over the back contacts of each two successive relays to conductor 2310. Assuming relays 2300 and 2309 released and the intermediate relays operated, including relay 2304, the circuit would extend from ground at the normal contact of relay 2309, right operated contacts of the intermediate relays including the right front contact of relay 2304, back contact of relay 2300 to conductor 2310. Each group of ten senders has a similar group of relays and for each such group having two senders idle a conductor such as conductor 2310 is grounded. If all of the senders are busy, a chain circuit over their middle left contacts operates relay 2311, marking the entire group busy. Relay 2311 in turn operates relay 1802 to open the test circuit previously traced.

The test circuit extends from ground on conductor 2310, over the back contact of relay 2311, right back contact of relay 2312, back contact of relay 2313, conductor 2314, back contact of secondary sender selector hold magnet 1452, armature 1810 of relay 1806, right back contact of relay 1802, conductor 1811, key contact 1910, outer left back contact of relay 2011, right winding of relay 2020 to battery. Similar circuits test the other sender groups and the switches which have access to them. Each sender group having two idle senders and an idle switch operates its corresponding sender group relay and each relay attempts to close a circuit for the corresponding link lock relay. Relay 2020, for example, closes a circuit from battery at the inner left front contact of relay 2000, outer left front contact of relay 2020, conductor 2012, key contact 1911, conductor 1912, winding of relay 2315 to ground.

Selecting sender group

For each group of senders in each sender control circuit, a relay such as relay 2315 is provided, and the relays pertaining to the same sender group in all of the sender control circuits are arranged in a chain in such a manner that a certain sender group is preferred by certain control circuits and when selected for use by a control circuit is locked away from other control circuits. Relays 2316 and 2317 belong to the same sender group as relay 2315 but appear at other control circuits. The sender control circuit shown has preferred access to the group of senders represented by relay 2020 as indicated by the fact that relays 2316 and 2317 receive their operating ground over the normal contact of relay 2315. With relay 2315 operated, the operation of the link lock relays 2316 and 2317 of other control circuits is prevented. Relay 2315 at its middle left contact closes a circuit for relay 2312, which disconnects ground from the front contact of relay 2313 to cancel the reserve test which is unnecessary when a sender group is found containing two or more idle senders. It also opens the sender group test circuit.

Relay 2315, in operating closes a locking circuit for relay 2020 which may be traced from battery through the left winding and inner left contact of relay 2020, conductor 2013, key contact 1913, conductor 1914, outer right contact of relay 2315, back contacts of relays 2316, 2317, etc. to ground thus locking the control circuit to the selected group of senders. This ground also extends over the inner right contact of relay 2315, conductor 2318, key contact 1915, winding of relay 2011 and battery. Relay 2011 opens the operating circuits of the sender group relays 2020, 2024, 2029, etc., provides a holding circuit for relays 1705 and 2289 and closes a circuit from ground at the inner left back contact of relay 2503, outer right front contact of relay 2011, outer right front contact of relay 2020, inner right back contacts of relays 2024, 2029, etc., inner right front contact of relay 2020, key contact 1916, conductor 1917, outer left front contact of relay 2315, to the winding of relay 2319 and

battery. Relay 2319 connects the control circuit to the selected group of senders and proceeds to test for an idle sender in the group.

Selecting idle sender

In order to distribute the use of senders and district junctors, preference is based on the location of the line calling. For this purpose relay 2240 grounds conductor 2624, as does the next higher numbered relay, while relay 2249 grounds conductor 2239 which is also grounded by the next lower numbered relay and the intermediate relays in pairs ground three other conductors. It being assumed that relay 2240 was operated and locked, conductor 2624 is grounded, preparing a circuit over armature 2623 of relay 2600, conductor 2811, fourth left contact of relay 2805, conductor 1813, armature 1812 of relay 1806, conductor 2331, armature 2330 of relay 2319, inner left back contact of relay 2332, over the back contact of relay 2300 to the winding of relay 2320, normal contacts of relays 2324, 2329, etc., to battery. If relay 2300 were operated to indicate that this sender was busy, the circuit would be extended to relay 2329 and in turn to the next lower numbered relays of the groups 2320 to 2329, while if some other conductor were grounded, the test chain would start at the armature of the proper relay of the group 2300 to 2309 and complete the circuit of the first relay of the group 2320 to 2329 which corresponded to an idle sender.

Assuming relay 2320 to be operated, it locks to battery at its own front contact and supplies a holding ground for relay 2312.

In addition it closes ground over its middle right contact to the winding of relay 2332 which opens the sender test circuits, closes an additional holding circuit for relay 2312, and completes a circuit from ground at its inner right contact, armature 2333 of relay 2319, conductor 2334, key contact 1918, conductor 1919, outer left back contact of relay 2503, inner right contact of relay 2406 to the winding of relay 2502 and battery. Relay 2502 connects ground to the off-normal relays.

If relay 2410 had been operated alone, indicating that only the one district junctor was available in that group, relay 2502 in operating would have closed a circuit from ground at the left back contact of relay 2408, outermost left front contact of relay 2502, outer left front contact of relay 2410, inner left back contacts of relays 2414, 2419, etc., conductor 2409, key contact 1920, conductor 1921, inner right front contact of relay 1415 to the traffic meter associated with the group of ten district junctors, indicating that all of the junctors of the group were simultaneously busy.

Operating hold magnet of secondary line switch

Relay 2502 also closes the circuit of the hold magnet of the secondary line switch having access to the selected group of districts. This circuit may be traced from the preference ground supplied to conductor 2331 from the front contact of relay 2240 as previously traced, over key contact 1937, conductor 1922, inner right contact of relay 2502, conductor 2524, middle right front relay 2410, conductor 2407, key contact 1923, conductor 1924, armature 1814 of relay 1806, conductor 1815, outer right contact of relay 2803, conductor 2823 to the winding of hold magnet 1241. The six right and four inner left contacts of relay 2803 are connected to the windings of the ten hold magnets of the group of ten junctors in the secondary line switches. The grounding of a particular contact indicates that the corresponding district junctor has been selected and the operation of the hold magnet extends the line link to the district junctor.

Test of group of district junctors

At this time the control circuit tests the group of district junctors for availability for use on future calls. Relay 2502 in operating closes a pair of circuits from ground at its third and fourth right contacts, conductors 2505 and 2506, key contacts 1925 and 1926, armatures 1825 and 1826 of relay 1806 through the windings of relays 1805 and 1801, respectively. These relays prepare test circuits for all of the district selectors of the group represented by relay 1806. Battery from idle selectors is connected as previously traced to conductor 1304 and over the back contact of the hold magnet of the primary sender selector, outer left contact of relay 1801, resistance 1816, windings of relays 1817 and 1818 in series to ground. Similar circuits extend from battery at idle junctors to the group of contacts of relays 1801 and 1805, ten being connected in parallel to the windings of relays 1817 and 1818 and the other ten being connected in parallel to the windings of relays 1819 and 1820. Relays 1818 and 1820 are marginal and operate only if at least two of these test circuits are completed, that is, if two out of the ten districts are idle, while relays 1817 and 1819 are sensitive relays, operating if the circuit is completed at any one district junctor. If relay 1818 fails to operate, relay 1801 locks over the back contact of relay 1818, right front contact of relay 1801 and the normal contacts of relays 1413 and 1412 when relay 1412 releases as described hereinafter. Similarly, if relay 1820 fails to operate relay 1805 locks under the control of relays 1412 and 1413. The test circuits are held closed as long as relays 1801 and 1805 remain operated so that if two district junctors become idle, relay 1818 or 1820 will operate, in turn releasing relay 1801 or 1805 and being released in turn together with relays 1817 and 1819.

If one district junctor in the group is idle, so that relay 1817, for example, is operated, relay 1817 closes a substitute test circuit from the back contact of magnet 1451, over the right front contact of relay 1817 to conductor 1835, which, when relay 2710 operates is extended through to the winding of group relay 2289 as a reserve test for groups having only one idle district when no group is found having two or more idle districts. Relay 1819 performs the same function for the second group of ten districts. If neither relay 1817 nor relay 1819 is operated, indicating that no idle districts are available, the locking ground for relays 1801 and 1805 is extended over the inner lower and upper contacts of relay 1800 in parallel, back contacts of relays 1819 and 1817 in series to the lower winding of relay 1800 holding that relay operated and opening both the regular and reserve test circuits.

Operating select magnet of primary sender selector

When relay 2319 was operated to connect the selected group of senders to the control circuit, a parallel circuit was closed over conductor 2335, armature 1822 of relay 1806, conductor 1821 to battery through the winding of select magnet 1403 of primary sender selector 1400, thereby

preparing the one sender link which connects the selected district junctor group with the selected sender group.

Operating select magnet of secondary sender selector

With relay 2320 operated to select an individual sender from the group, a circuit was closed from ground at armature 2336 of relay 2319 over the outer right front contact of relay 2320 to hold that relay operated and over the outer left front contact of relay 2320, armature 2337 of relay 2319, conductor 2338 to battery through the winding of select magnet 1453 individual to the selected sender in the secondary sender selector 1450. Magnet 1453 in operating closes a circuit from ground at its front contact, conductor 1414, key contact 1927, conductor 1928, left normal contact of relay 2507, outer right contact of relay 2406, winding of relay 2501 and battery.

Operating hold magnets of sender selectors

With relay 2501 operated, a circuit is closed from battery through the windings of hold magnets 1401 and 1402 (two switches are used in order to close through the large number of conductors) outer left contact of relay 1415, conductor 1416, key contact 1929, conductor 1930, outer right front contact of relay 2410, inner left front contact of relay 2501, conductor 1922, and key contact 1937 to conductor 2331 and to the preference ground as previously traced. Magnets 1401 and 1402 connect the selected district junctor to the sender link 1410 and magnet 1402 extends its operating ground over conductor 1404 of the sender link 1410 to the windings of the hold magnets 1451 and 1452 of the secondary sender selector, thereby connecting the district junctor over the sender link to the selected sender. Magnet 1452 closes a holding circuit for itself and the other sender selector hold magnets over conductor 1417, thereby extending the operating ground to the sender. Magnets 1401, 1402, 1451 and 1452 open their back contacts to mark the switches and links busy to other calls.

Magnet 1401 in operating closes ground over its lower front contact, middle upper back contact of relay 1302, lower normal contact of relay 1301, left back contact of relay 1306, resistance 1305 to conductor 1242 to hold the hold magnet 1241 of the secondary line switch.

Operating hold magnet of primary line switch

When hold magnet 1241 operated, it extended its operating ground over its lower front contact and the sleeve contact of the secondary line switch 1240 over armature 1223 of relay 1208, conductor 1224 and the line link test circuit as previously traced to the winding of relay 2269 and battery. With relay 2269 operated, a circuit was closed as previously traced from battery through the winding of the primary hold magnet 1201, contact of relay 1216, conductor 2632, armature 2631 of relay 2600, conductor 2250, outermost front contact of relay 2240, outer left contact of relay 2269, second front contact of relay 2289, back contacts of intermediate relays and relays 2282 and 2280, conductor 2628, armature 2627 of relay 2600, conductor 2822, inner left contact of relay 2800, conductor 1823, armature 1824 of relay 1806, key contact 1931, conductor 2508 to ground at the right back contact of relay 2503. Magnet 1201 connects the subscriber's line through to the line link and opens the circuit of line relay 1202, thereby removing ground from conductors 1203 and 1204.

When relay 2320 operates, it connects ground from armature 2336 of relay 2319, over the outer left front contact of relay 2320 to conductor 2341 to operate the sender connecting relays. When these relays have functioned and the connection with the calling line has been tested, as described in the application of R. Raymond above identified, ground is connected to conductor 1418, operating sender busy relay 2300. Relay 2300 opens the circuit of relay 2320 to prevent its operation on another call as long as the sender is busy. At its right back contact, it also opens the corresponding link in the chain circuits indicating two idle senders. Furthermore it closes a link in the sender group busy circuit by which relay 2311 is operated when all senders of a group become busy. In addition it connects conductors 1419 and 1420 together for controlling the ground which is to hold the established connection with the sender so that the connection will not be held by the sender unless its sender busy relay is operated.

Test of connection between line and sender

Before releasing, the sender control circuit determines that the hold magnets have all operated and that the tip, ring and sleeve conductors are complete between this line and the sender. The operation of relay 2300 as above described is an indication that the tip and ring conductors are properly closed.

The sender also extends the ground connected to conductor 1417 by the hold magnets 1402 and 1452 to conductor 1422, armature 2342 of relay 2319, conductor 2347, key contact 1932, conductor 1933, to the winding of relay 2507 and battery as an indication that these hold magnets have operated.

When line relay 1202 disconnects ground from conductor 1204 it releases relay 1711. With relay 1711 released a circuit is closed from ground at armature 2633 of relay 2600, conductor 1225, front contact of relay 1206, armature 1227 of relay 1208, conductor 2608, armature 2607 of relay 2600, conductor 1708, second left front contact of relay 1710, inner right contact of relay 1718, right left back contact of relay 1711, conductor 1720, armature 2721 of relay 2700, conductor 2722, outer left front contact of relay 2800, conductor 2820, armature 1831 of relay 1806, conductor 1832, armature 2343 of relay 2319, conductor 2344 to a relay in the sender which operates as an indication that the primary and secondary line switch hold magnets have operated.

Relay 2030 is a polarized relay with differentially arranged windings so that normally the relay will not operate on current that flows through both windings in series. When relay 2507 operated as above described, it closed additional operating grounds for relays 1801 and 1805 and additional holding ground for relay 2011 to prevent its premature release and false reoperation of any of the relays 2020 to 2029. It also prepares the circuit for relay 2030 and provides battery for relay 2510. It likewise opens the circuit of relay 2501 which now releases opening the operating circuits for magnets 1401, 1402, 1451 and 1452 which are held operated over conductor 1417 which, at this time is connected by the sender connecting relays to conductor 1422, thence as previously traced to conductor 1933, and in parallel with the winding of relay 2507

through the upper winding of relay 2030, inner left front contact of relay 2507, conductor 1928, key contact 1927, conductor 1414 to ground at the front contact of select magnet 1455. This ground through the winding of relay 2030 is sufficient to hold magnets 1401, 1402, 1451 and 1452 and also to operate relay 2030 against the opposition of the curent flow through the lower winding which is connected to ground over the inner right contact of relay 2400, upper winding of relay 2030 and thence to ground as above traced. Relay 2030 will not operate if the sleeve of the established connection is crossed with the holding ground of another connection since for this condition its upper winding is shunted and the lower winding receives additional current to overcome the operating energy of the upper winding. If relay 2030 does not operate, the timing relays function to operate an alarm as will be described hereinafter.

Assuming that relay 2030 does operate, it removes a shunt from the winding of relay 2510 and closes ground to its winding, causing relay 2510 to operate. Relay 2510 locks to ground at its middle left contact, prepares circuits for relays 2425 and 2503 and connects ground over its inner left contact, conductor 2511, key contact 1934, conductor 1938, armature 2345 of relay 2319, conductor 2346 to the sender to cause the sender to connect ground directly to conductor 1417 to hold the connection. The sender responds to ground on conductor 2346 by transferring conductor 1417 from conductor 1422 to direct ground, thereby opening the circuit of relay 2030 which now closes ground over its normal left contact, right front contact of relay 2510, left winding of relay 2503 and battery.

Test of connection through line switches

With relay 2503 operated, the circuit of relay 2319 and magnet 1403 is opened at the inner left back contact of relay 2503. Relay 2503 also opens the circuit of relay 2502 at its outer left back contact, disconnects ground from the operating circuit for the line hold magnet 1201 and locks to ground over its inner right front contact and the inner left contact of relay 2510. Relay 2502 in releasing connects the right winding of relay 2503 over the left back contact of relay 2502 and the outer right front contact of relay 2503 to conductor 2508 which extends to the winding of the line hold magnet and the sleeve of the subscriber's line. If the continuity of the sleeve through the line link and group control circuit is complete, a circuit will be closed from ground at the lower front contact of magnet 1401, through the district junctor circuit as previously traced to sleeve conductor 1242, sleeve contacts of the secondary and primary line switches, upper contact of relay 1216, conductor 2632, armature 2631 of relay 2600, conductor 2250, outer front contact of relay 2240, front contact of relay 2269, second front contact of relay 2289 and back contacts of the intermediate relays and relays 2282 and 2280, conductor 2628, armature 2627 of relay 2600, conductor 2822, inner left contact of relay 2800, conductor 1823, armature 1824 of relay 1806, key contact 1931, conductor 2508, outer right front contact of relay 2503, outer left back contact of relay 2502, conductor 2512, key contact 1935, armature 1833 of relay 1806, conductor 1834, middle left contact of relay 2800, conductor 2821, armature 2629 of relay 2600, conductor 2630, outer right back contact of relay 1711, third right front contact of relay 1710, winding of the line control release relay 1700 and battery. Since the right winding of the sender control release relay 2503 is also connected to this ground, the release of both circuits depends on the continuity of the holding ground through the district junctor, and line switches. If this fails, the timing relays function to operate an alarm.

Release of line group and control circuit

Relay 1700 closes holding circuits for itself over its right contacts to relays 1707, 1704, 1715 and 1716, 1702, 1722, 1709 and 1718 to insure that it releases last. It also closes ground over its middle left front contact, conductor 1721, armature 2723 of relay 2700, conductor 2724, to the left winding of relay 1601 and battery and over its inner left front contact, conductor 1727, armature 2733 of relay 2700, conductor 2734 to the right winding of relay 1601 and battery. Relay 1601 operates, opening the circuit of relay 1603 which releases, in turn releasing relays 1607, 2600 and 2700. Relays 2600 and 2700 disconnect the line control circuit from the line group circuit, thereby releasing relay 1208 which opens the circuits of relays 1215 and 1216 and of all select magnets including magnet 1211.

Relays 2600 and 2700 also release relay 2800 which in turn releases relays 2805 and 2803. In the line control circuit, the release of relay 2700 releases relays 1710 and 1704 which in turn release relays 1709, 1718, 1703, 2200 and 2240, while the release of relay 2600 releases relays 2289, 2269, 1705 and 1722. With all of these relays released, relay 1700 also releases and the line group and control circuit returns to normal, provided no other call in the line group is waiting for service.

The cross-points set up in the line switches for this call remain operated from ground on the sleeve conductor 1242 supplied first from the sender and later from the district junctor circuit of Fig. 13.

Traffic lock-out

If no calls are waiting in other horizontal groups, relay 1206 releases after the call is set up. When calls are waiting in other horizontal groups, ground from the front contact of the relay corresponding to relay 1205 of those groups, holds relay 1206 and prevents that group from placing any more calls. As each group is served the corresponding relay 1206 is operated and held. With relay 1206 operated, relay 1205 cannot reoperate. When there is no longer any operated relay like relay 1205, those relays corresponding to relay 1206 for groups which have been served release and waiting calls in groups already served may be extended.

Rotation of district group preference

When relay 1700 operates for the release of the control circuit, it closes a circuit from ground at its outer left contact, normal contact and winding of relay 1715, through resistance 1724 to battery. Relay 1715 locks to ground at its inner right contact, completing a circuit from battery through resistance 1725, winding of relay 1716, to ground at the inner right contact of relay 1715. Relay 1716 does not operate being shunted by ground from the outer left front contact of relay 1700 which is connected over the left back contact of relay 1716 to resistance 1725. When the control circuit has restored to normal, relay 1700 releases and relay 1716 operates. These relays remain operated throughout the next call. When relay 1700 operates at the release of the next call,

it connects ground over its outer left contact and the left front contact of relay 1716 to resistance 1724 in shunt of the winding of relay 1715, releasing that relay but holding relay 1716 operated over the normal contact of relay 1715. When relay 1700 releases relay 1716 also falls back.

The purpose of these relays is to prevent an originating subscriber from always getting the same district junctor and the same sender circuit during periods of light traffic. The circuit is arranged to prefer two groups of district junctors, each preferred alternately on successive calls. The circuits for operating the relays such as relays 2800, 2805 and 2803 or 2804, which identify the group of districts, are supplied over chained contacts of the group relays 2280 to 2289 and are introduced into the chain over contacts of relay 1715 so that relay 2280 is in preferred position when relay 1715 is operated and relay 2282 is in preferred position when relay 1715 is normal.

Release of sender control circuit

When relay 2800 releases it removes ground from conductor 2806, releasing the group relay 2000 which in turn releases relay 2315, opening the locking circuit of relay 2020 and the operating circuit of relay 2011. However, relay 2011 is held operated over the second left front contact of relay 2507. The release of relay 2803 releases relay 1412 and relay 1415. When relay 1412 releases, the locking circuits above described for the test relays of the district group are closed and relays 1801 and 1805 are held operated if less than two district junctors are available. With relays 2800 and 1415 released, relay 1806 releases, disconnecting the control circuit from this group circuit. Relay 1806 opens the operating circuits of relays 1801 and 1805 thus leaving these relays dependent on relays 1818 and 1820. Relay 1806 also opens the locking circuit of relay 2400, releasing the operated relays of the group 2410 to 2419. With relays 2315 and 1806 released relay 2319 also releases in turn releasing select magnet 1453. When magnet 1453 opens its contact it opens the holding circuit of relay 2507 and that relay releases, since relay 2400 is also released.

With relay 2507 released, relays 2011 and 2510 also release, finally restoring release relay 2503. Relay 2503 in turn releases relay 2402 opening the circuit of relay 1800, which, however, is held operated under the control of relays 1817 and 1819 if no district junctors are idle in the group of twenty. Relay 2402 also releases relay 2500 to reset the timing relays for the next call.

Class of service indication

Subscribers' lines requiring the same class of service are placed in the same relative position in each group of ten lines, so that the one of the line test relays 2240 to 2249, operated by the line is an indication of the class of service required by that line. The set of punchings 2815 which are grounded by the corresponding line test relays are cross-connected to the set of contacts 2817 so that a maximum of five classes of service indications may be passed into the sender through the sender control circuit. While the line control circuit and the sender control circuit are connected and connected to the sender, this subscriber's class indication is transmitted to the sender. The circuit closed by relay 2240, for example, may be traced from ground over the fourth front contact of that relay, conductor 2251, armature 2717 of relay 2700, conductor 2718, cross-connecting terminals 2816 and 2818, second right contact of relay 2805, conductor 2819, armature 1830 of relay 1806, armature 2348 of relay 2319 over conductor 2339 to the selected sender.

District frame indication

Likewise relay 2319 in operating connects ground to conductors 2349 and 2340 to identify to the sender the district junctor frame on which the district serving the call is located.

Emergency operation

Two line groups are arranged to work as mates so that if trouble develops in the control circuit of any frame, that frame may continue to operate, using the control circuit of its mate frame. Under this condition the two mate frames use the control circuit of one of them as a common control circuit, calls being served alternately on the two frames by the one control circuit shown in Figs. 17, 22, 26, 27 and 28. The group circuits of Figs. 12 and 16 are individual to the line group while the connecting relays of Figs. 26 and 27 are individual to the control circuit. The dotted rectangle of Fig. 21 is a convenient means of indicating the relationship between the two frames. All conductors entering the rectangle must be considered as emerging at the mate frame. In general, it may be said that the conductors from the control circuit extend directly to the contacts of relays 2600 and 2700 and the group circuit of the home frame, while they extend in parallel over contacts of relays, such as relays 2601 and 2701 at the mate frame to the mate group circuit. Conversely it may be said that the conductors from the line group circuit extend over contacts of relays 2600 and 2700 to the home control circuit and over contacts of relays 2601 and 2701 to the mate control circuit.

When relay 1205 operated to ground the start lead 1225 and operate relay 1603 it also connected ground to interrupter 1600. When relay 2600 operates it also closes ground to conductor 1225 thus maintaining the ground on interrupter 1600 until the line is connected through to the district junctor and sender. When interrupter 1600 closes its left contact it operates relay 1614 which locks to the start lead 1225 and prepares a circuit for relay 1615 which is completed if interrupter 1600 closes its right contact before relay 1614 is released. Relay 1615 operates relay 1616 which locks under the control of key 1617, lights lamp 1618 and operates an alarm over conductor 1619 and key 1620.

Relay 1615 also closes a circuit from battery through the winding of relay 1621, left back contact of relay 1604, inner right front contact of relay 1615, left back contact of relay 1601, to ground over key 1622. Relay 1621 locks over its own front contact to ground on key 1622. With relay 1621 operated and both control circuits working, as indicated by the fact that relay 1602 of both the home and mate frames are released, a circuit is closed which may be traced from battery through the right winding of relay 1601, inner left back contact of relay 1602 of the home frame, third left back contact of relay 1602 of the mate frame, right back contact of relay 1604, outer right front contact of relay 1615, inner right front contact of relay 1621 to ground on key 1622. Relay 1601 opens the circuit of relay 1603 which releases, in turn releasing relays 1607, 2600 and 2700, thereby disconnecting the frame from the home control circuit. Since relay 1700

has not been operated the control circuit does not return to normal.

When interrupter 1600 leaves its right contact relay 1615 releases, in turn releasing relay 1601. Since relay 1621 is locked, a circuit is closed from battery through the winding of relay 1602 of the home frame, outer left back contact of relay 1602 of the mate frame, inner left back contact of relay 1615, outer right front contact of relay 1621 to ground on key 1622. Relay 1602 closes an obvious circuit for relay 1604 which closes a holding circuit for relay 1602 to key 1622 independent of the mate frame relay. Therefore, relays 1621, 1602 and 1604 are locked to key 1622, lamp 1627 being lighted under the control of relay 1604. If conductor 1225 is still grounded when relay 1601 releases, relay 1603 reoperates closing a circuit from ground at its outer left front contact over the outer right front contact of relay 1602 to the winding of relay 1606 of the mate frame. This relay operates the mate connecting relays 2601 and 2701 of the home frame, thereby connecting the home frame to the mate control circuit. The control circuit on the mate frame continues to be used until key 1622 is operated. Since the circuits of relays 1606 and 1607 extend over the back contacts of each other, the control circuit is allotted to the two frames on an alternate basis.

Sender control timing circuit

The principal function of relays 2500, 2520, 2521, 2513, 2514, 2031, 2405 and 2422 is to time each call in order to dismiss the calling line link and group control circuit within a short interval if a trouble condition is encountered. These relays also serve to record the number of such trouble conditions and also operate an alarm each time that such a condition occurs. Relay 2500 operates when battery is connected to its left winding or when ground is connected to off-normal conductor 2523. Relay 2500 prepares the circuits for holding relays 2031, 2513 and 2514 during various intervals of the timing cycle and connects battery to relays 2520 and 2521.

Interrupter 2525 intermittently grounds conductor 2526. At the first closure following the operation of relay 2500, a circuit is closed from battery through resistance 2518, middle left contact of relay 2500, winding and normal contact of relay 2520 to ground on conductor 2526. Relay 2520 locks to ground at its right contact and closes a circuit from ground over its alternate contact through the winding of relay 2521, inner left contact of relay 2500 to battery through resistance 2517. Relay 2521 does not operate at this time since the battery is shunted over its normal contact by ground on conductor 2526. When the interrupter opens its contact relay 2521 operates. At the next closure of interrupter 2525, ground on conductor 2526 extends over the alternate contact of relay 2521 in shunt of the winding of relay 2520 which releases, transferring the circuit of relay 2521 to conductor 2526 so that relay 2521 remains operated until the interrupter again opens its contact, at which time relay 2521 also releases and relays 2520 and 2521 are ready for another cycle.

