

Dec. 10, 1946.

C. GILLINGS ET AL

2,412,258

TELEPHONE OR LIKE SYSTEM

Filed Dec. 8, 1943

25 Sheets-Sheet 1

Fig. 1

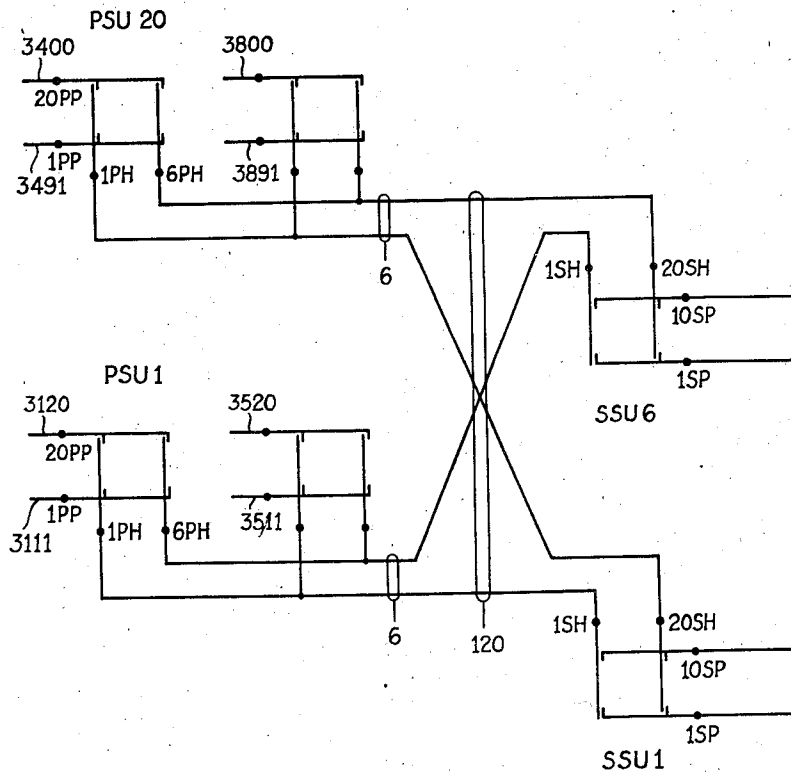
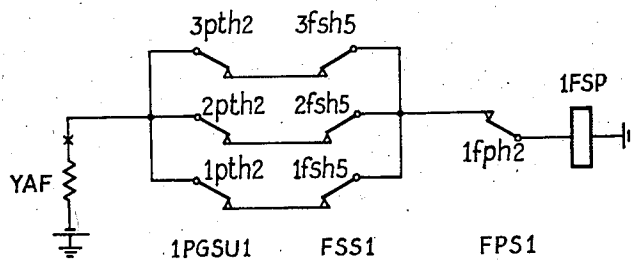


Fig. 26



INVENTORS
CHARLES GILLINGS
LAWRENCE JOHN MURRAY

BY Chas. H. Condy
ATTORNEY

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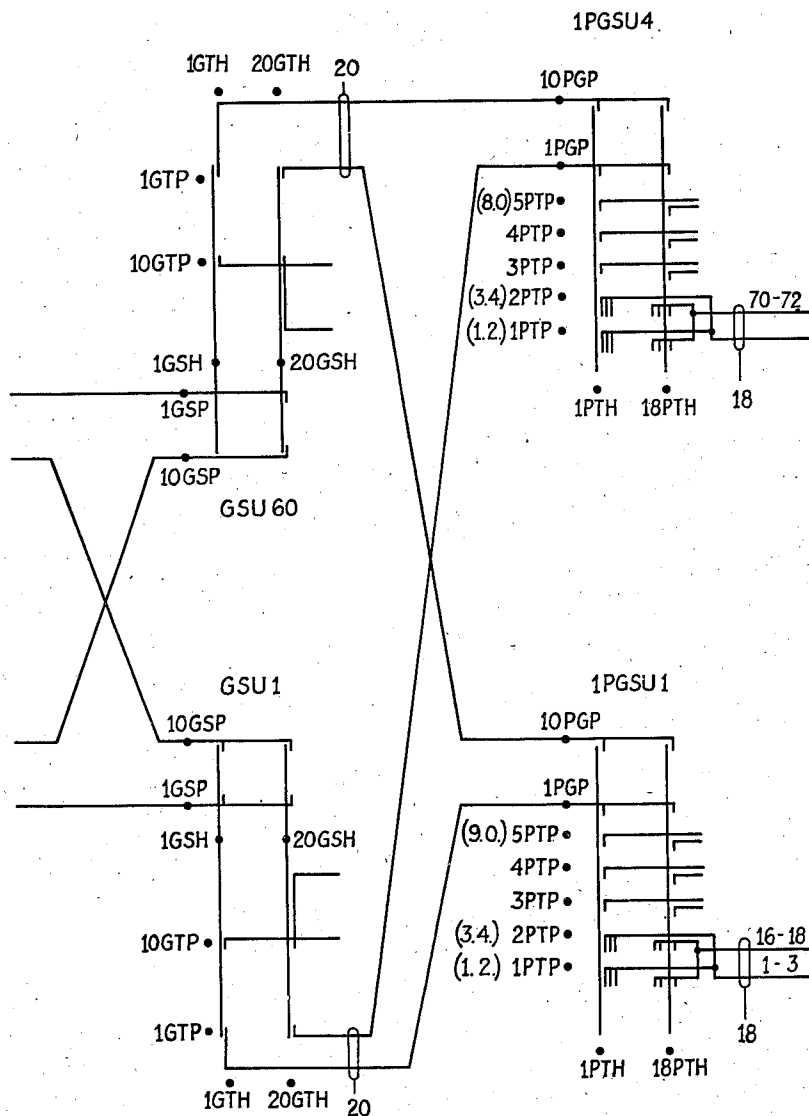


Fig. 2

INVENTORS
CHARLES GILLINGS
LAWRENCE JOHN MURRAY

BY

Chas. M. Condy

ATTORNEY

Dec. 10, 1946.

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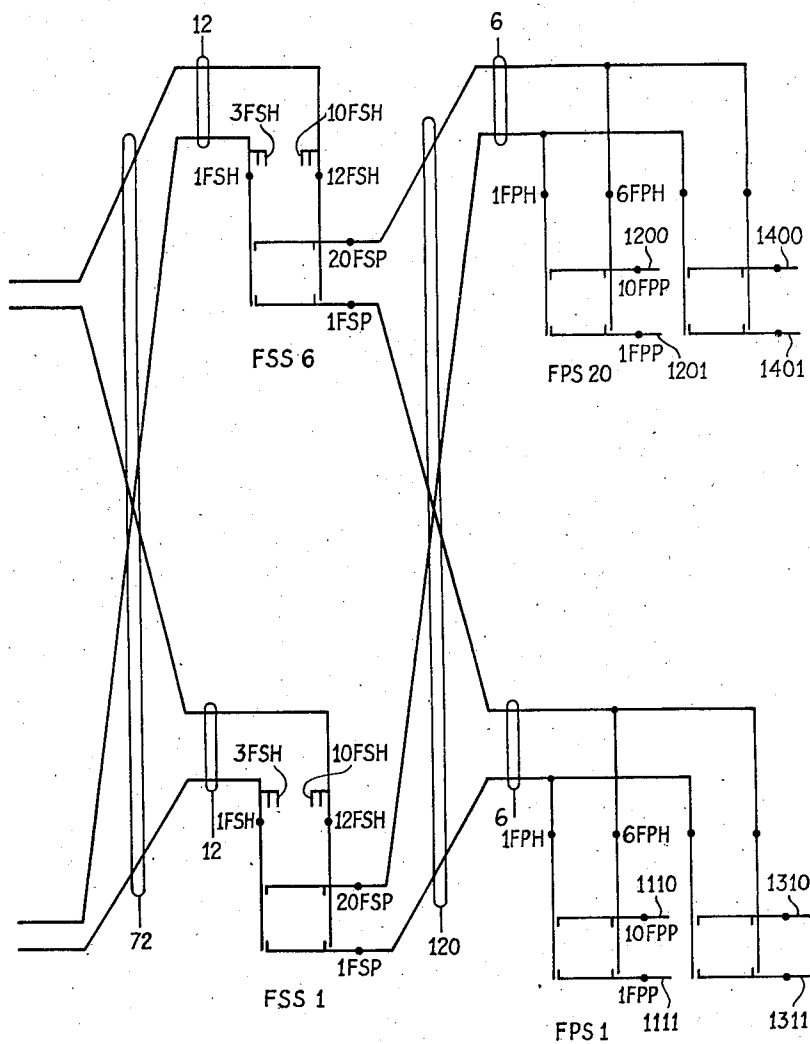


Fig. 3

INVENTORS
CHARLES GILLINGS
LAWRENCE JOHN MURRAY

BY *Charles C. Condy*
ATTORNEY

Dec. 10, 1946.

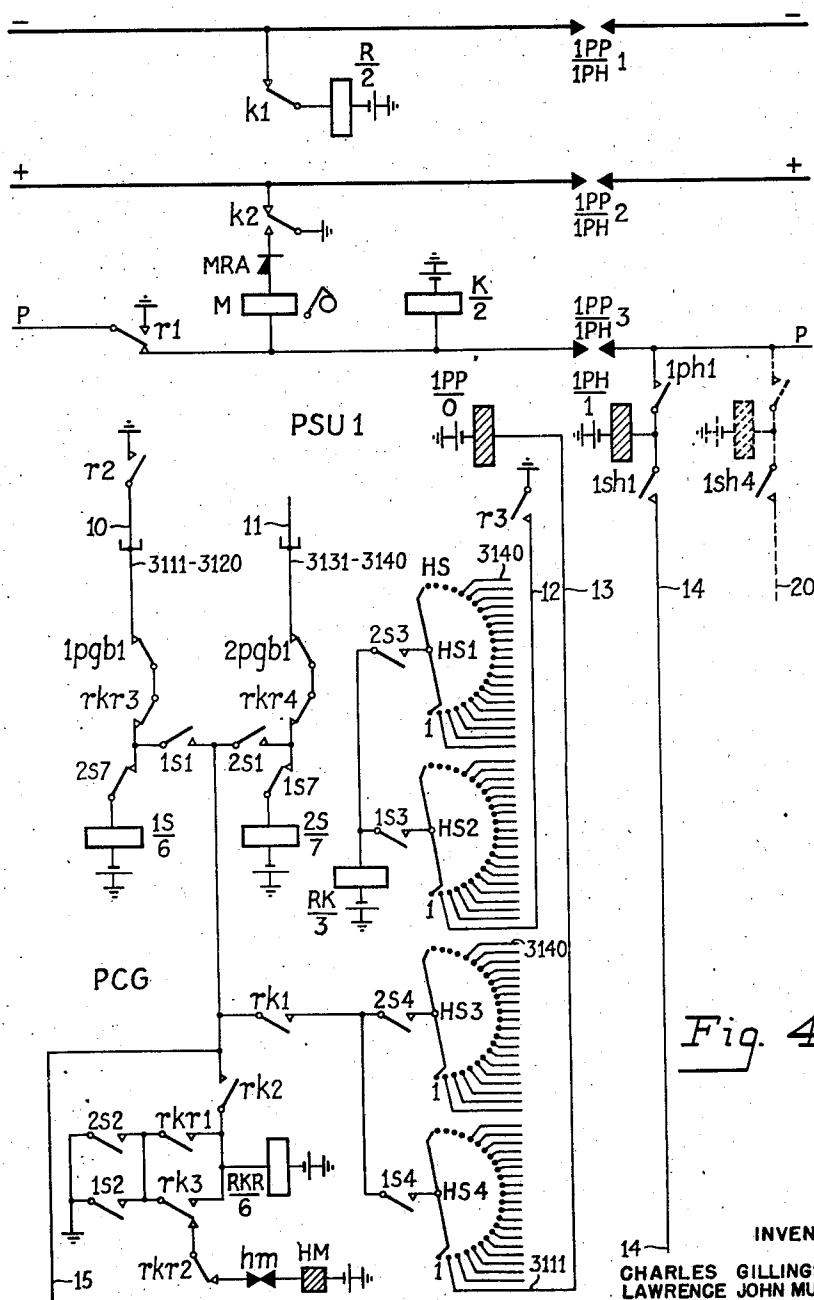
C. GILLINGS ET AL

2,412,258

TELEPHONE OR LIKE SYSTEM

Filed Dec. 8, 1943

25. Sheets-Sheet 4



INVENTORS

CHARLES GILLINGS
LAWRENCE JOHN MURRAY

BY

BY Chas. L. Candy
ATTORNEY

Dec. 10, 1946.

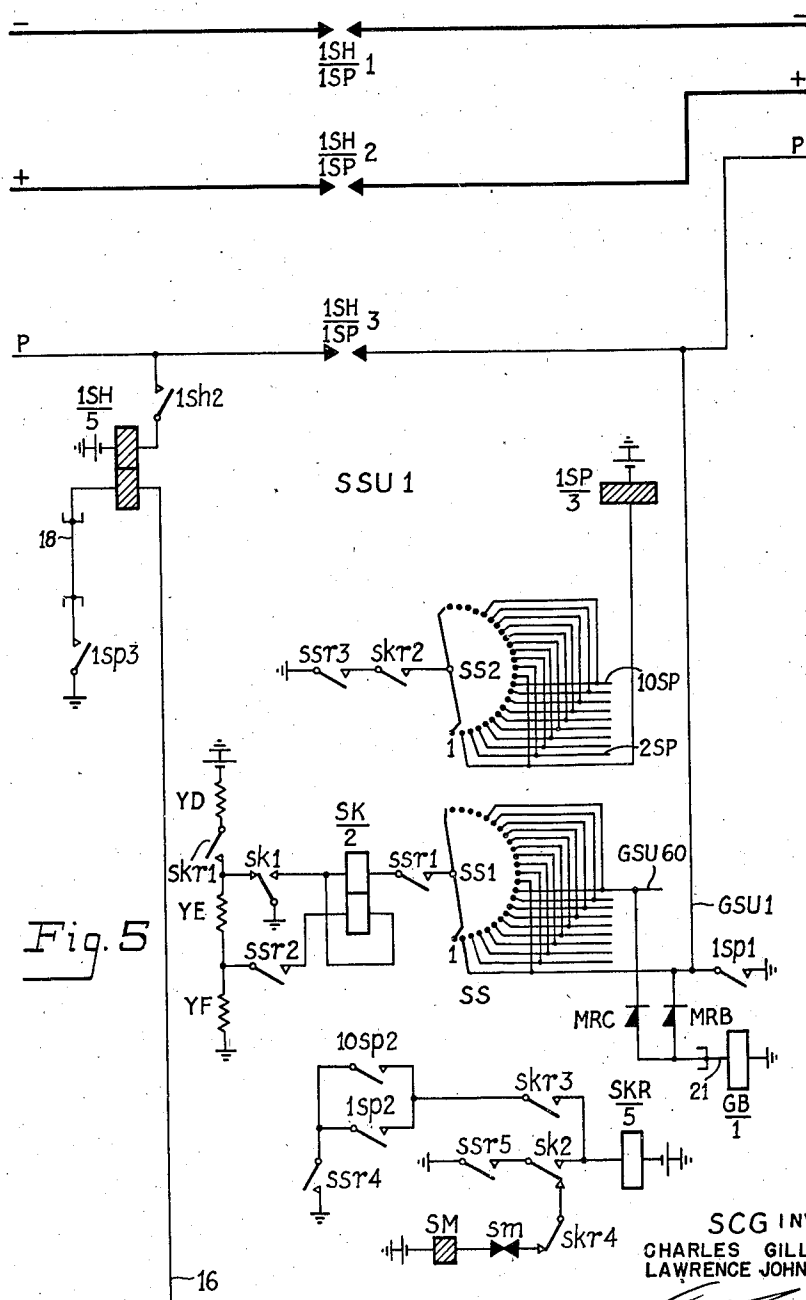
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25 Sheets-Sheet 5



SCG INVENTORS
CHARLES GILLINGS
LAWRENCE JOHN MURRAY

BY *Chas. L. Carby*
ATTORNEY

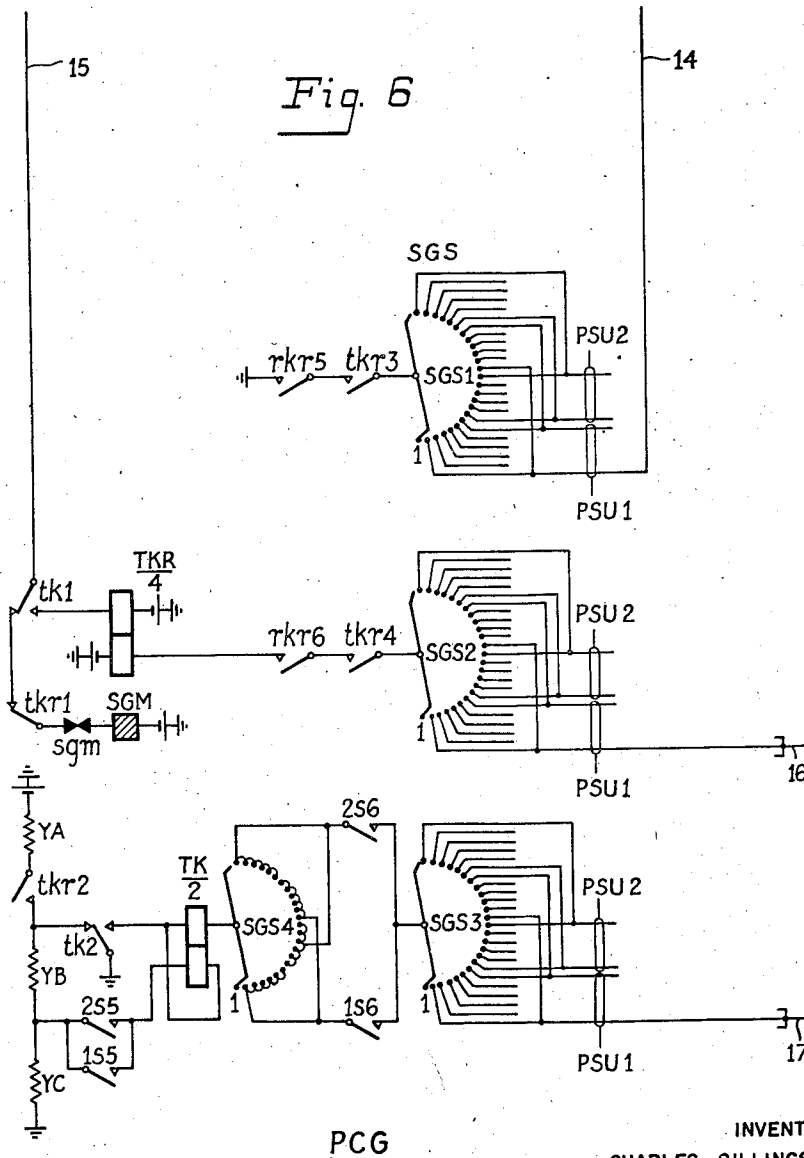
Dec. 10, 1946.

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TELEPHONE OR LIKE SYSTEM

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PCG

INVENTORS
CHARLES GILLINGS
LAWRENCE JOHN MURRAY
BY *Chas. T. Candy*
ATTORNEY

Dec. 10, 1946.

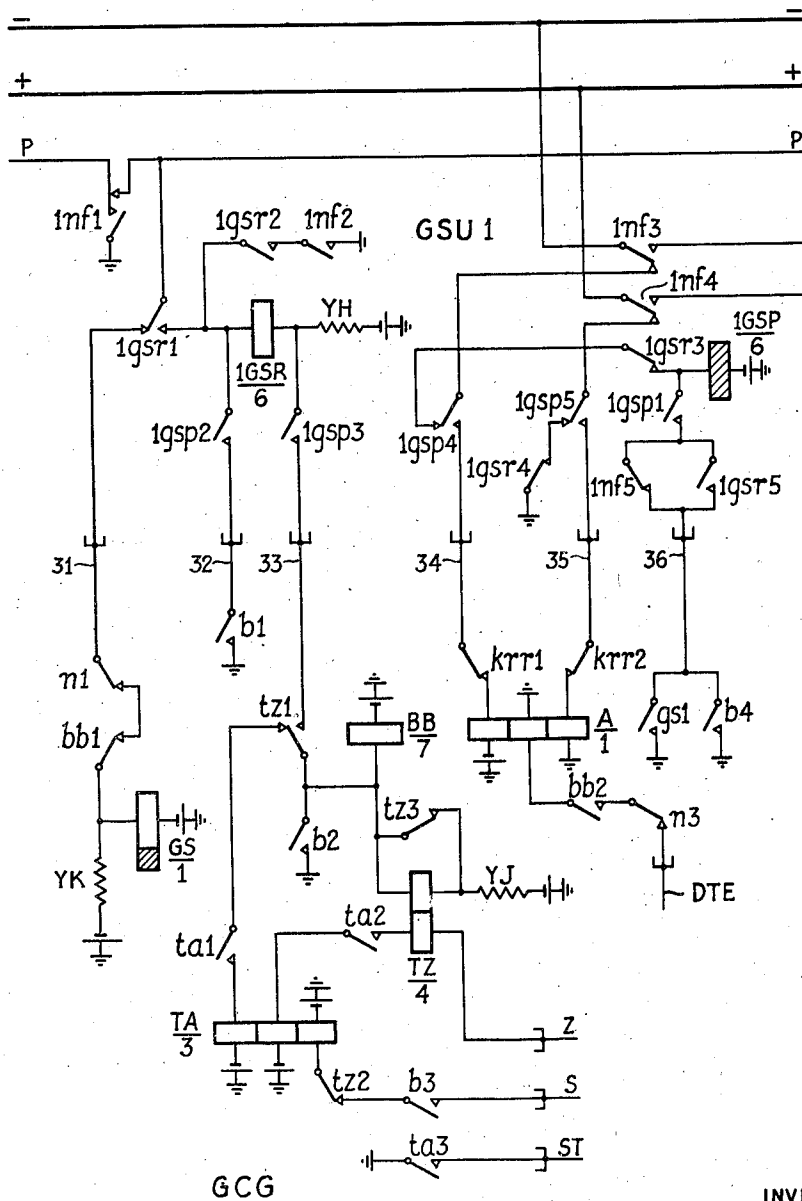
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TELEPHONE OR LIKE SYSTEM

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25 Sheets-Sheet 8



INVENTORS
CHARLES GILLINGS
LAWRENCE JOHN MURRAY

BY

BY Chas. T. Condy
ATTORNEY

Dec. 10, 1946.

