Mr. A. L. Lons.
20 JUL 1954

ELECTRICAL COMMUNICATION

Technical Journal of the
International Telephone and Telegraph Corporation
and Associate Companies

•

PENTACONTA DIAL TELEPHONE SWITCHING SYSTEM

MECHANOELECTRONIC TELEPHONE SWITCHING SYSTEM

UNITED STATES PATENTS ISSUED TO THE INTERNATIONAL SYSTEM

Volume 31 **JUNE, 1954** **Number 2**

www.americanradiohistory.com

ELECTRICAL COMMUNICATION

Technical Journal of the
International Telephone and Telegraph Corporation
and Associate Companies

H. P. WESTMAN, Editor
J. E. SCHLAIKJER, Assistant Editor

EDITORIAL BOARD

H. Busignies H. H. Buttner G. Chevigny E. M. Deloraine W. Hatton B. C. Holding H. L. Hull
J. Kruithof W. P. Maginnis A. W. Montgomery E. D. Phinney G. Rabuteau N. H. Saunders
C. E. Scholz T. R. Scott C. E. Strong A. E. Thompson E. N. Wendell H. B. Wood

Published Quarterly by the
INTERNATIONAL TELEPHONE AND TELEGRAPH CORPORATION
67 BROAD STREET, NEW YORK 4, NEW YORK, U.S.A.
Sosthenes Behn, Chairman William H. Harrison, President
Geoffrey A. Ogilvie, Vice President and Secretary

Subscription, $2.00 per year; single copies, 50 cents

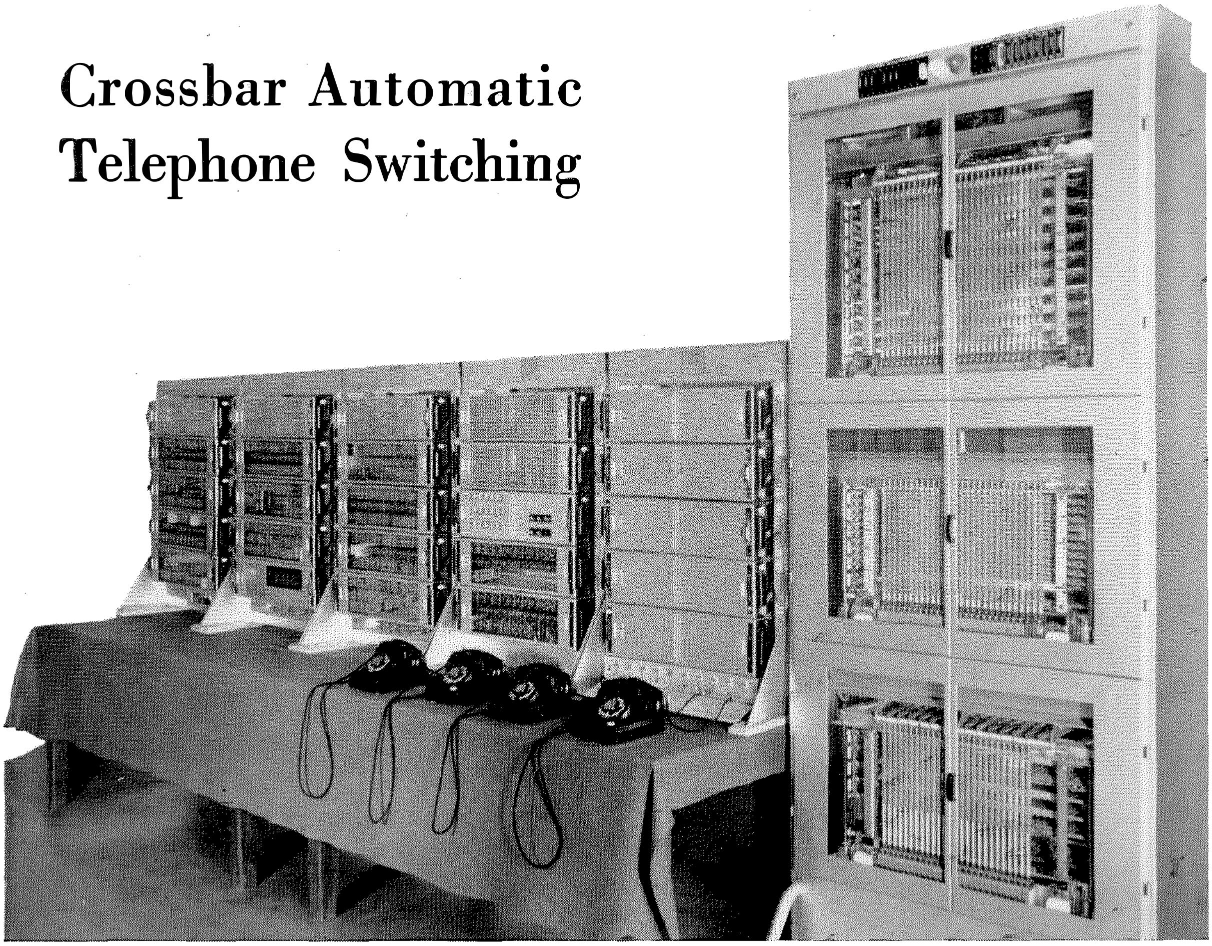
Copyrighted 1954 by International Telephone and Telegraph Corporation

Volume 31 JUNE, 1954 Number 2

CONTENTS

www.americanradiohistory.com

Crossbar Automatic Telephone Switching



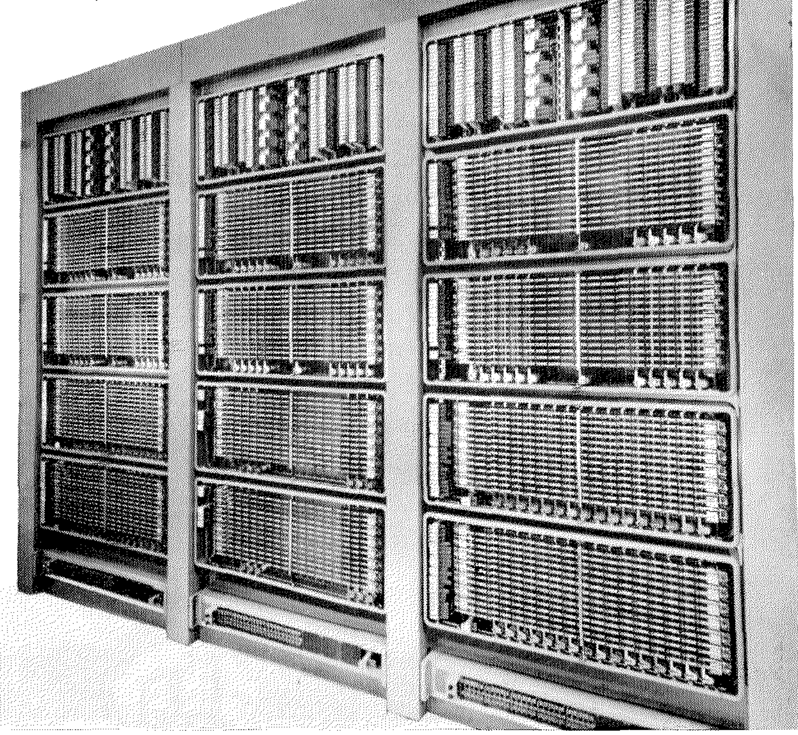
Mechanoelectronic crossbar equipment of Bell Telephone Manufacturing Company, International System associate in Antwerp, Belgium

CROSSBAR switches provide a means in automatic telephony for the interconnecting of subscribers' lines. By utilizing precious-metal contacts that are never required to make or break a current-carrying circuit, noise and its attendant maintenance expenses are minimized and long life is assured.

All of the speech-carrying circuits are routed through the crossbar switches, which are controlled by auxiliary apparatus that does the actual searching for the desired line. The functions of switching and communication are thus separated to their mutual advantage.

The auxiliary apparatus may employ electronic devices as does the Mechanoelectronic system or conventional electromagnetic components as in the Pentaconta system. Both are described in this issue.

Pentaconta crossbar apparatus of Compagnie Générale de Constructions Téléphoniques, International System associate in Paris, France



www.americanradiohistory.com

Pentaconta Dial Telephone Switching System

By FERNAND GOHOREL

Compagnie Générale de Constructions Téléphoniques; Paris, France

CONTINUOUS PROGRESS in the use of automatic telephone systems and their extension to ever-larger areas has made it necessary to give increased attention to a number of problems that formerly had been considered to be of minor importance.

One major problem is the quality of transmission. Automatic equipments insert numerous contacts in line circuits; the resistance of these and their composition have a direct bearing on the amount of noise they may produce. As connections are extended through more exchanges, the noise level increases and noise suppression or at least its attenuation becomes a major factor in providing high-quality telephone service.

Further, the number of successive selecting operations is increased when direct automatic switching is extended from local to national service and the "selecting time factor" must then be more carefully considered. Low-speed selectors were acceptable when no more than 4 or 5 were used to complete a connection; when 10 or more are involved, high-speed selectors become a necessity. The cost per minute of using a long-distance circuit is high, and it is therefore essential to reduce dead time, that is, time not used for conversation, to an absolute minimum.

Finally, automatic switching involves heavy capital investment and can, therefore, be justified only when the systems used are reasonably free from operating troubles and are inexpensive to maintain in good working order.

Do electromechanical systems that are in general use nowadays fulfil these requirements? Are there not more-appropriate solutions? Such are the questions that have arisen in recent years and have stimulated telephone engineers to design systems in which the quality of transmission is higher, selection speedier, and maintenance costs lower than for existing plants.

Such systems employ selectors that use almost no mechanical motion and in which circuits are established by pressure between precious-metal contacts. Their inability to choose a desired outlet among several junction channels necessitates the provision of controlling and selecting elements. These may have an important influence on the total cost, but if the selecting speed is high and therefore these auxiliaries are used for only a very short time, their number need not be large.

Depending on whether these controls are centralized or divided into smaller units, a line can be selected in a single operation or in successive stages. Two distinct types of systems have been produced: one using controls known as "common markers," the other using separate controls known as "stage markers." It follows that each system has its own operational characteristics. Generally speaking, successive selecting stages, the number of which may be increased or decreased as necessary, are best adapted to a wide range of exchange sizes but the system has less flexibility as regards arrangement, size, and number of trunk groups between offices.

The new "Pentaconta" system described in this article meets the requirements previously defined. The capacity of its selectors and their arrangement are such that it combines the merits of both stage-marker and common-marker systems.

1. General

It is well known that the greater the number of trunks to which each selector has access and consequently the number of contacts it carries, the smaller the number of selectors required to handle a given amount of traffic. On the other hand, the number of contacts required to handle the traffic, which is the product of the number of selectors by the number of contacts on each, decreases when the outlet capacity of selectors decreases.

Thus, for each type of selector there is an optimum design giving lowest cost for a required outlet capacity. It is obvious that the higher the cost of contacts, and this is especially the case of pressure contacts of precious metals, the more

www.americanradiohistory.com

chances there are for the optimum design to be reached with a lower outlet capacity per selector.

The foregoing considerations and the search for simple mechanical devices led to the use of low-capacity selectors (10 or 20 outlets) in systems using precious-metal contacts. Such selectors however cannot be used economically unless some special arrangement be made when grouping selectors of one stage with those of the next stage; such special arrangements necessitate auxiliary controls that are all-the-more complicated because the grouping includes a larger number of stages.

The use of selectors having more than 10 or 20 outlets obviates the need for complex controls, but does not require a prohibitive number of contacts. In fact, the number of selectors is then very much smaller, the number of stages is consequently reduced, and the number of selecting magnets is also considerably reduced, provided the selecting operation is made by means of electromagnets common to several selectors.

Selectors having a range of 50 outlets are used. The contacts are made by pressure between precious metals and their motions are very much like those of electromagnetic relays. Their operating efficiency allows them to be grouped in such a way as to reduce their number to a figure little different from that found necessary in the usual systems using 100-outlet selectors.

The reduced cost and great flexibility resulting from 50-outlet capacity coupled with stage group selection make the new system just as suitable for small 50-to-100-line exchanges or satellites as for the largest offices needed in heavily populated areas.

The system thus combines basic simplicity and operational flexibility. It has been designed to provide the most-modern operating facilities that administrations and private customers require at this time. In addition, it offers improved facilities for maintenance, increased efficiency of equipment, and higher quality of connections than existing systems.

1.1 Modern Service to Subscribers

Ordinary subscribers' lines, private-branch-exchange lines, party lines, and coin boxes of any kind can be equipped with the Pentaconta system.

Any calling line can be given a special category, such as for restricted service or as a pay station, and any called line may be classified for absentee service, as a changed number, or for other special considerations.

Any line can be given any directory number since the number does not depend on the position of the line at the exchange terminals. This is particularly interesting for private-branch-exchange groups, which can be given any number of lines in a group under a single directory number or with separate directory numbers for night service or other functions.

Party lines are assigned numbers having the same number of digits as any regular line; no restriction is introduced whatsoever in the directory number of a party line that would classify it as being in a special group of lines.

In no case will a calling subscriber lose a call. Either a busy signal is sent to the calling line or, if the call is not routed to the desired line for some reason (dead number, absentee subscriber, et cetera), it is routed automatically to an operator who gives all necessary information to the subscriber.

Malicious calls can easily be observed by an operator who will block the calling-line chain and identify the calling number.

Direct connections are made rapidly to certain special services, such as police or fire stations.

1.2 Maintenance

Various automatic features such as detection of false calls, testing of subscriber lines, and identification of a calling number are provided easily and reduce maintenance work considerably.

All main circuits are equipped with means to permit easy supervision of traffic and such data as the number of routed calls, time of occupancy, and the number of simultaneous calls in trunk groups can readily be checked.

If a call is not completed because of a faulty condition at a particular selection stage, the control device (register or marker) makes a second attempt. If it is not successful the second time, it releases the established connection, sends a busy signal to the caller, and automatically registers the relay conditions of the control devices when the fault occurred.

www.americanradiohistory.com

Common control relay circuits are never complicated due to the decentralization of controlling functions. The markers in particular are very simple devices.

A special arrangement for automatic call charging with time or zone metering can be provided at any outgoing trunk.

1.3 Efficiency of Installation

One principle of design is to release immediately all devices that are not engaged in the speech circuit. Connections are released as soon as the calling or called subscriber has hung up his receiver, if the called subscriber is busy, if the caller has not dialled the digits of the called number within a definite period of time, or if the line is in faulty condition. In all these cases, the selectors are released and a busy signal is sent to the calling line by the line equipment at the exchange terminals.

However, if an additional delay is asked for in the releasing of a connection when the calling or called subscriber has hung up, this can be had simply by changing wire connections in the cord circuit.

To reduce the time required for answering when the connection is completed to the called line, an immediate continuous ringing tone is sent to the called line followed by the usual interrupted tone.

Terminal selectors are used for originating and terminating traffic, thus making the final stage quite efficient.

Call finders and fifties selectors are identical. In cases where terminating traffic has increased and originating traffic has decreased, any finder may be used as a fifties selector by simply removing jumpers on an intermediate distributing frame.

Efficiency of trunks has also been improved by providing such features as overflow trunks in selection stages and alternative trunks for inter-office calls. If a direct access to a wanted group is not available, another path is tried through overflow selectors of the same stage.

Similarly if the group of outgoing trunks that gives access to the wanted office is entirely busy, the register reroutes the call through another office of the same network, thus giving the maximum efficiency to the direct-access trunks.

1.4 Quality of Connections

High-quality connections are obtained through two features inherent to the system: speed of operation and excellent transmission conditions.

The dial tone is received by the calling line less than half a second after removing the receiver from the cradle and the called line receives the ringing current less than half a second after the dialling of the last digit.

The speech circuits are always balanced to ground. Noise, cross-talk levels, and attenuation are well under the minimum required by international standards as a result of the careful design of the transmission bridges and of the quality of the selectors and their contacts on the line wires.

2. Elements

The two basic devices of the system are the electromagnetic relay and the multiswitch.

2.1 Electromagnetic Relay

The electromagnetic relay has been specifically designed for this system, in which it is used

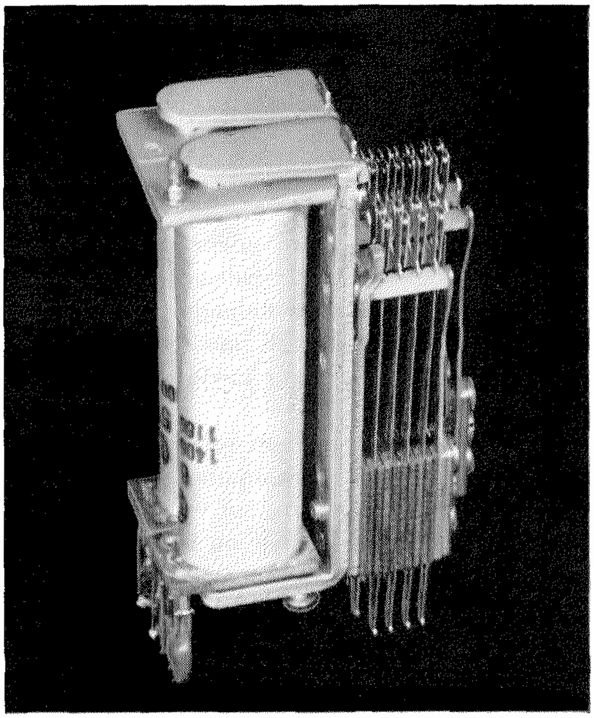


Figure 1—Twin relay using 2 flat operating coils and 1 pile-up of contact springs.

www.americanradiohistory.com

extensively for various purposes. One special feature is that the number of its contacts may vary within wide limits (from 1 or 2 up to 50). To make the constituent elements of relays as nearly uniform as possible and at the same time

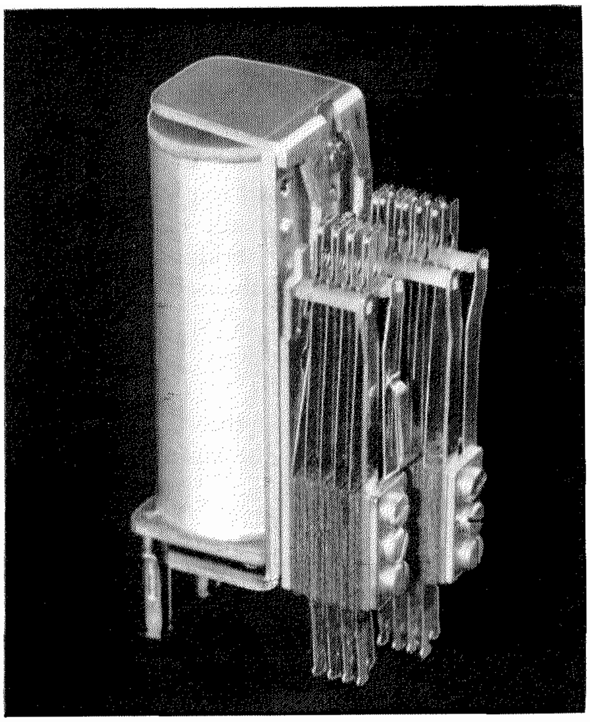


Figure 2—Relay having a single round operating coil and 2 pile-ups of contact springs.

minimize the space required by the contacts, the springs are assembled into independent pile-ups, which are mounted side by side according to the number required. Correspondingly, two types of coils are provided: a small one as wide as one spring pile-up and a larger model of twice that width.

The first type is used on relays carrying no more than 10 or 11 contacts and for which the operating requirements are not very critical.

The second type is used on relays carrying more contacts or when the available power is limited.

The yokes most commonly used are wide enough to accommodate 2 or 3 spring pile-ups and mount either 2 or 3 small flat coils or 1 large round coil. Figures 1, 2, and 3 show representative relays.

Any arrangement of contacts can be assembled in a pile-up (break, make-before-break, make, transfer, et cetera). A special contact that makes before any other contact moves can be added to any spring pile-up.

Double contacts are provided on each spring and are made of precious metal welded to the spring.

The contact springs are not tensioned but are maintained in position by two cards. These cards are identical. The first one holds the fixed springs and is itself maintained on the pile-up base by a tensioned spring. The other one holds the moving springs and is maintained against the armature arm by a spring, the tension of which is adjusted for a correct return to rest of the pile-up (closure of break contacts, speed of operation, et cetera).

Three types of armature are provided with 1, 2, or 3 arms according to the number of pile-ups controlled by the coil.

Each armature can be given a suitable magnetic gap by welding a small disk of appropriate thickness to the face opposite the coil.

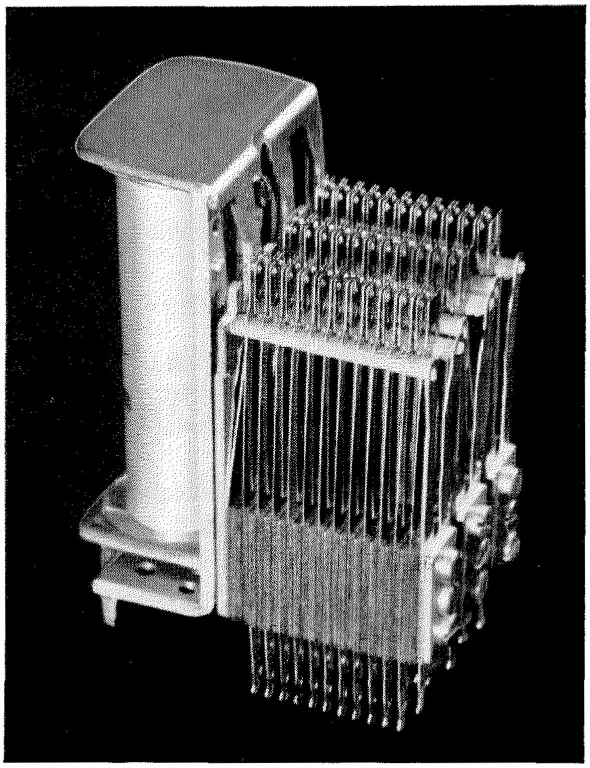


Figure 3—Relay having a single round operating coil and 3 pile-ups of contact springs.

www.americanradiohistory.com

2.2 Multiswitch

The multiswitch is an assembly of selectors having common means of selection. As already stated, the selector uses pressure contacts between precious metals and has the very limited mechanical motion that characterizes the crossbar principle.

Each selector carries 28 spring pile-ups as may be seen in Figure 4, and 26 of these correspond to the outlets at the rate of 2 in each pile-up; that is, 52 outlets in all. When the selector armature is attracted, all contacts of a pile-up are closed. Therefore 2 outlets would be connected at the same time if a further choice were not made by appropriate means. Such means, shown in Figure 5, are provided by dividing the contacts of the 26 first pile-ups into 2 series that are connected to the selector inlet through 2 sets of supplementary contacts included in the 27th and 28th pile-ups.

Consequently 2 pile-ups are moved at the same time, one corresponds to a selecting bar among 13 (pivoting downward or upward) and the other one to the 14th bar, which chooses one or the other contact series by pivoting upward or downward. The 14th bar is for that reason called the switching bar.

In the standard type (Figure 6), 17 selectors are accommodated on one multiswitch. As a rule, one of them is used for temporary duties such as testing, connecting to the marker, et cetera. The other 16 are used to establish connections. Within the multiswitch, space is provided to house the relays that control the multiswitch magnets and allow a given line to be selected.

In multiswitches, 4 wires are available for each inlet and each outlet. If 5-wire circuits are to be interconnected, 5-wire selectors are used

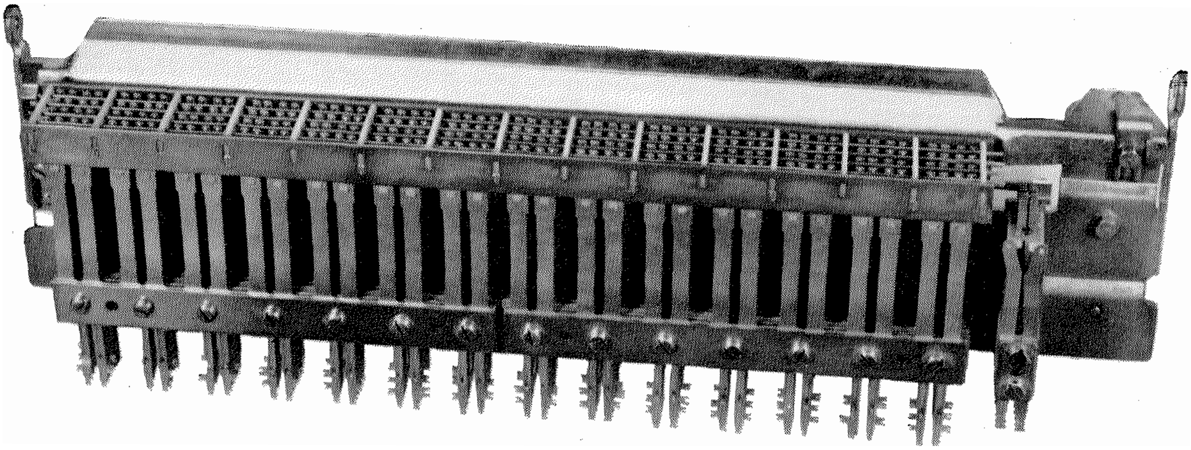


Figure 4—Side view of the selector.

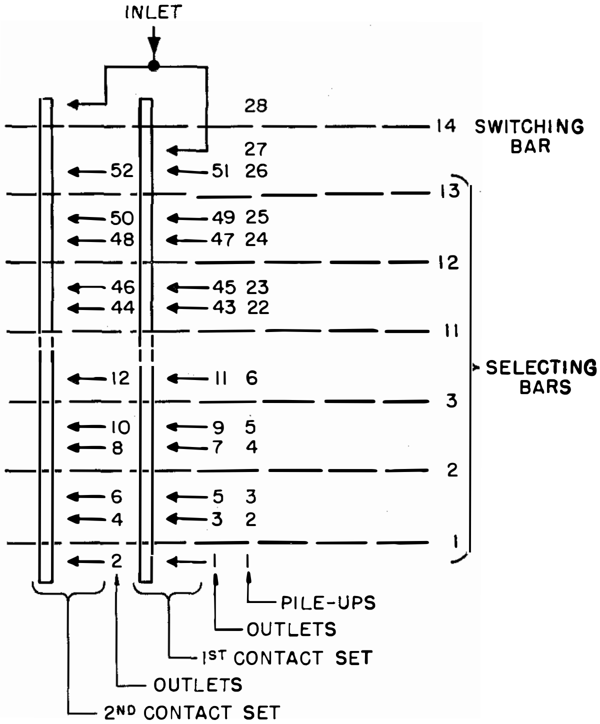


Figure 5—Arrangement of the 52-outlet selector. To connect outlet *3* with the inlet, selecting bar *1* is moved upward and switching bar *14* downward. For outlet *46*, bar *12* is depressed and *14* is moved upward.

www.americanradiohistory.com

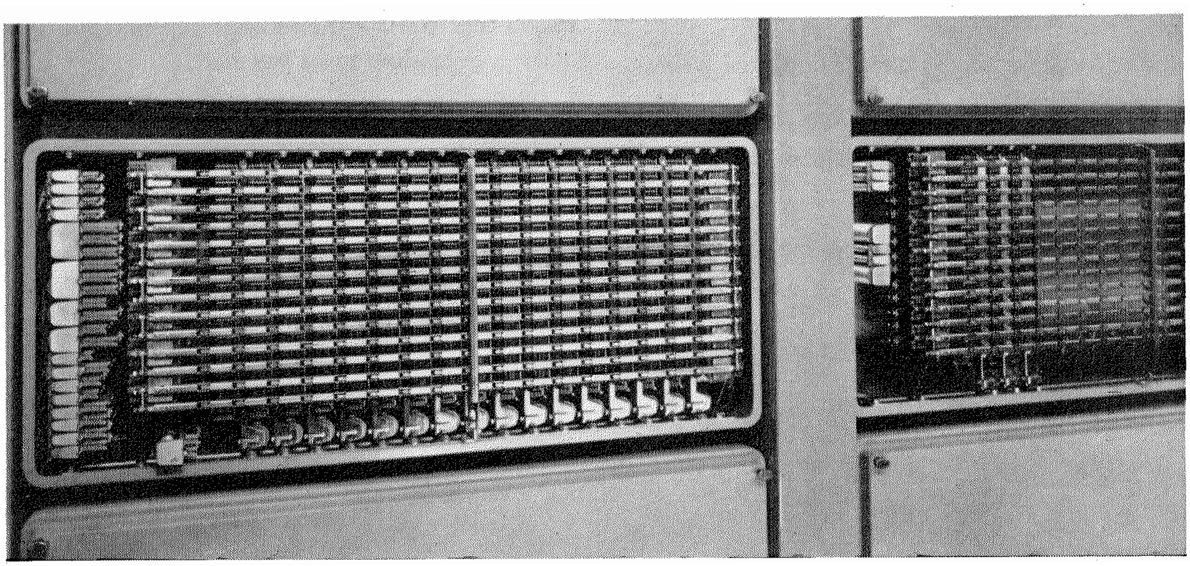


Figure 6—Multiswitch incorporating call finders and fifties selectors of a line-selecting element. The horizontal-bar magnets are at both ends of the crossbar array and the selector magnets are directly below it. The relay group is at the extreme left.

and only 15 selectors can be mounted in a multiswitch. If additional wires are needed, for example, 8 or 10 for register connection, each selector will utilize the entire set of contacts in each pile-up and will then provide 28 outlets in all.

The electromagnet of each selector is movable to permit adjustment of the magnetic gap to the armature.

Each electromagnet for a vertical and horizontal bar has its own set of contacts that are used for control purposes. It is similar to a relay pile-up and uses the same contact springs. Two of the make contacts in the pile-up of the selector electromagnet are connected in the *a*- and *b*-wire circuits and take over the function of breaking or making current on these wires, thus relieving the selector contacts of this wear-producing activity. The contact springs for the selecting-bar electromagnet are in a vertical plane and are moved horizontally by means of a particularly simple device that may be seen in Figure 7.

Each vertical multiple is made up of 2 sets of either 4 or 5 wires of rectangular cross section. A layer of precious metal 0.1 millimeter thick covers the contact side of each wire. The kind of precious metal used in the coating depends on whether the wire functions for conversation or control. The wires are mounted in 2 parallel planes in a diamond-shaped arrangement so as to conserve space.

The contact springs are flat and provide no tension; they are held in position by cards. The outer end of each card fits into a rectangular hole in a flat spring that provides sufficient tension to return the pile-up to its rest position.

The rest position of the card and contact springs is controlled by the contact of the inner end of the card against a small tongue of the vertical-multiple holding cage.

Double spring contacts of the same precious metal as the corresponding vertical wire are used. The contact itself is bar shaped and perpendicular to the vertical wire.

The frame that supports the selectors is made of sheet iron with internal stiffening ribs that provide great rigidity. Covers at front and rear give complete protection against mechanical shock and dust. Inlets and outlets are connected by means of lugs or tags to which cable wires are soldered.

3. Selection Process

In considering the economics of the design of an automatic telephone network, it is evident that lowest equipment costs will be had if the minimum number of selectors and selector

www.americanradiohistory.com

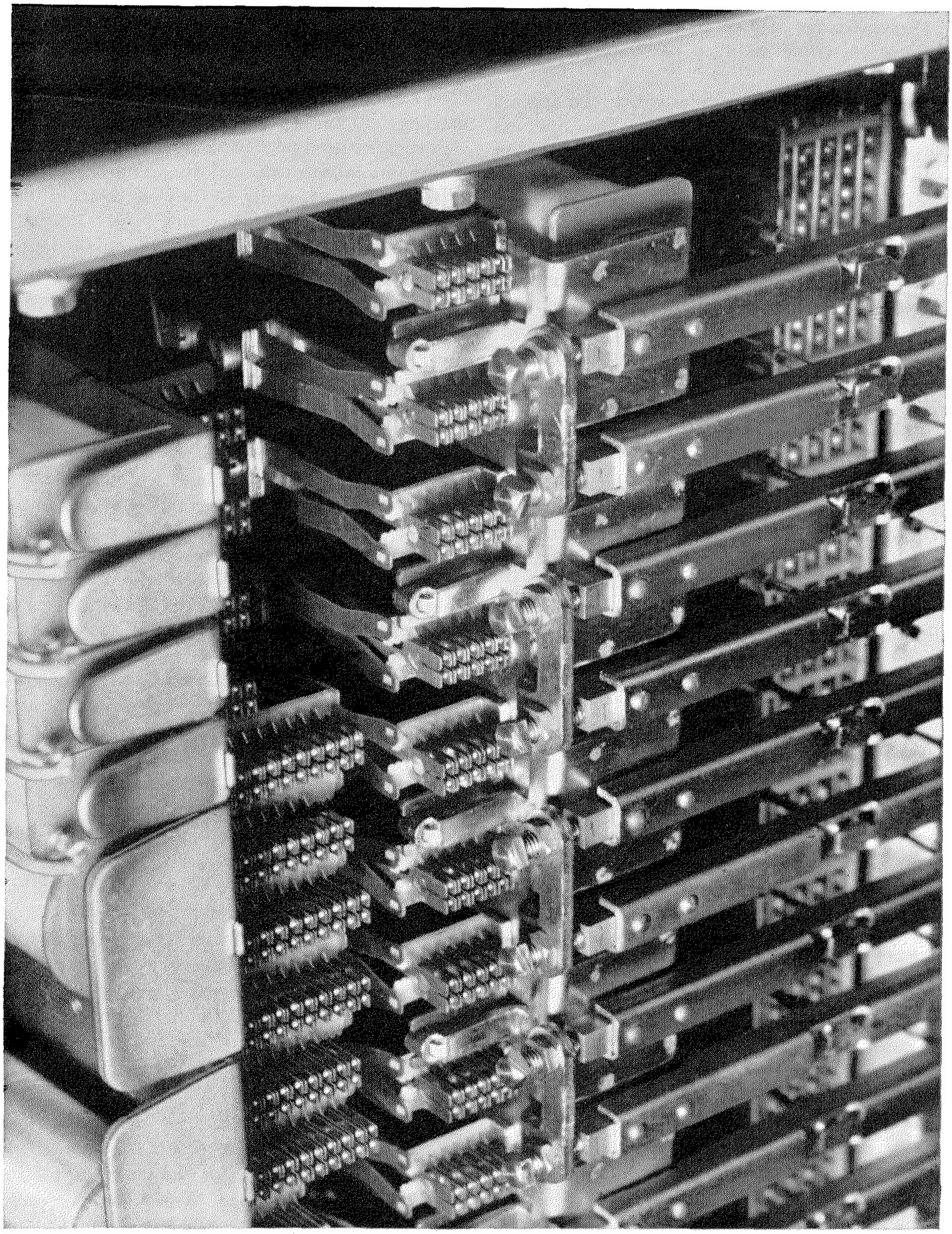


Figure 7—Detail of upper left corner of Figure 6 showing the horizontal-bar electromagnets and the mechanism that operates the spring pile-ups.

www.americanradiohistory.com

interconnecting trunks are used and each selector or trunk handles as much traffic as possible.

The same design principles cannot be applied to lines between subscribers' stations and exchanges if the traffic is limited to the number of calls to or from these subscribers' stations because such traffic is always small compared with that which selectors can handle.

Under these conditions, traffic in a telephone network goes through three successive processes: *A*—calls from subscribers' stations are concentrated into a reduced number of selectors, *B*—they are distributed among the various group of called stations, and *C*—they are expanded to the called stations. As a rule, process *B* entails no appreciable concentration or expansion.

Selectors in a telephone exchange may thus be divided into three groups: one or more concentrating stages in which the traffic on incoming trunks is lower than that on outgoing trunks, one or more distributing stages in which the traffic is approximately the same on incoming and outgoing trunks, and one or more expanding stages in which the traffic on outgoing trunks is lower than that on incoming trunks.

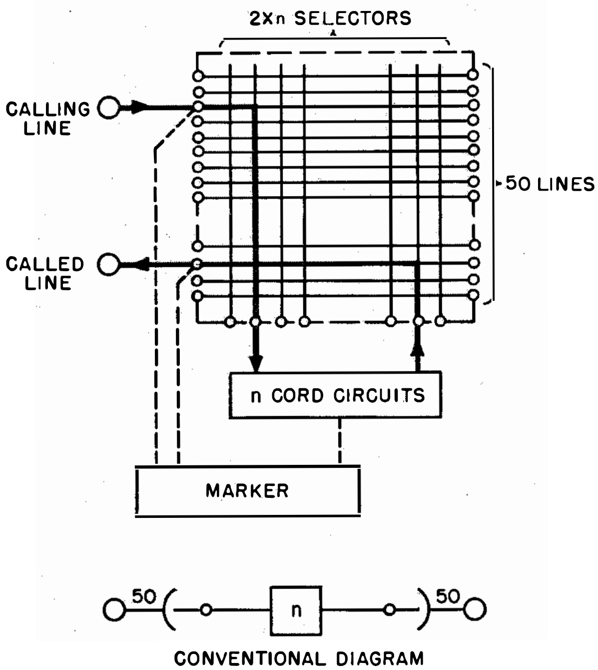


Figure 8—Exchange of 50 lines.

In the Pentaconta system, the processes of concentration, expansion, and distribution are treated in accordance with a single principle. The calling or called line or group of lines is marked temporarily and two different selecting elements are used depending on whether the case is one of concentrating or expanding the traffic (line-selecting element) or one of distributing traffic (group-selecting element).

The functions of each of the main elements used in the selecting operation will be more easily understood by considering a few instances in which the system is applied to exchanges of various capacities.

The simplest case is shown in Figure 8 in which concentrating the traffic and expanding it are carried out in a single stage. No group-selecting element is used. The example is that of a 50-line exchange. The 50 lines are horizontally multipled on every selector of one or more multi-switches, described in the preceding section; the number of such selectors is subject to the amount of traffic and is twice the number n of possible simultaneous connections. The marker first connects the calling line to a free cord circuit. When the called number is sent by the calling station to the cord circuit, the latter transfers the necessary information to the marker, which is thus enabled to select the called line and connect it to the cord circuit.

Figure 9 shows a 500-line exchange. Concentrating and expanding the traffic each require 2 successive selecting stages, but a group-selecting element is not yet necessary as the marker controls the whole group of 500 lines directly. The marker first connects the calling line to a free cord circuit through a free intermediate link. When the cord circuit receives the called number, it imparts the information to the marker, which in turn indicates it to selectors of the terminal stage. Connection to the called line is established through an intermediate link.

A 10,000-line exchange appears in Figure 10. Concentrating and expanding the traffic are done by means of line-selecting elements, each of which includes the devices shown in Figure 9. One line-selecting element is provided for each 500 lines, that is, 20 elements for 10,000 lines. Distributing and allocating the traffic is done by means of group-selecting elements, the number

www.americanradiohistory.com

of which is subject to the amount of traffic. Group-selecting elements not only handle local traffic but also traffic from and to other lines than those served by the exchange represented in the figure. Interoffice traffic arrives through incoming junctions from other exchanges or leaves through outgoing junctions to these exchanges.

In addition to the above, registers are used to establish connections. They are temporarily associated with the cord circuit through a register–finder, which is actually a selector of a multiswitch, the horizontal multiples of which are connected to junctors and the vertical elements to registers.

The selecting operation is divided into three stages: the object of the first stage is to connect the calling line to a free junctor and a free register; a first marker effects this operation and controls the connection. When the register is connected to the calling line, the latter sends to the register the number of the called line and the register causes the called line to be selected during the next 2 stages. The second stage extends the call to a selector belonging to the line-selecting element that serves the called line; this is done through a group-selecting element the marker of which receives from the register information as to which 500-line group includes the called line and designates free local junctions in this group. The third stage is the actual selection of the called line: as soon as the line-selecting element is connected to a register, the latter transfers the last 3 digits of the called number to the line-selecting-element marker, which designates the called line and the connection is completed. The marker and register are now released and free to control a new connection.

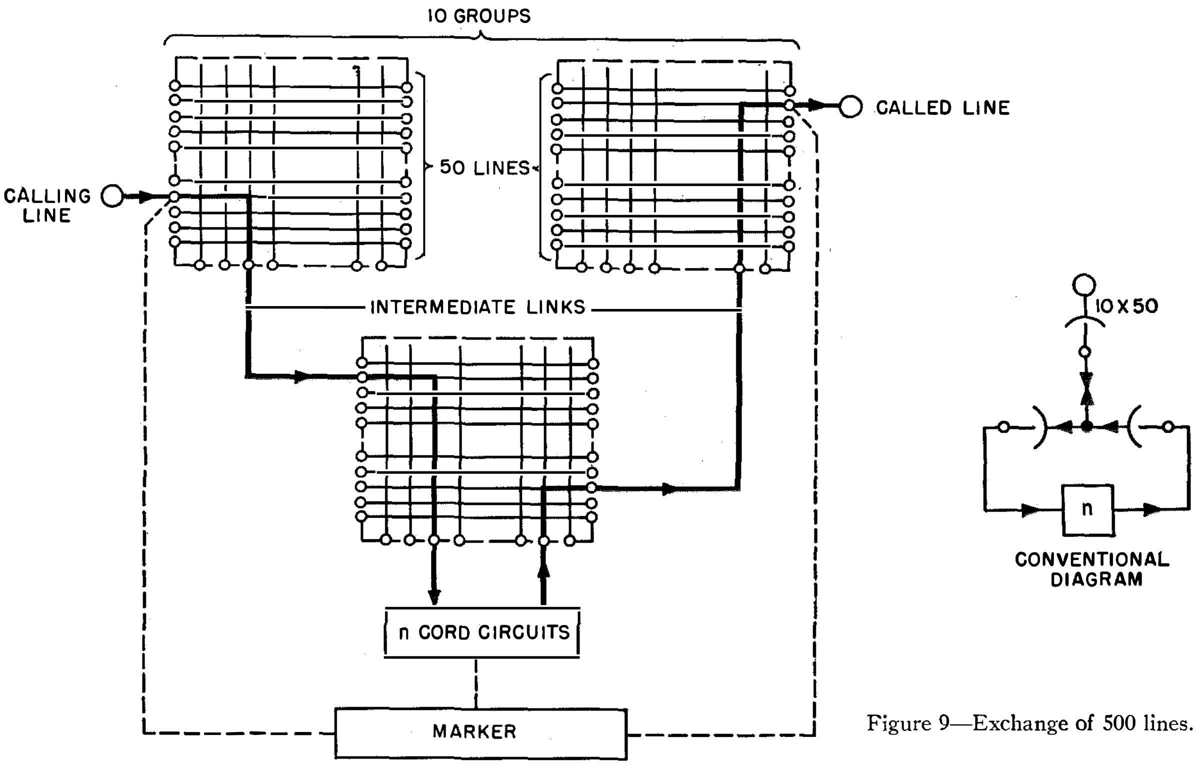


Figure 9—Exchange of 500 lines.

In case of an outgoing interoffice call, the group-selector marker designates free junctions going out to the desired office; in the same way, in case of an incoming interoffice call, the group-selector marker receives from the originating office information as to the desired group and marks free junctions to this group.