At the first operation of relay 2521 a circuit is closed from battery through the winding of relay 2513, back contact of relay 2031, left front contact of relay 2521, to ground at the outer right contact of relay 2500. Relay 2513 locks over the right back contact of relay 2514, outer left contact of relay 2500 to ground at the back contact of relay 2520, which releases while relay 2521 is held operated as above described. With relay 2513 held operated, the release of relay 2521 closes a circuit from battery through the winding of relay 2031, left front contact of relay 2513, left back contact of relay 2521 to ground at the outer right contact of relay 2500. Relay 2031 locks to ground at the inner right contact of relay 2500. When interrupter 2525 connects ground to conductor 2526 for the third time, relay 2520 reoperates, releasing relay 2513 which extends the locking ground of relay 2031 over the front contact of relay 2510 to the winding of relay 2425. Relay 2425 receives battery from the sender if the tip and ring conductors are not completed properly and serves to release the control circuit and record the condition on a meter. When relay 2521 now operates, a circuit is closed from battery through the winding of relay 2514, left front contact of relay 2031, left front contact of relay 2521, to ground at the outer right contact of relay 2500. Relay 2514 locks to off-normal ground on conductor 2404, closes circuits for relays 1801 and 1805, prepares circuits for lamps 2515 or 2516 according as relay 2501 or 2507 is operated when the timing is completed, lights lamp 2517, operates trouble meter 2528 and connects ground to conductor 2519 to operate the trouble recording meter of the line link and group control circuit being served at this time. It also closes a circuit from battery through the winding of relay 2422, key 2423, right back contact of relay 2032, to ground at the second left contact of relay 2514. Relay 2422 locks under the control of key 2423 and sounds an alarm.

When ground on conductor 2526 again shunts relay 2520, that relay closes a circuit from ground at its left contact, left front contact of relay 2500, outermost right front contact of relay 2514, through the winding of relay 2405 to battery. Relay 2405 releases relays 2289, 1705 and 1722 in the line control circuit, thereby releasing relays 2800, 2805 and 2803 to disconnect the line control circuit from the faulty sender control circuit and thereby releasing the off-normal relays 2400 and 2402, and relay 2500 which opens the circuit of relay 2405. Relays 2405 and 2521 close holding circuits for relay 2514 to prevent its premature release when ground is removed from conductor 2404 and to insure that the line control circuit is routed to another available sender control circuit. When interrupter 2525 removes ground from conductor 2526 relay 2521 releases opening the holding circuit for relay 2514 which also releases.

Holding sender control circuit in trouble

In case of repeated trouble the sender control circuit may be held off-normal to permit the maintenance force to determine the source of trouble. When it is desired to hold the circuit, a plug is inserted in jack 2424, transferring the alarm circuit closed by relay 2422 from a minor to a special alarm. A circuit is closed for relay 2032 over the lower contact of jack 2424 to ground at the inner contact of relay 2422, relay 2032 holding the operated relay of group 2000 to 2004. The middle contact of jack 2424 shunts the contact of relay 2405 thus preventing the release of the line control circuit until it times out and transfers to the mate frame.

False starts

As far as the sender control circuit is concerned, there is no difference between a trouble condition wherein the tip and ring conductors through the switches of the established connec-

tion are not closed properly and a normal "false start" call wherein the tip and ring conductors are closed momentarily to start a call and then immediately opened by the calling subscriber. On such false starts the closure usually continues until after a sender has been selected and the control circuit dismissed while a trouble condition prevents the dismissal of the sender in the normal manner. However, if such dismissal does not occur within the time measured by relays **2520** and **2521** as above described, relay **2513** in releasing operates relay **2425** to battery supplied by the sender and this relay operates a meter and also operates release relay **2503** to release the line control circuit. An abnormal number of such false starts recorded by a sender control circuit indicates trouble in the tip and ring connections. The insertion of a plug in make busy jack **1848** operates relay **1800**, thus removing the associated group of twenty districts from service and permitting the adjustment of relays **1817**, **1818**, **1819** or **1820** or switches **1400** or **1450**. Similar jacks are provided for operating relays **2311** and similar relays to remove a group of ten senders from service.

Relays **2420** and **2421** are used to control the sender link and control circuit when making an automatic test of district junctors.

District junctor circuit

The district junctor relay circuit shown in Fig. 13 has had no function up to the present since the sender selectors **1400** and **1450** connect the tip and ring conductors from the secondary line switch **1240** directly to the sender without requiring the cooperation of the district junctor relays.

The function of this circuit has been described in applicant's copending application above referred to, hence the operation will be described only briefly.

When the sender has received the office code and has been connected to the decoder marker **1500** through decoder marker connector **1501**, the sender connects ground through the sender selectors to conductor **1309**, operating relay **1307**. Relay **1307** controls the connection of the decoder marker **1500** with the district link and the district junctor by way of the district connector circuit **1503**. While the decoder marker is establishing the outgoing connection over the district and office links, it operates relay **1323** over conductor **1324** in the case of a charge call. Relay **1323** locks over its inner lower front contact and the back contact of relay **1311** to ground supplied from the sender to conductor **1425**. Relay **1307** is released when the decoder marker finishes its operation.

The sender then controls the equipment at the distant office over conductors **1313** and **1314** and upon receiving the reverse battery signal which indicates the completion of its function connects ground to conductor **1310**, completing a circuit over the back contact of relay **1307** to the winding of relay **1301** which operates and locks over the back contact of relay **1311**. Relay **1301** connects the line to battery and ground through the windings of battery feed relay **1312** and removes the battery from conductor **1304** by which the circuit was marked idle. It also connects ground from the back contact of relay **1311** to conductor **1242** in place of the ground from magnet **1401** and closes a substitute holding ground for relay **1323**.

When the sender is released from the district junctor, the hold magnets **1401**, **1402**, **1451** and **1452** of the sender link release and relay **1401** supplies ground to contacts of relays **1312** and **1315**.

The tip and ring conductors **1313** and **1314** outgoing to the distant office are connected over front contacts of relays **1301** to the winding of relay **1315** and through condensers **1316** and **1317** to the calling line. When the called subscriber answers, relay **1315** operates, connecting ground from the back contact of magnet **1401** to interrupter **1318**. If the connection is maintained for a sufficient length of time, interrupter **1318** closes its right contact operating relay **1306** which locks under the control of relay **1315**. When interrupter **1318** closes its left contact it operates relay **1319**, which locks under control of relay **1323**.

If both subscribers release, relays **1312** and **1315** both release, and as soon as interrupter **1320** closes, relay **1302** operates over the back contact of relay **1311**, front contact of relay **1301**, back contact of relay **1312** to ground at the back contact of magnet **1401**. Relay **1302** locks over this same circuit independent of the interrupter and closes a holding circuit for itself and an operating circuit for relay **1311** during the time that interrupter **1321** is closed. Relay **1302** provides a temporary busy ground to the line switch sleeve conductor and a holding circuit for relays **1319** and **1323**. Relay **1311** opens the holding circuit of relay **1301** which in turn opens the locking circuits for relays **1302** and **1323** so that these relays also release when interrupter **1321** opens followed by relays **1311** and **1319**.

As soon as relay **1301** closes its back contact, a circuit is closed from battery through resistance **1300**, outer upper back contact of relay **1301**, outer upper front contact of relay **1302**, upper front contact of relay **1323**, outer right front contact of relay **1319** to conductor **1325** and through the line switches to the subscriber's message register **1231**. When relay **1302** releases the metering pulse terminates.

If the called party disconnects but the calling party is slow in disconnecting, the release by the called party releases relays **1315** and **1306**. When, thereafter interrupter **1322** closes, it completes a circuit over the back contact of relay **1306**, front contacts of relays **1319**, **1312** and **1301** and back contact of relay **1311** to interrupter **1320**, thereby operating relay **1302** which functions as previously described. The release of relay **1301** opens the circuit for relay **1312**.

If the call had been directed to an operator's position where the talking battery is supplied from the answering cord, the decoder marker would have operated relay **1311** as well as relay **1301** and the tip and ring conductors would be connected through the junctor circuit independent of relays **1312** and **1315**. In this case release is under the control of the operator.

INCOMING CALL

Seizure of sender link and control circuit

In the case of a call incoming to the cross-bar office, the distant office seizes an incoming junctor such as shown in Fig. 58 and establishes a bridge across the fundamental circuit in the sender at the originating office. A circuit is thereby completed from battery through the upper winding of relay **5802**, upper back contact of relay **5801**, tip contact of jack **5800**, tip conductor **5819**, over the bridge at the originating office back to ring conductor **5820**, ring contact of jack **5800**, lower back contact of relay **5801** to ground

through the lower winding of relay 5802. At this time ground is connected over the outer lower back contact of relay 5805 in shunt of the lower winding of relay 5802 and battery is connected through resistance 5806 and the middle upper back contact of relay 5805 in parallel with the upper winding of relay 5802 to improve the operating conditions for the pulsing relay of the originating sender circuit. Relay 5802 operates in the circuit traced, connecting ground over its front contact and the inner lower back contact of relay 5805 to start conductor 5821 to summon a terminating sender.

The incoming junctor is connected to the terminating sender by means of a group of primary and secondary cross-bar switches similar to those connecting the district junctor with the subscriber's sender. One hundred incoming trunks appear in ten groups of ten in the primary sender selectors and thirty senders appear in three groups of ten in the secondary sender selectors. Three primary cross-bar switches are divided so that for each group of ten incoming junctors there are three verticals which are connected to three sender links which are in turn connected one to a vertical in each of the three secondary switches. The link frame may be used altogether with full selector incoming junctors or it may be used entirely with "B" switchboard junctors in which case only "B" senders are used. Or, if desired, the frame may serve a combination of the two kinds of incoming junctors, routing each to its own kind of sender. This latter arrangement is described and claimed in the application of W. W. Carpenter et al., Serial No. 68,263 filed March 11, 1936.

This link and control circuit, like the line group and control circuit is arranged to act as an emergency control circuit for an adjacent or mate frame. The dotted rectangle 4300 of Fig. 43 has been used as a convenient means of indicating the relationship between the two control circuits, and as in the case of Fig. 21, all conductors entering the rectangle emerge at the mate frame.

Test for presence of idle link and sender

When relay 5802 connects ground to conductor 5821 it completes a circuit over the inner back contact of relay 5121 which is individual to the junctor of Fig. 58, back contact of primary hold magnet 5125, conductor 5126, inner back contact of relay 3509, conductor 3530, right back contact of relay 5121, contact of jack 5147 to the winding of group relay 5122 and battery. The circuit of relay 5122 also extends in parallel over the back contacts of the hold magnets individual to the other two sender links which serve this group of trunks and over the back contacts of the corresponding sender group busy relays. Relay 5121 is operated if the control circuit is busy, hold magnet 5125 is operated if the corresponding sender link is in use with another trunk and relay 3509 is operated if all of the senders in the corresponding group are busy. Therefore relay 5122 can only operate if the control circuit is idle and an idle link to an idle sender is available.

Connecting junctor group to control circuit

Assuming that relay 5122 operates, at its middle right contact it closes a holding ground for itself over the contacts of magnet 5125 and relay 3509. It also connects ground over its outer right contact and the left back contact of relay 4446 to the winding of relay 4452 to start the control circuit functioning. With relay 4452 operated, a circuit is closed from battery through the winding of relay 4442, over the left back contact of relay 4450 or the inner left back contact of relay 4443 of the mate control circuit indicating that that control circuit is functioning, inner right back contact of relay 4450 and the outer right back contact of relay 4443 of the home control circuit to ground at the right front contact of relay 4452. Relay 4442 in turn closes circuits from battery through the windings of relays 5000 and 3600, over its right contacts in parallel, over the right back contact of relay 4445, conductor 4454 to ground at the inner left back contact of relay 4228. Relays 5000 and 3600 connect the group circuits to the home control circuit. Relay 4442 also opens the circuit of relay 4445 to prevent interference from the mate frame until the control circuit has completed its function. It also connects ground over the outermost front contact of relay 5000 to conductor 4454 to hold relays 5000 and 3600 operated.

Choosing junctor group

With relay 5000 operated, an indication of the group within which the calling junctor lies is given to the control circuit. Ground from the inner right contact of relay 5122 extends over conductor 5127, armature 5002 of relay 5000, conductor 5003, outer back contact of relay 4430 to the winding of relay 4429 and over the normal contacts of the lower numbered group test relays to battery at the back contact of relay 4420. Relay 4429 closes a holding circuit to battery at its inner upper front contact. If trunks in other groups were calling their relays might also operate, but preference is given to the highest numbered group by reason of the chain wiring of relays 4420 to 4429. Assuming relay 4429 operates, it extends its operating ground over its lower front contact over the upper back contact of relay 4410 to the winding of relay 4441 and battery. Relay 4429 also closes a circuit from ground over its outer upper front contact, armature 5004 of relay 5000, winding of relay 5120 to battery.

Choosing junctor

Relay 5120 in operating connects the start leads such as conductor 5821 through to the trunk test relays 4400 to 4409, conductor 5821 extending over armature 5128 of relay 5120, armature 5005 of relay 5000, inner lower back contact of relay 4410 to the winding of relay 4400 and battery. It will be noted that the start conductors of the ten trunks of the group are connected together at the contacts of relay 5121. Therefore the ground from conductor 5821 also extends over other back contacts of relay 5121 and front contacts of relays 5120 and 5000 to the windings of relay 4409 and the rest of the trunk test relays. Each relay locks to its operating ground independent of relay 4410. With all of the relays 4400 to 4409 operated, a circuit is closed from battery through the winding of relay 5121, armature 5129 of relay 5120, armature 5006 of relay 5000, right back contact of relay 4440, inner upper front contacts of relays 4400 to 4409, inner right contact of relay 4441 to ground at the middle lower front contacts of all of the relays 4400 to 4409. Relay 5121 in operating locks over its right front contact, armature 5142 of relay 5120, armature 5007 of relay 5000 to ground. It also disconnects the multiple ground from the trunk relays and releases relay 5122. Those relays, such as relay

4400 which correspond to calling trunks remain locked, but the remaining relays release.

The release of relay 5122 closes a circuit from battery through the winding of relay 4440, armature 5008 of relay 5000, armature 5131 of relay 5120, back contact of relay 5122, armature 5132 of relay 5120, armature 5009 of relay 5000, outer lower front contact of relay 4400 to ground over the operating circuit of that relay. Relay 4440 locks in a circuit from battery through its winding, armature 5008 of relay 5000, armature 5131 of relay 5120, left back contact of relay 5122, armature 5132 of relay 5120, armature 5009 of relay 5000, to ground at the fifth left contact of relay 4440. With relay 4440 operated a circuit is closed at its fourth left contact for relay 4430. Relay 4430 opens the operating circuits of the group relays 4420 to 4429, leaving the highest numbered operated relay, in this case relay 4429, locked over the inner front contacts of relay 4429, outer right contact of relay 4441 to ground at the middle lower contacts of the operated trunk test relays. When relay 4440 operates it closes a substitute holding circuit for relay 4429 which may be traced from battery over the inner upper front contact, winding and lower front contact of relay 4429, middle right front contact of relay 4440, armature 5011 of relay 5000, armature 5134 of relay 5120, back contact of hold magnet 5125, conductor 5126, inner back contact of relay 3509, conductor 3530, armature 5133 of relay 5120, armature 5012 of relay 5000, to ground at the third left contact of relay 4440. Parallel holding circuits extend over the other hold magnets and sender group relays serving the group. Therefore if all links or all sender groups become busy, relay 4429 releases, in turn releasing the group relay 5120 to normal so that other calling junctors may be served.

Relay 4440 also closes a locking circuit for the preferred trunk relay 4400 which extends over the inner and outer lower front contacts of relay 4400 to ground at the outer left front contact of relay 4440. This locking circuit prefers the lowest numbered relay, the higher numbered relays locking only over the back contacts of the lower numbered relays. However, if higher numbered relays were operated at this time they would remain locked to ground on the corresponding start lead.

Relay 4430 also closes an obvious circuit for relay 4410 which opens the operating circuits of the trunk test relays. Relay 4410 also opens the circuit of relay 4441 which releases, but due to its slow to release characteristic, only after an interval. Relays 4430 and 4410 in operating prevent the operation of any further group and trunk relays should additional calls be received.

Operating select magnet of primary sender selector

Relay 4410 also closes a circuit for the select magnet corresponding to the preferred trunk in the primary sender selector. This circuit may be traced from ground at the middle left back contact of relay 4228, conductor 4230, upper front contact of relay 4410, outer upper front contact of relay 4400, armature 5010 of relay 5000, winding of primary select magnet 5110 to battery. If relay 4409 had been the trunk relay operated, select magnet 5119 would have been chosen.

Test for idle sender group and link

In the meantime the control circuit has been testing for a sender group and sender. Since this is a full mechanical incoming trunk, group relay 5120 connects ground over its armature 5135 and armature 5013 of relay 5000 to conductor 5014 and the winding of relay 4226. When trunks incoming from mechanical and manual offices are both served, a relay similar to relay 4226 is provided for manual trunks and is operated from the group relays belonging to such trunks. With relay 4226 operated the three sender groups are tested to determine whether the link serving the calling trunk group is idle and whether there are two or more senders idle in the group. One such test circuit may be traced from ground at the left back contact of the link hold magnet 5125, armature 5136 of relay 5120, armature 5015 of relay 5000, conductor 5016, inner right back contact of relay 4221, right winding of relay 4202, left back contact of relay 4227, middle left front contact of relay 4226, conductor 4231, armature 3610 of relay 3600, right back contacts of relays 3502 and 3505, outer left back contact of relay 3510 to battery over the inner left back contact of the next lower unoperated relay in the chain. A similar circuit is closed over the outer back contact of each unoperated relay except relay 3519 to battery over the inner left contact of the next unoperated relay in the chain. Where operated relays intervene, the chain is extended to the following relay. This relay arrangement is disclosed and claimed in the application of A. J. Busch, Serial No. 68,240, filed March 11, 1936. Relays 3510 to 3519 are individual to the ten senders in one group and are operated when the corresponding sender is busy as will be described hereinafter.

Circuits similar to the one traced for relay 4202 are closed for relays 4201 and 4200 if the corresponding link and sender group are available. Assuming that relay 4202 is operated, a circuit is closed from ground through the winding of relay 3602, armature 3612 of relay 3600, outer right front contact of relay 4202, left back contact of relay 4218, conductor 4232, inner right front contact of relay 4440, conductor 4455, right back contact of relay 4228, resistance 4229 to battery.

Seizing sender group

Relay 3602 is individual to the group of senders represented by relay 4202 in this link circuit. A similar relay (not shown) is provided for each of the other sender groups. Relays 3603 and 3604 belong to the same sender group as relay 3602 but are a part of other link circuits. These relays are arranged in a lock-out chain in order to individualize the sender group to a particular link circuit and to prevent interference from other link circuits. In this case the link circuit shown has the preference for the sender group shown and relay 3602 in operating opens the circuits of relays 3603, 3604, etc. releasing any which may have attempted to operate. With relay 3602 operated a locking circuit is closed for relay 4202 which may be traced from battery through the left winding and over the inner left front contact of relay 4202, armature 3611 of relay 3600, outer left front contact of relay 3602, back contacts of relays 3603, 3604, etc. to ground. This same ground is extended over the inner left front contact of relay 3602, armature 3613 of relay 3600, to the winding of relay 4221 and battery. A circuit is also closed from ground at the middle right contact of relay 3602 to the winding of relay 3502 and battery. Relay 4221

opens the operating circuits of relays 4200, 4201 and 4202, causing relays 4200 and 4201, for which no locking circuits have been provided, to release.

Reserve sender group test

When relay 4441 closes its back contact, a circuit is closed from ground at the left back contact of relay 4441, outer right front contact of relay 4440, conductor 4456, winding of relay 4227 to battery. If none of the relays 4200, 4201 or 4202 has operated by this time, relay 4227 transfers their circuits from the regular test over back contacts of the sender relays 3510 to 3519, to the reserve test to battery over the back contacts of relays 3502 and 3505 and the similar relays of the other sender group circuits. Relay 3505 is operated over the outer left front contacts of relays 3510 to 3519 when all of the senders of the group are busy, thereby opening the circuit of the corresponding sender group relay. Therefore for groups having a single idle sender relay 3505 will now be unoperated and such a group may be selected. The operation of relay 3502 from relay 3602 when the regular test is satisfied cancels this reserve test, although relay 4227 is operated.

Selection of idle sender

With relays 4202 and 3602 operated and locked, the control circuit is ready to select an idle sender in the selected group. A circuit is first closed from ground over the middle left contact of relay 4221, inner left back contacts of relays 4200 and 4201, outer and middle left front contacts of relay 4202, armature 3614 of relay 3600, outer right contact of relay 3602, winding of relay 3500 to battery. Relay 3500 connects the circuits of the selected group of senders to the control circuit.

Relay 3500 connects ground to conductors 3531, 3532, 3533 and 3534. These conductors extend in multiple to the ten senders of the group but are ineffective until a sender has been seized. Conductor 3531 controls relays 3019 which reverses the direction of current flow over the contact of the stepping relay 3000 for calls received over part of the link circuits in order to save wear on the contact. Conductor 3532 supplies holding ground to the sender until after the off-normal relay 3700 has operated. Conductors 3533 and 3534 carry the identity of the trunk group to the sender for transmission to the marker.

Operating select magnet of secondary sender selector

Relay 3500 also closes a circuit from battery through the winding of relay 3508, armature 3535 of relay 3500, conductor 3536, armature 3615 of relay 3600, to ground at the outer left contact of relay 4226. With relay 3508 operated the circuits for selecting a sender are closed. Each trunk prefers a different sender so that relays 3600, 3500 and 3508 connect ten preference leads from the trunk relays 4400 to 4409 through the windings of the ten sender selecting relays 3520 to 3529 to contacts of the sender busy relays 3510 to 3519. Since trunk relay 4400 was operated, the circuit closed at this time extends from ground at the inner left front contact of relay 4440, middle upper front contact of relay 4400, conductor 4457, armature 3616 of relay 3600, conductor 3617, armature 3537 of relay 3500, inner right contact of relay 3508, right back contact of relay 3510, assuming this sender to be idle, winding of relay 3520, left normal contacts of relays 3524, 3529, etc. to battery. Relay 3520 operates and locks to battery at its inner left contact and to ground over its outer right contact and the inner contact of relay 3500. It connects ground over its middle right contact to the winding of relay 3502 to hold that relay operated. At its outer left contact it closes a circuit from ground over armature 3538 of relay 3500, conductor 3539 to the winding of the secondary select magnet 5100 individual to the selected sender. At the same contact it connects ground to conductor 3542 and the winding of relay 3716 to inform the sender that it has been selected. Relays 3524, 3529 etc., if operated, also open the battery chain to the lower numbered relays to prevent the false operation of one of them when the sender busy relay is operated as will be described later. Relay 3520 also connects ground over its inner right contact, armature 3540 of relay 3500, conductor 3541, armature 3618 of relay 3600, to the winding of relay 4225 and battery.

When relay 3500 operated, relay 4217 was connected in parallel over the four left back contacts of relay 4216, the four outermost armatures of relay 3600, armatures 3543 to 3546 of relay 3500 to conductors 3547 to 3550 leading in multiple to the group of senders to test them for the presence of false ground. If any one of these conductors is grounded falsely relay 4217 operates, opening the circuit of relay 4216 and blocking the progress of the call.

Operating sender selector

If relay 4217 does not operate, the operation of relay 4225 closes a circuit over the back contact of relay 4217 for relay 4216 which disconnects relay 4217 from conductors 3547 to 3550. With relay 4216 operated, a circuit is closed for hold magnets 5124 and 5125, belonging to the link circuit serving the calling trunk and selected sender, over the back contact of relay 5123, armature 5137 of relay 5120, armature 5017 of relay 5000, conductor 5018, middle right front contact of relay 4200, through the winding of relay 4215 shunted by the outer right back contact of relay 4220, inner right front contact of relay 4216, to ground at the inner right back contact of relay 4224. Magnets 5124 and 5125 operate, closing the cross-points prepared by select magnets 5100 and 5110. When magnet 5124 closes its cross-point, the operating ground for the magnets is extended over armature 5145 of the secondary selector, conductor 5146, to the sender.

Test of sender holding circuit

When relay 3520 connected ground to conductor 3542 the circuit extended through the right winding of relay 3716, left back contact of relay 3700, inner right back contact of relay 3704 to battery through resistance lamp 3705. Relay 3716 operates, closing a holding circuit from battery through its left winding and inner right front contact to conductor 3542. This holding circuit also extends from the right front contact of relay 3716, over the left back contact of relay 3714, to the winding of relay 2920 and battery. With relay 3716 operated, conductor 5146 extends over middle right front contact of relay 3716, conductor 3550, armature 3546 of relay 3500, armature 3619 of relay 3600, left front contact of relay 4216, winding of relay 4220 and battery. Relay 4220 opens the shunt around the winding of relay 4215 and relay 4215 operates, provided there is no false ground on the sleeve conductor of the

sender link. Such a ground, while holding the hold magnets and relay 4220 would be in shunt of the winding of relay 4215, preventing its operation and blocking the call.

Assuming relay 4215 operated, it closes an obvious circuit for relay 4214 which locks under the control of relay 4221. Relay 4214 connects ground over the outermost contact of relay 3600, armature 3543 of relay 3500, conductor 3547, middle left contact of relay 3716, winding of relay 3700 and battery. Relay 3700, at its third left contact connects ground to the winding of relay 3510, marking this sender busy to this and other link circuits. Relays 3700 opens the operating circuit of relay 3716 but that relay holds through its left winding and over conductor 3542.

Frame registration

In the meantime, with relay 2920 operated, the incoming frame is identified to the sender by ground connected to conductors 3533 and 3534 as previously described. Ground on conductor 3534 operates relay 2921 over the seventh right contact of relay 2920 while ground on conductor 3533 operates select magnet 2910 over the fourth left contact of relay 2920.

The register of the terminating sender comprises a cross-bar switch similar to that described in the application of R. Raymond above identified. When magnet 2910 operates, it extends its operating ground over its front contact to the winding of relay 3007 which in turn closes a locking circuit for itself and magnet 2910 over its inner front contacts and the back contacts of relays 3014 and 3021 in parallel, conductor 3728 to ground at the inner left contact of relay 3700.

Relay 3007 closes a circuit from battery through resistance 3013, winding and normal contact of relay 3012, middle right front contact of relay 3007, conductor 2923, to ground at the fourth right contact of relay 3700. Relay 3012 prepares a circuit from battery through resistance 3011, winding of relay 3010, left alternate contact of relay 3012 to grounded conductor 2923 but relay 3010 cannot operate as long as relay 3007 remains operated since it is shunted over its left back contact by the operating circuit of relay 3012. With relay 3012 operated a circuit is closed from battery through the winding of relay 3714, inner right front contact of relay 3012, to ground at the middle left front contact of relay 3510. Relay 3714 locks to ground at the outer right front contact of relay 3700 and closes a holding circuit for relay 3700 over the right normal contact of relay 3707. Relay 3714 also closes ground from its fourth left contact over the right normal contact of relay 3707, innermost left contact of relay 3714, outer left contact of relay 3716, conductor 3549, armature 3545 of relay 3500, armature 3620 of relay 3600, left back contact of relay 4224, outer right contact of relay 4214, winding of release relay 4228 and battery. Relay 3714 also extends this same ground over its second left contact and the back contacts of relays 3717 and 3718 in parallel to conductor 5146 to hold the hold magnets 5124 and 5125 operated. In addition relay 3714 releases relay 2920.

