

April 2, 1946.

H. H. SCHROEPPPEL

2,397,887

AUTOMATIC ALTERNATE ROUTING OF INTEROFFICE CALLS

Filed Oct. 5, 1944

5 Sheets-Sheet 1

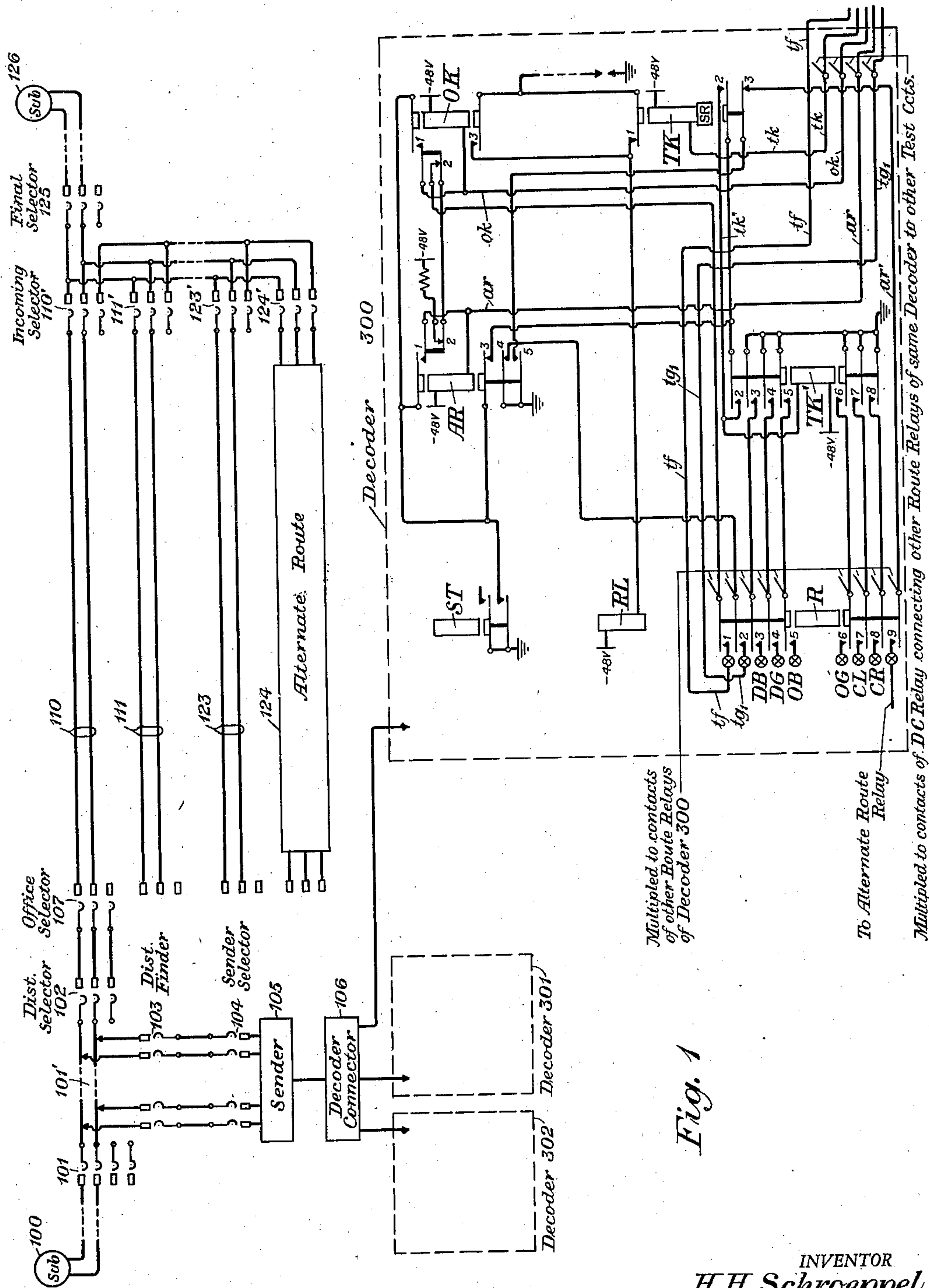


Fig. 1

BY

INVENTOR
H. H. Schroepfel

Claude Rose
ATTORNEY

April 2, 1946.

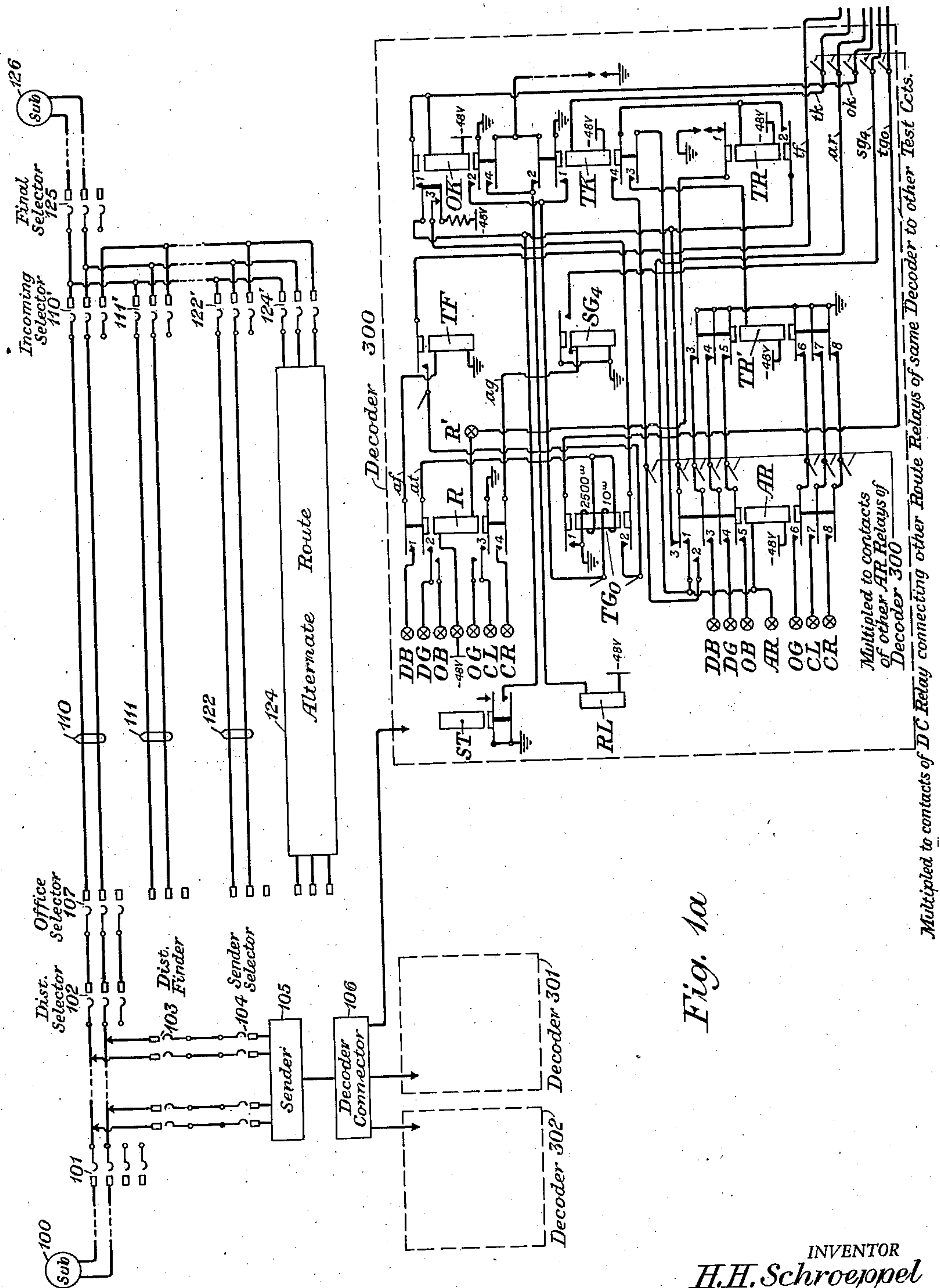
H. H. SCHROEPPPEL

2,397,887

AUTOMATIC ALTERNATE ROUTING OF INTEROFFICE CALLS

Filed Oct. 5, 1944

5 Sheets-Sheet 2



BY

INVENTOR
H. H. Schroepfel

Claude L. Rose
ATTORNEY

April 2, 1946.

