GRover 1924

The Introduction of Dial Telephone Service In The City of Toronto

A Centenary Narrative by Len Hicken

Preface

This narrative describes a significant episode in the history of The Bell Telephone Company of Canada (BTCO). It is the story of the beginning of BTCO's evolution from manual telephone service to automatic telephone service. I am telling this story now (2024) in recognition of the 100th anniversary of BTCO's first telephone exchange to be equipped for automatic (rotary dial) service. The exchange name was "Grover", and it was located in the east end (Beach district) of the City of Toronto. My intention was to make the narrative interesting and understandable for all readers, not just telephony enthusiasts, and I apologize for any failings in that regard. The actual equipment at the telephone exchange was known as the Step-By-Step switching system. For those readers who want to delve further into the mystique of this wonderful vintage electromechanical apparatus, I have included three appendices that hopefully will help satisfy your curiosity.

I would like to take this opportunity to pay tribute to the memory of Alexander E. Keith. For over a quarter century he played an immensely large role as a pioneer in state-of-the-art advancements to automatic telephony, both as a major inventor for the Strowger Automatic Telephone Exchange Company and as the long-time Chief Engineer for the Automatic Electric Company. Keith's substantial achievements were all incorporated in the SXS system installed in the Grover exchange. His brilliance, numerous patents and dedication were instrumental in turning Strowger's automatic switching concept into a functional, reliable and economical telephone switching system. A wonderful legacy from a brilliant man.

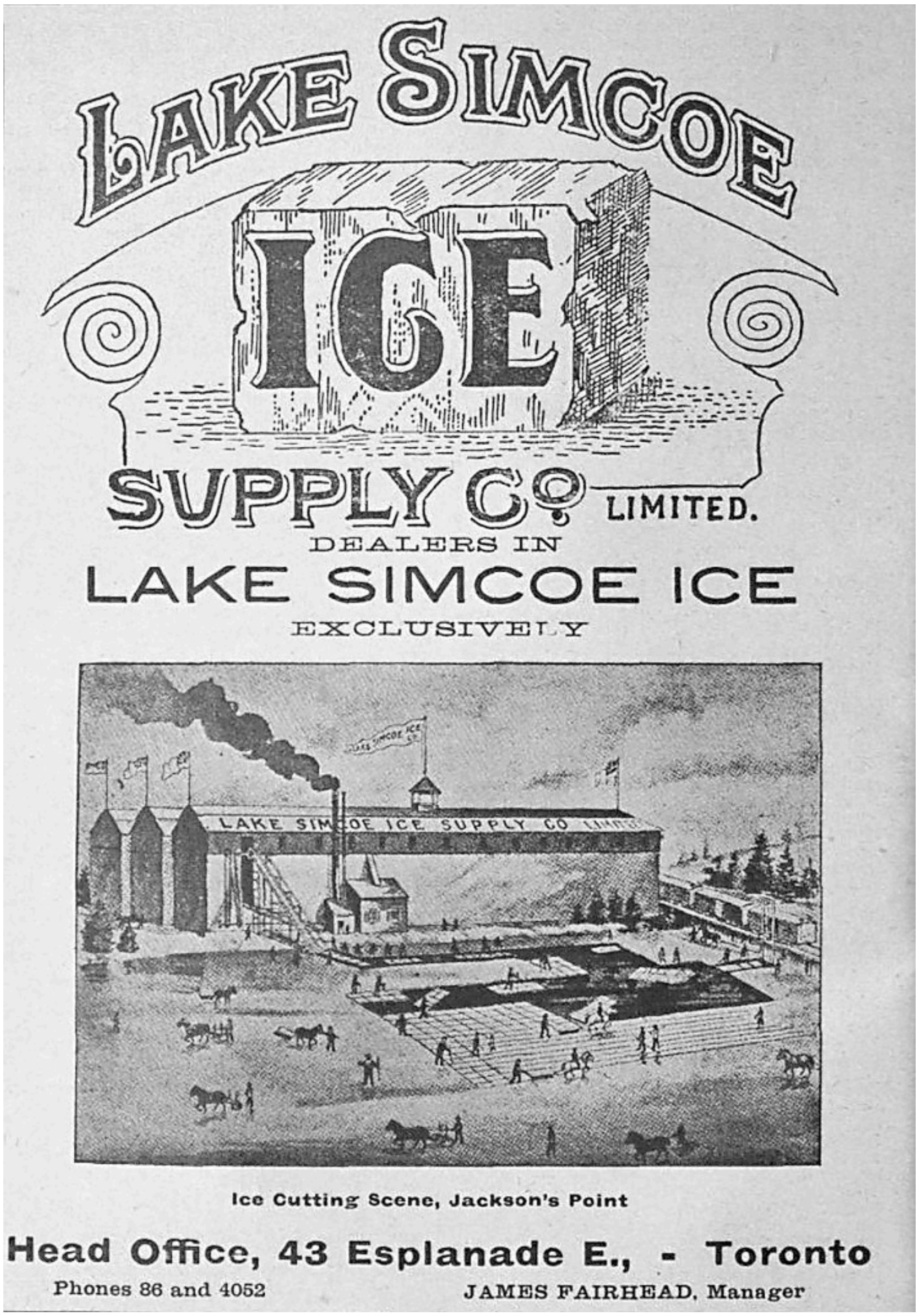
Alexander E. Keith

Len Hicken

London, Ontario
January, 2024

<u>**Grover 1924**</u>

In the year 1900, The Bell Telephone Company of Canada (BTCO) had less than 8,000 telephones in service in the City of Toronto. While today's Toronto telephone numbers consist of 10 digits, back then they ranged from just 1 to 4 digits in length.



Year 1900 Toronto Ad showing 2 and 4-digit telephone numbers

The Toronto telephone sets were simple devices, containing neither hand crank magnetos nor rotary dials. Batteries to power the telephones were not required at the subscribers' premises. Each telephone line consisted of a pair of wires that connected the telephone to a centralized switchboard located in its area of the city.