Release of control circuit

Release relay 4228 locks under the control of relays 4223, 4227, 4221, 4216, 4440 and 4441 if operated, to insure that it remain operated until the link circuit has restored to normal. It also connects ground over its left front contact, conductor 4233, armature 5019 of relay 5000, conductor 5020, inner right back contact of relay 4443, winding of relay 4446 and battery. Relay 4446 locks to ground at the left front contact of relay 4452, opens the circuit of relay 4452 and disconnects ground from conductor 4458, thereby terminating the timing operation. Relay 4452 releases relay 4442 which in turn releases relays 5000 and 3600, disconnecting the sender and group circuits from the control circuit. The release of relay 5000 in turn releases group relay 5120, select magnet 5110, relay 4440, the group test relay 4420 and trunk test relay 4400, as well as relays 4410 and 4430. Relay 3600, in releasing, restores the lock-out relay 3602, sender group connect relay 3500, sender test relay 3520, relay 3502 and relay 3508, also sender group test relay 4200, and the remaining operated relays of Fig. 42, relay 4228 releasing last.

Relay 5121 releases following the release of relay 5120 if no calls are waiting in other groups. When calls are waiting in other groups, the corresponding group start relay 5122 is operated, grounding conductor 5141, which is common to all groups, and thereby holding relay 5121 operated and preventing the extension of a new call in this group until other waiting groups have been served.

The trunk of Fig. 58 is now connected over the primary sender selector 5130 and secondary sender selector 5140 to the terminating sender which is shown in Figs. 29, 30 and 37.

Emergency operation of control circuit

Before proceeding to a description of the operation of the sender, the operation of the link control circuit in connection with a mate frame will be described. When conductor 5141 is grounded, this ground extends over the right back contact of relay 4446 to conductor 4458 and an interrupter. After an interval the interrupter grounds conductor 4459, operating relay 4453 which locks to conductor 4458. After a further interval of about 6 seconds the interrupter connects ground to conductor 4460, completing a circuit over the left contact of relay 4453 to the winding of relay 4447 and battery. Relay 4447 also locks to conductor 4458, lights lamp 4448, grounds conductor 4461 leading to the trouble desk and operates relay 4443 over the left contact of key 4444. Relay 4443 opens the operating circuits for relays 4442 in both the home and mate control circuits and the circuit of relay 4445 and transfers the circuit of relay 4446 from control by the sender relay 3700 and the release relays 4228 and 3707 to the transfer relays 4450 of the home and mate frames. In addition, relay 4443 closes a circuit for relay 4450 which is effective if the transfer relay 4450 and start relay 4452 of the mate control circuit are idle. The circuit may be traced from battery through the winding of relay 4450, over the outer right back contact of the mate relay 4450, left back contact of mate relay 4452 to ground at the inner right contact of relay 4443. Relay 4450 locks over its outer left contact to ground over key 4451 and therefore remains operated until released manually by the operation of key 4451. Relay 4450 further opens the circuit for mate relay 4442, operates relay 4446, lights lamp 4449, extends the start circuit from the front contact of relay 4452 to the winding of mate relay 4445, and opens the circuit of mate relay 4450.

Relay 4442, if operated, releases, in turn releasing relays 5000 and 3600. The operation of relay 4446 disconnects ground from conductor

4458, releasing relays 4453, 4447 and 4443. When relay 4443 releases, mate relay 4445 operates, locking independent of mate relay 4442, opening the circuits of mate relays 3600 and 5000 and closing circuits from battery through the windings of relays 5001 and 3601, over the right front contacts of mate relay 4445, mate conductor 4454, to ground at mate relay 4228. Relays 5001 and 3601 connect this group circuit to the mate control circuit. If, in the meantime, a call comes in on the mate frame, relay 4442 of that frame will be operated and when relay 4445 is released at the completion of the previous call, immediately seizes the control circuit for that frame.

Timing for sender connection

In the control circuit, relay 4221 operates as soon as the control circuit is associated with a group of senders. Relay 4221 at its inner right contact connects interrupter 4222 to conductor 4234, thereby grounding that conductor at half second intervals. Relays 4210 and 4211 function in the well-known manner, relay 4211 operating at the beginning of the first pulse and relay 4210 operating when ground is removed. Relay 4211 releases at the beginning of the second pulse and relay 4210 at the end, the cycle repeating as long as the ground pulses continue. If the circuit has not released when relays 4211 and 4210 have operated and relay 4211 has released, a circuit is closed from battery through the winding of relay 4218, outer right back contact of relay 4224, inner left back contact of relay 4220, right front contact of relay 4210, left back contact of relay 4211, conductor 4235, armature 5021 of relay 5000, conductor 5022 to ground over the right contact of key 4444. Relay 4218 locks under the control of release relay 4228. Relay 4218 opens the circuit of relay 3602, releasing the selected group of senders. Relay 4218 also closes a circuit from battery through the winding of relay 4223, left front contact of relay 4218, left contact of relay 4225, to ground at the right back contact of relay 4216. Relay 4223 also locks to the back contact of relay 4228. In selecting a sender group, the preference lead coming into the control circuit over conductor 4232, normally extends over the back contact of relay 4218 to the armature of relay 4202. With relays 4218 and 4223 operated this preference lead is extended over the front contact of relay 4223 to the armature of relay 4200, thus endeavoring to seize a different sender group.

Relays 4210, 4211, 4218 and 4223 are permitted to function if, because of false grounds relay 4217 operates as previously described, or if because the cross-points fail to close properly, relay 4220 does not operate. If relay 4220 operates, but because of double connections relay 4215 does not operate, when relay 4211 falls back, the circuit traced to relay 4218 extends over the left front contact of relay 4220 to the winding of relay 4224, which locks under the control of relay 4221. Relay 4224 closes a circuit from battery through the winding of relay 5123, conductor 5139, armature 3621 of relay 3600, inner right front contact of relay 4202, middle left front contact of relay 4224, to ground at the left back contact of relay 4214. Relay 5123 opens the circuits of hold magnets 5123 and 5124 opening the corresponding cross-points and disconnecting ground from relay 4220 which releases. It also connects ground over its left contact, conductor 5138, armature 3622 of relay 3600, outer left back contact of relay 4220, inner left front contact of relay 4224, to the winding of relay 4219 and battery. Relay 4219 operates and locks under the control of relay 4221.

Relay 4219 connects ground over its inner left contact, armature 3623 of relay 3600, armature 3544 of relay 3500, conductor 3548, outer right front contact of relay 3716, to the right winding of relay 3707 to release the sender as will be described later. It also connects ground over its middle left contact, outermost armature of relay 3600, armature 3543 of relay 3500, conductor 3547, middle left contact of relay 3716, winding of relay 3700 to battery, holding that relay and relay 3714 operated and passing ground over the inner right front contact of relay 3700, second left contact of relay 3714, back contact of relay 3717 or 3718, middle right front contact of relay 3716, conductor 3550 and thence as previously traced to the winding of relay 4220 and battery. Relay 4220 closes a circuit for relay 4218 over the outer left contact of relay 4219, inner right and left contacts of relay 4220 to the right front contact of relay 4210 and thence to ground as described above when relays 4210 and 4211 reach the proper point in their cycle. Relay 4218 functions as previously described to release the sender group selection relays and to bring about a second trial.

If the sender is selected and otherwise operates correctly but fails to send a release signal to the link within the prescribed length of time, the functioning of relays 4210 and 4211 will bring about the operation of relay 4224 as described. If relays 4220, 4215 and 4214 have been operated, when relay 4210 releases after operating relay 4224 it closes ground over its back contact, outer left front contact of relay 4224, outer right front contact of relay 4224, right front contact of relay 4214, winding of relay 4228 to battery. Relay 4228 functions in the usual manner to release the link control circuit. If relays 4220, 4215 and 4214 do not operate, the call is transferred to the mate control circuit.

Sender operation

Returning now to the sender, it will be remembered that the selection of the sender by the link circuit caused the operation of relays 3716 and 2920 and, when the link had checked the sleeve lead, relay 3700 was operated. Relay 3700 in turn operated the sender busy relay 3510. Magnet 2910 in operating to record the frame indication closed a circuit for relay 3007 which in turn operated relay 3012 and, with relay 3510 operated, operated relay 3714 which closed holding circuits for relay 3700 and hold magnets 5124 and 5125 over the back contacts of relays 3717 and 3718 and operated the link release relay 4228. The release of the link is made dependent on the frame registration as a check on that operation.

Relay 3714 in operating opens the circuit of relay 2920, and the link circuit in releasing releases relay 3716. When relay 3700 has operated, relay 3007 holds over its inner front contacts and the back contacts of relays 3014 and 3021, to ground on conductor 3728 from the inner left front contact of relay 3700. When relay 3012 operates as previously described, a circuit is closed from battery through the winding of the frame hold magnet 2901, back contact of magnet 2906, right back contact of relay 3010, outer right front contact of relay 3012, right winding of relay 3014, conductor 3720, to ground at the third left contact of relay 3714. The left winding of relay 3014 is connected in parallel with magnet 2901 but relay 3014 is differential to

this condition and does not operate. Magnet 2901 does operate, locking over its inner contact and conductor 2923 to ground at the fourth right contact of relay 3700. This locking ground shunts the right winding of relay 3014 permitting that relay to operate, opening one point in the locking circuit of relay 3007 and magnet 2910.

As soon as the cross-point of the primary and secondary link switches 5130 and 5140 have been closed conductors 3722 to 3726 are connected through to conductors 5822 to 5826 respectively. At this time battery through the winding of relay 3015 is connected over the inner right back contact of relay 3701, fifth left contact of relay 3700, and conductors 3726 and 5826 to the incoming conductor 5819 in parallel with battery through the upper winding of relay 5802. Ground through the winding of stepping relay 3000 is connected over the left back contact of relay 3701, fourth left contact of relay 3700 and conductors 3725 and 5825 to incoming conductor 5820 in parallel with the lower winding of relay 5802. However relay 3000 is shunted by ground at the outer lower back contact of relay 5805, at the right back contact of relay 3021 and at the left back contact of relay 3706 and therefore remains ineffective at present. Relay 3015 is also shunted by battery through non-inductive resistance 3727 over the outer right back contact of relay 3706 in order to permit the current in the branch circuit to build up rapidly and to prevent a false release of the stepping relay of the originating sender.

When relay 3700 operated, grounding conductor 2923, it completed a circuit from battery through resistance 3703, winding of relay 3704, to grounded conductor 2923. When relay 3716 releases a circuit is closed from ground at the right back contact of relay 3716, outer left and inner right front contacts of relay 3704, outer left front contact of relay 3700, conductors 3724 and 5824 to battery through the winding of relay 5801. Relay 5801 disconnects the windings of relay 5802 from the incoming trunk to improve the operating conditions for relay 3015.

Signal to originating sender

When relay 5801 operates, relay 3015 operates in series with the stepping relay in the sender at the originating office and closes a circuit from battery through the winding of relay 3706, outer left front contact of relay 3007, outer left back contact of relay 3021, middle right back contact of relay 3701, to ground at the contact of relay 3015. Relay 3706 locks to the front contact of relay 3015, closes an obvious circuit for relay 3021 and disconnects battery through resistance 3727 from in parallel with the winding of relay 3015 whereby it aided in the operation of the stepping relay of the originating sender. Relay 3021 locks to ground at the outer right contact of relay 3007 and opens the holding circuit of relay 3007 which now releases. When relay 3007 releases it opens the shunt around the winding of relay 3010 and that relay operates under the control of relay 3012. With relays 3021 and 3706 both operated the shunts are removed from the winding of relay 3000 and that relay operates in series with relay 3015 and the relays of the originating sender.

It will be remembered that relay 3019 was operated over conductor 3531 from the link circuit. This relay locks to ground at the outer right contact of relay 3700 and reverses the connection of ground to the contacts of relay 3000 for this call. Other link circuits do not ground conductor 3531 and the relay remains normal.

When relay 3000 operates it closes a circuit from ground over the outer right front contact of relay 3019, front contact of relay 3000, left front contact of relay 3019, left back contact of relay 3018, winding of relay 3016 and battery. Relay 3016 closes a locking circuit for itself from battery through its winding, left winding of relay 3018, back contact of relay 3017, front contact of relay 3016 to ground at the third right contact of relay 3021. Relay 3018 cannot operate being shunted by the operating circuit of relay 3016. With relay 3018 unoperated, ground from the second right contact of relay 3021 is connected over the back contact of relay 3018 to conductor 3022 but is ineffective until after relay 3001 has operated.

Transmission of revertive pulses

Relay 3000 also operates relay 3008 through the network 3009 which makes relay 3008 slow to operate to insure the operation of the stepping relay at the distant sender. Relay 3008 in operating closes ground to the winding of relay 3015 in shunt of the relays at the originating sender and relay 3000. Relay 3000 thereupon releases, opening the circuit of relay 3008 which releases in turn and opens the shunt around relay 3000. Relays 3000 and 3008 therefore cooperate to transmit a series of revertive pulses to the originating sender. When relay 3000 releases for the first time relay 3018 operates transferring this ground to conductor 3023. It also prepares a circuit from battery through the winding of relay 3017, right winding and left front contact of relay 3018 to the front contact of relay 3000. When relay 3000 reoperates this circuit is closed, holding relay 3018 and operating relay 3017. The operation of relay 3017 opens the locking circuit of relay 3016 and that relay releases. Therefore, when relay 3000 releases the second time relays 3017 and 3018 both release and ground is transferred back to conductor 3022.

Pulse recording

The number of pulses to be transmitted is controlled in the usual manner by the distant sender where the fundamental circuit is opened when sufficient pulses have been received, thereby preventing the reoperation of relay 3000. The number of pulses transmitted is recorded in the terminating sender by the alternate grounding of conductors 3023 and 3022.

The first pulse, grounding conductor 3023, completes a circuit over the left back contacts of relays 3004, 3002, and 3003 and the right back contact of relay 3005 to the winding of relay 3001 and battery. Relay 3001 operates, locking over the normal contacts of relays 3002, 3003, 3004 and 3005 over conductor 3024 to ground at the outer right front contact of relay 3021 or the outer left front contact of relay 3706, or over the normal contact of relay 3007 and conductor 3720 to ground at the third left contact of relay 3714.

The second pulse during which conductor 3022 is grounded, closes a circuit over the inner left front contact of relay 3001, to the winding of relay 3002 and battery. Relay 3002 locks over its right alternate contact and the normal contacts of relays 3003, 3004 and 3005 to grounded conductor 3024. Relay 3002 opens its normal contact, thereby releasing relay 3001.

At the third pulse, ground on conductor 3023 completes a circuit over the left back contact of relay 3004, outer left front contact of relay 3002 to the winding of relay 3003 and battery. Relay 3003 locks over its alternate contact and the normal contacts of relays 3004 and 3005 to grounded conductor 3024 and opens the holding circuit of relay 3002.

The second grounding of conductor 3022 during the fourth pulse closes a circuit over the left front contact of relay 3003 to the winding of relay 3004 and battery. Relay 3004 locks over the normal contact of relay 3005 and releases relay 3003.

The fifth pulse which grounds conductor 3023 for the third time causes the operation of relay 3005 over the left back contact of relay 3006 and the outer left front contact of relay 3004. Relay 3005 locks over the back contact of relay 3001 and its own alterate contact to conductor 3024 and releases relay 3004.

A sixth pulse extends a circuit from battery through the left winding of relay 3006, outer left front contact of relay 3005 to ground over conductor 3022. Relay 3006 locks through its right winding directly to conductor 3024.

The next four pulses operate relays 3001 to 3004 in the manner described, relays 3005, 3001, 3002 and 3003 releasing in turn so that for pulses 6, 7, 8, 9 and 10, relay 3006 is operated in combination with relays 3005, 3001, 3002, 3003 and 3004 respectively. Relays 3001 to 3005 when operated alone prepare circuits for the register select magnets 2910 to 2914 respectively and when operated in conjunction with relay 3006 prepare circuits for select magnets 2916 to 2919 and 2915, respectively.

Should an eleventh pulse be permitted because of faulty operation in the originating sender, ground will be connected to conductor 3023 and a circuit closed over the outer left front contact of relay 3004, left front contact of relay 3006, winding of relay 3020 and battery as an overflow or tell-tale signal. The function of relay 3020 will be described later.

When the fundamental circuit is opened at the originating office, relay 3000 fails to reoperate as above mentioned and relay 3015 also releases, in turn releasing relay 3706 which is slow to release, and, after an interval restores the fundamental circuit to its former condition, and opens the operating circuit for relay 3021.

Operating recorder switch

Assume by way of example, that the called line number dialed by the calling subscriber was 9299 and that the originating sender was set thereby to select the No. 4 incoming primary group. Therefore five revertive pulses are necessary to open the fundamental circuit and when relays 3015, 3021 and 3706 release, recording relay 3005 is operated alone. With relay 3021 released, a circuit is closed from ground at the right back contact of relay 3020, left normal contact of relay 3007, right back contact of relay 3006, fifth left contact of relay 3021, outer right front contact of relay 3005, winding of select magnet 2914 to battery. Magnet 2914 extends its operating ground to the winding of relay 3007, which locks over the back contacts of relays 3014 and 3021 to conductor 3728 as previously described.

With relay 3007 operated, the last locking circuit of the recording relay 3005 is opened and that relay releases. A circuit is also closed from grounded conductor 2923, over the middle right contact of relay 3007, left front contact of relay 3010, to resistance 3013 and battery in shunt of the winding of relay 3012. Relay 3012 releases, but relay 3010 is held operated from this same ground over the normal contact of relay 3012. With relay 3012 released and relay 3007 operated, a circuit is closed from battery through the winding of hold magnet 2906, over the back contact of magnet 2904, outer front contact of magnet 2901, right front contact of relay 3010, right back contact of relay 3012, right winding of relay 3014, to grounded conductor 3720. This magnet closes cross-point 2932 in the sender register switch 2900. As in the case of magnet 2901 when magnet 2906 locks over its inner front contact, to ground at the second left contact of relay 3700, it permits relay 3014 to operate, and when relay 3021 is operated at the reclosure of the fundamental circuit the holding circuit of relay 3007 and select magnet 2914 is opened and they release. At this time the holding circuit of relay 3010 is opened and that relay also releases.

Overlapping registration

It may be noted that, if the fundamental circuit is reclosed very quickly in the originating sender, reoperating relays 3015 and 3000, relays 3021 and 3706 may reoperate as soon as the select magnet has operated relay 3007. The next digit may be recorded, therefore, while the hold magnet is operating and locking and relay 3014 is checking the locking circuit. Relay 3007 cannot release until relay 3014 operates, and closes a locking ground for relay 3021 to hold that relay operated to prevent the reception of a third set of pulses until the first set has been locked in by the hold magnet and the second set recorded on the select magnet. Relays 3021 and 3706 are made slow to release to insure that the recording relays 3001 to 3006 have sufficient time to stabilize before the circuit is closed for the select magnet.

The sender transmits revertive pulses to satisfy the originating sender for incoming secondary group, final primary group, final tens and final units selections, the pulses for each selection being recorded on the recording relays, transferred to the select magnets and locked in by the successive operation of hold magnets 2905, 2904, 2903 and 2902. The circuits for the hold magnets are prepared by the prior operated magnets and relays 3010 and 3012 which are operated and released under the control of relay 3007. It may be noted that, since there never are more than five incoming primary and secondary group and final primary group selections only the lower half of the cross-points on these verticals of the register are equipped. Since final tens and units selections may reach ten, all of the cross-points in these verticals are wired.

Reverse battery signal

When the final units hold magnet 2902 operates, a circuit is closed from ground at the outer left contact of relay 3714, conductor 3729, inner front contact of magnet 2903, outer front contact of magnet 2902, conductor 2924, winding of relay 3701 and battery. Relay 3701 reverses the connection of the tip and ring conductors to battery and ground, that is, tip conductor 5819 which formerly extended over conductor 3726, fifth left contact of relay 3700 and inner right back contact of relay 3701 to the winding of relay 3015, now extends over the right front contact of relay 3701 to ground at the middle left contact of relay 3704. The ring conductor 5820 which previously

extended by way of conductor 3725, fourth left contact of relay 3700 and left back contact of relay 3701 to ground through the winding of relay 3000, now extends over the outer left front contact of relay 3701, inner left contact of relay 3704, middle right back contact of relay 3706 to battery through the winding of relay 3015.

This reverse battery signal indicates to the originating sender the completion of selections and the closure at that sender operates relay 3015. Relays 3706 and 3021 are not operated at this time since the circuit of relay 3706 is opened at the contact of relay 3701. Relay 3015 closes a circuit from battery through the winding of relay 3702, inner left front contact of relay 3701, inner right back contact of relay 3706, to ground at the contact of relay 3015. Relay 3702 locks to grounded conductor 2923 and extends its locking ground to resistance 3703 and battery in shunt of the winding of relay 3704 which now releases. When relay 3704 releases, it disconnects battery through relay 3015 and ground from the fundamental circuit. Relay 3702 is slow to operate and relay 3704 slow to release to supply the reverse closure for a measured length of time during which the originating sender has sufficient time to function.

Trunk closure

When relay 3704 releases, it disconnects ground from the circuit of relay 5801 and extends it to battery through resistance lamp 3705. A circuit is also closed from battery through the winding of relay 5805, conductors 5822 and 3722, outer right back contact of relay 3704, upper winding of relay 3713, back contact of relay 3709 to grounded conductor 3719. Battery through the lower winding of relay 3713 is connected in parallel with relay 5805. This arrangement provides an operating condition for relay 5805 but a non-operating condition for relay 3713. When the sender at the originating office has been dismissed and the district selector advanced to talking position, a bridge is connected across the trunk conductors operating relay 5802 which closes a locking ground for relay 5805. This ground shunts the upper winding of relay 3713 and the relay operates through its lower winding as a signal that it is time for the sender to establish connection with a marker.

Relay 3713 closes at its left contact an obvious circuit for relay 3709 which locks to ground on conductor 3719. Relay 3709 disconnects ground from the upper winding of relay 3713 and connects battery over the left normal contact of relay 3707, middle left contact of relay 3709 to conductor 3730 and over the outer left back contact of relay 3712, left back contact of relay 3020, left normal contact of relay 3718 to conductor 3731. Conductor 3731 extends to the windings of relays 5601 and 5603 and ground.

Connection of sender with marker

Fig. 56 shows in very schematic form the marker connector. This connector is essentially the same as that used in the past for connecting the panel sender with the decoder, such as shown in Patent 1,862,549, granted to R. Raymond et al. June 14, 1932. The circuit consists of a multicontact relay for each sender arranged in groups and a multicontact relay for each decoder for each group, together with control relays for determining the order of use and to prevent double connections. For each connection, one sender relay and one decoder relay are operated to close through a plurality of contacts between the sender and decoder. In the present disclosure, for simplicity, the single multicontact relay 5600 is shown. When relay 5601 operates from battery on the start lead 3731, it closes a circuit from battery on conductor 3730 through the winding of relay 5600, outer left contact of relay 5601, back contact of relay 5673 to ground. Relay 5600 locks over its own contact to ground over the middle left contact of relay 5601 and the back contact of relay 5673.

When the connection between the sender and marker has been established, twenty leads are closed, connecting the sender register 2900 to the registers 4900, 4910, 4920, 4800 and 4810 of the marker. In addition, a lead to relays 2921 and 2922 is closed to determine the tens designation of the frame and three check leads are closed as well as certain other leads which will appear hereinafter.

Transfer of registration to marker

Assuming that cross-points 2931 to 2936 were closed in registering the selections as above described, direct ground will be connected over none of the contacts of cross-point 2931; over the left contact of cross-point 2932 to conductor 2950; over the middle contact of cross-point 2933 to conductor 2952; over the middle contact of cross-point 2934 to conductor 2953; over the inner left contact of cross-point 2935 to conductor 2954, and over the outer left contact of that cross-point to conductor 2955; over the outer left contact of cross-point 2936 to conductor 2956, and over the inner left contact of the same cross-point to conductor 2957. Conductors 2950 and 2952 to 2957 are extended over contacts 5610 and 5612 to 5617 of relay 5600 to conductors 5650 and 5652 to 5657, respectively, operating thereover register relays 4913 and 4914 of thousands register 4910, relay 4922 of hundreds register 4920, relays 4804 and 4803 of the tens register 4800 and relays 4813 and 4814 of units register 4810. None of the relays of frame register 4900 are operated by direct ground from the frame vertical of the sender register nor is relay 4905 operated by direct ground from relay 2922 which might occur for other frame registrations.

Check of registering circuits

At the same time that these direct circuits are closed, a circuit is closed from ground over armature 5618 of relay 5600, conductor 5658, middle right back contact of relay 4824, conductor 4860, armature 5620 of relay 5600, conductor 5660, to the second or inner right contact of each cross-point where that contact is not grounded directly. Similarly, ground on conductor 5658 is connected over the inner right back contact of relay 4824 to conductor 4861, armature 5621 of relay 5600, conductor 5661 and the first or outer right contact of each cross-point to which ground is not supplied directly. A third circuit extends from ground on conductor 5658 over the outer left back contact of relay 4824, conductor 4862, armature 5622 of relay 5600, conductor 5662 to the two left contacts of those cross-points for which direct ground is not provided. A branch of conductor 5660 extends over the front contact of relay 2921 and the back contact of relay 2922 to conductor 2925, armature 5619 of relay 5600, conductor 5659 to the winding of relay 4905 and battery. A branch of conductor 5661 extends back over armature 5623 of relay 5600, conductor 5664 to the winding of relay 4827 and battery. A branch of conductor 5660 extends through contacts in the marker connector circuit, over armature 5624

of relay 5600, back contact of relay 5674, conductor 5665 to the winding of relay 4100 and battery.

At each of the closed cross-points, those registering conductors not grounded directly are grounded from conductors 5660, 5661 and 5662 so that relays 4901 to 4904, 4911 to 4914, 4921 to 4924, 4801 to 4804, and 4811 to 4814 are operated together with relays 4100, 4905 and 4827 provided the registering circuits between the sender and marker are complete. Relays 4823, 4822 and 4821 are connected to conductors 4862, 4860 and 4861, respectively, and also operate over the back contacts of relay 4824 if ground is connected to the corresponding conductors.

If all of the register relays operate, a circuit is closed from ground through the left winding of relay 4825, inner right front contacts of relays 4901 and 4902, inner left front contacts of relays 4903 and 4904, outer left front contact of relay 4905, inner left front contacts of relays 4914, 4913, 4912, 4911, 4921, 4922 and 4923, second left contact of relay 4924, inner right front contacts of relays 4804, 4803, 4802, 4801, 4811, 4812, 4813, 4814, 4821, 4822, 4823 and 4827, middle upper front contact of relay 4100, left winding of relay 4826 and battery.

Relays 4826 and 4825 both operate in this circuit, relay 4826 locking over its outer right contact and the left normal contact of relay 4824 to grounded conductor 5658. Relay 4825 also locks over its outer right contact and the left normal contact of relay 4824 to grounded conductor 5658. With relays 4826 and 4825 both operated, a circuit is closed from battery, through the winding of relay 4824, inner right contacts of relays 4826 and 4825, to grounded conductor 5658. Relay 4824 operates, locking over its inner left alternate contact to conductor 5658. The make-before-break character of the inner left contacts of relay 4824 holds relays 4825 and 4826 until the locking circuit of relay 4824 is fully established, after which these relays release. Relay 4824 at its second left front contact operates relay 4833.

The operation of relay 4824 disconnects ground from conductors 4860, 4861 and 4862, thereby releasing those register relays operated thereover as well as relays 4821, 4822, 4823, 4827 and 4100. If a false ground exists on one of these conductors or the conductor is connected falsely to a conductor which is grounded, the relays reached over that conductor will be held operated, the call will be blocked and the timing circuit will function to bring about the release of this marker and a second trial with another marker.