The foregoing general information on the method of selection will enable the reader to examine more closely the three main elements; the line-selecting element, group-selecting element, and register.

www.americanradiohistory.com

3.1 Line-Selecting Element

As shown by the previous examples, the line-selecting element receives calls from subscribers' stations or from lines with little traffic and also routes calls to these same lines.

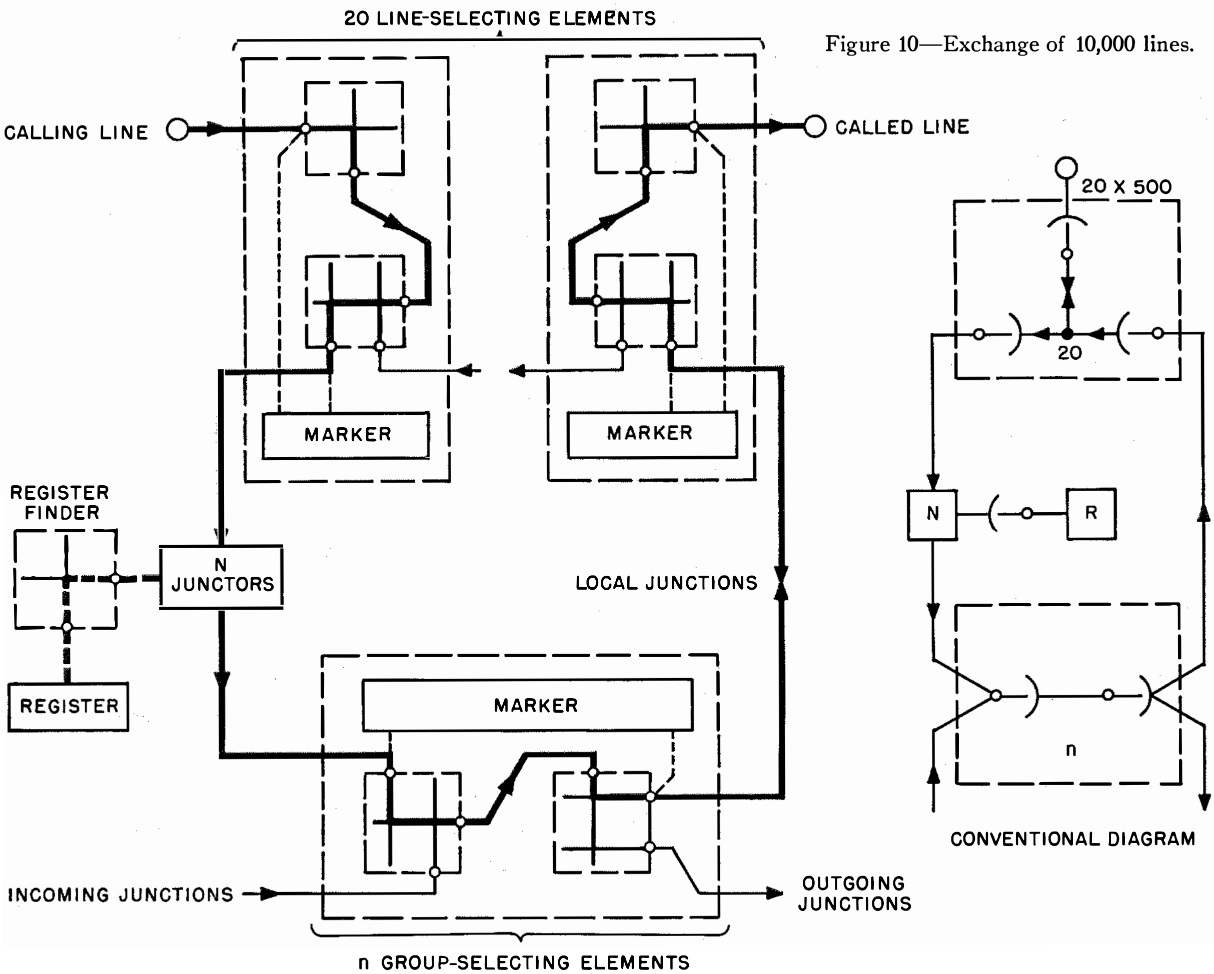


Figure 10—Exchange of 10,000 lines.

Except when the number of lines is smaller than 100, that is, when a single selecting stage is used, line-selecting elements have 2 selecting stages and their usual capacity is 500 lines.

Such lines may include ordinary lines from single subscribers' stations, party lines serving several subscribers, or private-branch-exchange lines from multiline subscribers, each called through a single number which in fact designates the group of lines. The 500 lines connected to a line-selecting element are not necessarily rigidly related to their call numbers; for instance, the 500 lines may include 200 ordinary lines using 200 call numbers, 100 2-party lines using 200 call numbers, and 200 private-branch-exchange lines using 100 call numbers; 600 stations in all.

The line-selecting element of Figure 11 includes all necessary devices to concentrate incoming traffic and expand outgoing traffic. It includes line and cutoff relays, selectors, and control circuits.

3.1.1 Line Relays, Cutoff Relays, and Selectors

Line and cutoff relays are supplied for each line. They are so designed that in case of line trouble, called subscriber being busy, permanent signal (receiver accidentally off the hook), or junctions being congested, the calling line locks on its own relay equipment until the handset is replaced on its cradle or the trouble is cleared;

www.americanradiohistory.com

the cord circuits and selectors already seized are then released.

Selectors are grouped on frames to make up multiswitches as described in section 2. The double selecting stage includes terminal selectors and call finder.

The horizontal multiple of a terminal selector is connected to 50 lines; 10 groups are therefore required to accommodate 500 lines. Each group has enough selectors to handle incoming and outgoing traffic from and to corresponding lines.

Call finders connect terminal selectors of the 10 groups to junctors and fifties selectors connect the same terminal selectors to group selectors. Finders handle incoming calls and fifties selectors care for outgoing calls.

Terminal selectors of a fifty (50-line group) are distributed on several multiswitches (usually 2 and occasionally 3 when the traffic is very heavy). A multiswitch receives terminal selectors from 2 fifties, the horizontal multiple of each multiswitch is therefore split in the middle as is evident from Figure 12. As a rule, there will normally be 10 terminal-selector multiswitches.

Fifties selectors and finders having access to the same terminal selectors are multipled together and mounted on the same multiswitch. As each one of these fifties selectors and finders cannot have access to every terminal selector, it becomes necessary to distribute them among several splits. Each split has access to 4 terminal selectors in each group, that is, 4×10 paths; the remaining 10 or 12 are reserved for overflow from one split to another as will be explained later.

3.1.2 Control Devices

Control devices, as may be seen in Figure 11, may include *A*—markers that are common to a number of terminal selectors, finders, and fifties selectors; *B*—testers and receivers that are intermediate devices between the marker and selectors; and *C*—connectors that are associated with selector multiswitches. These devices consist essentially of electromagnetic-relay networks.

Two markers are generally used for each line-selecting element, each one controlling half of the terminal selectors, fifties selectors, and finders. For heavy-traffic conditions, 3 markers would be provided.

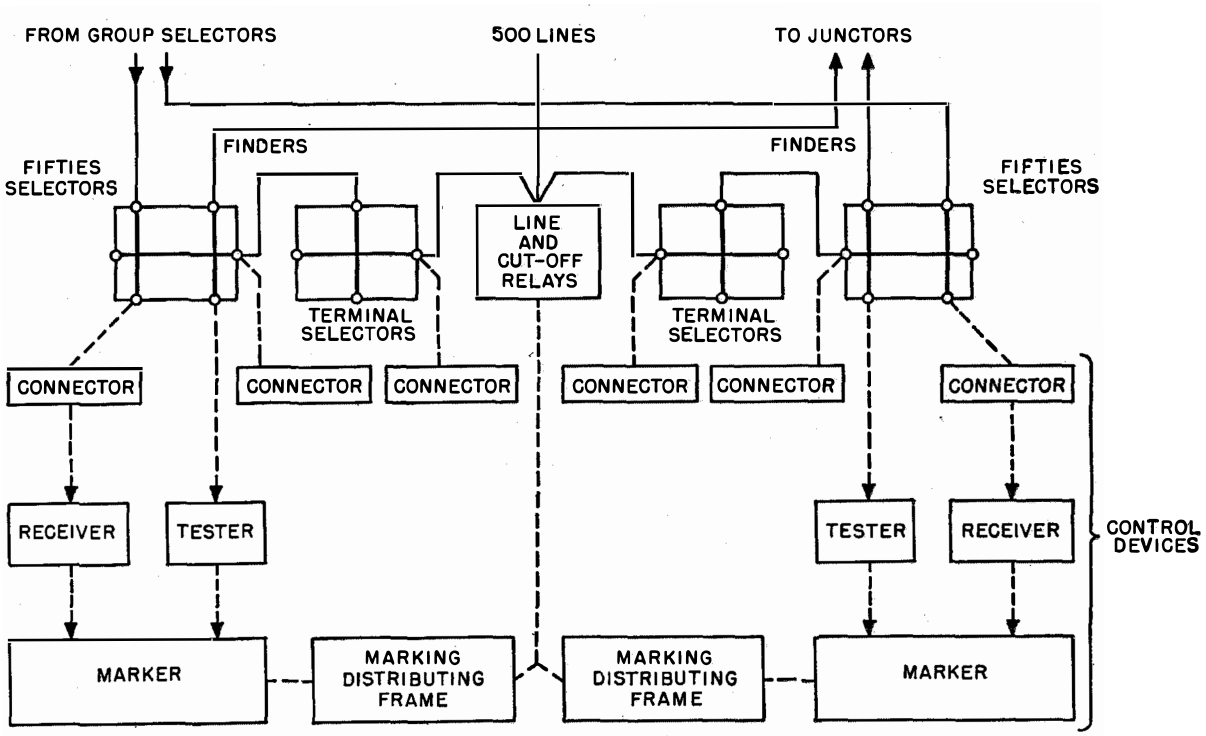


Figure 11—Arrangement of selector and control devices of the line-selecting element.

www.americanradiohistory.com

The purpose of the marker is to indicate calling and called lines to terminal selectors, to test for a free path between the marked line and the chosen finder or fifties selector, and to establish the connection through the available selectors.

A marking distributing frame is associated with each marker. As may be seen in Figure 13, it provides 2 series of connecting tags; one is the number-tag series corresponding to subscribers' numbers and the other is the position-tag series corresponding to lines connected to terminal selectors. A number is allocated to a line by establishing a connection between a number tag and a position tag. Thus complete independence is obtained between line positions on terminal selectors and the numbers allocated to the subscribers' lines.

The marking distributing frame provides several useful facilities.

A. The traffic load may be distributed evenly among various fifties in one line-selecting element by properly allocating heavy- and light-traffic lines to various groups of terminal selectors. They may be moved from one to another when necessary. The smaller the line groups, the greater is the unbalance among group loads. It is very helpful to have available an easy means of restoring balance.

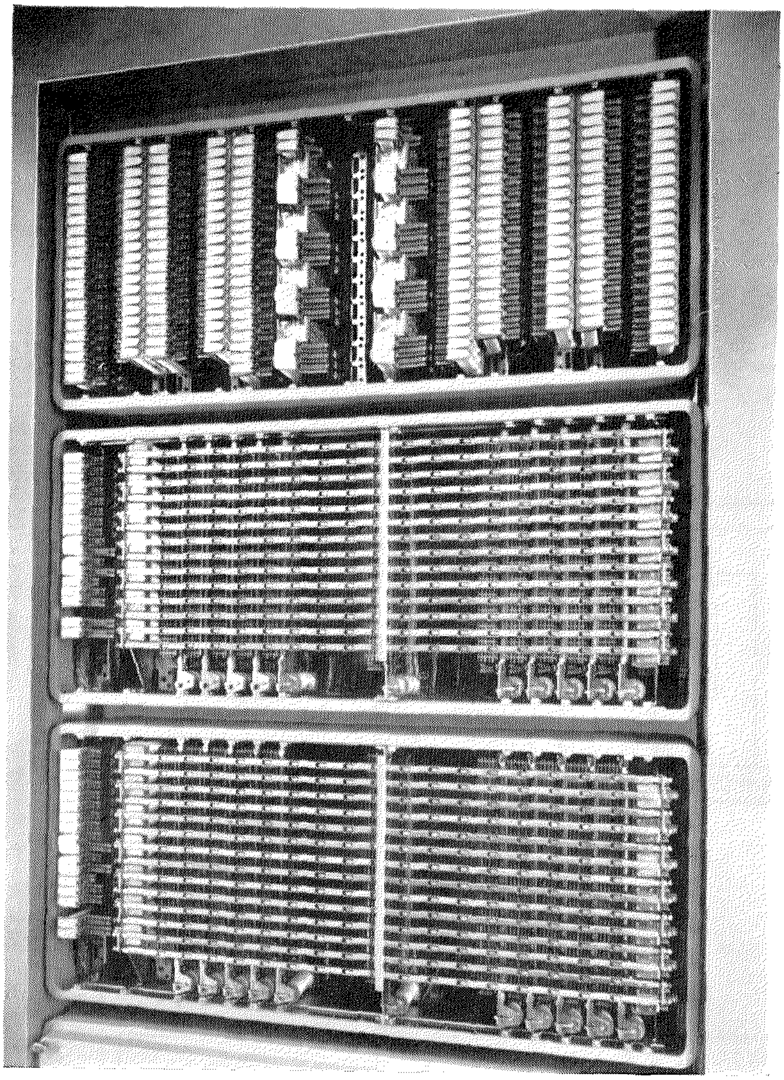


Figure 12—The top frame accommodates 104 lines and cut-off relays and the lower two frames house the 2 multiswitches of the terminal selectors that give access to these 104 lines.

B. Private-branch-exchange lines may be grouped under one call number and the lines made available through several terminal selector groups of one line-selecting element. No allowance for future growth is thus required in private-branch-exchange groups. No change in subscribers' numbers is ever necessary when, for instance, a single-line subscriber requires a second line or when a private-branch-exchange subscriber requires additional lines.

C. Several call numbers may be allocated to the same (party) line without having to lose line positions on terminal selectors. In fact, call numbers of stations on a party line need not be related to each other.

There are 2 or 3 receivers provided for each marker. They receive the last 3 digits of the called number from the register, as a rule, and transfer them as

www.americanradiohistory.com

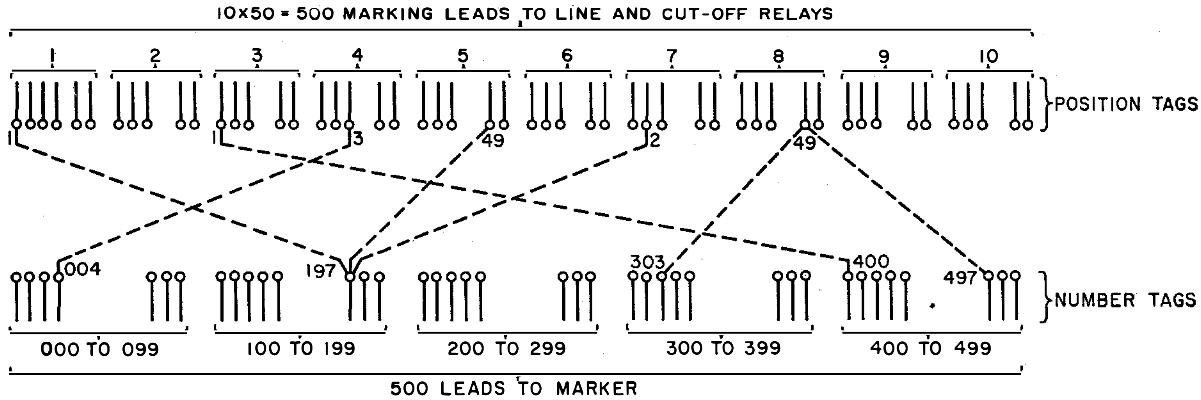


Figure 13—Marking distributing frame. Lines *004* and *400* are ordinary lines that are connected to position *3* of the 4th 50-line group and position *1* of the 3rd 50-line group, respectively. *197* is the number assigned to a group of 3 private-branch-exchange lines connected to positions *1*, *49*, and *2* of the 1st, 5th, and 7th 50-line groups, respectively. *303* and *497* are numbers assigned to subscribers on a 2-party line, both being connected to position *49* of the 8th 50-line group.

a whole to the proper marker when free. They are used on outgoing calls.

Testers are used on incoming calls to hunt for a free junctor having access to free registers. They are equal in number to the receivers and may be seen in Figure 14.

Connectors are divided into two kinds. As shown in Figure 15, incoming connectors are

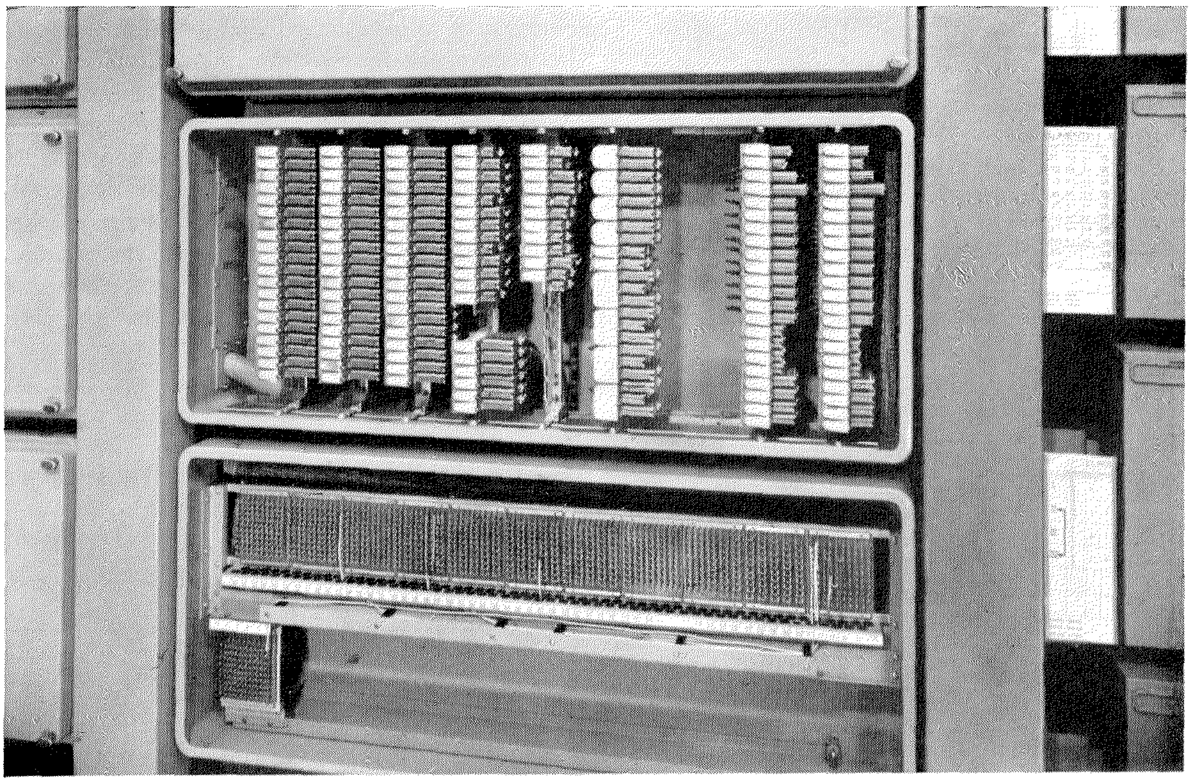


Figure 14—Line-selecting element marker. The two vertical banks of relays at the right are the two testers. Below is the marker distributing frame.

www.americanradiohistory.com

used to connect a receiver to each of the fifties selectors associated with it. They each include a few relays and one selector similar to the selectors of the multiswitch, but its own outlets, instead of being multipled with outlets of other selectors, are connected to inlets of the corresponding fifties selectors; the inlet of this particular selector is connected to the receiver. This selector connects the calling fifties selector to the receiver through the multiswitch selecting magnets.

Outgoing connectors are provided to control the selecting magnets of the associated multiswitches corresponding to calling or called lines, as well as those of intermediate trunks between finders and fifties selectors on one side and terminal selectors on the other side.

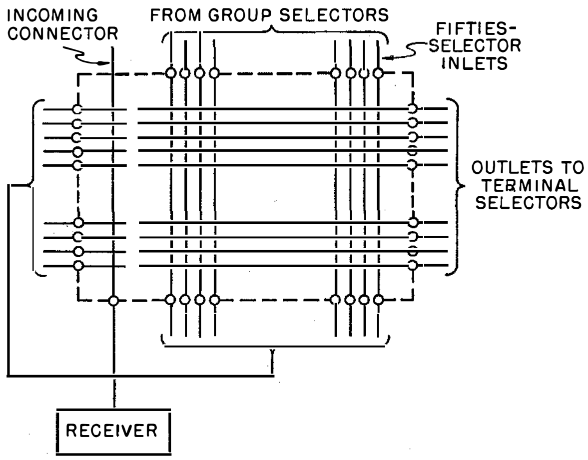


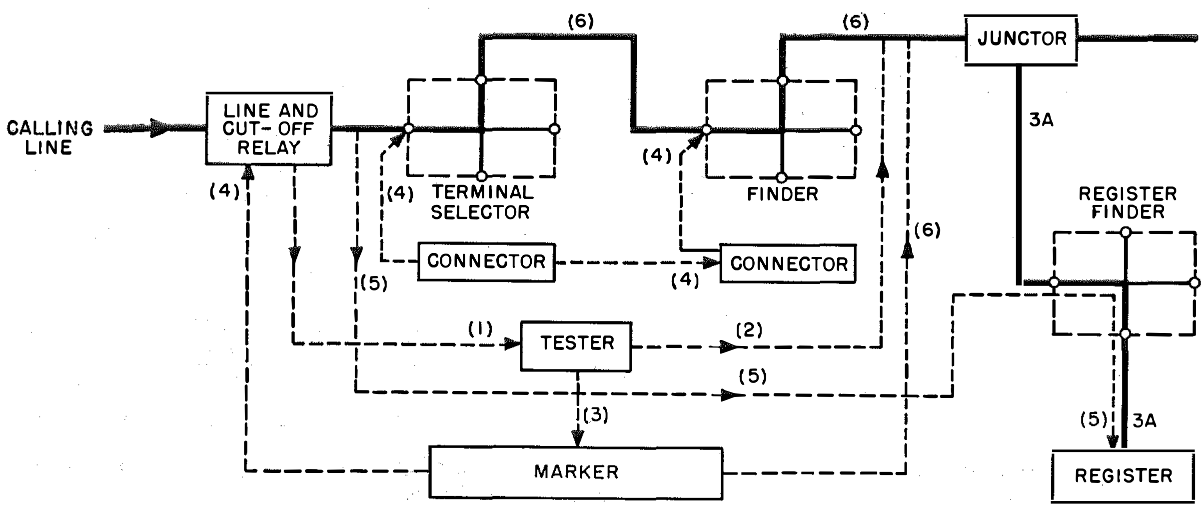
Figure 15—Connecting the fifties-selector inlets to the receiver. The first selector of a multiswitch is used. Its outlets are connected to the fifties-selector inlets and its inlet is connected to the receiver.

3.1.3 Operation

3.1.3.1 When a Station Is Calling

When a station is calling, the line relay of Figure 16 operates. This starts the testers *1* that serve finder sets having free finders and free paths to terminal selectors. Only one tester for each marker can operate at a time; it chooses a free finder *2*, the associated junctor of which has at its disposal at least one free register. When the choice has been made, the tester connects itself to a free marker *3*, or waits for one if none is immediately available. When the marker is connected to the tester, the calling line is marked on terminal selectors *4*, and a free terminal selector, which is accessible to the chosen finder, is also marked. Simultaneously, a free register *3A* hunts for the junctor associated with the chosen register finder. When these operations have been completed, a temporary connection is established *5* through the marker between a tag reserved for the calling line and the register. This tag is raised to a potential denoting the class of service of the calling station, that is, whether it be a restricted-service subscriber, coin-box station, et cetera, and the characteristic potential is transferred to the register which is thus notified how to handle the call with regard to its destination. As soon as this temporary connection has been made and the class

Figure 16—Below, connecting a calling line to a register.



www.americanradiohistory.com

of service is registered, the marker causes the calling line to be connected *6* to the register through terminal selector, finder, and register finder, and it then releases.

The necessary time for the above described operations is about 400 milliseconds.

To guard against 2 markers attempting to establish connection to the same line, an appropriate device (double test) is provided to connect only one of them. In the 2 splits served by 2 markers, lines are connected in reverse order so that when 2 calls are made simultaneously, each marker connects one of the 2 calling lines in the order of priority of its own split.

3.1.3.2 When a Single-Line Station Is Called

After a fifties selector (Figure 17) has been chosen by a group selector, a connection is established between the inlet of this selector and the associated receiver *1*, provided that the latter is free and that the register has received the identifying digits of the called station.

When this connection has been established, the receiver *2* receives the last 3 digits of the called number, usually as 3 coded impulses to save transmission time. These numbers are transferred as a whole to the associated marker *3*, either at once if it is free or as soon as it becomes available.

Transferring the called number into the marker causes a particular potential to be applied on the corresponding number tag in the marking distributing frame. This potential is transferred to the called-line position tag and, when free, the line is marked *4* on terminal selectors in the same way as for a calling line. A free terminal selector, which is accessible to the fifties selector on which the call has been connected, is then chosen. When both operations are completed (identifying the called line and choosing a terminal selector), the marker causes the connection to be established *5* and is then released. If the called line is found to be busy, the marker is released at once, the receiver notifies the register of the busy condition, and the register releases the connection and causes the busy tone to be sent to the calling line, terminating any further useless holding of the selectors in the line-selecting element.

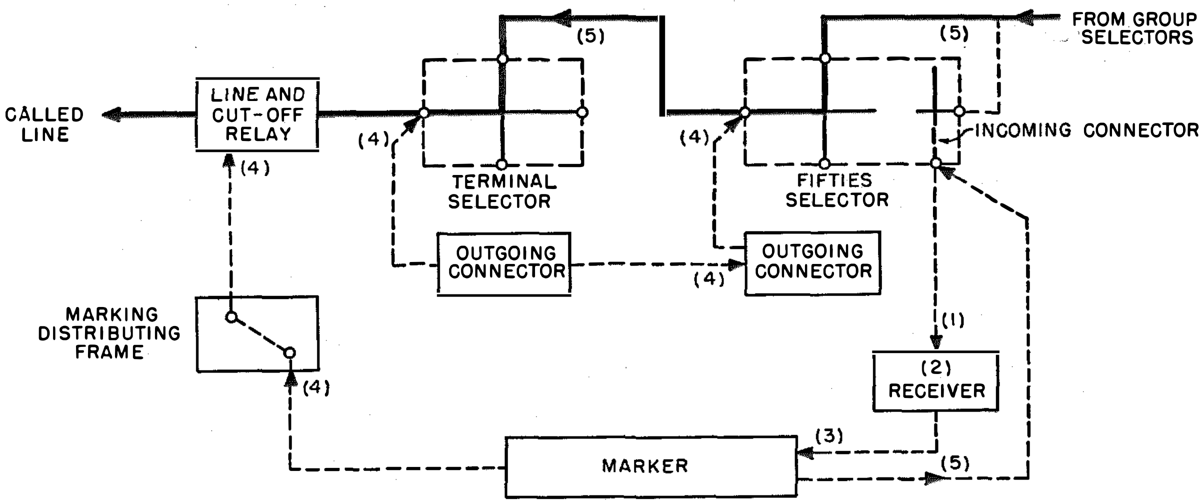


Figure 17—Connecting a called line through a line-selecting element.

It may happen that a particular fifties selector has no direct access to a terminal selector although other terminal selectors are free. To allow the call to proceed despite such a condition, overflow selectors are connected to a special group of 10 or 12 outlets from fifties selectors. Overflow selectors to which fifties selectors of one split have access are distributed over other splits of fifties selectors as indicated in Figure 18. Let us assume, for instance, that 14 terminal selectors are provided for each fifty,

www.americanradiohistory.com

which requires 4 splits (3 individual, 1 per split, and 1 common to 2 splits); split *1* will then have access to 12 overflow selectors, 4 in each of splits *2*, *3*, and *4* (and the same for split *2*). Thus each fifties selector has direct or indirect access to every terminal selector of each fifty.

When the outgoing connector of the split to released and the receiver is connected to the other marker that serves the chosen overflow split. The second marker is substituted for the first one and discharges, in turn, the same duties as the first one, although this time through connectors, terminal selectors, and overflow selectors under its own control.

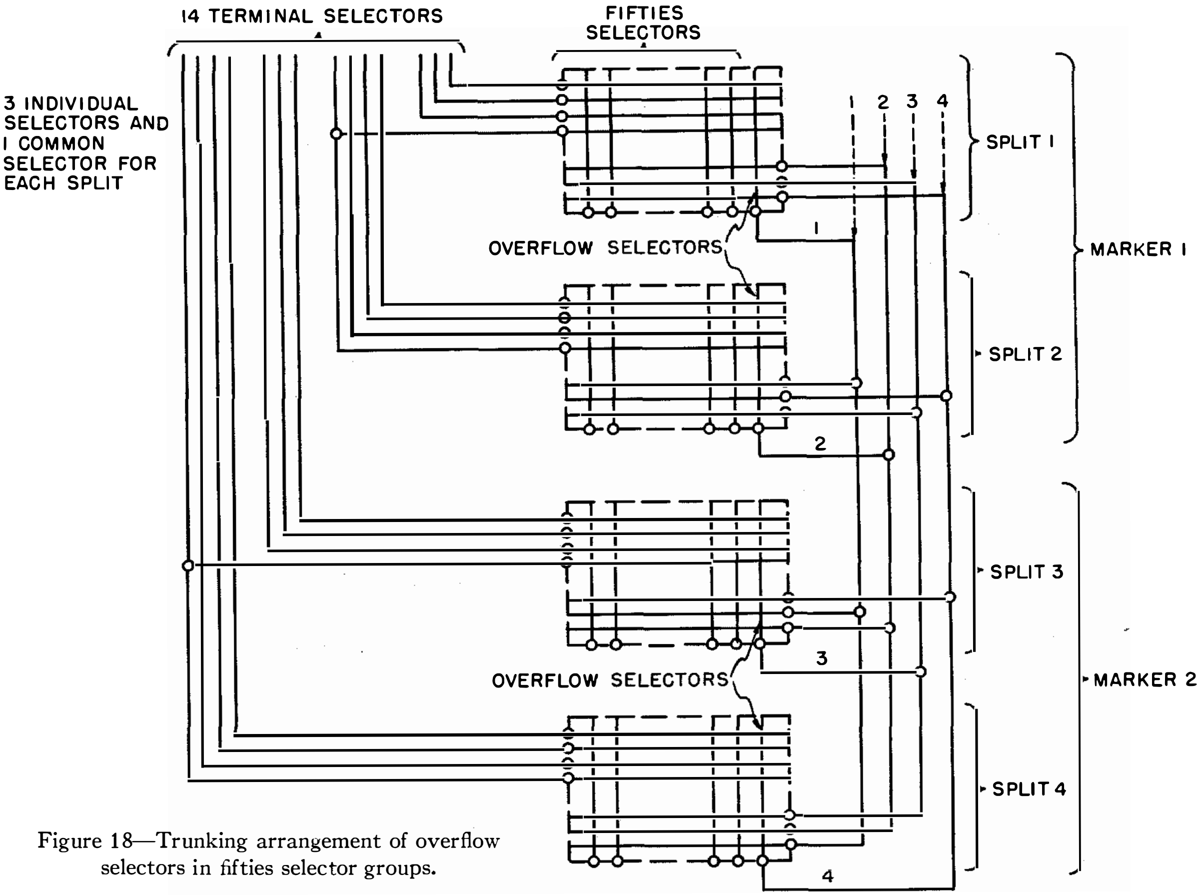


Figure 18—Trunking arrangement of overflow selectors in fifties selector groups.

which the calling fifties selector belongs cannot find a direct access to terminal selectors serving the called line, it chooses an outlet connected to an overflow selector in another split, provided the said split has direct access to terminal selectors serving the called line. Such an overflow selector is chosen, preferably, in an associated split, that is, under control of the same marker or, failing that, in another split under control of another marker. In the first case, the outgoing connector of the overflow split chooses a free terminal selector at once; the marker then establishes the connection and is released. In the second case, the marker is immediately

3.1.3.3 When a Party-Line Station Is Called

On the marking distributing frame, all number tags corresponding to station numbers of the same party line are connected to the same position tag. Such connections are made through a decoupling unit (rectifier, contact, resistance, or other), so as to avoid mixing numbers. The said number tags are also connected to common ringing-current selecting tags through a decoupling unit.

One set of tags is provided for each kind of ringing current. The called line is selected as already described for ordinary lines, but the

www.americanradiohistory.com

same line may be seized under several distinct numbers. When the receiver is connected to the marker, the called number is transferred to the latter, which causes a particular potential to be applied on the position tag as well as on the ringing-current selecting tag corresponding to the desired station. A temporary connection is established between said tag and a ringing-current selecting device that records the kind of ringing current required. Such ringing current flows as soon as the called line has been connected.

3.1.3.4 *When a Private-Branch-Exchange Station Is Called*

As may be seen in Figure 19, all position tags corresponding to lines of one private-branch-exchange group are connected on the marking distributing frame to a single-number tag denoting the group call number.

When the receiver after receiving the called number transfers it to the marker as for an ordinary line, the marker causes a particular potential to be applied to position tags of all lines in the private-branch-exchange group. Every free line in the group is then marked on terminal selectors in the same way as calling lines. These lines belong either to the same fifty or, preferably, to different fifties; in the former case, they appear on one terminal-selector group; in the latter case, they are distributed over several such groups.

When every free line has been thus marked, the outgoing connector of the fifties selector proceeds to hunt for a terminal-selector group that includes at least one of these lines and one free terminal selector that is accessible to the fifties selector concerned. Then connectors hunt for a free terminal selector and for one of the called lines accessible to that selector.

When none of the private-branch-exchange lines are free, the receiver sends the busy tone to the calling party as usual and the marker is released.

When free lines of one private-branch-exchange group all happen to be served by terminal-selector groups that are not directly accessible to the calling fifties selector, an overflow selector is used in the same way as for ordinary lines to reach a free terminal selector able to establish the connection.

It is often necessary to arrange that some lines in a private-branch-exchange group may be called by particular call numbers during certain hours. When this is the case, number tags corresponding to particular numbers are connected to position tags of these lines as shown in Figure 19B. Such position tags are also connected to the common number tag through a decoupling unit. Depending on whether the common or particular number is dialled, the connection is established either to any line in the group or to the particular line requested. Any line in a private-branch-exchange group may thus be allocated a particular call number.

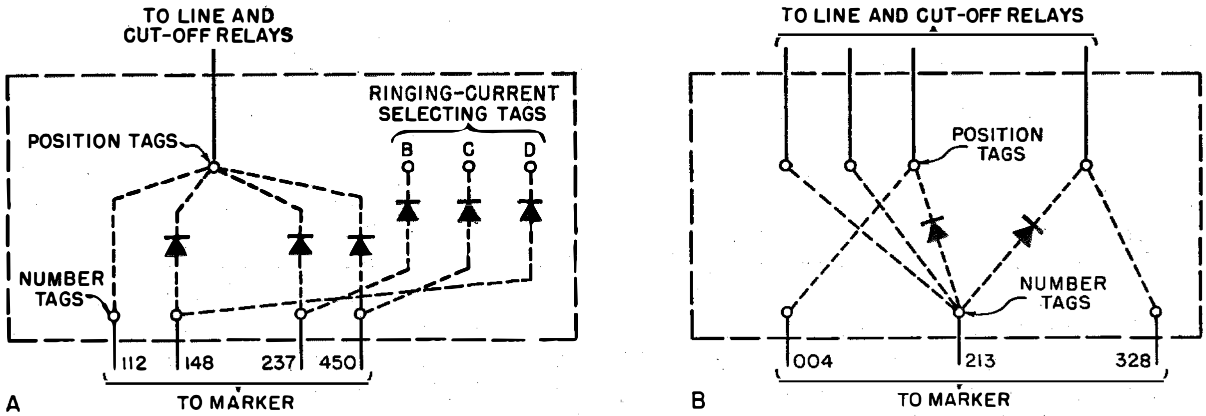


Figure 19—Wiring of marking leads on the marking distributing frame. At *A*, 4 party-line subscribers are called over numbers *112*, *148*, *237*, and *450;* ringing current is normal for *112*, *B* for *237*, *C* for *450*, and *D* for *148*. At *B*, 4 private-branch-exchange lines are called through number *213* and 2 of these lines may be called individually through numbers *004* and *328*.

www.americanradiohistory.com

3.1.3.5 *When a Special-Category Station Is Called*

On the marking distributing frame, the number tag of a special-category-station line is not connected to a position tag but to a tag that is reserved for the category, such as a changed number, dead line, or absentee service.

An appropriate signal is then sent to the register, which cancels the established connection and reroutes the call to the desired service.

From the foregoing, it is understood that the general control of a line-selecting element is distributed among several devices. The only common device, the marker, is duplicated (Figure 12) and plays a rather restricted part. It is a simple device and offers little probability of trouble. Any fault that may develop can involve only a small fraction of the line-selecting element and cannot disturb switching operations to any appreciable extent. Operational security is thus raised to a high degree.

3.2 Group-Selecting Element

The group-selecting element shown in Figure 20 consists of selectors grouped in two stages and control devices, including marking relays. It receives calls from local subscribers and from incoming trunks (other offices, long-distance circuits, operators, et cetera). It routes them to local subscribers, outgoing trunks, or special services, such as toll operator or information, that are available to subscribers.

Thus, the line-selecting element handles all 4 kinds of traffic (intraoffice, outgoing, incoming, and tandem) met within an exchange.

It consists of a double selecting stage in which the first-stage selector chooses a second selector only when the latter has free outlets to the called-line group (two-stage selection). It plays the same part as a single selecting stage of very large capacity. This capacity is in fact $50 \times 50 = 2500$ outlets, but it is seldom used in full. Practically, it is usually found more economical to have only 1500 or 1600 outlets, which are quite sufficient for most cases, and to add a second group-selecting element in larger offices of very-important networks. Such a second element will then often be used only for incoming and local traffic as may be seen in Figure 21.

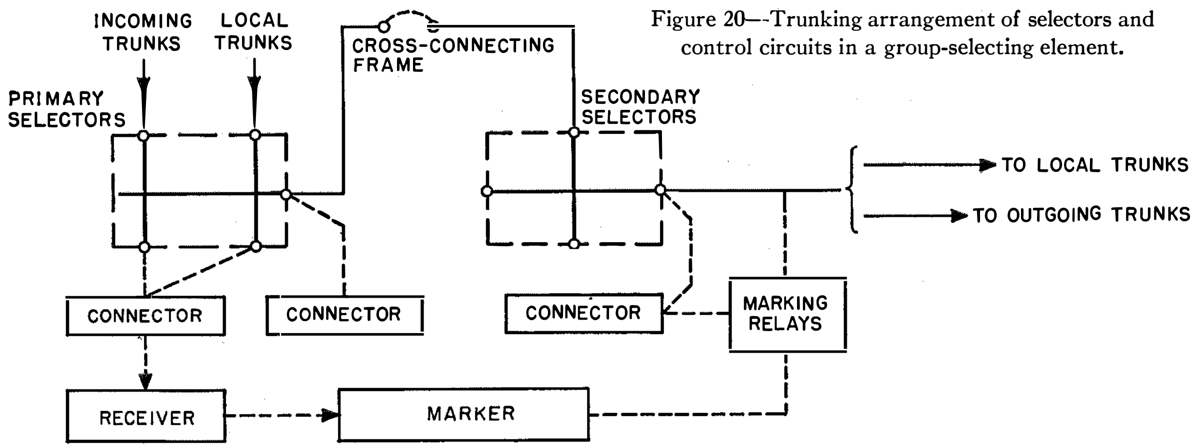


Figure 20—Trunking arrangement of selectors and control circuits in a group-selecting element.

A group-selecting element may have any number of outlets (within the limits previously stated) and also serve any number of line groups, each including any number of lines. The greatest flexibility is thus obtained for the trunking arrangement of outlets. Moreover, the two-stage selection facility is carried out in such a way that each line group may be considered as a perfect group so that outlets are used with maximum efficiency. This point is especially noteworthy as a great saving may thus be made in the number of interoffice trunks.

Group selectors are assembled on frames to make up multiswitches, as already described. The first stage includes primary selectors, the inlet of which is connected either to a junctor and finder to handle traffic from subscribers, to an incoming trunk from other offices or special services, or to an outlet from a preceding group-selecting element if the exchange capacity or the

www.americanradiohistory.com

nature of its traffic requires two successive group-selecting operations.

Forty outlets of primary selectors are generally connected to secondary selectors and 10 or 12 are connected to overflow selectors.

The second stage includes secondary selectors, the inlets of which are connected to outlets of primary selectors and the outlets of which go to secondary trunks toward which the traffic has to be routed.

Secondary selectors are assembled into secondary sections; each one has access to 50 outlets. If a group-selecting element has access to 1000 outlets, 20 secondary selections are provided; 24 would be used for 1200 outlets.

The 40 outlets from primary selectors having access to secondary selectors are connected through primary trunks to secondary selectors distributed among the various secondary sections by means of a cross-connecting frame indicated in Figure 20.

In one group-selecting element, the quantity of secondary selectors is usually over 40 and it becomes necessary to divide primary selectors into several splits known as primary sections.

Overflow selectors are also connected to outlets from primary selectors through overflow trunks and are distributed among the various primary sections. They enable a primary selector of a primary section to have access to secondary selectors connected to other primary sections and thus increase the efficiency of secondary selectors by increasing the number of possible paths.

As is the case for line selection, control devices consist of 3 parts and are shown in Figure 22. The marker is one of the control devices and is common to all selectors of one group-selecting element. The second and intermediate device is the receiver. The connectors are the third of the devices and are associated with the selector multiswitches. These devices consist essentially of electromagnetic-relay networks.

The marker designates the called-line group by means of marking relays which, for convenience in wiring, are located close to the secondary selectors. The marker also tests the chosen trunk and controls the connection.

Receivers (from 2 to 4 for each marker) receive information as to the called group from the register in the form of code impulses. Two such impulses permit 100 different types of information to be transmitted. The receivers transfer the information as a whole to the marker, when it is free.

Connectors are divided into two kinds.

Incoming connectors are similar to those of line-selecting elements and include a selector taken out from a primary multiswitch; they connect the inlet of primary selectors to the receiver that serves them.