H. H. SCHROEPPEL

2,397,887

AUTOMATIC ALTERNATE ROUTING OF INTEROFFICE CALLS

Filed Oct. 5, 1944

5 Sheets-Sheet 3

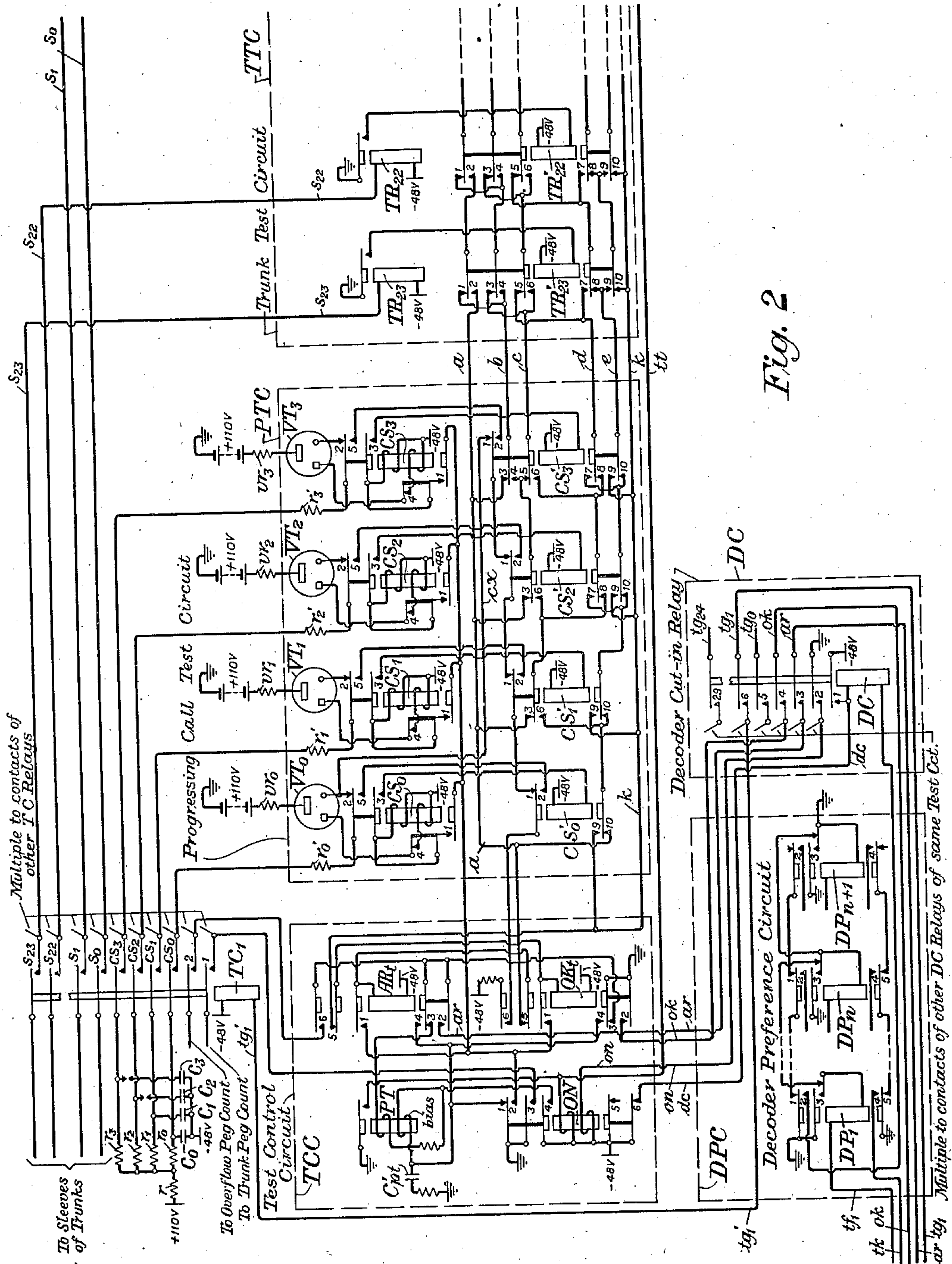


Fig. 2

INVENTOR
H. H. Schroepfel

BY

Claude R. Rose
ATTORNEY

April 2, 1946.

H. H. SCHROEPPEL

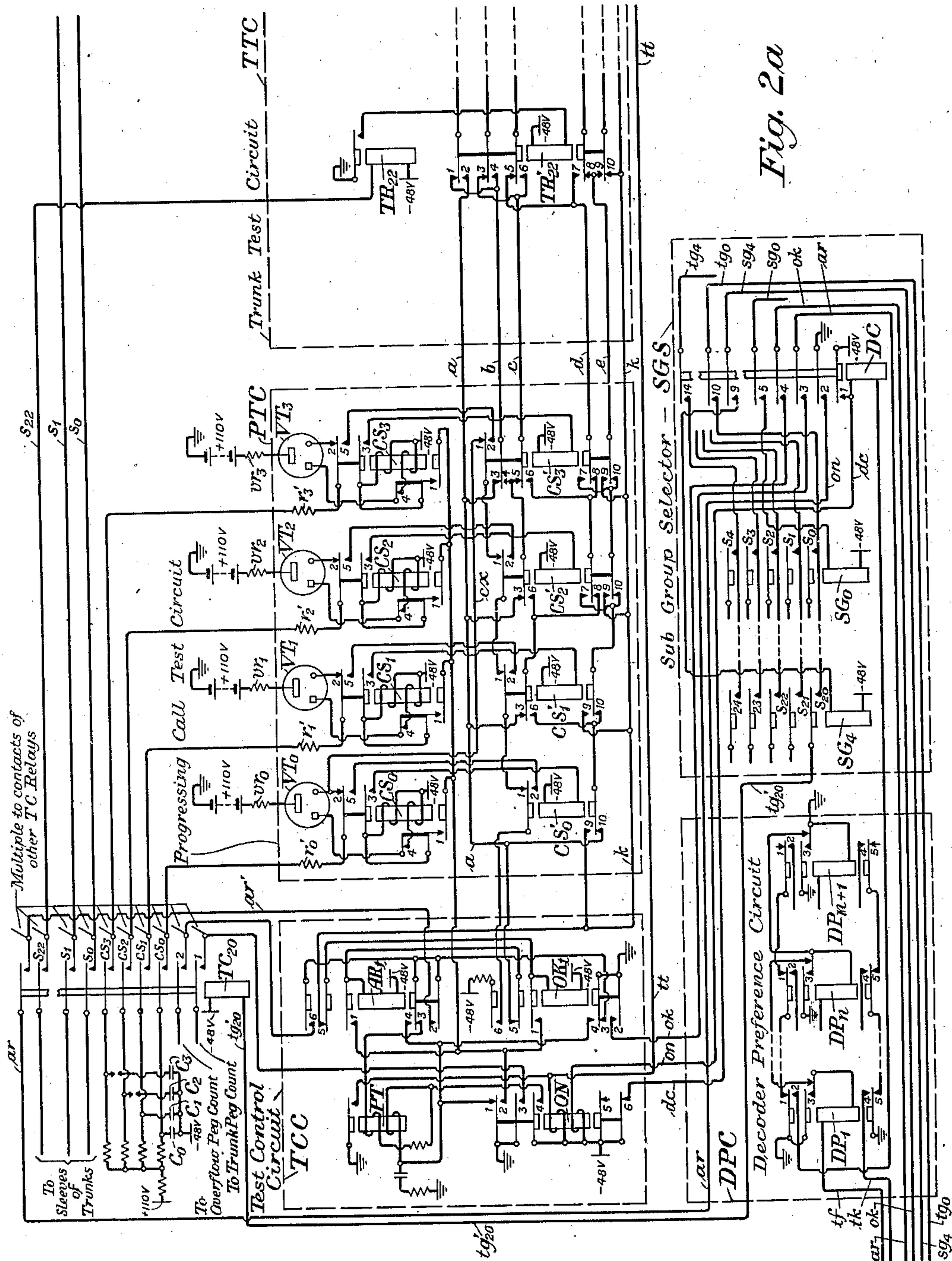
2,397,887

AUTOMATIC ALTERNATE ROUTING OF INTEROFFICE CALLS

Filed Oct. 5, 1944

5 Sheets-Sheet 4

Fig. 2a



BY

INVENTOR
H. H. Schroepfel

Claude R. Rose
ATTORNEY

April 2, 1946.

H. H. SCHROEPPPEL

2,397,887

AUTOMATIC ALTERNATE ROUTING OF INTEROFFICE CALLS

Filed Oct. 5, 1944

5 Sheets-Sheet 5

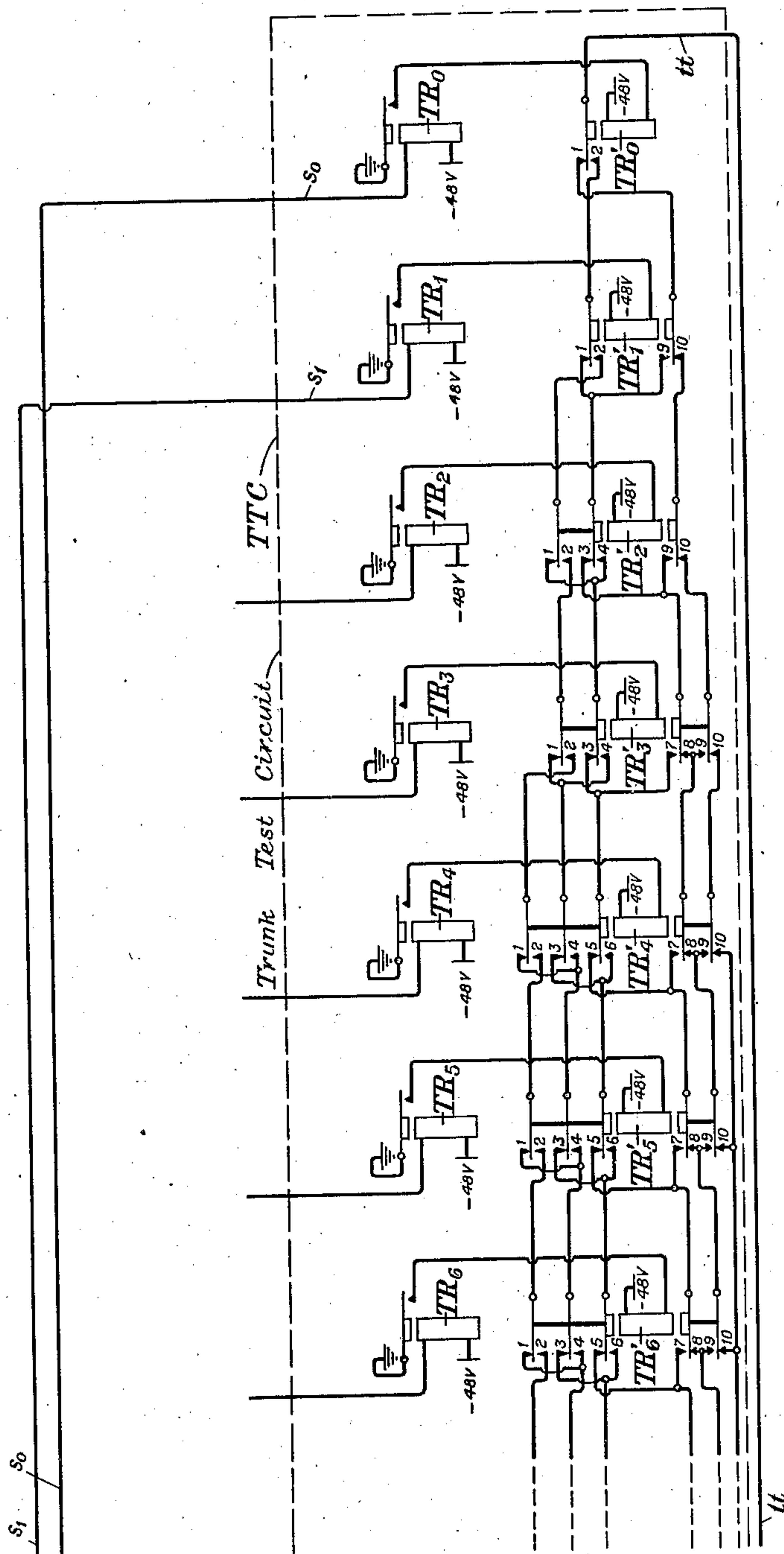


Fig. 3

BY

INVENTOR
H. H. Schroepfel
Cecile Rose
ATTORNEY

UNITED STATES PATENT OFFICE

2,397,887

AUTOMATIC ALTERNATE ROUTING OF
INTEROFFICE CALLS

Harold H. Schroepfel, Glen Rock, N. J., assignor
to American Telephone and Telegraph Com-
pany, a corporation of New York

Application October 5, 1944, Serial No. 557,302

9 Claims. (Cl. 179—18)

This invention relates to telephone exchange systems and more particularly to systems in which connections between subscribers' lines terminating in different offices of an exchange area are established by automatic switching mechanism over groups of interoffice trunks.