Translation

With relay 4824 operated and relays 4825 and 4826 released, a circuit is closed from grounded conductor 5658 over the outer right front contact of relay 4824, left back contacts of relays 4826 and 4825, left back contact of relay 4827, left back contact of relay 4821, to the contacts of the thousands register 4910. Ground is supplied to the contacts of the hundreds register 4920 over conductor 4925, normal contacts of relays 3904, 3903, 3902 and 3901, conductor 3913, back contact of relay 4822, outer left front contact of relay 4824 and grounded conductor 5658. Ground is also supplied to the contacts of the tens register 4800 from the third left contact of relay 4824 over the back contact of relay 4823.

It will be remembered that the lines of the office are arranged in large groups, called for convenience "choices", each choice including four frames on which are mounted ten horizontal groups of switches or levels which may contain from one to seven individual switches each serving ten lines. For selection as called lines for the purpose of testing their busy or idle condition the subscribers' lines are arranged in numercial groups of twenty which, being consecutive, all appear within the same hundred group and within a given choice, but which may be moved from choice to choice as desired. In an office of the usual size of 10,000 lines, there will be 500 such groups of lines.

The marker is connected to the lines through a line choice connector, one for each of the line choices. In each choice connector there are a number of hundreds relays, one for each hundred lines in the choice and a number of group relays, one for each group of twenty lines.

A group of twenty lines is identified from the line designation by a translation of the thousands, hundreds and tens digits. These digits as recorded in the marker combine to mark 500 sets of cross-connecting points, a few of which are shown in Fig. 63 by operating one of twenty "five-hundreds" relays such as relay 6304, one of five "hundreds" relays such as relays 6305 and 6306 and one of five "twentys" relays such as relays 6240 and 6244. These relays with their associated cross-connecting racks form what is known as a "translator". Since thousands register relays 4913 and 4914 were operated and hundreds register relay 4924 was not operated, the ground extended to the thousands register by the operation of relay 4824 extends over the outer left back contacts of relays 4912 and 4911, right front contact of relay 4914, outer right front contact of relay 4913, fifth right back contact of relay 4924 to conductor 4930 which is connected to the winding of relay 6304. Each of the conductors embraced by the bracket including conductor 4930 extends to a separate relay, like relay 6304, unless the corresponding group of five hundred lines is not equipped in which case the conductor is connected over conductor 4933 to relay 3910, the function of which will be described later.

The ground supplied to the hundreds register extends over the right back contact of relay 4923, right front contact of relay 4922, right back contact of relay 4921, conductor 4931 to the winding of relay 6305. Ground supplied to the tens register extends over the inner left front contact of relay 4804, inner left back contact of relay 4801, conductor 5252, winding of relay 5242 and battery to indicate that the wanted number lies in an odd ten. If the number were even, relay 5241 would have been operated. This ground also extends over the right front contact of relay 4804, left front contact of relay 4803, to the winding of relay 6244 and battery. The joint operation of relays 6244, 6305 and 6304 identifies the group of twenty lines lying between 9280 and 9299.

With relay 6244 operated, three circuits are prepared, one from battery through resistance 6207 over the right contact of relay 6244, to conductor 6208, a second from ground over the inner right contact of relay 6012, conductor 6015, inner left contact of relay 6244 to conductor 6209 and a third from ground through the winding of relay 6014, middle left back contact of relay 6012, conductor 6016, outer left contact of relay 6244 to conductor 6210. These three conductors are connected in multiple to the armatures of the five "hundreds" relays 6305, 6306, etc., and, since relay 6305 is operated, are extended to conductors

6311, 6310 and 6309, respectively. Conductors 6309, 6310 and 6311 are connected in multiple to armatures of the twenty "five-hundreds" relays 6304, etc. Since relay 6304 is operated, these conductors are extended to cross-connecting racks 6303, 6307 and 6308, respectively, thereby connecting battery to cross-connecting point 6314, ground through relay 6014 to point 6312 and direct ground to point 6313.

These cross-connecting racks are wired in accordance with the location of the lines in the frames and the location of any group of twenty line numbers may be altered by altering the connections at this point.

Connection with line choice

Each line choice connector has a start lead for each marker and these leads are brought into each marker at cross-connecting rack 6308. Each group of twenty consecutive numbers is a unit and will be referred to hereafter as a twenty-block. Each twenty-block has its own cross-connecting terminal in rack 6308 for the location and seizure of the line choice.

Assuming that terminal 6314 is cross-connected to terminal 6315 and thereover to the start conductor 6316 of the line choice connector shown, a circuit is completed over the second left back contact of relay 3800, winding of relay 3805, normal contacts of relays 3807 and 3809 to ground at the third left back contact of relay 3800. It will be noted that the circuit of relay 3805 extends over the back contacts of the higher numbered relays, so that these higher numbered relays have the preference in operating. However, the lower numbered relays have the preference in closing the circuit of the corresponding relay 3200. Therefore, if a low numbered relay, for example, relay 3805, is operated and locked controlling relay 3200, higher numbered relays, such as relays 3807 and 3809 may operate and lock but cannot operate their corresponding connecting relay. When relay 3805 releases, relay 3807 may operate its connecting relay and when it releases relay 3809 may, in turn, connect the marker to the choice. With relay 3809 operated, neither relay 3805 nor relay 3807 can reoperate. Relay 3805 locks over its inner left front contact to ground at the third left back contact of relay 3800. It also opens the circuit of relay 3119. It connects ground from the fourth left back contact of relay 3800 to the winding of relay 3200 and battery. Relay 3200 represents any necessary number of multicontact relays for controlling the requisite number of connections between the marker and the line choice.

At its right front contact, relay 3805 connects battery through resistance 3803, right back contact of relay 3802, right front contact of relay 3805 to conductor 3811.

Connection with incoming junctor

Relay 3200, in operating, connects ground over armature 3210 to conductor 3211 and the winding of relay 4835 as a signal to the marker that the connector has operated to connect it with the choice. Relay 4835 extends the battery connected to conductor 3811 over its outer right contact, inner right contact of relay 4824, conductor 4863 to the frame register 4900, and, since none of the frame relays were operated, over the right back contacts of relays 4903, 4904, 4902 and 4901, left back contact of relay 4903, third right back contact of relay 4905, conductor 4932, inner left back contact of relay 5732, winding of relay 5720, normal contacts of relays 5750 and 5760 to ground.

The incoming link and connector circuit of Fig. 57 represents the No. 0 connector having access to the No. 0 frame to which the incoming junctor of Fig. 58 is connected. Relays 5720, 5750 and 5760 are arranged in the same way as are the preference relays of the line choice connector in order to permit connection of only one marker to the frame at a time. Relay 5720 releases relays 5730 and 5731 and closes a circuit from battery through the winding of relay 5722, lower front contact of relay 5720 to ground at the right back contact of relay 5732. As in the case of the line choice connector, relay 5722 may be taken as representing such plurality of relays as are physically necessary to control the desired number of contacts. When relay 5722 operates, it connects ground over armature 5740 to conductor 5741, winding of relay 4834 and battery to tell the marker that it has been connected with the calling frame.

Operating hundred-block relay

When relay 3200 of the line choice connector has operated, it completes a circuit from ground through the winding of relay 6014 which is connected as previously described to terminal 6312 of cross-connecting rack 6303 and, assuming a cross-connection to terminal 6317, over conductor 3213, armature 3212 of relay 3200 to the winding of hundred-block relay 3104 and battery.

One relay, such as relay 3104 is furnished in the line choice connector for one hundred line terminals representing five twenty-blocks which may or may not have numbers and which may or may not be consecutively numbered. Relay 3104 represents the group of terminals within which the called line is located and prepares the circuits for five twenty-block relays. Relay 6014 which is connected in series with relay 3104 is marginal and operates only if, because of trouble, more than one hundred-block relay would be operated.

The connection of ground to terminal 6313 in cross-connecting rack 6307 serves to operate one of the relays 5300, 5302, 5304, 5306 or 5308. Assuming that terminal 6313 is connected to terminal 6319, a circuit is closed over conductor 6320 to the lower winding of relay 5308 and battery. Relay 5308 extends its operating ground over its inner lower front contact, conductor 6318 to battery through the left winding of relay 6302. Relay 6302 locks through its right winding and right contact, conductor 6321, outer right back contact of relay 6012, conductor 6017 to ground at the inner left contact of relay 4835 as soon as that relay operated.

Operating twenty-block relay

With relay 6302 operated, the circuits of the five twenty-block relays prepared by relay 3104 are extended over the left armatures of relay 6302 to the outer lower armatures of relays 5300, 5302, 5304, 5306 and 5308. Since relay 5308 is operated, a circuit is closed from ground through the winding of relay 5311, outer lower back contact of relay 5309, outer lower front contact of relay 5308, conductor 6322, inner left contact of relay 6302, conductor 3215, armature 3214 of relay 3200, outer left front contact of hundred-block relay 3104 to the winding of twenty-block relay 3108 and battery. Relay 5311 is marginal, operating only if, due to some

fault, the circuit is extended to more than one twenty-block relay. Relay **3108**, in operating connects ground over its next to outermost left contact, conductor **3136**, armature **3266** of relay **3200**, conductor **3267**, left winding of relay **4535** to battery as a signal to the marker that a block of twenty lines has been selected. Relay **4535** extends its operating ground to the winding of relay **4536** which also operates. Relay **4525** is operated through its left winding on most calls, the operation of relay **4536** indicating that a charge is to be made. Lines for which no charge is to be made are grouped under the control of twenty-block relays which have their outer armature connected to conductor **3121** and over armature **3216** of relay **3200** and conductor **3217** to the right winding of relay **4535**. In this case the operating ground is extended to the winding of relay **3907** which operates to tell the marker that no charge is to be made. The function of relay **3907** will be discussed hereinafter.

The twenty-block relays including relay **3108** also close two cross-connecting points for each of the twenty line circuits. The inner twenty contacts or sleeve contacts are brought out on rack **3111** where they are cross-connected to the hold magnets of the lines. The outer twenty contacts or number control contacts are brought out to rack **3105** where they are cross-connected to the windings of relays like relays **3101**.

Description of Fig. 3

At this point it may be well to refer to Fig. 3. This figure has been prepared to clarify the purpose of the relays, such as relay **3101**, in the main drawing. A further description will be found in the application of O. Myers, Serial No. 68,258 filed March 11, 1936.

The subscribers' lines come into the office and are terminated on racks, such as racks **323**, **331** and **332**, whence they are wired to the switch racks, such as strip **324**. Heretofore, the position of the line in the terminating switch has determined the number of the line and it has been impossible to alter the number of a line without altering its position in the switch or to transfer a line to a different position without correspondingly transferring the number.

In the present system there is no such hard and fast relationship between position and number. For purposes of illustration, five lines have been selected bearing the numbers **1250**, **1251**, **1252**, **2250** and **7250** which, in the usual telephone system, would appear in three different switch structures. The marker in receiving these designations would operate the same tens relay **301** and the same hundreds relay **302** together with three different five hundreds relays **303**, **304** and **305**. The registration would result in the marking of three points on the translator rack **306**.

For each line choice, including four line groups of ten levels each, there is, as pointed out heretofore, a line choice connector, each connector having a connector relay for each marker and controlled by a preference chain. These connector relays, such as **308**, **309** and **310**, are, in effect, wired to a cross-connecting rack, such as rack **307**. For each hundred lines in a choice, a hundred-block relay, such as relay **313**, **312** or **311**, is provided and is connected over contacts of the marker connector relays **308**, **309** and **310** to rack **307**. For each group of twenty lines which are consecutively numbered, if numbered at all, a twenty-block relay, such as relay **316**, **315** or **314**, is provided and these are also connected over contacts of a hundred-block relay and a marker connector relay, in effect, to rack **307**. Therefore, any one of the sets of points on rack **306** may be wired to rack **307** so as to cause the operation of any desired twenty-block relay. It is, therefore, possible to cause any subscriber's number to appear in any desired line choice and to use any desired hundred-block and twenty-block relays.

Each twenty-block relay has two sets of twenty contacts. One set leads over cross-connecting racks **317**, **318** and **319** to the sleeves of the twenty lines to which the relay is individual. The corresponding contacts of the second set are wired over racks **322**, **321**, **320** to racks **300**, **333**, etc.

For each level in each line group, a relay such as relay **325** to **330** is provided, each relay having three windings, the purpose of which will appear later. These relays are connected to racks **300**, **333**, etc., where they are cross-connected to contacts on the twenty-block relays, each contact being connected to the relay representing the level in which the corresponding line is located. Relays **325** to **330** when operated transmit to the decoder an indication of the location of the wanted line to guide the operation of the switches in establishing the connection.

If, for traffic reasons it is desired to move a particular line it may be moved in the same level merely by changing the connections between racks **323** and **324**. If it is to be changed to a different level or different line group, the wiring between racks **322** and **300**, for example, is also changed. In order to move a line from one choice to another, the group of twenty lines to which it belongs must also be moved and the cross-connections at racks **306** and **307** are also changed.

According to one possible wiring arrangement shown by way of example, lines No. 1250 to No. 1252, No. 2250 and No. 7250 all appear in the same choice, operating marker connector relay **310**. They also appear in the same hundred-block, operating relay **311**. Lines No. 1250 to No. 1252 naturally appear in the same twenty-block relay **316**, line No. 2250 in relay **315** and line No. 7250 in relay **314**. However, line No. 1250 is located in level No. 0 of line group No. 0, while line No. 1252 is located in level No. 8 of line group No. 4, and lines No. 2250 and No. 7250 are shown as both located in level No. 2 of line group No. 0.

There is one relay like relay **3101** for each of the forty horizontal levels in a choice, each relay having three windings. The terminals at rack **3105** are each connected to the relay belonging to the level and line group in which the corresponding line is located and to the winding of that relay belonging to the class of the line. That is, individual lines, the ring party on party lines and last lines of private branch exchange groups have their terminals connected to the right windings, the tip party on party lines have their terminals connected to the left windings and private branch exchange trunks other than the last have their terminals connected to the middle windings.

Relay **3101** and similar relays transmit to the marker the location and class of the called line. The ten relays belonging to one line group have their windings multipled together, the right windings extending to a relay in group **5900** to **5903**, the left windings to relays **5910** to **5913** and the middle windings temporarily to ground. The

relays of the No. 0 line group lead to relays 5909 and 5910; the relays of the No. 1 line group to relays 5901 and 5911, etc.

When relay 4835 operated, it closed a circuit from ground over its outer left contact, conductor 4864, middle right back contact of relay 6012, conductor 6018, over the outer right back contacts of relays 4500 to 4519, to conductor 4537 or over the right back contact of relay 4531 and the left normal contacts of relays 4519 to 4500 to conductor 4537 which extends to the winding of relay 5933 and battery and also over the right back contacts of relays 4701 and 4700 and conductor 4713 to the windings of relays 5240 and 5243 and battery. These relays prepare the test circuits for the called lines.

Test of called line—individual

Assuming that the wanted number refers to the line shown in Fig. 12 and is an individual line, contacts 3124 and 3125 will be connected together as are contacts 3122 and 3123. The operation of the twenty-block relay 3108 connects the sleeve terminals of the twenty lines belonging thereto to the windings of twenty test relays 5200 and 5219. The test circuit for line 1200, for example, extends from the winding of hold magnet 1201 and the sleeve contacts of the cross-points of primary line switch 1230, over conductor 1229, contacts 3125 and 3124 at rack 3111, twentieth front contact of relay 3108, armature 3218 of relay 3200, conductor 3219, inner right back contact of relay 4519, inner left back contact of relay 4526, winding of relay 5219, conductor 5251, outer left front contact of relay 4833, to battery. Similarly, the sleeve contacts of other lines are connected to the windings of relays 5200, 5209, 5210, etc. If any of these twenty lines is busy, ground on the sleeve conductor will operate the corresponding test relay.

Seizure of called line

When relay 4833 operated following the operation of relay 4824, circuits were prepared for polarized relay 4534 from battery over the inner left front contact of relay 4833, conductor 4865 to both windings of relay 4534, extending through the lower winding and resistance 4533, over conductor 4539 to ground at the inner right front contact of relay 4833. A second circuit extends through the upper winding of relay 4534 to ground at the back contact of relay 4535. In parallel to this last ground a circuit extends through condenser 4538, conductor 4540 to ground over the middle left contact of relay 4833 and resistance 4831. The upper winding of relay 4534 holds the relay contact in the position shown, overcoming the effect of the lower winding. Ground on both sides of condenser 4538 holds it discharged. When relay 4535 operates, as above described, it opens the circuit through the upper winding of relay 4534 allowing the lower winding to become operative and close the right contact of the relay. However, current flows in the circuit through condenser 4538 until that condenser is charged, thus continuing the opposition to the lower winding for a definite time and delaying the closure of the right relay contact. The purpose of this delay is to allow sufficient time for all of the relays of group 5200 to 5219 which have been connected to busy lines to operate fully.

When relay 4534 closes its right contact, it extends ground over that contact, normal contacts of relays 4530 and 4531, conductor 4541, left back contact of relay 4706, conductor 4714, outer right front contact of relay 5933, conductor 4724, left front contact of relay 5240, right contact of relay 5243, resistance 5248, left back contact of relay 4526, conductor 4542, back contact of relay 5310, conductor 5314, left back contact of relay 3900, conductor 3923, outer left back contact of relay 6012, conductor 6019, outer left front contact of relay 4813, right back contacts of relays 4811 and 4812, inner left front contact of relay 4813, left front contact of relay 4814, conductor 4866, inner left front contact of relay 5242, right back contact of relay 4521, to the left armature of relay 5219 connected to the wanted line. Relay 5242, which was operated to indicate that the wanted number was in an odd ten, connects the ten leads from the units register to the armatures of relays 5210 to 5219, inclusive. Had the number been located in an even ten and relay 5241 operated, it would have connected the ten leads from the units register to the armatures of relays 5200 to 5209, inclusive.

If relay 5219 were operated, the circuit above traced would extend over the front contact of that relay, left back contact of relay 5239, conductor 5253, left back contact of relay 4701, conductor 4715, outer left front contact of relay 5933, conductor 5934, to the winding of busy back relay 3908 and battery. The function of relay 3908 will be described hereinafter.

Assuming that the wanted line is idle and relay 5219 is not operated, the circuit extends over the back contact of relay 5219, to the winding of relay 4519 and battery. Relay 4519 locks over its inner left front contact and the right back contact of relay 4531 to grounded conductor 6018. It also disconnects this ground from the windings of relays 5933, 5240 and 5243, releasing these relays, which in turn open the operating circuit for relay 4519.

Recording location and class of called line

Relay 4519 also connects ground over its outer left front contact, conductor 4543, armature 3220 of relay 3200, conductor 3221, armature 3126 which is individual to the called line on relay 3108, terminals 3122 and 3123 at rack 3105, right winding of relay 3101, armature 3222 of relay 3200, conductor 3223, winding of relay 5900, winding of relay 5932 and battery. Relay 5932 is marginal, to sound an alarm if an attempt is made to operate more than one of the relays 5900 to 5903. Relay 5900 prepares for the test and seizure of the proper switches and links for connecting the line with the incoming trunk. Relay 3101 also operates in this circuit.

Before proceeding with the description of the establishment of the physical connection, the test of other types of lines will be described.

Party line

If the called number referred to the tip party on a party line, terminal 3122 at rack 3105 would have been connected to terminal 3127 and through the left winding of relay 3101 to the winding of relay 5910 and battery through the winding of relay 5932. Relays 5900 and 5910 differ only in their control of ringing.

Test of terminal hunting group—small

If the called number had been 9280, for example, and indicated a line leading to a private branch exchange having twenty trunks comprising a "terminal hunting group" the terminals 3128 and 3129 belonging thereto would have been

cross-connected to the proper sleeve conductor and to terminal **3130**, respectively. Eighteen of the remaining nineteen trunks would have their sleeve conductors similarly cross-connected and their contacts in rack **3105** connected to the middle winding of the relay, like relay **3101**, which indicates their position in the switch structure. The last trunk will have its terminal in rack **3105** cross-connected to the right winding of the proper relay such as relay **3101**. As soon as relay **3108** operates, a circuit is closed from battery through the winding of relay **5220**, inner right contact of relay **5240**, left back contact of relay **4500**, conductor **4544**, armature **3224** of relay **3200**, conductor **3225**, armature **3131** of relay **3108**, contacts **3129** and **3130** at rack **3105**, middle winding of relay **3101**, armature **3226** of relay **3200**, conductor **3227**, inner left front contact of relay **5933** to ground. Relay **5220** operates in this circuit. Similar circuits are closed for all of the lines belonging to the group except the last. Relays **5220**, **5229**, **5230**, etc. operate but relay **5239**, being connected to battery through one of the relays **5900** to **5903** under the present hypothesis, cannot operate. Assuming that the first ten trunks are busy, relays **5200** to **5209** will be operated as described for the individual line but relay **5210** will not be operated. Therefore when relay **4534** closes its left contact establishing a circuit from ground to conductor **6019**, as previously traced, over the right back contacts of units register relays **4813**, **4814**, **4812** and **4811**, left back contact of relay **4813**, conductor **4867**, inner right contact of relay **5241** (operated because the tens digit now is even) right back contact of relay **4526** to the armature of relay **5200** and thence over the front contact of relay **5200**, left front contact of relay **5220**, over similar contacts of intermediate relays, front contacts of relays **5209**, and **5229**, back contact of relay **5210** to the winding of relay **4510** to mark the first idle trunk. Relay **4510** opens the circuits of relays **5933**, **5240** and **5243** as previously described and connects ground to the middle winding of relay **3101** in place of battery through relay **5230**. When relay **5933** closes its back contacts, it transfers conductor **3227** from ground to the winding of relay **5900** and battery through relay **5932**, thereby preparing for the establishment of the connection in the same manner as for an individual line.

If all of the trunk lines had been busy, the circuit closed by relay **4534** would have extended to the armature of relay **5219** and over its front contact and the back contact of relay **5239** to the busy back relay **3908**.

Test of terminal hunting group—large

In the case of larger terminal hunting groups relays **5300** to **5310** function to permit the testing of groups containing as many as one hundred trunk lines. For a group of th's size, the hundred-block terminal at rack **6307** belonging to the called number will be connected to the winding of relay **5300** which will cause the operation of relay **6302** and the selection of the proper hundred-block and twenty-block relays in the line choice connector.

The twenty lines controlled by the operated twenty-block relay are tested in the manner described. Since there are more than twenty lines in the group, relay **5239** as well as the earlier relays of the group **5220** to **5239** will be operated and, if all of the lines in the tested group are busy, the circuit controlled by relay **4534** will extend over the front contacts of relays **5200** to **5239** in the manner previously traced, to the winding of relay **4530** and battery. Relay **4530** opens its operating circuit but closes a holding circuit over its alternate contact to ground at the right contact of relay **4534**. With relay **4530** operated, a circuit is closed from battery through the winding of relay **5301**, uppermost front contact of relay **5300**, upper back contacts of relays **5302**, **5304**, **5306**, and **5308**, conductor **5315**, right front contact of relay **4530**, conductors **4545** and **4864** to ground at the outer left contact of relay **4835**. Relay **5301** locks over its upper front contact, conductor **6321**, outer right back contact of relay **6012**, conductor **6017** to ground at the inner left contact of relay **4835**. It also extends its locking ground to the winding of relay **5310** which also operates, transferring the circuit controlled by relay **4534** from the units register, directly to the armature of relay **5200**. However, this circuit is open at this time at the contact of relay **4530**.

The operation of relay **5301** opens the circuit of the twenty-block relay in the line choice connector, thereby releasing relay **4535**, restoring the shunt to condenser **4538** and causing relay **4534** to open its right contact and close its left contact. The opening of the right contact of relay **4534** permits relay **4530** to release, opening the operating circuit of relay **5301** and closing a circuit from ground on conductor **4545**, back contact of relay **4530**, conductor **4546**, inner lower back contacts of relays **5309**, **5307**, **5305**, and **5303**, lower front contact of relay **5301**, upper winding of relay **5302** and battery. Relay **5302** then functions to select a new twenty-block relay and to cause the test of the twenty lines in that block. For a group of one hundred lines, relays **5303** to **5308** are operated in the manner described for relays **5301** and **5302** until all of the lines of the group have been tested. For the last line, the cross-connections at rack **3105** leave relay **5239** unoperated to permit the operation of the busy back relay if no idle line can be found.

Varying start of test in terminal hunting group

When a group of lines consists of more than forty, the starting point for terminal hunting may be varied between markers not arranged for no-test and number checking, and the twenty-block relays may be cut in by various hundred-block relays even where the numbers assigned are consecutive. The marker shown is equipped for no-test and number checking and in this marker the relation between assigned numbers and hundred-block and twenty-block relays must be maintained.

When such an arrangement is to be made, the terminal such as **6312** belonging to the twenty-block is connected to terminal **6323** at rack **6303**, operating relay **6300**. Also, the corresponding terminal at rack **6307** is connected to the upper winding of the proper relay in the lower row of Fig. 53 this relay locking to ground over conductor **6321**. With relay **6300** operated, the circuits for the twenty-block relays are closed over the right contacts of relays **6300** and rack **6301** instead of over contacts of relay **6302** and by the use of rack **6301** may be selected in a different order in different markers. At the same time, ground from the operated relay of Fig. 53 is connected over a contact of relay **6300** and rack **6303** to the desired hundred-block relay in the line choice connector. This arrangement permits the lines of a terminal hunting group to be connected through various hundred-block relays, thus furnishing a partial emergency arrange-

ment in that the disabling of one hundred-block relay will not stop service to an entire terminal hunting group. This relay may also be used for breaking up the consecutive numbers between the twenty-blocks.

Terminal hunting groups in more than one choice

If a terminal hunting group contains more than one hundred lines, when relay **4530** releases following the operation of relay **5309**, having tested the first hundred lines, a circuit is closed from ground on conductors **4864** and **4545**, right back contact of relay **4530**, conductor **4546**, lower front contact of relay **5309**, conductor **5316** outer right contact of relay **6300**, conductor **6324** to the winding of one of the extra group relays, relay **3903** for example, and battery. In view of the large amount of traffic to one line choice which a one hundred line group represents, it is necessary to locate the extra group on a different line choice. Relay **3903** locks over its innermost right front contact, normal contacts of relays **3902** and **3901**, conductor **3913**, left back contact of relay **4822**, outer left front contact of relay **4824** to grounded conductor **5658**. In locking, relay **3903** opens the operating circuit for relay **6305**, opening the connections to racks **6303**, **6307** and **6308**, releasing relay **6300**. The release of relay **6305** releases the marker preference relay **3805** in the line choice connector, which in turn releases relay **3200** and disconnects the marker from the choice. The disconnection from the line choice connector opens the circuit of relay **4835** which in turn disconnects battery from the incoming connector and releases relay **4834**. The release of relay **4835** releases such locked up relays as relays **5300** to **5310**.

When relay **4834** releases, it closes a circuit from ground over its inner left back contact, conductor **4869**, inner left front contact of relay **3903**, winding of relay **3900** and battery. Relay **3900** connects battery through resistance **6207**, conductor **6211**, middle left contact of relay **3900**, outer right front contact of relay **3903** to conductor **3914**, which is connected to the winding of the marker preference relay in the line choice connector leading to the line choice in which the extra group is located. It also connects ground over its inner right contact and the second right front contact of relay **3903** to conductor **3916** to operate the proper relay in Fig. 53. It connects ground over its outer right contact and the third right contact of relay **3903** to conductor **3915** to operate the desired hundred-block relay and at its outer left contact, it transfers the circuit controlled by relay **4534** from the relay of group **4500** to **4519** determined by the units register or by relay **5310** to the one corresponding to the start of the extra group.