Typical subscriber manual telephone desk stand (circa 1908)
(not shown is the subset, which contains a ringer, capacitor and induction coil mounted in a separate wooden box)
(COURTESY BELL CANADA'S HISTORICAL COLLECTION)

These switchboard locations were known as central offices or exchanges. Power for the telephones was provided from the exchange in a system known as "central energy" or "common battery". The telephone lines terminated on jacks (similar to headphone jacks on a stereo) on the vertical face of a switchboard. There were two functional types of jacks. Answering jacks were used when subscribers originated calls. Line completing jacks were used when subscribers received calls. Each answering jack had an associated lamp that would light up when a subscriber took the telephone receiver off-hook. Operators at the switchboards set up the connections using a series of cords and plugs. A subscriber placing a call would just remove the receiver from the telephone switchhook. An operator would see the lit lamp and plug into the answering jack and say "Number, please?". The subscriber would state the called number and the operator would complete the connnection by bridging the calling subscriber's answering jack and the called subscriber's line completing jack together with a paired cord and plug arrangement (of course, the procedure was more complex for calls to subscribers in a different exchange).

The Toronto Adelaide common battery manual switchboard exchange in 1921
(COURTESY BELL CANADA'S HISTORICAL COLLECTION)

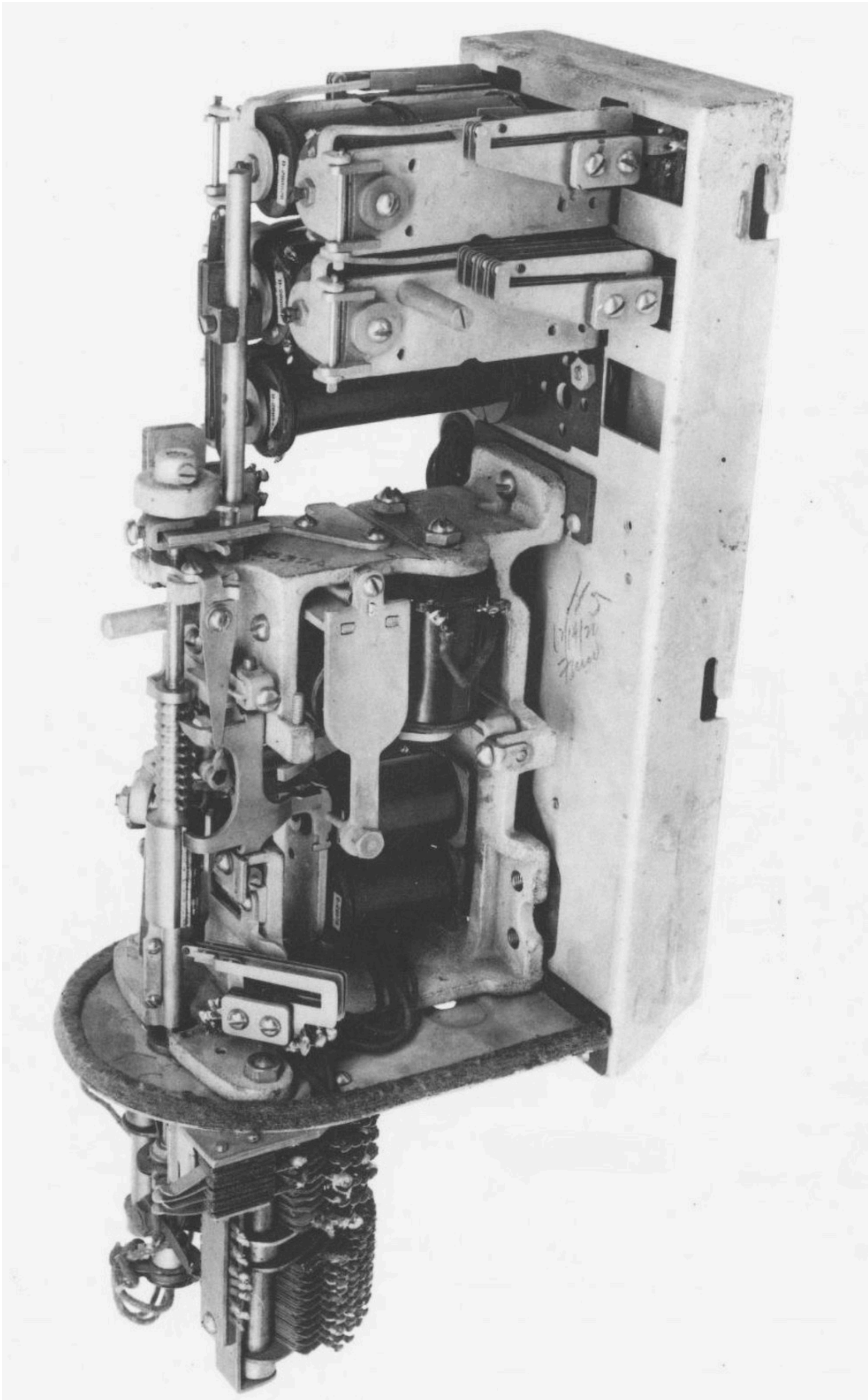
In 1900 there were three Toronto exchanges, consisting of a main exchange and two branch exchanges. The main exchange was located downtown; the first branch exchange was located in the north end; and the second branch exchange was located in the the west end. A series of "trunks" between each of the exchanges enabled operators at any one exchange to connect to the operators at either of the other two exchanges so that calls could be placed between different exchanges. Each exchange used its own distinct set of telephone numbers within the 4-digit range so that there were no duplicate number conflicts among the exchanges. The main exchange used numbers 1 to 2999 and 8000 to 8999; the north exchange used numbers 3000 to 4999; and the west exchange used numbers 5000 to 5999. By 1901, the growth in telephones was such that the existing arrangement was no longer tenable and it became necessary to use duplicate telephone numbers in each exchange. This meant that each exchange would require a unique identifier to be combined with the numeric telephone number in order to direct calls to the appropriate exchange. The method chosen to accomplish this was to assign a different name to each exchange, which was the method being used by the large Bell operating companies in the USA. For Toronto, the three names chosen were Main, North and Parkdale (the name of the neighbourhood in which the west end exchange was located). In 1903, a fourth exchange named Beach was added in the city's east end (this was a magneto manual exchange until 1907 when it became common battery). "The Beach" was a neighbourhood aptly named for its popular sandy shoreline on Lake Ontario. By 1920, Toronto had seven more exchanges as follows: College, Junction*****, Adelaide, Hillcrest, Gerrard, Belmont and Kenwood (*****BTCO had a Junction exchange in 1897, but it was not located inside the Toronto city limits. Toronto Junction was annexed into Toronto in 1909). The reasons for Toronto needing more than one exchange are explained in the BTCO newspaper notice below.