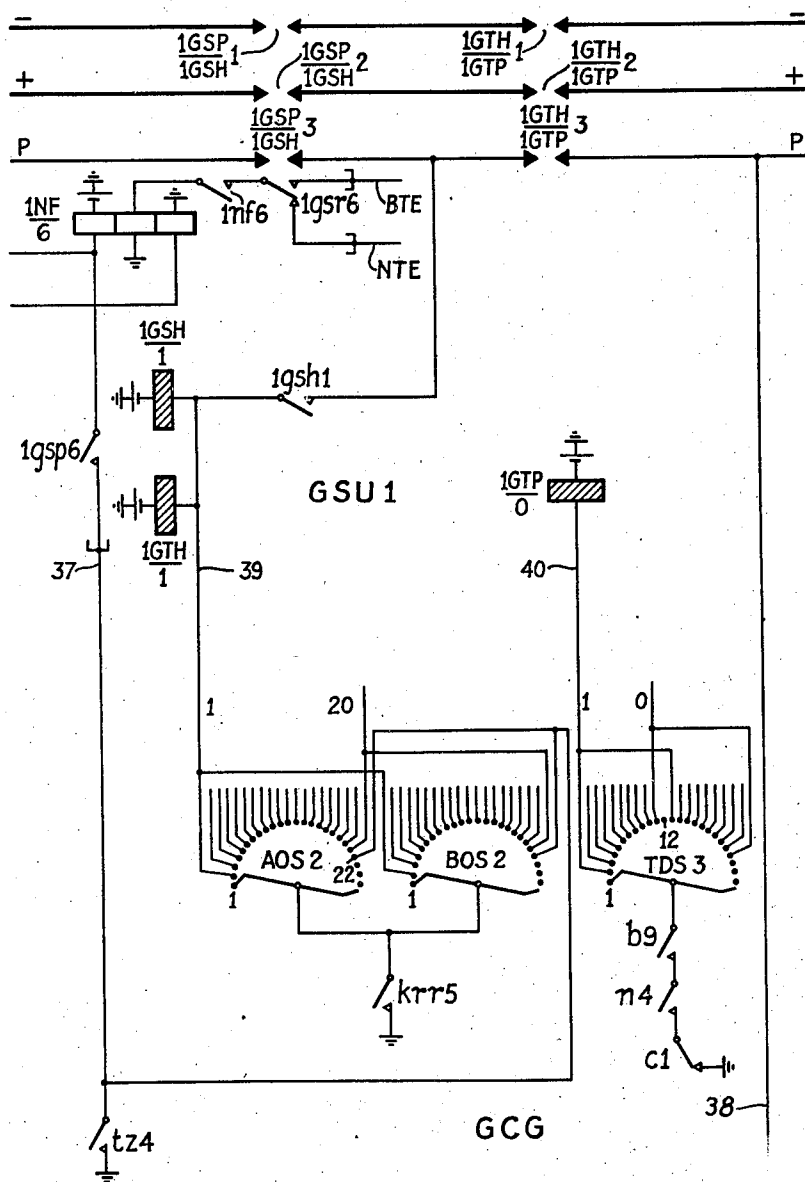
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INVENTORS
CHARLES GILLINGS
LAWRENCE JOHN MURRAY

BY

BY *Chas. T. Condy*
ATTORNEY

Dec. 10, 1946.

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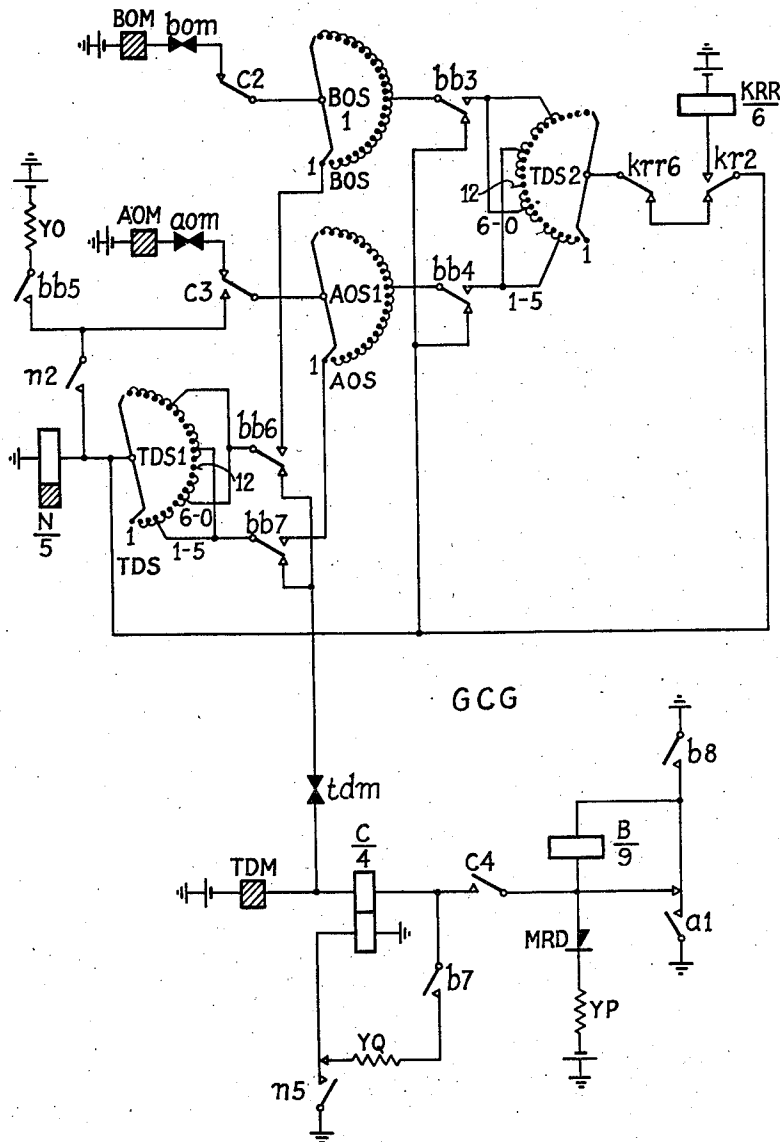


Fig. 10

INVENTORS
CHARLES GILLINGS
LAWRENCE JOHN MURRAY

BY *Chas. T. Canby*
ATTORNEY

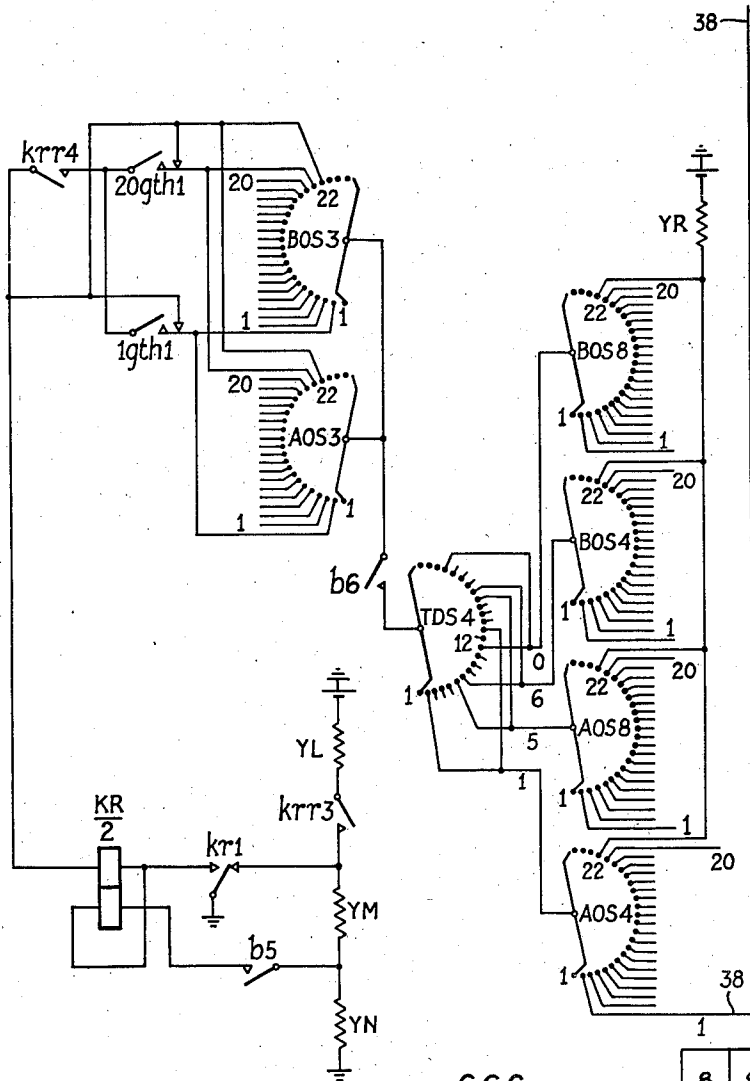
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GCG

Fig. 11a

8	9
10	11

Fig. 11

INVENTORS
CHARLES GILLINGS
LAWRENCE JOHN MURRAY

BY *Charles L. Condy*
ATTORNEY

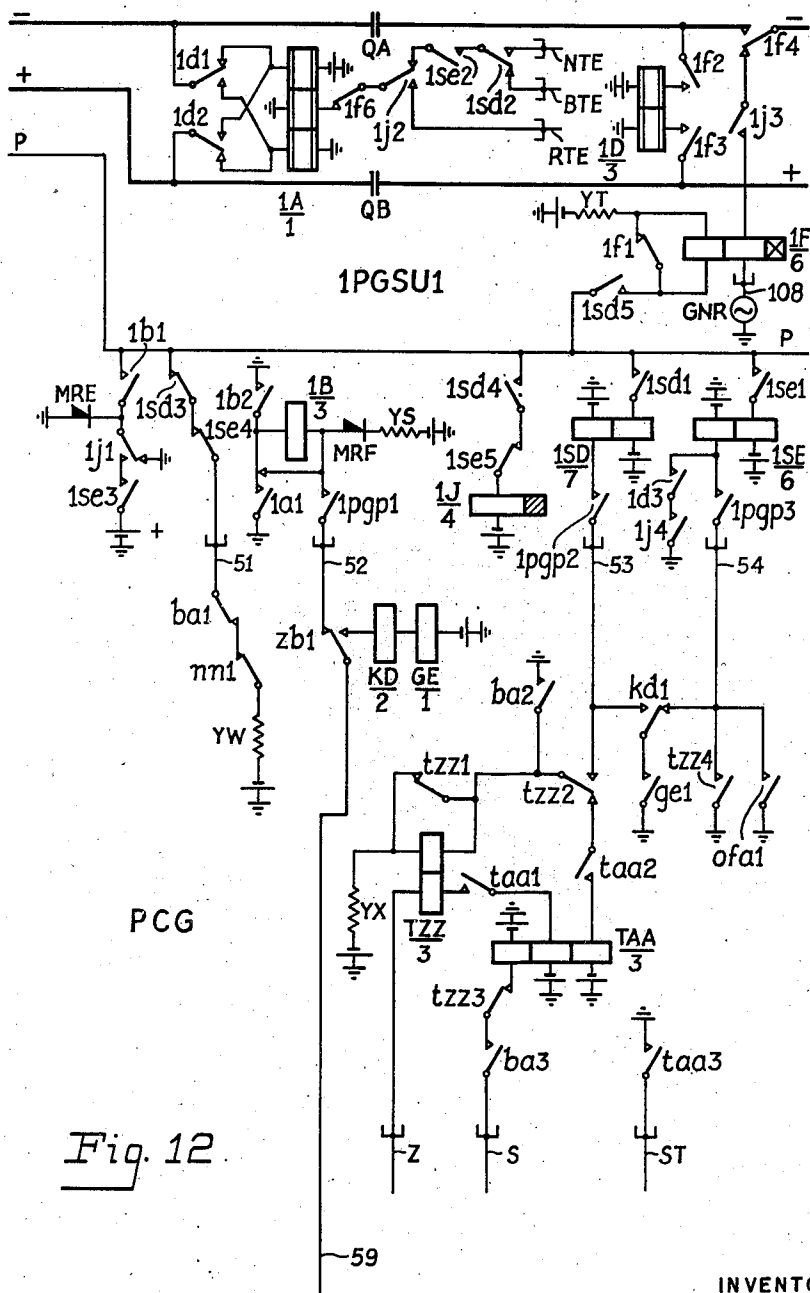
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INVENTORS
CHARLES GILLINGS
LAWRENCE JOHN MURRAY

BY

Chas. W. Candy

ATTORNEY

Dec. 10, 1946.

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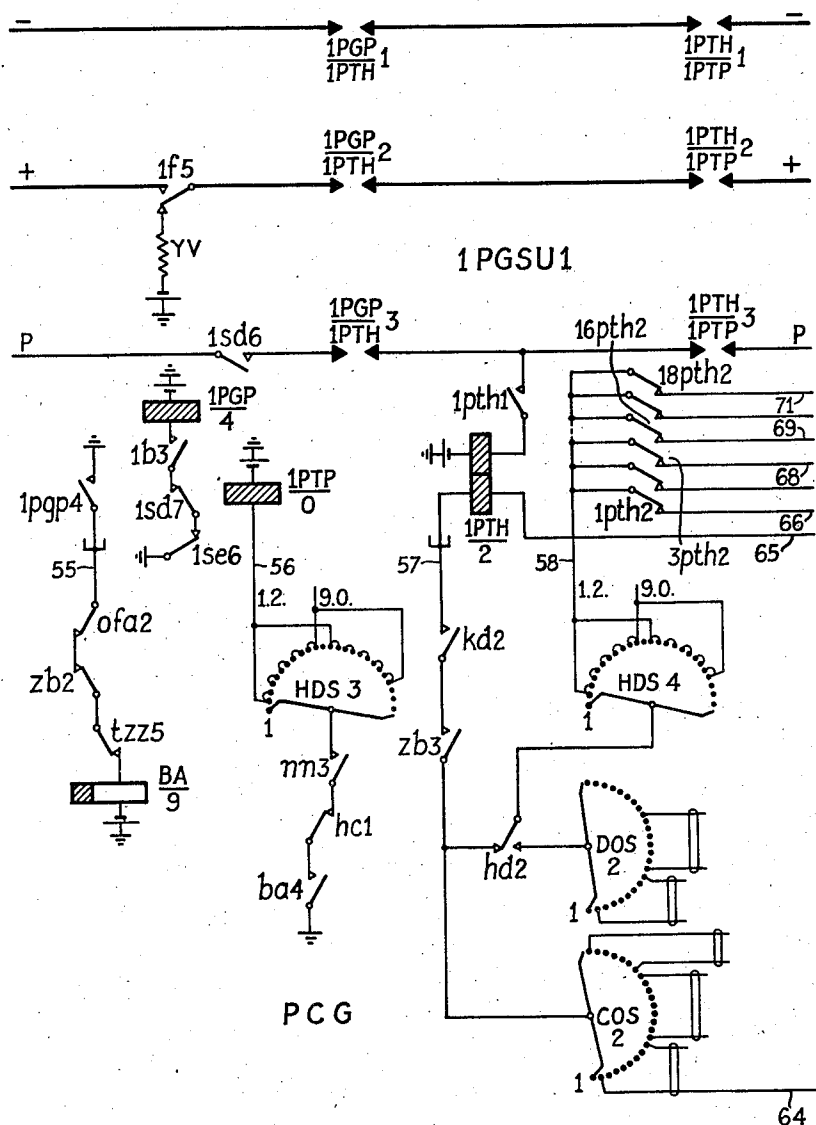


Fig. 13

INVENTORS
CHARLES GILLINGS
LAWRENCE JOHN MURRAY

BY *Charles E. Condy*
ATTORNEY

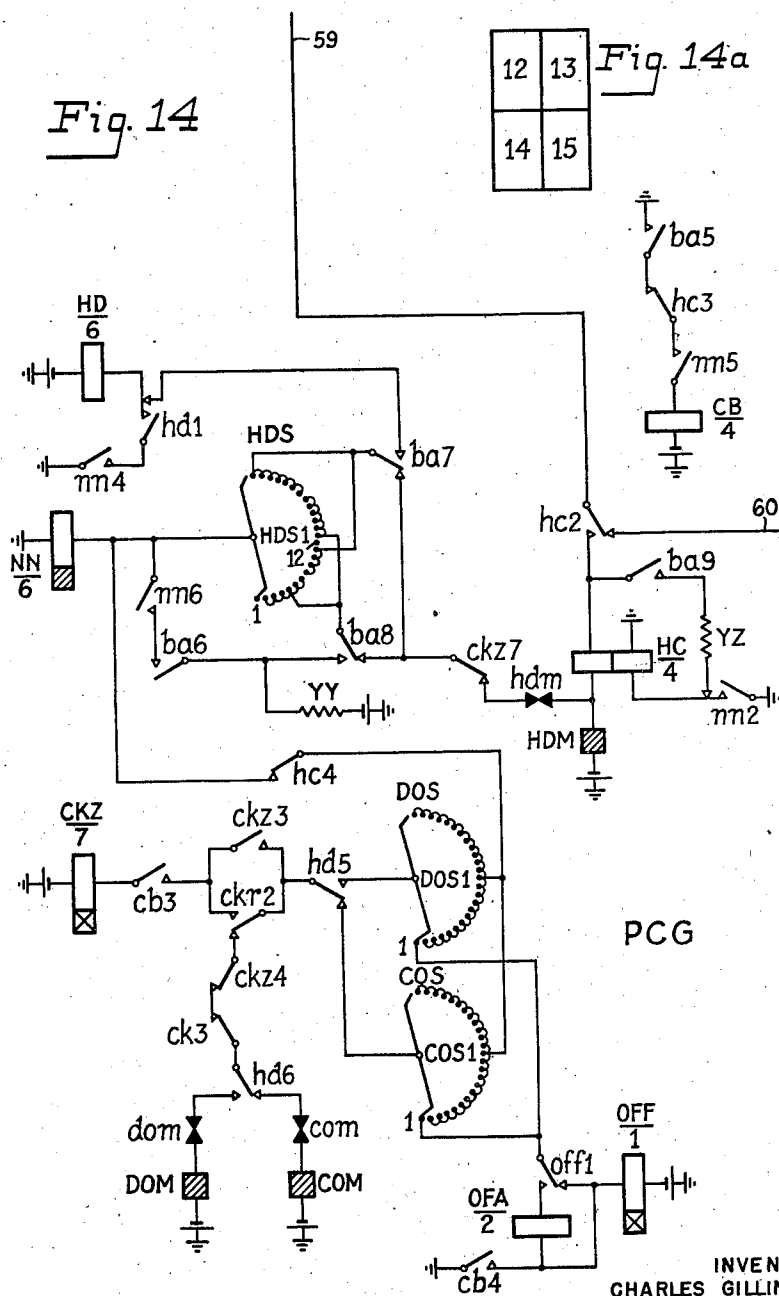
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25.Sheets-Sheet 14



INVENTORS
CHARLES GILLINGS
LAWRENCE JOHN MURRAY

BY Chas. M. Candy
ATTORNEY

Dec. 10, 1946.

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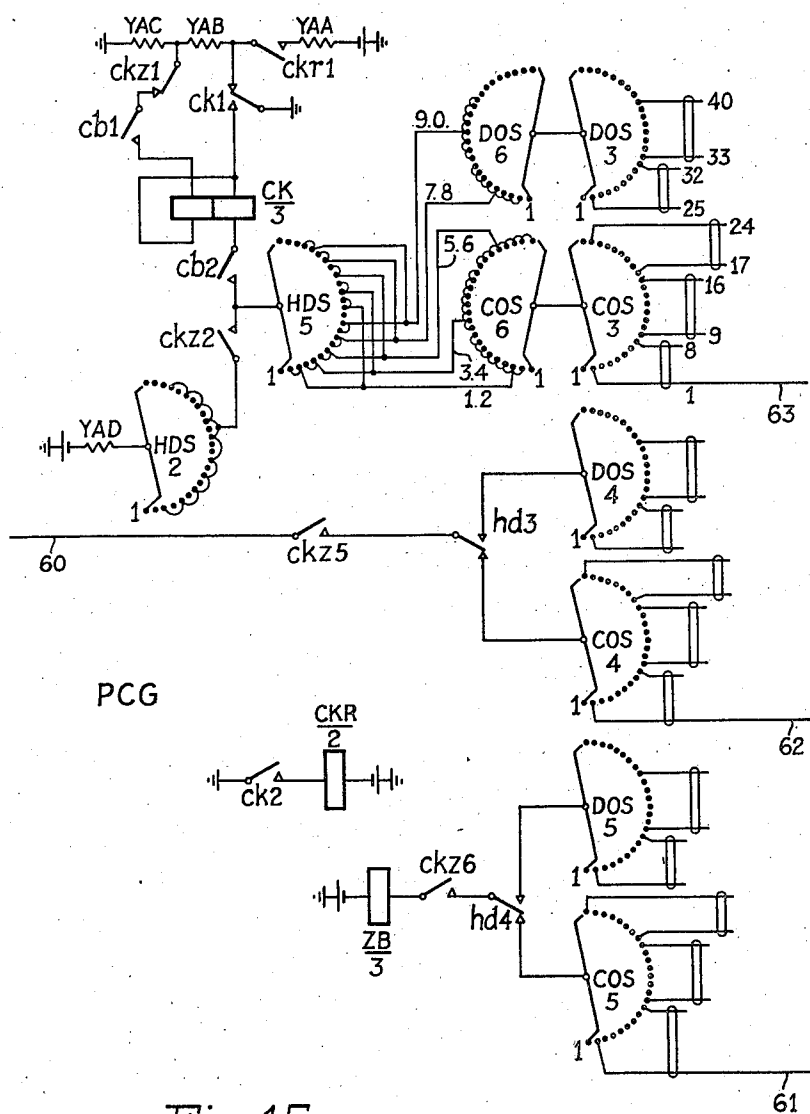


Fig. 15

INVENTORS
CHARLES GILLINGS
LAWRENCE JOHN MURRAY

BY *Chas. L. Candy*
ATTORNEY

Dec. 10, 1946.