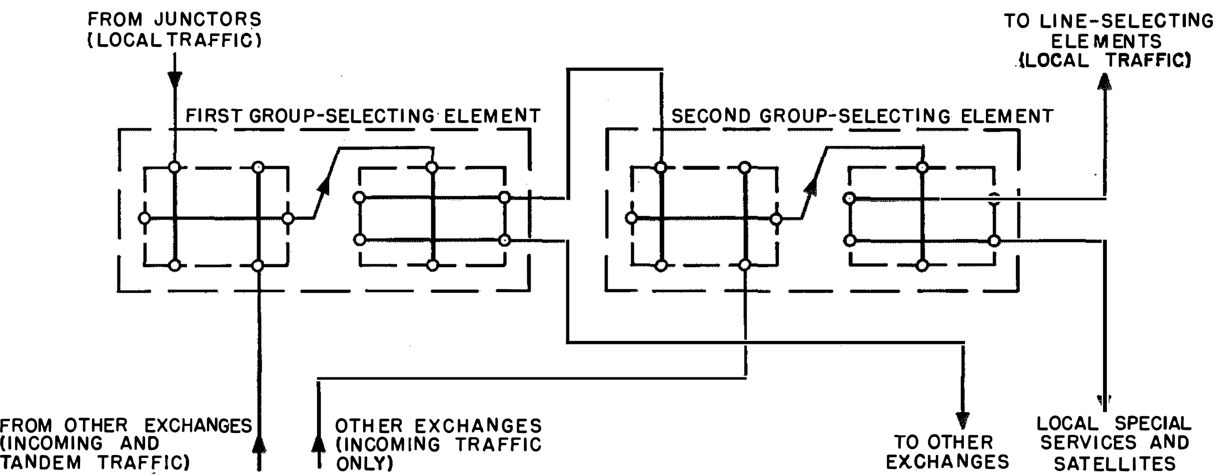


Figure 21—Two group-selecting elements as used in a very-large office.

Outgoing connectors are assigned to each primary or secondary section; they control selecting magnets of multiswitches and are used in choosing a primary overflow, or secondary trunk.

There are several group-selecting elements in an exchange, each being controlled by its own

www.americanradiohistory.com

marker. Outlets from the various group-selecting elements are multipled in whole or in part to obtain a graded multiple.

If groups consist of only a very small number of lines, it may be found useful to multiple all or part of these lines on several secondary sections inside the same group-selecting element so as to increase the number of paths from primary selectors. For greater convenience in arrangement and wiring, secondary selectors controlled by two markers, but having access to the same secondary trunks, are often accommodated on the same multiswitch.

Operation of the group-selecting element is outlined in Figure 22.

When a primary selector is seized by a call and the register has received information as to the called group, the incoming connector to which the primary selector is connected establishes a connection with the corresponding receiver *1* at once if it is idle or as soon as it becomes available.

The receiver *2* then receives code impulses, from the register designating the called group and transfers this information *3* to the marker as soon as the latter becomes available.

which the calling selector belongs chooses one of these primary trunks. The secondary section reached by this primary trunk chooses in turn one among the secondary trunks marked by the marker.

The marker tests the trunk, which might have been seized at the same time by another group-selecting element. If the test conditions are satisfactory, the marker causes the primary and secondary selectors to be connected *6* and is released at once. The time necessary for marking a line group, selecting a path, and connecting an inlet to the chosen outlet is about 350 milliseconds. Should the secondary trunk happen to be seized by another group-selecting element during the very short time it is being tested, the marker would cause another trunk to be selected.

When the calling primary section has no direct access to secondary sections having free trunks in the called group, the calling primary section chooses an overflow trunk reaching into another primary section that has possible paths to free trunks in the called group. The latter primary section then chooses a primary trunk and this causes a secondary trunk to be selected within a secondary section to which the primary trunk

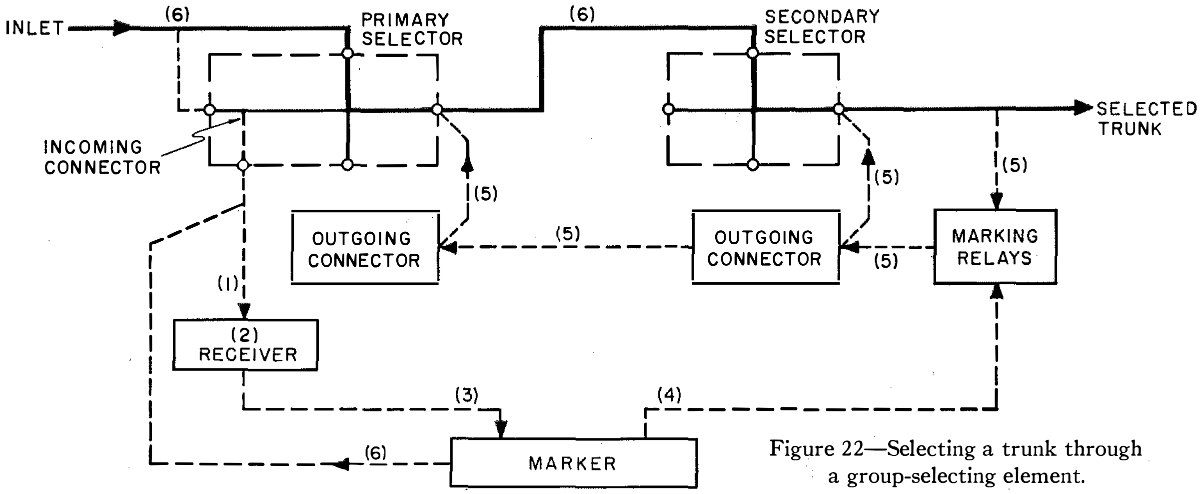


Figure 22—Selecting a trunk through a group-selecting element.

The marker marks *4* through the proper relays on the concerned secondary sections *5* every secondary trunk that is available at that time within the called group. These secondary sections in turn mark *5* on the primary sections every available primary trunk having access to these secondary sections. The primary section to

has access. Everything then operates as before except that 3 selectors (primary, overflow, and secondary) are used for the connection.

Alternative routing is provided. When a secondary trunk group to another office is busy and if auxiliary paths are available through a third office, the marker on receipt of information

www.americanradiohistory.com

as to the called group records that all trunks of the group are busy and passes the information on to the register, which releases the receiver and the marker. The register then indicates which group of auxiliary paths is available to handle the call and the marker acts through the auxiliary path in the same way as when a direct path is used.

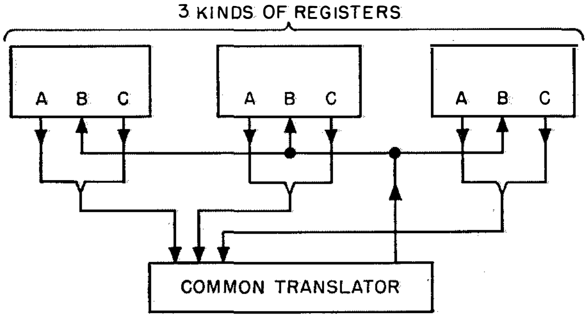


Figure 23—Common translator associated with registers serving various kinds of lines, such as for subscribers and local and long-distance operators. Classes *A* and *C*, which require the office code to be translated into other numerals, are separated in whole or in part depending on the kind of register. Lines of class *B*, which require preliminary selection, are common to all registers.

3.3 Register

The register assumes the same duties as other registers. Translators impart to the register such information as is necessary to route a call to its destination and eventually to apply the correct charge.

The translator is used during a very short time, from 75 to 100 milliseconds, so that the number of translators may be very small, 2 at most. As may be seen in Figure 23, they serve calls of all classes (full- or restricted-service subscribers, operators, long-distance circuits, et cetera) and impart to each of them the proper information, which may differ for the same called number.

The function of the register is therefore greatly simplified. It is used to receive the called number, transfer to the selector digits that denote the proper route, receive from the translator information to be sent on, and impart such information to the selectors when it is required.

The register may be considered as composed of 3 parts as shown in Figure 24.

The first of these parts is the receiver which successively receives the called-number digits as decimal impulses from the calling-station dial (subscriber or circuit), or as code impulses from either an operator using a key set or from a trunk sending code impulses. When the register is connected to the calling line, but before receiving digits from the calling station, the receiver is informed of the class of service to which the calling station is entitled. Such information is given by a potential of appropriate polarity or frequency on a special wire that is independent of the selector circuit.

The second part is the storer, which records in the form of a 4-element code the calling party's classification, each digit received by the receiver, and information supplied by the translator. As translation is governed by the relative positions of the elements that record the first digits received (2, 3, or 4 digits), such positions are transmitted to the translator. The number of such digits may vary, and the first 2 digits

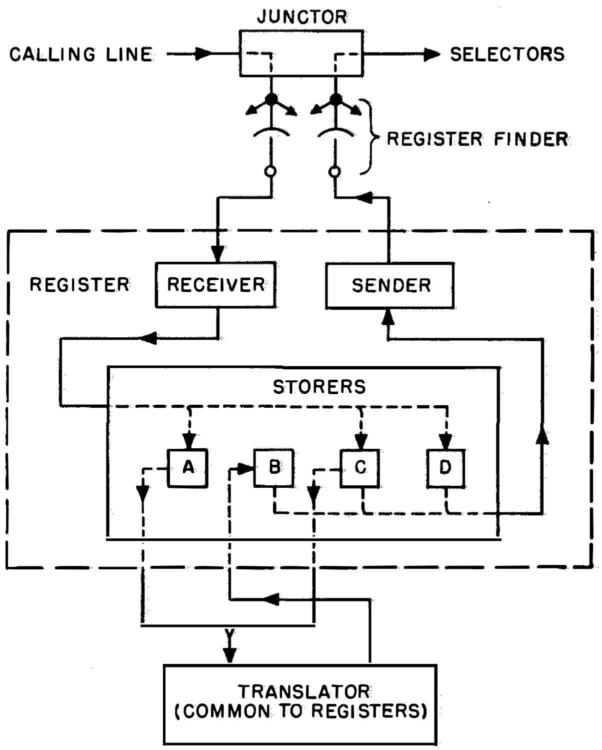


Figure 24—General trunking arrangement of register and translator. The 4 storers handle: *A*—classification of the calling line; *B*—preliminary selectors; *C*—number part to be translated; and *D*—number part not to be translated.

www.americanradiohistory.com

received, for instance, may immediately be transferred to the translator, which then informs the register whether they are or are not sufficient information on which to route the call. If they are, the register receives the necessary information for the selecting operation. If they are not, it is informed of how many digits the translator must receive before it can provide selection information. The translator will be seized again only after the third digit is received. In special cases, such as for national service, the fourth digit may be required.

The sender is the third element of the register. It successively sends to selectors the selection codes that appear on the storer. Such selection codes are made of a characteristic impulse (chosen among 10 or 11) composed of positive, negative, or positive and negative polarities sent on line wires, when the selector receiver is ready for them. If the selecting operation cannot be completed because of congestion, for instance, at a particular stage, the partly established connection is released and the sender makes another attempt to complete the connection. If again unsuccessful, the calling party receives the busy tone and any necessary alarm can be given to maintenance personnel by automatic means.

When the required connection between 2 stations involves the use of a toll numbering plan (nationwide numbering plan, for instance), the number of digits in the called number is greater than for local calls. For instance, a first 2-digit code will denote that the call is intended for national service, This code differs from the local regional code and the digits following the first 2 digits will compose the national call number proper (8 digits for instance). The first 2 or 4 digits will denote either the desired region or office and they will, of course, be translated quite differently from the same 2 or 4 digits denoting a local or regional call number. The same translator shown in Figure 23 is however used but it gives different information. So as not to load the local registers with what is needed for national operation (as this is only a small part of subscribers' traffic), an additional register is used and is shown in Figure 25.

The duties of receiving the called number and sending the selection codes are carried out by the main register, which also records digits not used to route the call (thousands, hundreds, tens, units). Because of this, the additional register needs only to include elements similar to those that make up the storer part of the main register.

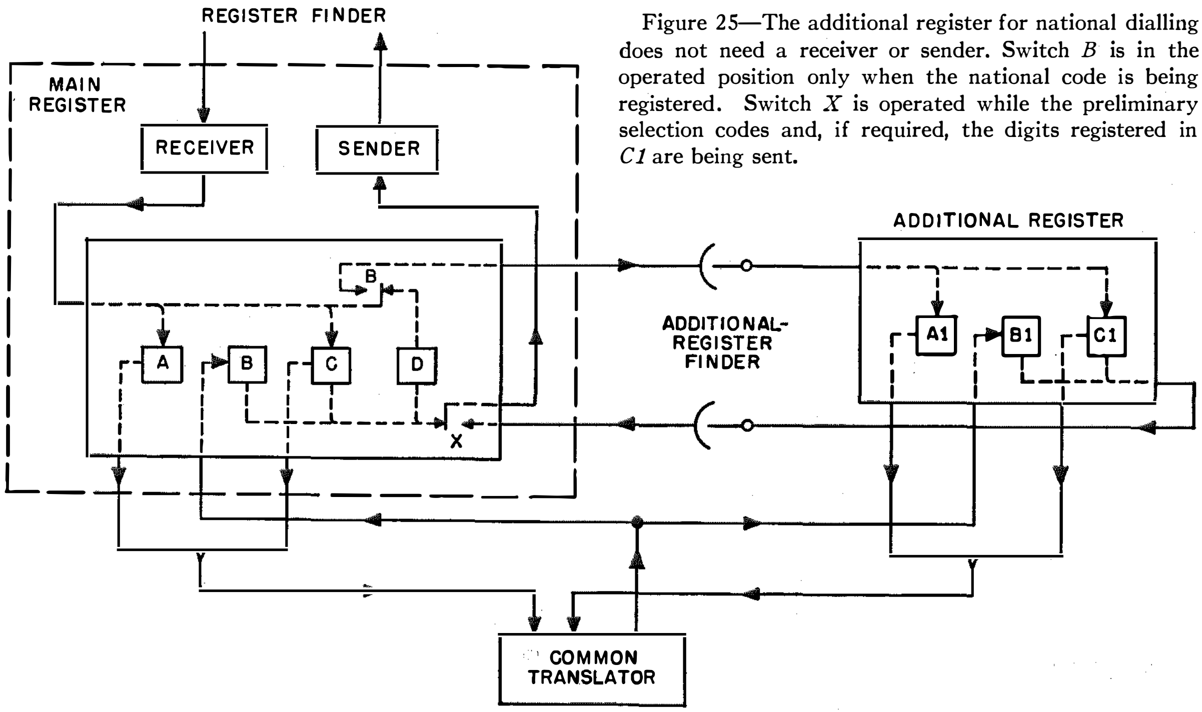


Figure 25—The additional register for national dialling does not need a receiver or sender. Switch *B* is in the operated position only when the national code is being registered. Switch *X* is operated while the preliminary selection codes and, if required, the digits registered in *C1* are being sent.

www.americanradiohistory.com

Such elements enable it to *A*—receive the 4 digits that preceed the thousands digit and which in part or in whole determine routing and charges for the call, *B*—transfer such digits to the translator, and *C*—receive from the translator corresponding selection information.

The number of selection codes the register can send includes several preliminary selection codes in addition to the whole of those translating the called numbers. The number of preliminary codes as well as the number of digits sent are, of course, subject to the routes that the call must follow and are determinated by the translator. Returning the full complement of digits allows rerecording and eventually retranslation.

One or more preliminary selection codes may be used to impart tariff information. This information may be inserted between other codes where it is most convenient for the charging device to make use of it.

Depending on the number of numerical codes to be translated, the translator is composed either entirely of relays or partly of relays and partly of magnetic and electronic devices.

The register is connected to the translator by means of a connecting relay. Each register may be connected to either of the 2 translators in an exchange depending on which is idle at the time. When the register is connected to the translator, the latter receives immediately and simultaneously information on the classification of the calling number and the first 2, 3, and 4 digits recorded as a code. Such information allows that part of the number that is used to route the call to be deciphered and to connect a jumper to the appropriate translating means.

When several paths may be used for the same number, depending on the calling party's class, several jumpers are used on the same number but relays indicating the calling party's class connect only the appropriate jumper.

For instance, a subscriber dials for long distance, but may or may not be entitled to such service. If he is, the translation jumper used will indicate the regular path to the register, if he is not, another jumper will be connected that will cause the call to be routed to the special-services circuit. In like fashion, a toll operator will have access either to terminal traffic circuits or to general traffic circuits depending on the origin of the call (local zone or distant offices).

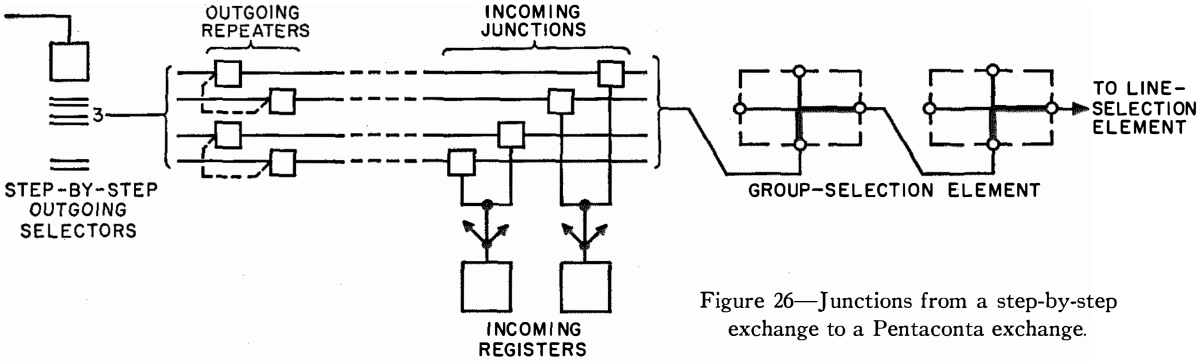


Figure 26—Junctions from a step-by-step exchange to a Pentaconta exchange.

By choosing a second jumper it will also be possible to use an alternative route, when the direct one is congested and the register queries the translator for another path.

3.4 Interconnection with Other Systems

When designing the Pentaconta system, careful attention was given to the problem of interworking with other existing systems.

As regards direct-dialling systems, problems arise on both incoming and outgoing trunks. Various solutions are available and a choice depends on traffic and cable costs.

A. Incoming trunks are connected to incoming registers, which receive the dial impulses in either of two ways.

In one of these arrangements, the dial impulses are received directly through relay contacts. One register is common to a small number of trunks, which are marked busy if the register is busy. This system is shown in Figure 26.

In the second arrangement, the incoming-trunk junctor is itself equipped to receive the first digit, which is dialled while a register is

www.americanradiohistory.com

being connected to the trunk. After connection, this digit is transferred to the register, which then receives the other digits. This arrangement is illustrated in Figure 27.

B. The connection to a trunk outgoing to a direct-dialling system can be controlled by the Pentaconta local register in three ways.

In one of these arrangements, shown in Figure 28, the connection is established to the outgoing trunk immediately after the first digit is dialled by the local Pentaconta subscriber. After the register releases, the other digits are sent directly to the distant office from the subscriber's dial.

In the second method, the register receives all digits dialled by the local subscriber, controls the local connection to the outgoing trunk in the way described above after translating if necessary, and then sends all other digits to the outgoing trunk and distant office with decimal pulses.

If the number of digits to be dialled in the office network is subject to variation from one office to another, the third procedure may be used. In it, the register disconnects itself as soon as all received digits are sent, and other digits to come are sent directly over the trunk to the distant office from the subscriber's dial.

In register-controlled systems, problems arise only with regard to the correct means for sending pulses or codes from the Pentaconta registers to those in the other systems and vice versa. Incoming junctors and outgoing junctors are then designed accordingly and pulsers may be added if they are needed.

4. Exchange Equipment

Devices used in Pentaconta exchanges are mounted on bays, which afford easy access to both front and rear sides. Bays are set next to one another in rows, the length of which is determined by the size of the switch rooms. Passages are provided between rows giving access on the front side to apparatus and contacts and on the rear side to wiring. Although this arrangement takes up more floor space than putting two adjacent rows together on their wiring sides, it is also much more convenient for maintenance than having to tilt the apparatus support to gain access to wiring. As a rule, the apparatus sides of two neighboring rows are placed opposite each other so that their wiring sides face each other; passages between apparatus sides, which are more frequently used, are wider than passages between wiring sides.

Multiswitches are mounted on frames screwed to the uprights of the bays. Relays are mounted either in frames similar to the multiswitch frames or on removable plates provided with connecting plugs that fit into fixed jacks on the bay itself. This arrangement is used for registers, in particular.

All apparatus is protected by covers against dust and mechanical injury. Metallic partitions, which thus enclose all the equipment, provide protection against fire.

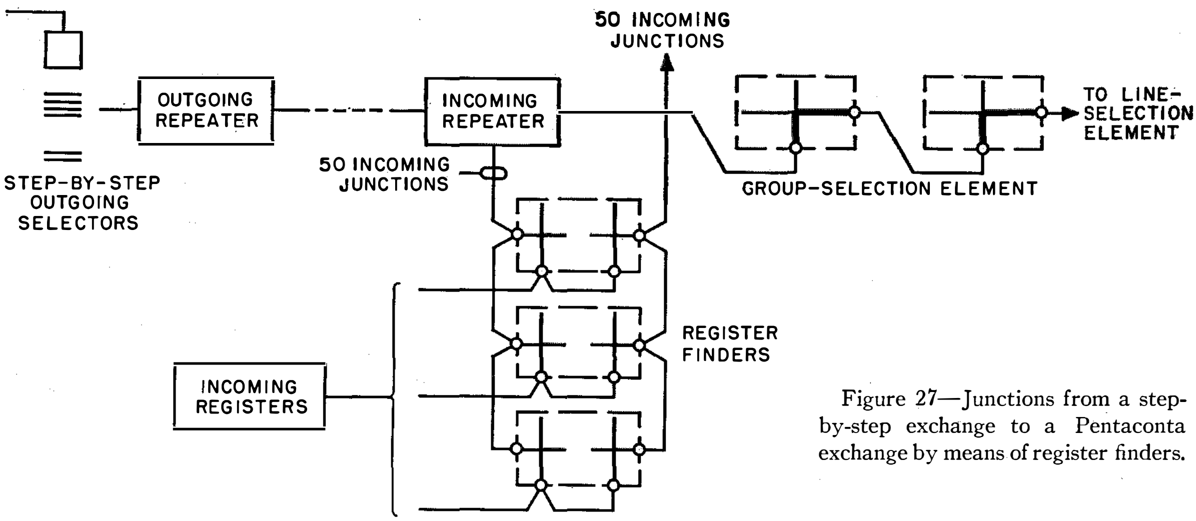


Figure 27—Junctions from a step-by-step exchange to a Pentaconta exchange by means of register finders.

www.americanradiohistory.com

Uprights are made of sheet metal formed into a C-shaped section. Connecting cables are laid on racks on top of the bays and run down inside the uprights to be soldered on connecting tags located on the sides of multiswitches or relay frames. The resulting appearance is very neat as may be seen in Figure 29; cleaning is done easily and economically.

Power is supplied through completely closed metallic structure located at the lower part of each bay. It encloses fuses, connecting tags, cutout strips, and other means used to distribute the direct current as well as the various signalling currents. As shown in Figure 30, the cables are enclosed in steel conduit where they pass from frame to frame. The power-supply system is thus adequately protected against fire.

The switching circuits are designed for a 48-volt direct-current supply. However, they may be adapted to any other direct voltage that may be required when extending an existing exchange.

Figure 31 shows the complete bays of apparatus of a line-selecting element. It can handle a total traffic of 66.6 erlangs, that is, 0.133 erlang for each line. For smaller traffic, the number of fifties-selector multiswitches and of finders is reduced. Line units are connected by cables to the main distributing frame (subscribers' lines) and to an intermediate distributing frame (finders and fifties selectors). By moving jumpers, the ratio between finders and fifties selectors may be varied to meet the demands for outgoing traffic and incoming traffic of the particular group of subscribers.

Figure 32 shows the group-selecting element. To facilitate cabling, it is divided into two parts; the primary-selector bays and the secondary-

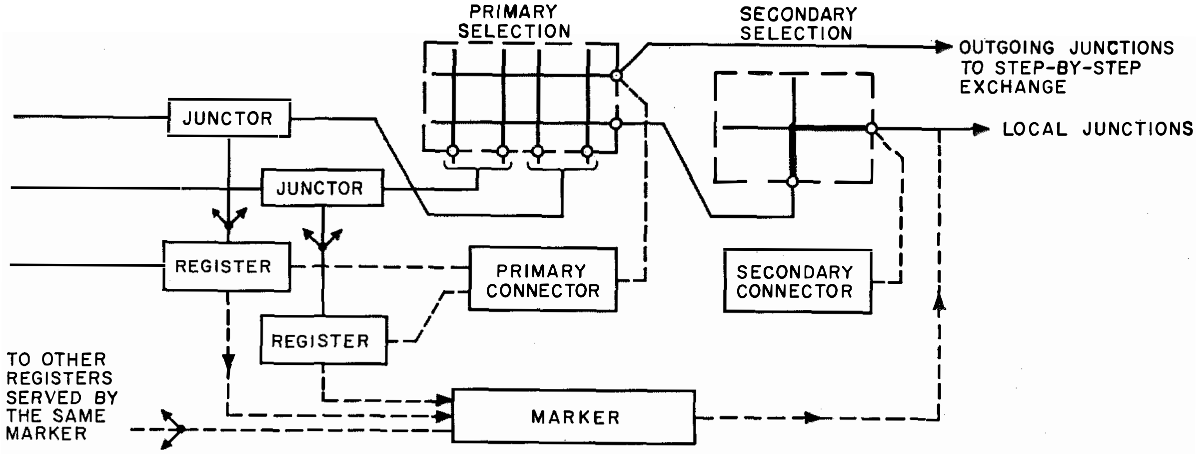


Figure 28—Group-selection element adapted to direct trunking to a step-by-step exchange.

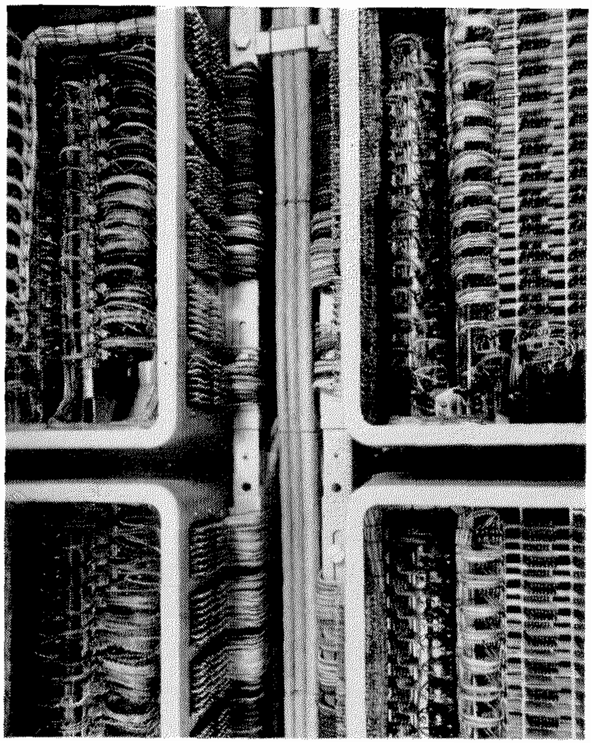


Figure 29—Each frame containing a multiswitch or relay group is wired at the factory. External cables are run vertically between bays and are soldered to terminals along the side of each frame.

www.americanradiohistory.com

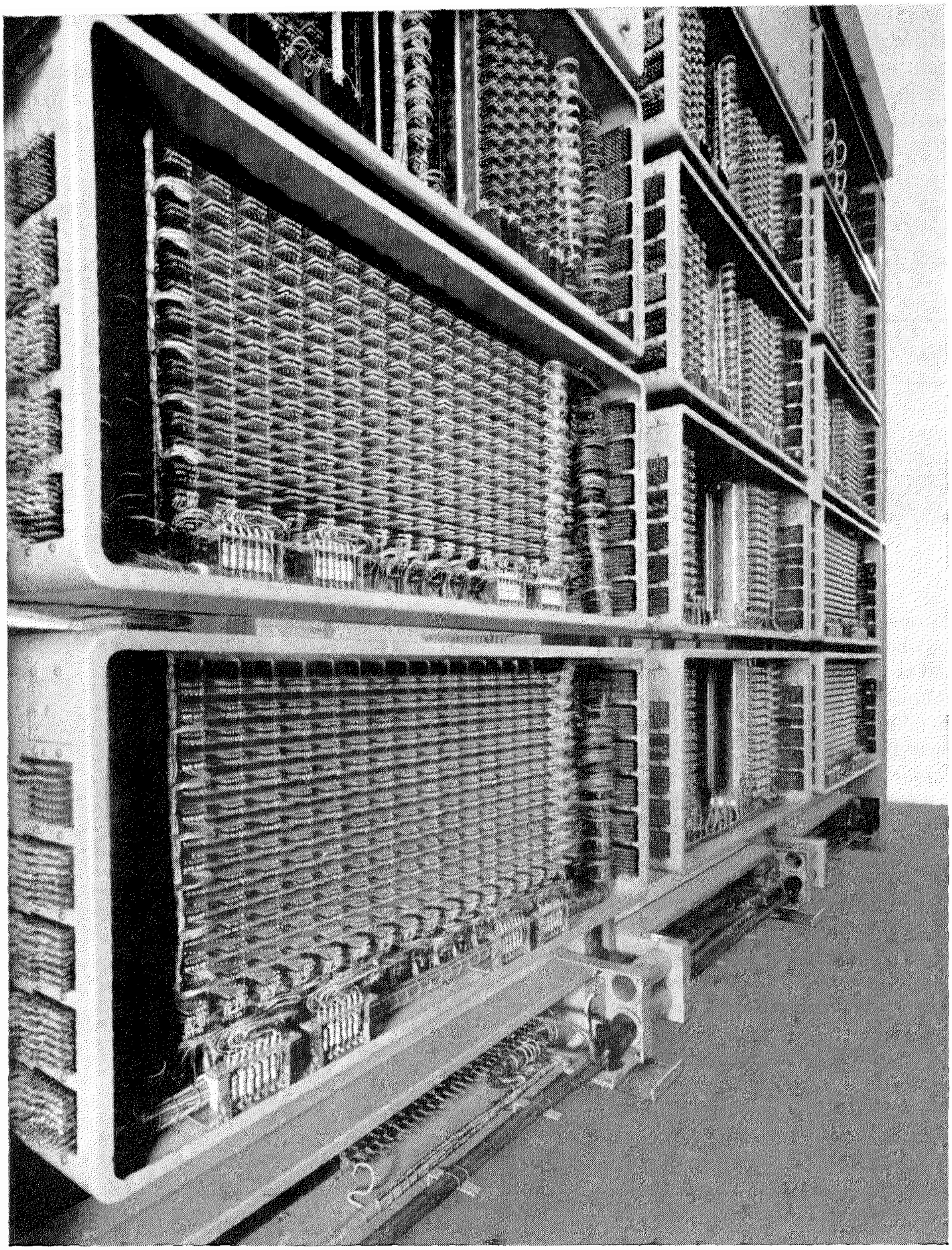


Figure 30—Rear view of bays showing the horizontal bare-wire multiples in the frames and the power cables at the bottom of the bays.

www.americanradiohistory.com

selector bays. Primary-selector bays of various group-selecting elements are set next to each other. Each group-selecting element has 1 or $1\frac{1}{2}$ primary-selector bays (3 bays to 2 elements) depending on the number of selectors allocated to each marker. This number may vary with the amount of traffic and the size of the exchange. A bay carries 6 multiswitches comprising 96 primary selectors and one additional frame that contains marker and receiver relays.

Each secondary-selector bay is often served by 2 markers and accommodates equipment corresponding to 10 secondary sections, or 500 lines. The 10 sections are contained in 5 multiswitches, the multiple of which has been split in half at the middle. Each secondary-selector bay also includes marking relays in sufficient quantity to provide all possible group combinations of outgoing trunks from secondary selectors. The marking relays are contained in boxes, the rear sides of which are provided with connecting tags. By connecting jumpers in an appropriate way between these boxes, secondary-selector outlets may be distributed in any way whatever among lines served by group selectors, such as local line-selecting elements, special services, and trunks to distant offices.

Junctors between finders and group primary selectors are mounted on bays that also accommodate associated registers and register finders.

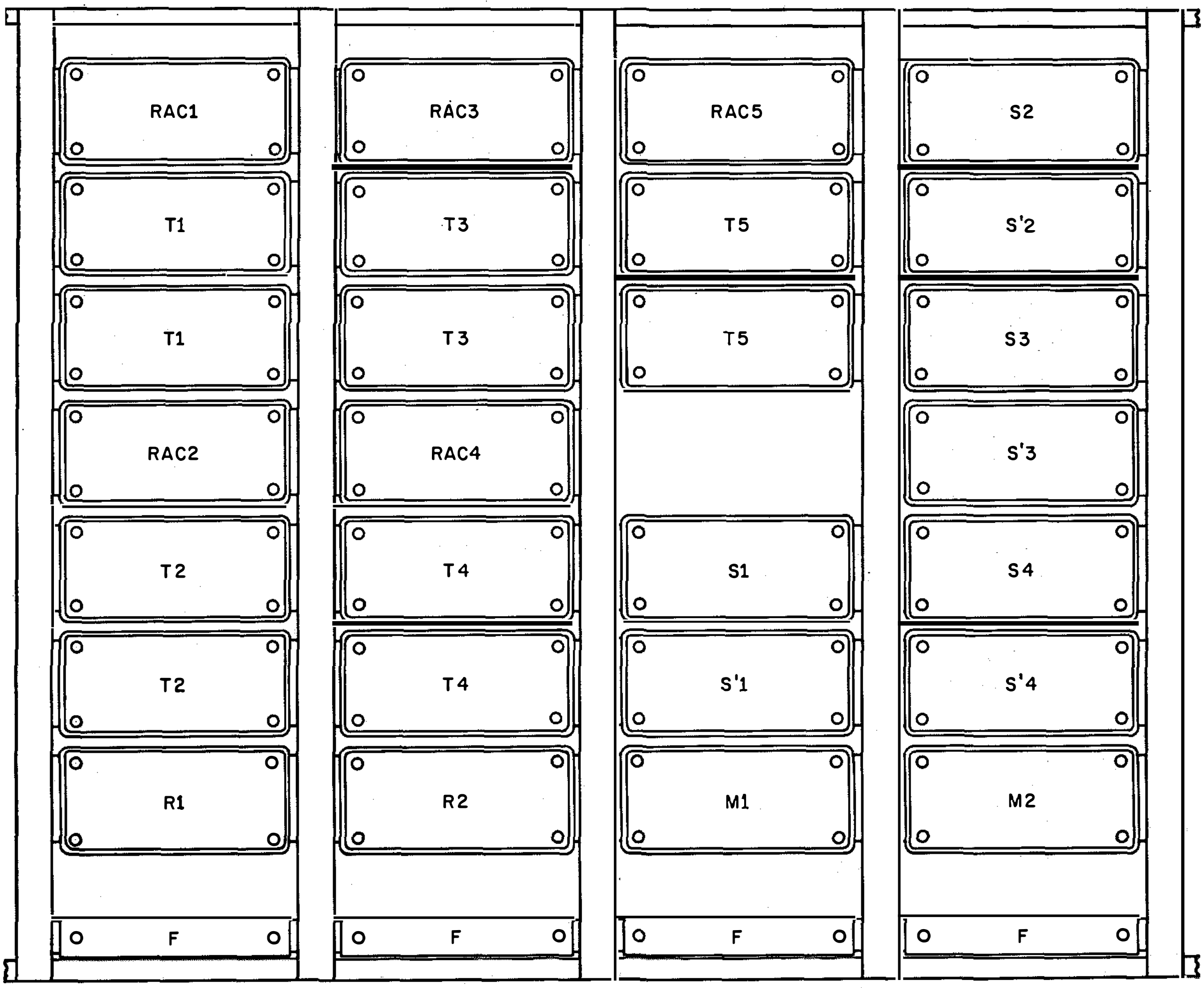


Figure 31—Line-selecting-element equipment bays. Over-all dimensions are 4 meters (13.1 feet) wide by 3.45 meters (11.3 feet) high. *RAC*—line and cut-off relays for 100 lines. *T*—16 terminal selectors. *S*, *S'*—32 fifties selectors and finders for 1 split. *R*—marking distributing frame for 500 lines. *M*—2 testers, 2 receivers, 1 marker, and 1 distributor. *F*—power distribution.

www.americanradiohistory.com

See Figure 33. There are 48 junctors as well as 6 registers provided to each bay. The latter are mounted on removable base plates that carry

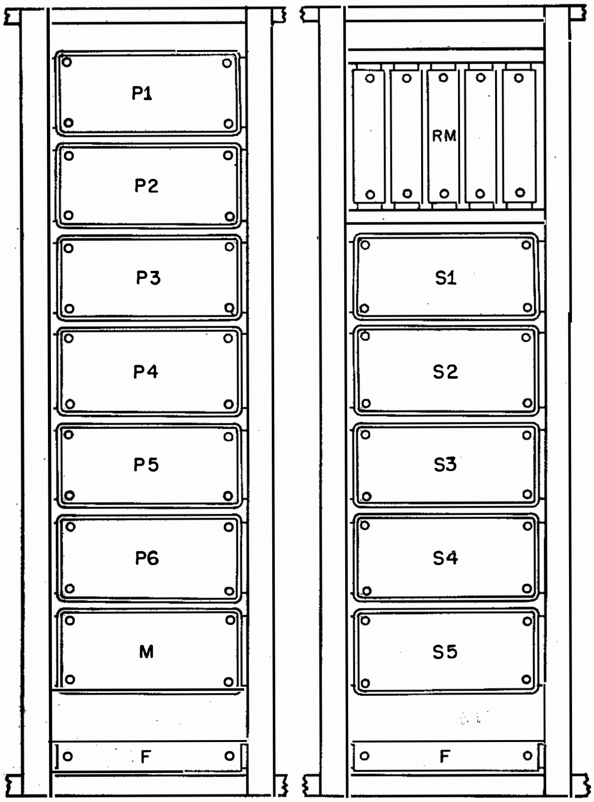


Figure 32—Group-selecting-element equipment bays. Each bay requires a horizontal space of 1 meter (3.28 feet) and is 3.45 meters (11.3 feet) high. *P*—16 primary selectors. *M*—4 receivers and 1 marker. *RM*—5×30 marking relays and marking distributing frame. *S*—16 secondary selectors. *F*—power distribution.

connecting jacks. The multiswitch that includes register finders contains an additional relay set acting as a finder tester. This relay set takes up as much space as 2 selectors, but this is of no inconvenience as not more than 12 register finders are necessary on a bay (2 finders to each register), each having access to 24 junctors.

A typical cabling diagram of an exchange using group selectors is shown in Figure 34. Line-selecting elements on the one hand and junctors, registers, and group selectors on the other hand make up the two parts of the arrangement.

Three intermediate distributing frames are used to simplify the laying of interframe cables,

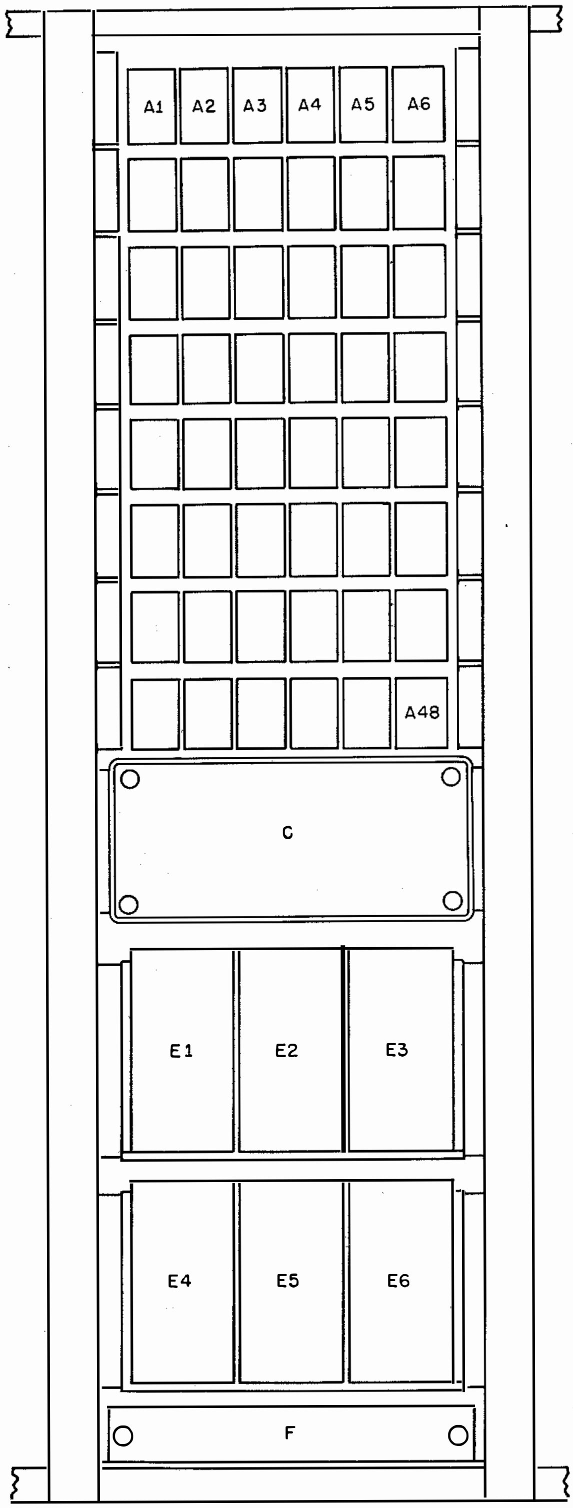


Figure 33—Cord-circuit and register bay requires a horizontal space of 1 meter (3.28 feet) and is 3.45 meters (11.3 feet) high. *A*—48 junctors or cord circuits, *C*—register finders, *E*—registers, and *F*—power distribution.

www.americanradiohistory.com

distributing of trunks among apparatus, and to provide facilities for future growth.

Connected from one side of a first intermediate distributing frame are cables to inlets of fifties selectors and finders, cables of trunks from distant offices and trunk boards, cables of outgoing trunks to distant offices, special services, et cetera. From the other side go cables to junctors as well as outlets from secondary selectors. The latter are connected to special tags that allow multipling and grading among secondary sections belonging to different markers.

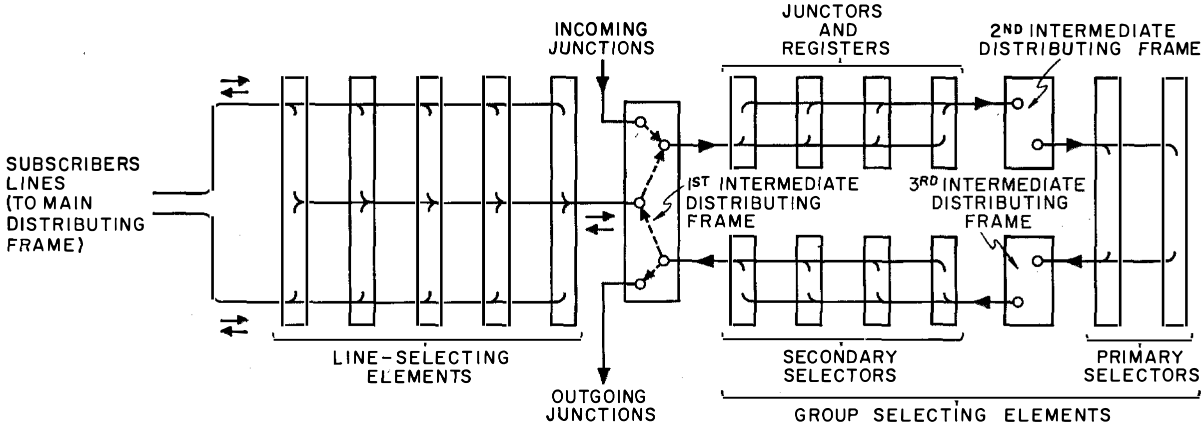


Figure 34—Typical cabling diagram for an exchange using group selectors.