BTCO Notice explaining exchanges, May 13 1918

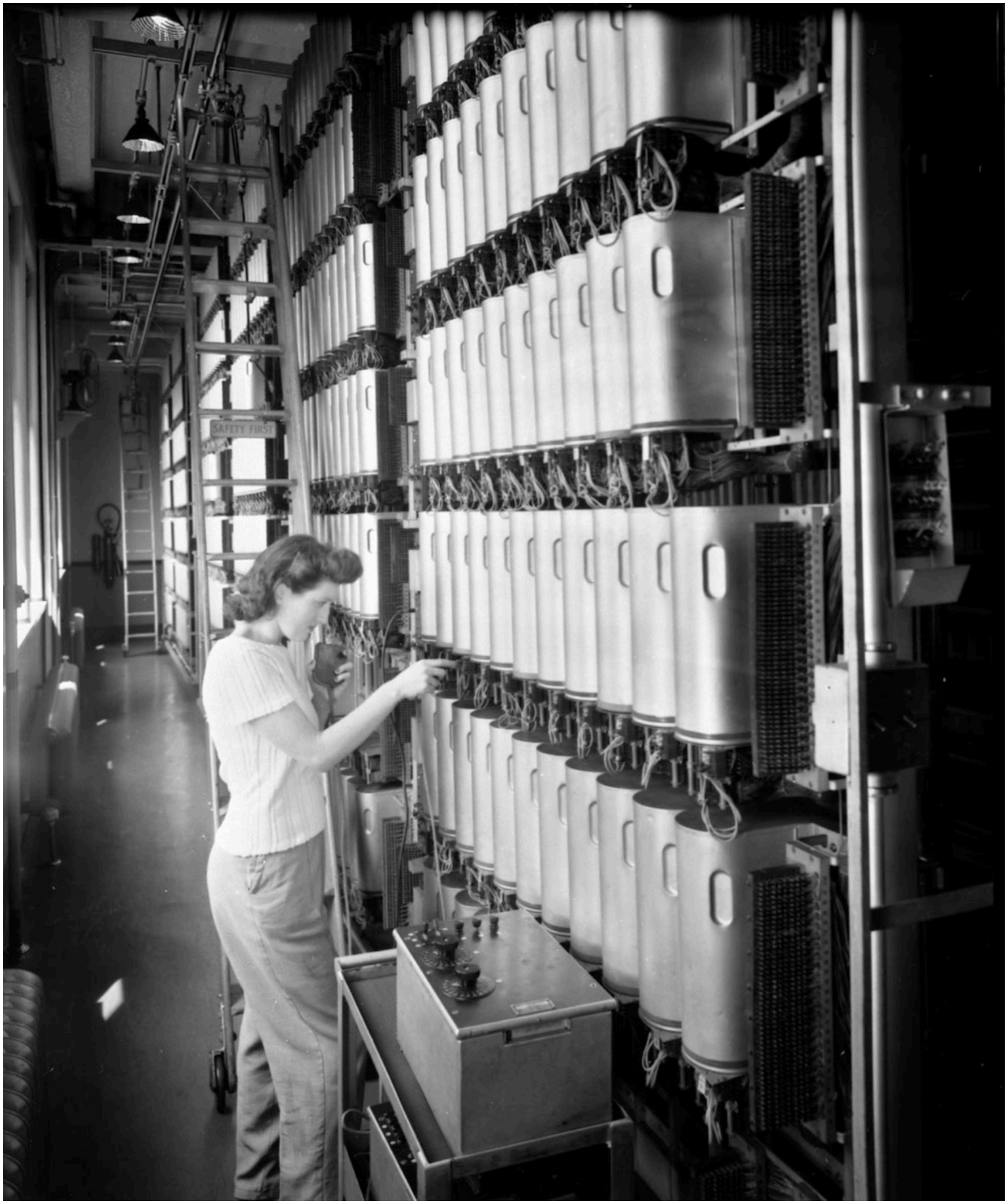
The reason for the limitation to 10,000 numbers on an exchange switchboard was due to restrictions imposed by the design of the equipment and the physical limitations of human operators. Based on the dimensions of the jacks and lamps, a maximum of 10,000 numbers could be placed within the reach of a single operator.

By the beginning of the twentieth century, new types of telephone switching systems had been developed and more were on the way. These were known as "machine switching" systems, or more commonly, "automatics" because the machinery at the exchange performed the task of connecting a calling telephone to a called telephone instead of a human switchboard operator. When you took your receiver off the switchhook to originate a call, the exchange machinery would send you a steady humming sound called "dial tone". This tone was the machinery's way of telling you it had seen your request for service, had connected you to the system and was now asking you for a "Number, please?" You replied, not by verbalizing the called telephone number to a human operator, but by manipulating a rotatable electrical device attached to your telephone, called a "rotary dial". In the early years of the twentieth century by far the most prevalent of the automatic systems in use was the step-by-step (SXS) type of equipment. This equipment was often referred to as "Strowger" equipment, after its inventor. While Almon Strowger held the patent for an automatic two-motion stepping device to complete telephone connections, it was the brilliant engineers he hired to work in his company, the Strowger Automatic Telephone Exchange, that made SXS a success story. Much of the credit belongs to Alexander Keith and two brothers, John and Charles Erickson, who in the mid 1890's designed, patented and manufactured the first viable two-motion stepping switch and the first rotary dial. Strowger's company established the Automatic Electric Company in 1901 and that company manufactured and refined the SXS system for decades thereafter.

SXS equipment was made up of a large quantity of electromechanical switches, with each switch having a number of ratchets, pawls, contact brushes (wipers), contact assembly arrays (banks), electromagnets and relays. A 10,000-line exchange would have between four and five thousand of these switches. The general methodology was that after each pull of the rotary dial, as the dial returned, it sent pulses to the SXS equipment. A pulse was simply a momentary opening and then reclosing of the electrical loop between the two wires connecting the telephone to the exchange. Each pulse had a duration of one-tenth of a second (or a pulse rate of 10 pulses per second), during which the loop was open for 60% and closed for 40% of the pulse duration. The number of pulses sent was equivalent to the numeral dialed. So, if the numeral 7 was dialed the loop would open and close 7 times (think of it as turning a light switch off and on rapidly 7 times). The numeral 0 was treated as if it were the number 10 and when dialed would send 10 pulses to the exchange. The pulses of the first numeral dialed were received by one of the SXS switches which, through electromechanical motions, enabled it to process the numeral received and connect to a succeeding switch. This succeeding switch would then be enabled to process the pulses of the next numeral dialed. A train of connected switches was built up, step-by-step as each numeral was dialed, until finally, after the last numeral had been pulsed, there was a completed connection between the calling and called telephones through a train of activated SXS switches. The last switch in the train had the ability to ring the called party and trip (shut off) the ringing when the party answered. A more detailed explanation of the SXS switching system is provided in Appendices 1, 2 and 3.