If an office should contain no such large groups, the relays **3903**, **3904**, etc., may be used to expand groups which simulate a large group by operating relay **5308**.

Increasing size of terminal hunting groups

In some cases a subscriber may wish to increase the number of trunks serving his branch exchange and additional lines in the same twenty-block may not be available. In this case, not more than twenty lines on one twenty-block relay in the same line choice may be added to the group. In order to do this, the last set of terminals of the former group in the twenty-block relay is specially cross-connected. Assuming that the first line on twenty-block relay **3110** has been an individual line and is now to be expanded to a private branch exchange group of two lines, retaining the same number, the corresponding sleeve contact will be cross-connected at rack **3111** to terminal **3135** and the number control terminal will be cross-connected at rack **3105** to terminal **3133**.

When the number has been registered and translated, the line choice selected and hundred-block relay **3104** and twenty-block relay **3110** operated, battery through the winding of relay **5200** will be connected over the innermost contact of relay **3110**, terminals **3134** and **3135** at rack **3111**, armature **3228** of relay **3200**, conductor **3229**, winding of relay **6000** and battery, neither relay **5200** nor **6000** operating. Relay **5220** is connected over the inner right contact of relay **5240**, left back contact of relay **4500**, to the first armature of the second set on relay **3110**, over terminals **3132** and **3133** on rack **3105**, through the right winding of relay **3103** to battery, neither relay **5220** nor relay **3103** operating. The operation of relay **3110** operates relay **4535** which causes relay **4534** to close its right contact after an interval, at which time relay **4500** operates. With relay **4500** operated, the sleeve contact of twenty-block relay **3110** is transferred from the winding of relay **5200**, over the right front contact of relay **4500**, conductor **4718**, inner right back contact of relay **4703**, left back contact of relay **4005**, inner right back contact of relay **4000**, conductor **6020**, right back contacts of relays **6010** and **6011**, conductor **4549**, winding of relay **4532** and battery, relays **4532** and **6000** remaining unoperated in the absence of false ground. Relay **4500** also substitutes direct ground for relay **5220**. This ground operates relay **3103** which extends the ground over its second left contact, armature **3240** of relay **3200**, conductor **3241**, winding of relay **6011**, and ground. Relay **6011** locks itself and relay **3103** to ground over conductor **6017**. Relay **6011** at its right front contact disconnects relay **4532** from the sleeve contact of relay **3110** and substitutes ground from the inner left back contact of relay **6012**. Relay **6000** now operates, locking to ground on conductor **6017**. Relay **6000** at its following contact closes a circuit for relay **6012** which then opens the operating circuit of relay **6000**. Relay **6012** in operating, disconnects the direct ground and ground through relay **6014** from the contacts of the translator relays thereby releasing the hundred-block and twenty-block relays in the line choice connector. It also opens the locking circuit for the relays of Fig. 53, releasing any which might have been operated. Relay **6012** also opens the circuit of relay **4500**. The release of relay **3110** releases relay **4535**, causing relay **4534** to open its right contact and close a circuit from ground over its left contact, conductor **4547**, inner left front contact of relay **6012**, winding of relay **6013** and battery. Relay **6013** locks under the control of relay **6000**. Relay **6013** connects ground to conductors **6025** and **6021**. Conductor **6021** extends over the outer left contact of relay **3103** to the winding of a hundred-block relay, while conductor **6025** extends over the third left contact of relay **3103** and a contact of the operated hundred-block relay to the winding of the twenty-block relay on which the added lines appear.

Relay **6011** substituted ground for relay **4532** in the connection to the sleeve contact of the twenty-block relay; relay **6012** disconnected this ground and relay **6013** now reconnects relay **4532**

to that contact. The purpose of relay **4532** will be discussed later. Relay **6013** also restores the locking circuit for the relays of Fig. 53 and prepares a circuit from the ground provided by relay **4534** and extended to conductor **3923**, over its third left contact, inner right contact of relay **6011**, outer left contact of relay **6000**, conductor **6022**, right back contact of relay **4526**, to the armature of relay **5200**.

Relays **6000**, **6002**, **6004**, **6006**, and **6008** are connected to terminals in rack **3111**, and in combination with relays **6010** and **6011** which are operated in accordance with the cross-connections at rack **3105** determine ten points at which the new groups of lines may start within the new twenty-block relay. It is intended that five relays, such as relay **3103**, and five added twenty-block relays be provided, thereby permitting a maximum of fifty added groups in which not more than two lines are added to each original group, with a net increase of one line per group. If the number of lines added to the original groups is more than two, the number of groups added must be proportionally decreased until the opposite extreme is reached of five added groups each containing twenty lines, with a net increase of nineteen lines per group, since one added line substitutes for the line sacrificed for cross-connecting.

When the wanted line is found idle or an idle line in a group is found, one of the relays **5900** to **5903** is operated.

Seizure of line group and control circuit

Returning to the establishment of the original call and assuming that relay **5900** is operated, as was previously described, indicating that the wanted line is located in the No. 0 frame of this particular choice, relay **5900** closes a circuit from ground at the left back contact of relay **4527**, conductor **4548**, through the winding of relay **5920**, right contact of relay **5900**, conductor **5935**, armature **3343** of relay **3200**, to conductor **3244**, leading to the line group control circuit of this frame. If no outgoing call is being handled, or as soon as the control circuit is freed from an outgoing call, conductor **3244** is extended over the middle left back contact of relay **1615**, outer right back contact of relay **1603**, first left back contact of relay **1602**, right winding of relay **1601** and battery. Relays **5920** and **1601** operate in this circuit, relay **1601** locking over the inner left back contact of relay **1602**, inner left front contact of relay **1601** and middle left back contact of relay **1615** to conductor **3244**, independent of relay **1603** and also opening the operating circuit of relay **1603** to prevent interference by any call originated in this frame. Relay **1601** also closes a circuit from ground at the inner left back contact of relay **1603**, outer left contact of relay **1601**, conductor **1626**, left winding of relay **3100** and battery, operating relay **3100**.

It may be noted that while this marker is completing a call in the selected frame, originating calls may be in progress or other frames in the same choice which use other line link control circuits. Since there is only one line choice connector, only one terminating call can enter a choice at a time.

Selection of line links for test

With relays **3100** and **3101** operated, a circuit is closed from ground over the back contact of relay **5932**, inner right contact of relay **5920**, conductor **3246**, armature **3245** of relay **3200**, front contacts of relays **3101** and **3100**, conductor **2706** to the winding of relay **1208** and battery. Relay **1208** connects the primary and secondary select magnets of the line link group serving line **1200** to the line choice connector, as well as the test circuits for the line links. It will be noted that relay **5920** locates the wanted line in a particular frame and relay **3101** in a particular level on the frame, thereby identifying the group of line junctors over which the incoming junctor may be connected to the wanted line.

Relay **5920** also closes a circuit from ground at its outer right contact, conductor **5940**, winding of multi-contact relay **6100** and battery.

Selection of line links and incoming links

Relays **6100** to **6103** are operated from relays **5920** to **5923** for the purpose of closing a sufficient number of contacts and each serves one of the four frames making up a line choice, their contacts extending in multiple to the contacts of the line choice relays like relay **3200**. These relays each prepare ten circuits for testing the line links of the horizontal group and ten circuits for operating the corresponding select magnets of the primary line switch. These circuits extend in multiple to the line group and control circuit where the operation of the horizontal group relay extends them to a particular level.

In addition relays **6100** to **6103** operate one of the relays **6200** and **6201** to indicate whether the frame is an odd or an even frame and one of the relays **6202** and **6203** to indicate whether it is a left or right frame. From the description of the skeleton drawings, it will be remembered that the right and left line frames connect with the right and left incoming frames respectively by separate groups of line junctors, while the line junctors are multipled to the two odd and the two even line frames. Therefore the frame on which the wanted line is located differentiates between two groups of incoming links and two groups of line junctors.

With relay **6100** operated, even relay **6201** and left relay **6202** are operated. Relay **6201** prepares the operating circuits for ten hold magnets of the secondary line switches serving the wanted line. Relay **6202** prepares the circuits for testing ten incoming links and for operating a line junctor relay in the line choice connector circuit, which in turn closes circuits for testing ten line junctors and further extends the circuits for operating the secondary line switch hold magnets.

Operating select magnets of secondary incoming selectors

When relay **4835** operated to indicate the operation of the line choice connector it grounded conductor **4870**, energizing the upper winding of polarized relay **4014** to hold its left contact open. It also completed a circuit over the normal contacts of relays **4008** and **4009** to the winding of relay **4113** and battery. With relay **4113** operated, when relay **4834** operates to indicate that the incoming connector had been seized, a circuit is closed from ground at the second right contact of relay **4834**, conductor **4874**, front contact of relay **4113**, conductor **5666**, armature **5626** of relay **5600**, conductor **3723**, through the sender link to conductor **5823**, winding of relay **5818** and battery. Relay **5818** operates, connecting ground to conductor **5827** to operate link cut-in relay **5735**. There are ten such relays in the incoming connector, each being associated with ten incoming junctors which connect to one primary incoming

switch. Each relay has ten contacts for the purpose of operating ten select magnets on the ten secondary incoming switches. The level of the select magnet on any particular secondary incoming switch is the same as the number of the primary incoming switch whose incoming links were cut through by the operated incoming link cut-in relay. Therefore, relay **5735** in operating closes a circuit from ground over the lower contact of jack **5737** over armature **5742** of relay **5735** through the winding of secondary select magnet **5712** to battery. Nine similar circuits are closed for the other nine secondary switches.

Operating select magnet of primary incoming selector

Relay **5818** also connects ground to conductor **5845** to operate primary select magnet **5702** individual to the incoming junctor in the primary incoming switch. It also connects relays **5811**, **5813** and **5815** to conductor **5828**, **5829** and **5830**, respectively, to receive ringing information from the marker.

Operating select magnets of secondary line switches

The ten select magnets of the secondary line switches for the ten line junctors which serve the wanted line are operated immediately following the operation of relay **1208**. For example secondary select magnet **1211**, is operated over armature **1212** of relay **1208** and the upper normal contact of jack **1610**.

Selection of incoming links for test

There are twenty incoming links connecting the primary incoming switch in which the incoming junctor appears with secondary incoming switches, any one of which may be used in completing the connection. The sleeve conductors of these incoming links are extended over contacts of the link cut-in relay and the marker connecting relay to the contacts of relays **6202** and **6203**, relay **6202** controlling those leading to the left secondary switches while relay **6203** controls those leading to the right secondary switches.

There are two hundred line junctors outgoing from the secondary incoming switches to the secondary line switches. These are divided into a left group and a right group, each group connecting in multiple to two of the four line groups or frames of a line choice. Each group may be considered as made up of ten vertical columns or rows of ten junctors each. Each vertical row of ten junctors, plus the leads to the twenty associated hold magnets on the secondary line switches, are cut into the marker by a line junctor relay, such as relay **3201**, in the line choice connector. This relay, therefore, corresponds to a vertical row of hold magnets on one incoming frame. It is operated by the marker and it is determined by the frames which the associated junctors connect, and by whether the first, second or some other junctor group is desired on the particular test. The selection of junctor groups will be described hereinafter.

Consideration of the arrangement of links and junctors as shown in the skeleton drawings of Figs. 4 to 11 reveals that on any one call on a particular test, there are not more than ten paths over which a call from a particular incoming to a selected line can be set up. Each of these paths consists of an incoming link, line junctor and line link. This set of link, junctor and link is what is referred to as a channel in the following description. In cases where there are less than ten line choices, additional groups of ten or less junctors may be used if the first group of ten junctors proves to be busy. In the skeleton drawings, it is assumed that there are ten choices, while in the detailed drawings, in order to indicate the operation of the repeated test arrangement, it has been assumed that there are only eight choices.

Channel test circuits

Two relays are provided for testing each channel, one for testing the incoming link and line junctor and the other for testing the line link. These are relays **3410** to **3419** and **3420** to **3429**, respectively. The test circuit for the line link shown in Fig. 12 may be traced from the sleeve conductor of that link over armature **1223** of relay **1208**, conductor **1224**, contact of jack **1610**, conductor **1623**, armature **3247** of relay **3200**, conductor **3248**, innermost contact of relay **6100**, conductor **6104**, outermost left back contact of relay **5410**, conductor **5416**, inner lower back contact of relay **3409**, winding of relay **3429** to battery. Nine similar circuits testing the other nine line links serving the wanted line are extended to the windings of relays **3420** to **3424**, **3425** etc. If any of the links are busy, they will be grounded and the test relay will operate.

The test circuit for the incoming link may be traced from the sleeve conductor **5743** of the link, armature **5744** of relay **5735**, ring contact of jack **5737**, armature **5745** of relay **5722**, conductor **5746**, armature **6215** of relay **6202**, conductor **6216**, outer upper back contact of relay **3409**, lower winding of relay **3419** and battery. In this case, the remaining nine links, as determined by relay **6202**, are tested by the lower windings of relays **3410**, **3414**, **3415**, etc., and where a link is marked busy by a grounded sleeve the corresponding relay operates.

Selection of line junctors for test

The selection of a group of line junctors for test depends on a number of conditions. Each incoming frame has two hundred outlets and each line switch frame has one hundred outlets, but is a part of a group of four, making up a choice which therefore has four hundred outlets. These outlets are joined by the line junctors, the line frames of the choices being multipled in pairs so that each choice is served by two hundred junctors. The line junctors are spread from the incoming frames to the line frames as evenly as possible.

In the simplest case, when there are ten incoming frames and ten choices, the distribution is very similar to the distribution between primary and secondary switches, the ten junctors from one incoming switch appearing in corresponding positions in each of ten choices, and ten junctors from each frame appearing in each half-choice. In this case, the test and operating leads for the line junctors may be controlled simply by a relay, such as relay **3201**, in the line choice connector, determined by the incoming frame over which the call originated.

If the number of incoming frames is less than ten, but is such that the ten junctors from any secondary line switch may be spread evenly thereover, for example, 2 or 5, each frame will be connected by the same plurality of junctors to each secondary line switch. In this case, by the use of a group of junctor group relays like **6400** and **6404** and a progress circuit involving sets

of relays 6401 to 6403 and 6405 to 6407, the marker will test a different set of ten junctors on successive calls or, if the first test finds all the junctors busy, on successive tests. In the case of two incoming frames, each frame will have fifty junctors leading in a desired direction and the marker will be equipped with five relays like relay 6400 and five sets of progress relays. In the present disclosure, it has been assumed that there are eight frames, so that only two junctor group relays and two sets of progress relays are needed. The junctor group relays control the operation of the proper line junctor relay in the line choice connector.

If there are any other number of incoming frames, for example 9, in each vertical row of line junctors at the line switch frame there will be one spare junctor and these spare junctors are spread over the frames as evenly as possible, giving eight frames one extra junctor and the ninth frame two extra junctors. These spare junctors are grouped under common line junctor relays. On a first test, ten junctors will be tested. In case all the first tested channels are busy, the group of spare junctors will be connected with by means of the line junctor relay and a junctor pattern relay is used to complete the test circuits for the junctors which may be used in the particular call. This junctor pattern relay transmits an artificial busy signal to the test relays which would test the junctors which do not lead in the desired direction. These relays are shown in Fig. 33. As many as ten such relays are needed in the case of nine incoming frames with smaller numbers for other cases. A normal pattern relay connects through the ten junctors primarily available and is operated from the first junctor group relay. The other group relays operate a particular pattern relay according to the number of the test, the frame calling and in some cases the line choice called. If the spare junctors are arranged in the same way in each choice, no choice relay is needed but if the pattern varies between choices, line choice relays, such as relay 6204 are provided to further control the operation of the pattern relay.

Returning specifically to the present disclosure, under the assumption that there are eight incoming frames, that there are other than ten line choices and that the junctor pattern varies with the line choice, the choice of a group of line junctors for test proceeds as follows:

When the line choice connector operates, relay 3200 closes a circuit from ground over armature 3249 and conductor 3250 to the winding of relay 6204 and battery. Similar relays are provided for the other line choices and operate from the associated line choice connector.

During the interval between calls, relay 5524 is idle and a circuit is closed from ground over its inner left back contact, conductor 5525, back contact of relay 6403, winding of relay 6402 and battery. Relay 6402 locks to ground at the right back contact of relay 6406. As soon as the marker is seized by the marker connector, ground is connected over armature 5663 of relay 5600, conductor 5669, over back contacts of relays 5514, 5512, 5505, 5501 and 5516 as a check of the normal condition of the timing circuit, third left back contact of relay 4834, to the winding of relay 5524 and battery. Relay 5524 operates, opening the circuit of relay 6402 and closing a circuit over its outer left front contact, conductor 5526, upper back contact of relay 4104, conductor 4114, left back contact of relay 6406, left front contact of relay 6402, winding of relay 6401 and battery. Relay 6401 operates and locks to ground at the right back contact of relay 6405. It also closes a circuit from ground at the right back contact of relay 6406, outer left front contact of relay 6401 to the winding of relay 6400 and battery. Relay 6400 closes through ten conductors by which the seizing incoming frame may operate a line junctor group relay. It also connects ground to conductor 6408 and the winding of the normal pattern relay 3300 which connects the ten line junctors to be first tested to the ten test relays 3410 to 3419. When relay 4835 operates following the connection of the marker to the line choice, a circuit is closed from ground at the middle left contact of relay 4835, outer left back contact of relay 4834, conductor 4875, right front contact of relay 6401, winding of relay 6403 and battery. Relay 6403 locks over its right contact, conductor 6411 to ground at the middle left contact of relay 4835, the operating circuit being opened when relay 4834 operates. If no second test is to be made, relay 6403 remains operated until the marker is released. Relays 6401 and 6402 remain locked until the next test is made whether on the same or a succeeding call.

When the incoming connector relay 5722 operates, it connects ground over armatures 5747 and 5748 to conductors 5749 and 5750. Conductor 5749 extends to terminal 6217 at cross-connecting rack 6218, where it is cross-connected to terminal 6221 at rack 6222 whence the circuit extends over conductor 6223, front contact of relay 6400, conductor 6409, terminal 6224 at rack 6225 cross-connected to terminal 6220 at rack 6219, upper contact of the inner set of armatures on relay 6202, conductor 6226, armature 3253 of relay 3200, terminals 3251 and 3252 at rack 3202, winding of line junctor relay 3201 and battery. Relay 3201 connects the test leads and the operating circuits for the hold magnets from ten junctors connecting the calling incoming frame with the called line frame, through to armatures of relay 3200.

When relay 4835 operated it closed a circuit from ground at its second right contact over conductor 4876 to battery through the winding of relay 4101 which supplies the upper windings of relays 3410 to 3419 with battery. With relay 3201 operated, the test circuit for line junctor 1232 may be traced from the sleeve conductor 1233, over conductor 1238, armature 3254 of relay 3201, armature 3200 of relay 3255, conductor 3256, armature 3301 of normal junctor pattern relay 3300, conductor 3302, middle upper back contact of relay 3409, upper winding of relay 3419, conductor 3433, front contact of relay 4101 and battery.

A circuit has now been prepared for each of the relays 3420 to 3429 and two circuits for each of the relays 3410 to 3419. Relays 3410 and 3420 test parts of the same channel comprising one line link, one incoming link and one line junctor connecting the two links. If any one of the elements of a channel is busy, the channel cannot be used.

Channel selection.

When relay 3201 operated, a circuit was closed from ground at the second lower front contact of relay 5818 in the incoming trunk circuit, conductor 5827, armature 5751 of relay 5735, armature 5752 of relay 5722, conductor 5753, left front contact of relay 5920, conductor 5936, armature 3237 of relay 3200, conductor 3238, armature 1239

of relay 1208 in the line link control circuit of the chosen frame, as indicated by the operation of relay 5920, conductor 1237, upper contact of relay 3201, armature 3235 of relay 3200, conductor 3239, winding of relay 4104 and battery. Relay 4104 in operating indicates that the incoming trunk and connector are connected with the marker, that the proper line group or frame, horizontal group and line junctor group have all been connected with and the channel test circuits should be complete.

Relay 4106 is a timing relay similar to relay 4534. It receives battery over conductor 4865 from the inner left front contact of relay 4833. The upper winding is connected through resistance 4107 to ground at the middle right contact of relay 4833 and the lower winding to ground at the lower back contact of relay 4104 and through condenser 4105 to ground over the outer right contact of relay 4833 and resistance 4832. The lower winding tends to hold the contact of the relay open while the upper winding tends to close it. With relay 4104 released, condenser 4105 is shunted and the current in the lower winding of relay 4106 overcomes that in the upper winding. When relay 4104 operates, it opens the circuit of the lower winding, but condenser 4105 charges through that winding to produce a current flow which delays the closure of the relay contact for a sufficient length of time for the test relays to operate. When relay 4835 grounded conductor 4876 it closed a circuit extending over the normal contacts of relays 3409 to 3400, through the winding of relay 4103 and battery. Therefore, when relay 4106 closes its contact it prepares a channel selecting circuit which extends from grounded conductor 4876, back contact of relay 4102, upper front contact of relay 4103, front contact of relay 4106, outer right back contact of relay 4703, inner upper back contact of relay 4100, to the upper armature of relay 3420. If relay 3420 is operated, the circuit extends to the armature of the next relay of this group over the front contact of relay 3420. If relay 3420 is unoperated the circuit extends over the back contact of relay 3420 to the armature of relay 3410. If relay 3410 is operated, the circuit extends to the armature of the same relay as from the front contact of relay 3420. If relay 3410 is also idle, the circuit extends to the winding of relay 3400. Similar circuits are closed by each of the relays of the two groups. Therefore, if any element of a channel is busy, that channel cannot be used and the selecting circuit advances to the next set of channel testing relays.

First group of channels busy

Assuming for the moment that all of the ten channels tested are busy at some point, the selecting circuit will extend over the armatures of relays 3420 and 3424 and intermediate relays over the inner lower back contact of relay 4100, over the armatures of relays 3425 to 3429, middle lower back contact of relay 4100, to conductor 5525, left front contact of relay 6403, left back contact of relay 6407, winding of relay 6406 and battery. Relay 6406 locks over conductor 6411 under the control of relay 4835 and opens the locking circuit of relay 6402 and the operating circuit of relay 6400, thereby releasing the normal pattern relay 3300 and opening the test circuits for the line junctors. Relay 6400 also opens the circuit of the line junctor relay 3201 in the line choice connector. The release of relay 3201 in turn releases relay 4104 which reestablishes the shunt around condenser 4105 and causes relay 4106 to open the selecting circuit. With relay 4104 released, ground from the front contact of relay 5524 is again connected to conductor 4114 and relay 6405 operates over the front contact of relay 6406. Relay 6405 extends ground from conductor 6411 to the winding of relay 6404. The selection of a junctor pattern relay and the line junctor relay for this second test is under the control of the line choice relay 6204 in addition to the other controls. The circuit for the second junctor pattern relay may be traced from ground over armature 5748 of relay 5722, conductor 5750, contact of second choice relay 6404, conductor 6410, contact 6227 at rack 6228, contact 6229 at rack 6206, contact of relay 6204, contact 6237 at rack 6231, contact 6232 at rack 6233, conductor 6234, contacts 3303 and 3305 at rack 3304, winding of pattern relay 3306 and battery. The two extra line junctors are cross-connected for this incoming frame so as to be available over links 0, 4, and 8. Therefore test leads for these junctors are completed in these channels by relay 3306, while the remaining line junctor test relays receive ground over the contacts of relay 3306.

Second channel test

The circuit for the second line junctor relay extends from ground over armature 5747 of relay 5722, conductor 5749, contact 6217 at rack 6218, contact 6221 at rack 6222, conductor 6223, contact of relay 6404, conductor 6412, contact 6235 at rack 6625, contact 6236 at rack 6206, contact of relay 6204, contact 6230 at rack 6231, contact 6238 at rack 6219, contact of relay 6202 and thence to the winding of a new line junctor relay in a circuit similar to that traced for relay 3201. The channel test is repeated. If these channels are likewise busy, ground is again connected to conductor 5525, extending over the front contacts of relay 6403 and 6406, conductor 6413, to the winding of overflow relay 3909 and battery. The function of relay 3909 will be described hereinafter.

Assuming that the tenth channel is available on the first test, neither relay 3429 nor relay 3419 will be operated and the channel selecting circuit will extend to the winding of relay 3409 and battery. As soon as relay 3409 operates it locks over its inner upper front contact to grounded conductor 4876, and opens the operating circuit of relay 4103 which in turn opens the operating circuit of relay 3409.

Operating select magnet of primary line switch

At its lower front contact, relay 3409 closes a circuit from ground to conductor 3437, armature 6108 of relay 6100, conductor 6109, armature 3264 of relay 3200, conductors 3265 and 2809, armature 1228 of relay 1208, winding of primary select magnet 1226 and battery, preparing the line link for seizure.

Testing incoming link hold magnet circuit

The operation of relay 3409 transfers the links and line junctor of the corresponding channel to testing and operating circuits. The sleeve conductor 5743 of the incoming link which previously extended over the outer upper back contact of relay 3409, now extends over the outer upper front contact of that relay, lower back contact of relay 4111 through the lower winding of marginal relay 4108 to ground. If the hold magnet 5701 is satisfactorily connected as indicated by the presence of battery, and if no double connection

or cross-connection to ground exists indicated by the absence of ground, relay **4108** operates, locking over its upper front contact to grounded conductor **4870**. Magnet **5701** may or may not operate at this time.

Testing line link and operating hold magnet of secondary line switch

At the same time the line link is being tested. This circuit extends as previously traced to the middle lower armature of relay **3409** and, with that relay operated, over its front contact, upper back contact of relay **4110** to the lower winding of relay **4109** and ground. If this link is also satisfactory, relay **4109** also operates, locking through its upper winding to conductor **4870** and extending this ground to the winding of relay **4110** which also operates. With relay **4110** operated the line link is transferred from the winding of relay **4109** to the winding of relay **4112** and battery over the upper back contact of relay **4111**. With relays **4108** and **4110** operated, ground from the left back contact of relay **5518** and conductor **5527** is extended over the lower front contacts of relays **4108** and **4110**, middle upper front contact of relay **3409** to conductor **3302**, leading to the sleeve conductor **1233** of the line junctor. A parallel circuit extends from ground over the middle upper front contact and inner lower front contact of relay **3409**, conductor **3434**, contact of relay **6201**, conductor **6239**, armature **3257** of relay **3200**, armature **3258** of relay **3201**, conductor **3259** to the winding of the hold magnet **1243** of the secondary line switch **1240**. Magnet **1243** operates in this circuit connecting its winding and sleeve conductor **1233** of the line junctor over its lower contact and over the sleeve contact of the cross-points to the sleeve conductor of the line link. This conductor being connected to the winding of relay **4112**, relay **4112** operates if the sleeve cross-point has closed properly. Relay **4112** locks over its outer upper front contact to conductor **4870** and operates relay **4111** over its inner upper front contact. Relay **4111** disconnects relay **4112** from the sleeve conductor.

Operating hold magnets of secondary and primary incoming selectors

The ground connected to the sleeve conductor **1233** of the line junctor also operates hold magnet **5711** belonging to that line junctor in the secondary incoming switch **5710**. Magnet **5711** extends its operating ground over the sleeve contact of the cross-point to sleeve conductor **5743** and the winding of the primary hold magnet **5701** which in turn closes its cross-point extending this ground over the cross-point to conductor **5754**, outer lower front contact of relay **5818**, conductor **5831**, armature **5755** of relay **5735**, armature **5756** of relay **5722**, conductor **5757**, lower front contact of relay **4112**, winding of relay **4001** and battery. The operation of relay **4001**, therefore, indicates the satisfactory closure of the cross-points at the secondary line switch and the primary and secondary incoming switches.