In exchange areas having a large number of local offices it is not always economical to provide direct groups of trunks for interconnecting each office with every other office, particularly where the offices are widely separated and the traffic load is relatively light. In such exchange areas it is sometimes more economical to route some traffic between certain offices through a tandem office which serves as a common intermediate distributing point, so that a number of small, inefficient trunk groups are combined into larger, more efficient groups.

It has heretofore been proposed to render more efficient the trunks in a group directly interconnecting any two offices by limiting the number of the direct trunks to the maximum required for handling normal traffic between such offices. Abnormal or overflow traffic between such offices is then automatically rerouted to a tandem office where the traffic may be directly routed to the desired office. Where traffic is increasing this proposal also may enable existing direct trunk groups between offices to be employed without the addition of further trunks thereto. When traffic loads increase beyond the capacity of such trunk groups the situation can be handled by rerouting calls through a tandem office. To accomplish the rerouting of calls through a tandem office in systems employing central office senders for controlling the setting of selector switches to establish connections, the sender must receive information as to the busy or non-busy condition of all trunks of a direct trunk group extending to an office. This is necessary in order to enable the sender to take the necessary steps to route the connection over an alternate route to the desired office in case no idle trunk in the normal group is available. This involves certain problems which will be discussed later.

In systems of the type disclosed in Patent No. 1,862,549 granted June 14, 1932, to R. Raymond and W. J. Scully, the establishment of connections from an originating office to any other office of the exchange area is made possible by district and office selectors. These are set to select an idle trunk of a group extending to the office in which a desired subscriber's line terminates, by a plurality of senders, groups of which are available to all subscribers' lines of the origi-

5 nating office. Each sender has registers for registering both the office and numerical designations of a desired line dialed by a calling subscriber. It also has controlling apparatus for controlling the setting of a district and an office selector to extend a connection to the office in which the desired line terminates, and apparatus for controlling other mechanism in the selected office for completing the connection.

10 A plurality of decoders is also provided common to all of the senders, an idle one of which becomes associated with a sender taken for use by a calling subscriber. The decoder is provided with office code registers to which the office code is transferred from the registers of the associated sender. The decoder is also provided with as many route relays as there are trunking points to which calls may be trunked from the originating office. The combined setting of the office code registers of the decoder determines which
20 one of these route relays shall be operated for any particular call. The operated route relay is instrumental in establishing in the associated sender a registration of the class of the call and
25 a decoded office code registration. The sender is thus directed to control the setting of proper district and office selector switches (or in certain cases a district selector alone), to select a group of trunks extending to the office in which
30 the desired line terminates.

In plans heretofore proposed for the alternate routing of interoffice traffic from panel type dial offices, provision has been made for switching from the group of trunks of the normal route to
35 an alternate route before all of the trunks of the normal route become busy. This is done in order to reservoir trunks for previously initiated calls which may not yet be completed when the route transfer is made. Such an arrangement
40 may result in unnecessarily shifting many calls to an alternate route when as a matter of fact trunks extending over the normal route are available at the time the route for the call is established.

45 In accordance with the present invention, a plan is provided which permits practically complete use of all original route trunks before recourse is had to an alternate route. The scheme herein proposed differs from plans of the prior art principally in that it not only determines the
50 busy condition of trunks actually in use, but it also provides a temporary record of each call which may be in course of extension to a trunk group. This record will persist long enough to
55 enable the trunk selection to be completed for

the recorded call. Consequently, if the number of trunks actually in use plus the number of progressing calls exceeds the total number of trunks in the group, the alternate route will be made available.

In order to avoid excessive decoder delays due to circuit lockouts, each decoder will have access to testing equipment which determines what trunks of the normal route group are busy, and how many calls are in progress of being extended to trunks of the group. This testing equipment determines whether a particular call shall be extended over a trunk of the normal trunk group or over an alternate route.

As herein disclosed, the maximum size of the original route group may be 23 or 24 trunks, depending upon whether the improved method is applied to an existing decoder installation or whether it is applied to a new installation. The number of trunks above referred to will be adequate for most cases. However, if it becomes necessary to provide for larger groups, additional facilities may readily be added. In order to determine the traffic requirements in this respect, the proposed system provides for a peg count of calls offered to the trunk group and also a count of overflow calls extended over the alternate route.

For a clearer understanding of the invention, reference may be had to the following detailed description taken in connection with the accompanying drawings in which

Figure 1 shows schematically a calling and a called subscriber's line, together with trunk switching equipment, senders, decoders, etc., by which connections may be extended between the subscribers;

Fig. 2 shows an arrangement for determining how many calls in progress are being extended to the trunks, and it also shows a portion of a test circuit for ascertaining what trunks are busy;

Fig. 3 shows other portions of the test circuit;

Fig. 1a is a modification of the arrangement shown in Fig. 1; and

Fig. 2a is a modification of that portion of the testing equipment which is shown in Fig. 2.

Figs. 1, 2 and 3, when laid end to end show those portions of the overall circuit arrangement which are essential to a proper understanding of the invention in the form it may assume when new installations are to be made. Similarly, Figs. 1a, 2a and 3 when laid end to end show the corresponding features of a modified arrangement adapted to be applied to existing installations.

SWITCHING EQUIPMENT AND TRUNKS OF FIGS. 1, 2, AND 3

Referring to Fig. 1, a line finder 101 is shown for establishing connection with a calling line such as 100 which has initiated a call to subscriber station 126 at a distant office. A district selector 102 and an office selector 107 are provided for establishing connections over a group of normal routing trunks such as 110 to 123, inclusive. An alternate route 124 is also provided for the purpose of establishing a connection to the desired subscriber when all of the trunks of the normal group are busy. Incoming selectors such as 110', 111', etc., are associated with the distant ends of the various trunks and final selectors such as 125 are provided to complete the connection to the wanted subscriber.

When a station such as 100 starts a call and a line finder such as 101 has established connection therewith, a district finder 103 and a sender se-

lector 104 operate to connect a sender 105 to the local trunk terminating in the line finder. A decoder connector 106 operates in a known manner to associate one of the decoders, such as 300, 301 or 302 to the sender 105. The decoder determines the routing control connections for operating the switches to complete the call. All of the switches, senders, decoder connectors, etc., shown schematically in Fig. 1 are of known type, and for a complete description thereof a reference may be had to the Patent No. 1,862,549 granted to R. Raymond and W. J. Scully hereinbefore referred to.

THE DECODER OF FIG. 1

The decoders 300, 301 and 302 are merely indicated symbolically and are of the type shown in said Patent No. 1,862,549, except for certain changes herein specifically pointed out. These changes are shown in connection with decoder 300 to the extent necessary for an understanding of the present invention. For those portions of the decoder which are not illustrated reference may be had to the aforementioned patent. The alternate route equipment shown at 124 may be of the type disclosed in detail in Patent No. 1,840,132 granted January 5, 1932, to T. H. Roberts. The incoming selectors 110', 111', etc., and the final selector 125 are of a well-known type commonly employed in panel switching systems. As their structural detail and method of operation form no part of the present invention, they are merely disclosed herein schematically.

In order that the background of the invention may be more clearly understood, let us assume that the subscriber at substation 100 of an originating office of an exchange area desires to establish a connection with the subscriber's line 126 which terminates at a distant office of the same exchange area. The calling subscriber, upon removing his receiver from the switchhook, obtains a connection with an idle sender 105 in the originating office through the operation of the line finder 101, district finder 103 and sender selector 104 in a well-known manner. The subscriber then dials the office code letters and numerical digits of the directory number of the wanted line 126.

In response to dialing, the office code and numerical designations are registered in the sender 105 in a well-known manner. Following the registration of the letters of the office code designation, and while the line number is dialed, the decoder connector 106 operates to associate an idle decoder with the sender. As herein illustrated, three decoders are provided. Assuming that the decoder 300 is free at this time, the decoder connector 106 causes this decoder to be associated with the sender 105, and also operates the decoder start relay ST.

Each decoder is provided with the usual receiving registers to which an associated sender transfers the letters of the office code designation. It also is provided with a route relay corresponding to each route over which connections may be extended from the originating office to other offices. In addition, it includes transmitting registers which are selectively set by any operated route relay. The transmitting registers are employed to transfer routing information back to the registers of the associated sender. These sender registers in turn control the functioning of the sender to establish the desired connection through district and office selectors (or through a district selector only), over the route indicated by the operated route relay of the decoder. Only

one route relay R is illustrated and its connections are not shown as they will be understood from Patent No. 1,862,549 previously referred to.

The fundamental principle of the system is that when a trunk of the normal route group 110 to 123, inclusive is available, the connection will be established over said trunk. If, however, no such trunk is available the connection will be transferred for completion over the alternate route 124. To this end, each decoder such as 300 is provided with a relay OK, which is operated when, after testing for busy trunks and calls in progress, it is found that a trunk of the regular group will be available. An alternate route relay AR is also provided, and this relay is operated when, upon test, it is found that no trunk of the normal route group will be available.

Each decoder is also provided with a release relay RL, which, when operated, permits the routing information set up by the decoder to be released to control the operation of the appropriate district selector, office selector or other switches, to complete the connection to the office of the called subscriber. A test connect relay TK is also included in the decoder and serves to indicate that trunk testing equipment has been associated with the decoder for testing purposes. In the arrangement of Fig. 1, a secondary test connect relay 'TK' is arranged to be controlled by the relay TK. Relay 'TK' operates to extend routing connections determined by the route relay R over contacts of said relay R. These connections control the operation of the district selector and office selector to extend the call to the distant office.