A SXS electromechanical switch (14" high, 4-1/2" wide, 12 lbs)



Technician working in a SXS equipment lineup
(COURTESY BELL CANADA'S HISTORICAL COLLECTION)

SXS was an immediate success with the independent telephone companies across the USA and dial telephone service became their main growth vehicle. SXS was also quick to arrive in Canada. It was first installed by the Yukon Electric Company of Whitehorse, Yukon in 1901. It became quite popular with many of the provincially owned, city owned and privately owned independent telephone companies across the country. In 1905, the Town of Toronto Junction, which at that time abutted the western border of the City of Toronto, had SXS dial capability courtesy of an independent company named the Stark Telephone Light and Power System. However, this arrangement only lasted about 4 years due to the bankruptcy of the Stark company.

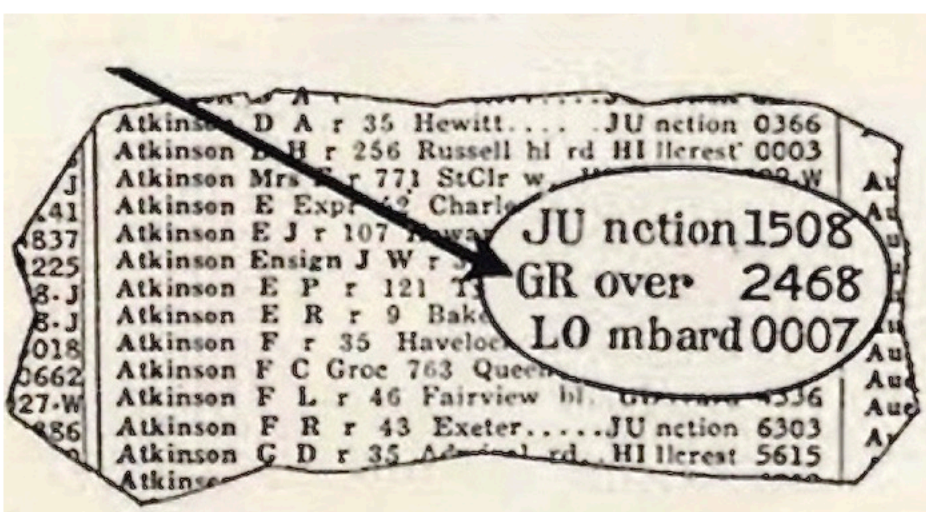
For most of the first two decades of the twentieth century, neither of the two largest telephone service providers in the USA and Canada shared the enthusiasm of the independent telephone companies for SXS automatic telephone service. In the USA, the giant of the telephony enterprises was known as the Bell System. This umbrella term referred to the intertwined relationships of AT&T, Western Electric, Western Electric Engineering (Bell Labs as of 1925) and the Bell Operating Companies (BOC's). The Bell System's reluctance to transition to automatic service was due to a number of reasons, including: lack of trust that subscribers could efficiently handle the "complexity" of operating the rotary dial, especially when 6 or 7 numerals had to be dialed; that subscribers would be averse to the burden of having to dial the numbers they were calling; the lack of perfection in the automatic switching system designs; the unsolved problem of how to handle exchange names; the feeling that the smoothly functioning manual switchboards were superior; and lastly, the huge capital cost of making the transition.

In Canada, by far the largest telephone company was BTCO. Although BTCO was never an official member of the Bell System, it was certainly a very close affiliate. Up until 1923, BTCO and its manufacturing arm, Northern Electric, had a variety of agreements with the Bell System. In 1920, AT&T owned 38.3% of BTCO, although this was declining annually, and Western Electric owned 44% of Northern Electric. In 1923 a mish-mash of former agreements was formalized into one long-lasting master agreement. This agreement gave BTCO access to the Bell System's management, administrative and operating procedures, technical information, documents, patents and technology. In short, BTCO "appeared" as if it were a BOC. In return BTCO paid the Bell System 1% of its annual gross revenues. With this close affiliation it was no wonder that BTCO followed the Bell System's approach to automatic telephone service.

By 1919, however, the Bell System had a change of heart regarding automatic switching. The difficulties of hiring, keeping and paying a rapidly increasing number of switchboard operators was getting out of control, as were the inefficiencies in the big cities of the excessive tandeming of calls requiring several operators to make the connections. The Bell System had also completed design work on its own automatic switching system called "panel". The Bell System was still very concerned about the ability of subscribers to accurately dial 6 or 7 numbers, so their plan was to use panel in big cities in a semi-automatic setup in which subscribers would retain manual telephones sets to reach operators, and operators would complete the calls by dialing into the panel switches which would route the calls to their destination. But these plans changed dramatically when one of the Bell System's engineers, William Blauvelt, came up with a way to allow the automatic switching systems to retain the much beloved exchange names to which the public had become familiar. His idea was to include most letters of the alphabet along with the 10 decimal numerals on the number plates of the dials. The finalized arrangement, which lasted for 7 decades without a change, displayed 3 letters per finger wheel hole associated with numerals 2 through 9 (numeral 1 was reserved for long distance access and service codes while numeral 0 was for reaching the local assistance operator).

Blauvelt's Letter/Number Dial Configuration
(COURTESY BELL CANADA'S HISTORICAL COLLECTION)

The brilliance was that the telephone directories would highlight the particular first 2 or 3 letters of the exchange names to be dialed by displaying them as boldface and capitalized. This allowed most of the existing exchange names and station numbers to be retained when converting from manual to dial service.



Blauvelt's Directory Listings Concept
(COURTESY BELL CANADA'S HISTORICAL COLLECTION)

So, the Bell System's plans for the big cities changed to fully automatic with dial telephone sets for the subscribers and panel switches to route the calls. The Bell System also changed its mind about step-by-step equipment. The Automatic Electric Company's SXS system had improved greatly during its first quarter century of development and the Bell System was confident enough to begin purchasing the switches from Automatic Electric to use in smaller cities and towns. This decision was also influenced by the fact that the SXS systems were much more economical than their panel counterparts.