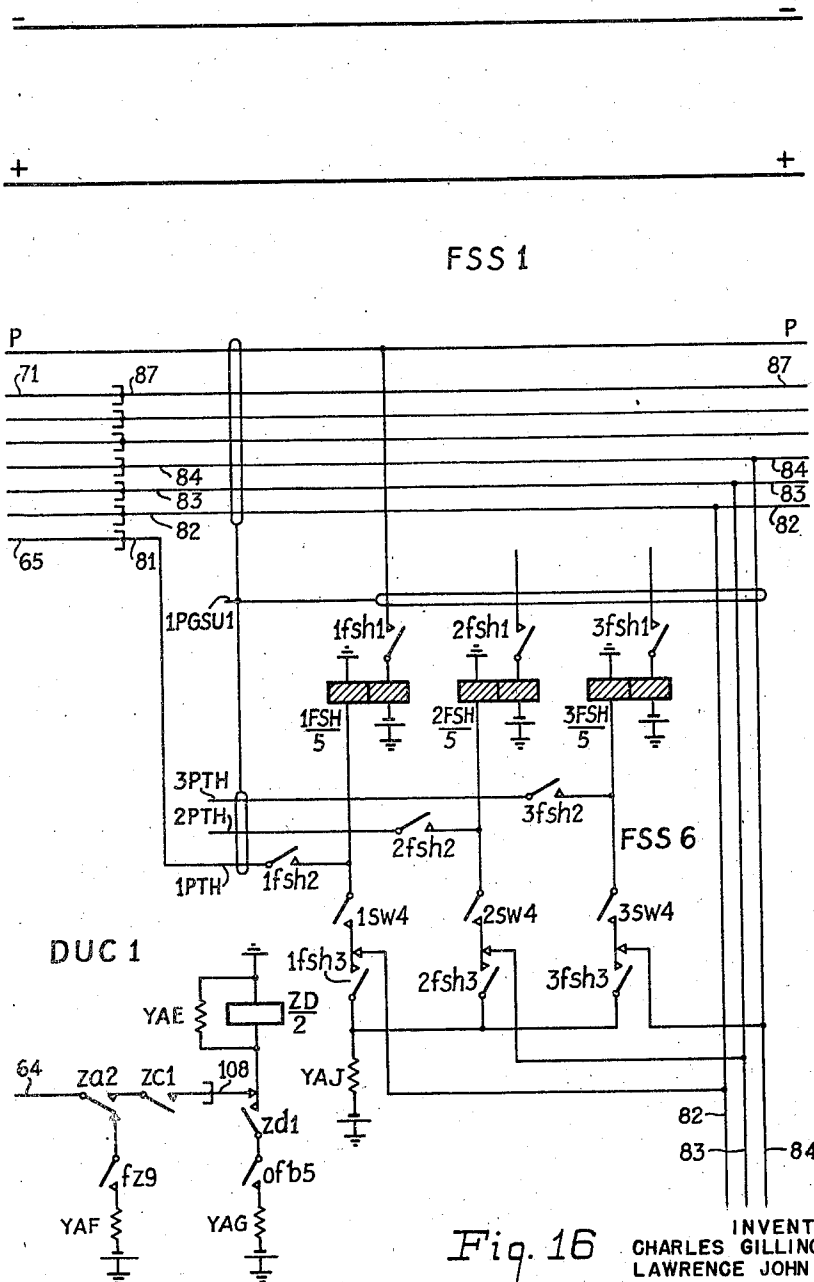
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16 INVENTORS
CHARLES GILLINGS
LAWRENCE JOHN MURRAY

BY *Chas. T. Condy*
ATTORNEY

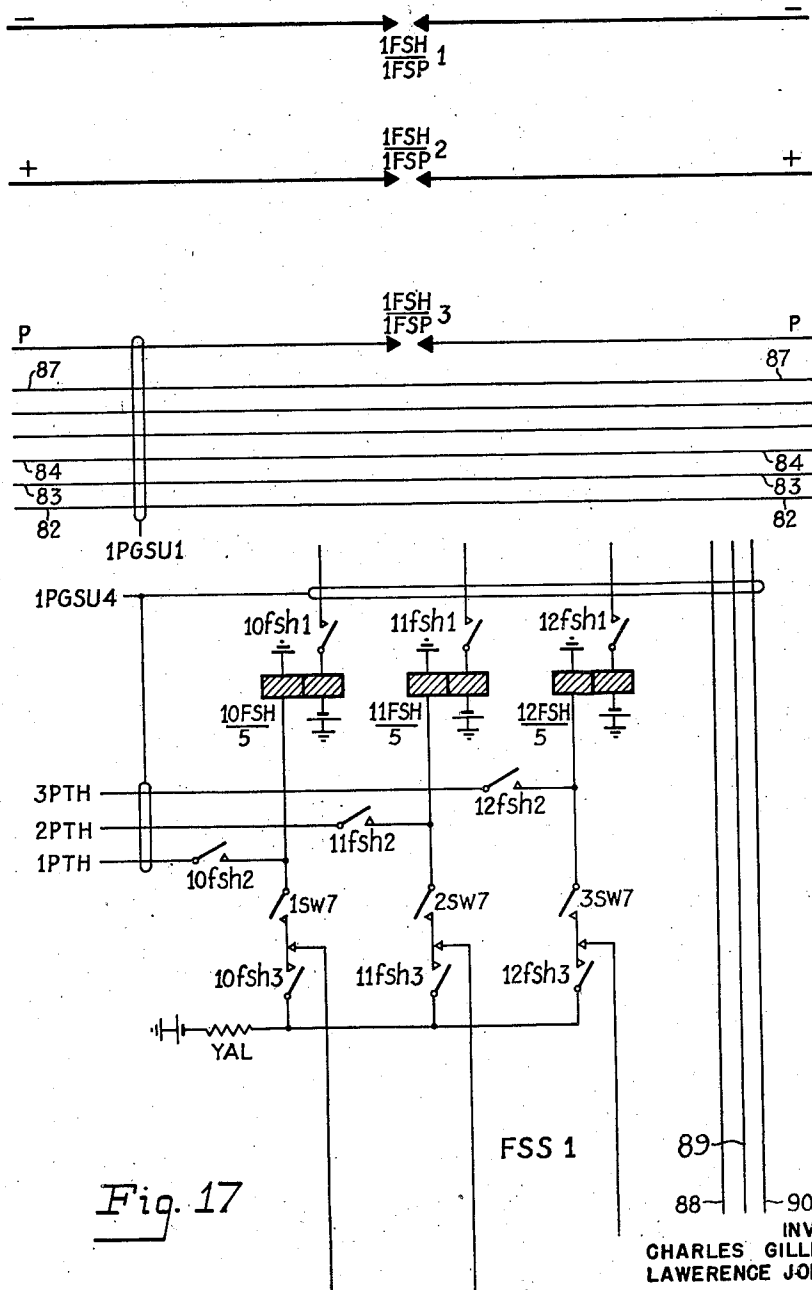
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TELEPHONE OR LIKE SYSTEM

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BY

Charles H. Candy
ATTORNEY

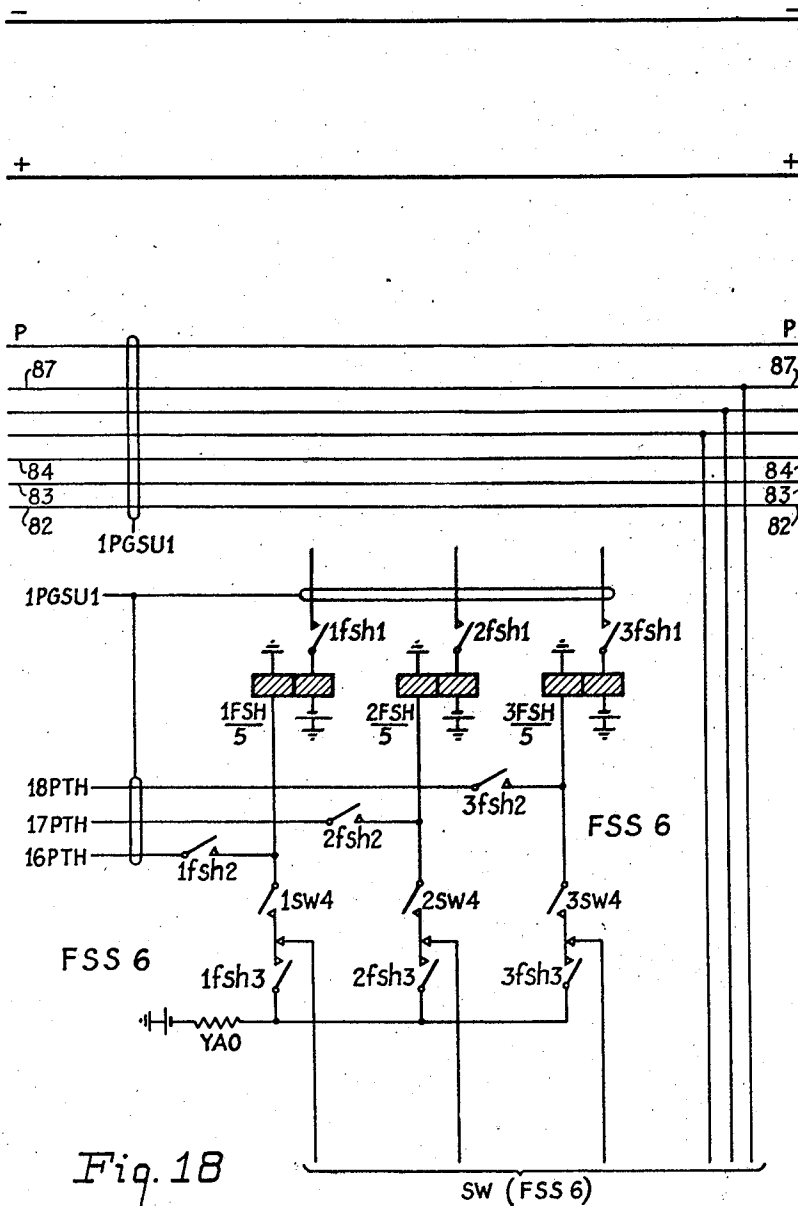
Dec. 10, 1946.

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25 Sheets-Sheet 18



INVENTORS
CHARLES GILLINGS
LAWRENCE JOHN MURRAY

BY *Chas. M. Candy*
ATTORNEY

Dec. 10, 1946.

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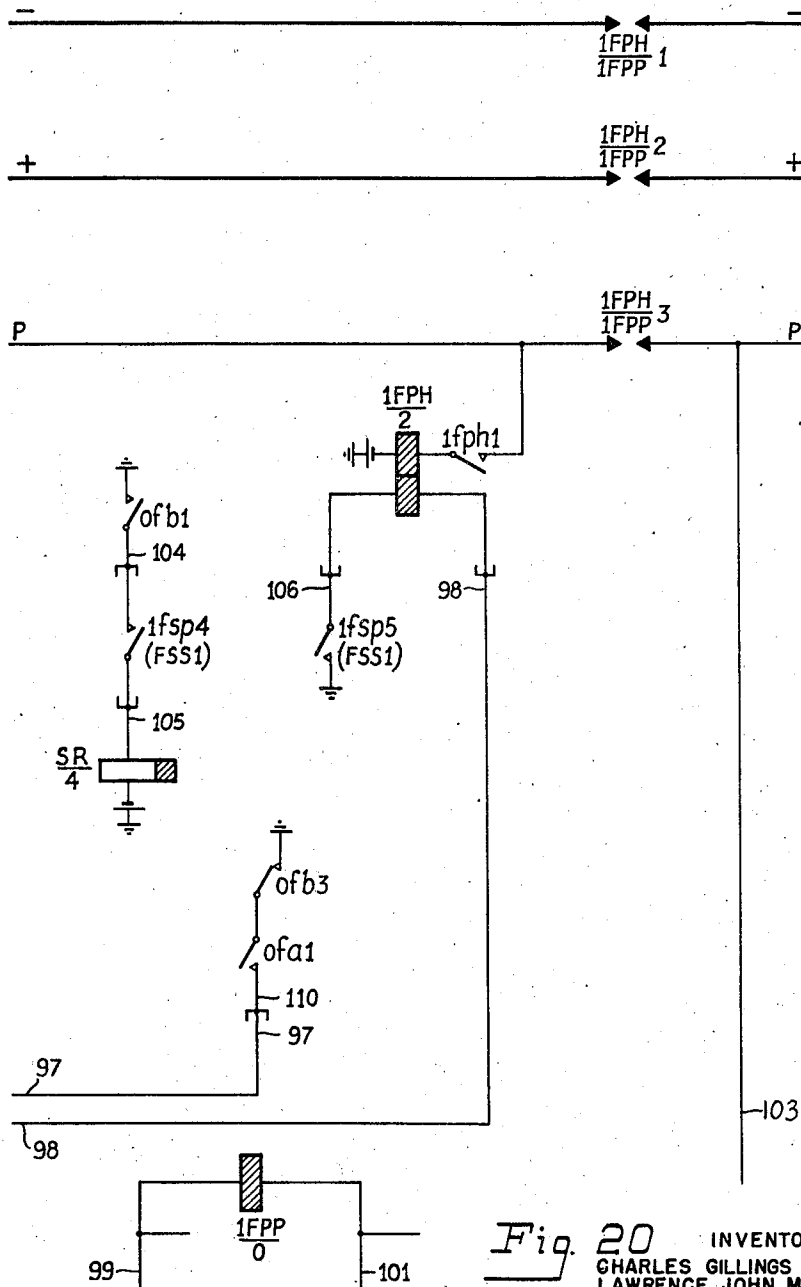


Fig. 20 INVENTORS
CHARLES GILLINGS
LAWRENCE JOHN MURRAY

BY Chas. L. Candy
ATTORNEY

Dec. 10, 1946.

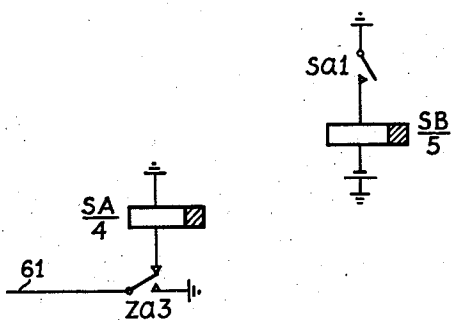
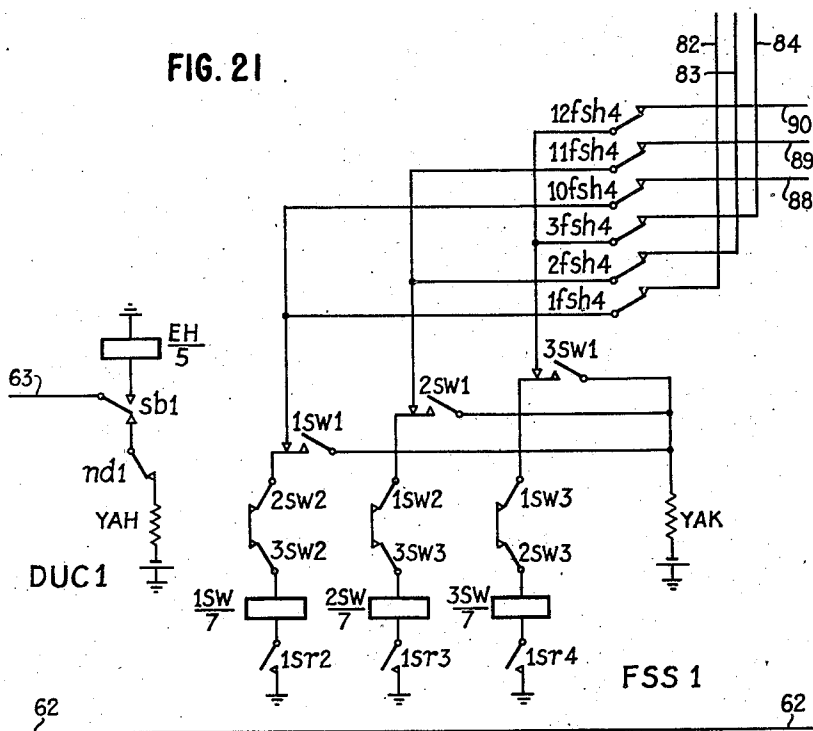
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FIG. 21



16	17	18	19	20
21	22	23	24	25

INVENTORS
CHARLES GILLINGS
LAWRENCE JOHN MURRAY

BY *Chas. W. Candy*
ATTORNEY

Dec. 10, 1946.

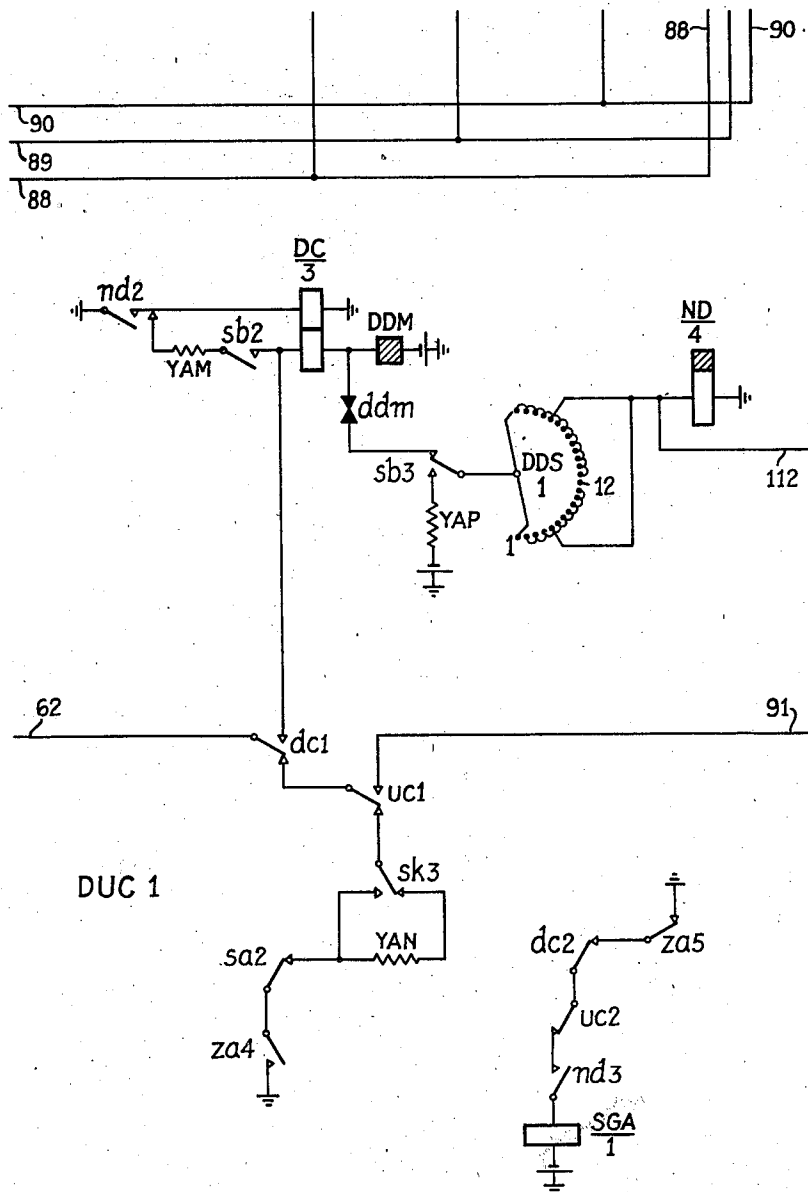
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INVENTORS
CHARLES GILLINGS
LAWRENCE JOHN MURRAY

BY

BY *Chas. M. Candy*
ATTORNEY

Dec. 10, 1946.

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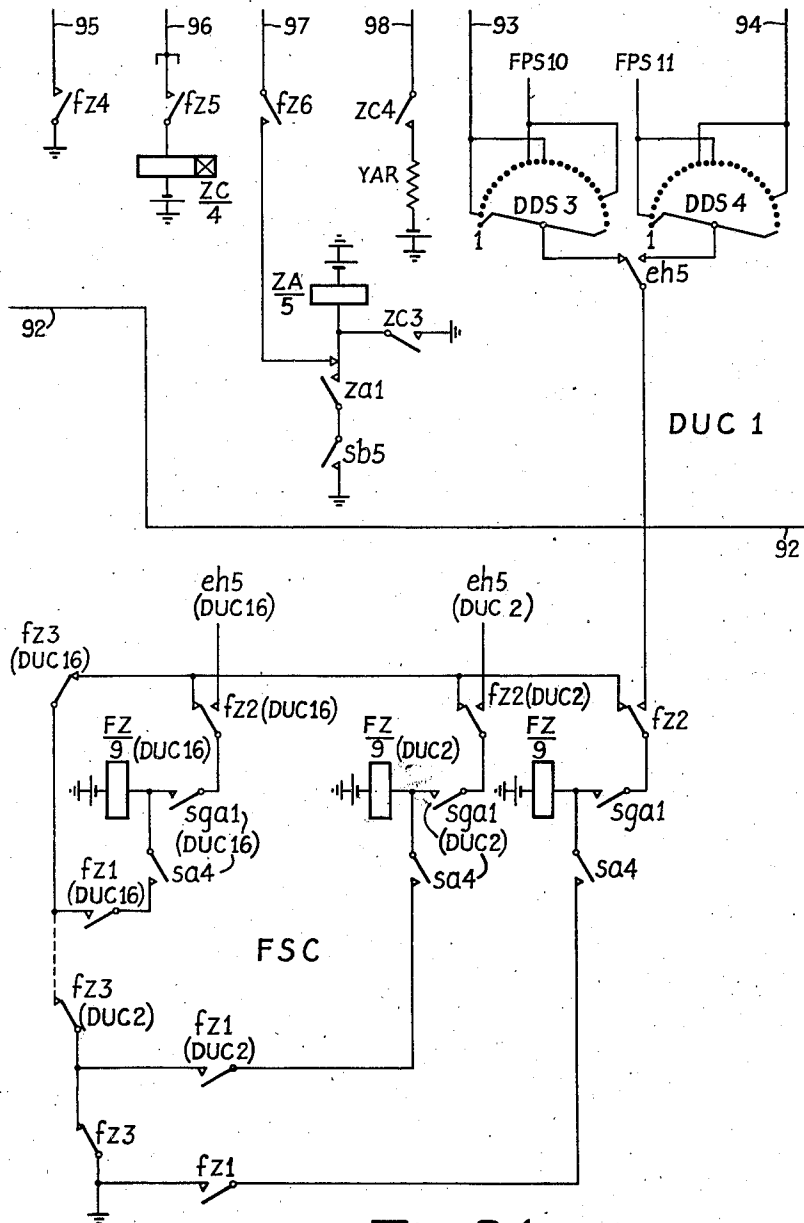


Fig. 24

INVENTORS'
CHARLES GILLINGS
LAWRENCE JOHN MURRAY

BY

Chas. W. Candy

ATTORNEY

Dec. 10, 1946.