Test of talking conductors

A false battery on the tip conductor or a false ground on the ring conductor of the incoming switches or line switches would cause a false charge by operating relay **5808** of the incoming junctor prematurely. Therefore, from the time relay **5818** of the incoming junctor operates, until relay **4001** operates as above described, the tip contacts of the primary incoming cross-points are connected over conductor **5833**, outer upper front contact of relay **5818**, conductor **5832**, armature **5758** of relay **5735**, armature **5760** of relay **5722**, conductor **5762**, outer right back contact of relay **4001**, second left back contact of relay **4000**, right winding of relay **4004** to ground and the ring contacts of the primary cross-points are connected over conductor **5834**, third lower front contact of relay **5818**, conductor **5835**, armature **5759** of relay **5735**, armature **5761** of relay **5722**, conductor **5763**, inner right back contact of relay **4001**, inner left back contact of relay **4000**, left winding of relay **4004** to battery. When the primary and secondary incoming switch cross-points and the secondary line switch cross-points are closed this circuit also tests for false battery and ground on the line conductors of the links and line junctor. If relay **4004** operates it locks under the control of relay **5518** and prevents the completion of the call.

Operating line hold magnet

Assuming that relay **4004** does not operate, when relay **4001** operates as above described, it closes an obvious circuit for relay **4002**, which in turn operates relay **4000**, relay **4000** locking to grounded conductor **4870**. When relay **4519** operated as previously described it connected relay **4532** over conductor **4549**, right back contacts of relays **6011** and **6010**, conductor **6020**, inner right back contact of relay **4000**, left back contact of relay **4005**, inner right back contact of relay **4703**, conductor **4718**, right front contact of relay **4519**, conductor **3219**, armature **3218** of relay **3200**, armature of relay **3108**, terminals **3124** and **3125** at rack **3111**, to the sleeve conductor **1229** of the line to test for the subsequent busying of the line. If the line has not become busy, when relay **4000** operates, it transfers the sleeve conductor from conductor **6020**, over the outer left front contact of relay **4002**, outer upper back contact of relay **4100**, left back contact of relay **4004**, inner lower front contact of relay **4104** to grounded conductor **5527**. This ground operates the line hold magnet **1201**, completing the connection between the line and the incoming trunk.

Test for double connections

During the interval between the operation of relay **4001** and the operation of relay **4000**, relay **4004** is connected in the reverse direction to the tip and ring conductors through the switches as a test for double connections which would indicate their presence by the ground and battery from the repeating coil on these conductors. In this case also the operation of relay **4004** renders relay **4000** ineffective to operate the line hold magnet.

Test of switch cross-point continuity

When relay **4000** operates, relay **4004** is disconnected from the tip and ring conductors and the tip conductor is extended over the inner left front contact of relay **4000**, conductor **4016**, outer right back contact of relay **4610**, conductor **4611**, right back contact of relay **4008**, through the full wave rectifier **4015**, and the lower winding of polarized relay **4014** to the source of ringing current **4018**. The ring conductor is extended over the second left contact of relay **4000**, conductor **4017**, inner right back contact of relay **4610**, conductor **4612**, left back contact of relay **4008** to ground through resistance **4007**. Relay **4014** has two functions, namely,

to inform the marker when the line hold magnet has operated and to check the continuity of the switch cross-points.

Relay **4014** operates if the cross-points are properly closed over the subset and the line loop because of the alternating character of the current, which, because of the high resistance of relay **4014**, does not ring the subscriber's bell. In the case of party lines the relay operates to the substation ground but does not ring the bell. It will be remembered that one of the relays **5910** to **5913** is operated when the called line grounds the tip side of the line and is to be signaled thereover. Any one of these relays closes a circuit from battery through the winding of relay **4610**, conductor **4613**, front contact of the operated relay, for example relay **5911**, and the back contact of the remaining relays, in this case relay **5910**, back contacts of relays **5903** to **5900**, conductor **5937**, left back contact of relay **4528**, conductor **4550**, left back contacts of relays **6011**, and **6010**, conductor **6023**, left back contact of relay **4711**, to ground at the back contact of relay **4710**. Therefore, when the called line is one which grounds the tip side of the line relay **4610** is operated, reversing the connection of relay **4014** to the line and preparing the operating circuit for that relay in case there is no ring party connected to the line at the time.

Test for false tip ground

Prior to this point in the operation of the marker, a test is made for a false ground on the tip conductor for the three fold purpose of detecting two-party lines on which the ground has been deliberately applied to avoid payment, to detect double connections which have been caused by the operation of the line hold magnet and to detect cross-connections between the tip conductor of the line and the message register lead. This test is made by relay **4113**.

It will be remembered that this relay was operated over the back contact of either relay **4008** or relay **4009** when relay **4835** operated, in turn operating relay **5818** in the trunk circuit. When polarized relay **4014** operates as above described it closes an obvious circuit for relay **4010**, which locks to grounded conductor **4870** and extends this locking ground to the winding of relay **4008**. Relay **4008** at its inner right back contact disconnects relay **4113** from ground and at the same time connects it over the back contact of relay **4100** and the right and left front contacts of relay **4008** to conductors **4612** and **4611** in parallel.

Ringing control

In the meantime, the operation of relay **5900** has transmitted a ringing start signal to the incoming selector. Relay **5900**, as well as the other relays of the group, closes a circuit from ground at the back contact of relay **4710**, left back contact of relay **4711**, conductor **6023**, left back contacts of relays **6010** and **6011**, conductor **4550**, left back contact of relay **4528**, conductor **5937**, left front contact of relay **5900**, conductor **5938**, outer right back contact of relay **3901**, right back contact of relay **3908**, left back contact of relay **4529** to the winding of relay **4605** and battery. The circuit is carried over the back contacts of relays **3901**, **3908** and **4529** to prevent ringing in the case of intercepted calls, calls to busy lines and no test calls. Relay **4608** is operated when relay **4834** operates, over the back contacts of relay **4604** and **4609** to test the non-operation of these ringing control relays, and over the back contacts of relays **4712**, **4711**, **3909** and **3908** to check the normal condition of the no-test, busy back and overflow relays. When relay **4605** operated it closed a circuit from ground at the inner left front contact of relay **4834**, conductor **4871**, third left back contact of relay **4000**, inner right front contact of relay **4608**, right front contact of relay **4605**, to the winding of relay **4604** which operates and closes a locking circuit over its left front contact to ground at the inner left front contact of relay **4010**. Relay **4605** also connects ground as above traced over conductor **4614**, armature **5764** of relay **5722**, armature **5765** of relay **5735**, conductor **5830**, third upper front contact of relay **5818** to the winding of relay **5815** and battery.

As previously mentioned if one of the relays **5910** to **5913** had been operated to indicate that the subscriber was to be rung over the tip side of the line relay **4610** would have been operated. Relay **4610**, when operated, connects ground from conductor **4871** over the fourth left back contact of relay **4000**, outer right front contact of relay **4608**, middle left front contact of relay **4610** to the winding of relay **4609** and over conductor **4615** to the winding of relay **5813**. Relay **4610** also closes a circuit from ground at its inner left front contact, back contacts of relays **3908**, and **4529** to the winding of relay **4605** and battery, which operates as above described to ground conductor **4614** and operate relay **4604**.

With relays **4605** and **4604** operated, a circuit is closed from battery through the winding of relay **4009**, conductor **4019**, left front contact of relay **4605**, middle left back contact of relay **3908**, outer right front contact of relay **4604**, back contacts of relays **4610** and **4609**, left back contact of relay **4600**, conductor **4616**, left back contact of relay **4924**, conductor **4934**, right back contact of relay **4601**, right back contact of relay **4602**, left back contact of relay **3909**, outer left back contact of relay **3908**, right back contact of relay **3907**, left back contact of relay **4603** and ground. It may be noted that the circuit is completed provided relays **4609** and **4610** are either both operated or both non-operated. Similarly, it extends over back contacts of relays **4600**, **4601** and **4924** or over front contacts of the same relays. Relay **4600** serves to control the polarity of the ringing current where four-party lines are employed and is operated whenever relay **4924** is operated, since the lines in the lower and upper five hundred groups require different superimposed ringing current. The incoming junctor shown serves two-party lines only and in an actual installation relays **4600** and **4601** and their associated wiring would be omitted or by-passed. Relays **4602** and **4603** are used for tone control or to mark free lines and therefore should be operated only in connection with a busy back or overflow condition or when the free line relay **3907** is operated. Therefore, the checking circuit extends over the back contacts of relays **3909**, **3908** and **3907** as well as over the back contacts of relays **4602** and **4603**; or if relays **4602** and **4603** are operated, over their front contacts and the front contact of one of the relays **3909**, **3908** or **3907**.

Relay **4009** in operating opens one point in the circuit of relay **4113** so that when relay **4008** connects relay **4113** to the tip and ring conductors it responds to the condition of the line. If no ground is present in excess of the allowable leak, relay **4113** releases, in turn releasing relay **5818**. If a false ground is present, and relays **4113** and **5818** remain operated, the marker timing circuit functions to bring about a second trial.

A line equipped with a coin box in which a coin has been deposited, or a two-party line, whose receiver has been lifted just prior to this test will have a ground on the tip of the line. In the case of the coin line, the marker will cancel the test for the tip ground on the second trial as will appear hereinafter and will set up the call to the line after having made a trouble indicator record. In the case of the two-party line, the marker will find the line busy on second trial and will return a busy signal.

Ringing circuit

When relay **5815** operated, it locked over its inner upper contact, back contact of relay **5810** to ground over the outer upper front contact of relay **5805**. Relay **5815** opens the shunts around condensers **5816** and **5817**, closes a circuit from the source of ringing current over conductor **5836**, inner lower front contact of relay **5815**, winding of relay **5810**, upper back contacts of relay **5813**, outer lower front contact of relay **5815** to the back contact of the third lower armature of relay **5818**. It also connects generator ground on conductor **5837**, over the lower back contact of relay **5813**, outer upper front contact of relay **5816** to the back contact of the uppermost armature of relay **5818**. Ringing tone is extended back to the called subscriber through condensers **5816** and **5817**.

When relay **5818** releases it closes the tip and ring conductors of the trunk through to the line and applies ringing current thereto. It also connects ground from the lowermost front contact of relay **5805** through low resistance **5812** and the lower alternate contact of relay **5818** to conductor **5754** to hold the primary and secondary hold magnets of the incoming and line switches operated.

Release of marker and sender

When relay **5818** releases, it opens the circuit of relay **5735** in the incoming connector and also the circuit of relay **4104**. When relay **4104** releases it disconnects grounded conductor **5527** from the sleeve of the called line, by which the hold magnets had been held. At this time relay **5818** should have completed its holding circuit for these magnets. The release of relay **5818** also opens the circuit of relay **4001**, but relay **4001** being slow to release remains operated for an interval, holding relay **4002** operated. When relay **4002** releases, the ground supplied by relay **5818** to conductor **5754** completes a circuit over the sleeve contact of the primary incoming cross-point, sleeve conductor **5743** of the incoming link, sleeve contact of the secondary incoming cross-point, sleeve conductor **1233** of the line junctor, sleeve contact of the secondary line cross-point, sleeve conductor of the line link, sleeve contact of the primary line cross-point, conductor **1229**, contacts **3125** and **3124** at rack **3111**, contact of relay **3108**, armature **3218** of relay **3200**, conductor **3219**, right front contact of relay **4519**, conductor **4718**, inner right back contact of relay **4703**, left back contact of relay **4005**, outer right front contact of relay **4000**, left back contact of relay **4902**, conductor **4020**, back contact of relay **4606**, conductor **4617**, left back contact of relays **4829** and **4828**, conductor **4872**, armature **5667** of relay **5600** in the marker connector, conductor **5668**, right winding of release relay **3707** of the sender, and battery.

Relay **3707** closes a holding circuit for itself to conductor **3719** which is grounded by relay **3714** to insure that it release after relay **3714**. It also supplies a substitute ground to the sender busy relay **3510** to mark the sender busy until fully released. It disconnects battery from the marker connector start conductor **3730** releasing the marker connector and disconnecting the sender from the marker. In addition, it disconnects ground from the locking circuit of relay **3700** which, in turn, opens the locking circuit of relay **3714**. These two relays remove the locking grounds from the other sender relays and when released also release relay **3707**. Relay **3707** also opens the holding circuit for the sender selector hold magnets **5124** and **5125**, thereby releasing the sender from the incoming junctor. However, the locking circuit of relay **3700** also extends over the second left contact of relay **3714** to the circuit of the hold magnets **5124** and **5125** so that, if a false ground is present which would prevent the restoration of the sender switches, relays **3700**, **3714** and **3707** will be held operated, permitting the timing equipment to function and signal the maintenance man.

The release of the marker connector releases all of the recording relays of Figs. 48 and 49. It also disconnects ground from conductor **5658**, releasing relay **4824**. Relay **4824** opens the circuits of the translator relays **6305**, **6304** and **6214**. The release of these relays opens the circuit of relay **3805** in the line choice connector which releases relay **3200** and the remaining line choice connector relays. Relay **3200** in releasing opens the circuit of relay **4835**, which disconnects ground from conductors **4864**, **6411**, **6017**, **4870**, **4876** and **5669**, releasing relays **6403**, **4519**, **6302**, **5308**, **4108**, **4109**, **4112**, **4010**, **4008**, **4000**, **4101** and **3409**.

Relay **4824** disconnects battery from the circuit of relay **5720** in the incoming connector circuit, releasing relay **5722**, which disconnects the connector from the marker, releasing all of the connector relays and in turn relay **4834**. Relay **4834** disconnects ground from conductors **4871**, **4877**, **4874** and **5669**, releasing any timing relays which may be operated.

Answer by called subscriber

When relay **5818** releases, ringing current is transmitted to the called line. When the called subscriber answers relay **5810** operates, opening the locking circuit of relay **5815** which releases, cutting off the ringing current. Relay **5813**, if operated, is also released by the operation of relay **5810**. When relay **5815** releases it replaces the shunts around condensers **5816** and **5817**, extending the tip and ring conductors **5833** and **5834** to ground and battery through the windings of relay **5808** which operates in series with the subscriber's line. Relay **5808** connects ground over conductor **5838** to prepare the time alarm circuit which returns ground over conductor **5839** to resistance **5812** and the sleeve conductor **5754** to supplement the holding ground supplied by relay **5805**. Relay **5808** also closes a circuit from ground at its lower front contact, lower back contact of relay **5811**, inner upper front contact of relay **5805**, resistance **5803** to the winding of relay **5801** and battery. Relay **5801** transfers the direct connection between the tip and ring conductors **5819** and **5820** of the interoffice trunk and the windings of relay **5802** to one under the control of relay **5805** which completes the talking circuit and at the same time

reverses the connection as a supervisory signal to the originating office.

Termination of connection

When the call is terminated by the calling subscriber, the trunk is opened at the originating office, releasing relay **5802** which, in turn, releases relay **5805**. Relay **5805** opens the circuit of relay **5802** and, if relay **5808** is still operated because the called subscriber has not disconnected, closes a circuit from ground at the lower front contact of relay **5808**, lower back contact of relay **5811**, inner upper back contact of relay **5805** to conductor **5840** and the timing circuit. With relay **5805** released, battery through resistance **5806** is connected over the middle upper back contact of relay **5805** in parallel with the upper winding of relay **5802** and ground over the outer lower back contact of relay **5805** is connected in parallel with the lower winding of relay **5802** to prepare the trunk for the next call. Relay **5805** removes ground at its contact from the holding circuit for the incoming and line switches, but these switches are held under the control of the called subscriber. When the called subscriber disconnects relay **5808** falls back, releasing the selector switches and the trunk and switches return to normal immediately.

Timed release of incoming junctor

If the called subscriber delays disconnection, the timing circuit functions in response to the ground connected to conductor **5840** by relay **5808**. After a predetermined interval the timing circuit disconnects ground from conductor **5839**, releasing the incoming and line switches. The release of the switches opens the circuit of relay **5808** and that relay releases, restoring the timing circuit and completing the release of the trunk.

Release on reselection of incoming junctor

If a second call reaches the trunk circuit during the timing interval, relay **5802** is operated causing the association of the trunk with a sender. The wanted number is recorded and a marker associated with the sender after which relay **5818** is operated as above described. Under these conditions relay **5818** disconnects the ground supplied by the timing circuit from the holding circuit of the incoming selectors, thereby releasing the switches and relay **5808**. Whether released by the timing circuit or by a second call, if the called subscriber keeps the receiver off the hook, the apparatus treats the condition as an originated call and, since no dialing occurs, completes it to a permanent signal operator.

Abandoned terminating call

If the calling subscriber abandons the call after it has reached the incoming junctor but before the connection is completed, relay **5802** releases, opening the locking circuit of relay **5805** and removing ground from conductor **5822**. This permits relay **3713** to reclose its right contact, operating relay **3708** over the outer left contact of relay **3709**. Relay **3708** operates slowly to avoid operating under transient conditions and closes a circuit for release relay **3707** which functions as previously described to release the sender, marker, incoming junctor relays, etc.

Called line busy

It will be remembered that, where the called line was busy, the busy back relay **3908** operated. This relay locks over its outer left front contact, conductor **4877** to ground to the inner right contact of relay **4834**. Prior to the operation of relay **3908** a circuit is closed from grounded conductor **4877** over the inner left back contact of relay **3908**, inner right contact of relay **3909**, conductor **3924**, back contacts of relays **4711** and **4712**, conductor **4716** to the winding of relay **4608** and battery, a parallel circuit existing from conductor **4877** over the left back contacts of relays **4609** and **4604** to the winding of relay **4608**. When relay **3908** operates it opens one circuit for relay **4608**. Relay **3908** closes a circuit from ground at its inner right contact, conductor **3912**, left back contact of relay **4704**, conductor **4717**, winding of relay **4602** and battery. Relay **4602** closes a circuit from battery through the winding of relay **4603**, left front contact of relay **4602**, left front contact of relay **4608**, conductor **4618**, right back contact of relay **4000** to grounded conductor **4871**. This ground also extends in parallel with the winding of relay **4602** over conductor **4619**, armature **5769** of relay **5722**, armature **5770** of relay **5735**, conductor **5828**, inner upper front contact of relay **5818** winding of relay **5811** and battery. Relay **5811** locks over its upper front contact to ground at the uppermost front contact of relay **5805**. Relay **3908** also closes a circuit from ground at its inner left front contact to conductor **4613** and the winding of relay **4610**. Relay **4610** operates, in turn operating relay **4609** and grounding conductor **4615** under the control of relay **4608**. Relay **5813** in the trunk circuit operates as previously described, locking under the control of relays **5810** and **5805**. Since relay **3908** is operated, relay **4610** cannot operate relay **4605**, and the previously traced circuit for relay **4009** cannot be completed. However, relay **3908** closes a substitute circuit for relay **4009** at its middle right contact. The operation of relay **4009** opens the second circuit for relay **4608** and that relay releases slowly to provide sufficient time to insure the operation of the ringing and tone control relays in the incoming junctor. When relay **4608** closes its back contact, a circuit is closed from ground at the left front contact of relay **4609**, back contact of relay **4608**, winding of relay **4607** and battery. Relay **4607** is slightly slow in operating to permit any operated incoming relays and corresponding marker relays to release if there should be a defective locking circuit in the incoming junctor. Normally the locking circuit holds both the junctor and the marker relay. Relay **4607** in operating closes locking circuits for relays **4609** and **4603**. Relay **4607** also closes an obvious circuit for relay **4606**, which grounds conductor **4617**, operating the release relay **3707** of the sender which functions in the manner above described.

In the junctor, the joint operation of relays **5813** and **5811**, together with non-operation of relay **5815**, connects busy back tone from conductor **5844** over the inner lower back contact of relay **5815**, through condenser **5814**, inner lower front contact of relay **5811**, middle lower front contact of relay **5813**, the third lower front contact of relay **5802**, lower back contact of relay **5801** to the ring conductor **5820** to inform the calling subscriber that the wanted line is busy. At the same time, low speed interrupted ground over conductor **5841** is connected over the inner upper back contact of relay **5815**, inner lower front contact of relay **5813**, outer lower front contact of relay **5811**, inner upper front contact of relay **5805**, resistance **5803** to battery through the winding of relay **5801**. Relay **5801** is operated

intermittently, transmitting a busy signal to any operators who may be involved in the connection.

Overflow

When no idle channel can be found, relay **3909** is operated as previously described. This relay functions very much like relay **3908**, locking to conductor **4877** and operating relays **4602** and **4610**. With relay **3908** unoperated, relay **4610** also operates relay **4605**. Relay **3909** opens the circuit first traced for relay **4009** but connects ground from the left front contact of relay **4603** over the outer left front contact of relay **3909** and the right front contact of relay **4602** to the armature of relay **4601** and thence as previously traced to the winding of relay **4009**.

Relay **4602** operates relays **4603** and **5811**, relay **4610** operates relays **4609** and **5813**; relay **4605** operates relays **4604** and **5815**, these relays locking as previously described. As in the case of a busy line the operation of relay **4009** releases relay **4608** which on closing its back contact operates relay **4607** and in turn relay **4606** and relay **4606** operates the sender release relay.

In the junctor, with relays **5815**, **5813** and **5811** all operated, ground interrupted at high speed is extended from conductor **5842**, over the middle upper front contact of relay **5815**, inner lower front contact of relay **5813**, outer lower front contact of relay **5811**, inner upper front contact of relay **5805**, resistance **5803**, winding of relay **5801** and battery, while an all trunks busy tone from conductor **5843** is connected over the middle lower front contact of relay **5815**, condenser **5814**, front contacts of relays **5811**, **5813** and **5805** to the ring conductor thus giving a characteristic indication to the calling subscriber and operator.

Ringing lead troubles

The purpose of the relay combinations used in controlling ringing or tone, such as relays **4610** and **4609** is to guard against trouble conditions which might arise in the leads for setting the junctor relays. These trouble conditions may be recited as follows:

1. False ground on conductor **4614** or the contacts and conductors connecting it with relay **5815**. This would result in false or premature ringing or would change a busy line indication to an all trunks busy indication.

2. Failure of relay **5815** to operate or lock due to an opening in either the operating circuit or the locking circuit which would result in failure to ring the called subscriber or would change an all trunks busy indication to a busy line indication.

3. Ground on conductor **4619** or its associated conductors which would result in no charge to the calling subscriber or false busy or overflow signal where a connection has actually been established.

4. Failure of relay **5811** to operate or lock due to an open circuit resulting in a false charge on a call to a free line, or a false ringing signal in place of a busy back or overflow signal.

5. Ground on conductor **4615** or its connected wiring would falsely operate relay **5813** to ring the wrong party, while

6. failure of relay **5813** to operate or lock due to open circuits would again result in ringing the wrong party.

7 and 8. Similar troubles in connection with relays **4600** and **4601** would result in ringing the wrong party.

In order to avoid these troubles, the marker tests for all of these trouble conditions and divides them into two classes, namely those which might cause false charges including items 4 to 8 inclusive and those which would not, including items 1 to 3. On those conditions where a false charge is not involved and where there is a possibility that the call may be successful if set up, namely when relay **4603** is operated when relay **4602** is not, or where relay **4604** is operated where relay **4605** is not, the circuit of relay **4009** cannot be completed, but a circuit is closed from ground at the inner right contact of relay **4604** and the right back contact of relay **4605** or from ground at the outer right front contact of relay **4603** and the left back contact of relay **4602**, to conductor **4620** and the winding of relay **4829** and battery. Relay **4829** locks to grounded conductor **5669**, opens the circuit of the sender release relay and extends it to the timing circuit and a contact of relay **5519** which operates after a record has been made of the trouble to release the terminating equipment, in the usual manner, the incoming junctor functioning as though there had been no delay.

If relays **4605** or **4602** do not operate when they should, relay **4009** cannot operate and the timing circuit functions to cause a second trial by transmitting a trouble release signal to the sender.

Timing and trouble release

The marker timing circuit shown on Fig. 55, times in four stages; first, a stage of one to two seconds, from the seizure of the marker to the completion of the check of the recording relays, second—a stage of from five to six seconds, from the seizure of the marker to the seizure of the line choice; third—from two to three seconds to cover the interval from the seizure of the incoming connector to the release of the marker; fourth—a one second stage, to cover the seizure and release of the trouble indicator.

The first and second timing stages start simultaneously with the operation of relay **5524**. Relay **5524** operates in a circuit from battery through the winding of the relay, third left back contact of relay **4834**, left back contact of relay **5516**, back contact of relay **5501**, right back contact of relay **5505**, inner left back contact of relay **5512**, left back contact of relay **5514**, conductor **5669** to ground at armature **5663** of relay **5600** in the marker connector. Relay **5524** locks under the control of relay **4834** to conductor **5669** and connects this conductor to conductor **5528** leading to the interrupter circuit, thereby causing the connection of interrupted ground to conductor **5529**. Relays **5512** and **5514** are of the well known type in which at the first closure of ground to the pulsing conductor relay **5514** operates, locks to ground at the inner left front contact of relay **5524** and prepares a circuit for relay **5512** to the same ground. When ground is disconnected from conductor **5529** relay **5512** operates. At the second ground closure relay **5514** is shunted and releases but relay **5512** is held over the normal contact of relay **5514** to conductor **5529**. When ground is disconnected for the second time relay **5512** also releases and the relays are ready for reoperation. This cycle repeats as long as interrupted ground is fed to conductor **5529**.

When relay **5514** releases at the second closure

of ground to conductor 5529, a circuit is closed from grounded conductor 5669, left back contact of relay 5514, left front contact of relay 5512, conductor 5531, back contacts of relays 5506, 5504 and 5502, winding of relay 5501 and battery. Relay 5501 locks over its inner left contact to ground at the outer right front contact of relay 5524 and grounds conductor 5530 to provide locking circuits for relays 5502 to 5507.

At the third closure of ground to conductor 5529 relay 5514 reoperates and connects ground from conductor 5669, over the left front contact of relay 5514, outer left back contact of relay 5512, conductor 5532, left back contact of relay 5505, back contact of relay 5503, outer left front contact of relay 5501 to the winding of relay 5502 and battery. Relay 5502 locks over its right front contact to conductor 5530.

When relay 5514 releases it connects ground as previously traced to conductor 5531 and thence to the left armature of relay 5502 and over its front contact to the winding of relay 5503 and battery, relay 5503 locking to conductor 5530. The subsequent reoperation of relay 5514 completes the previously traced circuit over conductor 5532 to the left armature of relay 5503 and over its front contact to the winding of relay 5504 and battery. Relay 5504 locks to conductor 5530. Similarly the next release and operation and release of relay 5514 result in the operation and locking of relays 5505, 5506 and 5507.