Back in Canada, BTCO was following these developments with great interest and began developing their own long-range plans for the introduction of automatic switching, which they announced in the 1919 annual report. Western Electric tried to convince Northern Electric to manufacture panel equipment for the largest Canadian cities, but BTCO overruled it and decided to proceed with the Automatic Electric designed SXS switches. After all, the largest Canadian cities were only about one-tenth the size of the largest American cities (Toronto 500,000 and New York 5,600,000) and the more sophisticated but very costly panel switches would have been overkill. Accordingly, in 1920 Northern Electric obtained a licensing arrangement to manufacture and sell Automatic Electric SXS equipment in Canada.
For Toronto, the plan was to slowly phase in the automatic exchanges over an estimated 18 to 20 years due to the massive capital outlays required for the conversions. It actually was completed within 12 years. By July 1936, all 21 Toronto exchanges were automatic. In addition to the cost of the actual SXS switching equipment there would be the requirement for associated power plants, transmission equipment, cables, telephone sets and last but certainly not least, the cost of new central office buildings and associated real estate. The existing manual central office buildings had not been designed to carry the much heavier floor loads of the SXS equipment.

Another major planning task was the development of a standardized numbering plan, which involved projections on the number and locations of exchanges in the foreseeable future along with deciding upon the actual exchange names to be used. The BTCO planners decided that a six-character telephone number would be suitable for Toronto. This would consist of the first two letters of an exchange name followed by four station digits. The word "station" refers to the numeric part of a telephone number that uniquley identified a subscriber within an exchange. The selection of exchange names was particularly important due to the limitations imposed by the design of the SXS equipment, which had no translation capabilities and routed calls based on the numerals that were dialed. The SXS equipment also did not recognize letters. It only responded to the number of pulses sent by the numeric assigned to any given finger wheel hole. This meant that the planners had to be careful that there would be no conflicts when selecting exchange names. For example, a subscriber dialing **AD**elaide-1000 would send the pulses 231000 to the SXS equipment. A subscriber dialing **BE**ach-1000 would also send the pulses 231000 to the SXS equipment. Since the SXS equipment did not have the capability to distinguish the difference in these two calls, the use of both of these central office names was not viable. Unfortunately, none of this had mattered when the existing manual exchanges were given names. As a result, it was found that 5 of the 11 existing manual exchange names would need to be changed before the first automatic office went into service.

Why we are changing the names of some Exchanges

Subscribers are asking why we are changing "Beach" to "Gladstone," "Belmont" to "Hudson," "College" to "Trinity."

The automatic telephone system, which is to be installed, unit by unit in Toronto, requires that the subscriber secure the number he wants by rotating a dial attached to his telephone instrument, instead of by calling an operator, as with the present manual system.

In calling, the subscriber first dials the two initial letters in the name of the Central Office he is calling, followed by each digit of the called party's number.

In Toronto, the initial letters of some Central Office names conflict. For example, to call an Adelaide number it will be necessary to dial first the letter "A" followed by the letter "D." This, as you will note by referring to the illustration of the dial above, necessitates using the same finger-holes on the dial as when the "BE" of "Belmont" or the "BE" of "Beach" are dialled—that is, the same impulse is transmitted to the automatic mechanism.

It is to correct this conflict in the initial letters of exchange names that changes are necessary in some Central Office names in Toronto.

¶ *Because of these, and many other changes, please always consult the new directory before calling a number.*

Frank Kennedy, *Manager,*
The Bell Telephone Company of Canada

BTCO Notice: Exchange Name Change (November 1922)

Another numbering issue that needed to be resolved was the standardization of four-digit station numbers. Up to this point in time, station numbers consisted of from 1 to four digits. For example, one subscriber on the Main switchboard might have had station number 3; a second subscriber might have had station number 33; a third subscriber might have had station number 333; and a fourth subscriber might have had station number 3333. Due to the limitations of the SXS equipment, such an arrangement would not work. All subscribers would need to have four-digit station numbers. The public was made aware of this requirement with newspaper adverts and beginning in June 1923, when new telephone directories were issued, all manual subscribers were given four-digit station numbers. The existing subscribers with one, two or three-digit station numbers simply had their numbers filled in with the appropriate number of leading zeros. So, in the example above, the first three subscribers' numbers would change to 0003, 0033 and 0333, respectively.

The reasons why your New Telephone Directory is quite different

BECAUSE

It is designed to enable a calling subscriber to use either the *Automatic* type of telephone which is being gradually introduced, or the present Manual telephone.

With the *Automatic* the first two letters of the central office name are dialled in calling a number. That is why these first two letters have been capitalized in every case.

The first letters of several of the old central office names conflicted, hence the new names

RAndolph replacing North
LAkeside replacing Parkdale

GRover and ELgin are the names chosen for the two *Automatic* exchanges now under construction.

The prefixing of zeros to every number under 1000 is also to meet *Automatic* requirements. The mechanism which does the work of an operator must go through the same number of steps for every number called. So when you want a number with no "thousands" no "hundreds" and perhaps no "tens" you tell the mechanism so by dialling a zero for each missing step in the number. Thus LAkeside 64 becomes LAkeside 0064 and is given to the operator as Lakeside oh, oh—six-four," the exchange name being repeated as hitherto and the zeros as "Oh, Oh."

P. Kennedy, Manager

The Bell Telephone Company
of Canada

BTCO Notice: Exchange Name Change (June 1923)

Offering a consistent numbering arrangement across all exchanges, manual or automatic, was the best way to avoid subscriber confusion and it would be quite some time before the manual exchanges disappeared. In addition, a name and 4 numerals were easier to remember than an expanded all numeral format. As well, the telephone directory listings would be consistent, being the same format for both manual and automatic subscribers. As a result, the exchange name and 4 numeral format was standardized, along with a detailed extensive plan for the selection of exchange names going forward.

BTCO decided that the first automatic exchange would be located in the east end of Toronto in very close proximity (1 km) to the Gladsone (formerly Beach) exchange. However, the new automatic exchange would not be an immediate replacement for the manual Gladstone exchange. The plan was that Gladstone subscribers would be gradually transferred to the new exchange building over a period of three years. By mid 1927, there were no Gladstone subscribers remaining and the manual exchange went out of service.