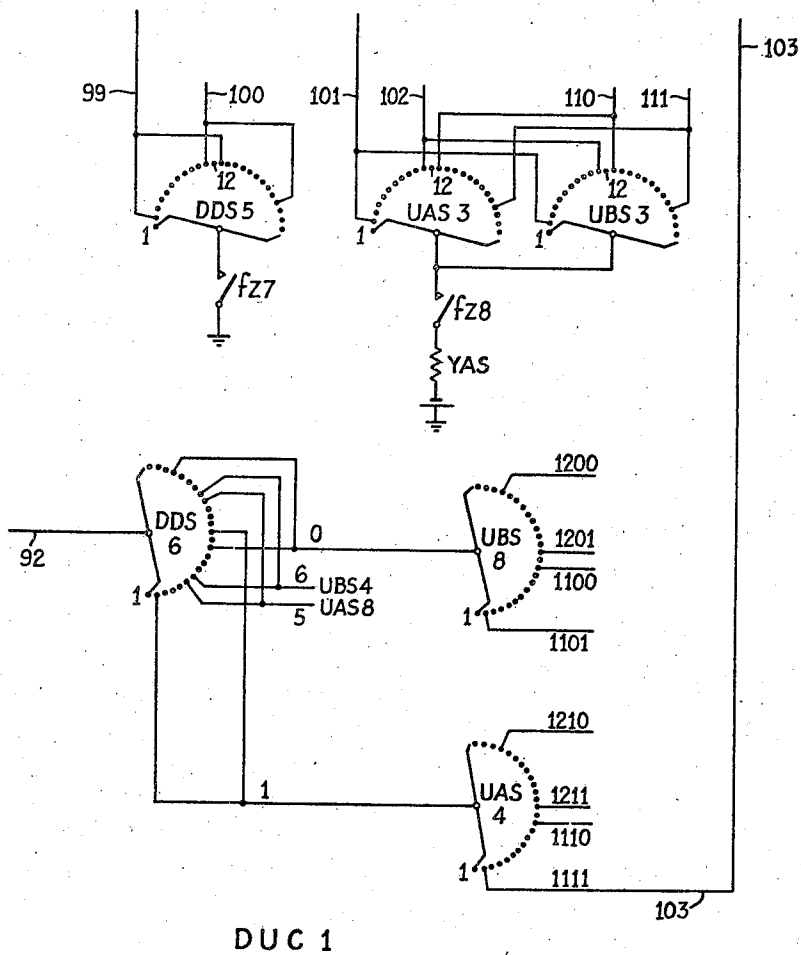
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25 Sheets-Sheet 25



INVENTORS
CHARLES GILLINGS
LAWRENCE JOHN MURRAY

CHARLES GILLINGS

LAWRENCE JOHN MURRAY

BY

Y *Chas. T. Condy*

ATTORNEY

UNITED STATES PATENT OFFICE

2,412,258

TELEPHONE OR LIKE SYSTEM

Charles Gillings and Lawrence John Murray,
Liverpool, England, assignors to Automatic
Electric Laboratories, Inc., Chicago, Ill., a cor-
poration of Delaware

Application December 8, 1943, Serial No. 513,370
In Great Britain December 31, 1942

19 Claims. (Cl. 179—18)

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The present invention relates to telephone and like systems, and is more particularly concerned with automatic telephone systems in which use is made of selecting switches of the crossbar type having sets of contacts arranged to form both rows and columns at right angles to one another.

In such switches there is usually provided for each of the columns a holding bar member operable under control of an electromagnet, while for each pair of adjacent rows of contact sets there is usually provided a selecting or preparing bar member which carries a number of flexible or flexibly mounted selecting fingers corresponding to the number of vertical columns, and which is operable under control of either of a pair of electromagnets to move the selecting fingers into position adjacent the contact sets of either of the pair of rows involved.

For a 100-point switch involving ten rows and ten columns of contact sets there will be provided five two-way horizontal selecting bars each of which will carry ten selecting fingers corresponding to the ten vertical holding bars which will be required and at each of the fifty intersection points two sets of contacts will be provided. In order to select a given set of contacts the associated horizontal bar will be twisted in a direction to bring its selecting fingers opposite the contact sets of the particular row of ten in which the required contact set is located and the subsequent operation of the vertical bar common to all the sets of contacts in the same column as that in which the required contact set is located will operate this contact set due to the fact that this will be the only one in the column having a selecting finger interposed between itself and the vertical bar.

When this contact set has been operated the horizontal bar may be released, but the contact set operated will remain held from the vertical holding bar. Subsequently a second or further set of contacts can be operated in similar manner provided it is in a different column to the one already operated, but it may be located on the same row.

It is the object of the invention to provide an automatic telephone system in which the contact and mechanical efficiency of crossbar switching mechanisms can be obtained without excessive capital cost by suitable trunking and grouping arrangements of the crossbar switches and by the use of common relays and common simple uni-directional switch mechanism for control purposes.

In one known system control equipment com-

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mon to the whole exchange has been provided which after the number of the required party has been dialled determines the route over which the connection is to be set up and causes the operation of crossbar switches to set up the call over the route selected. In this system the same crossbar switch may be used for more than one connection at a time.

In another known system crossbar switches have been individually controlled by equipment individual thereto but in such cases a crossbar switch could only be used for one connection at a time.

According to the invention in a telephone system employing crossbar switches controlled by selective prepare and hold operations control equipment is provided individual to each of a number of switching stages to enable one connection after another to be set up through the switching stage to which the control equipment is individual after the hold operations for the switching stage have enabled fresh prepare operations to take place.

The invention will be better understood from the following description of one method of carrying it into effect, reference being had to the accompanying drawings comprising Figs. 1-26.

Of these figures:

Figs. 1-3 when arranged side by side show the essential trunking arrangements of an automatic exchange system which is assumed to employ a four digit numbering scheme involving subscribers' numbers 1000-9999.

Figs. 4-7, when arranged in the manner shown in Fig. 7a, show circuits of the primary/secondary preselecting stage.

Figs. 8-11, when arranged in the manner shown in Fig. 11a, show circuits of the first numerical (thousands digit) group selecting stage.

Figs. 12-15, when arranged in the manner shown in Fig. 14a, show circuits of the second numerical (hundreds digit) selecting stage, which stage, in the example to be described, will be the penultimate selecting stage since the final stage will receive the last two digits of the four digit number dialled.

Figs. 16-25, when arranged in the manner shown in Fig. 21a, show circuits of the final primary/secondary switching stage via which access is had to the wanted subscriber in response to the dialling of the tens and units digits of the required number.

Fig. 26, at the foot of Fig. 1, shows elements of the test circuit for a link between a penulti-

mate selector and the final primary/secondary stage.

Referring now to the trunking diagram, the four essential switching stages involved are as follows:

(a) The primary/secondary preselection stage by means of which a subscriber can, by removing his receiver, be connected to a first numerical crossbar group selecting unit such as GSU1 via the intermediary of relatively small capacity primary and secondary crossbar switching units such as PSU1 and SSU1. A preselecting stage serves between two hundred and eight hundred subscribers' lines according to the traffic involved, and connects with a group of up to six first numerical group selecting units so that it can be said that any subscriber on the exchange has potential access to any one of a maximum number of six such units in a group.

(b) The first numerical selecting stage comprising so-called crossbar group selecting units such as GSU1 which give access to second numerical groups selecting units such as IPGSU1 and which are of the ten level twenty outlet per level type, and which can handle up to ten connections at any one time. The word "level" is used in place of the word "row," in view of the use of the word "level" in the well known step-by-step automatic telephone system as representing a group of outlets in a single row.

(c) The selecting units such as IPGSU1 of the second numerical stage will hereinafter be referred to as penultimate group selecting units and in the circuits of which are provided the battery feeding, ringing relays, and etc., required in the setting up and completion of a connection. These selecting units are of the five level eighteen outlet per level type, the five levels enabling access to be had to a desired one of five two hundred line groups of subscribers located in up to five so-called final primary/secondary switching groups. Each final group accommodates from a minimum of two hundred subscribers up to a maximum of one thousands subscribers, according to the traffic involved.

(d) The final primary/secondary switching stage, via which connection may be made between a calling penultimate selecting stage and a called subscriber. The dialling of the hundreds digit of a wanted subscriber's number enables a penultimate selecting unit to determine the two hundred line group and hence the final switching group in which this subscriber is located and the subsequent dialling of the last two digits, i. e. the tens and units digits of the number are effective on common equipment to select the called party within the selected group and thereupon to cause a final primary switching unit, such as FPSU1, on which this party is located, to function in conjunction with a secondary switching unit such as FSSU1, to connect this subscriber with the calling link incoming to the penultimate selector in question.

Having reviewed the essentials of the method of effecting a connection between a calling and called party on the exchange, the construction and grouping of the various crossbar switching units will now be reviewed in more detail.

In the ensuing paragraphs the various links involved in a connection will be referred to as such, but whenever it is desired to distinguish between such links and the vertical bar links within the various crossbar switching and group selecting units, then the former may be referred to as "external links" while the latter will be

referred to as "internal vertical bar links" or simply "internal links."

Referring now to the preselecting primary/secondary stage, each of the primary switching units is ordinarily arranged to accommodate twenty subscribers' lines and to have access to six outlets each of which extends to a secondary switching unit. Up to twenty primary units may be arranged in a column (units PSU1 and PSU20 of which are shown in the drawings) and one or two such columns, according to the traffic density involved, has or have access to a group of six secondary switching units SSU1—SSU6, each of which terminates twenty links from the primary units and has access to ten first numerical group selecting units.

Hence a group of sixty group selecting units such as GSU1—GSU60 serves one or two columns of primary switching units according to the traffic density, i. e. either four hundred or eight hundred subscribers, but it will be appreciated that these quantities may be altered to suit special traffic conditions. For instance, if extra heavy traffic conditions are involved each primary switching unit might be adapted only to accommodate ten subscribers and if only one such column was provided per group of six secondary switching units then the six selecting units would be serving two hundred subscribers only. In this latter case if the traffic should become lighter, two or more columns of two hundred subscribers each might be connected in parallel to the same set of outlets so that the six selecting units would then serve four hundred or more subscribers.

In the drawings where a total of eight hundred subscribers are assumed to share the one hundred and twenty links to the six secondary units, and hence to the six selecting units, the subscribers' numbers involved are assumed to range from 3111—3800 inclusive.

As regards the construction of the crossbar units PSU1—PSU20, these each comprise ten two-way horizontal selecting or preparing bars together with ten pairs of the associated bar controlling relays 1PP, 2PP; . . . 20PP, which connect with the twenty subscribers' lines concerned. In addition six vertical holding bars and associated controlling relays 1PH—6PH are provided to enable connection to be effected between a calling line and any one of the six outlets available to a switching unit. Similar remarks apply as regards the secondary switching units with the exception that in this instance there are twenty vertical bars and controlling relays 1SH—20SH and five two-way horizontal bars and five pairs of horizontal bar controlling relays 1SP, 2SP; . . . 10SP.

As regards the group selecting units, preferably these will each comprise two crossbar switching units with their vertical bars in effect coupled together as shown to form a group selecting unit. More specifically the coupling will be effected electrically by the connection of each column of vertically commoned contact springs of the spring sets in one unit with a corresponding column of vertically commoned contact springs on the other unit of the pair. As previously mentioned each group selecting unit is of the ten level twenty outlet per level type, and is capable of handling ten connections and for this purpose the ten incoming links per group selecting unit will connect with the horizontal bar controlling relays 1GSP—10GSP. The horizontal bars provided for the purpose of determining the selected one of the ten possible levels are con-

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trolled by the relays 1GTP—10GTP and the two sets of twenty vertical holding relays 1GSH—20GSH and 1GTH—20GTH are operable in pairs such as 1GSH and 1GTH or 2GSH and 2GTH and so on to enable the two units of the pair forming the group selecting unit proper to function to connect an incoming external link via a free internal link within the selector to a free one of the twenty outgoing links accessible from a selected level of the selector.

The reason for the splitting of a group selecting unit into two coupled parts is purely mechanical and is done to avoid having twenty rows and twenty columns on one mechanism. If however such an arrangement should prove a practical proposition, then obviously a single mechanism will be employed and one set of twenty vertical holding relays can then be dispensed with.

In the particular four digit automatic exchange being described, the next rank of switches will be the penultimate group selecting units which are arranged to provide a battery feed to the calling and called parties of a connection, but it will be appreciated that in larger capacity exchanges where another group selector stage or stages precede the penultimate group selector stage, then such stage or stages will be of the type already described.

As regards the penultimate group selecting units, these are generally similar in operation to the ordinary group selecting units but are different in several respects as will be shortly appreciated. Each of them terminates ten incoming links from the preceding group selector stage and has five levels of eighteen outlets each to give access to any of five two hundred line groups of subscribers in the thousands group which a particular penultimate selecting unit is serving. As previously mentioned the penultimate selecting unit is responsive to the hundreds dialled digit in response to which it determines the particular two hundred line group in which a called subscriber is located, while the dialling of the tens and units digits are effective on common equipment known as a DU control, three or more of which are provided per two hundred line group, and which will be described later, to determine the particular wanted subscriber in this group.

This subscriber is then made to simulate a calling subscriber and hence to search backwardly for the calling incoming link to the penultimate selecting unit in question and for this purpose the various subscribers on an exchange in addition to being grouped into preselecting primary/secondary switching groups as described are also grouped into final primary/secondary switching groups which function in a somewhat like manner to the former. For a given called party the final primary/secondary group concerned will have been decided in accordance with the hundreds digit dialled and this group enables the called party, selected by common equipment in response to the dialling of the tens and units digits, to be connected with the calling incoming link to the penultimate selecting unit in question.

Each of the final primary/secondary switching groups accommodates from between two hundred to one thousand subscribers according to the traffic involved so that in the former case the penultimate selecting units of a particular thousands group will serve five primary/secondary switching groups of two hundred lines each, while in the latter case they will serve a single one thousand line switching group. On the trunking diagram it is assumed that the traffic is such that

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a final primary/secondary switching group can accommodate four hundred subscribers, so that for a given thousands group, say, thousands group 1, with subscribers Nos. 1111–1000, levels 1–4 and 5–8 of the relevant penultimate selectors will be accessible from two final primary/secondary switching groups serving respectively the four hundred subscribers 1111–1400 and the four hundred subscribers 1511–1800. Levels 9 and 0 will be accessible from the first two hundred subscribers 1911–1000 of the primary/secondary switching group serving subscribers 1911–1000 and 2111–2200.

Considering the final primary/secondary group serving the four hundred subscribers 1111–1400 as shown in Fig. 3, each component final primary switching unit such as FPS1 accommodates ten subscribers and each unit has access to six links extending to final secondary units such as FSS1. Up to twenty final primary units may be arranged in a column (units FPS1 and FPS20 of which are shown in the drawings) and two such columns comprising four hundred subscribers in all will, in the present instance have access to a group of six secondary switching units FSS1—FSS6, each of which has access to twelve links to the levels of the penultimate selecting units of the thousands group in question. From the six secondary units there are thus a total of seventy-two links to the levels of the penultimate selecting units, it being estimated that this number of links is the maximum number which will ever be required by a final primary/secondary switching group under the heaviest traffic conditions. Under such conditions the minimum number of two hundred subscribers would be accommodated in one final group and the seventy-two links would thus be serving two hundred subscribers, while in the lightest traffic case where the maximum of one thousand subscribers in five columns of two hundred are accommodated by a final primary/secondary switching group, the seventy-two trunks would be serving one thousand subscribers.

If the penultimate selecting units are provided with sufficient outlets per level to give full availability between the secondary switching units and the selecting unit levels, i. e., if all the links to a final primary/secondary group are available from the levels of a penultimate selecting unit, then since the links are all in one group, the full complement of seventy-two will not be required, a number of the order of sixty being all that is necessary. Such a switching unit would, however, be cumbersome and expensive and, accordingly, for practical purposes the penultimate selecting units of each thousands group are divided up into four sets, each serving eighteen links to secondary switching units, 1PGSU1 and 1PGSU4 (Fig. 2) being examples of penultimate selecting units of the same thousands group "1" but of different sets.

It will be assumed at this stage that the traffic is very light as far as the subscribers in the thousands group "1" are concerned, so that these will all be accommodated in one final primary/secondary group which is accessible from all levels of the thousands group "1" penultimate selecting units. Under these circumstances each switch, in common with other switches of the same set, will have access to eighteen of the seventy-two available links to the final group concerned.

Returning to the consideration of the final secondary switching units such as FSS1, it will be remembered that each of these has access to

twelve penultimate selector links; these twelve links are sub-divided into four groups of three links each, each group extending to one of the four sets into which the associated penultimate selecting units are divided. Hence when a connection has to be made between an incoming link to a penultimate selecting unit and a given called subscriber there are just eighteen links over which this connection may be made and the controlling arrangements, as will be later described, will be such that only these eighteen links can be tested, the other fifty-four links extending from the relevant final primary/secondary switching group to the other three sets of penultimate selecting units serving the same thousands group being left alone. A called subscriber is thus prevented from being backwardly connected by this final primary/secondary group to a set of penultimate selectors other than that in which the penultimate selecting unit on which the calling incoming link terminates, is located.

Under very heavy traffic conditions where one final primary/secondary switching group serves two hundred subscribers' lines only, the four sets of eighteen links will extend to level 1.2 of the penultimate selectors in the corresponding sets.

If the traffic is lighter, two columns of two hundred subscribers each may be served by the same final primary/secondary switching group as shown in the drawings, and in this case the corresponding outlets of the two levels 1.2 and 3.4 of the relevant penultimate selecting units will be multiplied together as shown. In this instance therefore, two and one half final primary/secondary switching groups are served by the selecting unit of each particular thousands digit.

This process can be extended as required so that if the traffic proves very light then up to one thousand subscribers' lines in five columns of two hundred each will be served by one final primary/secondary switching group, in which case all five levels 1.2-9.0 of the relevant penultimate selecting units will be multiplied together. In this latter case it may prove unnecessary to provide switching levels on the penultimate selectors as the links from the final secondary switching units FSS1-FSS6 could terminate directly on the internal links within the penultimate selecting units, that is to say directly on the vertically commoned springs of the crossbar switch spring sets.

All the above described crossbar switching units are set under control of common groups of relays and simple unidirectional switch mechanisms or uniselectors of the 25 point reverse drive electromagnetically operated type, the function and arrangement of which will be better appreciated from the following circuit description. For the purpose of this description a through call will be traced from subscriber 3111 on primary switching unit PSU1 to subscriber 1111 on final primary switching unit FPS1 and for convenience it will be assumed that the call will be extended through units PSU1 and SSU1; group selecting unit GSU1; penultimate group selecting unit PGSU1 and final switching units FSS1 and FPS1.

In the circuits the number of contact units carried by each relay is shown beneath its designation, as for instance

$$\frac{K}{2}$$

(Fig. 4), and are designated individually in small letters which in this instance will be *k*1 and *k*2. A slow to release relay is shown with a

hatched portion at one end of the rectangle indicative thereof, while a slow to operate relay is shown with a cross at one end, such a relay being in some instances slow to release as well as slow to operate.

As regards the crossbar vertical and horizontal relays, these are indicated by hatched rectangles, the contact units individual thereto being indicated in the same manner as for ordinary relays. The sets of crossbar switch contacts proper which are closed at the intersection of any given pair of vertical and horizontal bars, say controlled by magnets 1PH and 1PP (Fig. 4) are designated consecutively

$$\frac{1PP}{1PH}, \frac{1PP}{1PH}^2$$

according to the set of contacts involved.

Of the various uni-selectors such as that shown in Fig. 4 which is designated HS, the various sets of wipers and banks are designated HS1, HS2, etc. The driving magnet which is indicated by a hatched square will in this instance be designated HM and the magnet interrupter contacts will be designated *hm*. All the uniselectors are of the 25 point type and where the number of outlets per bank is considerably less than twenty-five they are arranged to make multiple appearances thereon as will be appreciated from examination of the circuits.

The circuits of the primary/secondary preselecting stage, are illustrated in Figs. 4-7 which should be referred to in conjunction with Fig. 1 of the trunking diagram. In order to associate a free first numerical group selecting unit with a calling line via the intermediary of the primary and secondary switching units, a primary control group such as PCG (lower half of Fig. 4 and Fig. 6) is provided per forty subscribers' lines so that in the example described in connection with the trunking diagram a control group will be provided for each pair of primary switching units such as PSU1 and PSU2 in a column. For each column there will be ten primary control groups, and since the outlets of corresponding switching units in the two columns are multiplied together as shown in Fig. 1, then corresponding pairs of primary control groups will be likewise linked together as far as access to the secondary switching units is concerned.

The line circuit of subscriber No. 3111 (on unit PSU1) is shown and control group PCG will be therefore available to this subscriber and also to the thirty-nine other subscribers on units PSU1 and PSU2. In control group PCG there are provided two uni-directional switches HS and SGS, wipers and banks HS1-HS4 of the former serving to connect the control group with a calling one of the associated forty lines, while the wipers and banks SGS1-SGS4 of the latter serve to associate group PCG with a secondary unit control group.

As regards the secondary units such as SSU1-SSU6 (Fig. 1), each of these units has associated therewith a secondary control group such as SCG shown in the lower half of Fig. 5 and in Fig. 7, which is assumed to be associated with switching unit SSU1. The control group SCG employs a uni-selector SS, with wipers and banks SS1 and SS2, by which access is had to a free one of the ten first numerical selectors to which each secondary unit has access.

If subscriber No. 3111 originates a call the loop placed by his telephone across the left hand top set of incoming negative and positive conductors

(Fig. 4), operates line relay R, whereupon at contacts *r1* a guard earth is extended on to the incoming P lead and at contacts *r2* earth is extended over common lead 10 to bring up relay 1S in the primary control group PCG serving the twenty subscribers 3111-3120 on primary unit PSU1, while at contacts *r3* the calling line circuit is marked on the bank HS2 of the control group line hunting switch HS. The control group is also adapted to serve the twenty subscribers 3131-3140 on the unit PSU2 and discrimination as to which primary switching unit is concerned is effected by the relays 1S and 2S, relay 1S being operated for calls originated from unit PSU1 and relay 2S being operated over lead 11 for calls originated from unit PSU2.

Relay 1S in operating at its contacts *1s1* extends to start earth over lead 15 to magnet SGM of the secondary control group hunting switch SGS, and since the magnet circuit is completed via its interrupter contacts *sgm* the magnet operates in a self-interrupted circuit and commences to rotate the SGS switch wipers round the banks. At contacts *1s2* (Fig. 4) a self-interrupted driving circuit is completed for magnet HM of switch HS, at contacts *1s3* the cut-drive testing relay RK is connected up to wiper HS2, the bank of which connects with the line circuits of subscribers 3111-3120, at contact *1s4* a circuit is prepared for the prepare relays such as IPP, while at contacts *1s5* and *1s6* the cut-drive testing relay TK is connected up to the contacts such as 2-7 on bank SGS3 which connect up with the six secondary control groups and associated secondary switching units to which the calling unit PSU1 has access. From reference to Fig. 1 it will be seen that the six outlets on unit PSU1 connect with the first vertical internal link and associated control relay 1SH of each of the six secondary units SSU1-SSU6 so that access must be had from the primary control group PCG to all six available secondary units, but at the same time arrangements must be made to test on only the first vertical internal link of each secondary switching unit and not on the other nineteen internal links of each unit. This will be better appreciated as the description proceeds. When wiper HS2 encounters the calling line which will be marked by an earth potential in this instance contact 2, a circuit is completed over lead 12, operated contacts *r3* for relay RK which quickly operates and at contacts *rk3* opens the magnet driving circuit to halt the switch. At contacts *rk1* it extends the start earth over contacts *1s4*, wiper HS4 in position 2 and lead 13 to crossbar prepare relay IPP associated with subscriber No. 3111 on unit PSU1, relay IPP thereupon actuating its associated horizontal bar. Contacts *rk3* also bring up the relief relay RKR which locks via contacts *rk1* and *1s2* to earth and at contacts *rk3* disconnects the initial start earth circuit. The earth circuit to leads 13 and 15 is, however, maintained over contacts *1s2*, *rk3* or *rk1* and *rk2* so that the driving circuit for magnet SGM will not be interrupted if switch SGS has not found a free outlet by this time. Relay RKR in operating also at contacts *rk4* further disconnects any operating circuit for relay 2S from lead 11, this circuit having been initially broken by contacts *1s7*.