As will be described later, the operation is such that, as soon as the decoder obtains access to the testing apparatus, connections for eventually controlling the operation of the district selector and office selector are determined by the operated route relay such as R. These connections, however, do not become effective until the OK relay, in response to the proper trunk group, indicates that a normal trunk connection is available. If it should happen that no normal trunk route is available, the AR relay is operated in response to the test, and determines the setting up of a new set of district selector and office selector control connections for the alternate route, as will appear later. Under these conditions the previously established control connections by the route relay R become ineffective.

TESTING EQUIPMENT OF FIGS. 2 AND 3

The trunk testing equipment is shown in Figs. 2 and 3. For purposes of convenience, this equipment is divided into three parts: (1) the test control circuit TCC, which initiates the test and records the result thereof; (2) a trunk testing circuit TTC which determines whether or not the trunks of a chosen group are busy; and (3) a progressing call test circuit PTC which determines the number of uncompleted calls in process of being routed to the chosen group of trunks.

(a) Decoder Preference circuit

The testing apparatus which will be described more in detail later, has associated therewith a decoder preference circuit DPC which determines the order in which several decoders, having access to the same trunk testing equipment, may obtain control thereof. The decoder preference circuit includes a series of decoder preference relays DP₁, DP_n, etc. whose function will appear later.

Associated with the decoder preference circuit DPC is a decoder cut-in relay DC which, after the preference circuit has acted, establishes a connection from the decoder to the testing equipment. There is also provided a trunk group cut-in relay TC which establishes connections from trunks of the normal group to the testing equipment for testing purposes. The trunk group cut-in relay TC also establishes connections whereby temporary electrical records of calls in progress of completion may be temporarily recorded.

After the operation of decoder preference circuit the decoder cut-in relay DC gives access to any one of 25 different groups of trunks of as many as 24 trunks each. This is done by one of the contacts of relay DC operating a selected one of the 25 trunk group cut-in relays TC. The operating contact of the relay DC and consequently the TC relay to be selected are determined by the particular route relay of the decoder which is operated in accordance with registered office code letters.

(b) The test control circuit of Fig. 2

The test control circuit TCC includes four relays: (1) an off-normal relay ON for initiating the testing operation; (2) a condenser-timed relay PT, which delays determination of the result of the test until the various relays of the testing equipment have had an opportunity to operate; (3) a relay OK_t which responds when the test indicates that a trunk is available; and (4) an alternate route relay AR_t which when it responds indicates that no trunk is available, and that an alternate route must be established.

(c) The trunk test circuit of Figs. 2 and 3

The trunk test circuit TTC, shown in Figs. 2 and 3, consists of a series of trunk relays such as TR₀, TR₁, etc., one corresponding to each trunk of the chosen group, and connected over contacts of the trunk group cut-in relay TC to the sleeves of the several trunks. Each of the TR relays operates a subsidiary trunk relay such as TR₀', TR₁', etc. Circuits are controlled over contacts of these various trunk relays to afford information as to what trunks are busy, as will appear later.

(d) Progressing call test circuit of Fig. 2

The progressing call test circuit PTC is arranged to determine the number of calls in process of being routed over trunks of the chosen normal group. The apparatus of the progressing call test circuit is arranged on a percentage basis. The idea is to provide devices for recording an assumed maximum number of previously initiated calls which might be at a given moment in some stage of progress toward establishing connections to trunks of the group under test. As herein disclosed, it is assumed that the maximum number of calls in progress at any time toward a particular group of 24 trunks will not exceed four. Therefore, four sets of equipment for recording progressing calls are provided. Only two of these are shown actually connected for use, because in many instances the number of simultaneous progressive calls does not exceed two. However, all four sets of equipment may be used if desired.

Each set of progressing call recording equipment includes a vacuum tube of the trigger type, which is arranged to break down and ionize when a potential in excess of a predetermined maximum is applied to its operating electrodes. In

the arrangement illustrated in Fig. 2, four such tubes VT₀, VT₁, VT₂ and VT₃ are provided. Each of these tubes controls a call-storing relay such as CS₀, CS₁, etc., each of which in turn controls a subordinate call-storing relay such as CS_{0'}, etc.

The apparatus is so arranged that if no calls are in process of being established over any of the trunks, all of the condensers such as C₀, C₁, etc., will be charged to a potential high enough to operate the corresponding trigger tubes. Therefore, as soon as a trunk group cut-in relay, such as TC₁, is operated in response to a call in process of being routed, all of the trigger tubes such as VT₀, VT₁, etc., of the progressing call test circuit will be operated if no call is in progress of completion. If, however, calls are in progress on one or more of the trunks in the group when the test circuit is cut in, a corresponding number of the storage condensers C₀, C₁, etc., will have been discharged and will not yet have charged up to a potential sufficient to operate the corresponding trigger tube. Therefore, if one or more calls are in progress, a corresponding number of trigger tubes will fail to be operated.

The several trigger tubes control relays such as CS₀, CS₁, etc., and these relays in turn operate subsidiary relays such as CS_{0'}, CS_{1'}, etc. The vacuum tubes are less in number than the number of trunks in the group. Therefore, no particular vacuum tube is assigned to any particular trunk for the purpose of recording a call in progress of completion. The vacuum tubes and their associated relays are in effect arranged in a chain for successive operation. When a call in progress obtains control of the progressing call test circuit PTC, and the test indicates that the call should be routed over the original route by the operation of a relay OK_t as hereinafter described, the call will be registered upon the first idle tube from the left, for example. The term "idle" as herein applied has reference to a tube upon which no call is registered. As will appear later, when a progressing call seizes the progressing call test circuit PTC, the tubes upon which previously initiated but uncompleted calls have been registered do not operate, but only the idle tubes operate. The progressing call which has seized the test circuit, however, registers that call on the first idle tube from the left, by reducing to zero the voltage applied to its operating electrodes.

When the progressing call test circuit PTC is seized in connection with a call for which a trunk is sought, all idle vacuum tubes, if any, are at once operated and thereupon operate their corresponding CS relays. Each CS relay, when operated, is locked up and disconnected from the corresponding vacuum tube so long as the progressing call test circuit is in operation to make the necessary test. The CS relays thus operated, in turn operate corresponding CS' relays, which together with the TR' relays of the trunk test circuit TTC determine whether there is a trunk available or whether the call must be completed over an alternate route. In the former case, the operation of the relay OK_t upon the completion of the test applies a voltage over contacts of the CS' and CS relays associated with the first operated tube from the left, to reduce the normal charging potential of the condenser associated with that tube to zero. Consequently, the condenser will, for a predetermined time thereafter, register a progressing call busy condition against the group of trunks under test.

The testing circuits, as a whole, including the progressing call test circuit PTC and the trunk test circuit TTC, have the contacts of their relays so arranged that if the number of busy trunks indicated by trunk test circuit TTC, plus the number of progressing calls indicated by the progressing call test circuit PTC, is equal to or greater than the total number of trunks in the group, the relay AR_t in the test control circuit TCC will operate. The call under test will therefore be routed over an alternate route by the operation of the relay AR in the decoder.

OPERATION OF FIGS. 1, 2, AND 3

Further details of the apparatus will now be clear from a detailed description of the operation.

Let us assume that the subscriber at substation 100 connected to one office of an exchange area desires to establish a connection with the subscriber's line 126 which terminates at a distant office of the same exchange area. Upon removing his receiver from the switchbook he obtains a connection with the idle sender 105 in a well-known manner and then dials the office code letters and the numerical digits of the directory number of the desired line.

In response to dialing, the office code and numerical designations are registered in the sender 105. As soon as the letters of the office code designation have been so registered the decoder connector 106 is operated to associate an idle decoder such as 300 with the sender. Upon the connection of the decoder its start relay ST is operated.

(1) Initial operation of decoder of Fig. 1

Let it be assumed that the route relay R of decoder 300 is operated as a result of the registration of the letters of the office code designation. Upon closing its contact 1 route relay R establishes a circuit over test frame conductor *tf*, from minus 48 volt battery, over contact 2 of relay AR, contact 2 of relay OK, contact 4 of relay R, conductor *tf*, through winding of relay DP₁ of the decoder preference circuit DPC, thence over contact 3 of said relay DP₁, and (assuming the testing equipment is not busy in connection with some other decoder) over the number 3 contacts of other decoder preference relays, such as DP_n and DP_{n+1}, to ground. If no other decoder is in connection with the testing equipment, the decoder preference relay DP₁ associated with the decoder 300 is operated immediately and is locked up over its contact 3. If the testing equipment is associated with another decoder, operation of relay DP₁ awaits release of the decoder preference relay of such other decoder.

Relay DP₁, upon operating, connects ground over its ground contact 4 to the circuit *tk* which passes through the trunk test connect relay TK to battery. Over its contact 2, relay DP₁ completes a circuit from ground, through the winding of decoder cut-in relay DC, over conductor *dc*, and over contact 6 of the off-normal relay ON.

Relay TK in the decoder being operated, it opens at its contact 1 the circuit of the release relay RL of the decoder to prevent the decoder 300 from transmitting routing information for operating the district selector switch 102 and office selector switch 107 until it has been determined whether an idle trunk of the normal trunk group is available, or whether an alternate route will have to be used.

At contact 3, relay TK opens the conductor *ar'* to prevent the operation of an alternate route

relay (not shown) over contact 9 of the normal route relay R. By closing its contact 2, relay TK operates relay TK' over a circuit from ground, over a contact of the start relay ST, contact 3 of relay AR, contact 2 of relay TK, and through the winding of relay TK' to battery. Relay TK' is locked over its contact 2 independently of the relay TK, and at its contacts 3 to 8, inclusive, connects ground over the contacts 3 to 8, inclusive, of the route relay R to circuits associated with terminals DB, DG, OB, OG, CL and CR, whereby certain operations relating to district group selection, district brush selection, office group selection, office brush selection, determination of the class of call and selection of a compensating resistance are initiated. These operations are prevented for the moment, however, by the fact that the circuit of the release relay RL is held open at the contact 1 of the relay TK so that routing information cannot be released for the selection of a trunk.

(2) Trunk group selection in Figs. 1 and 2

The operation of the decoder cut-in relay DC by the relay DP₁ as above described, sets into operation testing equipment to determine whether an idle trunk is available in the normal trunk group selected, or whether it will be necessary to use an alternate route. The operation of the relay DC causes said relay to lock over its contact 1 independently of the off-normal relay ON. By closing its contact 2, relay DC connects ground to conductor *on* and through the lower winding of the off-normal relay ON to battery, thus operating relay ON. At its contacts 3 and 4, relay DC prepared circuits over conductors *ar* and *ok*, respectively, for a purpose which will be described later.