The name that was selected for the new automatic exchange was “Grover”. This name did not appear to have any local significance in terms of a well-known person or place in Toronto. Rather, it seems to have been selected based on the new systemic approach to the naming of exchanges. The planners had developed a list of suitable names, perhaps with input from the Bell System, that took into account future exchange growth, limitations of the SXS equipment, the length of the names and lack of any ambiguity in understanding what the first two letters of the names were by anyone hearing them spoken. The location for the new exchange was to be on the east side of Main Street just north of Kingston Road. BTCO purchased two properties in the intended location for a total cost of $4650. On October 5th 1922, a building permit was issued to BTCO by the City of Toronto to erect a two-story brick building. The estimated cost was $156,000. The building had been designed by Bell’s Chief Architect, William John Carmichael, who must have been pretty good at his job, since in his career with BTCO he designed nearly 100 exchange buildings. Construction began before the end of 1922. The side lines of properties fronting on Main Street in this area run parallel to Kingston Road. However, this part of Main Street is at an acute angle to Kingston Road. So, with the front of the new building running parallel to Main Street and its sides running parallel to Kingston Road, the building necessarily took on a trapezoid shape instead of a rectangle, with its south side being longer than its north side. A small wing jutted out from the rear north side of the building.

Spending Millions in Toronto for Telephones

No. 1 of a Series on Toronto's Telephone Development

Last Year, 24,500 Telephones were connected in Toronto.

Toronto is growing by leaps and bounds.

Even more rapid than the City's industrial and residential growth is the demand for telephone service.

Behind the scenes, largely hidden from public view, the work of telephone expansion is being pushed as never before. Millions of dollars are being expended to overtake arrears and provide necessary spare facilities.

In addition to the widespread extensions going forward in the North Toronto area, we are spending right now in other districts of the city for wire and cable facilities alone—for what we call "outside plant"—

In the East	$450,000
In the West	310,000
Downtown	280,000

The new "Grover" central office under way at Main Street and Kingston Road, requires an immediate appropriation of $156,000; and for its complete equipment a million and a half dollars will be needed.

¶ In the announcement of this series to follow, we plan to give details of the stupendous job we are carrying through in practically all the exchange districts of Toronto—a programme which, for the next five years, will require an outlay of millions of dollars.

Frank Kennedy, Manager

The Bell Telephone Company of Canada

BTCO Notice: Grover Expenditures (January 1923)

Location of proposed Grover exchange building prior to construction, October 11 1922
(COURTESY BELL CANADA'S HISTORICAL COLLECTION)

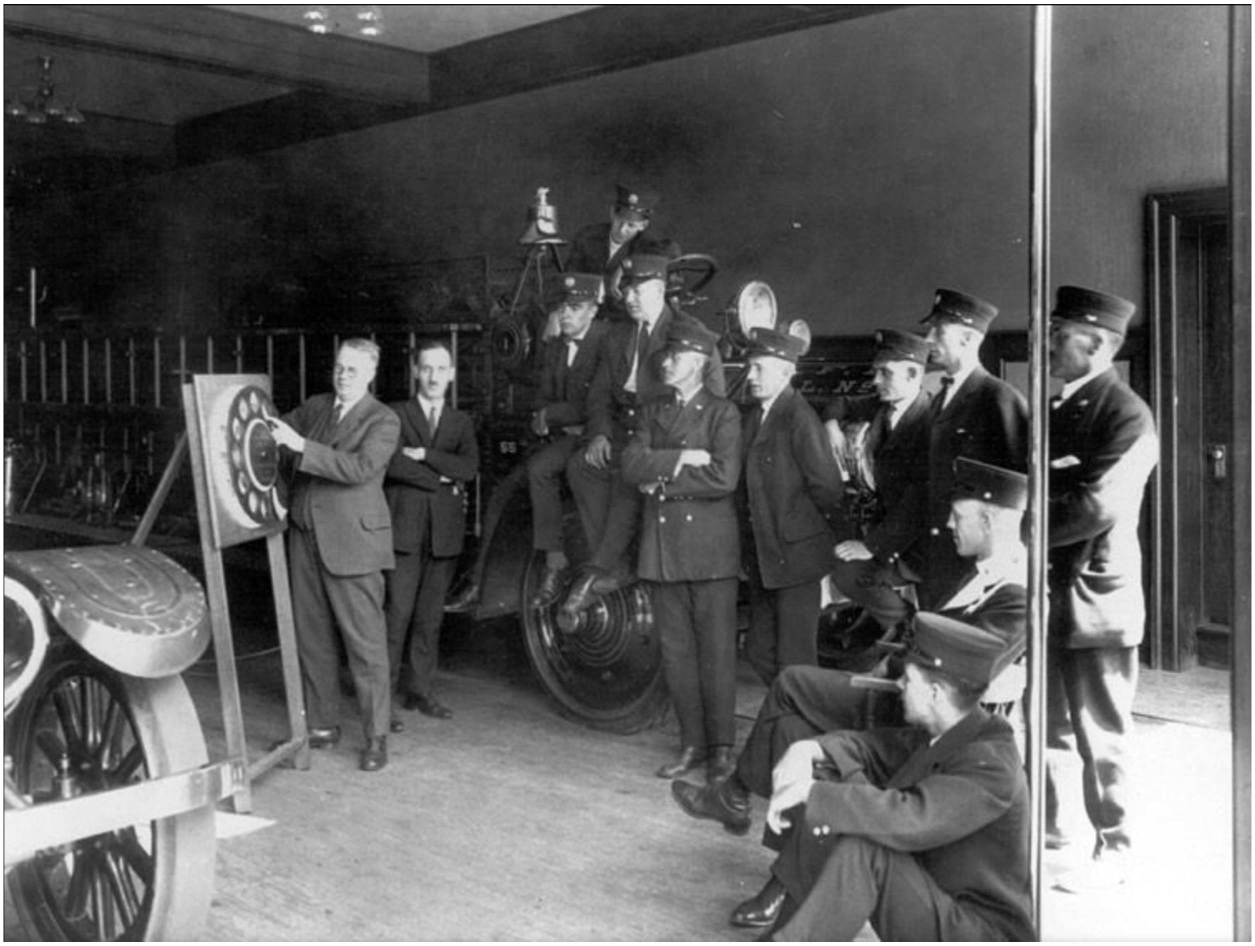
Grover exchange building under construction in 1923
(COURTESY BELL CANADA'S HISTORICAL COLLECTION)

The completed Grover exchange building on Main Street in 1924
(COURTESY BELL CANADA'S HISTORICAL COLLECTION)

As with many new buidings in the early days of an area's development, the street number of the new exchange building changed over the years. It began as 27, then 153 to 155 (don't ask), then 23, and finally 19 to 23 (likely due to the purchase of additional lots on its south side).