As regards the hunting for a free one of the six secondary control groups available to the calling primary switching unit PSU1, it will be understood from Fig. 6 that contacts 2-7 on bank SGS3 give access to the six secondary control

groups concerned, one of which, SCG, being accessible over test lead 17 which connects with contact 2 of bank SGS3. Referring to Fig. 7 it will be seen that in circuit with lead 17 are provided contacts *1sh3* of relay 1SH on secondary switching unit SSU1 so that if the first vertical internal link within this secondary unit is busy, then relay 1SH will be operated and will open lead 17 to mark this switching unit as busy to the hunting switch SGS. Although it will be dealt with fully later, it may be mentioned here that as regards the test lead which will extend from contact 3 on bank SGS3 this will connect with the SSR relay of the control group serving secondary unit SSU2 via contacts *1sh3* of the first vertical bar relay 1SH on that unit, and so on. Relay SSR in each secondary control group such as SCG is moreover accessible from twenty test leads extending from the ten primary control groups serving the twenty primary units in a column and on the basis of two test leads per primary control group. Of the two test leads shown lead 17 extends as described from group PCG and is in association with primary unit PSU1 while lead 19 extends from the control group serving primary units PSU19 and PSU20 and is in association with unit PSU20. Furthermore, each test lead is common, in the present instance, to the two primary control groups serving a pair of primary units in one column and a corresponding pair of primary units in the adjacent column, this being so since a primary switching unit in one column shares its outlets with the corresponding unit in the adjacent column.

It will be assumed that the first internal link on secondary unit SSU1 is free so that when switch SGS reaches position 2 earth will extend over resistance YC (Fig. 6), contacts *1s5*, windings of testing relay TK in series, wiper SGS4 in position 2, contacts *1s6*, wiper SGS3 in position 2, lead 17, contacts *1sh3* and *sgb21* (Fig. 7) and winding of the secondary group start relay SSR in parallel with resistance YG to battery. At this point it may be mentioned that unit SSU1 can only be marked as free to the hunting switch SGS if there is one or more of its outlets available to the group selectors. In case all the outlets are busy, a relay SGB, individual to unit SSU1, will be operated in a manner to be described later and at contacts *sgb21* opens any circuit to relay SSR thereby busying all twenty test leads incoming to the switching unit control group SCG. If relay SGB is normal, then relay TK will quickly operate and at contacts *tk1* (Fig. 6) opens the SGM magnet driving circuit and completes an operating circuit for relief relay TKR while at contacts *tk2* a guard earth is extended forward via the upper low resistance winding of relay TK on to lead 17 to bring up relay SSR. The reason for the use of the dual testing cut-drive type of relay TK and its more precise operation will be dealt with later.

If by the time relay TKR operates relay RKR (Fig. 4) has already operated thereby signifying that the calling line has already been located by the hunting switch HS then on operation of relay TKR battery will be extended forward over its lower winding, contacts *rk1* and *tkr4*, wiper SGS2 in position 2, and common lead 16 to prepare for the operation of relay 1SH on secondary unit SSU1 as soon as a free one of the ten outlets from this secondary unit to a first numerical group selecting unit has been found.

Relay SSR in operating at contacts *ssr1* and *ssr2* (Fig. 5) connects up the dual testing cut-

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drive relay SK on to wiper and bank SS1 contacts of which connect with the P leads extending to ten of the first group selecting units GSU1—GSU6. It is assumed that contact 2 of bank SS1 extends to group selecting unit GSU1 and the other nine outlets will extend to selected ones of the group selecting units GSU2—GSU6. Relay SSR at contacts *ssr5* also completes a self-interrupted driving circuit for magnet SM of switch SS and, assuming that the first group selector GSU1 of the ten available group selectors to the secondary unit is free, relay SK will quickly operate over the following circuit: earth, resistance YF, contacts *ssr2*, relay SK, contacts *ssr1*, wiper SS1 in position 2, outgoing P lead to an idle marking resistance battery YK in parallel with the start relays GS in the group selector control circuit of Fig. 8, which as previously mentioned shows part of the circuits of group selector GSU1 and its associated common equipment. Relay SK, which will be further discussed later, in operating at contacts *sk2* opens the SM magnet driving circuit and operates the relief relay SKR while at contacts *sk1* earth is extended forward over the upper low resistance winding in order to guard the outlet seized and at the same time to provide sufficient current to operate the group-selector control-set start relay GS. Relay SKR in operating at contacts *skr2* extends earth over wiper SS2 in position 2 to bring up the prepare relay ISP corresponding to the outlet seized. Relay ISP in operating actuates its associated horizontal bar and at its contacts *isp1* extends a full earth on to the outgoing P lead, which earth short circuits and releases relay SK, but relay SKR remains operated over contacts *ssr4*, *isp2* and *skr3* and thereupon maintains the magnet driving circuit open at contacts *skr4*. At contacts *isp3* an earth is connected up over lead 18, common to the other relays 2SH—20SH on the same unit, and onto which lead corresponding contacts of the other relays 2SP—10SP are adapted to extend earth to the lower winding of relay ISH, whereupon since there will be already connected to the other side of this winding a battery potential via relay TKR in the primary control group PCG, relay ISH will operate, and in so doing actuates its associated first vertical bar on unit SSU1 so that the set of contacts at the intersection of the vertical and horizontal bars in question will be operated; these are shown as

$$\frac{ISH}{ISP}^{1-3}$$

in Fig. 5. Relay ISH in operating also at its contacts *ish1* (Fig. 4) completes an operating circuit via earthed lead 14 for the corresponding vertical hold relay IPH on primary unit PSU1, at contacts *ish2* prepares a locking circuit for itself onto the P lead which will be earthed when the calling loop is extended forward to the group selecting unit GSU1 and at contacts *ish3* (Fig. 7) disconnects test lead 17 to mark the first link between the primary and secondary units PSU1 and SSU1 as busy. Relay TK (Fig. 6) then releases but relay TKR remains held in series with the lower winding of relay ISH. Relay IPH (Fig. 4) in operating actuates its associated vertical bar, whereupon since relay IPP has already operated the crossbar contacts

$$\frac{IPP}{IPH}^{1-3}$$

are closed and the calling subscriber's loop is

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thereupon extended through to the group selecting unit GSU1 which has been taken in use.

Relay ISH in operating at its contacts *ish3* (Fig. 7) in addition to disconnecting lead 17, opens the circuit for relay SSR which commences to release slowly, while relay IPH (Fig. 4) in operating at its contacts *iph1* extends the earthed lead 14 through on to the P lead. This earth thereupon extends backwards over contacts

$$\frac{1PP}{1PH}^3$$

to bring up the calling party's cut-off relay K, whereupon at contacts *k1* and *k2* the subscriber's line relay R is disconnected from across the line and relay R thereupon releases. Relay R in releasing at contacts *r3* releases relay RK and since relay RKR is operated at this time, then the holding circuit for relay IS which has up to this time been maintained over contacts *is2*, *rkr1*, *rkr2*, *is1* and *2s7* is disconnected at contacts *rkr2* so that relay IS releases, whereupon the circuit of relay RKR is opened at contacts *is2* and relay RKR releases in turn. The holding circuit for relay TKR on its lower winding will now be opened at contacts *rkr6* so that relay ISH which was holding in series therewith must now hold on its upper winding to the earthed P lead. The earth to the P lead via lead 14 and contacts *ish1* and *iph1* is also disconnected at contacts *rkr5* (Fig. 6) but by this time it will be understood that a guarding and holding earth will have been returned back over the P lead from the group selecting unit GSU1 in the following manner.

Circuits of this group selecting unit GSU1 are shown in the upper parts of Figs. 8 and 9, while circuits of a control group GCG which is provided individual to each group selecting unit such as GSU1 and which receives the first dialled digit so as to effect the setting up of the selecting unit are shown in the lower parts of Figs. 8 and 9 and in Figs. 10 and 11. In the group selecting unit circuit there is shown only the horizontal prepare relay IGSP together with the auxiliary relays IGSR and INF associated with the first out of the ten possible incoming external links to the selecting unit, which relays, in common with the corresponding relays of the nine other incoming links, have access over common leads 31—37 to group GCG. In addition the vertical hold relays IGSH and IGTH of the first vertical internal link and horizontal prepare relay IGTP associated with the first of the ten possible outgoing levels are also shown. The thousands dialled digit is adapted to be received on switch TDS in control group GCG, whereupon one of the level selecting relays IGTP—10GTP is operated in accordance with the digit dialled. One or other of the outlet control switches AOS or BOS, according as to whether digits 1-5 or 6-0 are dialled, is then caused to test over the twenty outlets of the selected outgoing level, and in accordance with the particular outgoing outlet taken into use a particular one of the twenty pairs of vertical hold relays is operated to switch the connection through and the control group is then released for use in piloting a subsequent call through the same group selecting unit. For instance, if relays IGSH and IGTH are operated the call is switched through to the succeeding selecting unit IPGSU1.

When the loop is extended forward over the speaking conductors of the first of the ten available outlets from the secondary switching unit

SSU1, the group-selecting unit horizontal prepare relay IGSP (Fig. 8) operates over the following circuit: earth, contacts *lgsr4*, *lgsp5* and *lnf4*, positive conductor via the preselecting primary/secondary stage and subscriber's loop, to the negative conductor, contacts *lnf3*, *lgsp4* and *lgsr3*, relay IGSP to battery. Relay IGSP at contacts *lgsp4* and *lgsp5* extends the calling loop through via common leads 34 and 35 and contacts *krr1* and *krr2* to relay A in the group selecting unit control circuit and although at these contacts it disconnects its own operating circuit it remains locked via contacts *lgsp1* and *lnf5* to lead 36 which is earthed via contacts *gs1*. Relay A thereupon operates and at contacts *a1* (Fig. 10) operates relay B in series with rectifier MRD in a conductive direction to battery via resistance YP. Relay B in operating at contacts *b1* (Fig. 8) extends earth up over common lead 32 and then via contacts *lgsp2* to operate relay IGSR in series with resistance YH, at contacts *b2* brings up relay BB, at contacts *b4* completes an alternative locking circuit for relay IGSP, at contacts *b7* (Fig. 10) completes an energising circuit for relay C through its series connected winding, resistance YQ and switch magnet TDM (non-operative in this condition), while at contacts *b8* relay B is locked up independently of the operated contacts *a1*. The crossbar relay IGSR in operating at contacts *lgsr1* extends the earthed lead 32 through onto the incoming P lead and this earth extends back to hold relays ISH, IPH and K in the preselecting primary/secondary stage. The functions of relays IGSR, BB and C will be dealt with later when the circuit operations of the preceding stage have been fully considered.

Returning to the operation of relay K (Fig. 4) in the calling line circuit, when relay R released and released relays RK and IS (Fig. 6) in turn, the operating circuit for the crossbar prepare relay IPP (Fig. 4) was disconnected at contacts *rkl*. In response thereto the associated horizontal bar would also release, but the pin or its equivalent which is engaged by the actuated first vertical bar remains held without appreciably restraining the restoration of the horizontal bar. It will also be remembered that when relay ISH operated relay SSR (Fig. 7) in the secondary control group SCG commenced to release slowly and when this does so contacts *ssr3* (Fig. 5) open the circuit of the crossbar horizontal relay ISP and on release of this relay the horizontal bar associated therewith restores, but the pin or its equivalent which is engaged by the vertical bar actuated by relay ISH remains held. At contacts *ssr4* relay SKR is released. Relay ISP in restoring at its contacts *isp3* removes the operating earth for relay ISH over its lower winding, while relay SKR in releasing at contacts *skr4* (Fig. 5) reprepares the driving circuit for the magnet SM in readiness for subsequent use of the secondary control set SCG and at contacts *skr5* reconnects the switching resistance YG across the winding of relay SSR, this latter arrangement being dealt with more fully later.

Both the primary control group PCG and the secondary control group SCG are now available for further use, and relay K in the calling line circuit, relay IPH on the primary switching unit PSU1 and relay ISH on the secondary switching unit SSU1 remain held for the duration of the call. Relay ISH in remaining operated at its contacts *ish3* (Fig. 7) marks the first vertical internal link on the unit SSU1 as busy so that

subsequent calls through unit SSU1 must be routed through one of the other links 2—20 via their corresponding vertical hold relays 2SH—20SH. At the same contacts unit SSU1 is busied as far as a subsequent call from unit PSU1 is concerned since this unit has access only to the first vertical link on unit SSU1.

It will be noted from Fig. 1 that each of the twenty primary switching units in a column have access to a vertical internal link on a secondary switching unit such as SSU1. When a vertical internal link has been taken into use as for instance the first vertical link on unit SSU1 as described, then this link must be marked busy to the primary units having access thereto and in this instance this is done by contacts *ish3* (Fig. 7) as described. When relay SKR releases after the call has been set up through unit SSU1 then it will be understood that the winding of relay SSR in parallel with resistance YG maintains an idle marking resistance battery to the nineteen other primary switching units in the column. The test lead 19 from primary switching unit PSU20 to the twentieth vertical internal link on unit SSU1 extends to relay SSR over contacts *20sh3* so that if this internal link is subsequently taken into use the lead is busied by the opening of contacts *20sh3* in response to the operation of the vertical hold relay 20SH.

There are six outlets from each primary switching unit in a column and from Fig. 1 it will be seen that the corresponding primary switching units in the second column to those of the first share access to the same sets of outlets. For example, the first unit in the second column and unit PSU1 will share the same set of six outlets. It is possible for calls to be originated simultaneously in these two switching units and hence both primary control groups concerned will be set in operation at the same time to test over the same set of six outlets to the secondary switching units. In other words two secondary group hunting switches may possibly test simultaneously for the same secondary control group and to avoid dual connection the dual testing cut-drive type of relay TK (Fig. 6) is employed in association with these switches. If two switches should land on the same contact simultaneously, then both of the TK relays will operate over their windings in series to the idle marking resistance battery in the secondary control group SCG comprising the comparatively high resistance, say 100 ohms, winding of relay SSR in parallel with the comparatively low resistance YG, say 150 ohms. Their respective relief relays TKR will be operated, while at the same time an earth will be extended forward over the upper low resistance winding of each relay TK on to the test lead such as 17 common to the two primary control groups in question, whereupon relay SSR in the secondary control group operates and functions as already described. In control group PCG relay TKR in operating at contacts *tkr2* extends a battery potential via resistance YA and YB and thence via contacts *1s5*, (or *2s5* if the call is originated from unit PSU2) and the lower winding of relay TK to earth via the operated contacts *tk2*, this winding being energised in an opposing direction to its upper winding. Similar remarks apply to the TK relay in the other control group.

In the case of a single connection from one TK relay to lead 17 the opposing flux produced in the lower winding on the operation of relay TKR will not be sufficient to overcome the holding flux in the low resistance upper winding and the

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relay will therefore hold, but in the case of a dual connection the holding flux produced in each due to the current through their low resistance upper windings will be halved, while the opposing fluxes due to their lower windings will remain the same. In these circumstances both the TK relays release and cause the associated hunting switches to continue searching. Due to the difference in speed of any two switches, after a few steps one will reach a free outlet before another, whereupon the associated TK relay will operate to guard the outlet seized and to disconnect the magnet driving circuit.

When subsequently the switch SS finds a free outlet to a first numerical group-selecting unit relay SK operates and it will be noted that the relay SK in each secondary control group is made of the same dual testing cut-drive type as the relay TK in each primary control group, this being done since it is possible for more than one SS switch to test simultaneously over outlets leading to the same group selector control group, in which is situated the idle marking resistance battery for the selector. Relay SK in operating brings in relay SKR and relay SKR sets up the dual test condition for relay SK in case it is required as already described for relay TK in the control group PCG. It will also be noted that relay SKR in operating at contacts *skr5* (Fig. 7) disconnects the resistance YG from across the winding of relay SSR; the comparatively high resistance winding of relay SSR is left connected to the other incoming test leads such as 19 (lead 17 being disconnected by contacts *ish3* when relay ISH operates in the example being described). With relay SSR alone connected to the incoming test leads it will be understood that no other TK relay will operate in series therewith and hence the secondary group SCG remains busied for so long as relay SKR is operated.

The primary switching unit in the second column corresponds to the primary unit PSU1 in the first column more particularly as regards the vertical hold relays, for instance one of the vertical hold relays corresponds to relay IPH on unit PSU1 and both these relays are associated with the same relay ISH on unit SSU1. Hence if the call has originated from unit PSU1 and relay ISH on unit SSU1 is taken in use, then relay ISH will be held from the P lead as already described when the connection to the group selecting units is effected. Correspondingly, when a call is set up from the unit corresponding to unit PSU1 in the second column, the relay corresponding to relay IPH will be held from the same P lead and this relay is shown dotted in Fig. 4, it being operated by contacts *ish4* of relay ISH when the first vertical link on secondary unit SSU1 is taken in use, contacts *ish4* extending over lead 20 to contact 2 of the SGS1 bank of the switch SGS in a control group corresponding to PCG and serving the primary units of the second column corresponding to units PSU1 and PSU2.

Referring again to the trunking diagram (Figs. 1 and 2) and considering a call originated by a subscriber No. 3111 on unit PSU1, connection with a first group selecting unit cannot be effected firstly if all the six available outlets are directly busied due to the operation of the relays ISH in each of the six secondary units SSU1—SSU6, while furthermore, any one of the outlets can be indirectly busied owing to the fact that on the associated secondary unit all ten outlets

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therefrom to group selectors are already in use. In the first instance with the relays ISH in all the units SSU1—SSU6 in an operated condition then contacts *ish5* (Fig. 7) on each of these relays will bring up the busy relay IPGB associated with the six outlets available from unit PSU1 and also from the corresponding unit in the second column. Relay IPGB in operating at its contacts *ipgb1* (Fig. 4) disconnects the start circuit over lead 19 to relay IS in control group PCG so that no further calls from the subscribers 3111—3120 can be dealt with, while in addition other contacts *ipgb2* (not shown) will disconnect the control group accessible to subscribers 3511—3520 in the second column, as these subscribers also utilise the same set of outlets. Any one of these forty subscribers must therefore wait until a free one of the six outlets becomes available. It will be noted from Fig. 4 that subscribers 3131—3140 also have access to control group PCG via lead 11 but such subscribers utilise a second set of six outlets which terminate on the relays 2SH in the various secondary units SSU1—SSU6, and only therefore, if the second link busy relay 2PGB (not shown) is operated will such subscribers be unable to set up a call. Returning again to primary unit PSU1 and its associated unit in the second column, if say all ten outlets from switching unit SSU1 are engaged all links thereto from the primary switching units must be busied and this is done in the following manner. For each secondary switching unit such as SSU1 a group busy relay GB (Fig. 5) is provided, this relay being connected over common lead 21 and thence via rectifiers such as MRB or MRC onto the outgoing P leads of all ten outlets from the switching unit. If any of the ten succeeding group selecting units are free then relay GB will remain operated to the idle marking resistance battery in the group selecting units control set, relay GB being of sufficiently high resistance to prevent any operation of the group selecting units control set start relay or to interfere with the operation of the cut-drive testing relay SK. If all ten group selecting units available to the unit SSU1 become busy then relay GB will release.

It may be mentioned here that rectifiers such as MRB and MRC are provided to prevent mutual interference between the outgoing P leads onto which relay GB is connected.

Relay GB in releasing at contacts *gb1* (Fig. 7) brings up relay SGB which is provided individual to each secondary switching unit and which in the present instance is assumed to be associated with unit SSU1. The operation of relay SGB is dependent upon the normal condition of relay SSR in the control group SCG of unit SSU1, this being done to prevent relay SGB operating while the last of the possible calls through the switching unit is taking place. Relay SGB in operating at its contacts *sgb21* (Fig. 7) disconnects the start relay SSR from all the twenty possible test leads such as 17 and 19 incoming to the unit so as to mark all these leads as busy and at contacts *sgb1*—*sgb20* simulates the operation of all the relays ISH—20SH on the unit SSU1 to prepare for the operation of one or other of the busy relays IPGB—20PGB when the requisite conditions obtain.

Considering now the circuits of the group selecting units GSU1 taken in use and its associated control group GCG, on seizure of the crossbar relays IGSP and A (Fig. 8), relays B and C (Fig. 10) and relays BB and IGSR (Fig. 8) are operated as already described. Relay C in operating

at its contacts *c4* (Fig. 10) prepares for the reception of the thousands dialled digit on to the magnet TDM of the switch TDS from contacts *a1* of relay A (Fig. 8) which is operated from the calling loop. Relay BB (Fig. 8) in operating at its contacts *bb1* disconnects the relay GS from all the incoming P leads so as to mark the group selecting units as busy, and this relay releases but relay IGSP remains held over operated contacts *b4*. At contacts *bb2* a dial tone source is connected up over lead DTE to the centre winding of relay A from whence it extends by induction into the outer windings and then on to the speaking leads and back to the calling party. Relay IGSR in operating at its contacts *lgsr1* extends earth from contacts *b1* and *lgsr2* back on to the incoming P lead as already described, and at contacts *lgsr3* prevents relay IGSP from being reconnected to the incoming negative lead on any subsequent release of this latter relay while at contacts *lgsr4* it prevents earth from being connected to the positive lead on the above condition. At contacts *lgsr5* the continued holding of relay IGSP is rendered independent of contacts *inf5*.

The calling subscriber on hearing the dial tone should now proceed to dial the thousands digit of the required number, but in case he should neglect to dial and so hold common equipment GCG unnecessarily, arrangements are made to release this equipment and to return busy tone to the calling subscriber if dialling does not take place within a predetermined period after seizure. This is effected in known manner by the use of the pair of relays TA and TZ (Fig. 8) in conjunction with a delay set (not shown) which is common to the exchange and which is arranged to supply earth pulses bearing a definite time relation to two common leads S and Z. On operation of relay B when the control group GCG is taken in use contacts *b3* (Fig. 8) connect the right hand winding of relay TA up to the S lead and if the delay set is in its normal position then an earth will be encountered on this lead and relay TA will operate. At contacts *ts1* it locks to earth on to left hand winding, at contacts *ts2* it connects its middle winding and the lower winding of relay TZ up to the Z lead, while at contacts *ts3* it extends earth on to the delay set start lead ST. After the predetermined period an earth pulse is applied from the delay set to the Z lead, whereupon relay TZ operates and at contacts *tz3* removes the short circuit from its upper winding over which it locks to the earthed contacts *b2* via resistance YJ. At contacts *tz1* and *tz2* the initial operating and locking circuits for relay TA are opened but this relay remains held via its centre winding and the lower winding of relay TZ. At contacts *tz1* earth is extended over lead *33* to short circuit and initiate the release of relay IGSR in the group selector, while at contacts *tz4* (Fig. 9) earth is extended up over lead *37* to bring up relay INF in the group selector. At the end of the Z pulse relay TZ remains held over its upper winding while relay TA releases. In the group selector relay INF in operating maintains earth on to the incoming P lead at *inf1* and disconnects any circuit therefrom to relay IGSR, while at contacts *inf2* a locking circuit is completed for relay IGSR but in this instance this circuit is ineffective owing to the short circuiting earth fed up over lead *33*. At contacts *inf3* and *inf4* the incoming speaking leads are transferred from relay A to relay INF, whereupon relay A releases and at contacts *inf6* num-

ber-unobtainable tone is, on release of relay IGSR, connected up over common lead NTE to the centre winding of relay INF from whence it returns to the calling party; relay IGSR in releasing releases relay IGSP. In the control group relay A in releasing at contacts *a1* short circuits and releases relay B, whereupon relays BB and TZ are released. An impulse through *b8*, *a1*, *c4*, relay C, magnet TDM causes the switch TDS to be stepped off normal. Subsequently a homing circuit is completed as described later. The control group GCG is then ready to handle a subsequent call through the group selecting units.