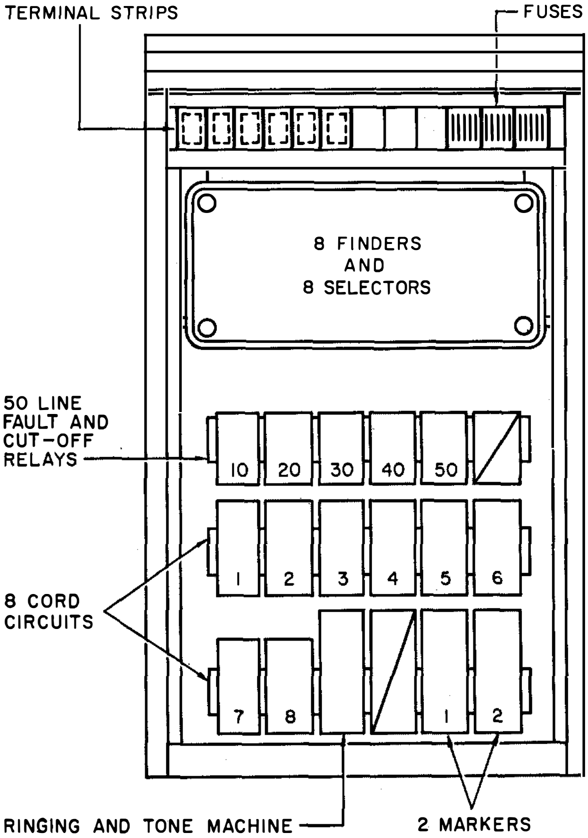


Figure 35—Exchange of 50-line capacity. The bay is 1.12 meters (3.7 feet) wide.

A secondary intermediate distributing frame makes it possible to cross-connect outlets of junctors (and consequently the registers) among various primary sections of group-selecting elements. It carries cables from junctors and to inlets of primary selectors.

A third intermediate distributing frame makes it possible, similarly, to distribute outlets of primary sections among various secondary sections. It has cables from outlets of primary selectors and to inlets of secondary selectors.

All these distributing frames are of the single-side type; they line up with bays. Soldering and connecting of jumpers is done on the front side. Their length depends on their capacity.

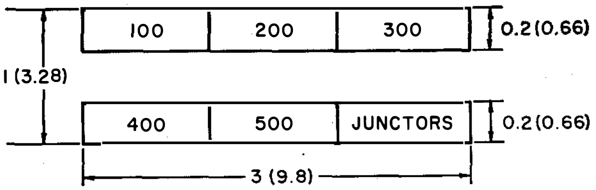


Figure 36—Layout of a 500-line exchange. The 500 line-selecting elements are in the numbered bays; the additional bay being of junctors. All bays should be at least 1 meter (3.28 feet) from the nearest wall. The bays are 2.3 meters (7.5 feet) high and the minimum ceiling height should be 2.6 meters (8.5 feet). Dimensions shown are in meters (feet).

www.americanradiohistory.com

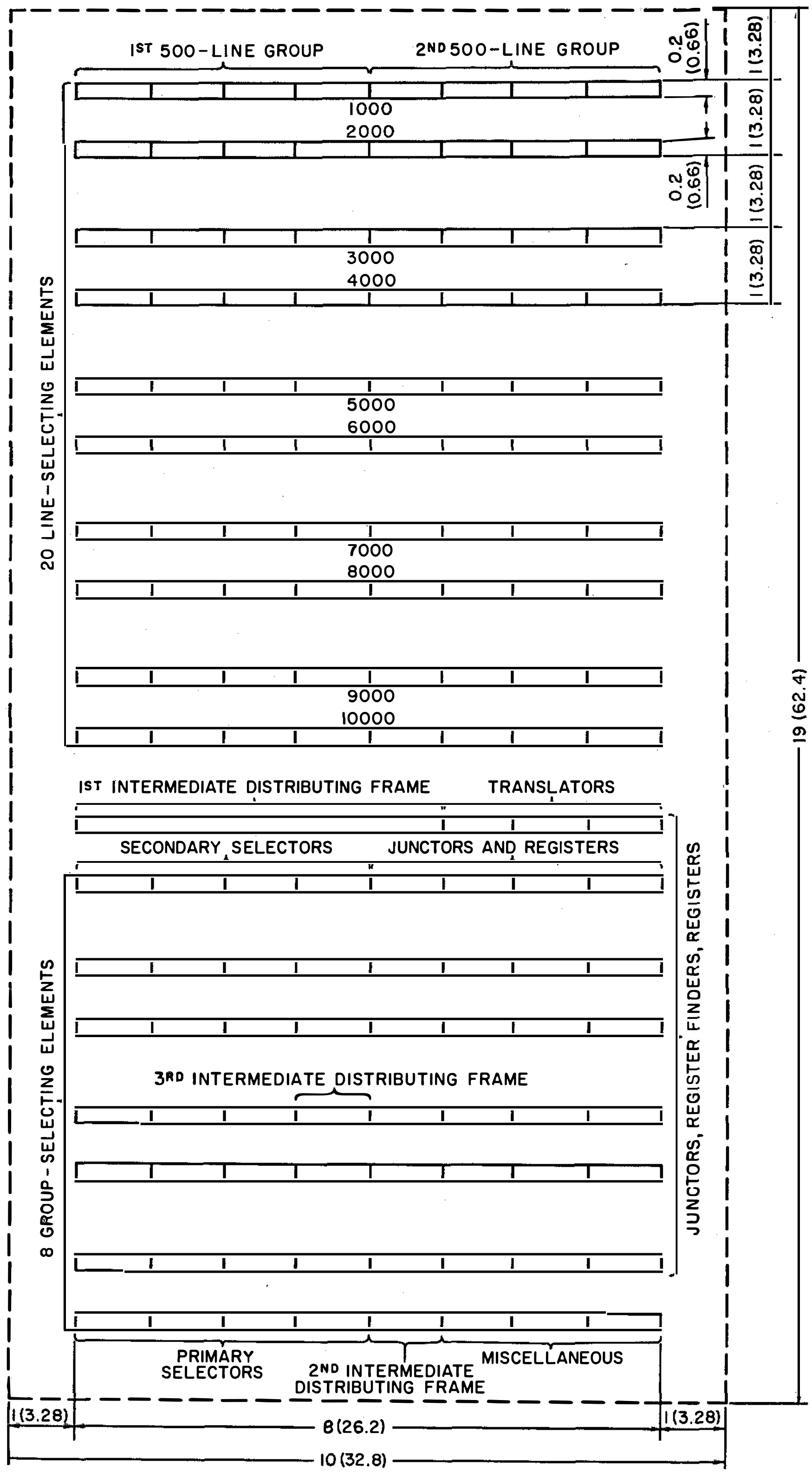


Figure 37—Typical layout of a 10,000-line exchange switch room. All bays are 3.45 meters (11.3 feet) high and minimum ceiling clearance should be 3.9 meters (12.7 feet). Other dimensions are given in meters (feet).

www.americanradiohistory.com

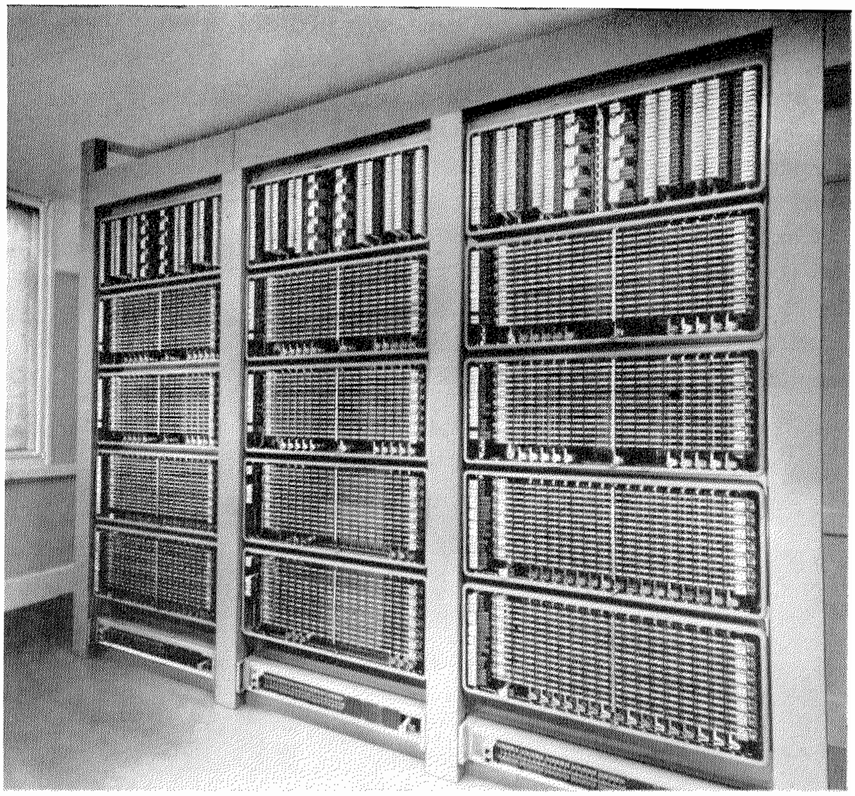


Figure 38—Left half of a 500-line exchange. At the top of each bay are 104 line and cutoff relays. The 6 multi-switches at the bottom of the bays are call finders and fifties selectors, the remaining multi-switches are terminal selectors.

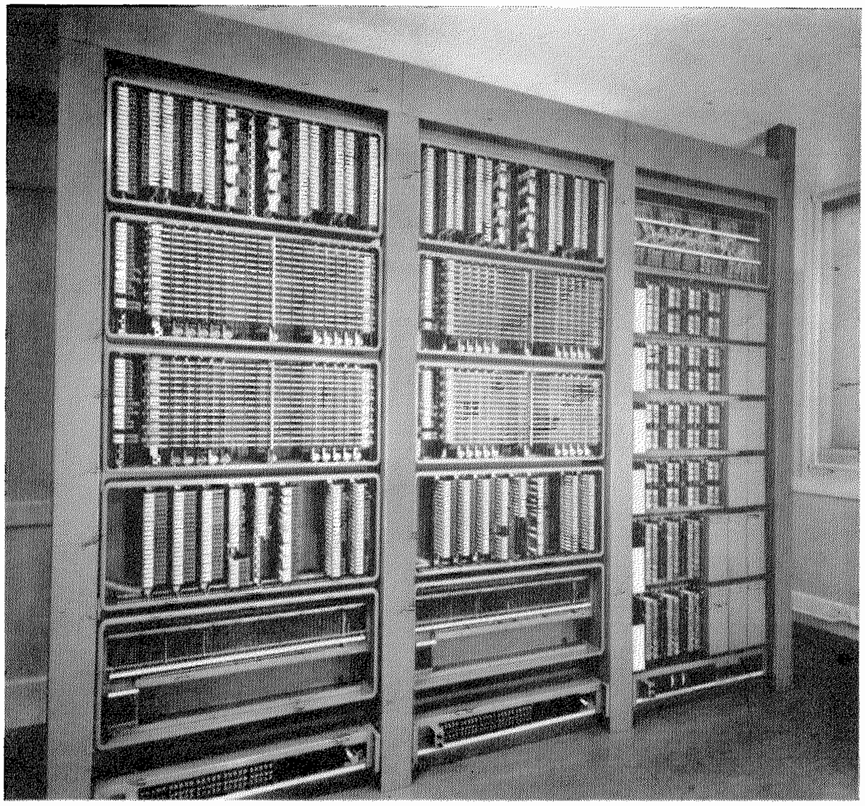


Figure 39—The right half of the 500-line exchange. The two bays at the left carry the remaining line and cutoff relays, terminal selectors, 2 markers, and their distributing frame. At the right is the intermediate distributing frame at top, 32 cord circuits, and 6 receivers.

www.americanradiohistory.com

Three typical arrangements of exchanges with capacities of 50, 500, and 10,000 lines are shown in Figures 35, 36, and 37.

The 50-line unit is enclosed in a metallic cabinet that can be placed against a wall in a room not necessarily reserved for telephone service only. Ceiling clearance of rooms for exchanges of larger capacity may not always permit the use of bays of standard height, so a 500-line exchange using bays of reduced height has been designed and is shown in Figures 38 and 39.

5. *Conclusions*

The simplicity and flexibility of the Pentaconta system allow it to be adapted readily to fulfil all the numerous and varied requirements of modern automatic switching systems. It is suitable for automatic trunk exchanges, rural exchanges, interworking with existing mechanical and electromechanical systems, time-and-zone metering, automatic message accounting, and similar applications. Pentaconta thus ranks among the most up-to-date systems in the automatic telephone field.

FERNAND GOHOREL was born in Rouen, France on August 18, 1897. He received the engineering degree from the Ecoles Nationales d'Arts et Métiers, where he was awarded the Gold Medal. He subsequently became Ingénieur Diplômé de l'Ecole Supérieure d'Electricité, Paris, in 1919.

On leaving college, he joined the telephone department of Compagnie Française Thomson–Houston. Later he was transferred to Compagnie Générale de Constructions Téléphoniques when that company was created and is now its managing director. As head of the joint research group of the International System French associates, he has personally supervised the development of the new Pentaconta switching system, which he describes in this issue.

Mr. Gohorel is president of the Syndicate of French Telephone Manufacturers, and his general activities in the industry are extensive.

www.americanradiohistory.com

Mechanoelectronic Telephone Switching System

By JAKOB KRUITHOF
International Standard Electric Corporation; Antwerp, Belgium

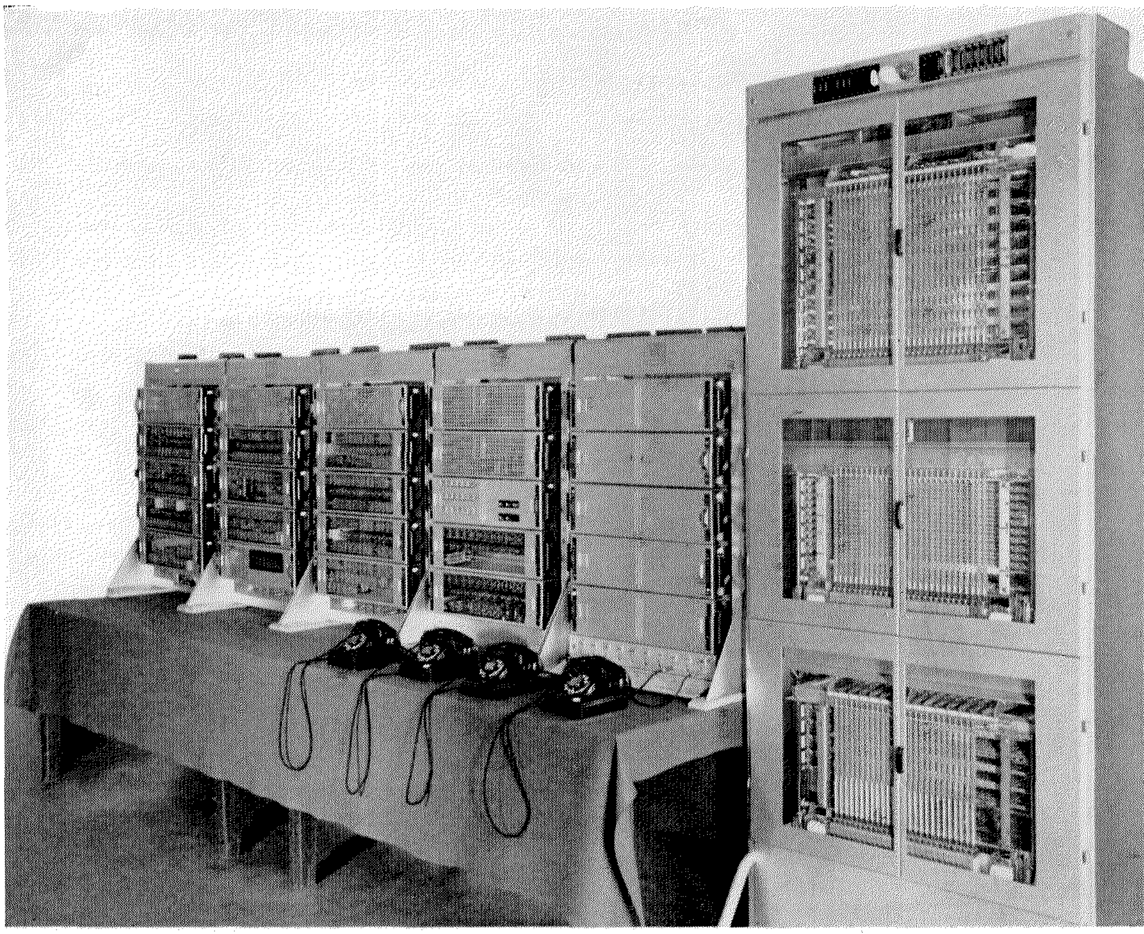
and MARTINUS DEN HERTOG
Bell Telephone Manufacturing Company; Antwerp, Belgium

DEVELOPMENT of modern machine switching systems for telephone service has been influenced by three distinct factors.

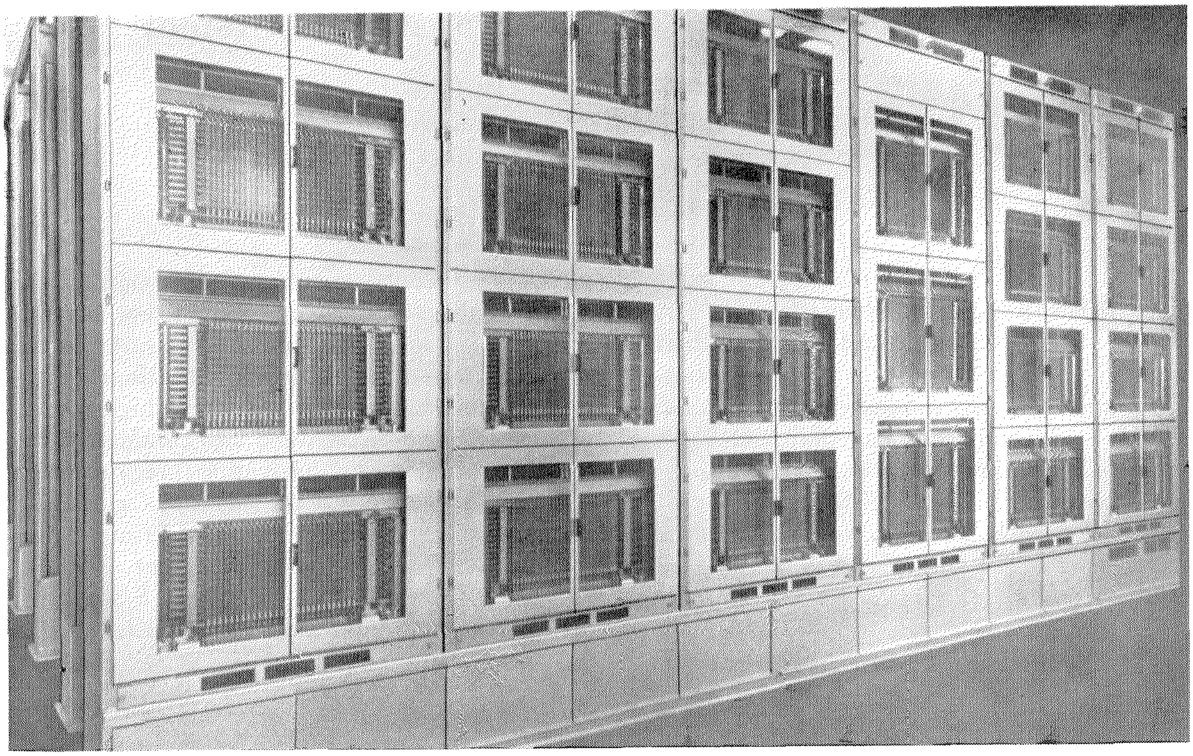
The first concerns fundamental apparatus design. It is an established fact that switches having ordinary sliding contacts are liable to cause disturbances in the talking circuit. After a certain time of use, the surrounding atmosphere forms on contact surfaces a thin film that is highly sensitive to vibrations and causes appreciable voltage variations. Although means are available to improve this condition, notably by periodic cleaning of the contact surfaces and by reduction of the disturbing vibrations, nevertheless the fact remains that a high-quality electric connection between two conductors can best be obtained by providing precious-metal contact surfaces. With the advent of automatic long-distance switching, the contact-noise phenomenon has become more prominent.

The crossbar switch invented by J. S. Reynolds in 1913 was the first attempt at switch design providing precious-metal, pressure contacts.

Demonstration model of the system.



www.americanradiohistory.com



Multiswitch bays in the Ski exchange, Oslo, Norway.

However, it was not brought into actual use until some years later.

The development of all-relay switching systems took place parallel to this. Possibly, it is the combination of the crossbar switch and all-relay switching system methods that suggested the application of the Reynolds type switch as a multiswitch, associated with the link and the marker that provides the directive control of the equipment and that performs the functions of hunting and selecting.

Another stimulus that instigated new trends of thought was the dynamic progress of electronic techniques and their growing reliability. The application of electronics to switching is attractive for its speed and absence of mechanical wear, implying easier maintenance. Switching engineers are not obliged, however, to accept electronic means as the only solution of their problems as they have other thoroughly tested electromechanical and electromagnetic devices at their disposal. They are, therefore, inclined to accept electronics only if it offers concrete advantages, such as simplification, smaller space occupancy, reduced maintenance, higher-speed operation, et cetera.

Yet another impulse was created by the rapid extension of long-distance dialling by the subscriber, which gave rise to a variety of problems. Multiple registration of the fee due on the subscribers' meters as adopted by several European administrations, although attractive on account of its simplicity, may not provide a complete solution for the call-charging problem of the larger countries. Long-distance dialling has, therefore, brought to the foreground the problems of identification, ticket printing, automatic call charging, and completely automatic billing. Accuracy being of prime importance for these services, simple and reliable means are indispensable. Where the function of identification of the calling subscriber's number had to be added to existing exchange equipments, the ways and means used were often rather complicated. With new systems, however, the requirement of perfect accuracy should be guaranteed and be obtained with simplicity and economy.

The mechanoelectronic (*ME*) switching sys-

www.americanradiohistory.com

tem is based on a newly developed multiswitch of the crossbar type in which connections are established by operating vertical and horizontal bars. The contact metal used is gold. The multiswitch has a capacity of 100 outlets, which eliminates the necessity of working switches in pairs or links. The capacity of the switch is sufficiently large to permit single-stage selection whereby complicated circuit arrangements, switching schemes necessitating the establishment of one call at a time through several selecting stages, and common markers, are rendered unnecessary. The switch is of compact design and both multiples, inlets, and outlets are of the jack-in type. In a following section, a description is given of the multiswitch and of the manner in which the three basic problems of contact quality, multiple design, and space occupancy have been solved. As the switch is of the passive type, all hunting and selecting operations are performed by auxiliary circuits.

All functions of calling, hunting, selecting, testing, discriminating, and identifying are performed by electronic means, for which pulse techniques are used. One electronic pulse generator is required for each exchange. The functions mentioned are performed by explorers and comparators, operation of which is based on coincidence of pulses applied to gate circuits. These electronic methods produce extremely high speeds of selecting and hunting.

The combination of a large-capacity multiswitch and electronic control places the *ME* system among the most modern available.

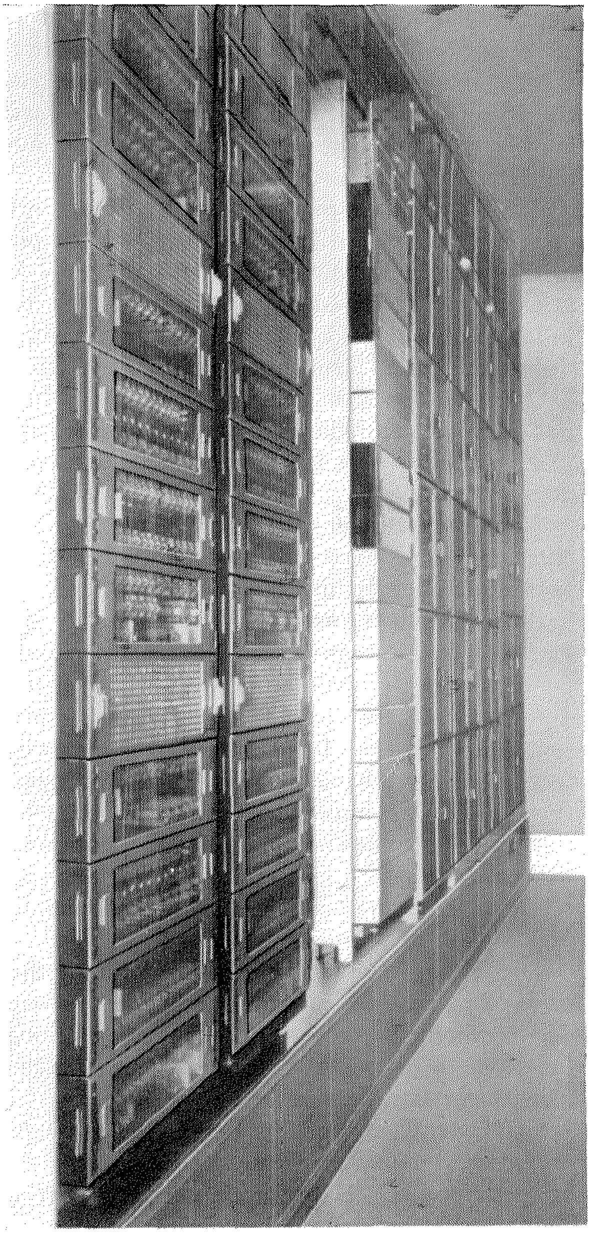
An order for a 2000-line trial exchange was received from the Norwegian telephone administration. This equipment was installed at Ski in the Oslo area and successfully cut over during the spring of 1954. This exchange permits both the administration and manufacturer to gain valuable experience on the behavior of electronic controls applied to switching systems by which further progress in the telephone switching art will undoubtedly be achieved.

1. *Fundamental Principles*

The *ME* system employs multiswitches of the crossed-contact type as the switching element. Depending on traffic and switching purposes, there is a choice among 3 capacities; 3, 12, and 18 panels on each of which are 2 subswitches. Switches with wiping contacts are not used.

The system is of the indirect type in that registers are utilized to receive the digits dialled by the subscribers and then assume complete directive control of selection.

Extensive use is made of electronic means for the establishment of connections. As the multiswitch incorporates pressure contacts instead of wiping contacts, as used in many existing



Ski exchange electronic control equipment.

www.americanradiohistory.com

machine switching systems, it cannot conveniently hunt or select. These functions are performed by auxiliary circuits called governors.

This auxiliary equipment need be connected to the equipment carrying the effective traffic only during the selection period. As a consequence, a minimum of equipment is engaged during the conversation period. To illustrate this, a local call in an exchange forming part of a multioffice area holds in use only 6 subswitches and 12 relays. These relays form the cord circuit; neither the line circuit nor the line-finder or selector circuits include any relay equipment.

The circuits have been designed to ensure continuity of operation. The mechanical apparatus is of sound construction, wear is negligible, and all parts are easily accessible.

Auxiliary apparatus of well-known design such as relays, capacitors, resistors, cold-cathode gas-filled tubes, and vacuum triodes are used. All apparatus is mounted on jack-in units, inserted in folded-sheet-steel bay frameworks of the type designed for the *7E* machine switching system.

Owing to the application of electronic switching principles and the negligible time a selector takes to perform its functions, the system operates at high speed.

Simultaneous operation of switches for different calls is a normal feature. Whether these switches belong to the same switching stage or to different stages, provided they are not located on the same multiswitches, they function independently. It is obvious, however, that of the different switches forming part of one multiswitch only one can be operated at a time owing to the basic mechanical principle of a crossbar-type switch. It is important, however, to mention that the electronic control equipment associated with a multiswitch can concurrently carry out selection, hunting, and testing operations for several calls at a time.

The *ME* system will interwork with any other type of automatic telephone switching system. The equipment performing the adaptational functions forms parts of the local and incoming register circuits exclusively.

For interoffice selection, voice-frequency binary-code sending equipment of the type developed for the *7E* system is used, permitting high-speed transmission of numerical information via any number or kind of tandem exchanges without impulse repetition, impulse correction or impulse regeneration. This ensures extremely reliable interoffice working. The same signalling system has also been adopted by the Comité Consultatif International Téléphonique for its European rapid-toll plan.

The latest type of circuit cross-connection or grading is incorporated. It is the so-called homogeneous grading developed on the basis of experimentally obtained traffic results. Two-stage selection can be provided permitting large junction groups to be operated on a full-availability basis, thus ensuring maximum junction efficiency and economy.

The needs and particular conditions applying to a number of operating telephone administrations throughout the world have been carefully studied so they could be provided for in a telephone system having universal application.

The present development has advanced only to the design of exchanges of 2000 to 10,000 lines for multioffice city areas.

However, it will be followed by the development of exchanges of smaller capacity. The multiselector will also be applied to the solution of many other switching problems.

2. *Operating Features*

A. Improved method of detecting and signalling false calls resulting from permanent loops grounded lines, and the like.

B. Testing by auxiliary switching equipment of the class and condition of a called line. A large number of conditions can be distinguished. The circuits permit various combinations of 32 different conditions and classes. The class of a line depends on cross-connections and may readily be changed.

C. On calls to busy lines, all selector and junction equipment is released and only finders and a cord circuit are held until the calling subscriber releases.

D. Lines may be placed in the absent-subscriber condition by remote control from an operator's position. Calls directed to such lines are automatically rerouted to an operator.

E. Identification of the calling number for automatic toll-call charging and calls to special services such as the telegraph office; for tracing false,

www.americanradiohistory.com

malicious, police, and fire calls; and for those to combined-line-and-recording positions. This feature has been designed as an integral part of the system.

Compared with previously known methods of identification, the novel methods employed offer several advantages.

F. Private-branch-exchange hunting facilities for lines with consecutive numbering, with nonconsecutive numbering, and for nonnumerical groups.

G. Absentee service with a record of calling numbers printed at the premises of the absent called subscriber.

H. Provision for repeated time-and-zone metering and for automatic call charging on rural and toll calls.

I. Possibility of holding the calling subscriber's line with switchhook supervision by a combined-line-and-recording operator with possibility for reringing.

J. For the detection of malicious callers, a line may be provided with a means by which the called subscriber can prevent the calling line from releasing; its number will be displayed at an operator's position.

K. Improved transmission. The supervisory and bridge relays used in the cord circuit and incoming selector circuits are not used for the transmission of dial impulses, permitting them to have high impedance and great sensitivity. This results in an extremely low speech attenuation (0.3 decibel compared with 0.7 decibel in other systems) and provides the possibility of operating with junctions having loop resistances of several thousands of ohms. Further, great care is taken to obtain a high degree of balance to ground of all supervisory bridges by selecting pairs of relays with equal characteristics. The balance obtained is of the order of 99.8 percent.

L. High-speed operation. The electronic equipment hunts at 5000 steps a second and selects a circuit within a wanted group at 455 steps a second. The operation of a multiswitch takes only a fraction of a second.

M. Direct-reading traffic-recording equipment as used for the rotary systems may be provided. Traffic-metering contacts are available in every circuit.

N. Pay stations of various types may be used. A special signal is given to the operators to whom a call may be routed for the purpose of coin control.

O. Party lines of various types may be introduced. The type described in this paper requires a party suffix to be added to the line number; it is based on a number per line. Arrangements may be made also for handling party lines on a number-per-station basis.

P. Delayed release. The cord circuits are arranged for immediate front release; the calling party's line is set free at once when he restores his handset. Should the called party not release, the cord circuit is forcibly released after some 20 seconds.

Should the called party release and the calling party fail to do so, the connection is forcibly released after some 20 seconds. This prevents a subscriber from blocking another line for an indefinite period of time. The line of the subscriber who failed to release creates a call and is subsequently routed to the false-call desk.

Q. Hold-over feature. The well-known hold-over feature of the rotary systems is maintained. In the event of a fault occurring, the train of selectors and certain of the auxiliary circuits are prevented from releasing, but an alarm is displayed. The calling line will be released. The hold-over feature may be disconnected by a key provided per register.

R. Nonexisting numbers dialled and calls to vacant directions are handled in the usual manner. Calls to dead lines are rerouted to an operator's position or a service tone is applied to the calling line. A line is also in the dead-line condition when its individual plug forming part of the line circuit has been removed for any reason.

3. *Multiswitch*

3.1 General

The multiswitch provides a capacity for mounting 3, 12, or 18 panels. Two subswitches, each of which can reach any one of a group of 100 outlets, are mounted on a panel. A multiswitch

www.americanradiohistory.com

equipped with 36 subswitches is equivalent to a bay of that number of 100-point rotary finders interconnected by ribbon cable. It is 76 centimeters wide, 55 centimeters high, and 29 centimeters deep (30 by 21.7 by 11.4 inches). Figures 1 and 2 show a front and rear view of a complete 12-panel multiswitch that contains 24 subswitches.

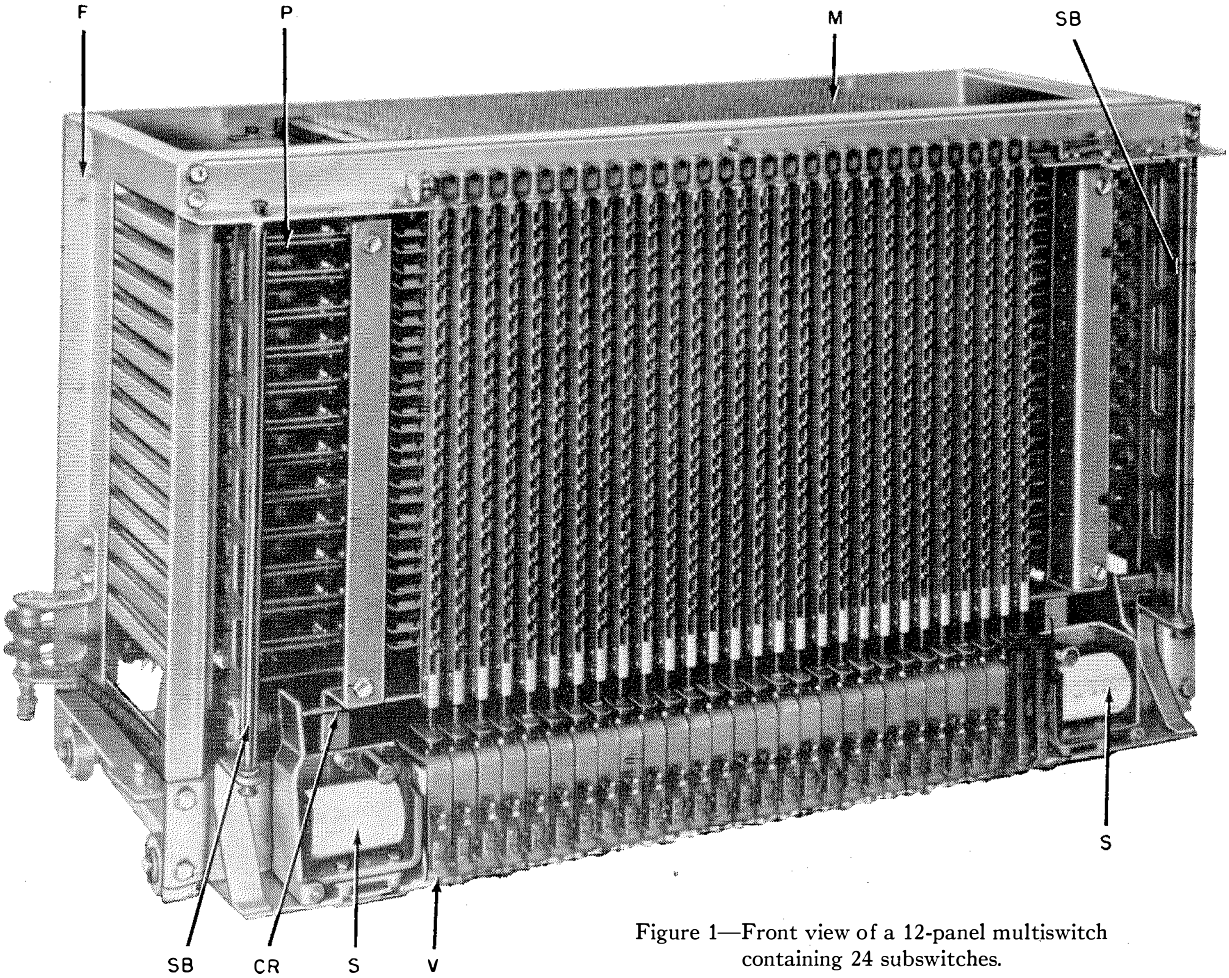


Figure 1—Front view of a 12-panel multiswitch containing 24 subswitches.

Through switching for 5 wires is provided, but with a minor change the switch can be arranged to provide 10-wire through switching. The number of outlets that can be reached then is reduced from 100 to 50.

To minimize microphonic-contact noise, the multiple contacts are of the precious-metal pressure type. Gold is used as the contact material; in the future it may be replaced by rhodium. These contacts do not close or open while the circuits are energized.

The multiple *M* is composed of bare wires running perpendicularly through the horizontally mounted subswitch panels *P*. Wire multipling ribbon cable and its soldering are thereby eliminated with their attendant possibilities of high-resistance noisy joints. High insulation resistance is guaranteed and is of special importance in tropical and subtropical countries.

For the operation of the subswitches, 26+2 vertical selection bars and associated electromagnets *V* are required. They are placed on the frame *F* into which the contact panels *P* slide. One panel mounts 2 subswitches. Two servomagnets *S* are located at the bottom corners of the frame to control the horizontal bars.

www.americanradiohistory.com

All wires leaving a multiswitch and the conductors that form the multiple are connected through jack-in contacts so that a complete switch can be removed from the bay on which it is mounted. Every detail or subassembly of the multiple switch has been designed so that all parts can easily be dismounted, inspected, and repaired, should the necessity arise.

The life of a multiswitch is very long as the amount of wear caused by the small mechanical movements is negligibly low. Its operation and release take no appreciable time.

Because of its compact and novel design, the space required for a multiswitch is reduced to a minimum. It is highly suitable for mass production as the variety of piece parts of which it is composed is restricted. It is also convenient to manufacture small quantities in factories of reduced capacity for the design permits wide manufacturing limits and operating margins. These features obviously reflect favorably on the maintenance of the exchanges.

The multiswitch can be used in unmodified form for many other switching purposes, such as private automatic branch exchanges, toll switching offices, telegraph exchanges, and signalling equipment.

The choice of the 100-line switching capacity has mainly been governed by principles of systems design. Too small a switching capacity (10 or 20 outlets) introduces the necessity of multistage or multilink selection, which in turn leads to complication of the circuits controlling the selection and to the introduction of so-called common marker circuits. Single-stage selection, on the other hand, permits the use of conventional switching methods and simplified systems design.

A multiswitch has the following:

A. Switch frame.

B. Contact panels.

C. Horizontal-bar servomechanism.

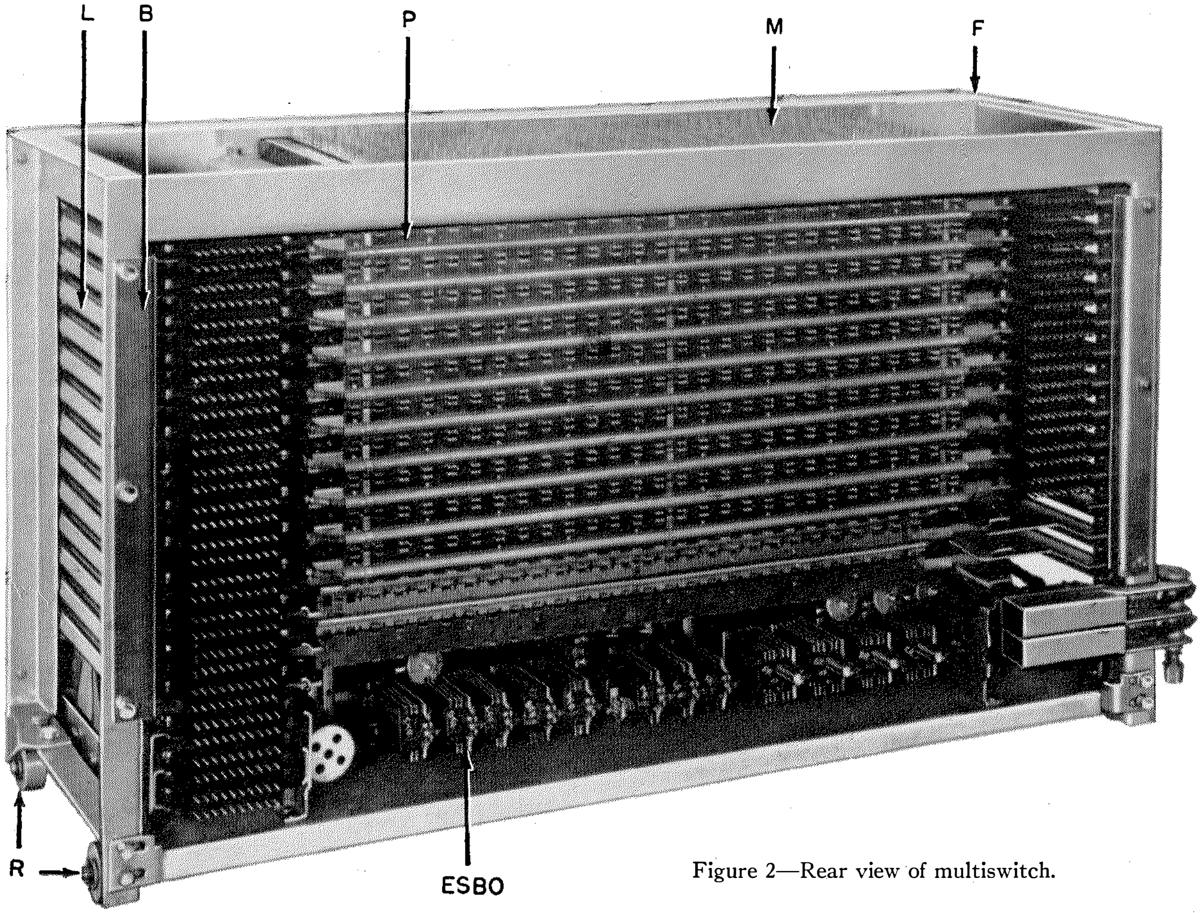


Figure 2—Rear view of multiswitch.

www.americanradiohistory.com

D. Selection mechanism.

E. Vertical multiple.

F. Esbo panel (electronic selection and bar-operation circuit).

3.2 Switch Frame

As may be seen in Figures 1 through 3, the frame *F* of the switch is composed of folded steel sheets, 3 millimeters (0.118 inch) thick, welded together to form a solid unit. It is designed for minimum weight and high structural strength. At the top and bottom of the front of the frame are two angle irons serving to support the vertical-bar assemblies and the servomechanism operating the horizontal bars.