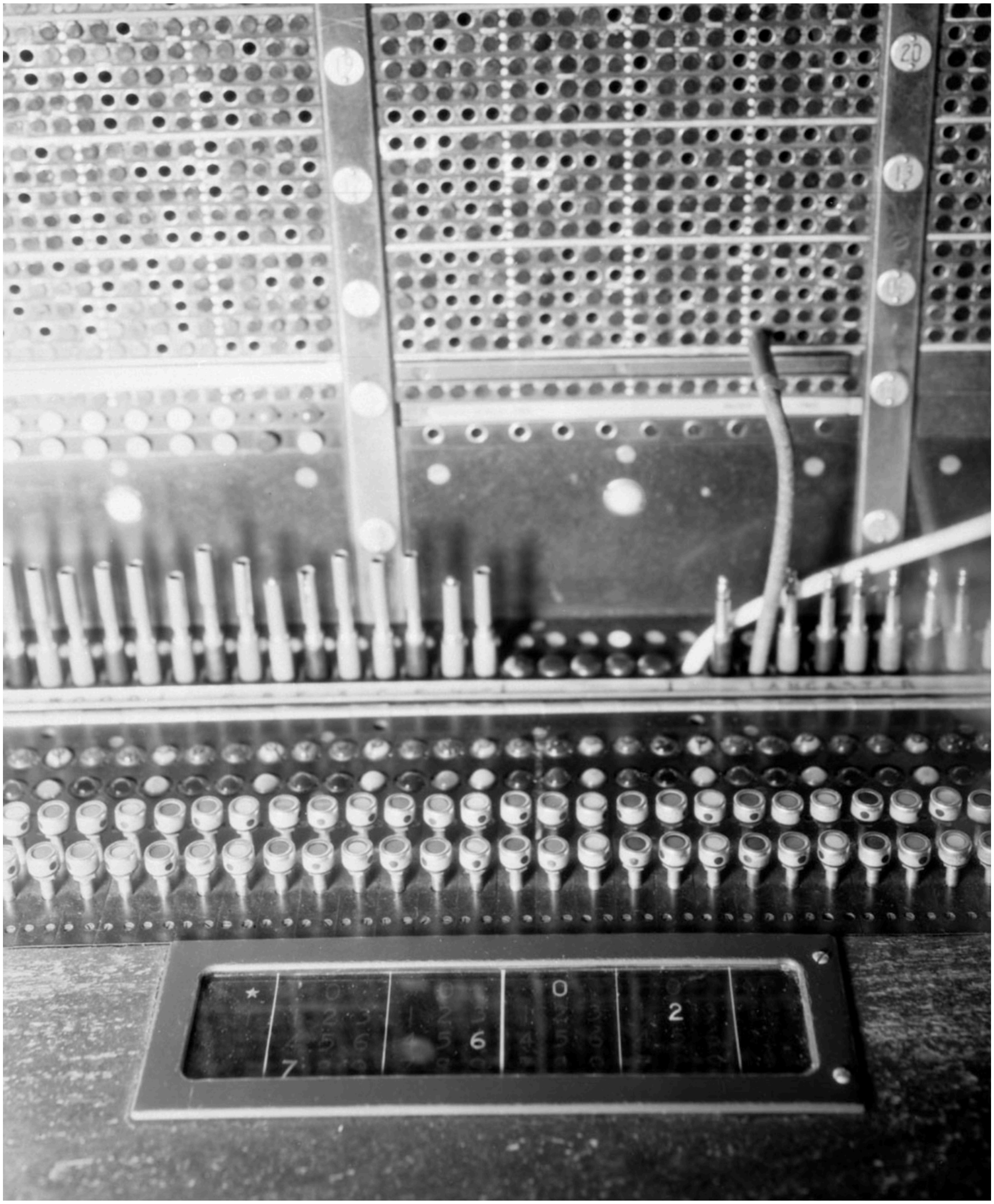
In order to handle growth in this new exchange area before the automatic system was ready, the Grover exchange was initially put into service in June 1923 as a manual exchange, temporarily co-located with the Gerrard exchange at 525 Logan Avenue. This allowed a base of Grover subscribers to grow that would not require number changes when the dial system cut into service. Sometime later in 1923 or early 1924, a manual switchboard was installed in the new exchange building on Main Street. All the Grover subscribers were then transferred to this building, still operating as a manual exchange.

Before Grover could be cut into automatic service a massive amount of training had to be completed. Internal BTCO training involved many departments such as traffic and equipment engineers, central office maintenance technicians, repair technicians, testers, telephone installers, commercial personnel and switchboard operators. External training was offered to the public in general, but was particularly necessary for the subscribers that would be changing from manual to automatic service. This was accomplished by a huge campaign that involved: mobile demonstration units that were taken to a variety of locations including public service groups, churches, businesses and schools; establishing a display room on Danforth Avenue in which passersby could come in and be educated; lantern slide shows; newspaper display ads; billing inserts; a comprehensive 12 page guide booklet; and a so-called “Flying Squadron” of twenty men that over a course of 6 weeks, were assigned the task of visiting every Grover subscriber to teach them how to use the rotary dial.