If the calling party commences to dial within the allowable predetermined period after receipt of dial tone, then on the first release of relay A an energising circuit is completed for magnet TDM as follows: earth, contacts *b8*, *a1* and *c4*, upper low resistance winding of relay C, magnet TDM to battery, the winding of relay B being short circuited during this time, while the lower winding of relay C is similarly short circuited in series with resistance YQ. On the re-operation of relay A at the end of the first impulse of the dialled train an energizing circuit is re-completed for relay B, and relay C now holds operated on both its windings in series with magnet TDM which will not hold in this condition, and which thereupon releases to advance its wipers to contacts 2 or 13, according to which half of the banks is being used. When switch TDC advances one step an operating circuit is completed for relay N over wiper and bank TDS1, operated contacts *bb7*, normal contact and wiper AOS1, and operated contacts *c3* and *bb5* to battery via resistance YO, and this relay at its contacts *n1* (Fig. 8) further disconnects the incoming P lead to relay GS, at contacts *n2* completes a local locking circuit for itself, and at contacts *n3* (Fig. 8) disconnects the dial tone circuit. At contacts *n5* it opens the holding circuit for relay C and at the same time short circuits the lower winding so that should there be no second impulse of the train as is the case in the present instance, where the wanted number is 1111, relay C will release after a slow release period governed by the short circuiting of its winding and will initiate hunting for a free outlet to a penultimate group selecting unit in a manner to be shortly described.

Relay B will have held operated during the single received dialled impulse and it may be mentioned here that the presence of the metal rectifier MRD in its initial energising circuit serves to prevent the slowing up of the operation of the magnet TDM which would otherwise result from the direct connection of a comparatively low value non-inductive resistance such as YP in parallel with its winding, neither magnet TDM nor relay C moreover will hold operated in series with relay B. Should there be two or more impulses in the train relays B and C will hold operated until the end of the train in similar manner as has been described for the single impulse in question.

At the end of the first dialled digit relay A remains operated and holds relay B, while relay C commences to release slowly, relay N remaining held over its local locking circuit *n2*, *bb5*, YO to battery. On release of relay C contacts *c1* (Fig. 9) extend earth over operated contacts *n4*, *b9* and wiper TDS3, which will be in position 2 or 13 when digit 1 has been dialled. Whereupon the crossbar relay IGTP will be operated to operate the horizontal bar associated with the first one of the ten levels of outlets. Contacts *c2* and *c3* (Fig. 10) complete a self-interrupted driving cir-

cuit for magnet AOM or BOM according as to whether a digit 1-5 or digit 6-0 has been dialled. In the present instance magnet AOM will be set in operation whereupon its wipers are caused to test over the twenty outlets of the selector outgoing level 1 in the following manner. On the operation of relay B contacts *b5* (Fig. 11) connect up the dual testing cut-drive relay KR via contacts of the group selector vertical hold relays 1GTH-20GTH to corresponding contacts 2-21 on banks AOS3 and BOS3 of banks AOS and BOS. The associated switch wipers are in turn connected up over the contacts *b6* and thence via wiper and bank TDS4 to any one of the wipers AOS4-AOS8, BOS4-BOS8 according to the position to which switch TDS has been set, i. e. in accordance with the value of the received digit. In the present instance where digit 1 has been dialled wipers AOS3 and BOS3 will be connected up via wiper TDS4 in position 2 or 13 to wiper AOS4 the bank of which gives access to twenty penultimate selecting units serving the thousands group 1, the test lead of the first one of the twenty outlets being designated 38. When on release of relay C switch AOS steps from position 1 to position 2 the magnet driving circuit is changed over to one involving contacts of the cut drive relay KR, the circuit now being as follows: earth, low resistance winding of relay N (Fig. 10), contacts *kr2* and *krr6*, wiper TDS2 in position 2 or 13, contacts *bb4*, bank and wiper AOS1, contacts *c3*, magnet interrupter contacts *aom* and magnet AOM to battery. If the first outlet on the selected level 1 is free then an idle marking resistance battery will be encountered on lead 38 (Fig. 11) whereupon relay KR will rapidly operate and will open the magnet driving circuit at contacts *kr2* (Fig. 10). If this outlet is busy then switch AOS will rotate its wipers until a free outlet is encountered when relay KR will operate and function as described. It is also possible for the first outlet on level 1 to be free and at the same time for the first outlet on another level or levels to be busy, in which case the first vertical internal link within the crossbar switch will already be in use and it is therefore necessary to make this outlet test as busy to the hunting switch AOS. This is done by means of the contacts 1gth1-20gth1 in the operating circuit of relay KR so that if outlet 38 were free but if at the same time the first vertical internal link is busy then relay 1GTH will be operated and the idle marking battery will be unable to reach relay KR since the circuit thereto will be opened at contacts 1gth1. In the next position of switch AOS contacts 2gth1 become effective to determine whether or not the second internal link is busy and so on.

Assuming that the outlet 38 is taken into use then relay KR in operating in addition to opening the magnet driving circuit also at contacts *kr2* (Fig. 10) completes an operating circuit for relay KRR, and at contacts *kr1* (Fig. 11) extends an earth forward over the upper low resistance winding of relay KR to guard the outlet seized.

Relay KRR in operating at its contacts *krr1* and *krr2* (Fig. 8) disconnects relay A from across the incoming speaking conductors, at contacts *krr3* (Fig. 11) prepares for the dual testing function of relay KR in case it should be required as described in connection with relay TK (Fig. 6), while contacts *krr4* prepare to maintain relay KR operated when the cross bar vertical holding relay 1GTH is operated by earth extended forward over contacts *krr5* (Fig. 9) and wiper AOS2 in position 2 and lead 39, and contacts *krr6* (Fig. 75

10) further disconnect the AOM magnet driving circuit. It will be noted that relay 1GSH is also operated in addition to relay 1GTH; their function will be described later.

Relay A in releasing at contacts *a1* (Fig. 10) short circuits and releases relay B, whereupon at contacts *b2* relay BB (Fig. 8) is released, at contacts *b4* relay 1GSP is released, at contacts *b9* (Fig. 9) relay 1GTP is released and at contacts *b6* (Fig. 11) relay KR is released and this relay in turn releases relay KRR. On release of relay BB homing circuits are completed via the low resistance winding of relay N for switch TDS via contacts *bb6* and *bb7* successively and for switch AOS via contacts *bb3* and *bb4*, and when both of these switches reach their home positions the holding circuit for relay N is opened at wipers and banks AOS1 and TDS1. When relay N releases after its subsequent slow release period contacts *n1* (Fig. 8) replace the idle marking resistance battery comprising resistance YK and winding of relay GS back on to the common test lead 31 of the common control group GCG so that this group is now ready to set up any further call through the associated group selector GSU1.

Meanwhile in the crossbar relays 1GTH and 1GSH in operating operate their associated vertical bars which together constitute the first vertical internal link within the crossbar unit, whereupon the sets of contacts

$$\frac{1GSP}{1GSH}1-3 \text{ and } \frac{1GTH}{1GTP}1-3$$

at the intersection of the vertical and horizontal bars in question are operated to extend the incoming conductors negative, positive and private, through to the penultimate group selector taken in use which will be assumed to be 1PGSU1 in the trunking diagram of Fig. 2. Relay 1GSH in operating at its contacts 1gsh1 completes a locking circuit for itself and also for relay 1GTH on to the P lead which is earthed from control group GCG over lead 32 (Fig. 8). Before the control group is freed for further use an earth will have been returned back over the P lead from the penultimate group selecting unit 1PGSU1 in a manner to be described so that these two crossbar relays will no longer be dependent upon the earth supplied to the P lead by the earthed contacts *b1* (Fig. 8) and these two relays and in addition relay 1GSR in the group selecting unit will remain held from the earth which has been returned from the succeeding selecting unit 1PGSU1.

Returning now to the search for a free outlet by switch AOS in the control group GCG, if all outlets prove to be busy switch AOS will rotate its wipers to contacts 22 when a battery potential via resistance YR will be encountered which feeds back over bank and wiper AOS4, bank and wiper TDS4, contacts *b6* and wiper and bank AOS3 to bring up relay KR. Relay KRR functions as before described with the exception of contacts *krr5* (Fig. 9) which extend earth over wiper AOS2 in position 22 and then over common lead 37 to operate relay INF over its left hand winding. Relay INF in operating at its contacts *inf3* and *inf4* (Fig. 8) connects itself across the incoming speaking conductors on to which it locks and at contacts *inf2* (Fig. 8) completes a locking circuit for relay 1GSR. At contacts *igsr6* busy tone is connected up over common lead BTE to the centre winding of relay INF from whence it is induced into the loop

circuit of the calling party. During this time the common control proceeds to release in normal manner so as to be available for use in setting up further calls in the group selecting unit, while it will be noted that contacts *Inf1* (Fig. 8) maintain earth on the incoming P lead associated with the first link incoming to the group selecting unit so as to mark this link as busy and also to hold the preselecting primary secondary stage until such time as the calling party releases.

When he does so, relay *INF* releases, whereupon relay *IGSR* releases in turn and the earth is removed from the incoming P lead so as to release relays *ISH* and *IPH* in the preselecting stage and also to release the subscriber's cut off relay *K*. The subscriber's line circuit, the first vertical internal link on primary switch unit *PSU1* and its associated outlet to unit *SSU1* together with the first vertical internal link within the latter unit are then available for further use.

Circuits of the penultimate group selecting unit *PGSU1* are shown in the upper parts of Figs. 12 and 13, while circuits of a control group *PCG* which is provided individual to each selecting unit such as *PGSU1* is shown in the lower parts of Figs. 12 and 13 and in Figs. 14 and 15. In the selector selecting unit there is shown the horizontal prepare relay *PGP*, together with the auxiliary relays *IA*, *IB*, *ID*, *IJ*, *IF*, *ISD* and *ISE* which are required for battery feeding, impulsing and ringing purposes and etc.; all these relays being associated with the first one of the ten possible incoming links to the selector. Similar relays are provided for each of the other incoming links. In addition the vertical hold relay *IPTH* of the first vertical link and the horizontal prepare relay *IPTP* associated with the first of the five possible outgoing levels are also shown.

The hundreds dialled digit is adapted to be received on switch *HDS* in control group *PCG*, whereupon one of the level selecting relays *IPTP*—*SPTP* is operated in accordance with the digit dialled. One or other of the outlet control switches *COS* or *DOS*, according as to whether digits 1-5 or 6-0 are dialled, is then caused to hunt for a free one of the DUC (tens and units digits) controls (to be later described) serving the two-hundred line group in which is accommodated the 100 line group dialled, selective hunting over the requisite set of DU controls being determined by the level switch *HDS*. Each DU control which subsequently received the dialled tens and units digits serves to determine the wanted subscriber in the particular two-hundred line group which it controls and from three to eight DU controls will serve such a group in accordance with the traffic involved. For the five two-hundred line groups accessible from the penultimate selecting unit there will be five sets of DU controls, any one set of which may comprise up to eight DU controls, and hence to meet the requirements of hunting over the up to eight outlets to any one predetermined set of controls, three sets of controls are accessible from the banks of switch *COS* and the remaining two from the banks of switch *DOS*. Thus if hundreds digit 1-6 is dialled, control switch *COS* will hunt and its search will be restricted by the level selecting switch *HDS* to the up to eight DU controls serving the two-hundred line group in which the hundred line group dialled is located, while if digit 7-0 is dialled switch *DOS* will come into operation.

In the present instance where thousands and

hundreds digits *11* have been dialled then switch *COS* will be adapted to hunt over the up to eight DUC controls serving the first two hundred lines in the thousands digit 1 group. Circuits of one such DUC control *DUC1* are shown in Fig. 16 (Bottom left side), Fig. 21 (left-hand side); Figs. 22 and 23; Fig. 24 (upper part), the lower part containing the final switching control group *FSC* the function of which will be appreciated later, and Fig. 25.

Referring to Figs. 2 and 3 of the trunking diagram it will be remembered that the traffic is assumed to be such that a final primary/secondary group will accommodate four hundred subscribers. Access to the group serving subscribers 1111-1400 will be had over levels 1.2 and 3.4 of the penultimate selecting units serving the thousands group "1" and since, as previously mentioned, these selecting units are subdivided into four groups (selecting units *PGSU1* and *PGSU4* being representative of groups 1 and 4), the selecting unit *PGSU1* which is involved in the call under discussion will give access from levels 1.2 and 3.4 to eighteen out of the seventy-two possible links to the final primary/secondary group serving subscribers 1111-1400. These eighteen links are spread out over the six secondary units *FSS1*—*FSS6* of the final group, three terminating on relays *IFSH*—*3FSH* of unit *FSS1*, three on relays *IFSH*—*3FSH* of unit *FSS2* and so on up to unit *FSS6*. As regards penultimate selecting units such as *PGSU2* (not shown) the corresponding links will terminate on relays *4FSH*—*6FSH* of units *FSS1*—*FSS6* respectively, for selecting units such as *PGSU* (not shown) they will terminate on the relays *IFSH*—*2FSH* respectively and for selecting units such as *PGSU4* they will terminate on the relays *10FSH*—*12FSH* respectively. The three relays *1FSH*—*3FSH* on unit *FSS1* which are accessible from selecting unit *PGSU1* are shown in Fig. 16, while the three relays *10FSH*—*12FSH* on the same switching unit, which are accessible from selecting unit *PGSU4* are shown in Fig. 17. There is also shown in Fig. 18 the three relays *1FSH*—*3FSH* on unit *FSS6* which are accessible from selecting unit *PGSU1*. Fig. 19 shows circuits of two of the sets of twenty prepare relays, namely *1FSP* and *20FSP*, on units *FSS1* and *FSS6* while Fig. 20 shows the first vertical hold relay *IFPH* and the prepare relay *IFPP* on unit *FPS1* (ref. Fig. 3) on which the required party 1111 is located and by means of which connection thereto will be effected as will be described in the ensuing paragraphs. It will be appreciated that for subscriber 1111 relay *IFPP* on unit *FPS1* will always be involved as this is associated with the subscriber, but any of the relays *IFPH*—*6FPH* will be used according to the particular one of the six available links in the switching unit which is utilised.

Referring to the circuits of the penultimate group selecting unit *PGSU1*, Figs. 12-15, when the loop is extended forward over the speaking conductors of the first of the ten available outlets from the group selecting unit *GSU1*, relay *IA* (Fig. 12) operates and at its contacts *1a1* brings up relay *IB*. Relay *IB* in operating at contacts *1b1* extends a guarding and holding earth on to the incoming P lead, at contacts *1b2* completes a local locking circuit for itself and at contacts *1b3* brings up the selector horizontal prepare relay *IPGP*. This relay in operating actuates its horizontal bar and at contacts *1pgp1*—*1pgp4* (Figs. 12 and 13) extends the circuits through to

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the associated control group PCG, whereupon relay BA (Fig. 13) is operated over the earthed lead 55. Relay BA in operating at its contacts *ba1* (Fig. 12) disconnects the idle marking resistance battery from lead 51 which connects with the incoming P lead and renders the whole of the incoming leads to switch IPGSU1 unavailable until PCG is released at contacts *ba3* connects the delay relay TAA up to the S lead of the delay set and at contacts *ba9* (Fig. 14) brings up relay HC on its series connected windings in series with resistance YZ and switch magnet HDM (non-operative in this condition). Relay HC in operating at its contacts *hc2* connects up magnet HDM in series with its own low resistance left-hand winding on to lead 59 which connects via contacts *zb1* lead 52 and the selector impulse responding circuit. The control group PCG is now ready to receive the hundreds dialled digit.

When the subscriber dials the hundreds digit relay 1A responds and at its contacts *1a1* extends pulses of earth over leads 52 and 59 to magnet HDM, relays B and HC holding operated during the train. When switch HDS steps off its normal position 1 or 12, according as to whether it is being operated over the first or second half of its bank at this time, relay NN (Fig. 14) operates over the following circuit, earth, low resistance winding of relay NN, wiper and first off-normal contact of bank HDS1, contacts *ba8* to battery via resistance YY. If the digit dialled is 7-0 a circuit will subsequently be completed via contacts *ba7* to battery via the winding of relay HD and this relay in operating prepares for testing over outlet control switch DOS instead of COS. Relay NN in operating at its contacts *nn2* (Fig. 14) short circuits the right hand winding of relay HC to enable it to hold during impulsing, at contacts *nn4* it locks relay HD if this relay is operated, and at contacts *nn6* completes a local locking circuit for itself via contacts *ba6* and resistance YY to battery.

At the end of the impulse train, which in this instance will comprise a single impulse since subscriber 1111 is required, relay HC releases after its slow period and at its contact *hc1* (Fig. 13) extends earth over wiper HDS3 in position 2 or 13 and then over lead 56 to operate the selector switch level selecting relay IPTP associated with the first level which gives access to the 200 line group in which is located the particular 100 line group dialled. At contacts *hc2* (Fig. 14) the impulsing circuit over lead 59 is extended through the lead 60 in readiness for the tens and units dialled digits which will be extended to the DU control to be taken into use and at contacts *hc3* (Fig. 14) an operating circuit is completed for relay CB which at contacts *cb1* and *cb2* (Fig. 15) connects the outlet testing relay CK up to wiper HDS5 in readiness for testing for a free DUC control. At contacts *cb3* (Fig. 14) an operating circuit is prepared for relay CKZ and at contacts *cb4* a self-interrupted driving circuit is completed for magnet COM or DOM according as to whether digits 1-6 or 7-0 have been dialled. In the present instance where digit 1 has been dialled, relay HD will not be operated and hence a self-interrupted driving circuit is completed for magnet COM as follows: earth, contacts *cb4* and *off1*, normal contact and wiper COS1, contacts *hd5*, *ckr2*, *ckz4*, *ck3* and *hd6*, magnet interrupter contacts *com*, magnet COM to battery; relay OFF is energised directly from contacts *cb4* but is slow-to-operate so that it does not interfere with the initial step of switch

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COS. When the switch steps off from its home position 1 on to position 2 the self-interrupted driving circuit is maintained independently of contacts *cb4* over wiper and bank COS1, contacts *hc4* and winding of low resistance relay N to earth. It will be remembered that switch COS gives access to three groups of DU control arrangements so that if digit 1 or 2 is dialled the switch COS is adapted to test over the first group only, if digit 3 or 4 is dialled to test over the second group and so on. Where digit 1 is dialled as in the present case testing is to take place over the first group and it will be seen from Fig. 15 that while switch COS is moving over the eight positions, 2-9, relay CK is connected up to an outlet test lead such as 63 in the following manner: When switch COS steps to position 2 connection will be made to test lead 63 by wiper COS3 and if the associated DUC control DUC1 is free an idle marking battery via resistance YAH (Fig. 21) will be encountered and this will feed back over bank and wiper COS3, wiper and bank COS6, bank and wiper HDS5, contacts *cb2*, windings of relay CK in series and contacts *cb1* and *ckz1* to earth via resistance YAC. Relay CK thereupon operates and at its contacts *ck1* extends a guarding and holding circuit forward via its right hand low resistance winding while at contacts *ck2* it brings up relay CKR and at contacts *ck3* (Fig. 14) it disconnects the COM magnet driving circuit.

Assuming that the first outlet was busy then there would have been an earth potential via the low resistance winding of relay EH (Fig. 21) on lead 63 and relay CK would not have operated so that the switch would have stepped on to contact 3 so as to test the next DUC control. If all the eight DUC controls in the group are busy then switch COS will continue to rotate from contact 9 which connects with the last DUC control of the group until it again reaches its home position 1. It will be remembered that when the switch COS initiated the step from position 1 an energising circuit was completed for the slow to operate relay OFF and by this time this relay will have operated and at its contacts *off1* will have connected up relay OFA. Hence when switch COS again reaches contact 1 it will be unable to step off again on to contact 2 owing to the resistance of relay OFA in the energising circuit to the magnet but relay OFA will operate and at its contact *ofa1* (Fig. 12) extends earth up over lead 54 to bring in relay 1SE while at contacts *ofa2* (Fig. 13) it disconnects the energising circuit for relay BA. Relay 1SE in operating at its contacts *1se1* locks to the earthed P lead, at contacts *1se2* connects busy tone from lead BTE to the centre winding of relay 1A from whence it returns to the calling party and at contacts *1se6* (Fig. 13) it disconnects relay IPGP whereupon connection between the incoming link and the associated part of the penultimate selecting unit is severed from the control group PCG. Relay BA in releasing releases relays CB, OFA and OFF and at contacts *ba7* and *ba8* (Fig. 14) a self-interrupted driving circuit is completed for magnet HDM over bank and wiper HDS1 to the earthed low resistance relay NN so as to home switch HDS to either of its home positions 1 or 12. Relay NN remains operated during this time and at contacts *nn1* (Fig. 12) disconnects the idle marking battery to guard the control group against intrusion until it is ready for further use. When relay NN releases the control group is now normal and the idle

marking battery is replaced on the lead 51 at contacts *nnl*.

It may be mentioned here that if the subscriber after seizing a control group fails to dial within a predetermined period relays TAA and TZZ come into operation in the same manner as was described for the group selector and release the control group PCG. They also operate relays 1SD and 1SE over leads 53 and 54 to return number unobtainable tone over lead NTE (Fig. 12) to the calling subscriber.

Returning now to the switching through of the selector control group PCG to a free DUC control DUC1, which is the first of the group, when relay CKR operates it prepares at contacts *ckr1* (Fig. 15) for dual testing on the part of the relay CK, in case it is required, at contacts *ckr2* (Fig. 14) it further disconnects the COM magnet driving circuit and completes an operating circuit via contacts *cb3* for relay CKZ over contacts *hd5* and wiper and bank COS1, to the earthed relay NN. Relay CKZ in operating at its contacts *ckz1* (Fig. 15) removes the dual test condition from the winding of relay CK, at contacts *ckz2* (Fig. 15) provides a circuit for operating the EH relay in the DU control taken in use if an even hundreds digit has been dialled, this circuit being dealt with later. At contacts *ckz3* (Fig. 14) a locking circuit for relay CKZ is completed independently of relay CKR, at contacts *ckz4* the COM magnet circuit is further disconnected at contacts *ckz5* (Fig. 15) the impulsing lead 60 is extended over contacts *hd3* and wiper and bank COS4 and then in the present instance over the impulsing lead 62 into the seized DU control, while at contacts *ckz6* the winding of relay ZB is connected over contacts *hd4* and wiper and bank COS5 over lead 61 to operate the earthed relay SA in the seized DUC control, the resistance of relay SA being such that relay ZB is inoperative in this condition.