In order to determine what group of trunks will be selected, test decoder cut-in relay DC is provided with a set of 25 additional contacts designated *tg*₀ to *tg*₂₄, inclusive, to select one of 25 trunk group cut-in relays such as TC₁. Which one of these contacts will become effective when the relay DC is operated, depends upon which group relay R was operated in the process of registering in the decoder routing information determined by the office code letters. In the case illustrated, the operated route relay R, at its second contact, completes a circuit over conductor *tg*₁ from ground, over contact 4 of the alternate route relay AR (which is not operated at this time), over contact 2 of route relay R, over conductor *tg*₁, thence over the *tg*₁ contact of relay DC, and over conductor *tg*₁' through the winding of trunk group cut-in relay TC₁ to battery.

It will be evident that the operation of the relay DC gives access through 25 trunk group cut-in relays such as TC₁ to 25 groups of trunks, each group in the case illustrated including 24 trunks. The 24 trunks selected by the trunk group cut-in relay TC₁ have their sleeves connected to the 24 contacts of relay TC₁ designated *s*₀ to *s*₂₃. These contacts are in turn connected to the windings of the trunk test relays TR₀ to TR₂₃ of the trunk test circuit TTC.

(3) Preliminary operation of test control circuit TCC of Figs. 2 and 3

Returning now to the off-normal relay ON, which was operated through its lower winding by contact 2 of the decoder cut-in relay DC, it will be seen that the relay ON when operated disconnects battery at contacts such as 5 and 6 from the various DC relays to prevent the oper-

ation of other DC relays. The actuated relay DC, however, holds up its armature because of its locking circuit previously described. By closing its contact 2, relay ON applies locking ground to a number of relays as will appear hereinafter. At its contact 3 relay ON connects ground over the number 1 contact of trunk group cut-in relay TC₁ to operate a peg count to record the fact that an additional call has come in to the group of 24 trunks controlled by the relay TC₁.

At its contact 4, relay ON connects battery through a resistance and the upper winding of timing relay PT, and thence over contact 3 of relay AR_t and contact 3 of relay OK_t to ground. At the same time the biasing current for relay PT will be caused to flow from battery, over contact 4 of off-normal relay ON, through the lower or biasing winding of relay PT, and through the condenser C_{pt} and series resistance to ground. The current through the biasing winding is sufficient to prevent the operation of the armature of the relay PT by its upper operating winding until the condenser has been charged up to a point where very little current flows through the condenser. The operation of the relay PT is therefore delayed long enough to enable the various testing relays to perform their functions as will be described later. The relay PT when actuated establishes a circuit *tt* which extends over contacts of the testing relays to determine whether the OK signal or an AR signal will be returned to the decoder, as will be described later. The OK signal indicates that one of the selected group of 24 trunks is to be used to complete the call, whereas the sending of the AR signal means that an alternate route must be employed.

(4) Operation of trunk test circuit TTC

As already pointed out, the sleeves of the 24 trunks constituting the selected subgroup are connected over the contacts of the group cut-in relay TC₁ to the various individual trunk testing relays TR₀ to TR₂₃, inclusive. Each trunk that is busy, therefore, connects ground to the winding of one of the TR trunk testing relays and the operated TR relays in turn operate corresponding relays of the group TR₀' to TR₂₃', inclusive. This sets up a connection within the trunk test circuit TTC, as will be described later, which takes a part in determining whether an OK or an AR signal is to be sent to the decoder. It will thus be seen that the trunk test circuit TTC operates in effect to record what individual trunks of the selected group of 24 are busy.

(5) Operation of progressing call test circuit PTC of Fig. 2

In order to make allowances for any calls which have been already initiated and are in the course of progress toward the selected trunk group without yet having seized a trunk to make it busy, the invention is arranged to determine how many such calls are in progress. It is for this purpose that the progressing call test circuit PTC is provided as has already been stated. It consists of a number of vacuum tubes such as VT₀ to VT₃, inclusive, having associated therewith CS and CS' relays. The trunk group cut-in relay TC₁ is also provided with contacts such as *cs*₀, *cs*₁, *cs*₂, and *cs*₃, which lead to suitable resistances R₀ to R₃, inclusive, and thence through a common resistance to plus 110 volt battery. Bridged to the resistances R₀ to R₃, inclusive, are condensers C₀, C₁, C₂ and C₃. While four condensers are provided, some of them may be

disconnected, if it is unlikely that as many as four calls in progress will be registered at the same time. The lower electrodes of the condensers are connected to a minus 48 volt battery. It will thus be evident that the normal charge on each of the condensers is 158 volts.

The vacuum tubes VT_0 , VT_1 , etc. are designed so that when a voltage greater than some critical value such as 70 volts is applied to the control electrodes of the tube, the high resistance of the tube will be broken down and the corresponding CS relay operated. If voltages less than this are applied to the control electrodes the tubes will be unaffected and the associated relays will not be operated.

For example, let us consider the case of vacuum tube VT_1 . Assuming that the condenser C_1 is charged to the full potential of 158 volts, upon the operation of the relay TC_1 the charge of the condenser C_1 is applied over contact cs_1 to relay TC_1 , through a resistance r_1' , and thence over contact 2 of relay CS_1 to the right-hand control electrode of vacuum tube VT_1 . From this point the circuit extends through the high resistance of the tube to the left-hand control of the electrode, over the normal make contact 4 of relay CS_1 and through the lower winding of said relay to minus 48 volt battery.

If the full charge of 158 volts on condenser C_1 is applied across the control electrodes of vacuum tube VT_1 , it is evident that the resistance of the vacuum tube will break down because the voltage thus applied is greater than 70 volts. This will be the case when no call in course of progress has been registered on the condenser C_1 , as will be described later. When the resistance of the tube VT_1 breaks down a circuit is completed from plus 110 volt battery through resistance r_2 to the upper electrode of the vacuum tube VT_1 , and thence through the low resistance within the tube to the left-hand control electrode of the tube and over contact 4 and the lower winding of relay CS_1 to minus 48 volt battery. The relay CS_1 is thereupon operated.

The operation of the relay CS_1 , by opening its contacts 2 and 4 disconnects both the right-hand and left-hand control electrodes of tube V_1 from the relay CS_1 . By closing its contact 1, the relay CS_1 completes a locking circuit from battery, through its upper winding, over said contact 1, and thence over contact 2 of the off-normal relay ON to ground. The relay CS_1 is thereby held operated during the testing operation. By closing its contact 5, relay CS_1 may register a progressing call upon the condenser C_1 , as will be explained later. During the period that the relay CS_1 is locked up it will be independent of the vacuum tube VT_1 . At its contact 3, relay S_1 completes an operating circuit for relay CS_1' from negative battery, through the winding of relay CS_1 , over contact 3 of relay CS_1 , over contact 1 of said relay, and thence to ground over contact 2 of relay ON.

If, as will be described later, the operation of the testing equipment indicates that a trunk of the selected group of 24 is available, relay OK_t will be operated as described later. The operation of this relay will, at its contact 6, connect minus 48 volt battery over said contact and over contacts of certain of the CS' and CS relays to one of the condensers C_0 to C_3 , inclusive.

For example, let us assume that when the test circuit PTC is set into operation by the relay TC_1 , the condenser C_0 is fully charged to 158 volts, as will be the case if no progressing call

has been registered upon it. The vacuum tube VT_0 will operate and lock up the relay CS_0 . The latter relay in turn operates the relay CS_0' . Under these conditions, as soon as a relay OK_t operates (if it does operate), minus 48 volt battery will be connected over contact 6 of relay OK_t , over contact 2 of relay CS_0' , over contact 5 of relay CS_0 , and thence over contact cs_0 of relay TC_1 to the upper terminal of condenser C_0 . Both terminals of condenser C_0 will now be at the same potential and said condenser will be at once fully discharged.

When so discharged, a progressing call is registered upon said condenser and remains effective long enough for the selection of the trunk to be completed. Upon the opening of the contacts of relay CS_0 by the release of the progressing call test circuit PTC as later described, the discharging potential is disconnected from the condenser C_0 . Until it has had time to charge up again to the break-down voltage for the tube, which may be assumed to be 70 volts, the condenser C_0 continues to register a progressing call. The time required for the charge to build up to this point is sufficient to allow a progressing call to be completed. Hence such a call is only registered during substantially the time it is actually in process of being established.

The action above described, whereby a progressing call is registered on the condenser C_0 when the vacuum tube VT_0 is operated, will take place regardless of whether the vacuum tubes VT_1 , VT_2 , and VT_3 to the right of vacuum tube VT_0 are operated or not. If progressing calls had been registered on condensers C_1 , C_2 , and C_3 at the time the progressing call test circuit PTC was set into operation, vacuum tubes VT_1 , VT_2 , and VT_3 to the right of vacuum tube VT_0 would not operate. The call under consideration would still be registered on the condenser C_0 instead of the condenser C_1 because there is a direct connection from contact 2 of relay CS_0' to said condenser. On the other hand, if no calls had been registered on the condensers C_1 , C_2 , and C_3 , so that the vacuum tubes VT_1 , VT_2 , and VT_3 respond when the test circuit PTC is operated, the same result still obtains. This is because the discharging connection is applied to the condenser C_0 over the contacts of operated relays CS_0' and CS_0 .

On the other hand, if the condenser C_0 had previously been discharged and had not been charged up to 70 volts at the time the progressing call test circuit PTC was operated, relays CS_0 and CS_0' would not be operated by vacuum tube VT_0 . Therefore, if vacuum tubes VT_1 , VT_2 , and VT_3 operate when the test circuit PTC is used, the discharging connection from the negative 48 volt battery would be completed over contact 6 of relay OK_t , over contact 1 of unoperated relay CS_0' , over contact 2 of operated relay CS_1' , over contact 5 of relay CS_1 , and over contact cs_1 of relay TC_1 to the upper electrode of condenser C_1 . In this case the condenser C_1 would be discharged and a progressing call registered thereon instead of the condenser C_0 . The operation or non-operation of the relays CS_2 and CS_3 further to the right do not affect this result.