Space is provided at the top of the frame for the jacks of the multiple wires.

On both side flanges of the frame, a lattice work *L* provides supports into which the contact panels can be slid, one above the other. After placement, they are locked in by two bars *B*.

At the bottom of the frame, there is some space at the height of the electromagnets of the vertical bars, which space is used for the location of a panel mounting the equipment for the electronic selection and bar-operation circuit.

The back of the frame is open. Rollers *R* mounted on the base of the frame permit easy removal of the complete unit.

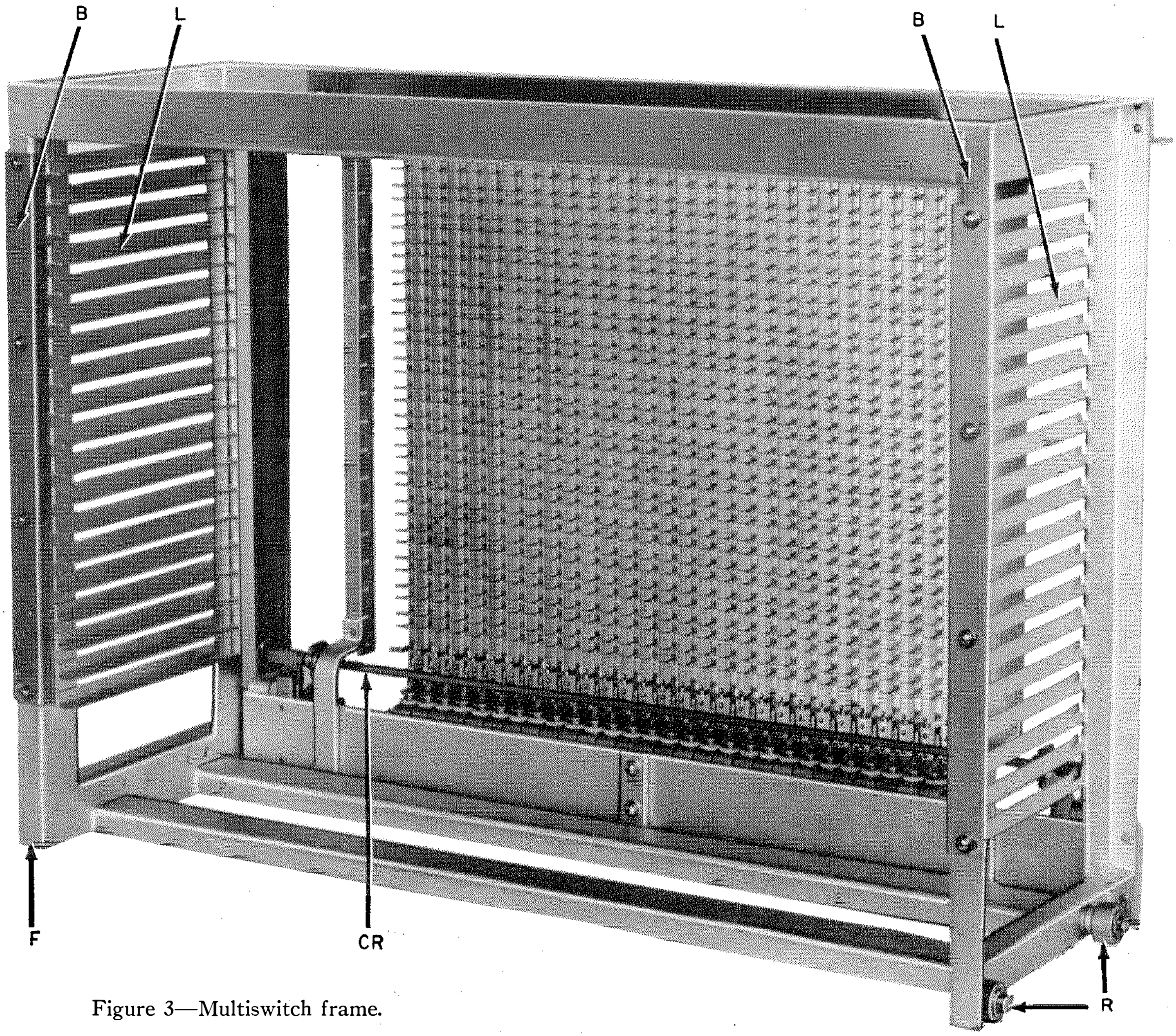


Figure 3—Multiswitch frame.

www.americanradiohistory.com

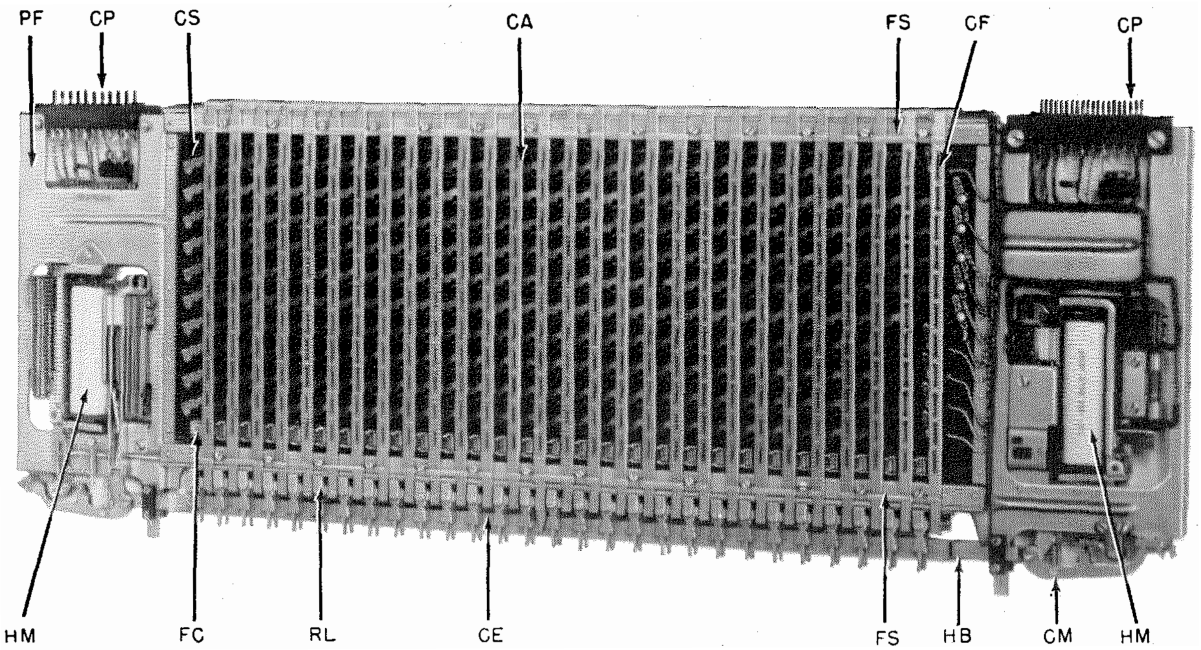


Figure 4—Top view of contact panel on which the subswitches are mounted.

3.3 Contact Panel

The subswitch panels P are double sided and accommodate 2 of these switches. A subswitch has access to 104 outlets, and each outlet comprises 5 conductors.

Figure 4 shows a top view of a complete contact panel. It consists of a flat frame PF with the contact-spring assembly CA located in the middle, 2 electromagnets HM on the outer side, and 2 horizontal bars HB at the front side.

Running along the top and bottom surfaces of the panel are 10 phosphor-bronze contact strips CS fixed to a common phenol-fiber sheet. Each strip carries 27 contact springs to form the movable contacting elements of a subswitch.

Holes in each phenol-fiber sheet allow the free passage of the vertical multiple wires. These wires are inserted after all the panels have been placed in the frame. The contact springs in their neutral positions do not touch the multiple wires. The contact springs are split and carry welded gold-plated double contacts on both sides. The contact springs are joined and operated as a group by a sliding contact finger CF; one contact finger operates one row of 10 contacts and a total of 28 fingers are mounted on each side of the contact panel.

A contact finger consists of a metallic part supported at both ends FS by the frame and of an insulating part provided with slots that grip the contact springs. Each finger can be moved longitudinally in two directions and is held in a normal position by a small centering device FC. In this manner, each contact spring is kept in a neutral position between 2 vertical multiple wires.

When one of the contact fingers, numbered 1 to 26, is moved in one direction, 10 contact springs are slightly displaced in the same direction and then make contact with the 10 vertical wires placed at that side of the springs. Ample "follow" is provided. When a contact finger is displaced in the opposite direction, the same 10 springs make contact with the 10 multiple wires placed at the other side of the springs.

Each of the 2 groups of 10 contacts operated by one finger belongs to 2 outlets having 5 conductors apiece, so that one contact finger serves for 4 outlets.

The 27th and 28th contact fingers act on only 5 springs as may be seen in Figure 5, and one of these 2 is always operated simultaneously with any of the other 26 contact fingers. They serve to connect the 5 inleads IL of a subswitch to one

www.americanradiohistory.com

or the other group of 5 strips of contact springs. Where the metallic part of a finger protrudes at the front of the panel frame, it is coupled to a rectangularly bent lever *RL* carrying a small coupling element *CE* that is normally pushed upwards by a small spring. Figure 6 shows an enlarged view.

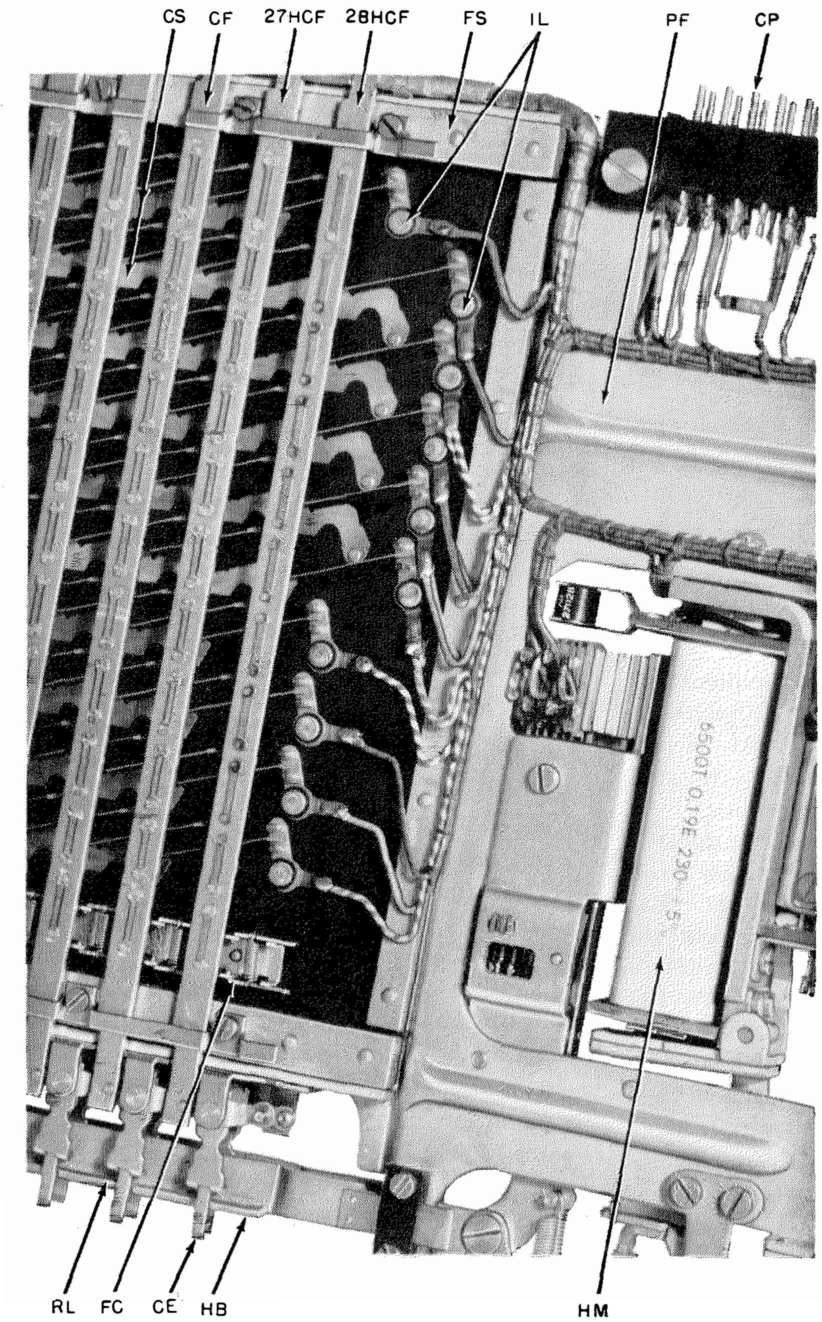


Figure 5—Close up of the 27th and 28th contact fingers.

At the front of each contact panel, 2 horizontal bars *HB* are located, one above the other. The upper bar serves for operating the contact fingers of the upper subswitch of the panel and the other for operating those of the bottom subswitch. Each bar is provided with 28 recesses *CR* into which the small coupling elements *CE* may drop. A horizontal bar moving to the left or to the right moves the finger to which it is coupled either forward or backward.

Electromagnets *HM*, one for each subswitch, are mounted at the outer ends of the panel. When the armature of *HM* is attracted, it moves 2 coupling members *CM* outward. These 2 levers are pivoted at the extremity of the horizontal bar. In this position, the coupling members engage with the front edge of a flat steel bar, *SB* in Figure 1, extending from the top to the bottom of the multiswitch frame and pivoted at its extremities.

The horizontal magnet *HM* is provided with a number of contact springs as is the horizontal bar.

At the back of the panel in Figure 6 may be seen a group of jack-in contact pins *CP* to which all the conductors leaving the panel are connected.

3.4 Servomechanism for Horizontal Bars

At the bottom of the frame as shown in Figures 1 and 2 are 2 servomagnets *S*, which actuate the 2 flat steel bars *SB* already mentioned. These bars are coupled together by means of a rod *CR* (see Figure 3) and are kept in a neutral position by a centering device. Both flat bars

www.americanradiohistory.com

move to the left when one magnet is energized and to the right when the other magnet is operated.

To operate the horizontal bar of a subswitch, first the horizontal magnet *HM* must be energized and move the coupling members *CM* outward so that they may be engaged by the vertically mounted flat steel bar *SB*. Then one of the servomagnets *S* is operated, depending on whether the horizontal bar is to be moved to the left or to the right and whether a contact finger has to establish contact with the multiple wires located in front or behind the contact springs.

It is, therefore, by a choice between the left or right servomagnets and by that between the 27th or the 28th contact fingers *HCF* (see Figure 5), that one of the 4 contact groups controlled by each of the 26 other fingers is selected.

The manner in which the coupling members *CM*, forming part of a horizontal-bar assembly operate, is shown in Figure 7.

At *A*, the mechanism is at rest. The armature *HA* of the horizontal magnet is not attracted and the two coupling members *CM* are held back by small springs.

B shows the situation after the armature has been attracted. A cam *HC* actuated by the armature has moved the two coupling members *CM* outward so that they may now be engaged by the flat steel bar *SB* actuated by the servomagnet *S*.

C and *D* show the conditions after one or the other servomagnet has been operated. In *C*, the horizontal bar has been pulled to the left and in *D* to the right. During this operation, pressure or pull is exercised on only one of the coupling members and the free one drops behind the cam *HC* placed on the armature.

When the servomagnet releases, it removes the pressure between the flat steel bar and the coupling member, which then also drops back. During conversation, the horizontal magnet remains energized with the horizontal bar hooked to the cam in one of the two operated positions, as is shown in *E* and *F*.

When the horizontal magnet releases, the horizontal bar, its coupling elements, and the contact fingers restore to normal.

3.5 Selecting Mechanism

The selecting mechanism is mounted at the front of the frame of a multiswitch and consists of 28 independent vertical-bar assemblies, each actuated by a plunger-type electromagnet.

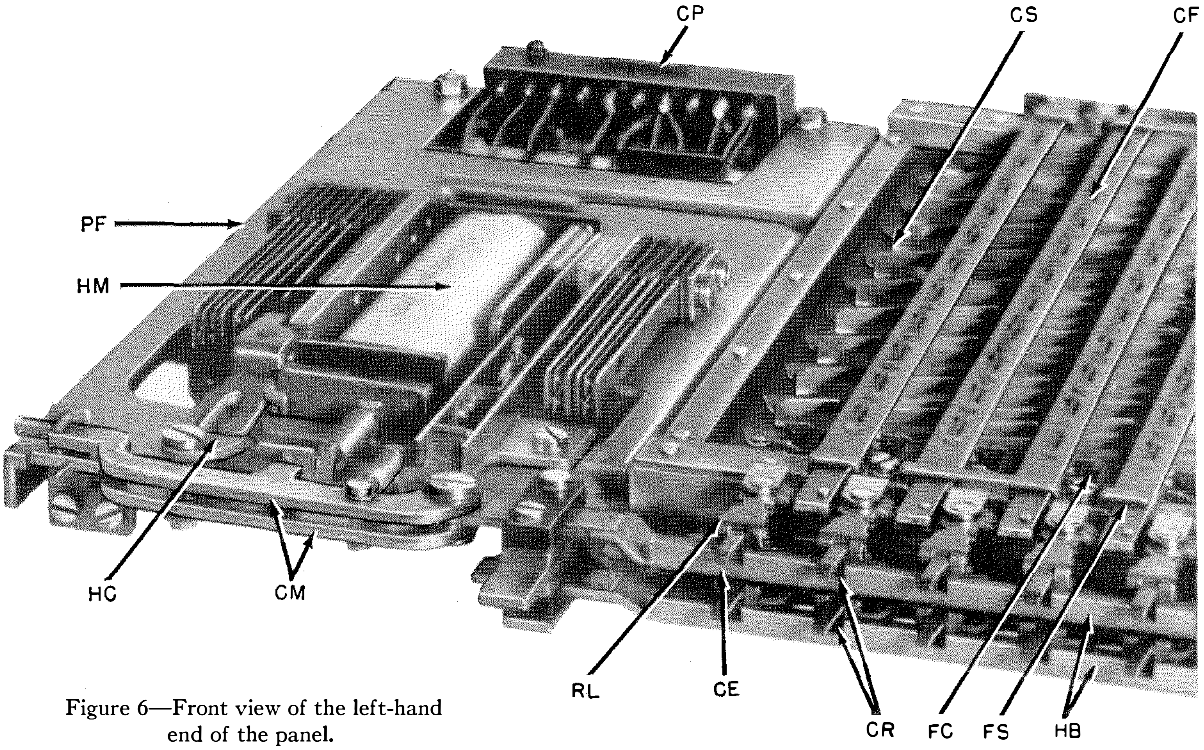


Figure 6—Front view of the left-hand end of the panel.

www.americanradiohistory.com

Each of 26 vertical bars serves for the selection of one of the 26 groups of 4 outlets, whereas the 27th and the 28th bars serve for selection of one of 2 groups of 5 strips of contact springs.

Each vertical bar carries a number of small clamped equally spaced phosphor springs *PS* and the assembly is so placed that these springs just rest on the small coupling elements *CE* (Figure 6) associated with the levers *RL* of the fingers.

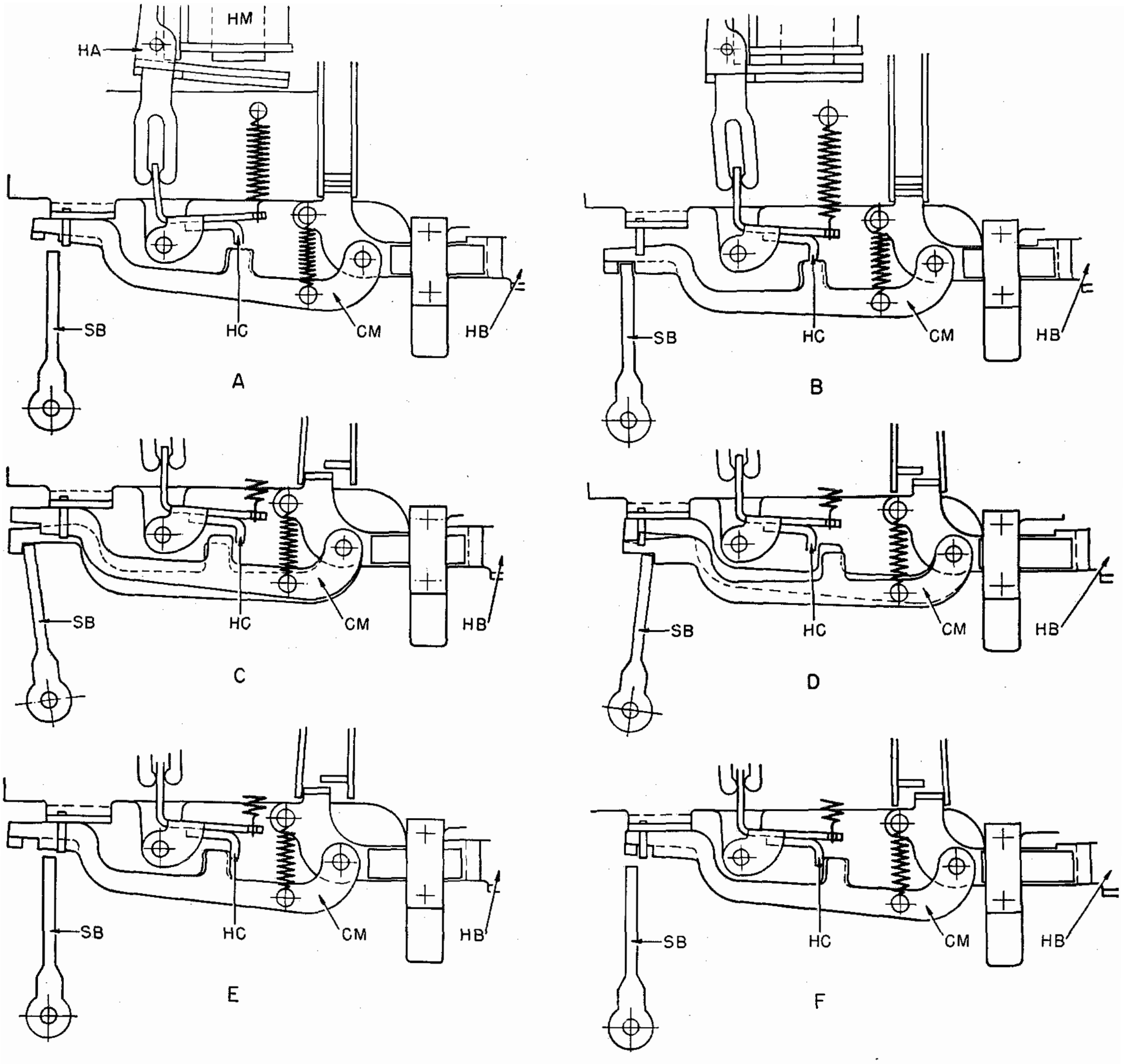


Figure 7—Horizontal-bar assembly.

Each vertical bar, *VB* of Figure 8, extends over the entire height of a multiswitch and is supported at the top by a small bearing. There is also mounted at this point, a spring that tends to move the bar upward. At the bottom, the bar is provided with a soft-steel plunger *VP* that operates into the inner shell of the electromagnet *VM* as a guide.

These elements, as already stated, are pushed upward by a small spring. When their tips are moved left or right, the levers and, consequently, the contact fingers must follow.

By operation of a vertical bar, all associated coupling elements of the contact fingers located on different contact panels but in one vertical row, one above the other, are lightly pushed into

www.americanradiohistory.com

the recesses *CR* provided on the horizontal bars.

When one of the horizontal bars is then moved to the left or to the right, it takes the small coupling element with it and, consequently,

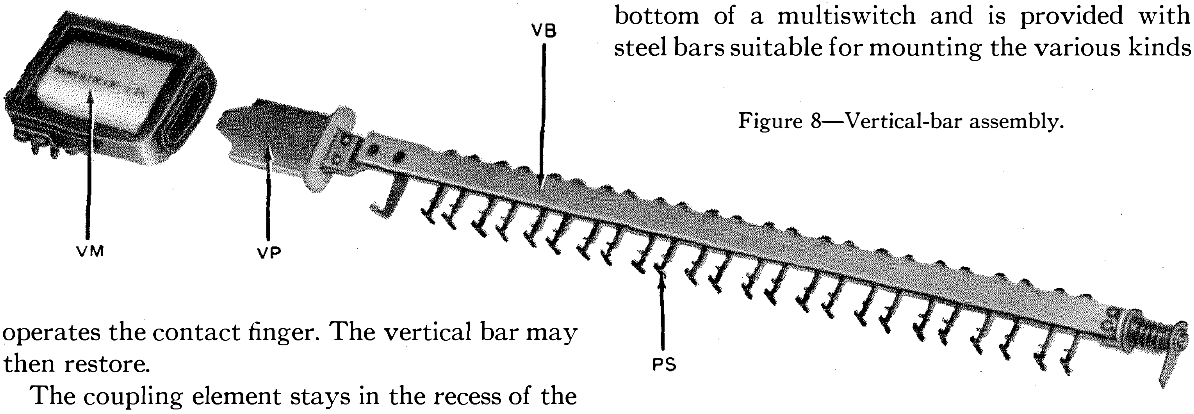


Figure 8—Vertical-bar assembly.

operates the contact finger. The vertical bar may then restore.

The coupling element stays in the recess of the horizontal bar owing to the friction between the side of the recess and the tip of the small coupling element.

3.6 Multiple

The multiple is composed of 26 identical assemblies. An assembly consists of 20 rods, each of 1.75-millimeter (0.069-inch) thickness and plated with a light coat of gold. The rods project slightly at the top and thus form jacks for the female parts of the jack-in assemblies.

The latter assemblies are mounted next to each other on a horizontal rod fixed to the multiswitch-bay framework in such a manner that they can be moved upward and away from the multiple assemblies, which are inserted through the holes of the contact panels.

3.7 Electronic Selection and Bar-Operation (Esbo[1]) Panel

The jack-in-type esbo panel is located at the bottom of a multiswitch and is provided with steel bars suitable for mounting the various kinds of apparatus required for the esbo circuit serving the multiswitch. A typical panel is illustrated in Figure 9.

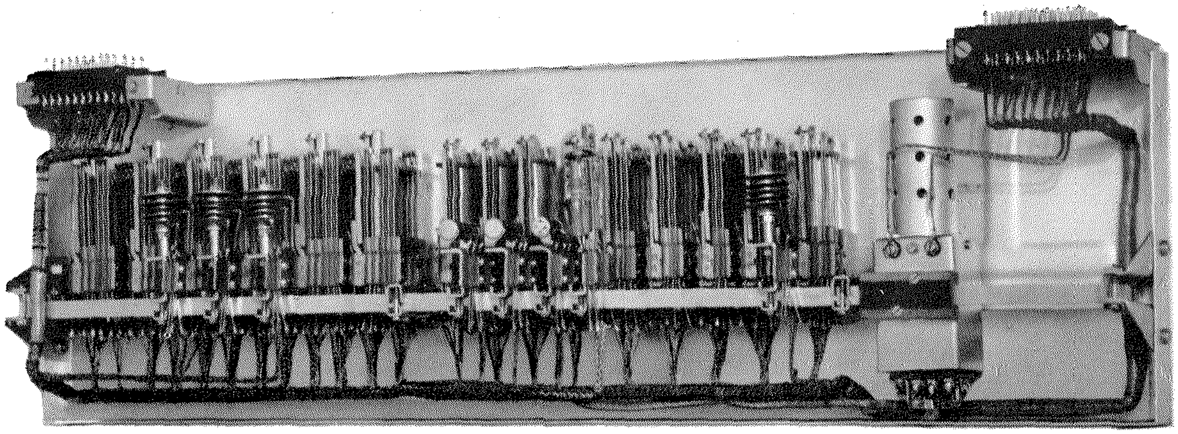
3.8 Operation

The sequence of operation necessary for the establishment of a connection on one of the subswitches is as follows.

The esbo circuit operates one of the 26 vertical bars plus the 27th or the 28th bar as the case may be. At the same time, the horizontal magnet of the subswitch on which the call is waiting for completion is operated.

[1] The electronic selection and bar-operation circuit is called an esbo and will be referred to as such in the balance of this paper.

Figure 9—Esbo panel.



www.americanradiohistory.com

By a second operation, the proper servomagnet is temporarily energized whereupon the call is switched through. The vertical bar is then restored. The horizontal-bar magnet remains energized.

3.9 Vertical-Bar Contact Panel

To facilitate proper circuit operation, each vertical bar is provided with 2 pairs of contacts that serve for subsequent signalling.

These contacts act on 4 of the 20 multiple wires and are mounted on a special contact panel, which is slid into the frame in the same manner as a normal contact panel. As may be seen in Figure 10, it carries no horizontal bars.

3.10 Absent-Subscriber-Service Panels

In the panels for absent-subscriber service shown in Figure 11, one contact finger is provided per line so that 2 panels are required for each 100-line subscribers' group. These fingers have only 2 positions, operated and non-operated, as compared with the 3 positions of the fingers of the contact panels. The fingers are temporarily coupled to the horizontal bar in the manner already described but whether the finger is moved from the nonoperated to the operated position or vice versa depends on whether the left- or the right-hand horizontal servomagnet is operated in combination with the proper horizontal magnet. A finger moved to the operated position may stay there for an indefinite time as it is locked by a small pawl even though the horizontal magnet is released.

For restoring the finger to normal, the proper *HM* magnet is operated again together with the proper *VB* bar while the other servomagnet is energized.

An operated finger of an absent-subscriber-service panel connects impulse source Nd_9 to the *d* wire of the line circuit as explained in the last paragraph of section 4.5.

4. *Principles of Electronic Control*

4.1 Impulse Sources

An electronically operated impulse generator is provided for each exchange. It supplies a variety of positive impulses recurring at regular intervals but differing in basic voltage level, amplitude, recurrence period, and impulse duration. The manner in which this generator functions, its fundamental concepts, characteristics, and facilities will be described in a later article.

The duration of the main impulses is either 0.2 or 1 millisecond. The impulse of 0.2 millisecond corresponds to 5000 impulse periods per second, which frequency has been chosen with regard to the firing time of the cold-cathode tubes widely used in the system.

The various impulse sources that are provided by the generator may be grouped according to their basic potential, amplitude, recurrence fre-

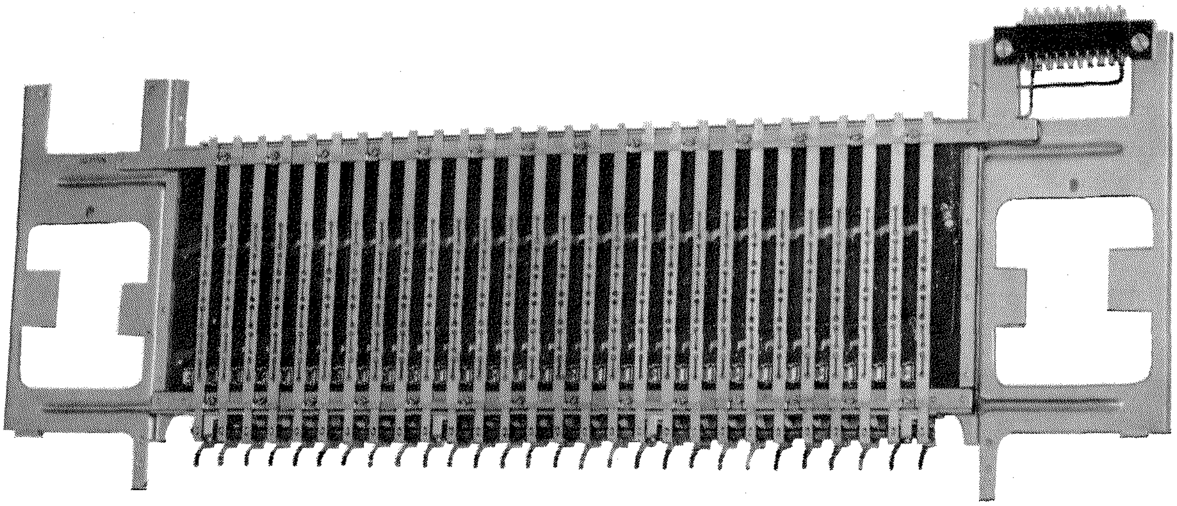


Figure 10—Vertical-bar contact panel.

www.americanradiohistory.com

quency, and time position; certain conventions have been adopted for identification of the various sources according to these characteristics.

A capital letter is used to distinguish the types of impulse sources according to their basic potential and amplitude, a small letter indicates their recurrence frequency, and a number marks the time position. In this manner, every impulse source receives a distinct code that serves as a reference and contains all data necessary for quick understanding. The various characteristics are defined in Table 1.

All sources are capable of absorbing current during the periods between impulses and of supplying a potential during the impulses. The sources for series *Nd* and *Pd* (marked by an asterisk) are designed to supply current during the impulses.

TABLE 1

CHARACTERISTICS OF PULSE SERIES

Type	Groups	Basic Voltage	Amplitude in Volts	Crest Voltage
N	*a,b,c,e*	−40	16	−24
N	*d*	−40	24	−16*
P	*a,b,c,e*	0	16	+16
P	*d*	0	24	+24*
R	*a,b,c,d,e*	−110	60	−50

reason the 3 potentials of the *N* sources are negative with respect to ground.

The *R* sources are used in the recorders, where they serve to fire cold-cathode tubes and thus require an amplitude of 60 volts.

As will be seen in Table 2, group *a* includes 5 impulse sources, which are distinguished by subscript suffixes 1 to 5, the impulses of which are shifted by 0.2 millisecond. Those of group *b* are shifted by 1 millisecond.

The reason why the *b*-group impulses are of 1 millisecond, compared with 0.2-millisecond impulses for all other main sources, lies in the fact that the same recurrence period is employed for both groups *a* and *b*. The reason for this follows.

The connecting of +24 volts to the input terminal of the so-called gate circuit shown in

TABLE 2

CHARACTERISTICS OF GROUPS

Group	Number of Sources and Recurrence Period (Expressed in Number of Impulses)	Impulse Duration in Milliseconds
a	5	0.2
b	5	1.0
c	4	0.2
d	11	0.2
e	3	0.2

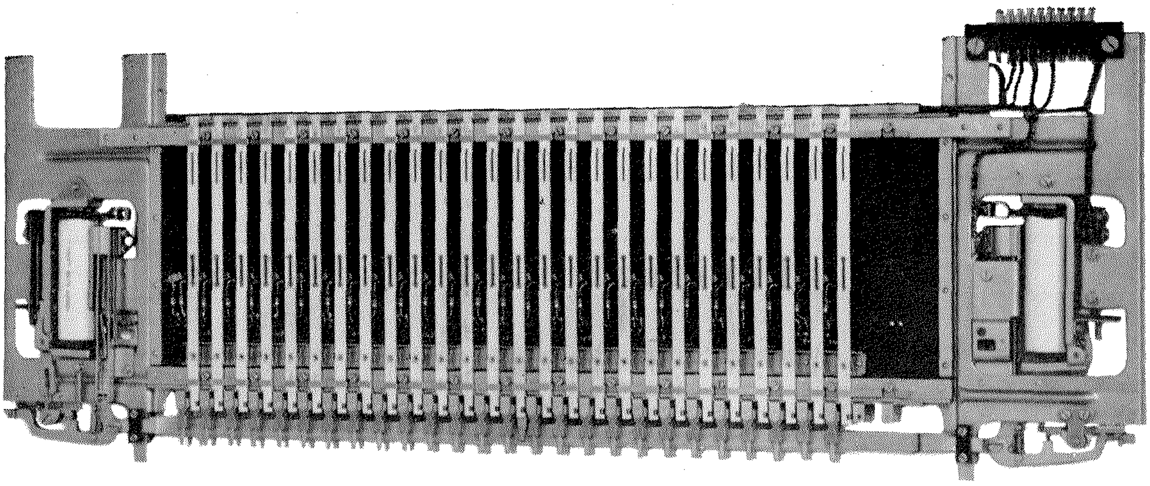


Figure 11—Absent-subscriber-service panel.

The various basic voltage levels have been chosen for circuit reasons. The *N* sources, for instance, which are used in the subscriber's line explorer exclusively, must operate in conjunction with the −48-volt supply of the line and for this

Figure 12A and of impulse source Pd_1 to the control terminal provides a +24-volt impulse at the output terminal once every 11 impulses. Connecting sources Pc_1 and Pd_1 to the two control terminals of the gate circuit shown in Figure

www.americanradiohistory.com

12B and +24 volts to its input terminal provides an impulse at the output terminal every 4 × 11 impulses. The two sources combined, therefore, supply an impulse to the output terminal of the gate circuit only at their moment of coincidence; that is, in time position *1* of a cycle of 44 impulses. Similarly, sources Pc_1 and Pd_2 combined provide an impulse in time position *13* of the 44-impulse cycle.

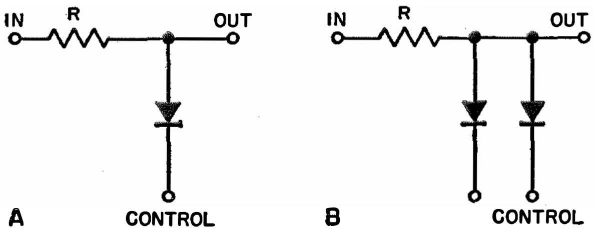


Figure 12—Typical gate circuits.

From the use of the coincidence principle, as explained here, it becomes self-evident that the recurrence periods of the sources may not have a common factor. As the recurrence periods of the *a* and *b* groups are the same, and as they are used in combination, impulses of different lengths have to be introduced.

A variety of gate circuits is used for the several purposes described in the following paragraphs.

Figure 13 shows the voltage waveforms of impulse sources Na_1 to Na_5, Nb_1 to Nb_5, and Nc_1 to Nc_4 in their respective time positions.

Besides these main impulse sources, the system utilizes 2 auxiliary series having impulses of a duration of 0.025 millisecond occurring 5000 times per second. They are used for timing purposes in impulse-regeneration circuits. The basic voltage of the one is +3 volts with an impulse potential of −21 volts (negative going) and of

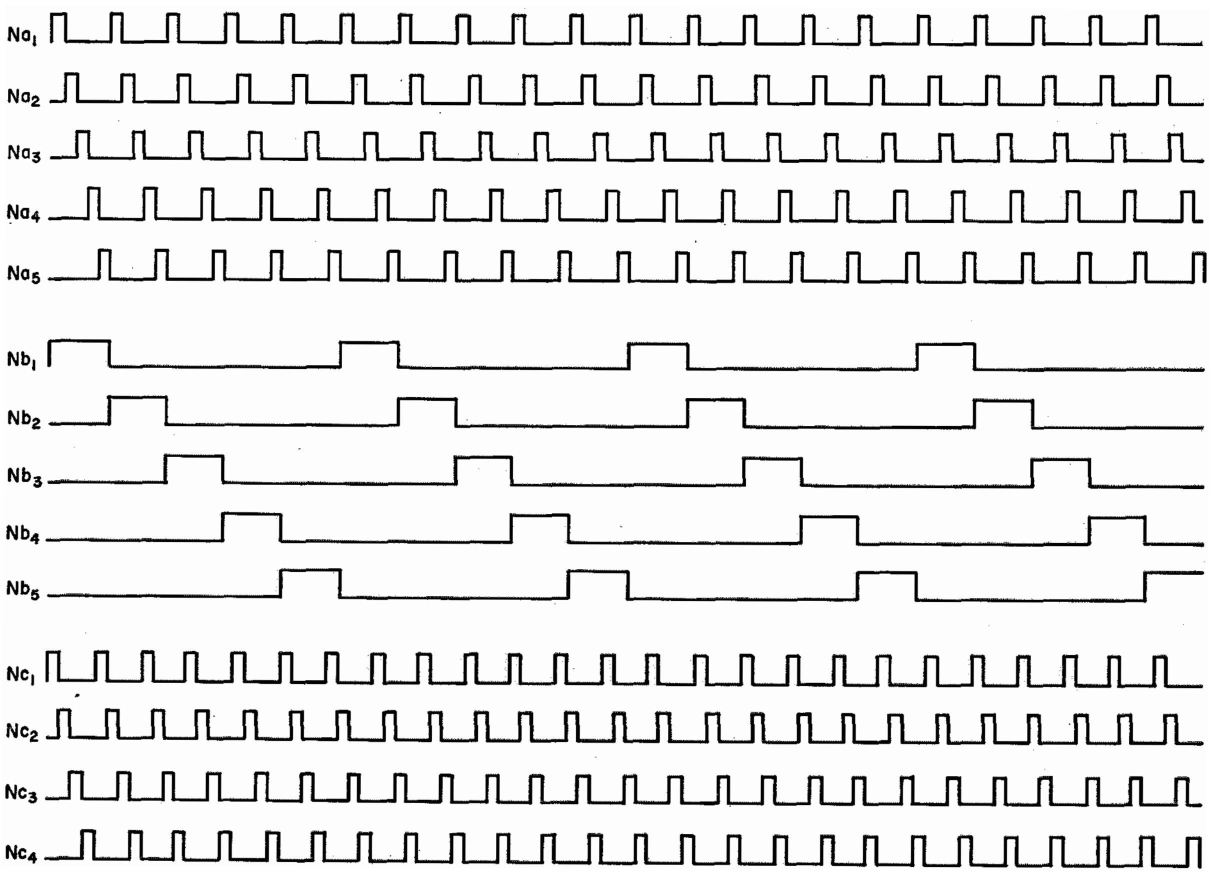


Figure 13—Voltage waveforms of the impulse sources used in the line explorer. *Na* and *Nc* pulses are 0.2 millisecond long and *Nb* pulses are 1 millisecond in duration. All pulses start from −40 volts and have crests of −24 volts, having positive-going 16-volt amplitudes.

www.americanradiohistory.com

the other −53 volts and −13 volts (positive going).

4.2 Call Detection

The subscriber's line circuit is of the fully electronic type and employs no mechanically operated apparatus such as relays.

It is shown in Figure 14 and consists of only 3 radio-type resistors and 2 small rectifiers. Each line further occupies one position in the 100-line multiple of a multiselector that accommodates both the line finders and the final selectors.

When the handset rests on the cradle, the *a* wire of the subscriber's line is connected to ground via a 15,000-ohm resistance and the *b* wire to −48 volts through a 30,000-ohm resistance.

When a call is originated, the potential of the *b* wire is changed to approximately −16 volts by the current flowing through the 15,000- and 30,000-ohm resistances, the subscriber's loop, and the station equipment.

This change in potential of the *b* wire is utilized to signal to a later circuit over a single wire per group of 100 lines the calling condition of the line and its identity within the group.

This objective is realized in an electronic manner by using a combination of gates called explorers and a number of impulse sources connected as shown.