Relay SA in operating at its contacts *sa1* brings up relay SB and the latter in operating at contacts *sb1* connects up relay EH on to the odd-or-even hundreds discriminating lead 63 and at contacts *sb2* (Fig. 22) brings up relay DC in series with resistance YA and magnet DDM (non-operative in this condition). Relay DC in operating at its contacts *dc1* connects up the impulsing lead 62 to its low resistance winding in series with magnet DDM. Since an odd hundreds digit has been dialled no operating circuit will be completed for relay EH over lead 63, but if an even hundreds digit has been dialled then this relay would have operated over lead 63 and then via bank and wiper COS3, wiper and bank COS6, bank and wiper HDS5, contacts *ckz2* and wiper HDS2 to battery via resistance YAD. At contacts *eh2* and *eh4* (Fig. 23) it would have completed self-interrupted driving circuits for magnets UAM and UBM so that the units digit switches UAS and UBS would have taken up their second home position 12 in readiness for operation over the second halves of their banks which are used when an even hundreds digit is concerned, and at contacts *eh5* (Fig. 24) it arranges to give access from the control group DUC1 to the even hundreds final primary switch units FPS11—FPS20 over wiper and bank DDS4. It will also be noted that on operation of relay SB the removal by contacts *sb1* of the DU control idle marking battery via resistance YA from lead 63 will release relay CK if an odd hundreds digit has been dialled, but this is without effect, since

relay CKZ is operated and is maintained independently of relay CK.

The equipment is now ready to receive the tens digit of the called number, in this case "1," and in response thereto a pulse of earth is transmitted forward from contacts *1a1* of the impulsing relay 1A in the penultimate selector and over leads 52, 59, 60 and 62 into the group DUC1 where it finds a circuit over contacts *dc1* and the low resistance lower winding of relay DC to battery via magnet DDM of the digit switch DDS. Switch DDS thereupon makes one step to position 2 or 13 (according to which half of the bank is being used) and an operating circuit is immediately completed for relay ND via bank and wiper DDS1, contacts *sb3* and resistance YAP to battery. Relay ND in operating at contacts *nd2* opens the initial operating circuit for relay DC and short circuits its upper winding so that this relay will hold operated during the impulses of the tens digit train.

At the end of the tens digit train relay DC releases after its slow period, whereupon an operating circuit is completed for relay UC (Fig. 23) over its lower winding via wipers UBS2 and UAS2 in their home positions 1 in this instance or 12 in the even hundreds digit case, resistance YAQ, contacts *nd4* and *dc3*, upper winding of relay UC, wiper and bank DDS2 to battery via magnet UAM or UBM according as to whether digits 1-5 or 6-0 have been dialled, switch UAS being brought into operation if any of the digits 1-5 have been dialled, while switch UBS is brought into operation if any of the digits 6-0 have been dialled. In this case where digit "1" has been dialled, switch UAS via the intermediary of its magnet UAM will be utilised, and hence when the units digit 1 is dialled the impulse received over lead 62 will extend via contacts *dc1* and *uc1* and then via lead 91 and the upper low resistance winding of relay UC to battery via wiper DDS2 in position 2 and magnet UAM. On the first step of the units switch UAS the lower winding of relay UC is short circuited via wiper and bank UAS2 so that relay UC will hold operated during the impulsing and at the end of the units digit 1 when switch UAS will in this instance have been positioned to contacts 2 relay UC will release after its slow period and at contacts *uc1* (Fig. 22) disconnects the impulsing lead 62 and prepares to use this lead for sending signals back to the penultimate selecting unit, while at contacts *uc2* (Fig. 22) an operating circuit is completed for the "finished dialling" relay SGA.

The tens and units having now been dialled, the control group DUC1 is now in effect positioned on to the called line 1111 via wipers and banks DDS6 and UAS4 (Fig. 25) awaiting a signal to test that line.

Referring again to Figs. 2 and 3 of the trunking diagram it will be seen that to effect connection between the calling link incoming to relay 1PGP on the penultimate selector 1PGSU1 and the called line 1111 it is necessary to cause the final primary/secondary group in which the called subscriber 1111 is located to connect with this link via the switching levels of selector 1PGSU1 via one of the vertical internal links within it.

As previously mentioned, a final primary/secondary group may accommodate from between two hundred and one thousand subscribers and for each two hundred subscribers a maximum of eight DUC controls is provided. In the present instance where there are assumed to be 400 sub-

scribers per final primary secondary group there will be eight DUC controls associated with the first two hundred and eight with the second two hundred. Therefore, for the final primary/secondary group in which the called subscriber is located there can be a total of sixteen calls in the "awaiting to test condition" i. e., effective on DUC controls, and since all these calls may wish to switch through to subscribers on the same final primary switching unit it is necessary to ensure that only one of the sixteen DUC controls serving the final primary/secondary group can switch through to a subscriber at any one time after the tens and units have been received. There is, furthermore, the possibility of there being two or more calls switching into the same two hundred line group from two or more penultimate selecting units. For these reasons it is necessary to complete a testing circuit only for one out of a number of like penultimate selecting units at a time and to allow one DUC control only out of the number serving a final primary/secondary group (sixteen in this instance) to be in a switching condition at any one time.

For the final primary group in which the wanted subscriber 1111 is located the sixteen DUC controls concerned are designated DUC1—DUC16. In each of these control groups an FZ relay is provided i. e. relay FZ for group DUC1; relay FZ (DUC2) for group DUC2 and so on, the sixteen FZ relays being connected up to form a chain circuit in the manner indicated in Fig. 24. This chain circuit forms what is known as the final switching control for the final primary/secondary group in question, and when relay SGA operates in control DUC1 at completion of dialling contacts *sga1* complete an operating circuit for relay FZ as follows: earth, contacts *fz3* of each of the FZ relays of the groups DUC1—DUC16 in series, the contacts *fz2* and *sga1* to battery via relay FZ. If none of the other controls DUC1—DUC16 are ready to switch through at this time, then no other SGA relay will be operated and relay FZ in operating will first complete a locking circuit for itself via contacts *sa4* of the DUC1 group start relay SA and make first contacts *fz1* to earth. At contacts *fz2* the initial operating circuit for relay FZ is opened, while at contacts *fz3* operating paths for any other of the FZ relays are opened. Had another FZ relay, say relay FZ (DUC16) attempted to switch at the same time as relay FZ of Fig. 1, it will be seen that the latter in operating would have disconnected relay FZ (DUC16), since the operating circuit for this other relay is completed over contacts of the DUC1 FZ relay. Group DUC16 would then have to wait until the call in DUC1 had been put through (say in one half second) after which relays SA, SGA and FZ of DUC1 are released and the other FZ relay can then cut in and cause its associated control DUC16 to proceed to switch, in a manner as will be described for control group DUC1.

Returning to the operation of relay FZ of group DUC1, relay IFPP of the wanted party 1111 on final primary switching unit FPS1 is operated over the following circuit: earth, contacts *fz7* (Fig. 25), wiper DDS5 in position 2 or 13, lead 99 which connects with relay IFPP on unit FPS1 and also with the FPP relays of the nineteen other subscribers (1112—1110, 1211—1210) have tens digit 1, in the two hundred line group of subscribers 1111—1200 which the group DUC1 is serving. Since switch UAS has been positioned to contact 2 in response to units digit 1, bat-

tery via resistance YAS will therefore be connected over contacts *fz3* and wiper UAS3 in position 2 and then over lead 101 to the right hand side of a relay IFPP, lead 101 also extending to the FPP relays of nine other subscribers (1211—1911) in the odd hundreds group and having a units digit 1. Relay IFPP of the unit FPS1 (that is the relay corresponding to the line having the tens digit 1 and the units digit 1) then operates.

In connection with the wipers and banks DDS5, IAS3 and UBS3 it might be explained that the position of wiper DDS5 in response to a tens digit 1 selects twenty subscribers in the two hundred line group and having a tens digit 1. For this digit 1 the subscribers concerned will be the first ten in the odd hundred and the first ten in the even hundred, and it is now necessary to determine the particular one in the ten. This is effected by the units switch UAS or UBS, these two switches being set respectively to one of the contacts 2—11 if the hundreds digit concerned is odd as previously described or to one of the contacts 13—22 if the hundreds digit concerned is even. Other contacts on the banks DDS5, UAS3 and UBS3 extend to other FPP relays in the two hundred line group concerned. For instance if wiper DDS5 had been positioned to contact 11 in response to a tens digit "0" and wiper UAS3 or UBS3 had been positioned to the same contact by units digit "0" wiper DDS5 would have selected the last twenty subscribers 1101—1100 and 1201—1200 in the two hundred line group and having the tens digit "0," while switch UAS or UBS in being in operation on the first half of its bank would have determined that the odd hundreds group subscribers 1101—1100 were concerned and the position of wiper UAS3 or UBS3 to contact 11 would have defined the subscriber in the set of ten as 1100, connection to the relevant relay IFPP (unit FPS10) being effected over lead 102. Alternatively, if switch UAS or UBS had been set from the second home position 12 to contact 22 in response to a units digit "0," the subscriber concerned would have been in the even hundreds group 1201—1200, and the position of wiper UAS3 or UBS3 would have defined the subscriber as No. 1200 over lead 111.

In the present instance relay IFPP on unit FPS1 in operating actuates its horizontal bar to prepare for connection with a subscriber No. 1111 over any of the six vertical internal links within the unit FPS1.

It will be remembered that the incoming link to the penultimate group selecting units PGSU1 terminated on relay IFPP it is necessary to connect this link through to the subscriber's line terminating on relay IFPP (unit FPS1) to effect the required connection between the calling and called subscribers 3111 and 1111.

The dialling of the hundreds digit 1 on to selecting unit PGSU1 has already determined that the bottom set of eighteen links (Fig. 2) can be used for the connection and relay IFPP has been operated by this digit.

When relay FZ in control group DUC1 is operated it will be seen from reference to Fig. 16 that contacts *fz9* extend a battery via resistance YAF back over resting contacts *sa2*, lead 64, bank and wiper COS2, resting contacts *hd2*, wiper HDS4 in position 2 or 13 and lead 58 which connects with all the above-mentioned eighteen links.

Six of the eighteen links are shown and are designated 66—71 and it will be understood that connection from the DU control to these links is

only effective provided the corresponding internal links within the penultimate selector are free as determined by the condition of the break contacts of the PTH relays in series therewith. For instance, if the first vertical internal link is busy relay 1PTH will be operated and contacts 1pth2 will disconnect the battery connection to the first one of the set of eighteen links, and this link will therefore be marked as busy to the testing circuit in the final primary/secondary group.

Referring again to Figs. 2 and 3, it will be seen that in order to effect connection with subscriber 1111 over the bottom set of eighteen links from the penultimate selecting unit 1PGSU1 it is first of all necessary to find a free one of the available eighteen links between the penultimate selector and the six final secondary switching units FSS1—FSS6. It will be seen that three links extend to each secondary switching unit and that from each secondary switching unit there is one link extending to each final primary switching unit FPS1. For test purposes the busy or idle condition of any one of the eighteen links as far as the eighteen internal links within the selector 1PGSU1 are concerned is determined by contacts of the relays 1PTH—18PTH on that selector. A link to a secondary switching unit such as FSS1 will, however, also be busy if the corresponding internal link within that unit is busy and for this purpose a break contact of the relevant FSH relay must also be included in the link test circuit. As far as the final primary switching unit is concerned, for a unit such as FPS1 there is only one link extending between it and the unit FSS1 and this link terminates on relay 1FPH (FPS1) so that if this link is already in use all three of the corresponding links incoming to the secondary switching unit FSS1 should be marked as busy, and this is effected by including in the link test circuit break contacts of relay 1FPH. The elements of the test circuit for the first three of the bottom set of eighteen links from the penultimate selecting unit 1PGSU1 is shown in Fig. 26 from which it will be seen that if all of the three corresponding vertical internal links within the penultimate selecting unit are busy as indicated by the operated condition of contacts 1pth2, 2pth2 and 3pth2 of the relays 1PTH—3PTH in selecting unit 1PGSU1, then the link will be busied to the distant test relay 1FSP which is associated with the link between secondary unit FSS1 and final primary switching unit FPS1, but if any of the relays PTH are normal then the first stage of the link can be marked as free. If all the PTH relays are normal but if at the same time all the vertical internal links within the secondary switching unit FSS1 are busy, then the connection to final primary switching unit FPS1 via switching unit FSS1 will be busied by contacts 1fsh5—3fsh5. Assuming that all the PTH and FSH relays are normal the decision as to whether the call can be set up over unit FSS1 to unit FPS1 will rest with the relay 1FPH controlling the first vertical internal link within the unit FPS1 and if this relay is operated then the path will be regarded as busy regardless of the condition of the other relays, the circuit being disconnected by contacts 1fph2. In other words if all of the first set of three vertical internal links within the switch 1PGSU1, or if all of the first set of three vertical internal links within the secondary switching unit FSS1, or if the first vertical internal link within the final primary switching unit FPS1, prove to be busy, then testing for a connection to the wanted final primary

switching unit FPS1 must be effected over the second set of three vertical internal links within the unit 1PGSU1, over the first set of three vertical internal links within the second secondary switching unit FSS2 and then over the second vertical internal link within the wanted unit FPS1. If this path proves to be busy for any of the above reasons described, testing will take place over the next set of three internal links of unit 1PGSU1, the first set of three internal links on unit FSS3 and the third link on unit FPS1 and so on.

Circuit considerations of the testing of the first three out of the set of eighteen links from the selecting units 1PGSU1 will now be given. Referring to Fig. 13 it will be remembered that resistance battery potential which will be known as a free line battery potential is connected up on operation of relay FZ on to lead 58 and then via contacts 1pth2—3pth2 to leads 66—68. These three leads extend through to Fig. 16 where they connect with leads 82, 83 and 84 respectively, which it will be understood are common to all corresponding outlets of the first one of the four groups of penultimate group selectors serving thousands digit 1. In this figure and in Figs. 17, 18 and 19 it will be noted that certain sets of conductors are looped together and given the reference 1PGSU1 or 1PGSU4 and it will be understood that the leads concerned are common to the penultimate selector referred to and also to other like selectors in the same quartered subdivision of the group serving thousands digit "1." Leads 82—84 (Fig. 16) extend through Figs. 17 and 18 into Fig. 19 where they connect with contacts 1fsh5—3fsh5 of relays 1FSH—3FSH on unit FSS1 so that as previously mentioned it will be seen that the busy or idle condition of each of these links is dependent upon the operated or normal condition of the vertical hold relays 1FSH—3FSH on unit FSS1.

Referring again to Fig. 3 of the trunking diagram, at the primary switching unit FPS1 connection can be made to the called party by operating any one of the relays 1FPH—6FPH. To get access to a unit FPS1 relay 1FSP in any one of the secondary units FSS1—FSS6 must be operated, since these relays terminate the six possible inlets to unit FPS1. In case all the links (external and internal) through to unit FPS1 are free, it is arranged by putting the FSP relays in a chain circuit that only one can be operated at a time.

The chain circuit for the six possible relays 1FSP in each of the units FSS1—FSS6 which can be utilised for the connection in question, i. e. to unit FPS1 are shown in Fig. 19 which also shows the relays in the secondary switching units which can be used for gaining access to unit FPS20. When relay FZ operates to indicate that the control group DUC1 can switch through, then earth potential is extended to the six relays 1FSP (FSS1)—1FSP (FSS6) as follows:—earth, contacts f21 (Fig. 24), contacts sa4, sga1, f22 and eh5. An odd hundreds digit has been dialled and hence relay EH will be normal so that the earth connection will extend over resting contacts eh5 to the odd hundreds wiper and bank DDS3. In response to the dialling of the tens digit "1" wiper DDS3 will be in position 2 or 13 and hence the earth connection will extend upwards over lead 93 a chain circuit similar to that in which the FZ relays are arranged to the six relays 1FSP in the units FSS1—FSS6.

If now the first vertical internal link within

the unit FFS1 is free the earth potential on lead 93 will extend upwardly over the chain connected changeover contacts 1fsp3 of the relays 1FSP in each of the units FSS1—FSS6 and then over contacts 1fsp2 (FSS1), upper winding of relay 1FSP on unit FSS1, contacts 1ph2 of unit FFS1 and also via break contacts of the first vertical hold relay of the corresponding final primary switching unit in the second column (ref. Fig. 3), it being appreciated that the operating circuit for 1FSP must also be broken if the first vertical link within the corresponding unit to FFS1 of the second column is also engaged. If any of the pairs of corresponding relays 1FSH and 1PTH on unit FSS1 and selector 1PGSU1 respectively are normal thereby indicating that the internal links are free, then the free line marking battery previously referred to and via resistance YAF (Fig. 16) will be encountered so that relay 1FSP (FSS1) will operate. This relay in operating at its contacts 1fsp1 (FSS1) completes a local locking circuit for itself and at contacts 1fsp2 (FSS1) disconnects its operating circuit, while at contacts 1fsp3 (FSS1) the chain circuit to the other five FSP relays in the chain is opened and the earth lead 93 is extended up to operate relay OFB which is common to the four hundred line final primary/secondary group in question, and which in operating indicates that a connection between the unit FFS1 and the calling link incoming to selecting unit 1PGSU1 can be established.

Should there have been no free line battery connected up to relay 1FSP (FSS1) owing to the busy condition of any one of the external or internal links, then one or other of the other five FSP relays concerned will operate, it being appreciated that 1FSP (FSS1) has priority over 1FSP (FSS2) and the latter has priority over 1FSP (FSS3) and so on in cases where two or more relays try to switch simultaneously, since the circuit for 1FSP (FSS2) extends over break contacts 1fsp3 (FSS1) and so on.

Assuming that relay 1FSP (FSS1) is operated it now remains to determine which of the three possible vertical internal links within the secondary unit FSS1 are to be utilised, and this is done in the following manner. When relay OFB operates to indicate that a link has been found a start relay SR (Fig. 20) which is individual to the secondary unit FSS1 is operated over the following circuit: earth, contacts ofb1, lead 104 which is common to the final primary/secondary group and then via contacts 1fsp4 (FSS1) on to lead 105 which is common to corresponding contacts of all twenty FSP relays on unit FSS1. From lead 105 the earth extends to relay SR. Relay SR then operates and in so doing at contacts sr1 (Fig. 19) extends earth on to lead 96 which is common to the final primary/secondary group and this lead extends through to all the control groups DUC1—DUC16. In group DUC1 relay FZ is operated so that contacts fz5 connect relay ZC up to the earthed lead 96, whereupon this relay commences to operate slowly. Referring to Fig. 21, at contacts sr2—sr4 relay SR proceeds to determine which of the three vertical internal links within the switching unit FSS1 are to be used by operating one of the three relays 1SW—3SW which are provided individual to the unit FSS1 and which are arranged in a miniature chain circuit and one of which switches through to the free line marking battery in the penultimate switching unit concerned and thereupon cuts out the others. The earthed relays 1SW—

3SW are connected up over resting contacts 1fsh4—3fsh4 to leads 82—84 previously mentioned and it will also be noted that they are connected up to contacts of the other nine relays 4FSH—12FSH on unit FSS1, but there is no possibility of there being a battery on the leads connecting with the latter contacts, since such a battery is only applied from the DU control and via the penultimate selector to three out of the possible leads incoming to the switching unit FSS1 in question. It may be mentioned here that relays 1FSH—3FSH in Fig. 13 connect up over the bracketed leads SW (FSS6) at the foot of the figure with three SW relays common to unit FSS6. Returning to the consideration of unit FSS1, if say all of the first three vertical internal links on switching unit FSS1 are free and if the corresponding links within the penultimate group selector are also free, then all three relays 1SW—3SW will attempt to switch to the free line marking battery supplied from the control group DUC1, the circuit being completed over leads 82—84 in Fig. 21, the same leads in Fig. 16, and then via leads 56—58 respectively and into Fig. 13, contacts 1pth2—3pth2, and lead 58, bank and wiper HDS2, contacts hd2, wiper and bank COS2, lead 64 to battery via contacts za2 and fz9 and resistance YAF. Under these conditions the first relay to operate will cut off the other two relays; for instance, if relay 1SW operates first it will cut off the other two relays at contacts 1sw2 and 1sw3 and will lock over its contacts 1sw1 to battery via resistance YAK. If two relays, say 1SW and 2SW should operate together then they will cut off each other's operating circuits and both will release, the interaction continuing until one relay gets up sufficiently before the other to open its circuit before it has time to operate.

It will be assumed that relay 1SW operates first, in which case relays 2SW and 3SW are cut off at contacts 1sw2 and 1sw3. At contacts 1sw4 (Fig. 16) the associated vertical hold relay 1FSH on unit FSS1 is operated via its own contacts 1fsh3 to lead 82 to which is connected the free line battery as described, while at other contacts 1sw5, 1sw6 and 1sw7 operating circuits are prepared for the corresponding relays 4FSH, 7FSH and 10FSH of the second, third and fourth groups of three inlets to unit FSS1 from the second, third and fourth groups of penultimate selecting units. Since, however, no free line battery can be supplied at this instance from any of the other groups of penultimate selecting units in the same thousands group, the circuit to relays 4FSH, 7FSH and 10FSH are not completed. Relay 1FSH in operating actuates its vertical bar to complete the connection at contacts

$$\frac{1FSH}{1FSP}^{1-3}$$

between the first of the three links from selecting units 1PGSU1 and the link between relay 1FSP and switching unit FFS1, while at contacts 1fsh1 it connects its right hand winding to the P lead in readiness for holding therefrom, at contacts 1fsh3 completes a temporary locking circuit for itself via resistance YAJ, at contacts 1fsh2 extends a marking battery via resistance YAJ over common lead 81 and then via lead 65 (Fig. 13) to the corresponding vertical hold relay 1PTH on selector 1PGSU1. Relay 1PTH cannot yet operate however, as its circuit is not completed until the switching through operation has been effected at the final primary switching unit FFS1.

During the operation of the relays 1SW and

IFSH relay ZC in the control group DUCI (Fig. 24) will have been slowly operating and when it does so the particular vertical hold relay corresponding to the operated relay IFSP on unit FSSI is operated over the following circuit: battery, resistance YAR (Fig. 24), contacts *zc4*, lead 98 common to the primary/secondary group in question, lower winding of relay IFPH of the corresponding switching unit FPSI of the two columns, contacts *1/sp5* (FSSI) to earth.

Relay IFPH in operating actuates its vertical bar to effect connection at contacts

IFPH
IFPP 1—3

between the link extending to unit FPSI from unit FSSI and the line of subscriber No. 1111.

We now have a connection set up to the wanted subscriber from the penultimate selecting unit via the units FSSI and FPSI, but before actually switching through at the penultimate selecting unit by operating relay IPTH therein so as to complete the connection between calling and called parties, it is first of all necessary to know whether the wanted subscriber is free or not.