As another example of what may happen, let us suppose that at the time the progressing call test circuit PTC was set into operation, progressive calls had been registered on condensers C_0 , C_1 , and C_2 so that said condensers are not charged up to the critical voltage of 70 volts. Under these conditions, none of the relays CS_0 , CS_1 or CS_2 would be operated. Consequently, the discharg-

ing voltage will be applied over contact 6 of relay OK_t, over contact 1 of relays CS₀', CS₁', CS₂', over contact 2 of relay CS₃', over contact 5 of relay CS₃, and over contact cs₃ of relay TC₁ to condenser C₃. The call under consideration will, therefore, be registered on condenser C₃.

The foregoing is on the assumption that no preceding call is registered on the condenser C₃. If prior calls still in progress have been registered on all four condensers, none of the four vacuum tubes would operate. Consequently, none of the relays CS₀' to CS₃' would be operated. In this case the call under consideration would be registered by connecting negative 48 volt battery over contact 6 of relay OK_t, over contact 1 of relays CS₀' to CS₃', inclusive, thence over conductor cs, and over contact 5 of relay CS₀', to condenser C₀. If at this time the condenser C₀ was partly discharged, but insufficiently charged to operate the vacuum tube VT₀ as a result of a previously registered call, the condenser C₀ will be again fully discharged to register a new call in progress.

(6) *Final operation of test control circuit TCC of Figs. 2 and 3 to choose alternate route*

Assuming that the various busy trunks in the said group have had an opportunity to register their busy condition by operation of the TR relays in the trunk test circuit TTC, and that various vacuum tubes and associated relays in the progressive call test circuit PTC have indicated the number of uncompleted calls in progress, we will now consider how the testing apparatus operates to determine whether the normal or alternate routing is to be used, i. e., whether an OK signal or an AR signal is to be sent to the decoder 300.

It has already been pointed out that the operation of the relay PT is delayed by the action of the current flowing through its biasing winding to charge the condenser C_{pt}. As soon as the relay PT operates, however, it closes a circuit from ground over its front contact and through the upper winding of the off-normal relay ON to hold the off-normal relay operated. The relay PT also connects ground over its front contact to the conductor *tt* and thus extends a circuit over said conductor and the contacts of the 'TR' relays and CS' relays to operate either the relay AR_t or the relay OK_t.

Let us assume that all of the trunks are busy except trunks number 0 and number 22, and that the progressing call test circuit PTC indicates that four calls are progressing toward the trunks. Under these conditions, the circuit extending from the contact of relay PT over the conductor *tt* will be extended over contact 1 of the relay TR₀', contact 9 of relay TR₁', contact 4 of relay TR₂', contact 4 of relay TR₃', contact 4 of relay TR₄', and thence over contact 4 of other TR relays until the circuit arrives at the contact of the relay TR₂₂', which is not operated. At this point the circuit will not pass over contact 4 of relay TR₂₂', but over the back contact 3 of said relay, and thence over front contact 6 of the operated relay TR₂₃' to conductor *c*. Since four progressing calls are registered in the progressing call test circuit PTC, none of the CS' relays are operated. Consequently, the circuit continues from conductor *c* over contact 5 of relay CS₃', contact 3 of relay CS₂' to conductor *a*, and thence over contact 5 of relay OK_t and through the winding of relay AR_t to battery.

The relay AR_t, on being operated, locks over its contact 1, and over contact 2 of relay ON, to

ground. At its contact 2, relay AR_t grounds the *ar* lead to the decoder 300 from ground at contact 3 of relay OK_t, over contact 2 of relay AR_t, over conductor *ar*, and over contact 3 of relay DC. From this point it continues over conductor *ar* into the decoder 300, where the circuit passes through the winding of relay AR in the decoder to battery. The result of the operation of the relay AR in the decoder will be described later.

Returning to relay AR_t in the test controlling circuit TCC, at its contact 3 said relay opens the operating winding of relay PT. Also by closing its contact 4, relay AR_t connects ground to the condenser C_{pt} to discharge said condenser in preparation for the next call and causes relay PT to release. At contact 5, relay AR_t opens the operating path of the relay OK_t to avoid false operation of the latter. By closing its contact 6, relay AR_t connects ground over contact 3 of relay OK₃, over contact 6 of relay AR_t, and over contact 2 of relay TC₁, to operate the overflow peg count, thereby registering the fact that an additional call had been routed over the alternate route. It will be recalled at this point that the trunk peg count has already been registered by the operation of the off-normal relay ON to close its contact 3.

Returning again to relay PT, which was released by the opening of contact 3 of relay AR_t, it will be noted that the release of relay PT disconnects ground from the upper winding of relay ON. Said relay ON still remains operated, however, through its lower winding and over the conductor *on* and over contact 2 of relay DC to ground.

(7) *Final operation of decoder of Fig. 1 to choose alternate route*

Returning now to relay AR in the decoder, which, it will be recalled, was operated by the relay AR_t in the test control circuit TCC, it will be noted that the relay AR locks up to ground over its contact 1 and over the contact of relay ST. By opening its contact 2, relay AR disconnects battery from the circuit extending over contact 2 of relay OK and over contact 1 of the route relay R to the conductor *tf*, and thence through the winding of the relay DP₁ in the decoder preference circuit. The latter relay is released with results which will be presently described.

At its contact 3, relay AR opens the locking circuit of the relay TK', causing the release of said relay and consequently the opening of paths DB, DG, OB, OG, CL and CR. This prevents routing the call over any of the trunks of the selected groups 110, 111, etc. Relay AR, by opening its contact 4 disconnects ground from the path over the contact 2 of relay R, over conductor *tg*₁, over a contact of the relay DC, and thence over conductor *tg*₁' and through the winding of the relay TC₁ to battery, thus releasing the trunk group cut-in relay TC₁.

Relay R, at its contact 5 connects ground to a circuit leading over back contact 3 of relay TK (which has in the meantime been released by the release of the relay DP₁) and thence over conductor *ar*' and contact 9 of route relay R to operate an alternate route relay (not shown) in the decoder 300. The alternate route relay then proceeds to operate in the usual manner, causing the district selector 102 to select the alternate route 124. The call will then be completed over the incoming selector 124', and selector 125 to the calling subscriber's station 126. The relay AR is then released by the deenergization of the start

relay ST in the regular course of the completion of the call. The decoder is thus restored to normal in a well-known manner.

Returning to the relay DP₁, which it will be recalled was released by the operation of the relay AR, said relay DP₁, in addition to releasing the relay TK in the decoder at its contact 4, opens at contact 2. This disconnects ground from the circuit of relay DC, which is released, thereby restoring the decoder preference circuit to normal.

The release of relay DC, by opening its contact 2, disconnects ground from the lower winding of the off-normal relay ON so that the latter is released. Relay ON, by opening its contact 2 disconnects locking ground from the relay AR_t in the test control circuit and from any CS and CS' relays which have been operated in the progressing call test circuit PTC. It will be remembered, however, that under the conditions assumed, none of the vacuum tubes VT₀ to VT₃ was operated. Therefore, no CS or CS' relays had been operated. If, however, any had been operated, as might be the case if less than four calls were in progress when the trunk group cut-in relay TC₁ was energized, such relays would have been released.

The release of the relay TC₁, already described, disconnects all of the sleeve conductors of the selected group of trunks from the relays S₀ to S₂₃, inclusive. Thus all of the relays in the trunk test circuit TTC are released and the apparatus is restored to normal.

(8) *Final operation of test control circuit TCC of Fig. 2 when normal route trunk is available*

The foregoing is an example of a condition under which an AR signal will be sent to the decoder. A typical situation resulting in an OK signal will now be described.

Let us assume that all trunks excepting those corresponding to conductors S₀, S₁ and S₂₂ are busy, and that the progressive call test circuit PTC shows progressing calls registered on vacuum tubes VT₀ and VT₂ but not on vacuum tubes VT₁ and VT₃. Under these conditions, all of the trunk test relays of the TR' group will be operated except relays TR₀', TR₁' and TR₂₂'. Also, when the progressing call test circuit PTC is set into operation in the manner already described, relays CS₁ and CS₃ will be operated and locked up under the assumed conditions, and they in turn will operate the relays CS₁' and CS₃'.

From the foregoing it follows that, when the relay PT operates and connects ground to the conductor tt, the circuit over said conductor will be extended over the back contact 1 of relay TR₀', back contact 10 of relay TR₁', front contact 9 of relay TR₂', front contact 7 of relay TR₃', front contact 6 of relay TR₄', and over contact 6 of succeeding TR' relays until relay TR₂₂' is reached. At said relay the circuit continues from contact 6 of the immediately preceding relay, over back contact 5 of relay TR₂₂', and thence over front contact 7 of relay TR₂₃' to conductor d. From conductor d the circuit proceeds over contact 7 of relay CS₃', contact 10 of relay CS₂', contact 9 of relay CS₁', and thence over conductor k, over contact 5 of relay AR_t, and through the winding of relay OK_t to battery.

Relay OK_t, upon being operated, locks up over its contact 1 to ground over contact 2 of relay ON. At contact 3 relay OK_t opens the upper operating circuit of relay PT, and by closing contact at 4, relay OK_t discharges the condensers.

Relay PT is thereby restored to normal. At its contact 5 relay OK_t opens the path to operate the relay AR_t, thereby preventing false operation of the latter.

By closing contact 6 relay OK_t connects minus 48 volt battery over contact 1 of relay CS₀', over contact 2 of relay CS₁', over contact 5 of relay CS₁, through resistance r_1 , over contact cs₁' of relay TC₁ to discharge the condenser C₁. This registers a progressing call on a condenser C₁, so that on the next operation of the progressing call test circuit PTC, if it occurs within the time required to recharge condenser C₁ to the breakdown voltage of the vacuum tube VT₁, said tube VT₁ and its associated relays will not be operated.

(9) *Final operation of decoder of Fig. 2 when normal route trunk is available*

Relay OK_t, at its contact 2, connects ground to the conductor ok, and thence over contact 4 of relay DC, over the ok conductor leading into the decoder 300, and through the winding of relay OK in the decoder 300 to battery. Relay OK upon being operated, locks up over its contact 1 to ground over contact of relay ST. By opening contact 2 relay OK removes battery from the conductor tf thus releasing the relay DP₁ in the decoder preference circuit DPC. At its contact 3, relay OK completes a circuit for the release relay RL in the decoder 300. This permits the routing information established by the route relay R over the circuits DB, DG, OB, OG, CL and CR to effectively operate the district selector 102 and office selector 107 to route the call over one of the idle trunks of the group 110 to 123, inclusive. The subscriber's circuit, of course, is completed to the substation 126 over that one of the incoming selector switches 110' to 123', inclusive, associated with the chosen trunk and by a final selector 125. The relay OK of the decoder is released after the call is completed by the release of the start relay ST in a well-known manner.