Relay 5506 closes an obvious circuit for relay 5511 which in turn operates relay 5518. Relay 5518 connects ground over the left back contacts of relay 5517 to conductors 5533 and 5534 to light a lamp and operate a signal. It also grounds conductors 5537, 5536 and 5535 to summon the trouble indicator and transmit information to it. When a record has been made, relay 5519 operates locking under the control of relay 5518 and connecting ground from its left front contact, outer right front contact of relay 5518, left back contact of relay 5507, right back contact of relay 4829, conductor 4873, back contact of relay 5674, winding of relay 5673 to battery. Relay 5673 locks through the winding of relay 5674 and opens the operating and locking circuits of relay 5600 which releases the marker. Relay 5674 remains shunted until the marker removes ground from conductor 4873 when relay 5674 operates reclosing the circuits of relay 5600. Relays 5673 and 5674 remain operated under the control of the sender over a circuit indicated but not shown. If the marker fails to establish the connection on second trial, ground on conductor 4873 is extended over the front contact of relay 5674, armature 5670 of relay 5600, conductor 5671, right winding of sender trouble release relay 3718 and battery. Relay 3718 locks to ground at the middle right front contact of relay 3714 and disconnects battery from conductor 3731 releasing the marker connector and marker. The sender then restores to normal as will be described hereinafter.

If relay 5519 has not operated by the time relay 5507 operates, the latter relay connects ground to the trouble release circuit.

The release of the marker connector releases relay 5524 in turn releasing relay 5501 which permits relays 5502 to 5506 to release. Relay 5511 being slow to release holds relay 5518 operated, grounding conductor 5538 which holds the marker busy to the marker connector for an interval.

On a normal call, the timing circuit does not progress to the operation of relay 5506 before it is reset for the next timing stage. The operation of relay 4834 following the seizure of the incoming connector releases relay 5524 and when all the relays locked to relay 5524 release, a circuit is closed from grounded conductor 5669 over back contacts of relays 5514, 5512, 5505 and 5501 as previously traced, left back contact of relay 5524 outer right front contact of relay 4834 winding of relay 5516 and battery. Relay 5516 locks to conductor 5669 under the control of relay 4834 and grounds conductor 5528 to cause the interrupter circuit to function. It also provides locking ground for relays 5512 and 5514, and operates relay 5504 directly. The operating ground for relay 5504 serves as locking ground for relays 5505, 5506 and 5507. When relay 5506 operates, it gives a trouble release signal in the manner above described.

The fourth timing stage is the continuation of the timing for one second following the operation of relay 5506 after which relay 5507 operates. This interval is allowed for the seizure and release of the trouble indicator and the release of the marker. Relay 5507 grounds conductors 5539 and 5540 to operate the proper lamp and alarm and also transmits the trouble release signal to the sender.

The first timing stage is marked by the operation of relay 5501. If the checking relays 4821, 4822 and 4823 have not released and relay 4824 operated before relay 5501 operates, relay 5511 is operated over the inner right front contact of relay 5501 to ground at the front contact of relays 4821, 4822 or 4823 or the back contact of relay 4824. Relay 5511 functions as previously described.

If a false ground appears on conductor 5538 which would hold the marker permanently busy, relays 5520 and 5521 function. These relays are controlled over conductor 5541 from an interrupter rendered effective whenever conductor 5538 is grounded. Relay 5521 is operated, followed by relay 5520 and, when, at the end of a 27-second interval, conductor 5541 is again grounded, relay 5521 is released, relay 5520 being held in the usual manner. A circuit is then closed from ground at the right back contact of relay 5521, right front contact of relay 5520, winding of relay 5508 and battery. Relay 5508 locks to conductor 5538 and grounds conductors 5539 and 5540 to sound an alarm.

Unequipped numbers

Numbers may be left blank in blocks of five hundred, one hundred, twenty or individually. In each case corresponding equipment, cross-connections or both may be omitted and a call to one of these numbers is ultimately routed to the intercepting operator. If a block of five hundred numbers is omitted, the corresponding relay 6304 may be omitted, and the contact of relay 4924 cross-connected over conductor 4933 to the winding of relay 3910. Where a block of twenty numbers is omitted, the corresponding contact in cross-connecting rack 6303 is wired to conductor 4933 and relay 3910. Where a single number is left blank the corresponding contacts of the twenty-block relay in the line choice connector are left disconnected.

The sequence of operations when the number dialed is one in an omitted block of five hundred numbers is as follows: The ground which would operate a relay like relay 6304 operates relay 3910. Relay 3910 extends battery connected through resistance 6207 to conductor 6211, over its left contact and the inner right back contact of relay

3911 to conductor 3918 leading to the marker preference relay in the line choice where the local intercept trunks are located. The seizure of the line choice causes the operation of the incoming connector which operates one of the class relays 3905, 3906 or 3911 by grounding one of the conductors 3927, 3926 or 3925. Since the junctor of Fig. 58 is one incoming from a full mechanical office, relay 3905 would be operated. Relay 3906 is operated by local manual junctors, while relay 3911 is operated from toll junctors. Since no twenty-block relay has been operated, relay 4534 is normal as well as relays 4500 to 4519. With class relay 3905 operated, relay 3910 closes a circuit from ground at its right contact, left back contact of relay 3911, inner right back contact of relay 3906, outer left front contact of relay 3905 to the winding of relay 3901 and battery. Relay 3901 is also operated with class relay 3906 operated, while relay 3902 is operated when class relay 3911 is operated. Relay 3901 when operated locks over its inner right contact to grounded conductor 3913.

Where a block of twenty lines is omitted, the relays like relays 6304, 6305 and 6240 are operated, and a line choice connector and the incoming connector are operated, followed by relay 3905, 3906 or 3911. Since relay 3910 is operated in place of the hundred-block relay of the line choice, relay 3901 or 3902 is operated.

Where an individual line is left blank, the line appears idle and the corresponding relay in the group 5200 to 5219 does not operate. Similarly, the corresponding one of the group hunting relays 5220 to 5239 cannot operate, and the relay of group 4500 to 4519 operates, releasing relay 5933 as previously described. When relay 5933 operated, it in turn operated relay 5930. This relay is slow to release and does not close its back contact for an interval during which one of the relays 5900 to 5903 and 5910 to 5913 normally operates. Since the number control lead is open, none of these relays can operate and relay 5930 closes a circuit from ground over the back contact of relay 4710, left back contact of relay 4711, conductor 6023, left back contacts of relays 6010 and 6011, conductor 4550, left back contact of relay 4528, conductor 5937, back contacts of relays 5900, 5901, 5902, 5903, 5910, 5911, 5912, 5913, and 5930, conductor 5939 and thence under the control of the incoming class relays 3905, 3906 and 3911 to one of the intercept relays 3901 or 3902.

Intercepted calls

As pointed out above the marker distinguishes in routing calls to intercept operators between those incoming locally and those incoming from a toll operator. Relays 3901 and 3902 operate in the same manner. Assuming that relay 3901 has been operated, relay 3901 locks and opens the circuit of relay 6305 or other hundreds relay. The release of relay 6305 opens all of the translator cross-connections, restoring the line choice connector and incoming connector to normal. Relays 4834 and 4835 are thereupon released. Relay 5516 also releases, permitting relay 5524 to reoperate and start the first timing cycle again. With relay 3901 operated, when relay 4834 closes its inner left back contact it grounds conductor 4869, completing a circuit over the second right contact of relay 3901 to the winding of relay 3900 and battery. Relay 3900 prepares a locking circuit for itself over conductor 6411 which is completed when relay 4835 reoperates. Relay 3900 connects battery from conductor 6211 over the outer right front contact of relay 3901 to conductor 3918 to select the line choice connector serving the intercept lines. It also grounds conductor 3919 over the third right contact of relay 3901 to operate the proper hundred-block relay and conductor 3920 over the inner left contact of relay 3901 to operate the necessary twenty-block relay. It also transfers the circuit controlled by relay 4534 from the units register to conductor 3921 which is cross-connected to the armature of relays 5200 to 5219 so as to cause the test of the intercept lines to start at the proper point. The call is set up in the regular manner except that, since intercept calls require no charge the outer contact of the twenty-block relay is wired to conductor 3121 in place of the next to outer contact being wired to conductor 3136 and relay 4535 operates through its right winding, in turn operating relay 3907 in place of relay 4536. Relay 3907 closes a circuit from ground at its outer left front contact, outer right back contacts of relays 3911 and 3906, inner right front contact of relay 3905, conductor 3912, left back contact of relay 4704, conductor 4717, winding of relay 4602 and battery. It may be noted that this circuit is ineffective where the incoming call is controlled by a manual operator since in that case it is desirable to return supervision. Relay 4602 operates the no-charge relay 5811 in the incoming junctor. Relay 3907 also supplies an additional ground for conductor 5669. In addition it closes a link in the checking circuit for relay 4009 including a front contact of relay 3905 and front contacts of relays 4602 and 4603. Relay 3901 opens the circuit of relay 4605 preventing the setting of ringing in the junctor.

In the junctor, relay 5811 locks under the control of relay 5805. Relay 5811 opens the operating circuit of relay 5801 to prevent charging the calling subscriber. Since relay 5815 is not operated, ringing does not occur, but the release of relay 5818 connects battery and ground through the windings of relay 5808 to the tip and ring conductors leading to the intercept position where it signals the operator who challenges on the line.

Relay 3902 functions in the same manner as relay 3901 except that it may select a different line choice, hundred-block relay, twenty-block relay, etc.

Other free lines, such as lines to the business office, etc. are grouped together on twenty-block relays which have their outer contact wired in the same way as intercept lines. Relays 3907, 4602, 4603 and 5811 are operated to cancel the charge as described above.

Sleeve guard

An originating call does not connect ground to the sleeve of the calling line until after the subscriber sender has been seized. A terminating call does not lock out originating calls in a line link group until after the line test has been completed. It is evident, therefore, that there is an unguarded interval in which the terminating marker may select a line which appears to be idle because a subscriber sender has not yet been seized for that line, but which is actually busy and will appear so at the time the marker is able to lock out the line link group.

To detect this condition, the sleeve guard feature consisting of relays 4532 and 4531 is used. It is the function of these relays to detect a ground on the sleeve of the called line subsequent to its selection, to cause the seizure of a new line if the

first line is in a terminal hunting group and other lines are available, or to return busy back if no other lines are available.

The operation of one of the relays **4500** to **4519**, **4519** for example, closes a circuit from battery through the winding of relay **4532**, conductor **4549**, back contacts of relays **6011** and **6010**, conductor **6020**, inner right back contact of relay **4000**, left back contact of relay **4005**, inner right back of relay **4703**, conductor **4718**, right front contact of relay **4519**, conductor **3219**, armature **3218** of relay **3200**, sleeve contact of the twenty-block relay **3108**, contacts **3124** and **3125** at cross-connecting rack **3111** conductor **1229** to the sleeve contacts of the primary line switch. If ground is connected to these sleeve contacts prior to the operation of relay **4000**, relay **4532** operates, in turn operating relay **4531**. Relay **4531** opens the locking circuit of relay **4519** and also opens the operating circuit for the relays of that group. The release of relay **4519** restores the circuits of relays **5219** and **5239** which repeat their test. Relay **4519** also opens the circuit of relay **4532** which releases after an interval to reclose the operating circuit for the relays of group **4500** to **4519**. If the called line is an individual line, relay **5219** closes the circuit of busy relay **3908**. If the called line is a line in a terminal hunting group of which it is not the last, the joint operation of relays **5219** and **5239** will initiate testing in another group as previously described.

Line link percent load register

Where an office has a seasonal load, at which time it would be very undesirable to rearrange lines, it is possible to calculate what load on a line link group during non-busy times would correspond to an over-load during busy times, record the occurrences of this load and make the readjustments during the light load period. For this purpose relay **3430** is provided.

When relay **4835** operates it connects ground over conductor **4876** to the windings of relay **3430** in parallel over the ring contact of jack **3431**. At this time all of the relays **3420** to **3429** are released and battery through a separate resistance is connected over the back contact of each relay, over the tip contact of jack **3431** to the upper winding of relay **3430**. This energizes relay **3430**, which is polarized, in a direction to hold the contact open. When the line links are tested the relays **3420** to **3429** corresponding to busy links operate, transferring the resistance battery to the lower winding of relay **3430** which energizes relay **3430** in a direction toward closing its contact. The relays testing idle line links maintain their circuits for the upper winding of relay **3430**. While the adjustment of relay **3430** and the value of the resistances may be varied, in the present case it is so adjusted that with four of relays **3420** to **3429** operated, relay **3430** will close its contact, completing a circuit from ground over that contact, conductor **3425**, armature **6105** of relay **6100**, or over the corresponding armature of the operated line group or frame relay, conductor **6106**, armature **3236** of relay **3200**, conductor **3260**, armature **1234** of the horizontal group relay **1208** to conductor **1235** leading to the register individual to the line link group. One or more resistances such as resistance **3436** may be connected in parallel with the upper winding of relay **3430** to render the arrangement more sensitive.

Second trial

Where the marker is seized to make a second trial after a trouble release of the first trial, the marker connector relay **5674** connects direct ground to conductor **5665**, operating relay **4100** which now remains operated throughout the attempt to establish the connection. Relay **4100** rearranges the channel selecting circuit to prefer the sixth channel, the circuit now extending from grounded conductor **4876**, back contact of relay **4102**, upper front contact of relay **4103**, front contact of relay **4106**, outer right back contact of relay **4703**, outer upper front contact of relay **4100** to the armature of relay **3425**. If this and the succeeding channels are busy the circuit extends from the front contact of relay **3429** or **3419**, over the outer lower front contact of relay **4100** to the armature of relay **3420** and if all channels are busy from the front contacts of relays **3414** and **3424**, over the middle lower front contact of relay **4100** to overflow relay **3909**.

Relay **4100** also cancels the test for tip ground by opening the circuit of relay **4113**. It also removes the shunt around the winding of relay **4011**. Therefore, when relay **4104** closes the operating circuit for the hold magnet, relay **4011** is included in the circuit and operates only if the hold magnet battery is present. Relay **4011**, if operated operates relay **4013** which locks to conductor **4870** and closes a shunt around relay **4011** to permit the hold magnet to operate. If relay **4011** fails to operate, when relay **4000** operates, a circuit is closed from ground at the inner upper front contact of relay **4100**, middle right front contact of relay **4000**, back contact of relay **4011**, conductor **5939** and thence through contacts of incoming class relays **3911**, **3905** and **3907** to the winding of relay **3901** or **3902**, routing the call to an intercept operator.

Relay **4100** also cancels the continuity test above described by closing a circuit from ground over conductor **4870** inner lower front contact of relay **4100**, right front contact of relay **4002**, back contact of relay **4003** to the winding of relay **4010**, operating that relay and in turn relay **4008** to simulate a successful completion of the continuity test. This serves to permit test connections to defective lines as well as possibly successful connections in spite of defects.

Cross detecting relays

There are two general methods used for detecting crosses by the marker. The first is the use of a marginal relay which will not operate on a normal closure but will operate if there is a cross which will produce twice or more the normal current. The second method is the connection of a non-marginal relay to leads to be tested. Relays **6014** and **5932** are examples of the first method. Relay **6014** is included in the circuit of the twenty-block relay and if a cross exists by which more than one twenty-block relay might be operated, relay **6014** operates connecting ground over conductor **6024** to the winding of relay **4828**. Relay **4828** locks to grounded conductor **5669**, connects ground over its right contact to conductor **5538**, opens the release conductor preventing the release of the marker and permitting the timing circuit to sound an alarm.

Relay **5932** is connected in the circuit of the group relays **5900** to **5913** and **5910** to **5913** and operates if a cross would cause more than one of these relays to operate. In operating, relay

5932 disconnects the ground by which the line link cut-in relay 1208 of the line group is operated thereby blocking the completion of the call.

Relays 3432, 5931, 5244, 4830 and 4829 are typical of the second method. Relay 3432 is connected over the back contacts of relays 3400 to 3409 to the operating circuits for the select magnets of the primary line switch. A false ground on one of these circuits will operate relay 3432, as will a cross between two leads following the operation of one of the relays 3400 to 3409 to ground the desired conductor. Relay 3432 grounds conductor 6024 to operate relay 4828.

Relay 5931 is connected, during the operated period of relay 5930 to conductor 5939 over which relays 3901 and 3902 are operated, and prior to the operation of relay 5933 is connected to conductor 5934 over which relay 3908 is operated. A false ground on either of these conductors operates relay 5931 which also operates relay 4828.

Relay 5244 is connected over conductor 5256 and the back contact of relay 4833 to the windings of the sleeve test relays 5200 to 5219 during the registration of the wanted number, operating if a false ground is present on any of these test leads between the marker and the line choice. If operated, relay 5244 locks to ground at the inner left back contact of relay 5519, and grounds conductors 5538 and 5669 to hold the marker busy and control the timing circuit.

Relay 4830 is connected over the back contact of relay 4113 to conductor 5666 over which relay 5818 of the incoming junctor is operated until the incoming connector has operated, and if operated, operates relay 4828.

The function of relay 4829 has already been described in connection with the ringing control relays.

Special calls

There are three types of special calls which may be set up by the marker, namely, number checking calls; no test calls, including calls from the test desk and from the verification operator, and calls from the outgoing trunk test board for routine tests of subscribers' lines. Certain features of the marker operation in this connection form the basis of the applications of F. A. Korn, Serial No. 68,255, filed March 11, 1936, and Serial No. 68,256 filed March 11, 1936, and of Patent No. 2,075,527, granted March 30, 1937 to F. A. Korn et al.

Most of the terminating markers are not equipped for making these special calls and, speaking generally, the equipment of Figs. 47 and 54, as well as relays 4522 to 4529 are not provided. Therefore, when a special call is to be established the marker connector selects one of the few terminating markers arranged to handle this traffic and the sender operates relay 5602 which connects ground to conductor 5672, completing a circuit which extends over the left back contacts of relays 3901 and 3902, conductor 3922, winding of relay 4706 and battery. Relay 4706 opens the circuit for operating one of relays 4500 to 4519 and connects relays 4700, 4701 and 4704 to conductors 4721, 4720, and 4722, respectively. These conductors are extended to the incoming connectors and through them to ground in the special incoming junctors. Conductor 4720 is grounded by no-test junctors, conductor 4721 by junctors from the outgoing trunk test board and conductor 4722 by number checking trunks.

Number checking call

In the case of a number checking call, registration, translation and the seizure of the line choice connector and incoming connector proceed in the same manner as for a regular call. Relays 5200 to 5219 and 5220 to 5239 are connected to the block of twenty lines but none of the relays 4500 to 4519 can be operated since relay 4706 has opened that circuit. After the incoming junctor has been connected with, relay 4704 operates, in turn operating relays 4522 to 4529 which open the sleeve test circuits through relays 5200 to 5219, releasing any which may have operated. Relay 4527 disconnects ground from the windings of relays 5920 to 5923 to prevent their operation in case of failure to check as will be described below.

Relay 4526 further opens the line selecting circuit; relay 4528 opens the circuit for operating the ringing control relays and relay 4529 opens the circuit of relay 4605 controlled by relay 4610. Relay 4704 also closes a circuit from battery through the winding of relay 4705, outer right front contact of relay 4704, to ground at the right back contact of relay 5249. Relay 4705 holds open the circuit of relay 4712.

A circuit is then closed from source 5250 of 135 cycle alternaturing current, left back contact of relay 5249, left front contact of relay 4526 to conductor 4542 and thence as previously traced through the units register to the contact of relay 5242, left front contact of relay 4529, through condenser 4569, left front contact of relay 4525, inner left back contact of relay 4519, conductor 3219 to the sleeve of the called line which is connected as shown in the above-identified Korn application, Ser. No. 68,256, to the operator's position and thence through the incoming junctor and connector to conductor 5768 and through the winding of relay 4707 to ground provided the correct line number has been given and the marker and operator are connected to the same line. Relay 4707 operates relay 4710 through resistances 4708 and 4709, in turn operating relay 4711. Relays 4710 and 4711 disconnect ground from conductor 6023, disabling relay 5415. Relay 4711 closes direct circuits for relays 4605 and 4610 which when operated together transmit a signal to the incoming junctor and checking operator that the check was satisfactory. Relay 4711 also opens the circuit of relay 4608 which causes a release signal to be sent into the marker in the usual way. The marker is then released in the regular manner.

In the case of a terminal hunting group, some or all of the relays 5220 to 5239 will be operated according to the number of lines in the group. In this case, the 135 cycle current will be connected directly to the first line of the group, and a branch of this circuit will extend to the right armature of the corresponding relay of the group 5220 to 5239, over the front contact of that relay, to the armature of the next relay, and also through the next condenser and contact of relays 4522 to 4525, to the sleeve of the next line. Similarly the alternating current is passed to the third line over the front contact of the second relay and so on. If any one of the lines of the group is connected to the operator's position, the checking circuit will be completed and relay 4707 will operate.

If the group extends into another block of twenty lines, relay 5239 will be operated, and the checking current will be extended to condenser 5254 and the full wave rectifier 5245 which

feeds relay 5247 in parallel with resistance 5246. With relay 4704 operated, relay 5415 operates following the operation of relay 4536 or 3907 from the line choice connector. This relay is slow to operate and if the calling line is in the first twenty-block, the operation of relays 4707, 4710 and 4711 renders relay 5415 ineffective. If the check is unsuccessful in the first twenty-block, when relay 5415 operates, with relay 5247 operated, a circuit is closed from ground, back contact of relay 4710, left back contact of relay 4711, conductor 6023, back contacts of relays 6010 and 6011, front contact of relay 5415, front contact of relay 5247, winding of relay 4530 and battery. Relay 4530 functions as for a regular call to release the first twenty-block and seize the next twenty-block of the terminal hunting group. The action of the marker for the second twenty-block is the same as for the first.

If the check is unsuccessful in a group where relay 5239 is not operated, relay 5247 does not operate and the operation of relay 5415 operates relay 5249 over the back contact of relay 5247. Relay 5249 disconnects the 135 cycle current, opens the circuit of relay 4705 which releases and after a further interval permits relay 4712 to operate over the back contact of relay 4705, the right front contact of relay 5249 to ground over the operating circuit of relay 5249. Relay 4712 operates after an interval, opening the circuit of relay 4608 which releases slowly to release the marker. Relay 4712 also closes an obvious circuit for relay 4610 which, operated alone, transmits a checking failure signal to the operator.

If a private branch exchange has, in addition to its two-way lines, a group of lines used only for outgoing service, the marker will not normally have access to this group. Since one of these lines may be one to originate a call requiring number checking, relay 4706 in operating closes a circuit from ground at its inner right contact, conductor 4723, armature 3234 of relay 3200, conductor 3261, winding of relay 3102 and battery. With relay 3102 operated, a line which is normally wired as a last line of a group, is wired as an intermediate line. That is, with relay 3102 normal the number control contact of a last line is wired over the back contact of relay 3102 to the right winding of the group relay like relay 3101, while with relay 3102 operated, it is wired over the front contact of that relay to the middle winding of the group relay. The additional group is checked in the same manner as the other lines.

No test call

This type of call may originate at a verification position at an "A" switchboard or at a test desk. If the line is idle, the call is set up over the same switches as a regular call. Relay 4701 is operated from the incoming junctor. This relay supplies ground to the right windings of relays 5400 to 5409 to electrically polarize them in a direction to hold their contacts open. It opens the circuits of relays 5240 and 5243, thereby opening the circuits of relays 5220 to 5239, so that every line acts as an individual line. With these relays released, the operating circuit for relays 4500 to 4519 is opened, but relay 4701 closes a substitute link in that circuit and the connection is established in the usual manner. With relay 4701 operated, the circuit of relay 4519, for example, extends from battery, through the winding of relay 4519, back contact of relay 5219, back contact of relay 4529, inner front contact of relay 5242, conductor 4866, left front contacts of relays 4814 and 4813, right back contacts of relays 4812 and 4811, left front contact of relay 4813, conductor 6019, outer left back contact of relay 6012, conductor 3923, left back contact of relay 3900, conductor 5314, back contact of relay 5310, conductor 4542, left back contact of relay 4526, resistance 5248, conductor 5255, second left front contact of relay 4701, conductor 4724, right front contact of relay 5933, conductor 4714, inner right front contact of relay 4701 (paralleling the contact of relay 4706 which is now open), conductor 4541, normal contacts of relays 4530 and 4531 to ground at the right contact of relay 4534.

If relay 5219 were operated, indicating that the line was busy, the circuit above traced would extend from ground to the armature of relay 5219, over the front contact of that relay, back contact of relay 5239, conductor 5253, outer left front contact of relay 4701, winding of relay 4703, and battery. Relay 4703 locks to grounded conductor 5658.

It will be remembered that relay 4103 operates over the normal contacts of the channel relays 3400 to 3409 as soon as the line choice connector operates. Therefore, when relay 4701 operates, it closes a circuit from battery through the winding of relay 5411, outer right front contact of relay 4701, to ground at the lower front contact of relay 4103. Relay 5411 closes an obvious circuit for relay 5412. It also closes a circuit from battery through the winding of relay 5413, outer right front contact of relay 5411, over a contact of the operated line group relay, for example, armature 6110 of relay 6100, conductor 6107, armature 3262 of relay 3200, conductor 3263, armature 1229 of the horizontal group relay 1208 to conductor 1236 leading to the sleeve of the no-test junctor for the group of lines including the called line. If the no-test junctor is in use by some other marker, ground will be present on conductor 1236 and relay 5413 will operate, in turn operating overflow relay 3909 to transmit a signal back to the originating operator or test man.

Relay 4703 closes a circuit from ground at its inner left contact, inner right contact of relay 4701 to the windings of relays 4522 to 4525 and battery. These relays open the sleeve test circuits to relays 5200 to 5219, thereby releasing the relay which was operated from the busy line. With relay 5219 released, the circuit controlled by relay 4534 is extended to the winding of relay 4519 and battery, relay 4519 locking as previously described. Relay 4703 also connects positive battery through resistance 4702, to conductor 4718, over the right front contact of relay 4519, conductor 3219 and thence to the sleeve of the wanted line which is connected at a cross-point of the primary line switch to one of the line links.

Relay 4703 also closes a circuit from ground at its inner left contact to the winding of relay 5410 and battery. Relay 5410 connects ground through the left windings of relays 5400 to 5409 to the sleeve conductors of the line links serving the wanted line. The circuit of relay 5409, for example, may be traced over the outer front contact of relay 5410, conductor 6104, inner upper front contact of relay 6100, conductor 3248, armature 3247 of relay 3200, conductor 1623, contact of jack 1610, conductor 1224, armature 1223 of relay 1208 to the sleeve of the line link and thence to ground over the established connection. Negative battery through resistance 1218 is also connected over armature 1221 to the sleeve conductor. Relays 5400 to 5409 are adjusted to

respond only to the positive battery supplied by relay 4703, being unresponsive to ground or to the negative battery present when testing. Assuming that the link shown is the one in use, relay 5409 will operate closing a circuit from ground at its contact, conductor 5417, winding of relay 3409 and battery. Relay 3409 locks to conductor 4876, and closes a circuit from ground over its outer lower front contact, conductor 3437, armature 6108 of relay 6100, conductor 6109, armature 3264 of relay 3200, conductors 3265 and 2809, armature 1228 of relay 1208, to the winding of primary select magnet 1226 and battery. Magnet 1226 prepares the cross-points of the wanted line link before the no-test junctor as well as before the other idle lines.

The operation of relay 3409 opens the circuit of relay 4103 which in turn releases relay 5411. When relay 5411, which is slow to release, closes its back contact, it extends the no-test junctor sleeve, to which the hold magnet is attached, to ground at the middle left contact of relay 4703, thereby connecting the link with the no-test junctor in parallel with the previous connection. When relay 5411 releases, it also releases relay 5412, which connects ground from the outer left contact of relay 4703, back contact of relay 5412, outer right back contact of relay 3909 to conductor 4617 to operate the release relay of the sender and restore the control circuits to normal. Relays 5411 and 5412 are made slow to release to allow time for the select and hold magnets to energize, close the cross-points and operate the holding relay of the no-test incoming junctor.