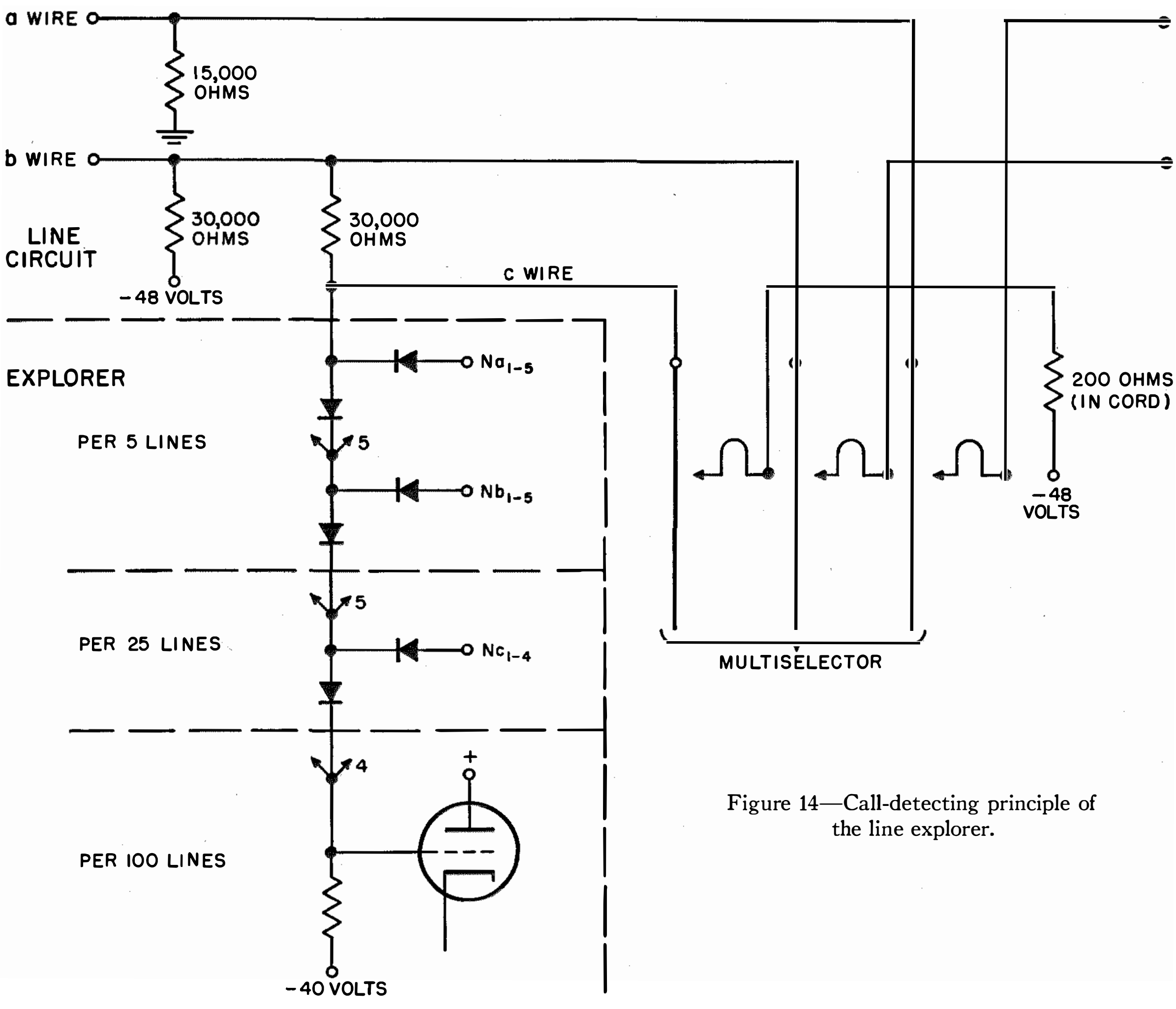


Figure 14—Call-detecting principle of the line explorer.

www.americanradiohistory.com

A high ohmic resistance shown at the bottom of the figure tends to keep the potential of the common wire at −40 volts. From this common wire 4 branches spread out, each of which is provided with a decoupling rectifier and a second rectifier to connect them to 4 different impulse sources Nc_1 to Nc_4. Each of these 4 branches divides into 5 branches, each of which is again provided with a decoupling rectifier and connected via a second rectifier to one of 5 different sources called Nb_1 to Nb_5. In a similar manner, each of these 4 × 5 branches again splits in 5 branches provided with the proper rectifiers and connected to 5 different sources Na_1 to Na_5.

The 100 final branches are connected to the *c* wires of the group of 100 line circuits. A *c* wire is connected to its *b* wire via a 30,000-ohm resistance.

Figure 13 shows the waveforms and potentials of the 14 impulse sources employed. The potentials vary between −24 and −40 volts. The impulses of sources Na_1 to Na_5 and Nc_1 to Nc_4 have the same length, 0.2 millisecond, but those of sources Nb_1 to Nb_5 are 5 times as long, 1 millisecond. One will readily recognise that coincidence between the impulses of an *Na*, an *Nb*, and an *Nc* source occurs once every 20 milliseconds, so that a line signals its calling condition 50 times per second.

When a subscriber's line is at rest, the *b* wire is at −48 volts and the common wire connected to the grid of the triode is at any moment at a more-positive potential, supplied either from one of the 3 impulse sources or from the −40-volt voltage divider. In this condition, therefore, no current passes from the *b* wire through the 3 series rectifiers to the common wire. Also the 3 branch rectifiers involved in the path running from each line to the common wire are permanently in the nonconductive condition because the potential applied to them from the impulse sources is either equal to or positive with respect to the −40 volts prevailing on the common wire. Consequently, when none of the lines of the group is in the calling condition, the potential of the common wire is maintained at −40 volts.

When a subscriber's line originates a call, the potential of the *b* wire is raised to approximately −16 volts and a current passes through the 3 rectifiers in series, which raises the voltage of the common point from −40 to −24 volts during the time the 3 impulse sources involved in the path running from the *c* wire to the common wire simultaneously provide a potential of −24 volts. The duration of this time corresponds with the length of an *Na* or *Nc* impulse and it happens only at the time position allotted to that particular line by the specific choice of a combination of the 3 sources mentioned.

During each interval between two successive impulses, current will flow from the *b* wire, which is at −16 volts, through the 30,000-ohm resistance connected between the *b* and *c* wires to the −40 volts provided by one or more of the 3 impulse sources. However, the difference in potential is absorbed by the 30,000-ohm resistance, so that the −40 volt potential of the common wire is virtually not affected.

The gate circuits of the line explorer, therefore, serve the purpose of time selection, i.e., a direct-current signal applied to one of the input terminals of a gate network is transmitted to the output terminal at a selected time, while a small number of sources is employed.

By applying −48 volts through a low ohmic resistance to the *c* wire, the calling condition is cancelled during conversation.

When two or more lines of a 100-line group call simultaneously, each of these lines will produce an impulse in its own time position.

Section 4.4 describes the manner in which the time position of these impulses are recorded. The reader will note that interference between successive impulses is excluded and no special measures need be taken to prevent other subscribers' calls from becoming effective while a first call in a 100-line group is being handled.

4.3 Group Selection and Hunting

For the purpose of selection and hunting, an explorer or tree of gates of the type shown in Figure 15 is provided per multiselector. In most respects, the arrangement is identical to that used for call detection. The gate wires of 100 outlets taper down via 20 and 4 branches to a common wire connected to a cathode-follower.

There are 14 different sources; Pa_1 to Pa_5, Pb_1 to Pb_5, and Pc_1 to Pc_4; that supply the same impulses as the *N* sources mentioned in the preceding paragraph with the exception that the

www.americanradiohistory.com

basic voltage lies at 0 volts and the impulse potential is +16 volts.

One combination of 3 sources identifies the position of an outlet in the multiple of the selector to which it is connected. In case an outlet also appears in the multiple of another multiselector, it is provided with another gate circuit associated with the explorer of that selector, the combination of impulses indicating its location in the other selector's multiple.

In addition to these 14 sources, a 4th group of 11 sources, designated Pd_1 to Pd_{11}, is provided for grouping the outlets into levels. They are cross-connected in any wanted manner to each outlet via a gate per outlet. The outlets of level *1* may be connected to source Pd_1; those of level *2* to Pd_2, etc. The recurrence period of a *Pd* source corresponds to 11 impulses and the length of the impulse is 0.2 millisecond.

The scanning period of a group of 100 outlets is equivalent to 11 × 100 impulses of 0.2-millisecond duration over which period the 100 impulses identifying the 100 outlets are scattered. This is equivalent to a selector running at a speed of 455 steps per second.

The governor connects the *Rd* impulse source that corresponds to the wanted level to the control terminal of the comparator so that all impulses except those of the wanted group of outlets are absorbed.

The impulse regenerator brings the impulses received to the proper basic and impulse voltages required for the correct operations of the recorder and reshapes the impulses. For the latter purpose, each impulse that arrives is delayed by one time unit.

Figure 15 also shows an impulse-blocking tube *BV*, the purpose of which is described later.

4.4 Recorder

A recording circuit, the principle of which is shown in Figure 16, is used for the determination and registration of the time position of an impulse arriving on a signalling wire, such as the common wire mentioned in the preceding section.

The circuit is mainly composed of cold-cathode trigger tubes, each of which is associated with a relay and a gate. The cathodes are connected to −150 volts via a 30,000-ohm resistance. The gates are connected between the trigger cathodes

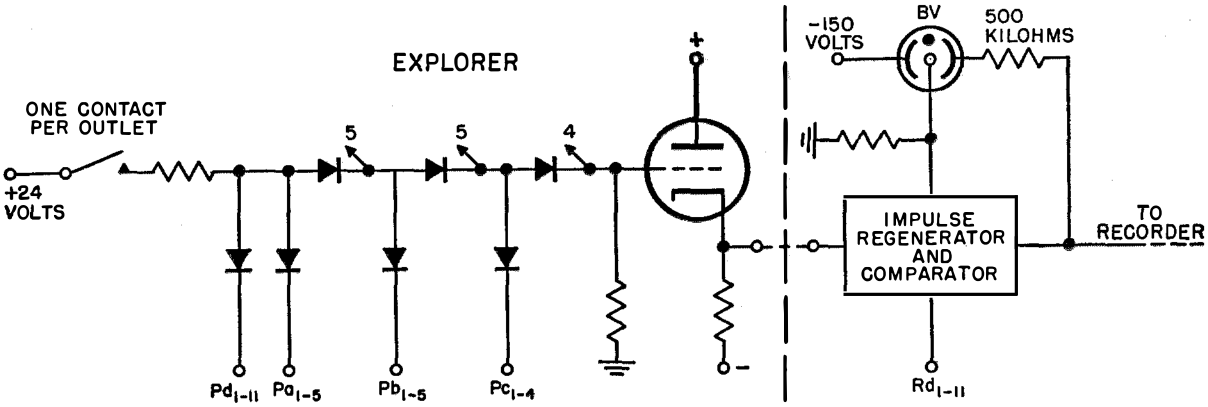


Figure 15—Group-selection principle.

An outlet provides an impulse only when it is free, that is, when +24 volts is connected to its gate wire.

At the governor circuit, which controls the selection and hunting, the signalling wire that conveys the impulses is connected to a comparator and impulse-regenerator circuit and from there to a recorder, which is described in the following section.

and the signalling wire. When idle, this wire is at −110 volts. The relays are connected to the anodes and via some auxiliary relay contact to ground. Impulse sources Ra_1 to Ra_5, Rb_1 to Rb_5, and Rc_1 to Rc_4, which are in synchronism with and similar to those used in the call-detector circuit, are connected to the control terminals of the gates. Their voltage basis, however, is −110 volts and that of the impulses −50 volts.

www.americanradiohistory.com

When the circuit is in the nonoperated condition, the voltage across the anode-cathode space (main gap) is therefore 150 volts, which is insufficient to provoke breakdown. To fire the tube, the potential of the trigger cathode must be changed from −110 volts to approximately −70 volts. The −50-volt impulses supplied at the control terminals of the gates are unable to trigger the tube as the rectifier forming part of the gate is connected so that no current can pass from the impulse source to the trigger anode.

An impulse from a free outlet characterized by sources Pa_1, Pb_1, Pc_1, and Pd_1 will arrive in time position *1* on the inlet wire of the impulse comparator and regenerator shown in Figure 15. If source Rd_1 is connected by the governor to the comparator, the impulse regenerator will create an impulse in time position *2*. This impulse ar-

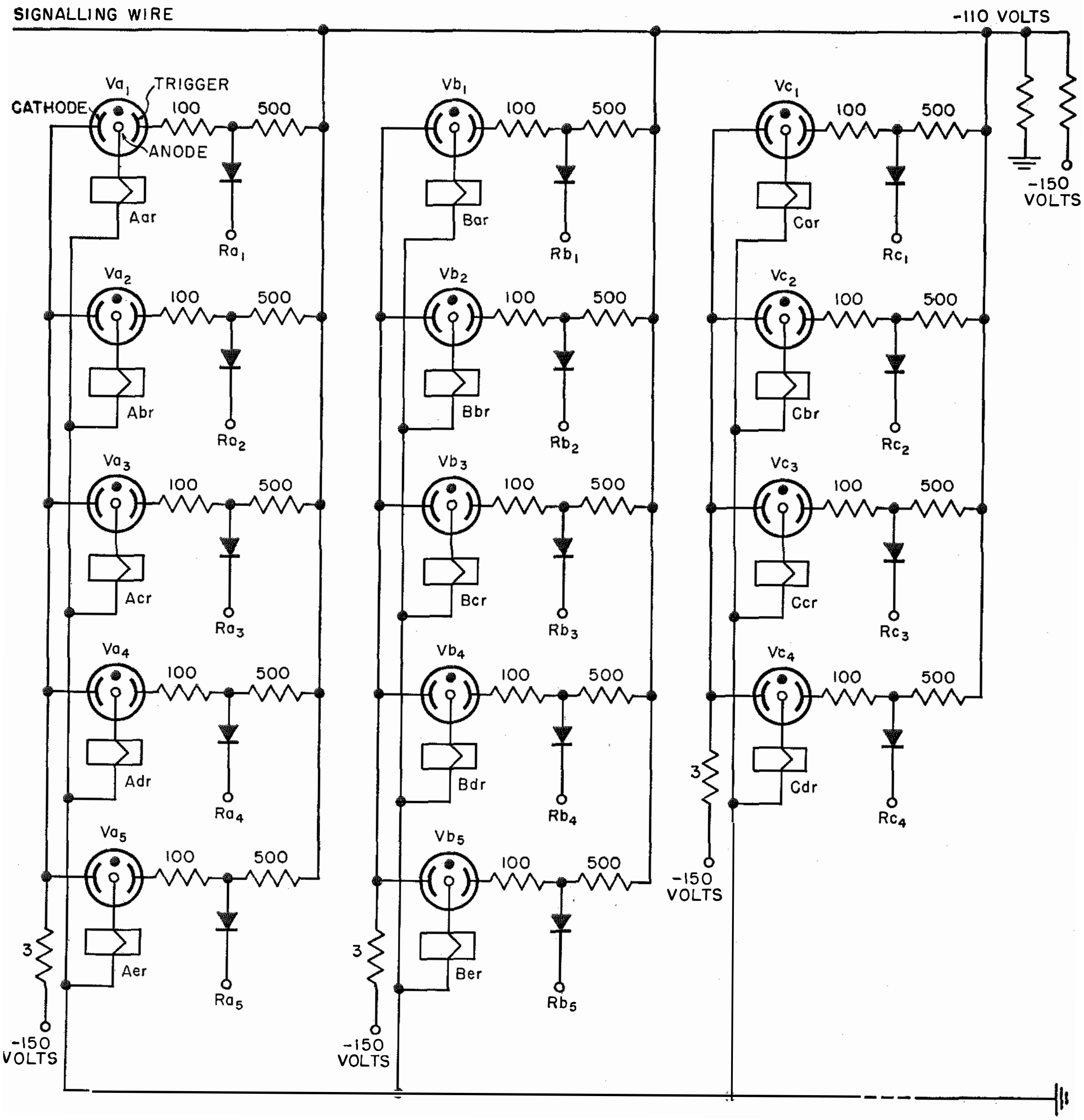


Figure 16—Recording principle. Resistance values are in kilohms. Relay windings *Aar*, *Bar*, *Car*, etc., are 1650 ohms each.

www.americanradiohistory.com

rives on the signalling wire of Figure 16, where it will find -50 volts on the control terminals of the gates associated with the tubes Va_2, Vb_1, and Vc_2, and -110 volts on all other tubes V, as sources Ra_2, Rb_1, and Rc_2 at that particular moment must be the only 3 sources providing an impulse (see Figure 13). As a result, the tubes Va_2, Vb_1, and Vc_2 will fire and relays *Abr*, *Bar*, and *Cbr* will operate.

The currents flowing through the 500-kilohm gate resistance of all other tubes are absorbed by the various impulse sources.

It should be observed that the impulse passed by the comparator (see Figure 15) and regenerated with a delay of one time unit by the regenerator fires the blocking tube *BV*, which acts on the comparator–regenerator circuit in such a manner that it immediately prevents any following impulses from passing through. This forestalls the breakdown of any other *V* tubes of Figure 16 by an impulse that may possibly arrive in the next time position.

By the operation of a combination of 3 relays, one in each group, the time position of the arriving impulse and thus the identity of the group selector outlet is determined. It remains registered until the common ground is removed.

The recorder circuit described in connection with group selection is used for many other purposes, they form part of the *A* governors to record the identity of a call detector, subscriber's line, et cetera.

4.5 Final Selection and Class–of–Line Indication

In the esbo circuit associated with a 100-line group, no explorer is needed for selection purposes as the register on receipt of the last two digits of an ordinary subscriber's number is sufficiently informed to determine which vertical bars of the multiselector have to be operated to carry out the selection of the line concerned.

However, whether the wanted line is free or busy has to be investigated, and hunting for a free line in a group has to take place in case the number dialled indicates a private-branch-exchange group, the first line of which is engaged. This requires the provision of an explorer for every 100-line group and advantage has been taken of this necessity to incorporate in the system a number of interesting features.

The explorer used is of the type already described and consists of the gate circuits and *Na*, *Nb*, and *Nc* sources shown in Figure 17. The individual wires of the 100 lines, however, are not connected to or disconnected from a direct-current potential to indicate the free or the busy condition as in the case of the group-selector explorer; but they are connected to a variety of combinations of impulse sources *Nd*.

All sources used for the explorers described in the preceding paragraphs are capable of absorbing current during the periods between the impulses and of supplying a potential only during the impulses. The *Nd* sources, however, are capable of absorbing current during the periods between the impulses and of supplying current for the impulses. For this reason, the *Nd* sources supply -16 volts instead of -24 volts to cater for the loss caused by the gate network.

The combination of 25 sources mentioned establishes a scanning period of $4 \times 5 \times 5 \times 11$ or 1100 time positions.

In case of an ordinary line, source Nd_7 is permanently connected to the control terminal *A* and Nd_{11} to terminal *B*. The impulse sources *Na*, *Nb*, and *Nc* in combination determine the number of the line within the 100-line group and its position in the multiple of the multiswitch.

As a result of this arrangement, a free ordinary line will provide 2 impulses on the common signalling wire within one complete cycle.

At the other end of this wire, the governor circuit selects the line by the connection of the proper 3 sources to 3 gate-controlled terminals in a manner similar to that already described for group selection.

The recorder comprises 11 tubes and gates controlled by *Rd* sources, and if the line is free the 7th and 11th tubes will fire. Thereupon the call is completed.

When the line is engaged, the final selector connects the Nd_6 source in parallel to the Nd_{11} source on the *B* terminal via a resistance shunted by a rectifier. The effect is that the Nd_{11} impulse is absorbed via the rectifier by the Nd_6 source and an Nd_6 impulse is supplied instead.

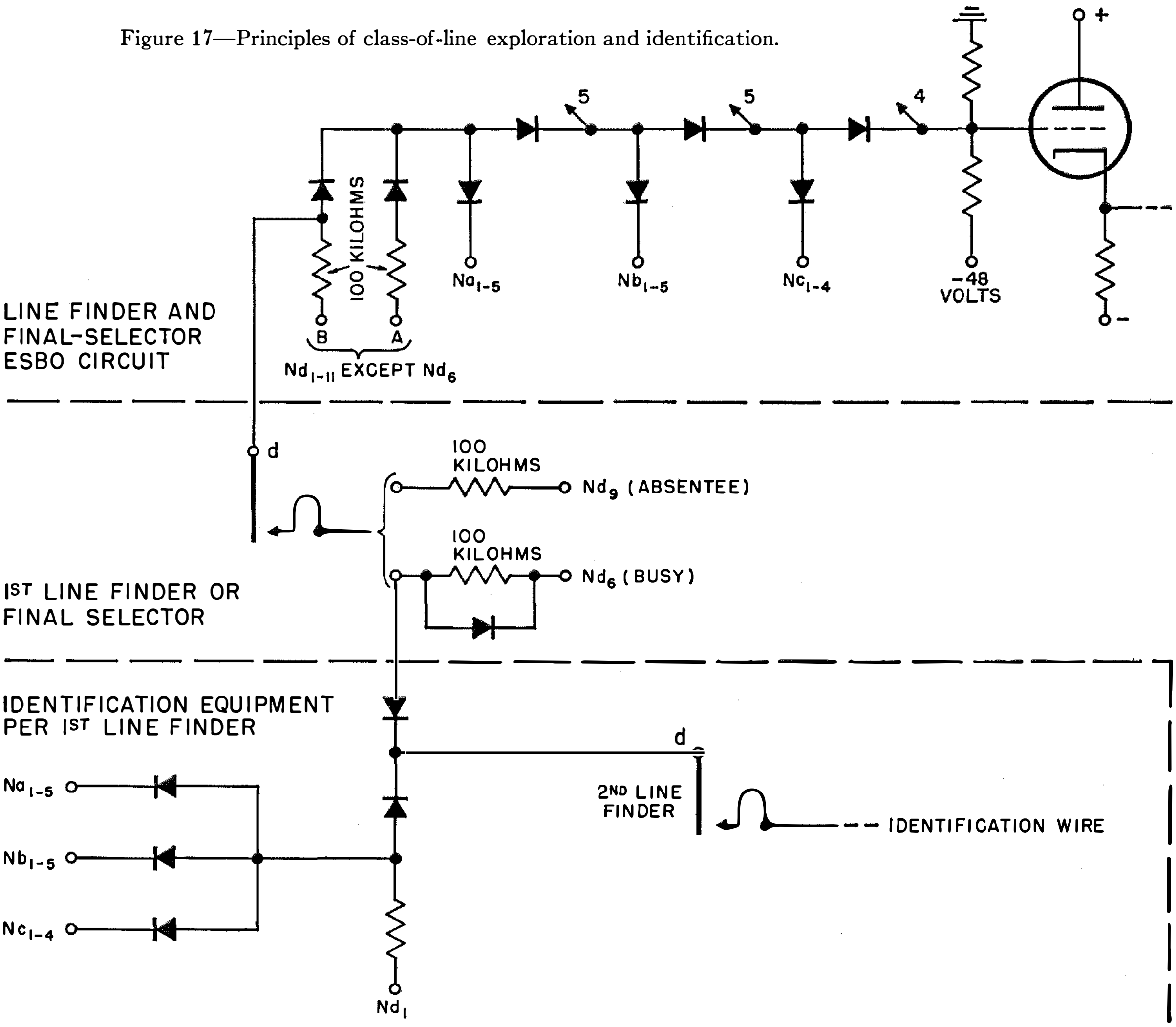
Subsequently, any governor selecting the same line will find impulses in time positions that will fire the 7th and 6th tubes and will then recognize that the line is busy.

www.americanradiohistory.com

Table 3 explains in detail the manner in which the various combinations of impulse sources are used to distinguish a variety of classes of lines.

In case the first line of a nonconsecutively numbered private-branch-exchange group is called, described, will respond to the first impulse received and thereby register the location of a free line of the wanted group in the multiple of the final selector. The call is then completed in the normal manner.

Figure 17—Principles of class-of-line exploration and identification.



the first of the 5 groups in the table, the governor will select this line and receive either sources *1* and *7* or *1* and *6*. In the first case, the call will simply be completed to the line corresponding to the private-branch-exchange number. In the latter case, hunting has to take place in the first-hundreds' impulse cycle. The governor removes the 3 numerical sources previously connected to the gate-controlled terminals mentioned and connects Pd_1. A 3-digit recorder, as already

From this it is apparent that the number of any of the associated private-branch-exchange lines can be used as a first number and further that their numbering need not be consecutive. This has the advantage that any available line in a 100-line group may serve for extending any of these 5 private-branch-exchange groups.

It will be noted from the table that the line that is used for the directory number has the characterizing Nd source connected to the gate-

www.americanradiohistory.com

TABLE 3

Impulses That Distinguish Classes of Lines

Class of Line	Description of Line Class	*Nd* Impulse Sources Connected to		Impulses Supplied in 100-Second Cycles When Line is		
		A Terminal	*B* Terminal	Free	Busy	Absentee (If Free)
1	1st Line of 1st Nonconsecutive Private-Branch-Exchange Group (Unrestricted)	*1*	*7*	*1+7*	*1+6*	*1+7+9*
2	1st Line of 2nd Nonconsecutive Private-Branch-Exchange Group (Unrestricted)	*2*	*7*	*2+7*	*2+6*	*2+7+9*
3	1st Line of 3rd Nonconsecutive Private-Branch-Exchange Group (Unrestricted)	*3*	*7*	*3+7*	*3+6*	*3+7+9*
4	1st Line of 4th Nonconsecutive Private-Branch-Exchange Group (Unrestricted)	*4*	*7*	*4+7*	*4+6*	*4+7+9*
5	1st Line of 5th Nonconsecutive Private-Branch-Exchange Group (Unrestricted)	*5*	*7*	*5+7*	*5+6*	*5+7+9*
6	1st Line of 1st Nonconsecutive Private-Branch-Exchange Group (Restricted)	*1*	*8*	*1+8*	*1+6*	*1+8+9*
7	1st Line of 2nd Nonconsecutive Private-Branch-Exchange Group (Restricted)	*2*	*8*	*2+8*	*2+6*	*2+8+9*
8	1st Line of 3rd Nonconsecutive Private-Branch-Exchange Group (Restricted)	*3*	*8*	*3+8*	*3+6*	*3+8+9*
9	1st Line of 4th Nonconsecutive Private-Branch-Exchange Group (Restricted)	*4*	*8*	*4+8*	*4+6*	*4+8+9*
10	1st Line of 5th Nonconsecutive Private-Branch-Exchange Group (Restricted)	*5*	*8*	*5+8*	*5+6*	*5+8+9*
11	Other Lines of 1st Nonconsecutive Private-Branch-Exchange Group (Unrestricted)	*7*	*1*	*7+1*	*7+6*	*7+1+9*
12	Other Lines of 2nd Nonconsecutive Private-Branch-Exchange Group (Unrestricted)	*7*	*2*	*7+2*	*7+6*	*7+2+9*
13	Other Lines of 3rd Nonconsecutive Private-Branch-Exchange Group (Unrestricted)	*7*	*3*	*7+3*	*7+6*	*7+3+9*
14	Other Lines of 4th Nonconsecutive Private-Branch-Exchange Group (Unrestricted)	*7*	*4*	*7+4*	*7+6*	*7+4+9*
15	Other Lines of 5th Nonconsecutive Private-Branch-Exchange Group (Unrestricted)	*7*	*5*	*7+5*	*7+6*	*7+5+9*
16	Other Lines of 1st Nonconsecutive Private-Branch-Exchange Group (Restricted)	*8*	*1*	*8+1*	*8+6*	*8+1+9*
17	Other Lines of 2nd Nonconsecutive Private-Branch-Exchange Group (Restricted)	*8*	*2*	*8+2*	*8+6*	*8+2+9*
18	Other Lines of 3rd Nonconsecutive Private-Branch-Exchange Group (Restricted)	*8*	*3*	*8+3*	*8+6*	*8+3+9*
19	Other Lines of 4th Nonconsecutive Private-Branch-Exchange Group (Restricted)	*8*	*4*	*8+4*	*8+6*	*8+4+9*
20	Other Lines of 5th Nonconsecutive Private-Branch-Exchange Group (Restricted)	*8*	*5*	*8+5*	*8+6*	*8+5+9*
21	Single Line (Unrestricted)	*7*	*11*	*7+11*	*7+6*	*7+11+9*
22	Single Line (Restricted)	*8*	*11*	*8+11*	*8+6*	*8+11+9*
23	Directory Number of Nonnumerical Private-Branch-Exchange Group	*9*	*10*	*9+10*	—	—
24	All Lines but Last of Unrestricted Private-Branch-Exchange Group with Consecutive Numbering	*11*	*7*	*11+7*	*11+6*	*11+7+9*
25	All Lines but Last of Restricted Private-Branch-Exchange Group with Consecutive Numbering	*11*	*8*	*11+8*	*11+6*	*11+8+9*
26	Last Line of Unrestricted Private-Branch-Exchange Group with Consecutive Numbering	*7*	*11*	*7+11*	*7+6*	*7+11+9*
27	Last Line of Restricted Private-Branch-Exchange Group with Consecutive Numbering	*8*	*11*	*8+11*	*8+6*	*8+11+9*
28	2- or 4-Party Line (Number Per Line with Suffix)	*7*	*8*	*7+8*	*7+6*	—
29	Multislot Coin Box	*7*	*10*	*7+10*	*7+6*	—
30	Single-Slot Coin Box	*8*	*10*	*8+10*	*8+6*	—
31	Changed Number	*10*	*11*	*10+11*	—	—
32	Dead Line	*10*	*6*	*10+6*	—	—

www.americanradiohistory.com

control terminal A whereas for all associated private-branch-exchange lines, this source is connected to the B terminal. As on busy lines, the sources on the B terminal are replaced by Nd_8, their impulses do not appear in the hundreds cycle allotted to this group. Consequently, busy lines of a private-branch-exchange group do not react on an explorer searching for a free line in that group with the exception of the line characterizing the group whose impulse remains while the line is busy. If all lines of a private-branch-exchange group are busy, the explorer will complete its search through the whole hundreds cycle of the group without meeting any impulse characterized by that particular Nd source. Finally, it will again test the first line on which the Nd source remains present. This fact provides a signal to the governor that all lines of the private-branch-exchange group have been tested and found busy.

Any private-branch-exchange line may be called by its individual number during nighttime, when the city lines may have been connected through to only certain stations of the private branch exchange. Calling such a line when busy by dialling its number does not cause private-branch-exchange hunting.

The same esbo and the associated class-of-line explorer is also utilized for originating calls as explained in section 7.1, and it will be noted from Table 3 that source Nd_7 serves, in general, to indicate "no restriction" and source Nd_8 designates "restriction." The system, therefore, provides the possibility of excluding restricted lines from calling certain facilities. How far this restriction may be imposed depends on the requirements of a specific customer. Certain lines may thus be barred from toll service.

Should the first private-branch-exchange line group mentioned above be permitted to establish calls on a restricted basis only, source Nd_8 is substituted for sources Nd_7 on control terminal B of the first line of the group and on control terminal A of all other lines. (See line classes *1* and *6*, also *11* and *16*, of Table 3.)

If the lines of a private-branch-exchange group can be consecutively numbered, their lines are marked by sources Nd_{11} (terminal A) and Nd_7 or Nd_8 depending on whether they are permitted unrestricted or restricted service, with the exception of the last line for which the order of connection to terminals A and B is reversed. (See line classes *24* and *25*, also *26* and *27*, of Table 3.) When such a group is called and the first line is found busy, the governor will try to select the next line and will continue to do so until a free line is found or until the code 7+6 or 8+6 (last line busy) is returned by the scanner, whereupon a busy tone is applied to the caller's line.

The system further provides for a third type of private-branch-exchange grouping for which the gates associated with the calling number of the group (directory number) are connected to sources Nd_9 and Nd_{10}. (Class *23* in Table 3.) On receipt of these 2 types of impulses, the governor operates the vertical bar of the multiswitch via the esbo. A contact is thereby closed and by means of a multiple gate circuit an impulse in a characteristic time position is returned whereby the private-branch-exchange group is identified and recorded at the register circuit. The connection already established is then released and the information received is used for the establishment of a new connection, possibly via a completely different train of switches. A free line is then selected in the manner already described for group selection and via a special group of selectors giving access to these large private-branch-exchange groups. This arrangement provides for a number of large private-branch-exchange groups to which any exchange line may be assigned and which has only one calling number. The traffic originated by the lines of such a group pass via the first line finders, to which the lines remain connected. This feature, therefore, permits the distributing of incoming traffic from large private-branch-exchange groups over a number of first-line-finder groups.

In case the called line appears to be a 2- or 4-party line, the governor is informed by the receipt of codes *7* and *8*. The register is ordered to wait for a further figure (suffix) to be dialled by the subscriber, on receipt of which the proper type of ringing is initiated.

The codes *7–10* and *8–10* are used for coin boxes and the indication thereof is used to effect in certain cases a special routing of the call to conform to the prescribed method of handling coin-box calls.

Changed numbers and dead lines are marked by codes *10–11* and *10–6*, which permit

www.americanradiohistory.com

the application of special tones to the calling lines.

Source Nd_9 is exclusively used for so-called absentee service. If required, the system may provide this service in which case 4 special switches (one per 25 lines) are supplied per 100-line group. In this manner, one special finger is provided per line as described in section 3.10 and when operated connects an Nd_9 source in addition to the Nd_7 and Nd_{11} sources (single line). On receipt of the *9* code in the recorder, the automatic selecting equipment releases the established connection and chooses a route to the absentee-service operator instead.

4.6 Identification

Identification of the calling subscriber's number is a feature required in conjunction with long-distance dialling by subscribers. It also simplifies false-call tracing, identification of malicious callers, and serves a number of other interesting purposes.

The solution offered by the electronic circuits is of striking simplicity, when compared with the highly complicated, cumbersome, and slow methods used in other, even modern, automatic systems.

The identification scheme employed is shown in the lower left corner of Figure 17. It makes use of the class-of-line explorer already available per final-selector esbo and of the fact that a group of first line finders serves a block of 100 numbers; there is no jumpering between the subscribers' lines and the first-line-finder multiple.

It will readily be understood that the potential of the *d* wire of a subscriber's line circuit, when busy, stays near −40 volts during the complete 1100-impulse cycle but that in one time position the potential rises to some −24 volts, that is, when there is coincidence between source Nd_6 and the particular combination of *Na*, *Nb*, and *Nc* sources that identifies the number of the line.

When, therefore, the comparator (a gate circuit similar to Figure 12A) of the identification circuit is connected to Rd_6, its associated recorder will receive a code that corresponds to the last 2 digits of the caller's number.

In the first-line-finder circuit, another gate circuit is connected via a decoupling rectifier to the identification wire that provides during the 100-impulse cycle of Nd_1 an impulse that corresponds to the thousands and hundreds figures of the line number.

The comparator of the identification circuit then connects source Rd_1, whereupon its associated recorder will register a code in concordance with the thousands and hundreds figures.

4.7 Explorers Operating in Parallel

For the arrangements described in the foregoing paragraphs, single explorers are used. They may be compared to a finder continuously hunting over a group of terminals and are sometimes called electronic finders.

In some instances, a number of circuits are provided with explorers that operate in parallel and explore the same group of circuits.

If a number of identical explorers were used, confusion could result when a circuit of one group would signal its free condition at the same time to several circuits of a former group. Such an arrangement would lead to considerable complications in the electronic circuits. To avoid these, the sources are connected by means of a staggered arrangement, which may best be explained by referring to Table 4. This table supposes 6 primary circuits and 12 secondary circuits. The circuit diagram is given in Figure 18.

In time position *1* (coincidence between sources Pc_1 and Pe_1) the impulse paths between P_1 and S_1, P_2 and S_{11}, P_3 and S_9, P_4 and S_7, P_5 and S_5, and P_6 and S_3 are opened. In time position *2* (coincidence between sources Pc_2 and Pe_2) the paths P_1–S_2, P_2–S_{12}, P_3–S_{10}, etc., are opened.

By this arrangement, simultaneous testing of a secondary circuit by more than one primary circuit is excluded. The arrangement is comparable to a group of 6 mechanical 12-point switches

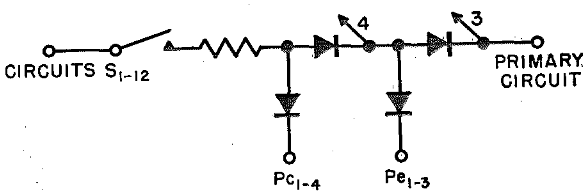


Figure 18—Circuit arrangement for operating in parallel the explorers forming part of circuits P_1 to P_6.

www.americanradiohistory.com

rotating continuously in synchronism and staggered so that when switch *1* stands on terminal *1*, switch *2* stands on terminal *3*, *3* on *5*, et cetera.

Table 5 indicates which secondary circuits are explored by the various primary circuits in the 12 different time positions.

4.8 Explorer Serving for Return Signalling

When a secondary circuit is tested by an explorer of a primary circuit, that is if an impulse indicating the free condition of a particular secondary circuit is registered at the primary circuit, the received impulse instantaneously disables the recorder of that primary circuit. This circuit, therefore, will stop any further exploration. Its diagram is given in Figure 19.

On the other hand, the secondary circuit must be rendered busy and be prevented from signalling the free condition to other primary circuits. This is performed by sending a seizure impulse from the primary circuit to that particular secondary circuit. This seizure impulse is, for reasons of practical circuit design, transmitted in the time position following that in which the first-mentioned impulse was received.

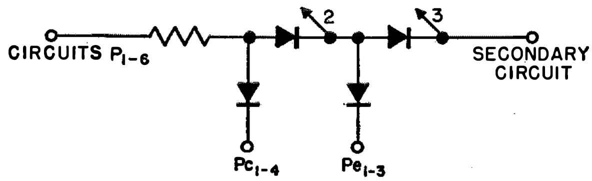


Figure 19—Circuit arrangement for operating in parallel the explorers forming part of circuits S_1 to S_{12}.

TABLE 4

Source Connections for Explorers for Circuits P_1 to P_6

To → Secondary Circuits	P_1 Source Pc	P_1 Source Pe	P_2 Source Pc	P_2 Source Pe	P_3 Source Pc	P_3 Source Pe	P_4 Source Pc	P_4 Source Pe	P_5 Source Pc	P_5 Source Pe	P_6 Source Pc	P_6 Source Pe
S_1	1	1	3	3	1	2	3	1	1	3	3	2
S_2	2	2	4	1	2	3	4	2	2	1	4	3
S_3	3	3	1	2	3	1	1	3	3	2	1	1
S_4	4	1	2	3	4	2	2	1	4	3	2	2
S_5	1	2	3	1	1	3	3	2	1	1	3	3
S_6	2	3	4	2	2	1	4	3	2	2	4	1
S_7	3	1	1	3	3	2	1	1	3	3	1	2
S_8	4	2	2	1	4	3	2	2	4	1	2	3
S_9	1	3	3	2	1	1	3	3	1	2	3	1
S_{10}	2	1	4	3	2	2	4	1	2	3	4	2
S_{11}	3	2	1	1	3	3	1	2	3	1	1	3
S_{12}	4	3	2	2	4	1	2	3	4	2	2	1

TABLE 5

Time Positions for Explorers for Circuits P_1 to P_6

Secondary Circuit Explored in Time Unit	Explorers Associated with Primary Circuit P_1	P_2	P_3	P_4	P_5	P_6
1	S_1	S_{11}	S_9	S_7	S_5	S_3
2	S_2	S_{12}	S_{10}	S_8	S_6	S_4
3	S_3	S_1	S_{11}	S_9	S_7	S_5
4	S_4	S_2	S_{12}	S_{10}	S_8	S_6
5	S_5	S_3	S_1	S_{11}	S_9	S_7
6	S_6	S_4	S_2	S_{12}	S_{10}	S_8
7	S_7	S_5	S_3	S_1	S_{11}	S_9
8	S_8	S_6	S_4	S_2	S_{12}	S_{10}
9	S_9	S_7	S_5	S_3	S_1	S_{11}
10	S_{10}	S_8	S_6	S_4	S_2	S_{12}
11	S_{11}	S_9	S_7	S_5	S_3	S_1
12	S_{12}	S_{10}	S_8	S_6	S_4	S_2

To transmit this impulse to the proper secondary circuit only, every secondary circuit is provided with an explorer operating in the opposite direction and having one branch per primary circuit.

It is obvious that these 2 groups of explorers operate in synchronism. Perfect synchronism would be obtained if the 2 paths between a primary and a secondary circuit, the one for the forward direction and the second for the back-

www.americanradiohistory.com

ward direction, were controlled by exactly the same sources.

In order that the seizure impulse from a primary circuit be transmitted to a secondary circuit in the time position following that in which the test impulse was received at the primary circuit, the sources controlling the second path are so chosen that there is always a delay of one time position between a forward and an associated backward impulse.

Table 6 indicates the combinations of sources connected to the 12 explorers that form part of the 12 secondary circuits S_1 to S_{12} and which may serve to send back impulses to the 6 primary circuits P_1 to P_6.

The sources are so chosen that the explorers may be used for return signalling required in connection with the 6 explorers to which Tables 4 and 5 refer.

It will be noted that when the explorer associated with circuit P_4 accepts an impulse from circuit S_{12}, in time position *6* (sources Pc_2 and Pe_3) the path from P_4 to S_{12} is opened in the next time position.

Table 7 indicates which primary circuits are explored by the various secondary circuits in the 12 different time positions. Comparison with Table 5 shows at a glance the shifting of one time unit.

TABLE 6

SOURCE CONNECTIONS FOR EXPLORERS FOR CIRCUITS S_1 TO S_{12}

To ↓ Secondary Circuits	Primary Circuits											
	P_1		P_2		P_3		P_4		P_5		P_6	
	Source		Source		Source		Source		Source		Source	
	Pc	Pe	Pc	Pe	Pc	Pe	Pc	Pe	Pc	Pe	Pc	Pe
S_1	2	2	4	1	2	3	4	2	2	1	4	3
S_2	3	3	1	2	3	1	1	3	3	2	1	1
S_3	4	1	2	3	4	2	2	1	4	3	2	2
S_4	1	2	3	1	1	3	3	2	1	1	3	3
S_5	2	3	4	2	2	1	4	3	2	2	4	1
S_6	3	1	1	3	3	2	1	1	3	3	1	2
S_7	4	2	2	1	4	3	2	2	4	1	2	3
S_8	1	3	3	2	1	1	3	3	1	2	3	1
S_9	2	1	4	3	2	2	4	1	2	3	4	2
S_{10}	3	2	1	1	3	3	1	2	3	1	1	3
S_{11}	4	3	2	2	4	1	2	3	4	2	2	1
S_{12}	1	1	3	3	1	2	3	1	1	3	3	2

TABLE 7

TIME POSITIONS FOR EXPLORERS FOR CIRCUITS S_1 TO S_{12}

Explorers Associated with Secondary Circuit Providing Impulse Path in Time Position	Primary Circuit Explored					
	P_1	P_2	P_3	P_4	P_5	P_6
2	S_1	S_{11}	S_9	S_7	S_5	S_3
3	S_2	S_{12}	S_{10}	S_8	S_6	S_4
4	S_3	S_1	S_{11}	S_9	S_7	S_5
5	S_4	S_2	S_{12}	S_{10}	S_8	S_6
6	S_5	S_3	S_1	S_{11}	S_9	S_7
7	S_6	S_4	S_2	S_{12}	S_{10}	S_8
8	S_7	S_5	S_3	S_1	S_{11}	S_9
9	S_8	S_6	S_4	S_2	S_{12}	S_{10}
10	S_9	S_7	S_5	S_3	S_1	S_{11}
11	S_{10}	S_8	S_6	S_4	S_2	S_{12}
12	S_{11}	S_9	S_7	S_5	S_3	S_1
1	S_{12}	S_{10}	S_8	S_6	S_4	S_2

4.9 DOUBLE-STAGE SELECTION

Normally, a selection consists of choosing a free outlet via one selector but in certain instances the electronic principles described can be applied advantageously to provide an arrangement in which an outlet that is reached via 2 consecutive selection stages is chosen by a single selection process.