The release of the relay DP₁ in the decoder preference circuit DPC opens at its contact 4 the original energizing circuit of relay TK in the decoder, and at contact 2 opens the circuit of relay DC. The release of relay DC in turn releases the off-normal relay ON of the test control circuit TCC and the trunk group cut-in relay TC₁. As a consequence, the testing apparatus will be restored to normal in a manner already described.

It will, of course, be evident that the numerous combinations of busy trunks and progressing calls will operate either the relay AR_t or the relay OK_t over various circuits. Without attempting to trace all the possible combinations, it will be clear how the relays AR_t and OK_t operate under various conditions from the following table:

Number of idle trunks	Grounded from TTC to PTC	Number of stored calls	Number of CS' relays operated	Relay (AR _t) or (OK _t) operated
0	a	4, 3, 2, 1 or 0	0-4	(AR _t)
1	b	None	4	(OK _t)
1	b	1, 2, 3 or 4	Less than 4	(AR _t)
2	c	Not more than 1	3 or 4	(OK _t)
2	c	2, 3 or 4	Less than 3	(AR _t)
3	d	Not more than 2	2 or more	(OK _t)
3	d	3 or 4	None or 1	(AR _t)
4	e	Not more than 3	1 or more	(OK _t)
4	e	4	None	(AR _t)
More than 4	k	0, 1, 2, 3 or 4	0-4	(OK _t)

MODIFIED ARRANGEMENT OF FIGS. 1A, 2A, AND 3

A modified arrangement is shown in Figs. 1a, 2a, and 3. For convenience in tracing the circuits the sheets containing these three figures should be arranged end to end.

The arrangement shown in these three figures is designed primarily for use in existing decoder installations. To this end the circuit is so designed that it may be readily wired into existing installations and that it may use relays and other equipment of the kind employed in such installations. In principle, the system is very similar to that already described, the principal differences being certain changes in the circuit arrangement of the decoder, and also some modification in the method by which a group of trunks is selected. For selection purposes, the 25 groups of trunks available are divided into 5 subgroups of 5 trunks each. Each group of trunks in this case is 23 instead of 24, because one contact of the TC relay which selects a final group of trunks is used to complete the *ar* circuit instead of connecting a test relay of the trunk test circuit TTC to the sleeves of a trunk.

In order to select a trunk group out of a total of 25, group selector SGS is provided which includes a relay DC. Relay DC has 5 contacts used for selecting one of 5 subgroup relays such as SG₀ to SG₄, inclusive. In addition, the relay DC employs 5 contacts to complete circuits from decoders to 5 contacts of each of the SG relays. By means of this arrangement the decoder, in selecting a group of trunks, acts through the subgroup selector SGS to first select from the set of trunk groups available a limited subsidiary group of 5 trunk groups, from which the final group of 23 trunks is selected in accordance with the particular route relay operated in the decoder.

In general, the test control circuit TCC, the progressing call test circuit PTC, and the trunk test circuit TTC, are the same as in the system already described, and the operation is very similar. So also, the trunks and switches by which connections are extended from subscriber to subscriber are the same in Fig. 1a as in Fig. 1. Therefore, further details of the apparatus may be understood from a description of the operation of those parts of the circuit in Figs. 1a and 1b which are different from those in Fig. 1 and Fig. 2, respectively.

(10) Initial operation of decoder of Fig. 1a

Assuming the dialing, recording and translating operations have proceeded to the point where the route relay R is operated in decoder 300 of Fig. 1a, the operation of the relay R results in the energization of a test circuit finder relay TF, a trunk subgroup relay SG₄, and a final trunk group relay TGo over conductors *af*, *at* and *ag*, respectively. Actually, there will be five SG relays, SG₀ to SG₄, inclusive, and five TG relays, TG₀ to TG₄, inclusive, associated with the decoder such as 300. By arranging matters so that different route relays operate different combinations of these relays in pairs, any desired final group of 23 trunks may be selected. The SG relays are for the purpose of determining the subgroup of five trunk groups out of a total of twenty-five groups available, and the TG relays function to select the final group of 23 trunks out of a subgroup of five final groups.

The TF, SG and TG relays operated determine the trunk testing circuit wanted and the final trunk group to be tested. The operation of relay SG₄ connects ground to the conductor *sg*₄ to de-

termine the subgroup of five final trunk groups to be selected. The operation of relay TGo at its contact 1 connects ground to the conductor *tgo* to determine the final group of twenty-three trunks from the subgroup of five, as will appear later.

By the operation of relays TF and TGo, a circuit is established from battery over the normal contact 3 of relay OK, over contact 2 of relay TGo over the closed contact of relay TF, over conductor *tf*, through the winding of the decoder preference relay DP₁, over contact 3 of said relay, and over the third contact of other decoder preference relays (if they are not operated) to ground. Relay DP₁ operates and locks up over its make contact 3. At its contact 2 it connects ground to the circuit leading to relay DC, through the winding of said relay, and over conductor *dc* to battery over the back contact 6 of off-normal relay ON. Relay DC is thereby operated with results which will be described later.

Upon the operation of relay DP₁, it connects ground over its contact 4 to the conductor *tk* and through the winding of the relay TK to battery. Relay TK, upon operating, at its contact 1 connects ground to the low resistance winding of the relay TGo. In this connection it should be noted that the upper winding of the relay TG₁ is of high resistance, and that the decoding relays (not shown), which are normally operated over contact 2 of the route relay R, are in series with this high resistance winding. The decoding relays are marginal and hence prevented from operating in series with the high resistance winding. They do not operate until such time as the low resistance winding of the relay TGo is cut in by the operation of the relay TK, as just described. Therefore the decoding operation of the decoder 300 is held up until after the operation of the relay TK, when it is permitted to proceed.

At its contact 2 relay TK opens the circuit of the relay RL to prevent the decoder from releasing the decoded routing information for trunk selection until the trunk testing operations have been completed, as will be described later. By closing its contact 3, relay TK completes a circuit for relay TR' from battery, through the winding of said relay, over contact 3 of relay TK, over contact 3 of alternate route relay AR, and thence to ground over the contact of start relay ST. The operation of relay TR' is used to make ineffective the switching controlling circuits DB, DG, OB, OG, CL, and CR associated with the contacts of relay AR for a short time after relay AR is operated and relay R is released. This occurs if the test circuit indicates that the call should be directed to the alternate route, as hereinafter described, to permit cancellation of switching information previously transmitted to the sender by the like designated contacts of relay R before new switching information is transmitted by the contacts of relay AR.

(11) Selection of final trunk group by subgroup selector SGS in Fig. 2a

Returning now to the relay DC, which it will be recalled was operated by the decoder preference relay DP₁, it will be noted that the relay DC, upon operating, locks up over its number 1 contact. Contact 2 connects ground to the conductor *on* to operate the off-normal relay ON through its lower winding. It will also be noted that the relay DC has five contacts connected to conductors *sg*₀ to *sg*₄ for the purpose of determining which one of the subgroup relays SG₀

to SG₄ is to be operated, to thereby determine a subgroup of five final trunk groups out of the total of twenty-five groups. Since the operation of the relay SG₄ in the decoder connected ground to the conductor sg₄ as already described, this grounded connection extends over the appropriate contact of the relay DC to operate the subgroup relay SG₄.

It will also be noted that the relay DC has 5 contacts connected to conductors tg₀ to tg₄, inclusive. These contacts are used to determine which final group of 23 trunks of the subgroup of five final groups is to be selected. As already described, the operation of the relay TG₀ grounded the conductor tg₀. This ground is extended over said conductor, over the appropriate contact of the relay DC, and thence over contact s₂₀ of operated relay SG₄ to the conductor tg₂₀'. The circuit continues over the latter conductor through the winding of the final trunk group cut in relay TC₂₀, which is operated.

(12) *Operation of testing equipment of Figs. 2a and 3 when normal route trunk is available*

The final subgroup of trunks has now been selected and the test control circuit TCC has been started into operation by the energization of the off-normal relay ON. The delayed action relay PT after a short interval is operated over contact 4 of the off-normal relay ON, as described in connection with Fig. 2.

The operation of the relay TC₂₀ connects the sleeves of the final group of 23 trunks to the TR relays of the trunk test circuit TTC in the same manner as described in connection with Figs. 2 and 3. Likewise, the vacuum tubes and associated relays of the progressing call test circuit PTC are operated in accordance with recorded progressing calls registered on the condensers C₀ to C₃, as described in connection with Fig. 2.

Upon the operation of the relay PT, ground is connected to conductor tt and a circuit is completed from said conductor over contacts of the TR' relays and TS' relays to operate either the relay OK_t or the relay AR_t in the test control circuit TCC, depending upon whether a trunk of the final group of 23 is available, or whether the alternate route has to be used. This, of course, depends upon the combination of TR' relays and TS' relays employed, as has already been fully pointed out in connection with Figs. 2 and 3.

Assuming that a trunk is available and that the relay OK_t is operated, the relay OK_t, by closing its contact 6, registers a progressing call upon one of the vacuum tubes at the progressing call test circuit, in the manner previously described. At its contact 2, said relay OK_t connects ground to the conductor ok, which passes over contact 4 of relay DC and thence into the decoder 300, where the conductor ok connects to the winding of the relay OK.

(13) *Final operation of decoder of Fig. 1a when normal route trunk is available*

Relay OK in the decoder 300, when operated as above described, locks up over its contact 1. At its contact 2, relay OK connects ground to the lower resistance winding of relay TG₀ independently of the connection heretofore extending over contact 2 of relay TK. By opening the contact 3, relay OK disconnects battery from the trunk test finding conductor tf, already traced over contacts of relays TF and TG₀. This releases the decoder preference relay DP₁ and the relays controlled thereby. At its contact 4 relay OK closes

the circuit of the release relay RL of the decoder, so that the decoding process controlled over contact 2 of relay TK is now permitted to proceed, thus establishing a connection to the subscriber station 126 over one of the trunks 110 to 122, inclusive.