Testing for the free or engaged condition of the wanted party's line is therefore performed on operation of relay ZC by a relay SK in the control group DUCI in the following manner. On operation of relay ZC the following testing circuit is completed: earth, contacts *ofb4* (Fig. 23), lead 107, common to the primary/secondary group, contacts *zc2* and *sa3*, upper winding of relay SK, lead 92 through Fig. 24 to Fig. 25, wiper DDS6 in position 2, wiper UAS4 in position 2, lead 103 on to the P lead of subscriber No. 1111. Relay SK now proceeds to test the condition of the called line and during this time it will be understood that relay ZC in operating at contacts *zc3* (Fig. 24) will bring up relay ZA which at contacts *za1* locks to earth via contacts *sb5* and at contacts *sa3* (Fig. 21) extends earth back over lead 61 into the control group PCG associated with penultimate selecting unit IPGSU1 so that relay ZB in the control group PCG operates, while at the same contacts relay SA in the control group DUCI which was operated on seizure of this control group now commences to release slowly.

If the subscriber's line is free then during the slow release time of relay SA relay SK will operate in series with the called subscriber's cut-off relay such as relay K (Fig. 4) which is normally connected to the incoming P lead and at contacts *sk1* (Fig. 23) will complete a local locking circuit for itself via contacts *sb4* and lead 112 to the earthed relay ND, while at contacts *sk2* it extends a full earth forward to operate the subscriber's cut-off relay and so disconnects his line relay from across the speaking leads in readiness for switching through of the incoming call.

When relay SA releases after its slow period an earth potential to indicate that the called subscriber has been found to be free is returned to the control group PCG associated with penultimate selecting unit IPGSU1 over the following circuit: earth, contacts *za4*, *sa2*, *sk3*, *uc1* and *dc1* (Fig. 22), lead 62, through Fig. 21 to the control group PCG (Fig. 15), bank and wiper COS4, contacts *hd3* and *ckz5*, lead 60, contacts *hc2* (Fig. 14), lead 59, operated contacts *zb1* (Fig. 12) to battery via relays KD and GE in series.

Relays KD and GE in operating at contacts *ge1* and *kd1* extends earth upward over common lead 53 to operate relay ISD in the penultimate se-

lecting unit IPGSU1, while at contacts *kd2* (Fig. 13) an earth potential is connected up to the lower winding of relay IPTH via contacts *zb3*, wiper and bank COS2, lead 64, contacts *za2* and *zc1*, lead 108 common to the final primary/secondary group, contacts *zd1* to earth via the winding of relay ZD and resistance YAE in parallel. It will be noted that when relay ZA operated following the operation of relay ZC the free line

marking battery via resistance YAF was disconnected at contacts *za2* from the eighteen links to the secondary units, but relays IFSH and ISW which have been operated therefrom remain locked as described, independently of this free line battery. Relays ZD and IPTH now operate in series, the former temporarily locking over contacts *zd1* and *ofb5* to battery via resistance YAG and at contacts *zd2* (Fig. 19) disconnects the operating circuit of relay OFB which commences to release slowly. Relay IPTH in operating at contacts *1pth1* prepares a locking circuit for itself and at contacts *1pth2* opens the corresponding link between selecting unit IPGSU1 and unit FSSI while it also actuates its vertical bar to effect connection at the sets of contacts

IPGP 1—3 and IPTH
IPTH 1—3 and IPTP 1—3

between the calling link incoming to relay IPGP on the selecting unit IPGSU1 and the outgoing link taken into use to the secondary unit FSSI.

Meanwhile relay ISD (Fig. 12) in the selecting unit IPGSU1, in operating at contacts *isd1* locks to the earthed P lead, at contacts *isd4* completes an operating circuit for relay 1J, at contacts *isd5* prepares a locking circuit for the ring trip relay 1F, at contacts *isd6* (Fig. 13) extends the earthed P lead through to the called subscriber via the units FSSI and FPSI so that relays IPTH, IFSH, IFPH and the called party's K relay are now held operated from this lead. At contacts *isd7* the operating circuit for the prepare relay IPGP is opened but the pin or its equivalent which is engaged by the vertical bar actuated by relay IPTH remains held. Relay 1J in operating at contacts *1j2* connects a ringing tone earth over lead RTE to the centre winding of relay 1A from whence it returns to the calling party and at contacts *1j3* a circuit is completed to ring the called party's bell as follows: earthed ringing current generator GNR, common lead 108, winding of relay 1F, contacts *1j3* and *1j4* to the subscriber's negative line via the operated crossbar contacts on the units IPGSU1, FSSI and FPSI, the return circuit being completed via the called party's bell of the positive line via the crossbar switching contacts to battery via contacts *1j5* (Fig. 13) and resistance YV.

On release of relay IPGP in the selecting unit IPGSU1 the earth is removed from common lead 55 at contacts *1pgp4*, whereupon relay BA commences to release slowly. On release of relay BA relays CB and CKZ (Fig. 14), ZB (Fig. 15) and KD and GE (Fig. 12) are released and at contacts *ba7* and *ba8* (Fig. 14) a self-interrupted driving circuit is completed for magnet HDM to restore switch HDS to one of its home positions 1 or 12, relay NN holding during this time to maintain the control group PCG busy during the homing of the switch. On release of relay NN relay HD (Fig. 14) releases. On release of relay HD a self-interrupted driving circuit is completed for magnet COM of switch COS to the earthed relay BNN which re-operates and at contacts *nn1* (Fig. 12) replaces the guard on the in-

coming test lead until switch COS has restored to its home position 1. The control group PCG is now ready for the setting up of a further call through the penultimate selecting unit (PGSU).

Meanwhile, in the final primary/secondary group relay OFB (Fig. 19) will have been released slowly since its circuit was opened on operation of relay ZD and when relay OFB releases relay SR (Fig. 20) associated with the secondary unit FSS1 in question will commence to release slowly. On its release relay ZC (Fig. 24) in the control group DUC1 releases. It will be remembered that when relay ZA operated to extend a signal to relay ZB to initiate the final switching through, relay SA commenced to release slowly and on its release signalled back from the control group DUC1 to initiate the ringing of the called subscriber. On release of relay SA the holding circuit for relay SB is opened at contacts *sa1* (Fig. 21) and when relay SB releases after its slow period switches DDS and UAS or UBS as the case may be are homed, the magnet driving circuits being completed via relay ND which remains operated and at contacts *nd1* (Fig. 21) maintains the control group DUC1 busy until the homing is completed. Relay ND in releasing marks the control group DUC1 as free, at contacts *nd3* (Fig. 22) releases relay SGA, while all other relays which have been operated will be released and the control group DUC1 will be ready to deal with any further calls to the group of 200 subscribers Nos. 1111-1200 which it serves.

When the called party replies relay 1F (Fig. 12) operates and at contacts *1/4* and *1/5* it trips the ringing and extends the lines through. At contacts *1/1* it makes the local locking circuit for itself effective to the earthed P lead, while at contacts *1/2* and *1/3* it connects the called subscriber's battery feeding relay ID across the lines and at contacts *1/6* it opens the ringing tone circuit. Relay ID in operating at contacts *id1* and *id2* reverses the battery on to the incoming speaking conductors for supervision purposes and at contacts *id3* completes an operating circuit for relay 1SE. Relay 1SE in operating opens the holding circuit of relay 1J which commences to release slowly and during the slow to release time of relay 1J a positive battery is connected up over contacts *1se2*, *1/1* and *1b1* on to the incoming P lead so as to actuate the rectifier-connected meter M (Fig. 4) in the calling party's line circuit. In Fig. 12 rectifier MRE is provided to maintain a guarding and holding earth on the P lead during the transit time of the contacts *1/1*.

Conversation now proceeds between the calling and called parties and at the end of conversation the connection will remain held until the calling party hangs up. When this occurs relay 1A (Fig. 12) releases and brings down relay 1B, whereupon at contacts *1b1* the guarding and holding earth is removed from the P lead and all relays held operated therefrom are now released and the links in the various crossbar switching equipments which have been used for the purpose of this call are now free for further use.

Returning again to the testing of the called line, it will be remembered that this is effected by relay SK (Fig. 23) in the control group DUC1 during the slow to release time of relay SA (Fig. 21).

If the called line should prove to be busy, then relay SK will fail to operate and hence when relay SA releases after its slow release period, then

instead of contacts *sa2* and *sk3* (Fig. 22) returning a full earth back to the relays KD and GE in the control group PCG, it will be seen that in this instance since contacts *sk3* are normal a resistance YAN is introduced into the circuit so that relay KD which is a relatively inefficient relay will fail to operate but relay GE will still operate. Relay GD in operating brings in relay 1SE in the penultimate selector and this relay at contacts *1se2* connects up busy tone over common lead BTE to the centre winding of relay 1A and from which it is induced into the leads to the calling party while at contacts *1se3* it releases the prepare relay 1PGP (Fig. 13), so that relay BA in the control group PCG is released as before to free the control group for further use. The control group DUC1 proceeds to release in a manner already described, but since relay KD has not been operated in the penultimate selector no operating circuit will have been completed for relay 1PTH, and hence when relay SR (Fig. 20) is released following release of relay OFB there will be no holding circuit for relay 1FSH since the P lead has not been extended through. Similarly, on release of relay ZO in the control group relay 1FPH will fall since there is no holding circuit therefor, over the P lead. Only the switches up to and including the penultimate selector will therefore be involved while the calling party continues to hold after receiving the busy tone, the switches of the final primary secondary group being released for further use.

When subsequently the calling party hangs up, the switches up to and including the penultimate selector are freed.

Reference should now be had to Fig. 24, and consideration will be given to the operations resulting from the operation of relay FZ. It will be remembered that earth was extended up via wiper and bank DDS3 and lead 93 to the six relays 1FSP of the units FSS1 and FSS6 to search for a link between the penultimate selector 1PGSU and the primary unit FPS1. At the same time as this is done an earth is extended up over contacts *fz4* and lead 95 and then via lead 109 common to the primary/secondary group and contacts *ofb2* to the battery connected slow to operate relay OFA. If there is a link available one of the relays 1FSP will operate before relay OFA has time to get up and in so doing will bring up relay OFB to disconnect the circuit of relay OFA at contacts *ofb2*. If, however, there is no link available relay OFB will fail to operate and relay OFA will operate after its slow period. Relay OFA in operating at contacts *ofa1* (Fig. 20) extends earth via lead 110 common to the primary/secondary group and then via lead 97 into the group DUC1 where it finds a circuit over contacts *fz6* and *za1* to the battery connected relay ZA. Relay ZA in operating functions as before described to bring up relay ZB (Fig. 15) in the control group PCG and to release relay SA in Fig. 21. On release of relay SA earth is extended forward via resistance YAN (Fig. 22) to bring up relay GE in the penultimate selector control group and so return busy tone to the calling party; the control group PCG being freed for further use on the operation of relay 1SE as described and the group DUC1 being freed on release of relay SA.

What we claim as new and desire to secure by Letters Patent is:

1. In a telephone system wherein connections are extended from a calling line through a non-numerical switching stage and then through suc-

cessive numerical switching stages to any desired called line, a switching unit at each of said stages, control equipment individual to each of said switching units, and means including a crossbar switch in each of said switching units operated selectively by the control equipment individual to that unit thereby to extend connections one after another through the associated switching stage and to maintain a plurality of such connections extended concurrently.

2. In a telephone system wherein connections are extended step by step through successive switching stages, a switching unit at each switching stage, control equipment individual to each switching unit, and a crossbar switch in each switching unit operated selectively by the control equipment individual to that unit to extend connections one after another to the next switching stage and to maintain a plurality of such connections extended concurrently.

3. In a telephone system wherein connections are extended progressively through successive non-numerical and numerical switching stages, a plurality of switching units at each stage, each switching unit at a non-numerical stage including a single crossbar switch and control equipment individual thereto for operating the associated switch to extend connections to the next switching stage, and each switching unit at a numerical switching stage including a plurality of crossbar switches and control equipment individual to that particular switching unit for operating the crossbar switches in said unit to complete connections to the next switching stage.

4. In a telephone system wherein connections are extended step by step through successive switching stages, a switching unit at each switching stage, a crossbar switch in each switching unit having a plurality of preparing magnets and a plurality of holding magnets, control equipment individual to each switching unit having means for selecting and operating any preparing magnet and any holding magnet in that unit's crossbar switch, thereby to cause said crossbar switch to complete a connection to the next switching stage, means for releasing said control equipment responsive to the operation of said holding magnet thereby to condition said control equipment to reoperate said crossbar switch to complete another such connection, and means controlling the operated holding magnet over said completed connection to maintain said magnet operated after said control equipment has been released.

5. In a telephone system wherein a connection is extended through successive switching stages under the control of impulses corresponding to a called telephone number, a switching unit at each said stage, each switching unit including a crossbar switch, control equipment individual to each switching unit, means in the control equipment individual to a particular switching unit for receiving part of the impulses corresponding to a called number and selectively operating the crossbar switch in said particular unit to extend a connection to the next switching stage, whereby the remaining impulses corresponding to said called number are transmitted over said extended connection to the next switching stage, and means whereby the crossbar switch in said particular switching unit is reoperable while said connection is extended to extend other connections under the control of the associated control equipment in accordance with impulses of other called numbers received by said control equipment,

6. In a telephone system wherein connections are extended progressively through a non-numerical switching stage and successive numerical switching stages, a switching unit at one of said numerical switching stages, a plurality of lines incoming to said unit from a preceding switching stage, a plurality of groups of lines outgoing from said unit to a succeeding switching stage, control equipment individual to said switching unit having means operated directly by impulses over any one of said incoming lines to select a particular group of outgoing lines, means in said control equipment then operated to search for an idle outgoing line in the selected group, a pair of crossbar switches in said switching unit operated responsive to the finding of an idle outgoing line to complete a connection from said one incoming line to said idle outgoing line in the selected group over said two switches in series, said crossbar switches effective to maintain said connection for an interval of time, and said crossbar switches reoperated by said control equipment during said interval to complete other connections between certain of said incoming lines and certain of said outgoing lines.

7. In a telephone system wherein connections are extended progressively through a non-numerical switching stage and successive numerical switching stages, a switching unit at one of said numerical switching stages, said unit including a primary crossbar switch having a plurality of incoming lines over which that unit may be seized from a preceding switching stage and a secondary crossbar switch having a plurality of groups of outgoing lines extending to a succeeding switching stage, means operated responsive to the seizure of said unit over any particular one of said incoming lines to condition said primary switch to extend a connection from said particular line to said secondary switch, control equipment individual to said switching unit having means operated directly by impulses over said particular line to select a particular group of outgoing lines and condition said secondary switch to complete a connection to each line in the selected group, means in said control equipment operated to search for an idle outgoing line in the selected group, and means in said control equipment operated responsive to the finding of an idle outgoing line for operating said primary switch to complete a connection from said particular line to said secondary switch and operating said secondary switch to further extend said connection to said idle outgoing line in the selected group.

8. In a telephone system, a primary crossbar switch, a plurality of secondary crossbar switches, lines incoming to said primary crossbar switch, lines outgoing from each of said secondary crossbar switches, different links extending from said primary switch to the respective ones of said secondary switches, control equipment individual to each of said crossbar switches, the control equipment individual to said primary switch having means governed by a predetermined condition on any one of said incoming lines for determining which incoming line has said condition upon it, means in the control equipment individual to said primary switch operated to find an idle link extending to any particular one of said secondary switches, means in the control equipment, individual to said particular secondary switch, thereupon operated to find an idle line outgoing from said particular secondary switch, said primary switch and said particular

secondary switch operated by said three means to complete a connection from any incoming line having said predetermined condition thereon to any idle line outgoing from said particular secondary switch.

9. In a telephone system, a plurality of primary crossbar switches, a plurality of secondary crossbar switches, lines incoming to each of said primary crossbar switches, lines outgoing from each of said secondary crossbar switches, a plurality of links extending from each primary switch to the respective ones of said secondary switches, control equipment individual to each of said crossbar switches, the control equipment individual to each primary switch having means governed by a predetermined condition on any one of said lines incoming to that switch for determining which incoming line has said condition upon it, the control equipment individual to each primary switch also having means governed by said predetermined condition on any one of said lines incoming to that switch for finding an idle link extending from that primary switch to any particular one of said secondary switches, means in the control equipment individual to said particular secondary switch thereupon operated to find an idle line outgoing from said particular secondary switch, and means operated responsive to the finding of said idle outgoing line for operating said primary switch to connect said idle link to the incoming line having said predetermined condition on it and operating said particular secondary switch to connect said idle link to said idle outgoing line, whereby the incoming line having said predetermined condition on it and said idle outgoing line are interconnected via said idle link.

10. In a telephone system, a plurality of primary crossbar switches, a plurality of secondary crossbar switches, lines incoming to each of said primary crossbar switches, lines outgoing from each of said secondary crossbar switches, a plurality of links extending from each primary switch to the respective ones of said secondary switches, control equipment individual to each of said crossbar switches, the control equipment individual to each primary switch having means governed by a predetermined condition on any one of said lines incoming to that switch for determining which incoming line has said condition upon it, the control equipment individual to each primary switch also having means governed by said predetermined condition on any one of said lines incoming to that switch for finding an idle link extending from that primary switch to any particular one of said secondary switches, means in the control equipment individual to said particular secondary switch thereupon to find an idle line outgoing from said particular secondary switch, and means operated responsive to the finding of said idle outgoing line for operating said primary switch to connect said idle link to the incoming line having said predetermined condition on it and operating said particular secondary switch to connect said idle link to said idle outgoing line, whereby the incoming line having said predetermined condition on it and said idle outgoing line are interconnected via said idle link, means effective to maintain said two switches operated independently of their respective control equipments and to release said equipments, said control equipments thereafter reoperable while said two switches remain thus operated to control their respective switches to complete other connections

between incoming lines and outgoing lines via said links.

11. In a telephone system wherein connections are extended through a non-numerical switching stage and then through successive numerical switching stages, a primary crossbar switch and a plurality of secondary crossbar switches in said non-numerical stage, lines incoming to said primary switch, lines outgoing from each of said secondary switches, different links extending from said primary switch to the respective ones of said secondary switches, control equipment individual to each of said crossbar switches, the control equipment individual to said primary switch having means governed by a predetermined condition on any one of said incoming lines for determining which incoming line has said condition upon it, means in the control equipment individual to said primary switch operated to find an idle link extending to some particular one of said secondary switches, means in the control equipment individual to said particular secondary switch operated to find an idle line outgoing from said particular secondary switch, said primary switch and said particular secondary switch operated by said last three means to complete a connection from any incoming line having said predetermined condition thereon to an idle line outgoing from said particular secondary switch, a switching unit at each of said successive numerical stages, control equipment individual to each of said units, and a crossbar switch in each of said switching units operated selectively by the control equipment individual to that unit to extend connections one after another from different ones of said outgoing lines through the associated numerical switching stage and to maintain a plurality of such connections extended concurrently.

12. In a telephone system wherein connections are extended progressively through successive switching stages, each stage having a plurality of crossbar switching units and a control unit individual to each switching unit for operating that switching unit to complete connections through the associated stage, means in a control unit in the penultimate switching stage operated directly to select an idle control unit in the final switching stage and to complete a circuit to the selected control unit independently of any crossbar switching unit in the penultimate switching stage, and means in the selected control unit operated directly over said circuit and thereupon effective to operate the crossbar switching unit corresponding to that unit selectively to complete a connection through the final switching stage.

13. In a telephone system wherein connections are extended progressively through successive switching stages, thereby to establish a connection from each calling subscriber's line to a particular desired called subscriber's line, a plurality of crossbar switching units at each stage, a control unit individual to each switching unit for operating that switching unit to complete connections through the associated stage, and battery feed means at the penultimate stage of each connection thus established for supplying current to the calling and called subscribers' lines in that connection.

14. In a telephone system wherein connections are extended progressively through successive switching stages, thereby to establish a connection from each calling subscriber's line to a particular desired called subscriber's line, a plurality

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of crossbar switching units at each stage, a control unit individual to each switching unit for operating that switching unit to complete connections through the associated stage, and means at the penultimate stage of each connection thus established for transmitting ringing current to the called subscriber's line included in that connection.

15. In a telephone system, means for setting up a connection progressively through a train of crossbar switches and, while said connection is established, setting up a second connection progressively through the same train of switches, said means including a plurality of registers corresponding respectively to different crossbar switches in said train, each register having means for selectively controlling its corresponding crossbar switch to extend said connections there-through, and means for temporarily associating each of said registers with every connection incoming to its corresponding crossbar switch from a preceding switch in the switch train, thereby to receive information over such incoming connection and operate said switch-controlling means in accordance therewith.

16. In an arrangement for setting up a connection progressively through a train of crossbar switches and, while said connection is established, setting up a second connection progressively through the same train of crossbar switches, a plurality of separate control units corresponding respectively to the switches of said train, and means in each of said control units for selectively controlling its corresponding crossbar switch to set up each of said connections through that particular switch in accordance with information received by said control unit over the portion of that connection extended to said particular switch through the preceding part of said switch train.

17. In an arrangement for setting up a connection progressively through a train of crossbar switches and, while said connection is established, setting up a second connection progressively through the same train of crossbar switches, a plurality of registers corresponding respectively to said crossbar switches, means for associating each of said registers with every connection incoming to its corresponding crossbar switch thereby to receive, over the portion of such connection extended through the preceding part of the switch train, a variable number of impulses, and means controlled by each register for selec-

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tively operating its corresponding crossbar switch in accordance with the received impulses thereby to further extend said incoming connection through said switch to the next switch in the train.

18. In a switching system, a crossbar switch having a plurality of incoming lines, a control unit common to said lines, means for seizing any one of said lines and transmitting a plurality of digits over that line, means in said control unit for registering only one of the digits transmitted over said line and, in accordance with the value of the registered digit, selectively operating said crossbar switch to complete through said switch a connection over which are transmitted the remaining ones of said digits, means effective, in the event that another one of said lines is seized while said connection is in existence, to associate said control unit with said other line, said means in said control unit thereupon effective, as before, to register a single digit transmitted over said other line and, in accordance with the value of the registered digit, to selectively operate said crossbar switch to complete another connection therethrough, whereby plurality of connections through said switch may exist concurrently.

19. In a telephone system wherein each connection between a calling line and a wanted line is extended through successive switching stages, a switching unit individual to a particular one of said stages, said unit including a crossbar switch having a plurality of lines incoming from a preceding stage, means for seizing different ones of said incoming lines substantially simultaneously and transmitting over each seized line impulses corresponding to part of the directory number of a wanted line, means in the switching unit individual to said particular switching stage temporarily associated with each seized line for registering only the impulses corresponding to one digit of the directory number transmitted over that line and operating said crossbar switch selectively in accordance with the registered digit thereby to extend through said switch a connection over which the impulses corresponding to the remaining part of the directory number are transmitted to a subsequent switching stage, whereby connections through said crossbar switch from all of said seized incoming lines may exist concurrently.

CHARLES GILLINGS,
LAWRENCE JOHN MURRAY.