A case in point is the selection of an outgoing junction via a first group selector (acting as *A* selector) and a junction selector (acting as *B* selector). The circuit complication introduced by such an arrangement is largely offset by the

www.americanradiohistory.com

increased efficiency of the junctions, which now operate in so-called ideal groups.

In a similar manner, selection of a register by an *A* governor is controlled not only by the fact that the register chosen must be free but also whether it can provide access to the calling subscriber's line via a proper cord circuit and first line finder.

Figure 20 shows the electronic circuit principles on which double-stage selection is based. Every *A* selector is provided with an explorer identical to the one described in section 4.4. The final branches to which the *e* wires of the *A* selector outlets are connected have the 2 usual control terminals. One terminal is used for the connection of *Pa* sources; the second terminal is not connected directly to a *Pd* source but jumpered instead to a wire of the *B*-selector esbo circuit serving the multiswitch on which that particular *B* selector is located.

Each *e* wire of a *B*-selector outlet is provided with a gate circuit controlled by sources Pd_1 to Pd_{11}, which provide the level or group indication.

If there are free outlets on the first *B*-selector level, one or more *e* wires apply +24 volts to gate circuits connected to Pd_1. These impulses will, therefore, appear on the common esbo wire. This wire will thus carry all *Pd* impulses except those indicating a direction that is engaged.

The comparator by simply applying an *Rd* source that corresponds with the wanted level on the *B* selector will permit only such impulses to react on the recorder that indicate a *B* selector that is free and that provides access to a free junction in the wanted group.

The code registered by the recorder indicates the location of the selected outlet of the *A* selector so that selection may proceed.

The blocking impulse passes via an explorer arranged for return signalling and arises in the proper *B*-selector esbo, where it operates a monostable multivibrator acting on the lead carrying the *Pd* pulses. The purpose of this circuit is to absorb temporarily all *Pd* impulses on the impulse wire and thus render the *B* esbo circuit briefly inaccessible to other calls. The time

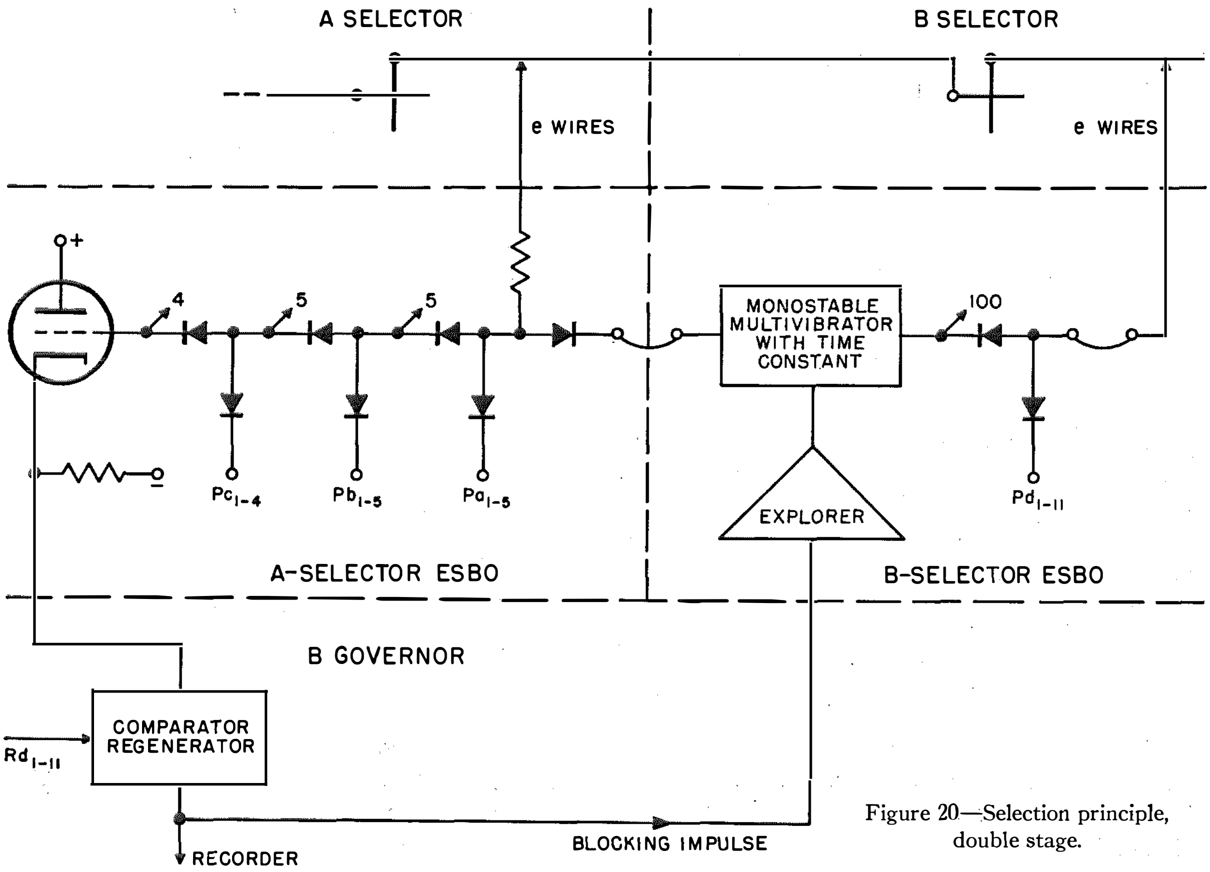


Figure 20—Selection principle, double stage.

www.americanradiohistory.com

lag after which the monostable multivibrator is restored to normal is sufficient for the governor to connect itself to the B esbo and to busy an outlet in the wanted group.

4.10 Sequence Test

Before engaging the esbo circuit, a governor tests whether the circuit is free or busy. In the former case, it renders the esbo instantaneously busy.

Advantage is drawn from the availability of impulse sources to differentiate the moments at which the various governors test. For this reason the test is called a sequence test and may be compared to the double test used in the rotary systems.

The test wire of the esbo circuit in the free condition shown in Figure 21 is connected through a 5100-ohm resistance to +24 volts when busy to ground. At the moment the governor tests, it connects the test wire to the grid of a cathode-follower and places two gate circuits in parallel. The control terminals of these gate circuits are connected to a combination of R sources characteristic for the governor.

At the moment of coincidence of the connected sources, +24 volts is extended to the grid of the triode, the plate circuit of which acts on the trigger electrode of a cold-cathode tube. The latter tube fires and the test relay *Tr* operates. At the same time, the test wire is reduced to ground potential because the anode of the cold-cathode tube connected to the esbo test wire assumes a more-negative potential as a result of its becoming conductive.

5. *Basic Principles of Circuit Design*

To increase the certainty and speed of operation and to facilitate maintenance, all circuits have been designed to perform in the so-called "chain" manner, that is by a compelled sequence of functions whereby timing relations are avoided.

A special effort has been made to reduce the variety of relays employed, the number of types of coil windings for the relays, and to avoid the use of relays having more than one winding. This facilitates the manufacture of the system.

All circuits have been standardized. It is anticipated that ME exchanges may be built to interwork with any other system without adaptation of any circuits but the registers and the junction circuits.

The complete train of local-switching equipment is common for local and toll traffic.

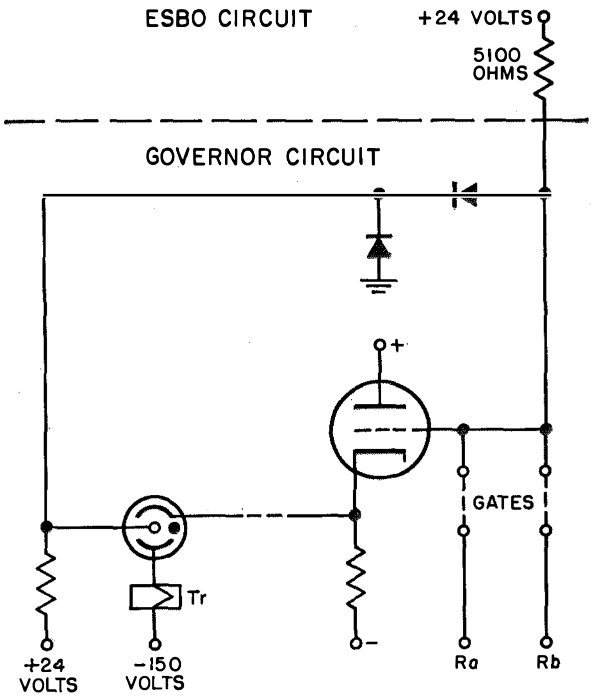


Figure 21—Principle of the sequence test.

All circuits have been so designed that they become inaccessible and cannot tie up other circuits whenever battery is missing as would be the case if a fuse were blown or removed.

On successive calls, a subscriber is always connected to different cords and registers, so that in case of a failure of one of these circuits, no permanent inability to establish calls results during slack hours.

The moment the subscriber's loop is closed for the purpose of originating a call, the line will instantly test busy to final selectors. This is a useful feature in connection with private automatic branch exchanges providing automatic connection to the city exchange. It avoids the possibility of an extension of the private branch exchange seizing a city line some moments before this same city line may have been taken by a final selector, in which case two persons who do not desire to speak to each other are connected.

www.americanradiohistory.com

The electronic control of the selectors or finders is so arranged that operation is as for nonhoming switches, that is hunting starts anywhere in the multiple. This arrangement offers the advantage that traffic is on the average equally distributed over all outlets resulting in even wear of the apparatus. Further, successive calls will never seize the same switch twice in succession.

The system is arranged to give any desired type of toll switching facilities. Means may be provided so that if offering is required on busy lines, this will not be repeated on the same line of a private-branch-exchange group if several consecutive toll switching calls would find the group busy.

6. *Typical Junction Diagram*

A typical junction diagram and associated floor plan have been prepared to give a complete picture of the manner in which the *ME* system can be applied to a 10,000-line exchange in a multioffice area.

The diagram of such an exchange is shown in Figure 22 and is based on an originating busy-hour calling rate of 0.05 erlang per line and an average call duration of 120 seconds. Such traffic figures may be considered as medium-heavy. Some 60 percent of the traffic is outgoing and incoming. Four groups of outgoing junctions lead to distant exchanges and a 5th group handles special-service traffic. The various special services are considered to be centralized in a distant office. Among the incoming junctions, there is a group that handles the switching of toll traffic.

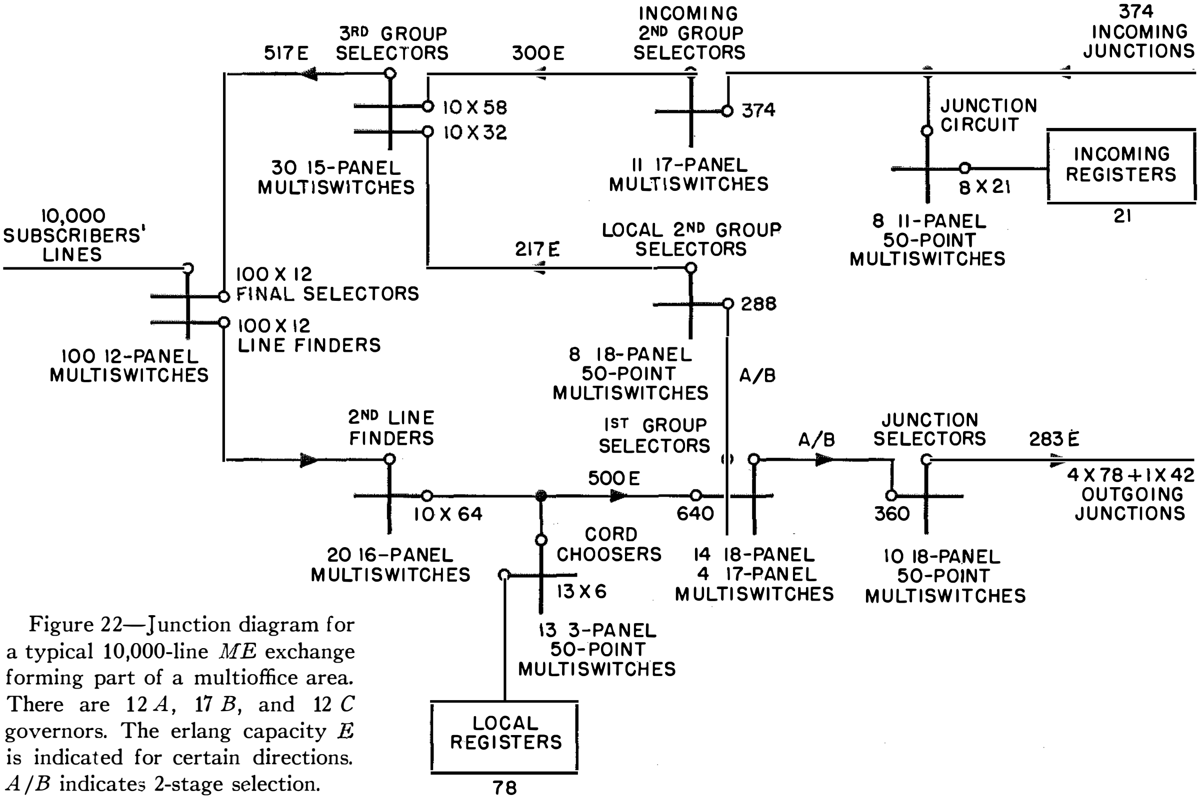


Figure 22—Junction diagram for a typical 10,000-line *ME* exchange forming part of a multioffice area. There are 12 *A*, 17 *B*, and 12 *C* governors. The erlang capacity *E* is indicated for certain directions. *A/B* indicates 2-stage selection.

A call is extended to a register via 100-point first and second line finders and 50-point cord choosers. Outgoing calls are routed via 100-point first group selectors and 50-point junction selectors, which operate in two-stage selection as indicated by *A/B*. The junction selectors have 50 points only as a junction need not appear more than once in the multiples. As a rule, every local circuit appears in 2 multiple splits in a manner designated as "homogeneous grading."

Local calls are routed via local and third group selectors and final selectors. All these switches

www.americanradiohistory.com

are of the 100-point type except the local group selectors, which need only 50 points as they operate also as B selectors in conjunction with the first group selectors.

On a local call, therefore, 6 subswitches in all remain engaged during conversation and the number of relays engaged amounts to 12, which all form part of the cord circuit. Neither the selectors nor the line circuits include any relays.

On an outgoing call, 4 subswitches remain engaged during conversation and a total of 14 relays, each outgoing junction circuit consisting of 2 relays. On incoming calls, 3 successive subswitches complete a connection with relays located at the incoming end only.

The various quantities of circuits required are indicated on the diagram together with the number of multiswitches and of double-sided contact panels that must be provided.

All circuit requirements are based on the traffic quantities indicated and a loss probability of $P = 0.01$, except the auxiliary circuits, which are based on $P = 0.001$. However, as the cost of a contact panel is rather low compared with that of the multiswitch and its associated esbo circuit, especially as no relay circuits are associated, the cost of the exchange is hardly affected by a somewhat more liberal calculation. In the case of the line finders, 12 circuits per group are shown although 11 circuits would be sufficient to carry the traffic. As the contact panels are double sided, the 12th subswitch is automatically provided.

7. *Method of Operation*

7.1 Extending Calling Line to a Free Register

The *ME* system belongs to the group of indirect automatic switching systems, that is, the digits sent by the subscriber's dial are received in register circuits.

As in the rotary systems, first and second line finders are employed. Whereas, however, in these systems the line finders hunt in a group and in a manner backward to the direction of the call, in the *ME* system the identity of the calling line is signalled to an *A* governor that chooses a free register and through this selects the calling line via second and first line finders.

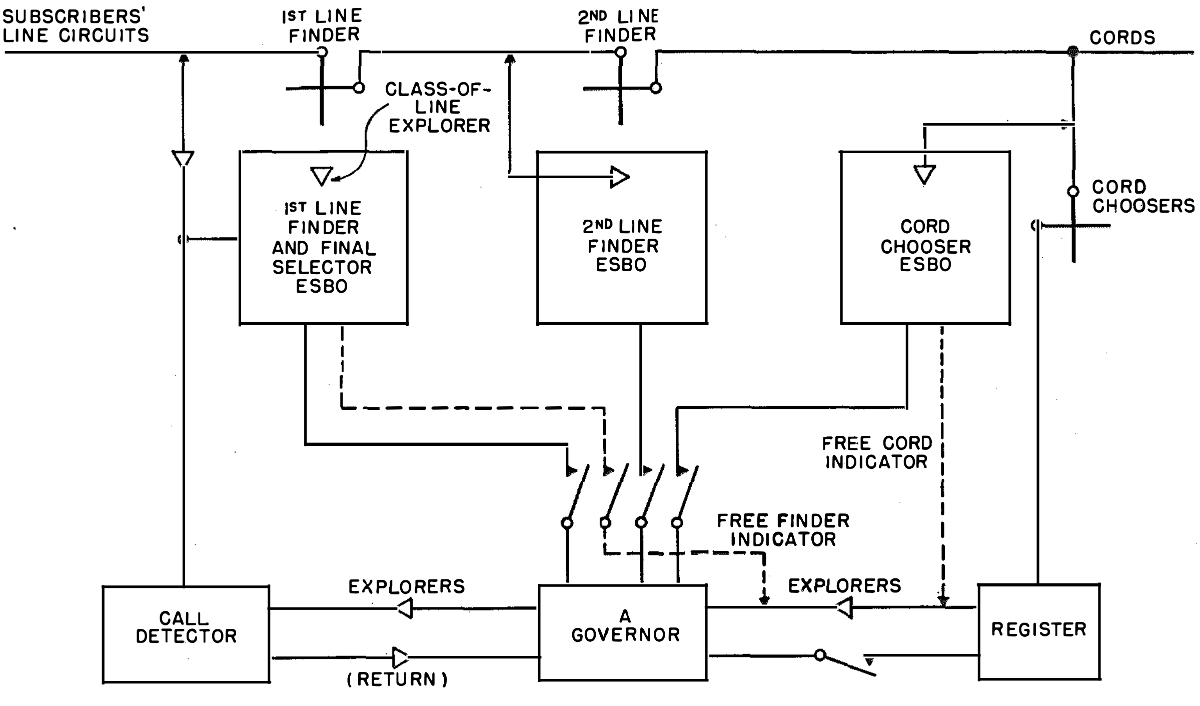


Figure 23—Principle of extending a calling line to a free register.

www.americanradiohistory.com

The general principle underlying the connection of a calling line to a register is shown in Figure 23. The lines have, via first and second line finders located on multiswitches, access to cord circuits. The cord circuits have access to registers via cord choosers. While the line finders are of the 100-point 5-contact type, the cord choosers are of the 50-point 10-contact type.

A group of 100 subscribers is served by one multiswitch, which mounts both first line finders and final selectors and which is served by an esbo circuit. The equipment common for 100 lines further comprises an electronic explorer and a call detector.

The multiswitches that mount the second line finders and cord choosers are each also provided with an esbo.

The complete operation of extending a line to a register is controlled by an *A* governor, which can connect itself by means of relays to any of the 3 types of esbo circuits mentioned and also to any register.

Before an esbo is engaged, a sequence test is performed by the governor as was described in section 4.10.

One group of *A* governors is provided per exchange and their quantity is determined by the traffic they handle. Owing to the short holding time, only a small number is required.

The calling condition of a line is signalled via a a line explorer to a call detector that in turn engages a free *A* governor.

The call detector and *A* governor for this purpose act as the primary and secondary circuits, respectively, as referred to in sections 4.7 and 4.8.

The time position of the return impulse identifies the call detector and thus the 100-line group in which the calling line is located. This information is stored by the *A* governor and used to operate a connecting relay that establishes a metallic connection between the line esbo and the governor. Via a contact of this relay, the pulse wire of the line explorer is connected to the governor and the time position of the calling impulse is recorded and signifies the last 2 digits of the caller's number and serves to locate the multiple wires of the calling line on the multiswitch. The proper combination of vertical bars and servomagnets is operated by the governor via the esbo circuit.

An explorer is provided for each combined line finder and final-selector esbo and serves to indicate the class of the calling line. Its impulse wire is also brought to the governor, which, later transmits the information to the register.

Concurrently with the operations described above, the governor hunts for a free register.

As the cord chooser has a capacity of 50 cords, one register may reach only that number. This rather-limited accessibility is improved by permitting the *A* governor to select through an explorer a register that has access to an appropriate free cord circuit that in turn has access to a free finder in the calling group. In this instance, one group of cords serves 1000 lines. This exploration is accomplished in a manner similar to the double-stage selection described in section 4.9.

The governor now operates two relays that connect it metallically to the chosen register and to the cord-chooser esbo associated with the multiswitch on which the register subswitch is located. This esbo circuit includes an explorer through which the governor selects a cord in the correct group. By knowledge of the time position of the impulse recorded, the governor operates the proper vertical bars via the esbo; at the same time the proper horizontal magnet is operated via the register. By the operation of the proper servomagnet, the connection between the register and the cord is made. The cord-chooser esbo is then released.

The identity of the second-line-finder esbo associated with the cord chooser is derived from the identities of the cord group and the register subgroup. The governor operating the corresponding relay attaches itself to the proper esbo and obtains from the impulse wire of the explorer the time position of a free first line finder in the proper group.

The vertical bars of the second-line-finder multiswitch are again operated via the esbo and the horizontal magnet of the second line finder via the register and the cord chooser. Operation of the proper servomagnet completes the through connection, whereupon the esbo is released. The horizontal-bar magnet is held from the register.

The governor now operates the horizontal-bar magnet of the first-line-finder circuit engaged by the register via the cord chooser and second line finder, the vertical bars already having been operated via the first-line-finder esbo. By a sub-

www.americanradiohistory.com

sequent operation of the proper servomagnet, the connection between the calling line and a register is completed.

The first-line-finder esbo is released and the *A* governor transfers the class-of-line indication to the register, whereupon it releases and restores to normal.

7.2 Group Selection

When a register is connected, matters proceed in a well-known manner in that a dial tone is applied to the line and the digits dialled by the subscriber are stored in the register.

As soon as the number of digits received is sufficient to complete all local group selection, that is, up to a final selector, an outgoing junction, or a special-service circuit, the register calls for a free *B* governor. See Figure 24.

These governors serve the purpose of group selection exclusively and are provided in sufficient number to handle the traffic.

A connecting relay that corresponds to the code received by the recorder forming part of the *B* governor is operated.

The first-group-selector esbo then signals its identity by electronic means to the governor, whereupon a relay is operated closing the leads between the 2 circuits.

In the meantime, the register transmits the wanted-level indication to the governor, which connects itself to the impulse wire of the explorer forming part of the first-group-selector esbo and records the first free impulse that arrives in the wanted cycle (section 4.4). After a sequence test (section 4.10), the esbo circuit is engaged by the governor, which then operates the corresponding vertical bars of the first-group-selector multiswitch. The horizontal-bar magnet is operated at the same time via the register and cord circuits.

Before operating a servomagnet to complete connection through the first group selector, the

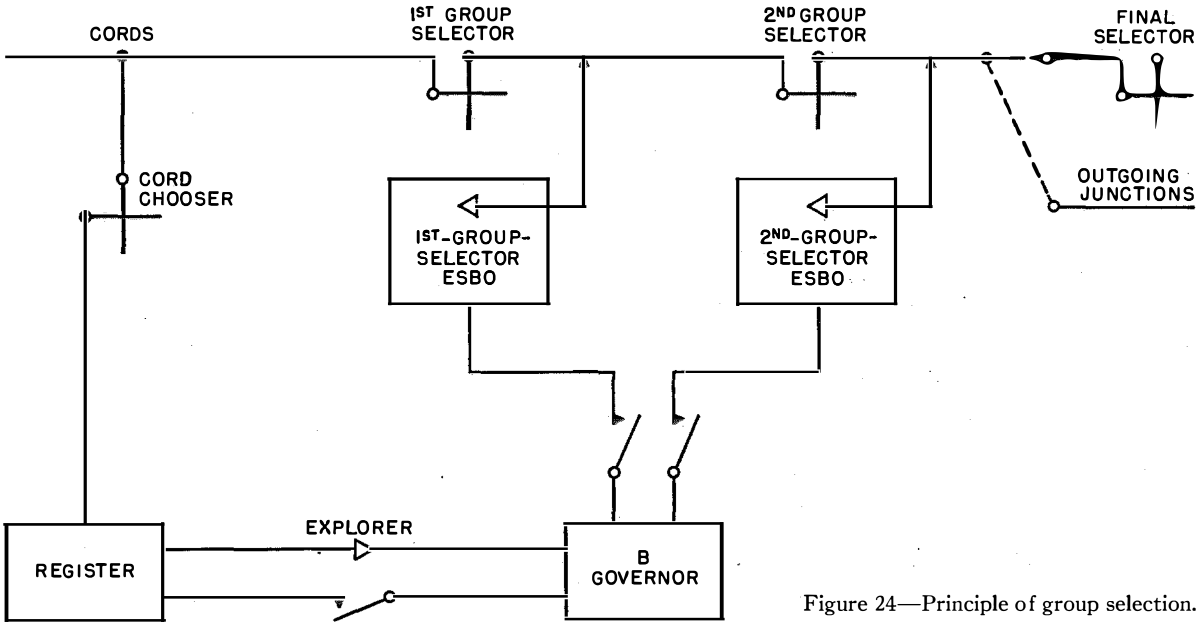


Figure 24—Principle of group selection.

condition on the test wire of the selected outlet is investigated, this wire being connected to the governor via a contact operated by the vertical bar. The latter carries out a sequence test on this wire to determine if the outlet is free or busy and to render it engaged for other calls.

When this sequence test proves successful, the horizontal servomagnet is energized, thus completing the connection.

When calling for a *B* governor, the register applies a potential to its gate circuits forming part of the explorers associated with these governors. In the manner explained in section 4.7, the *B* governor tests all registers in sequence and the time interval between the moment a register is tested by different *B* governors is sufficient to operate a connecting relay and remove the calling condition in the register.

www.americanradiohistory.com

Each first-group-selector esbo includes an additional explorer that signals to the *B* governor the identity of the multiswitch on which the required group selector is located and consequently that of its associated esbo. After receipt of this information, the *B* governor releases the first-group-selector esbo and connects itself to the new esbo.

The *B* governor then receives from the register the group signal for the next selection and for this and all further group selections it proceeds in the same manner as described for the first group selector.

When the *B* governor completes the selection of an outgoing junction, it is informed of this fact by the identity explorer of the last esbo, whereupon it is released. The register then transfers the necessary digits to the distant exchange by means of 4-element codes composed of 2 different frequencies as first applied in the *7E* machine switching system.

When the *B* governor completes the selection of a special-service line, the cord circuit is advanced to the talking condition and the register is released.

7.3 Line Selection

The esbo circuit of a penultimate multiswitch differs from other group-selector esbos in that it does not include an identity explorer. This stems from the fact that the identity of the final esbo is known from the thousands and hundreds figures. Selection within the local block of 10,000 numbers is in broad terms performed on a decimal basis.

Line selection is controlled by a group of *C* governors sufficient in number to carry the traffic. See Figure 25. The moment the subscriber starts to send the units figure, the register connects itself metallically to a *C* governor in a manner identical to that described for the *B* governors.

The register transfers the thousands and hundreds figures to the *C* governor so as to permit this circuit to operate the connecting relay of the proper final-selector esbo circuit. It also transfers the last 2 digits of the wanted line; these are first utilized by the governor to obtain from the impulse wire of the class-of-line explorer the condition and the class of the line (section 4.5).

If the desired line is free, a sequence test is made on the esbo and it is engaged. The proper combination of vertical bars is operated by the governor via the esbo and the proper horizontal-bar magnet via the register and the train of group selectors already engaged. The condition of the *c* wire of the wanted line is again checked via the vertical-bar contacts by means of an electronic direct-current comparator circuit to make sure that no call was originated on this line during the short time that elapsed since the line condition was explored. The proper horizontal servomagnet is then temporarily energized and the call is switched through. The cord is switched through to the ringing condition and the register, *C* governor, and esbo are released.

If the called number belongs to a single line that is busy, the cord circuit is switched through to the busy condition immediately after the class-of-line explorer has signalled this condition, whereupon all auxiliary circuits are released. Also the various group selectors already engaged are released so that during the time the calling subscriber receives the busy tone, only a line finder and a cord circuit remain engaged.

If the called number belongs to the first line of a private-branch-exchange group having non-consecutive numbering and this line happens to

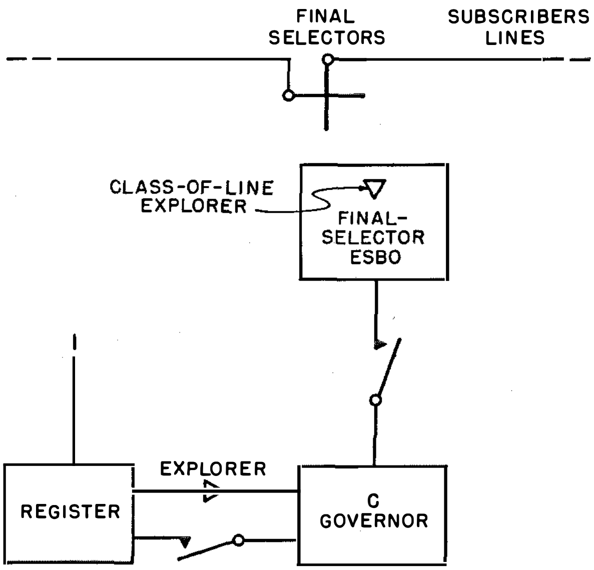


Figure 25—Principle of final selection.

www.americanradiohistory.com

be busy, the C governor hunts by means of the class-of-line explorer for a free line belonging to that private-branch-exchange group.

When such a line is found, the C governor proceeds in the manner described for a free single line. If no line of the wanted private-branch-exchange is found free after the exploration of the 100-line group, busy tone is passed to the caller. The system provides for 5 groups of private branch exchanges with nonconsecutive numbering in each 100-line group.

If the called line forms part of a private-branch-exchange group with consecutive numbering, if it is not the last line of this group, and if it is found busy (Nd_6 in Table 3) the busy signal is combined with the select-next-line indication Nd_{11}. When receiving this combination of signals, the C governor changes the source combination connected to its comparator to instruct it to explore the next line. This process is repeated until a free line is reached or until the last line is found busy. When busy, the last line is marked by the same indication as a busy single line, by sources Nd_6 and either Nd_7 or Nd_8. It should be mentioned that all lines of a consecutively numbered private-branch-exchange group should have the same tens figure. In each 100-line group, any number of private-branch-exchange groups with consecutive numbers may be connected within the capacity available.

If the called line is characterized by a rerouting signal, for example, by an indication marking a nonnumerical private-branch-exchange group, a changed-number line, a dead line, or a line in the absentee condition (sources Nd_9 or Nd_{10}), a corresponding signal is sent to the register, which releases the complete connection and auxiliary circuits and reroutes the call to the wanted destination.

8. Floor Plan

A typical floor-plan layout for a 10,000-line exchange is shown in Figure 26.

The corresponding junction diagram shown in Figure 22 indicates the various amounts of equipment that have been located on this plan.

In total, some 120 meters (394 feet) of single-row switch racks are required for this medium-heavy-traffic exchange providing for some 55 percent of trunked traffic. Part of the rack space is occupied by cross-connecting frames and an outgoing-junction test desk. A standard bay height of 3 meters (9.8 feet) has been adopted. A switch bay of this height can mount six 3-panel, five 12-panel, or four 18-panel multiswitches.

Five nearly identical single-row switch racks each mount the equipment for a 2000-line block, A first-line-finder-and-final-selector switch bay mounts the complete equipment for five 100-subscriber-line groups, that is, 500 line circuits, 5 line and class-of-line explorers, 5×12 first line finders, 5×12 final selectors, and 5 esbos. The call detectors are placed in row 7.

The 4 second-line-finder multiswitches mount on one bay. Cord circuits are mounted two-per-relay-unit, and each bay provides for 18 units.

The first group selectors, local second group selectors, and junction selectors are situated near their associated cross-connecting frame. Rows *3*, *4*, *5*, and *6* accommodate the local registers, explorers, governors, connecting relays, and pulse generator.

The incoming junction circuits, together with their junction choosers, incoming registers, and register-connecting relays are located on rows *1* to *3*.

The outgoing junction circuits are located near the outgoing junction test desk.

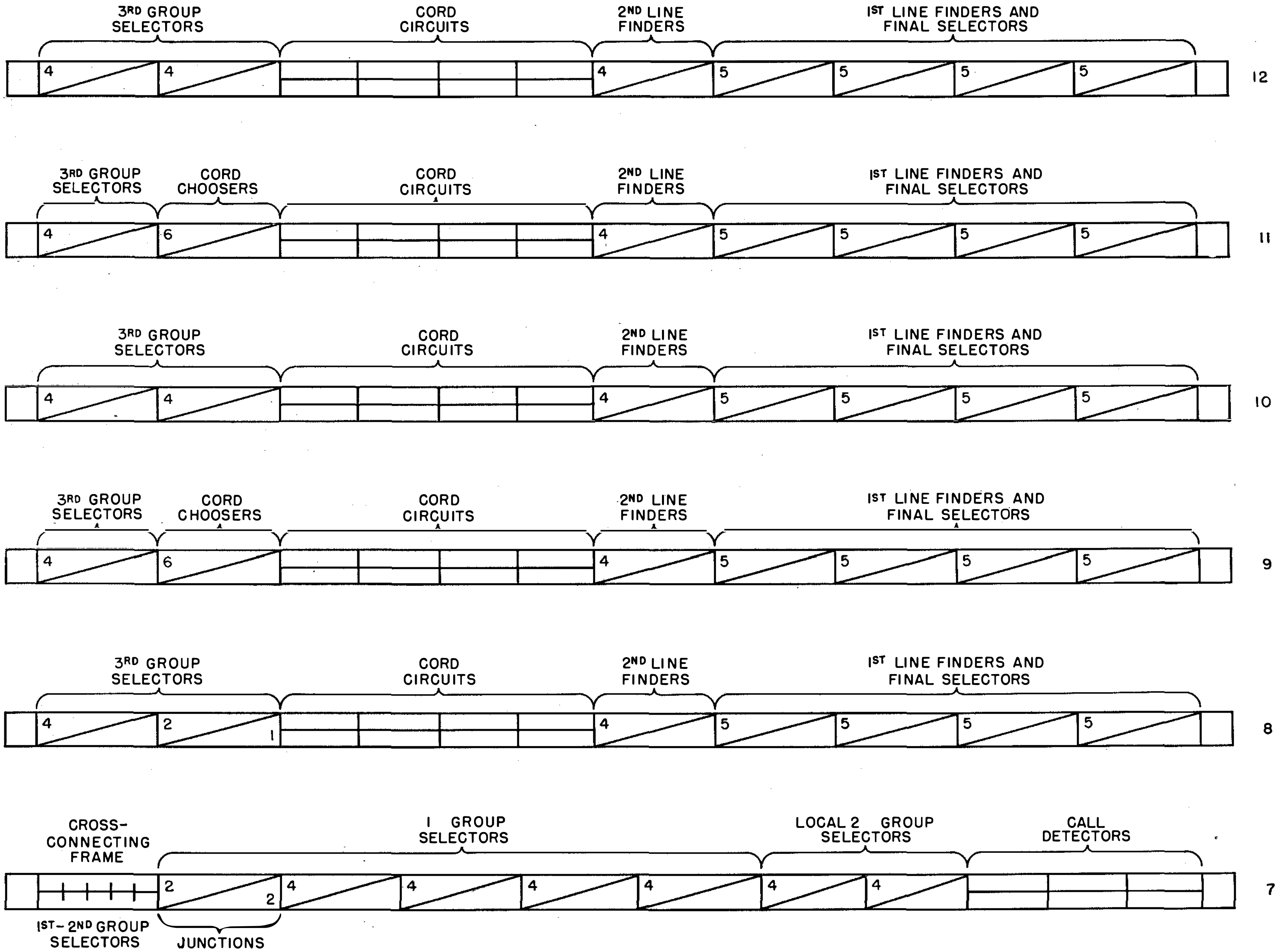
The plan further provides sufficient bay space for routine test equipment and miscellaneous equipment, such as alarm circuits, identification equipment, et cetera.

From this floor plan, it can be concluded that the floor space occupancy of the system is quite modest.

The switch racks employed are of the kind developed for the *7E* machine switching system, the latest type of which is shown in Figure 27. With this type of rack, the switchboard cabling runs from the bays downward instead of upward, as has been the general practice. This new method of cabling offers several advantages, such as better protection against fire, neater appearance of the exchange, and easier installation.

The transverse cable runs may either be placed on top of the switch-rack ends, on the floor in one of the aisles, or against the ceiling of the floor below. The latter is the most economical and neatest solution although the second can be applied to advantage in small exchanges.

www.americanradiohistory.com



www.americanradiohistory.com

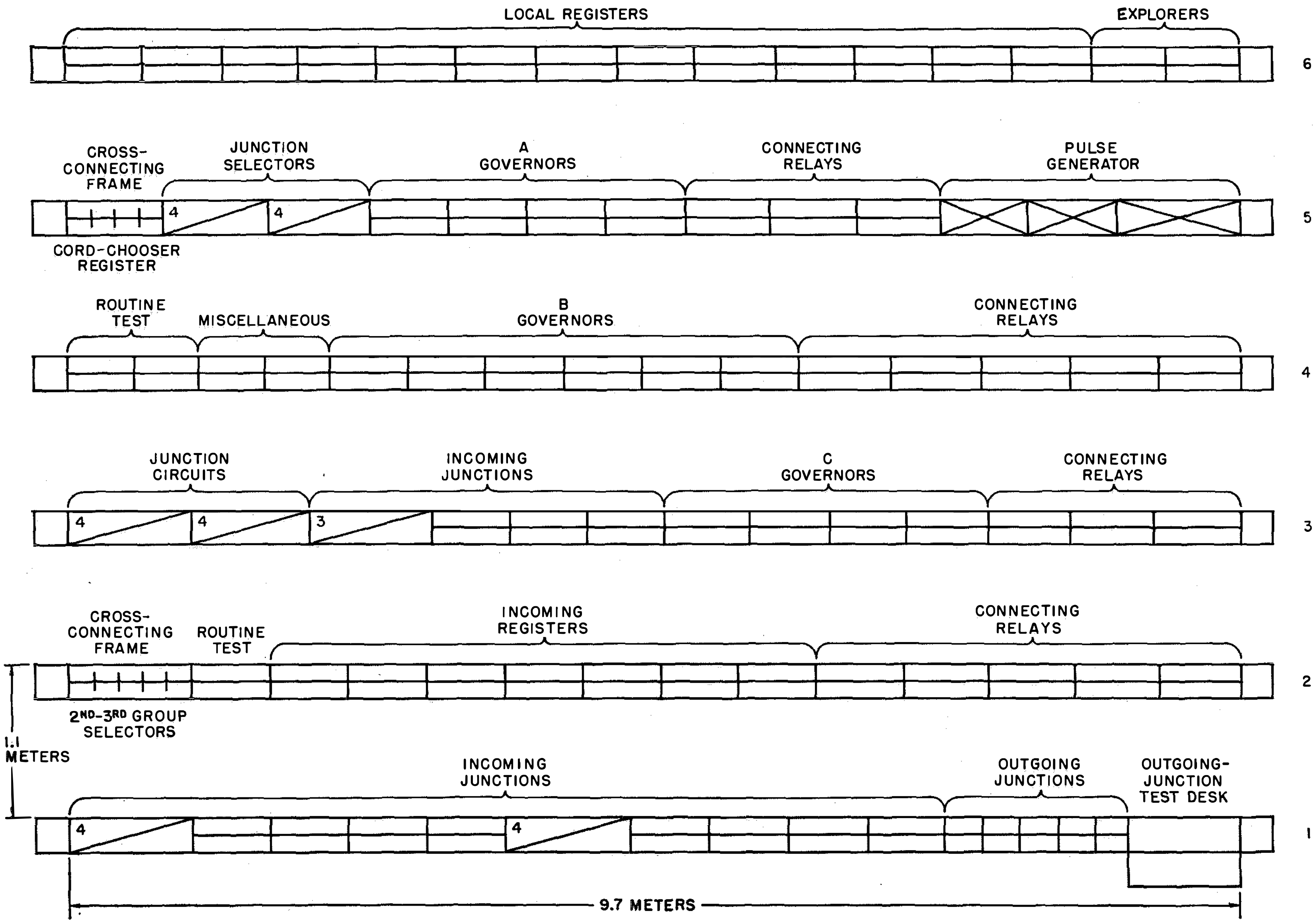


Figure 26—Typical switch-rack layout for a 10,000-line exchange.

www.americanradiohistory.com

9. *Apparatus Units and Bays*

Figures 28 and 29 show front and rear views of a call-detector unit, mounting 3 circuits.

The unit is of the jack-in type developed for the *7E* system and consists of 2 bakelite flanges mounting the fuses, jacks, and lamps. The terminals located at the back of the unit jack into the associated female contacts mounted on the bay. Levers located on the sides of a pair of flanges lock the unit in the bay.

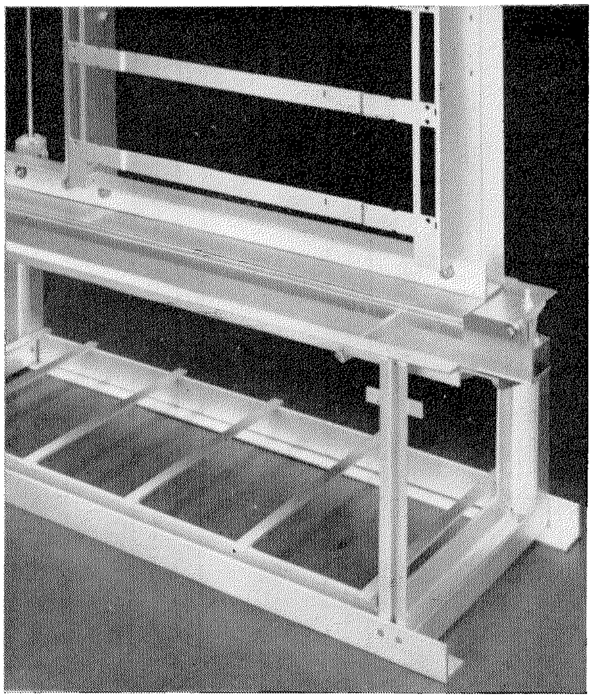


Figure 27—Construction of lower part of switch rack.