At its contact 4 relay DP₁ releases the relay TK. By opening its contact 2, relay DP₁ disconnects ground from the circuit of the relay DC and releases the latter. Relay DC, in falling off, releases relay SG₄ and off-normal relay ON. The remaining relays of the control circuit TCC, progressing call test circuit PTC and trunk test circuit TTC, are restored to normal in the manner already described in connection with the arrangement of Figs. 1, 2, and 3.

It will be understood, of course, that as the decoding process proceeds, the start relay ST and the route relay R are released. The former opens the locking circuit of relay OK, which is restored to normal. The release of the route relay R restores the relays TF, SG₄ and TG₀ to normal, so that the decoder is now ready for a new call.

(14) *Operation of decoder and testing equipment of Figs. 1a, 2a, and 3 when no normal route trunk is available*

In case the relay AR_t in Fig. 2a has been operated instead of the relay OK_t, relay AR_t would have locked up and performed other functions as already described in connection with Fig. 2. By closing its contact 2, it connects ground over contact 3 of relay OK_t, over said contact of relay AR_t, over conductor ar', over the upper contact of relay TC₂₀, thence over conductor ar, over contact 3 of the relay DC, into the decoder 300, where the conductor ar is connected to the winding of the alternate route relay AR.

The relay AR is thereby operated and locks up over its contact 1 and over a contact of the relay ST to ground. By closing contacts 1 and 2, the relay AR also completes a circuit for the relay TR from ground, over contact 2 of the relay ST, over contacts 1 and 2 of the relay AR, and thence over contact 4 of the relay TK to battery through the winding of relay TR. By opening its contact 3, relay AR opens the circuit previously traced for relay TR', which is now released.

The operation of relay TR at its contact 1 releases the route relay R so that the routing determined by that relay will be defeated. Relay R upon releasing opens the operating circuits of relays TF, SG₄, and TG₀. The release of relays TF and SG₀ releases the DP relay of the decoder preference circuit, causing the trunk test circuit to restore to normal as previously described. The release of relay DP also releases relay TK.

Relay TR' is made slow release so that the selections directed by the contacts of relay AR are not made effective until the relays previously operated by the contacts of relay R have had time to restore. As soon as relay TR' is restored to normal, the decoding of the alternate route proceeds. The release of relay TK closes the operating path of the RL relay, and when the routing information has been recorded in the sender, relay RL operates and causes the decoder to restore to normal.

While this invention has been disclosed in certain specific arrangements which are deemed desirable, it will be obvious that the general principles herein set forth may be embodied in many other organizations, widely different from those

illustrated, without departing from the spirit of the invention as defined in the appended claims.

What is claimed is:

1. In a switching system, trunks extending between offices and over which interoffice connections may normally be routed, alternate facilities over which connections between offices may be routed, switches for establishing interoffice connections from a calling subscriber at one office to a second office at which a called subscriber's line terminates, a decoder for controlling the operation of said switches to complete a connection from said first office to said second office in response to a code, said decoder including means to determine the group of trunks over which such connections would normally be routed, means to indicate the busy or idle condition of each trunk of the normal group, means associated with said group of trunks to indicate the number of uncompleted calls in progress toward trunks of said group, testing equipment for testing how many trunks of said group are busy with established calls and how many uncompleted calls already initiated are being routed to trunks of said group, and means whereby said decoder will route a call over alternate facilities when said test indicates that established calls over trunks of said group and previously initiated calls being routed thereto will utilize all of the trunks of said group.

2. In a switching system, trunks extending between offices and over which interoffice connections may normally be routed, alternate facilities over which connections between offices may be routed, switches for establishing interoffice connections from a calling subscriber at one office to a second office at which a called subscriber's line terminates, a decoder for controlling the operation of said switches to complete a connection from said first office to said second office in response to a code, said decoder including means to determine the group of trunks over which such connections would normally be routed, means to indicate the busy or idle condition of each trunk of the normal group, means associated with said group of trunks to indicate the number of uncompleted calls in progress toward trunks of said group, testing equipment for testing how many trunks of said group are busy with established calls and how many uncompleted calls already initiated are being routed to trunks of said group, means whereby said decoder will route a call over alternate facilities when said test indicates that established calls over trunks of said group and previously initiated calls being routed thereto will utilize all of the trunks of said group, and means whereby said decoder will route a call over a trunk of said group when the total number of established calls and calls being routed to said trunks is less than the number of trunks.

3. In a switching system, trunks extending between offices and over which interoffice connections may normally be routed, alternate facilities over which connections between offices may be routed, switches for establishing interoffice connections from a calling subscriber at one office to a second office at which a called subscriber's line terminates, a decoder for controlling the operation of said switches to complete a connection from said first office to said second office in response to a code, said decoder including means to determine the group of trunks over which such connections would normally be routed, means to indicate the busy or idle condition of each trunk of the normal group, means associated with

said group of trunks to indicate the number of uncompleted calls in progress toward trunks of said group, a testing circuit for testing the number of trunks of said group over which established calls have been routed, a testing circuit for testing the number of calls already initiated and in progress of being routed to said group of trunks, and means jointly controlled by said testing circuits to cause said decoder to route a call over a trunk of said group when the number of completed calls already routed plus the calls in progress of being routed over trunks of said group is less than the number of said trunks.

4. In a switching system, trunks extending between offices and over which interoffice connections may normally be routed, alternate facilities over which connections between offices may be routed, switches for establishing interoffice connections from a calling subscriber at one office to a second office at which a called subscriber's line terminates, a decoder for controlling the operation of said switches to complete a connection from said first office to said second office in response to a code, said decoder including means to determine the group of trunks over which such connections would normally be routed, means to indicate the busy or idle condition of each trunk of the normal group, means associated with said group of trunks to indicate the number of uncompleted calls in progress toward trunks of said group, a testing circuit for testing the number of trunks of said group over which established calls have been routed, a testing circuit for testing the number of calls already initiated and in progress of being routed to said group of trunks, and means jointly controlled by said testing circuits to cause said decoder to route a call over alternate facilities when the number of completed calls already routed plus the calls in progress of being routed over trunks of said group will utilize all of said trunks.

5. In a switching system, trunks extending between offices and over which interoffice connections may normally be routed, alternate facilities over which connections between offices may be routed, switches for establishing interoffice connections from a calling subscriber at one office to a second office at which a called subscriber's line terminates, a decoder for controlling the operation of said switches to complete a connection from said first office to said second office in response to a code, said decoder including means to determine the group of trunks over which such connections would normally be routed, a testing circuit for testing the number of trunks of said group over which established calls have been routed, storage devices for maintaining a record of each call in progress of being routed to said group of trunks until such call is completed to a trunk of the group, a testing circuit for testing the number of records of calls in progress to said group of trunks, and means jointly controlled by said testing circuits to cause said decoder to route a call over a trunk of said group when the number of completed calls already routed plus the calls in progress of being routed over trunks of said group is less than the number of said trunks.

6. In a switching system, trunks extending between offices and over which interoffice connections may normally be routed, alternate facilities over which connections between offices may be routed, switches for establishing interoffice connections from a calling subscriber at one office to a second office at which a called sub-

scriber's line terminates, a decoder for controlling the operation of said switches to complete a connection from said first office to said second office in response to a code, said decoder including means to determine the group of trunks over which such connections would normally be routed, a testing circuit for testing the number of trunks of said group over which established calls have been routed, storage devices for maintaining a record of each call in progress of being routed to said group of trunks until such call is completed to a trunk of the group, a testing circuit for testing the number of records of calls in progress to said group of trunks, and means jointly controlled by said testing circuits to cause said decoder to route a call over alternate facilities when the number of completed calls already routed plus the calls in progress of being routed over trunks of said group will utilize all of said trunks.

7. In a switching system, trunks extending between offices and over which interoffice connections may normally be routed, alternate facilities over which connections between offices may be routed, switches for establishing interoffice connections from a calling subscriber at one office to a second office at which a called subscriber's line terminates, a decoder for controlling the operation of said switches to complete a connection from said first office to said second office in response to a code, said decoder including means to determine the group of trunks over which such connections would normally be routed, a testing circuit for testing the number of trunks of said group over which established calls have been routed, a plurality of condensers, means for maintaining a condition of charge within certain limits upon any of said condensers during such time as an incompleting call is in progress of being routed over a trunk of said group, a trigger tube for each condenser whose operation depends upon the condition of charge of the condenser, devices controlled by each tube responding to the operation thereof, and means controlled by the number of trunks of the set over which calls have been routed and by the number of tubes operated to determine whether a call shall be routed over a trunk of said group or over alternate facilities.

8. In a switching system, trunks extending between offices and over which interoffice connections may normally be routed, alternate facilities over which connections between offices may be routed, switches for establishing interoffice connections from a calling subscriber at one of-

5 fice to a second office at which a called subscriber's line terminates, a decoder for controlling the operation of said switches to complete a connection from said first office to said second office in response to a code, said decoder including means to determine the group of trunks over which such connections would normally be routed, a testing circuit for testing the number of trunks of said group over which established calls have been routed, a plurality of condensers, means for maintaining a condition of charge within certain limits upon any of said condensers during such time as an incompleting call is in progress of being routed over a trunk of said group, a trigger tube for each condenser whose operation depends upon the condition of charge of the condenser, devices controlled by each tube responding to the operation thereof, and means controlled by said testing circuit and said vacuum tubes to cause said decoder to route a call over a trunk of said group when the number of completed calls already routed plus the calls in progress of being routed over trunks of said group is less than the number of said trunks.

9. In a switching system, trunks extending between offices and over which interoffice connections may normally be routed, alternate facilities over which connections between offices may be routed, switches for establishing interoffice connections from a calling subscriber at one office to a second office at which a called subscriber's line terminates, a decoder for controlling the operation of said switches to complete a connection from said first office to said second office in response to a code, said decoder including means to determine the group of trunks over which such connections would normally be routed, a testing circuit for testing the number of trunks of said group over which established calls have been routed, a plurality of condensers, means for maintaining a condition of charge within certain limits upon any of said condensers during such time as an incompleting call is in progress of being routed over a trunk of said group, a trigger tube for each condenser whose operation depends upon the condition of charge of the condenser, devices controlled by each tube responding to the operation thereof, and means controlled by said testing circuit and said vacuum tubes to cause said decoder to route a call over alternate facilities when the number of completed calls already routed plus the calls in progress of being routed over trunks of said group will utilize all of said trunks.

HAROLD H. SCHROEPPEL.