In some cases, none of the relays 5400 to 5409 will operate. This may be due to a trouble ground, a make busy direct ground applied over jack 1610, for example, or by other special circuits. If none of these relays operate, the operation of relay 4106 after the line group and control circuit has been seized will close a circuit from ground on conductor 4876, back contact of relay 4102, upper front contact of relay 4103, contact of relay 4106, outer right front contact of relay 4702, to the winding of relay 5414 and battery. Relay 5414 connects ground from the front contact of relay 4103, outer right contact of relay 4701, front contact of relay 5414, to conductor 4715, front contact of relay 5933, conductor 5934, winding of relay 3908 and battery. Relay 3908 returns a line busy signal to the incoming junctor in the usual manner.

Calls from outgoing trunk board

This type of call is completed in the same manner as a regular call except that relay 4706 delays testing until after relay 4700 operates and that relay 4700 opens the circuit of relays 5243 and 5240 which prevent the operation of relays 5220 to 5239. Each line is, therefore, treated as though it were an individual line.

Emergency operation of connectors

Both the line choice connector and the incoming connector are provided with a set of emergency relays for use in case trouble is encountered with the regular relay chain. In the case of the line choice connector these emergency relays are shown as relays 3806, 3808 and 3810. These relays are brought into service automatically. Whenever a marker preference relay, such as relay 3805 operates, it opens the circuits of relays 3117, 3118 and 3119. These relays are operated over the normal contacts of the marker preference relays when the circuit is idle. If the operating path for any one of these relays fails to close when the marker preference relay releases, ground is connected in shunt of the winding of relay 3115 which is normally energized in a circuit from battery through resistance 3120, right normal contact of relay 3113 to the winding of relay 3115 and ground. Relay 3115 releases when shunted to close a circuit from ground over its back contact, contact of key 3116, winding of relay 3802 and battery. Relay 3802 in turn operates relay 3800. Relay 3800, in operating, disconnects ground from the regular relay chain, and transfers the marker start leads from the regular chain to the emergency chain. It also disconnects battery from relays 3118 and 3119 to render them ineffective following the transfer. Relay 3802 locks under the control of key 3116, supplies battery for the incoming connector, ground for locking the emergency chain and for operating the cut-in relays like relay 3200, grounds conductor 3812 and lights lamps 3804 to give a visible and audible alarm until the relays are released.

The incoming connector operates in substantially the same manner in this regard.

The line choice connector also provides a test for false grounds on the numerical sleeve leads in the connector while idle. With relays 3118 and 3119 operated the numerical sleeve leads are connected in multiple to the right winding of relay 3113 which operates when a false ground is found, locking over key 3114, grounding conductor 3137 to sound an alarm and lighting lamp 3112 to identify the connector.

Sender tell tale

In describing the sender circuit it will be remembered that, in case more than ten pulses are required to satisfy the originating sender for any selection, relay 3020 is operated. Relay 3020 locks over its left front contact to grounded conductor 3720. At its left back contact it disconnects battery from conductor 3731 leading to the marker connector to release the connector and the marker. At its right back contact relay 3020 opens the ground normally used for operating the select magnets of the sender register 2900. At its outer right contact relay 3020 closes a circuit for relay 3701 which transmits a reverse battery signal to the originating sender in the usual manner.

However, since this reverse battery signal is premature that sender recognizes it as such and releases the connection after giving the proper signal to the calling subscriber. During release at the originating office, a trunk closure is made, operating relay 5802 which connects ground to the locking circuit of relay 5805 and operates relay 3713. Relay 3713 operates relay 3709. With relay 3709 operated, a circuit is closed from ground at the inner right front contact of relay 3020, inner left front contact of relay 3709, inner right back contact of relay 3712, right back contact of relay 3717, to the right winding of relay 3707 and battery. Relay 3707 restores the sender and link to normal as previously described.

When a call is abandoned during selections the originating sender functions to cancel the register control and therefore receives more than ten revertive pulses without opening the fundamenal circuit resulting in the operation of relay 3020 which functions as above described.

When relay 3714 operates at the time the sender is seized, it connects the left winding of relay 3710 over the third right contact of relay 3714 to conductor 3732 leading to the timing in-

terrupter and alarm circuit. When the interrupter grounds conductor 3732, relay 3710 operates, locking through its right winding and over its right contact to grounded conductor 3719. Thirty seconds later, if the sender has not already released normally, the interrupter grounds conductor 3733 completing a circuit over the left contact of relay 3710 to the right winding of 3712 and battery. Relay 3712 also locks to conductor 3719. In addition it lights lamp 3711 individual to the sender and grounds conductor 3734 to sound an alarm after an interval if the release of the sender is delayed. At its outer left contact relay 3712 closes a circuit for relay 3701 which transmits a reverse battery signal to the originating sender. One second later, conductor 3732 is again grounded, completing a circuit over the third right front contact of relay 3714, inner right front contact of relay 3712, right back contact of relay 3717 to the right winding of relay 3707 and battery, relay 3707 functioning as before.

Sender trouble conditions

If no selections are recorded the timing relays will cause the transmission of the premature reverse battery signal and the release of the sender. If dialing is incomplete so that registration cannot be completed, the originating and terminating senders cooperate to the end that the reverse battery signal is transmitted. Trunk closure is temporary, operating relays 3713 and 3709 and then releasing relay 3713 to operate relay 3708 over the outer left front contact of relay 3709 and the right contact of relay 3713.

After the marker has made a second attempt to establish a connection and has failed, it grounds conductor 5671 which operates trouble release relay 3718. This relay locks under the control of relay 3714 and opens the start lead to the marker to prevent summoning another marker. The timing relays then release the sender.

If it is desired to prevent the restoration of the sender to normal under the control of the timing relays, a plug such as plug 3735 is inserted in jack 3736 operating relay 3717. With this relay operated, the second connection of ground to conductor 3732 instead of operating relay 3707 as above described, completes a circuit over the inner right contact of relay 3712 and the right front contact of relay 3717, right winding of relay 3718 and battery. Relay 3718 locks under the control of relay 3714, opens the lead for summoning a marker and disconnects ground from conductor 5146 releasing the link cross-points. All of the operated relays remain in that condition. Ground on conductor 3734 causes a delayed audible alarm.

What is claimed is:

1. In a telephone system, a plurality of telephone lines, a plurality of switches serving said lines both as line switches and as final selector switches, said lines and switches being arranged in a plurality of groups, line control circuits, one for each of said groups, for controlling the switches on outward calls from said lines and a marker device common to all of said groups for controlling said switches to complete inward calls to said lines.

2. In a telephone system, a plurality of telephone lines, a plurality of switches serving said lines both as line switches and as final selector switches, said lines and switches being arranged in a plurality of groups, line control circuits, one for each of said groups, for controlling the switches on outward calls from said lines, a marker device common to all of said groups for controlling said switches to complete inward calls to said lines, and means to prevent simultaneous control of said switches by said line control circuit and said marker.

3. In a telephone system, a plurality of telephone lines, a plurality of switches serving said lines both as line switches and as final selector switches, said lines and switches being arranged in a plurality of groups and subgroups, line control circuits, one for each of said groups, for controlling the switches on outward calls from said lines, a marker device common to all of said groups for controlling said switches to complete inward calls to said lines and a relay for connecting each of said subgroups with said line control circuit and with said marker device.

4. In a telephone system, a plurality of telephone lines, a plurality of switches serving said lines both as line switches and as final selector switches, said lines and switches being arranged in a plurality of groups and subgroups, line control circuits, one for each of said groups, for controlling the switches on outward calls from said lines, a marker device common to all of said groups for controlling said switches to complete inward calls to said lines, a relay for connecting each of said subgroups with said line control circuit and with said marker device, and means for operating said relay under the control either of a line in said subgroup or of said marker.

5. In a telephone system, a plurality of telephone lines, a plurality of switches serving said lines both as line switches and as final selector switches, said lines and switches being arranged in a plurality of groups, line control circuits, one for each of said groups, for controlling the switches on outward calls from said lines, a marker device common to all of said groups for controlling said switches to complete inward calls to said lines, a relay for connecting each of said subgroups with said line control circuit and with said marker device, means for operating said relay under the control either of a line in said subgroup or of said marker, and means to prevent simultaneous control of said switches by said line control circuit and said marker.

6. In a telephone system, a plurality of lines, a plurality of switches serving said lines both as line switches and as final selector switches, said lines and switches being divided into a number of line groups, line control mechanisms, one for each of said line groups, for controlling said switches to extend calls originating on said lines, and a marker mechanism common to all of said line groups for controlling any of said switches to complete calls incoming to said lines, each of said line control mechanisms having means for preventing said marker mechanism from associating itself with the corresponding line group.

7. In a telephone system, a plurality of lines, a plurality of switches serving said lines both as line switches and as final selector switches, said lines and switches being divided into a number of line groups, line control mechanisms, one for each of said line groups, for controlling said switches to extend calls originating on said lines, and a marker mechanism common to all of said line groups for controlling any of said switches to complete calls incoming to said lines, said marker mechanism having means therein

for rendering any one of said line control mechanisms ineffective while the marker is connected with the corresponding line group.

8. In a telephone system, subscribers' lines, combined line switch and final selector switch mechanisms comprising a plurality of primary cross-bar switches and a plurality of secondary cross-bar switches, links interconnecting said primary and secondary switches, means for testing said links for an idle one when an originating call is made on one of said lines, and other testing means for testing said links for an idle one when a terminating call is being completed to one of said lines.

9. In a telephone system, subscribers' lines, combined line switch and final selector switch mechanisms comprising a plurality of primary cross-bar switches and a plurality of secondary cross-bar switches, links interconnecting said primary and secondary switches, two sets of test relays, means for associating said links with one of said sets of test relays when an originating call is made on one of said lines and means for associating said links with the other of said sets of test relays when a terminating call is being completed to one of said lines.

10. In a telephone system, subscribers' lines, combined line switch and final selector switch mechanisms comprising a plurality of primary cross-bar switches and a plurality of secondary cross-bar switches, links interconnecting said primary and secondary switches, two sets of test relays, means for associating said links with one of said sets of test relays when an originating call is made on one of said lines, means for associating said links with the other of said sets of test relays when a terminating call is being completed to one of said lines, and means controlled by said test relays for seizing an idle one of said links.

11. The combination in a telephone system, of subscribers' lines, a plurality of primary cross-bar switches and secondary cross-bar switches serving said lines, both as line switches and as final selector switches, links interconnecting said primary and secondary switches, trunks outgoing from said switches, trunks incoming to said switches, testing means for testing said links in conjunction with said outgoing trunks, and other testing means for testing said links in conjunction with said incoming trunks.

12. The combination in a telephone system, of subscribers' lines, a plurality of primary cross-bar switches and secondary cross-bar switches serving said lines both as line switches and as final selector switches, links interconnecting said primary and secondary switches, trunks outgoing from said switches, trunks incoming to said switches, testing means for testing said links in conjunction with said outgoing trunks, other testing means for testing said links in conjunction with said incoming trunks, and means common to a group of said links for connecting said links with either of said testing means.

13. The combination in a telephone system, of subscribers' lines, a plurality of primary cross-bar switches and secondary cross-bar switches serving said lines both as line switches and as final selector switches, links interconnecting said primary and secondary switches, trunks outgoing from said switches, trunks incoming to said switches, testing means for testing said links in conjunction with said outgoing trunks, other testing means for testing said links in conjunction with said incoming trunks, means common to a group of said links for connecting said links with either of said testing means, and means common to a plurality of groups of said links for connecting said trunks to the corresponding testing means.

14. The combination in a telephone system, of telephone lines, a plurality of groups of trunks, automatic switches having access to said trunk groups for extending calls from said lines, and means for giving said switches preference to a limited number of said trunk groups and for shifting the preference among the groups of said limited number of groups.

15. The combination in a telephone system, of telephone lines, a plurality of groups of trunks, automatic switches having access to said trunk groups for extending calls from said lines, and means for giving said switches preference to two of said trunk groups and for shifting the preference between the groups on alternate calls.

16. The combination in a telephone system, of telephone lines, a plurality of groups of trunks, automatic switches having access to said trunk groups for extending calls from said lines, a series of relays one for each of said trunk groups, a preference circuit controlled by said relays for selecting a trunk group to be connected with, and means for starting said preference circuit at one of a limited plurality of said relays.

17. The combination in a telephone system, of telephone lines, a plurality of groups of trunks, automatic switches having access to said trunk groups for extending calls from said lines, a series of relays one for each of said trunk groups, a preference circuit controlled by said relays for selecting a trunk group to be connected with, and means for starting said preference circuit at a different one of a limited plurality of said relays on successive calls.

18. The combination in a telephone system, of telephone lines, a plurality of groups of trunks, automatic switches having access to said trunk groups for extending calls from said lines, a series of relays one for each of said trunk groups, a preference circuit controlled by said relays for selecting a trunk group to be connected with, and means for starting said preference circuit at either one of two of said relays on alternate calls.

19. In a telephone system, a cross-bar switch, a plurality of lines appearing respectively in the contact rows of said switch, a group of trunks for extending calls from said lines, and means depending on the location of a calling line in said switch for selecting one of said trunks for use in extending a call.

20. In a telephone system, a cross-bar switch, a plurality of lines appearing respectively in the contact rows of said switch, a group of trunks for extending calls from said lines, a series of relays for identifying the location of a calling line in said switch, a series of test relays for identifying idle trunks in said group of trunks, a preference chain circuit including contacts of said trunk test relays and means under the control of said line relays for starting said preference circuit at a contact of the corresponding relay in said series of trunk relays.

21. In a telephone system, a cross-bar switch, a plurality of lines appearing respectively in the contact rows of said switch, a group of trunks for extending calls from said lines, a series of relays for identifying the location of a calling line in said switch, a series of test relays for identifying idle trunks in said group of trunks, a circuit for selecting one of said trunks for use

in extending a call, means under the control of said line position identifying relays for directing said circuit to corresponding ones of said trunk relays, and means for completing said circuit over the first of said relays identifying an idle trunk.

22. In a telephone system, a cross-bar switch, a plurality of lines appearing respectively in the contact rows of said switch, a group of trunks for extending calls from said lines, a series of relays for identifying the location of a calling line in said switch, a series of test relays for identifying idle trunks in said groups of trunks, a plurality of preference circuits interconnecting relays in said series of relays, and means for selecting one of said trunks for use for extending the call including the relay identifying the calling line, the corresponding preference circuit and one or more of said trunk relays according as said trunks are busy or idle.

23. The combination, in a telephone system, of a plurality of selective switches, a plurality of subscribers' lines appearing in the contacts of said switches, controlling mechanism operable in accordance with the directory numbers of said lines for selectively operating said switches to complete calls to said lines, and distributing means whereby any one of said lines may at will be shifted to appear in any of the contacts of any of said switches without changing the directory number.

24. In a telephone system, a plurality of switches, subscribers' lines appearing in the terminals of said switches, a controlling mechanism common to said switches for receiving the designation of a called subscriber's line, said mechanism serving to selectively operate said switches to complete a connection to the line as a called line, relays, one for each of said switches, identifying leads respectively individual to said lines, circuit means including the leads of all lines appearing in a particular switch for operating the corresponding relay, means controlled by the operated relay for connecting said controlling mechanism to the corresponding switch, and distributing means whereby said identifying leads may be shifted from one relay to another to enable said lines to be shifted from one switch to another without changing the directory numbers.

25. In a telephone system, a plurality of switches arranged in levels, subscribers' lines appearing in the terminals of said switches, a controlling mechanism common to said switches for receiving the designation of a called subscriber's line, said mechanism serving to selectively operate said switches to complete a connection to the called line, relays, one for each level of said switches, identifying leads respectively individual to said lines, circuit means including the leads of all lines appearing in a particular level for operating the corresponding relay, means controlled by the operated relay for connecting said controlling mechanism to the corresponding switch level, and distributing means whereby said identifying leads may be shifted from one relay to another to enable said lines to be shifted from one switch level to another without changing the directory numbers.

26. In a telephone system, a plurality of line choices, each of said choices comprising a plurality of subscribers' lines and a plurality of selective switches, the lines and switches of a choice being divided into a plurality of groups, said lines being further divided into subgroups, a switch controlling marker common to all of said choices, means for connecting said marker to the switches in any one of said choices, a translator in said marker responsive to a called line designation recorded therein for selecting the choice of lines and the subgroup of lines in said choice containing the called line, and distributing means between said translator and said line choices to enable a subgroup of lines to be moved from the switches of one line choice to the switches of another line choice without changing the directory numbers of said lines.

27. In a telephone system, automatic switches, a group of private branch exchange lines appearing in the terminals of said switches, said lines being divided into subgroups, switch controlling markers common to said switches, a connector for connecting said markers individually to the switches containing said private branch exchange group, test means in said markers for testing said lines, one subgroup at a time, relays one for each of said subgroups of lines, for connecting the marker test means to said lines, a testing mechanism in said markers for causing successive operation of said relays to test said subgroups successively until an idle line is found, the order of testing varying according to the marker making the test.

28. In a telephone system, automatic switches, a group of private branch exchange lines appearing in the terminals of said switches, said lines being divided into subgroups, switch controlling markers common to said switches, a connector for connecting said markers individually to the switches containing said private branch exchange group, test means in said markers for testing said lines, one subgroup at a time, relays one for each of said subgroups of lines, for connecting the marker test means to said lines, a testing mechanism in said markers for causing successive operation of said relays to test said subgroups successively until an idle line is found, means under the control of the registered line designation for determining the starting point for testing the first of said subgroups, means for automatically determining the starting point in testing other subgroups, and means for varying the order of testing said subgroups according to the marker making the test.

29. In a telephone system, automatic switches, subscribers' lines and a group of private branch exchange lines appearing in the terminals of said switches, said subscribers' lines and private branch exchange lines being divided into subgroups, one of said subgroups being comprised of a number of private branch lines followed by a number of subscribers' lines, other subgroups being comprised only of private branch exchange lines, a marker having means for testing said lines by subgroups, and means effective when the marker has tested the last one of the private branch exchange lines in the subgroup also containing subscribers' lines for disassociating the marker from that subgroup and for associating it with the next subgroup containing private branch exchange lines of the same private branch exchange group.

30. In a telephone system, automatic switches, subscribers' lines and groups of private branch exchange lines appearing in the terminals of said switches, said subscribers' lines and branch exchange lines being divided into groups in certain of which branch exchange lines terminate the group and in others of which the branch exchange lines are followed by subscribers' lines, a marker

having means for testing said lines by subgroups, means normally effective when the marker has tested a branch exchange line as the last line of the subgroup to disassociate the marker from that subgroup and associate it with another subgroup containing other branch exchange lines of the same group, and other means operated when the marker has tested the last one of the branch exchange lines in a subgroup also containing subscribers' lines for identifying the subgroup containing additional private branch exchange lines of the same group and for controlling the transfer of the association of the marker to that subgroup.

31. In a telephone system, a plurality of line groups, each comprising a number of selective switches and a plurality of telephone lines, a plurality of incoming switches for extending incoming calls to said lines by way of said first-mentioned selective switches, trunks interconnecting each of said incoming switches with the selective switches of a particular line group, said trunks being divided into groups all of which comprise a uniform number of trunks, some of said groups comprising only trunks coming from a particular incoming switch, a certain one of said groups comprising trunks from each of a plurality of said incoming switches, a testing means for testing said trunks by groups and arranged to test a full group at a time, and means effective when a call is being extended from a particular incoming switch to said particular line group and when the trunks of said certain group are being tested, for rendering busy to the test means all trunks in such certain group coming from incoming switches other than said particular incoming switch.

32. In a telephone system, a plurality of line groups, each comprising a number of selective switches and a plurality of telephone lines, a plurality of incoming switches for extending incoming calls to said lines by way of said first-mentioned selective switches, trunks interconnecting each of said incoming switches with the selective switches of a particular line group, said trunks being divided into groups all of which comprise a uniform number of trunks, some of said groups comprising only trunks coming from a particular incoming switch, a certain one of said groups comprising trunks from each of a plurality of said incoming switches, a testing means for testing said trunks by groups and arranged to test a full group at a time, relays for connecting said testing means with the group of trunks to be tested, and means controlled by the relay connecting said test means with said certain group of trunks for rendering busy to the test means all trunks in such certain group coming from incoming switches other than said particular incoming switch.

33. In a telephone system, a plurality of line groups, each comprising a number of selective switches and a plurality of telephone lines, a plurality of incoming switches for extending incoming calls to said lines by way of said first-mentioned selective switches, trunks interconnecting each of said incoming switches with the selective switches of a particular line group, said trunks being divided into groups all of which comprise a uniform number of trunks, some of said groups comprising only trunks coming from a particular incoming switch, a certain one of said groups comprising trunks from each of a plurality of said incoming switches, a testing means for testing said trunks by groups and arranged to test a full group at a time, relays for connecting said testing means with the group of trunks to be tested, means controlled by the relays connecting said test means with said certain group of trunks for rendering busy to the test means all trunks in such certain group coming from incoming switches other than a particular incoming switch, and means for operating the particular relay in accordance with the incoming switch over which the call is being extended.

34. In a telephone system, a plurality of line groups, each comprising a number of selective switches and a plurality of telephone lines, a plurality of incoming switches for extending incoming calls to said lines by way of said first-mentioned selective switches, trunks interconnecting each of said incoming switches with the selective switches of a particular line group, said trunks being divided into groups all of which comprise a uniform number of trunks, some of said groups comprising only trunks coming from a particular incoming switch, a certain one of said groups comprising trunks from each of a plurality of said incoming switches, a testing means for testing said trunks by groups and arranged to test a full group at a time, relays for connecting said testing means with a group of trunks to be tested, and means to alternately operate a relay for connecting said testing means with one of said groups comprising only trunks coming from a particular incoming switch and a relay for connecting said testing means with said certain group of trunks.

35. In a telephone system, a plurality of line groups, each comprising a number of selective switches and a plurality of telephone lines, a plurality of incoming switches for extending incoming calls to said lines by way of said first-mentioned selective switches, trunks interconnecting each of said incoming switches with the selective switches of a particular line group, said trunks being divided into groups all of which comprise a uniform number of trunks, some of said groups comprising only trunks coming from a particular incoming switch, a certain one of said groups comprising trunks from each of a plurality of said incoming switches, a testing means for testing said trunks by groups and arranged to test a full group at a time, relays for connecting said testing means with a group of trunks to be tested, means to alternately operate a relay for connecting said testing means with one of said groups comprising only trunks coming from said particular incoming switch, and a relay for connecting said testing means with said certain group of trunks, and means controlled by the relays connecting said test means with said certain group of trunks for rendering busy to the test means all trunks in said certain group coming from incoming switches other than a particular incoming switch.

36. In a telephone system, a plurality of line groups, each comprising a number of selective switches and a plurality of telephone lines, a plurality of incoming switches for extending incoming calls to said lines by way of said first-mentioned selective switches, trunks interconnecting each of said incoming switches with the selective switches of a particular line group, said trunks being divided into groups all of which comprise a uniform number of trunks, some of said groups comprising only trunks coming from a particular incoming switch, a certain one of said groups comprising trunks from each of a

plurality of said incoming switches, a testing means for testing said trunks by groups and arranged to test a full group at a time, relays for connecting said testing means with a group of trunks to be tested, means to alternately operate a relay for connecting said testing means with one of said groups comprising only trunks coming from said particular incoming switch and a relay for connecting said testing means with said certain group of trunks, means controlled by the relays connecting said test means with said certain group of trunks for rendering busy to the test means all trunks in said certain group coming from incoming switches other than a particular incoming switch, and means for operating a particular relay in accordance with the incoming switch over which a call is being extended.

37. In a telephone system, a plurality of line groups, each comprising a number of selective switches and a plurality of telephone lines, a plurality of incoming switches for extending incoming calls to said lines by way of said first-mentioned selective switches, trunks interconnecting each of said incoming switches with the selective switches of a particular line group, said trunks being divided into groups all of which comprise a uniform number of trunks, some of said groups comprising only trunks coming from a particular incoming switch, a certain one of said groups comprising trunks from each of a plurality of said incoming switches, a marker for controlling the connection between an incoming switch and a wanted line group, means in said marker for testing said trunks by groups, means for successively testing a plurality of trunk groups, relays for connecting said trunk groups to said marker and means for operating a relay to connect a particular trunk group with said marker under the joint control of the incoming switch, the selected line group and the number of the test.

38. In a telephone system, a plurality of line groups, each comprising a number of selective switches and a plurality of telephone lines, a plurality of incoming switches for extending incoming calls to said lines by way of said first-mentioned selective switches, trunks interconnecting each of said incoming switches with the selective switches of a particular line group, said trunks being divided into groups all of which comprise a uniform number of trunks, some of said groups comprising only trunks coming from a particular incoming switch, a certain one of said groups comprising trunks from each of a plurality of said incoming switches, a testing means for testing said trunks by groups and arranged to test a full group at a time, and means to determine whether said particular group or one of said other groups shall be tested first in connection with a particular call.

39. In a telephone system, a plurality of line groups, each comprising a number of selective switches and a plurality of telephone lines, a plurality of incoming switches for extending incoming calls to said lines by way of said first-mentioned selective switches, trunks interconnecting each of said incoming switches with the selective switches of a particular line group, said trunks being divided into groups all of which comprise a uniform number of trunks, some of said groups comprising only trunks coming from a particular incoming switch, a certain one of said groups comprising trunks from each of a plurality of said incoming switches, a testing means for testing said trunks by groups and arranged to test a full group at a time, and means to determine whether said particular group or one of said other groups shall be tested first in connection with a particular call, comprising means responsive to the number of the tests made on a previous call.

40. In a telephone system, a plurality of the line groups, each comprising a number of selective switches and a plurality of telephone lines, a plurality of incoming switches for extending incoming calls to said lines by way of said first-mentioned selective switches, trunks interconnecting each of said incoming switches with the selective switches of a particular line group, said trunks being divided into groups all of which comprise a uniform number of trunks, some of said groups comprising only trunks coming from a particular incoming switch, a certain one of said groups comprising trunks from each of a plurality of said incoming switches, a testing means for testing said trunks by groups and arranged to test a full group at a time, relays for connecting said testing means with a group of trunks to be tested, means to alternately operate a relay for connecting said testing means with one of said groups comprising only trunks coming from said particular incoming switch and a relay for connecting said testing means with said certain group of trunks, and means to determine whether said first relay or said second relay shall be operated first in connection with a particular call.

41. In a telephone system, a plurality of line groups, each comprising a number of selective switches and a plurality of telephone lines, a plurality of incoming switches for extending incoming calls to said lines by way of said first-mentioned selective switches, trunks interconnecting each of said incoming switches with the selective switches of a particular line group, said trunks being divided into groups all of which comprise a uniform number of trunks, some of said groups comprising only trunks coming from a particular incoming switch, a certain one of said groups comprising trunks from each of a plurality of said incoming switches, a testing means for testing said trunks by groups and arranged to test a full group at a time, relays for connecting said testing means with a group of trunks to be tested, means to alternately operate a relay for connecting said testing means with one of said groups comprising only trunks coming from said particular incoming switch, and a relay for connecting said testing means with said certain group of trunks, means to determine whether said first relay or said second relay shall be operated first in connection with a particular call, comprising means responsive to the number of tests made on a previous call.

42. In a telephone system, a plurality of telephone lines, a plurality of switches serving said lines both as line switches and as final selector switches, said lines and switches being arranged in a plurality of groups, control circuits, one for each of said groups, for controlling the switches on outward calls from said lines and a different control circuit common to all of said groups for controlling said switches to complete inward calls to said lines.

WARREN W. CARPENTER.