Figure 30 shows a rear view of a cord-circuit relay unit mounting 2 circuits. The relays and other circuit equipment are mounted on 3 bars fastened to the inside of the bakelite flanges. This arrangement has the advantage that no mounting plates are used, thereby eliminating a piece part of which a great variety are often used.

The jack-in units carry front and rear covers that can readily be removed; the units are completely dustproof.

The line unit shown in Figure 31 comprises 4 terminal strips having T-shaped terminals, on the front end of which small plugs containing the line resistors are inserted. The line explorer and the class-of-call explorer are mounted on 2 assemblies next to the terminal strips. These assemblies are pivoted at their ends so as to permit easy changing of the class-of-line jumpers, which are clearly visible in the photograph.

The unit also includes the jack-in assemblies for connecting the subscribers' lines and associated equipment to the switch multiple.

The units shown in Figures 32 and 33 contain explorers such as are provided between registers and governors.

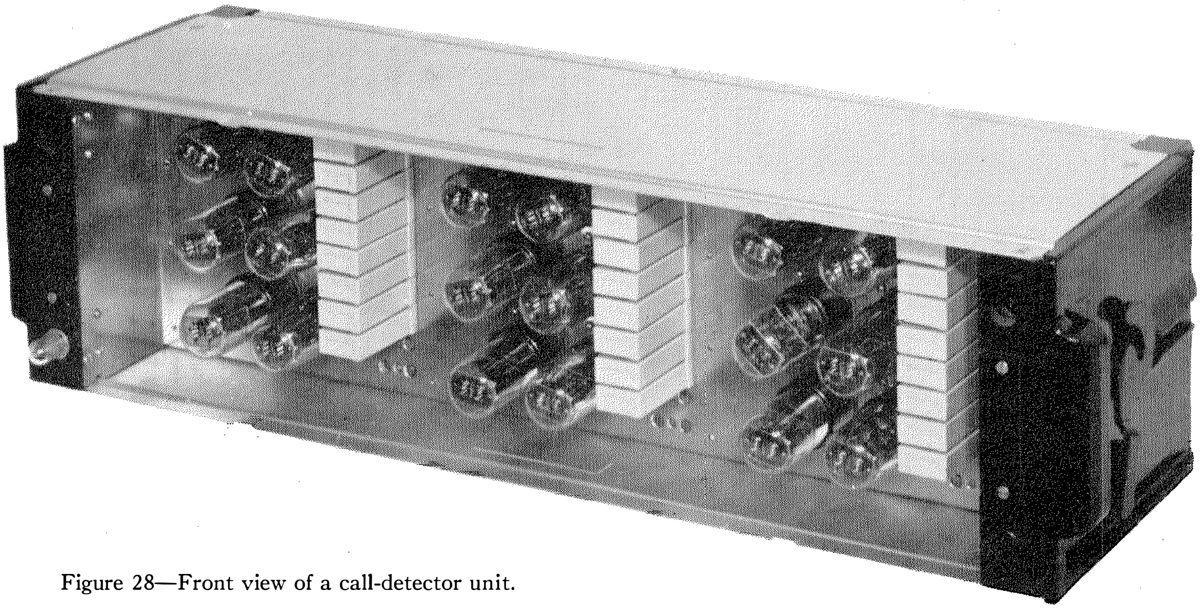


Figure 28—Front view of a call-detector unit.

www.americanradiohistory.com

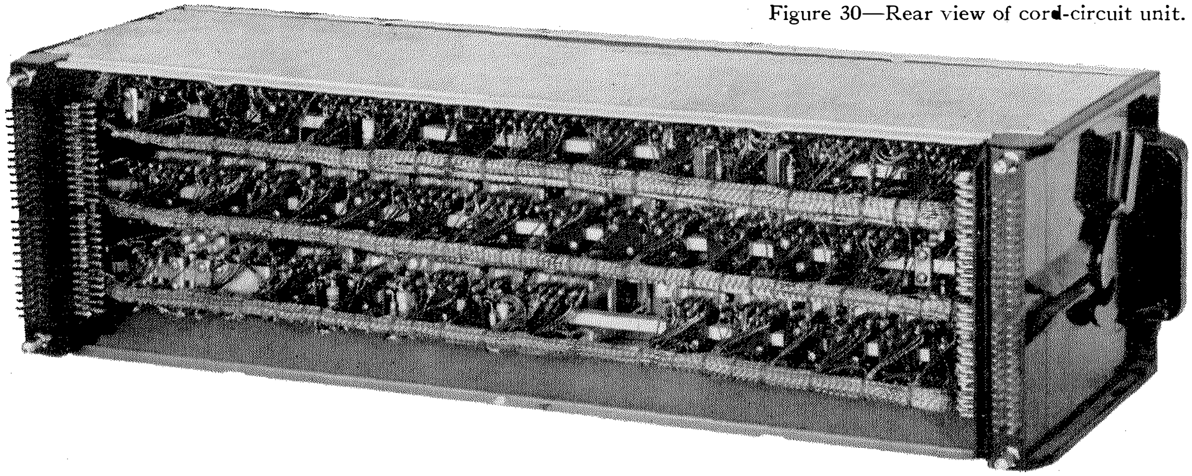


Figure 30—Rear view of cord-circuit unit.

Figure 34 shows a front view of a 4-digit register circuit. It contains only a restricted amount of apparatus, mostly relays, as the electronic selection control equipment forms part of the governors.

Figures 35, 36, and 37 are front views of the three types of governors employed.

A completely equipped first-line-finder-and-final-selector bay is shown in Figures 38 and 39.

10. Cabling and Cross-Connection

As the system operates with stage-by-stage selection, the general cabling layout corresponds in all major respects to that of systems using 100-point switches such as the *7D* or *7E* rotary systems.

The explorers hunt for a free outlet in a manner comparable with that of a nonhoming switch and for this reason homogeneous gradings are used, that is, gradings in which all outlets are connected to the same number of splits. The traffic offered is on the average evenly distributed over the outlets, and this arrangement provides a better efficiency than if, for example, part of the outlets were connected to 2 multiple splits and another part to 3 splits.

Figure 40 shows a typical homogeneous grading for 6 splits numbered from I to VI. Cyclic slipping is shown and the numbers placed in small

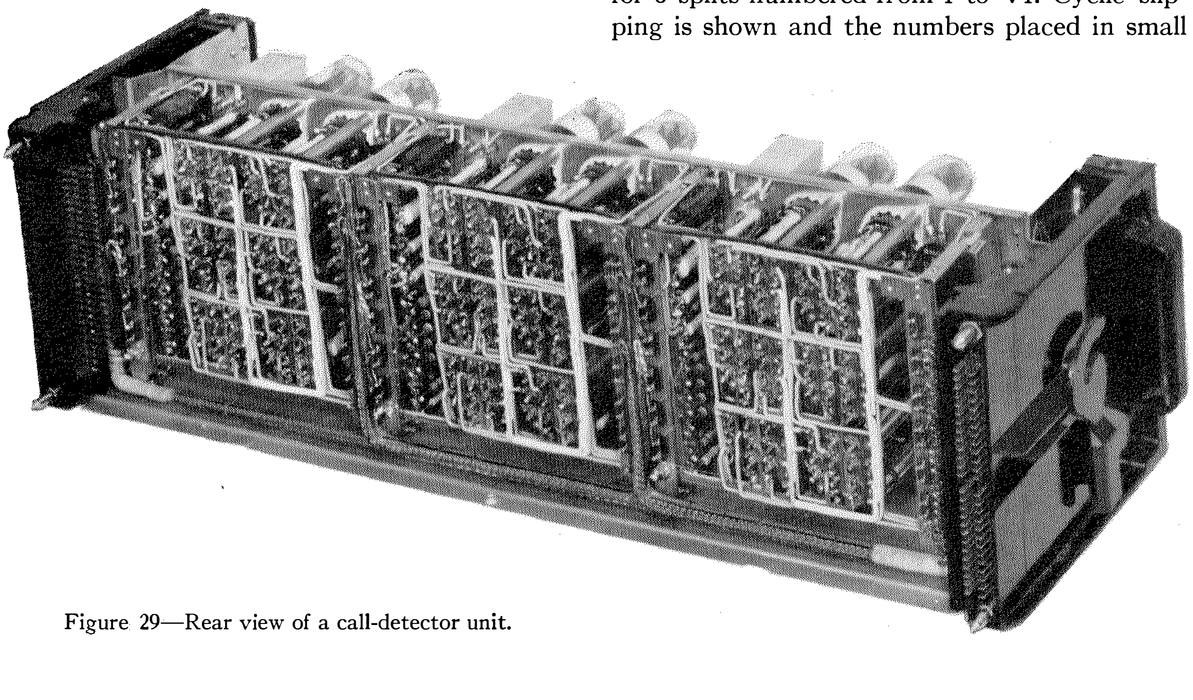


Figure 29—Rear view of a call-detector unit.

www.americanradiohistory.com

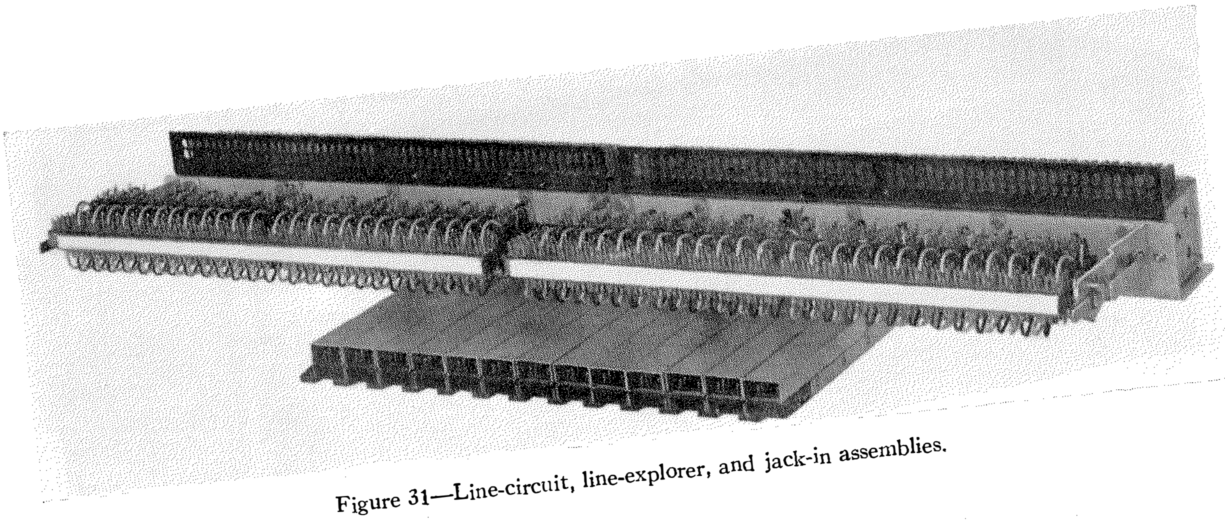
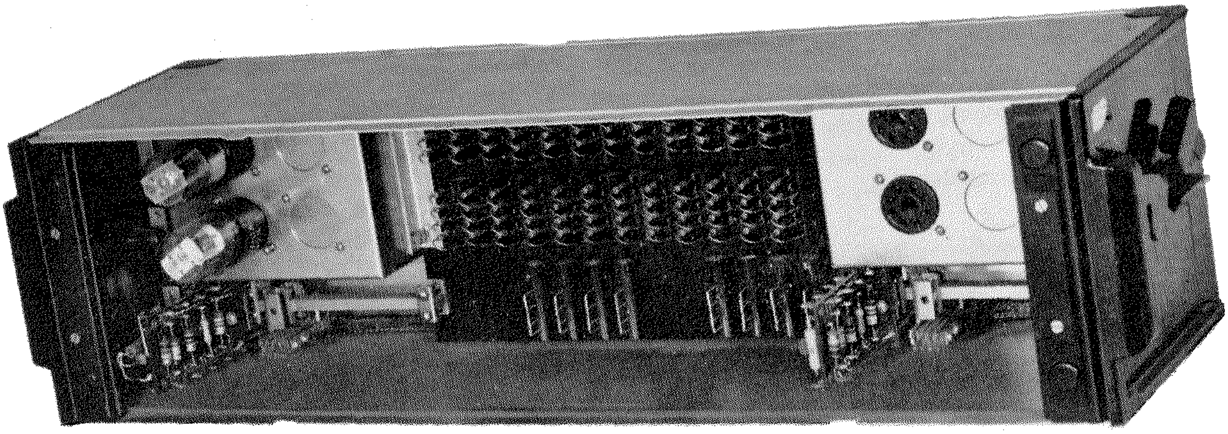


Figure 31—Line-circuit, line-explorer, and jack-in assemblies.

Figure 32—One type of explorer that is located between the registers and governors.



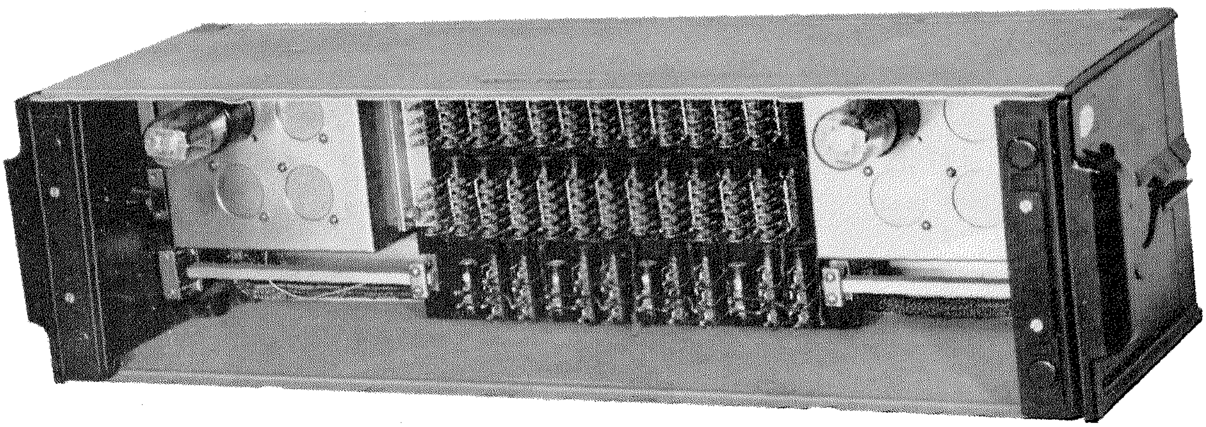


Figure 33—Another type of explorer.

www.americanradiohistory.com

circles indicate the numbers of the outlets connected. With 6 splits, 1 block of 6 sets of each 10 time positions permits obtaining 2 complete cycles so that the complete 6 sets of 100 time positions provide 20 complete cycles. When assigning the outlets to the various levels, care must be taken so that the outlets belonging to one level are evenly scattered over the 100 time positions and that the nearest approach is made to complete cycles. For example, for a level of 20 outlets, time positions *1*, *6*, *11*, *16*, etc., which provide a spacing of 5 units and 4 full cycles, should be chosen.

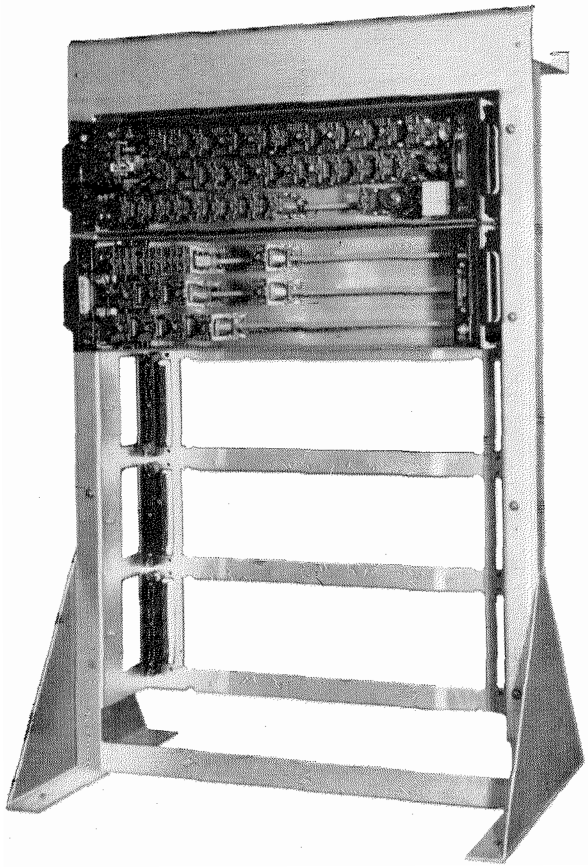


Figure 34—Four-digit register.

The switchboard cable is composed of cotton-covered black-enamelled wires with standard code coloring but with an acetate coating. This reduces fire hazard compared with the use of waxed cable ends.

11. Maintenance Facilities

Great care has been taken to produce reliable service while restricting maintenance to a minimum and facilitating the tracing of faults. The latter is of special importance as the various

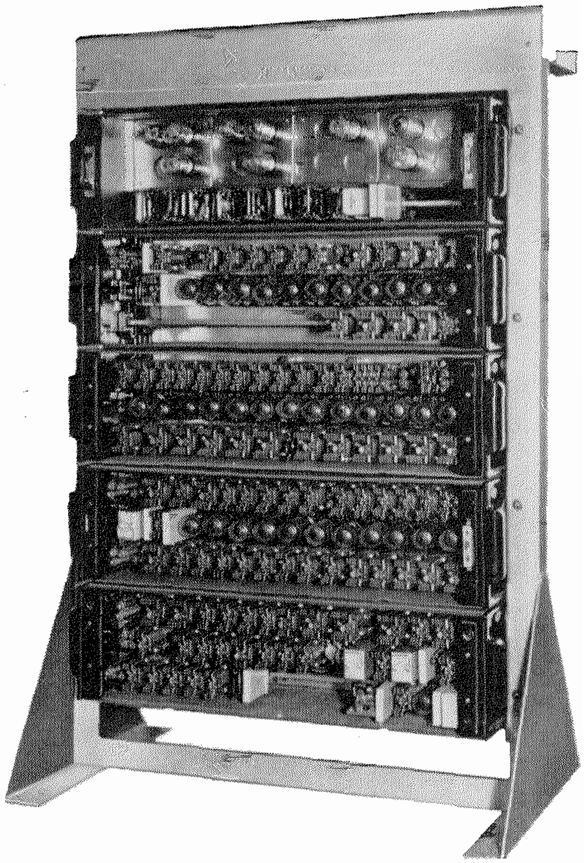


Figure 35—*A* governor.

selecting operations happen at high speed and no mechanical and visible hunting takes place.

One of the main features that constitute an aid to locating faults is the holdover facility mentioned in a previous section.

Further, efficient routine test methods may be provided by which incipient faults are detected before they develop into machine or circuit troubles. The equipment under routine test remains in its proper location on the racks and no interference with the exchange traffic can occur.

Maintenance is further reduced by the elimination of the usual two relays in the subscriber's line equipment. A call detector operating on an

www.americanradiohistory.com

electronic basis is associated with every group of 100 subscribers' lines. These call detectors are tested in rotation once every 100 seconds.

The multiple switch has already proved its reliability under actual traffic conditions. As it can easily be disassembled, all parts are accessible both for inspection and repair.

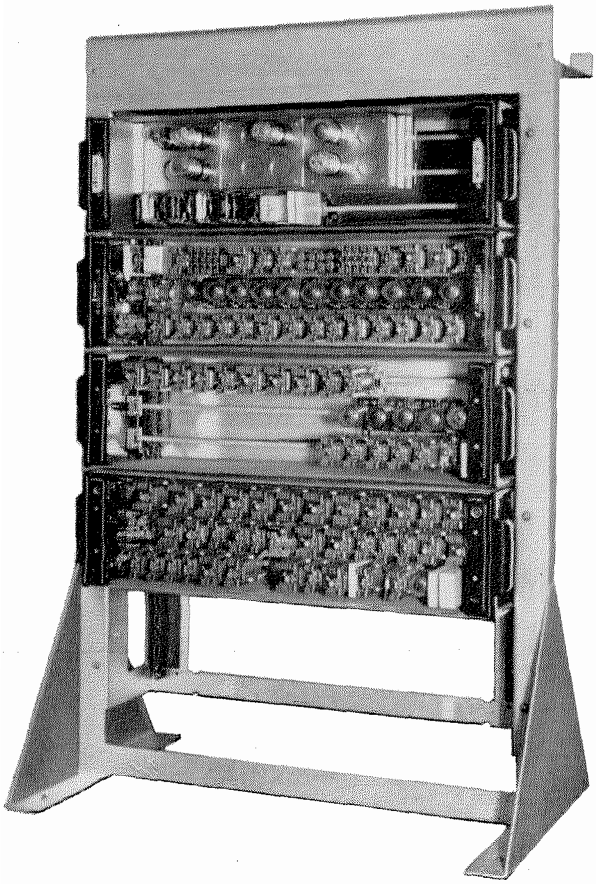


Figure 36—*B* governor.

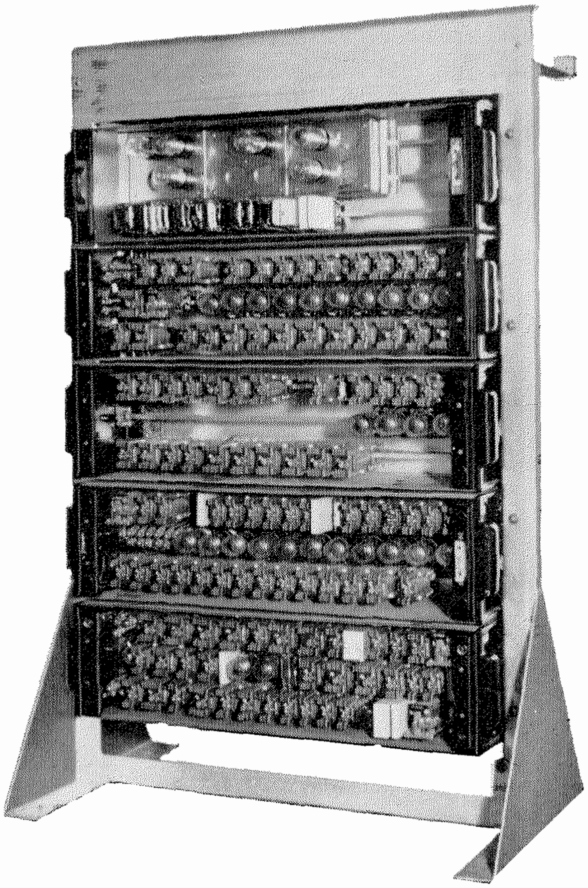


Figure 37—*C* governor.

All circuits and switches are of the jack-in type so that a faulty circuit or switching element can readily be replaced and repaired on the bench.

Maintenance is also facilitated by the absence of close adjustment limits and by the wide operating margins of the multiswitch.

The relays are of modern design and of robust construction. They provide heavy contact pressure and stable adjustment. Where necessary, the relay contacts are protected by spark quenchers.

All but a few of the relays are designed with such wide limits that only mechanical readjustment of spring and armature tensions is needed, thus avoiding the necessity of checking current limits. They have demonstrated highly satisfactory service coupled with long life.

All circuits operate in the so-called "chain" manner, by a compelled sequence of operation, which avoids timing relations. Operation is certain and fast, the locating of troubles is facilitated.

Counting of impulses is restricted to the input stepping equipment of the registers.

All relay units and multiswitches are completely enclosed, thus providing excellent protection against dust or damage.

www.americanradiohistory.com

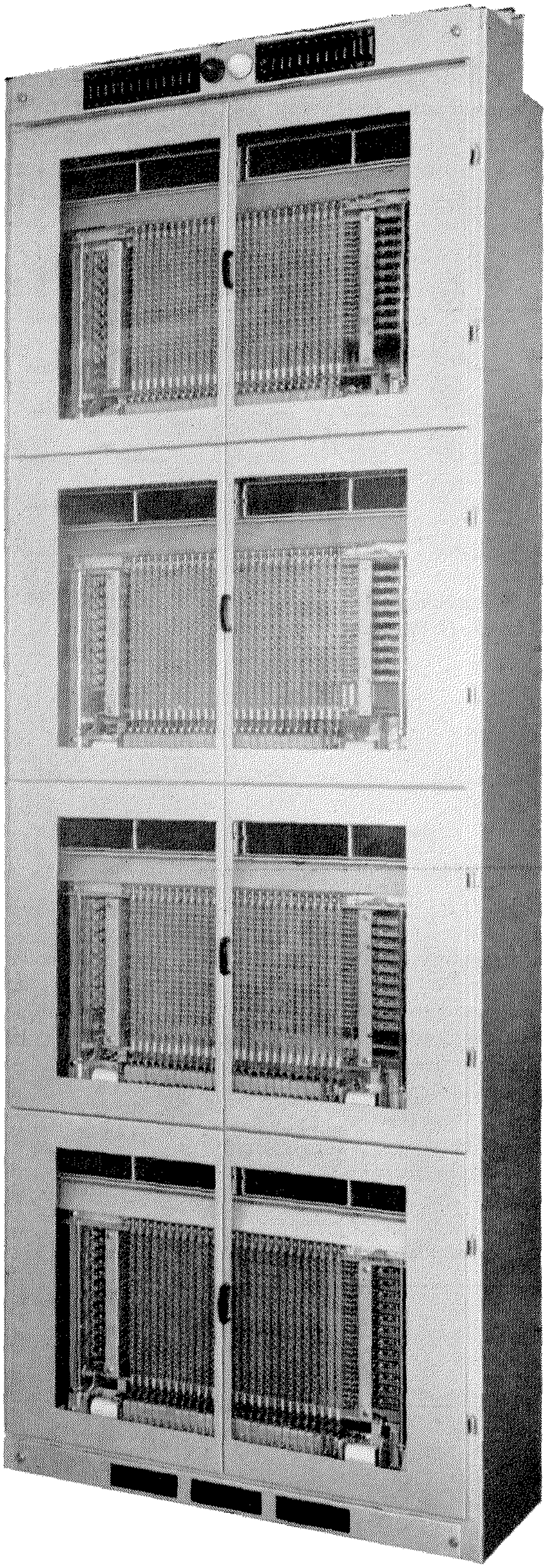


Figure 38—Front view of multiswitch bay.

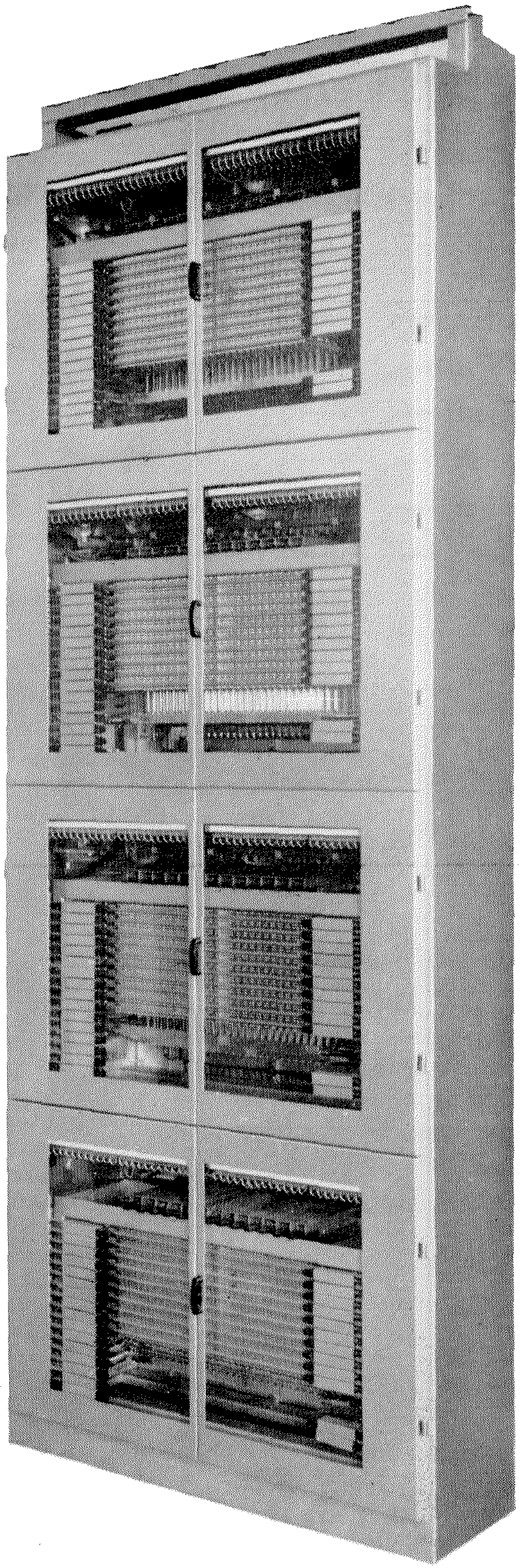


Figure 39—Rear view of multiswitch bay.

www.americanradiohistory.com

The local cable forms are enclosed inside dust-proof coverings and are thus effectively protected against the disintegrating effect of light.

The busy jack of engaged circuits may be plugged in without disturbing existing connections.

All common leads may be individually isolated by cutout jacks in each to facilitate the tracing of trouble.

The junctions between offices are of the 2-wire type and are generally operated in only one direction. They may be taken out of service at either end and are automatically isolated in case of trouble.

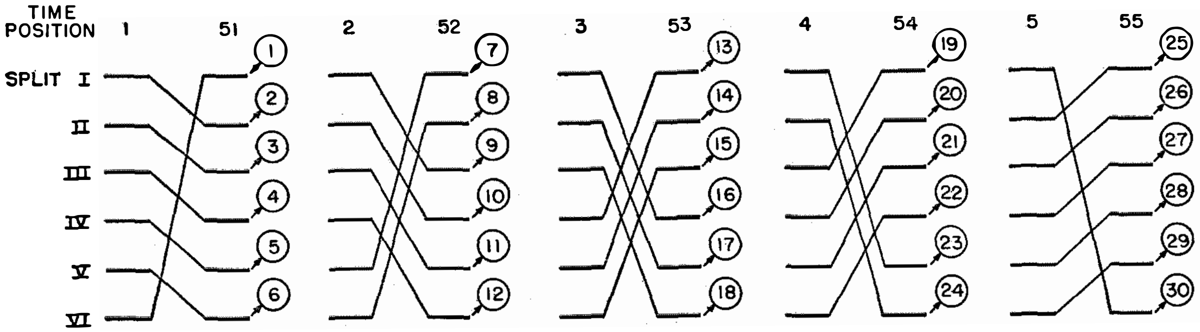


Figure 40—Typical homogeneous grading. Outlet numbers are in circles. The same arrangement repeats itself for blocks of time positions *6* to *10* and *56* to *60*, *11* to *15* and *61* to *65*, etc.

Martinus den Hertog was born in Utrecht, Netherlands, on February 25th, 1901 and entered the services of Bell Telephone Manufacturing Company at Antwerp as a student engineer in 1921 in the equipment engineering department. He was transferred in 1925 to the automatic-circuit design department of which he became the head in 1933. In this capacity, he was charged also with switching-system development and has contributed to some important projects in the field of rotary switching systems, such as the rotary automatic toll system and the *7E* switching system. Since 1953, he has been chief engineer for switching systems.

Martinus den Hertog

• • •

Jakob Kruithof was born in Rotterdam, Netherlands, on November 6, 1894. He received the degree of Electro-Technical Engineer from Delft Technical High School in Holland in 1922 and of Doctor in Applied Sciences from Ghent University in Belgium in 1945.

Dr. Kruithof is Technical Development Administrator of Bell Telephone Manufacturing Company in Antwerp, Belgium, and Assistant Technical Director of the International Standard Electric Corporation.

Jakob Kruithof

www.americanradiohistory.com

United States Patents Issued to International Telephone and Telegraph System; November, 1953—January, 1954

UNITED STATES patents numbering 34 were issued between November 1, 1953 and January 31, 1954 to companies in the International System. The inventors, titles, and numbers of these patents are given below; summaries of several that are of more-than-usual interest are included. In cases where equivalent Canadian patents have already issued, their numbers are given in parentheses.

P. R. Aigrain, Signal Translation System, 2,660,618 (582,697).

R. S. Bailey, Velocity-Modulated Electron Discharge Device, 2,667,597.

J. I. Bellamy and R. P. Arthur, Contact-Spring Switch Assembly, 2,665,352.

G. E. Beszedics, Automatic Regulator of High Sensitivity for Regulating Alternating-Current Voltages, 2,664,540.

D. W. Black, Selenium Rectifier, 2,660,698.

J. H. Brundage, Switching System, 2,663,010.

A. G. Clavier and D. L. Thomas, Phase Changer, 2,663,847 (614,019).

R. B. Colton, E. Labin, and G. A. Deschamps, Two-Way Communication System, 2,666,845 (638,260).

M. den Hertog and C. de Zeeuw, Selection System for Electrical Circuits or Equipments, 2,667,540 (602,299).

L. A. de Rosa, Radio Impulse System for Oscillograph Calibration, 2,662,977.

M. den Hertog, Cyclic Pulse Telecommunication Selection System, 2,664,467 (602,408).

H. Donn, Current Supply Circuit for Television Receivers, 2,663,805.

C. E. H. Frykdahl, Cabinet Construction, 2,662,660 (605,212).

R. Goerlich, Pneumatic Carrier, 2,667,314 (630,099).

F. P. Gohorel, Automatic Telephone System, 2,660,620.

D. D. Grieg, A. M. Levine, and C. L. Estes, Electrical Signal-Translating System, 2,659,049.

R. A. Hampshire, F. W. Iden, and P. L. Hancock, Mechanical Modulator, 2,660,709 (637,251).

A. Horvath, Coaxial-Line-Resonator Electron Discharge Device, 2,662,937.

O. J. Klein, Selenium Dry-Disk Rectifier, 2,663,831 (611,575).

H. E. Lauckner, Selenium Rectifier with Varnish Intermediate Layers, 2,660,697.

A. J. Montchausse, Commutating Mechanism for Crossbar Switches, 2,664,468 (597,941).

L. W. Parker, Electronic Color Television, 2,660,684.

A. H. Reeves and C. de Boismaison, Stabilized Crystal-Triode System, 2,663,767 (615,753).

W. K. Sindzinski and W. F. Hamm, Unloader for Belt Conveyer, 2,663,403.

L. Staschover, Frequency-Discriminator Circuit, 2,667,576.

E. Touraton and R. Zwoboda, Ultra-High-Frequency Vacuum Tube, 2,660,689.

R. Urtel, Method and Means for Generating Impulses of Large Keying Ratio, 2,660,672 (626,885).

T. Von Hauteville, Arrangement of Electrodes for Dielectric Radio-Frequency Heating of Nonconductors, 2,660,660.

A. J. Warner and A. R. Gobat, Primary Cells, 2,661,388.

A. J. Warner and A. R. Gobat, Primary Cells, 2,663,749 (633,971).

A. J. Warner, Synthetic Cable-Jacketing Compositions, 2,662,932 (638,113).

E. P. G. Wright and J. Rice, Automatic Telephone Ticketing System, 2,667,538 (82,019).

E. P. G. Wright, Electric Connecting Device, 2,667,542 (620,772).

N. H. Young, Simultaneous Control System for a Plurality of Picture-Signal Characteristics, 2,660,613 (611,468).

www.americanradiohistory.com

Selenium Rectifier

D. W. Black
2,660,698—November 24, 1953

A selenium rectifier in which an insulating lacquer essentially of nylon is provided between the counterelectrode and the selenium layer.

Primary Cells

A. J. Warner and A. R. Gobat
2,661,388—December 1, 1953

A primary cell in which the composite cathode is composed of a base of a conductive material other than silver coated with a microcrystalline layer of a silver halide. The crystals comprising this layer are all substantially perpendicular to the surface of the base electrode. The anode is magnesium. A porous electrical insulating material separates the cathode and the anode.

Ultra-High-Frequency Vacuum Tube

E. Touraton and R. Zwoboda
2,660,689—November 24, 1953

A travelling-wave-tube amplifier utilizing a helical wave-transmission conductor and provided with annular damping means for sectionalizing the helix. The adjacent sections are coupled electrically by the flow of the electron beam along the axis of the helix.

Simultaneous Control System for Picture-Signal Characteristics

N. H. Young
2,660,613—November 24, 1953

A system for controlling the characteristics such as the contrast and brightness of the various color components of a television picture signal derived from a picture film. A storage device in the form of a calculator keyboard is arranged in advance of transmission of the film so that the various picture characteristics can be adjusted in accordance with the film density during transmission of the picture signals. The control may be made either manually by an operator having a program sheet or can be accomplished automatically through a preset coder device.

Pneumatic Carrier

R. Goerlich
2,667,314—January 26, 1954

A pneumatic-dispatch-system carrier arrangement in which automatic control of destination of the carrier is effected by strips that may be used to interconnect different conductive rings on the body to set up a code for controlling the path of the carrier.

Modern Coaxial-Cable Technique in Great Britain

By ERIC BAGULEY

Correction for Volume 30, Pages 186–216; September, 1953

MR. G. E. ROSSITER of the engineer-in-chief's department, British Post Office, has pointed out that K_3 of Table 2 and K_3 of Table 4 are different quantities from K_3 as defined in (4), (5), (6), and (7).

The figures in column 4 of Table 2 are, in fact, the average measured values of Z_s as defined in (4) for the frequency 2·5 megacycles per second. Similarly, the first two figures in column 3 of Table 4 are the average measured values of Z_s at 2·5 megacycles per second and the last two figures are the average measured values of Z_s at 20 megacycles per second.

For cable designs *3*, *4*, *5*, and *6*, the average measured values of K_3 may be obtained from column 4 of Table 2 by subtracting 0·6 ohm from the figures there given for these four designs. The value of K_4 for those cables is 0·9, independent of normal commercial variations in the dimensions of the coaxial pairs.

www.americanradiohistory.com

INTERNATIONAL TELEPHONE AND TELEGRAPH CORPORATION

MANUFACTURE AND SALES

North America

UNITED STATES OF AMERICA —

Divisions of International Telephone and Telegraph Corporation

Capehart–Farnsworth Company; Fort Wayne, Indiana

Coolerator Company; Duluth, Minnesota

Federal Telephone and Radio Company; Clifton, New Jersey

Kellogg Switchboard and Supply Company; Chicago, Illinois

Federal Electric Corporation; Clifton, New Jersey

International Standard Electric Corporation; New York, New York

International Standard Trading Corporation; New York, New York

IT&T Distributing Corporat on; New York, New York

Kellogg Credit Corporation; Chicago, Illinois

Thomasville Furniture Corpor tion; Thomasville, North Carolina

CANADA — (*See British Commonwealth of Nations*)

British Commonwealth of Nations

ENGLAND —

Standard Telephones and Cables, Limited, London

Creed and Company, Limited, Croydon

International Marine Radio Company Limited, Croydon

Kolster-Brandes Limited, Sidcup

CANADA — Federal Electric Manufacturing Company, Ltd., Montreal

AUSTRALIA —

Standard Telephones and Cables Pty. Limited, Sydney

Silovac Electrical Products Pty. Limited, Sydney

Austral Standard Cables Pty. Limited, Melbourne

NEW ZEALAND — New Zealand Electric Total sators Limited, Wellington

Latin America and West Indies

ARGENTINA — Compañía Standard Electric Argentina, S.A.I.C., Buenos Aires

BRAZIL — Standard Electrica, S.A., Rio de Janeiro

CHILE — Compañía Standard Electric, S.A.C., Santiago

CUBA — Compañía Distribuidora de Productos Standard S. A., Havana

MEXICO — Standard Electrica de Mexico, S.A., Mexico City

PUERTO RICO — Standard Electrica de Puerto Rico, Inc., San Juan

Europe

AUSTRIA — Vereinigte elephon- und Telegraphenfabriks A. G., Czeija, Nissl & Co., Vienna

BELGIUM — Bell Telephone Manufacturing Company, Antwerp

DENMARK — Standard Electric Aktieselskab, Copenhagen

FRANCE —

Compagnie Générale de Constructions Téléphoniques, Paris

Le Matériel Téléphonique, Paris

Les Téléimprimeurs, Paris

GERMANY —

C. Lorenz, A.G., Stuttgart

Mix & Genest A. G., and Subsidiaries, tu tgart

G. Schaub Apparate a G.m.b.H., Pforzheim

Süddeutsche Apparatefabrik G.m.b.H., Nuremberg

ITALY — Fabbrica Apparecchiature per Comunicazioni Elettriche, Milan

NETHERLANDS — Nederlandsche Standard Electric Maatschappij N.V., The Hague

NORWAY — Standard Telefon og Kabelfabrik A/S, Oslo

PORTUGAL — Standard Eléctrica, S.A.R.L., Lisbon

SPAIN —

Compañía Radio Aérea Marítima Española, Madrid

Standard Eléctrica, S.A., Madrid

SWEDEN — Aktiebolaget Standard Radiofabrik, Stockholm

SWITZERLAND — Standard Telephone et Radio S.A., Zurich

TELEPHONE OPERATIONS

BRAZIL — Companhia Telefônica Naciona , Rio de Janeiro

CHILE — Compañía de Teléfonos de Chile, Santiago

CUBA — Cuban American Telephone and Telegraph Company, Havana

CUBA — Cuban Telephone Company, Havana

PERU — Compañía Peruana de Teléfonos Limitada, Lima

PUERTO RICO — Porto Rico Telephone Company, San Juan

CABLE AND RADIO OPERATIONS

UNITED STATES OF AMERICA —

American Cable & Radio Corporation; New York, New York

All America Cables and Radio, Inc.; New York, New York

The Commercial Cable Company; New York, New York

Mackay Radio and Telegraph Company; New York, New York

ARGENTINA —

Compañía Interna ional de Radio, Buenos Aires

Sociedad Anónima Radio Argentina, Buenos Aires (*Subsidiary of American Cable and Radio Corporation*)

BOLIVIA — Compañía Internacional de Radio Boliviana, La Paz

BRAZIL — Companhia Radio Internacional do Brasil, Rio de Janeiro

CHILE — Compañía Internacional de Radio, S.A., Santiago

CUBA — Radio Corporation of Cuba, Havana

PUERTO RICO — Radio Corporation of Porto Rico, San Juan

RESEARCH

UNITED STATES OF AMERICA —

Federal Telecommunication Laboratories; Nutley, New Jersey; *a division of International Telephone and Telegraph Corporation*

International Telecommunication Laboratories, Inc.; New York, New York

ENGLAND — Standard Telecommunication Laboratories, Limited, London

FRANCE — Laboratoire Central de Télécommunications, Paris

ASSOCIATE LICENSEES FOR MANUFACTURE AND SALES IN JAPAN

Nippon Electric Company, Limited, Tokyo

Sumitomo Electric Industries, Limited, Osaka

www.americanradiohistory.com