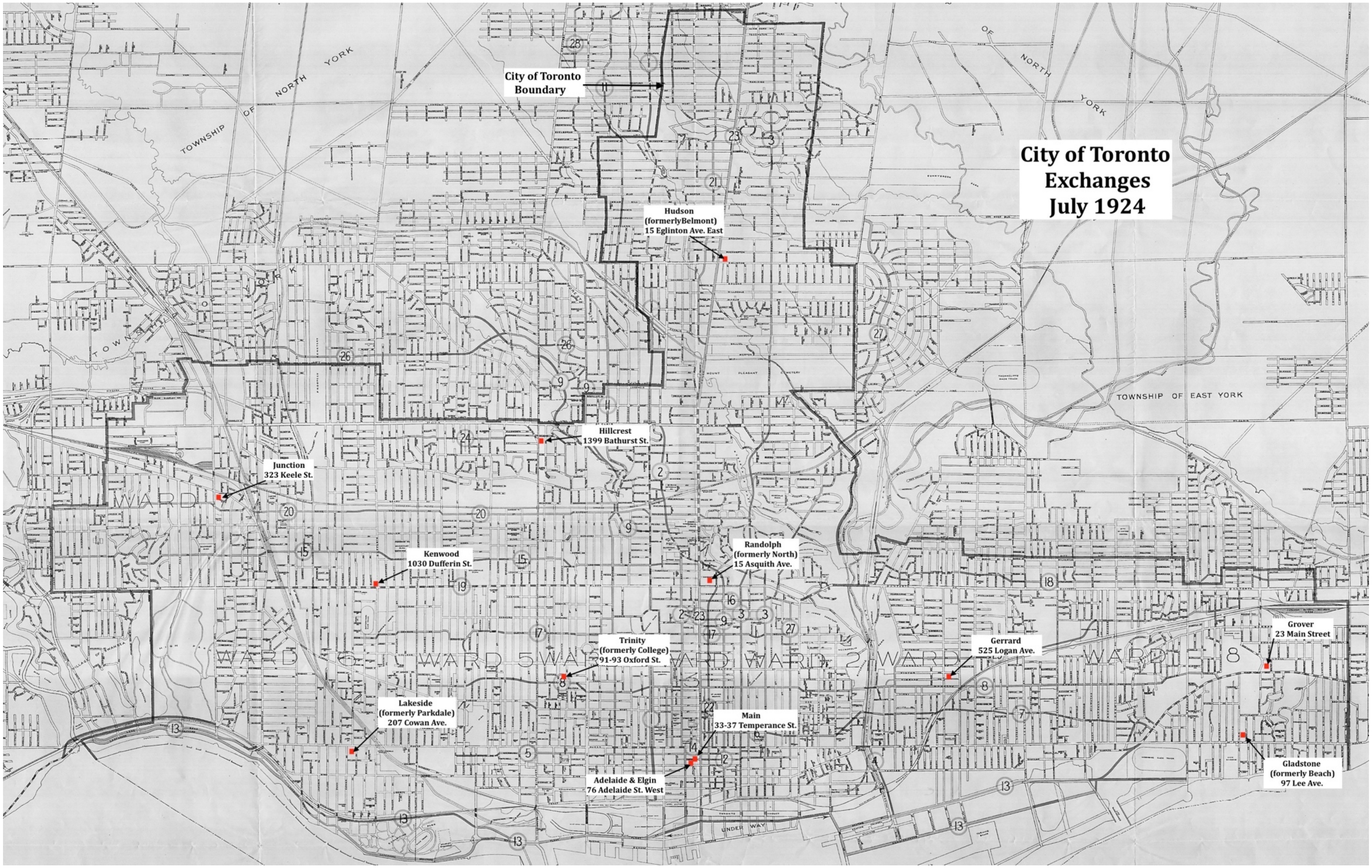


Dial training for firemen in advance of the Grover cutover (summer 1924)
(COURTESY BELL CANADA’S HISTORICAL COLLECTION)

In July of 1924, besides Grover, there were twelve other exchanges in the City of Toronto, all of which, of course, were manual. It was necessary for the Grover SXS equipment to interface with these exchanges. Each of these exchanges required modifications to the cord switchboard equipment. All “A” boards (which handled originating calls), had to be equipped with dials. This would allow operators, who received a request for connection to a Grover number, to plug into a Grover trunk and dial the station number of the called party. At each location a number of “B” boards (which handled incoming calls), needed to be equipped with expensive Call Indicator equipment ($14,000 per unit). The Call Indicator would receive the station numbers outpulsed from the SXS dial office and convert them into a display of lit lamps identifying each of the called station number digits. Upon seeing the called station number displayed, the operator was able to plug the incoming trunk cord into the jack of the called party and complete the call.



Call Indicator Display Panel on Incoming "B" Switchboard showing called station number 7602
(COURTESY BELL CANADA'S HISTORICAL COLLECTION)


City of Toronto
Exchanges
July 1924
City of Toronto
Boundary
Hudson
(formerlyBelmont)
15 Eglinton Ave. East
Hillcrest
1399 Bathurst St.
Junction
323 Keele St.
Kenwood
1030 Dufferin St.
Randolph
(formerly North)
15 Asquith Ave.
Trinity
(formerly College)
91-93 Oxford St.
Gerrard
525 Logan Ave.
Grover
23 Main Street
Lakeside
(formerly Parkdale)
207 Cowan Ave.
Main
33-37 Temperance St.
Adelaide & Elgin
76 Adelaide St. West
Gladstone
(formerly Beach)
97 Lee Ave.
TOWNSHIP OF NORTH YORK
OF NORTH YORK
TOWNSHIP OF EAST YORK
WARD
WARD 5
WARD 2
WARD 8

"Trunking" Toronto's Telephone Talks

No. 8 of a Series on Toronto's Telephone Development

Toronto exchange has grown from an upstairs room to 12 central office buildings.

The expense of the new "Grover" automatic office now being built on Main Street does not end with the $1,500,000 required for that office alone.

"Grover" subscribers must be able to reach not only other "Grover" subscribers but all those connected with our eleven exchanges throughout the city!

The equipment necessary in these eleven offices to complete automatic calls is costing over $900,000; while the necessary cable to connect the various city exchanges with "Grover" will involve an outlay of $94,000.

In Toronto every day, over 700,000 calls are "trunked." That is, 700,000 calls pass daily between subscribers in one central office district and those in another central office district. To take care of this great volume of traffic an elaborate system of switchboards and "trunk" cables, is necessary.

An increase in the number of subscribers in any one exchange means additional trunk cables to all the others.

For instance, a growth of 1,600 subscribers in "Gerrard" during the past twelve months made necessary an expenditure of $63,000 for additional trunk cables to carry traffic between "Gerrard" and "North" and "Gerrard" and "Adelaide."

Our expenditure in 1922 on additions to trunk cables exceeded $100,000 and 1923 plans involve a further outlay of over $150,000

Frank Kennedy, Manager

The Bell Telephone Company of Canada

Associated expenditures in addition to the Grover exchange

On Saturday, July 19th 1924 with all the planning, training, equipment installations and switchboard modifications completed, everything was ready to go. For the previous two days a team of operators had been calling the Grover subscribers to ensure that they were aware and ready for the change-over. The Grover building would get quite crowded. Attendees from BTCO included: president L.B. McFarlane; vice-president K.J. Dunstan; Toronto Manager Frank Kennedy and three other Toronto supervisors; five representatives from various BTCO departments in Montreal (since they would be performing their own cutover in 1925); six representatives from AT&T; two representatives from Northern Electric; at least thirteen cutover technicians; the 23 operators still handling calls through the Grover manual switchboard; a number of newspaper journalists; and two telephone engineers from Japan who were there investigating automatic equipment upgrades for their country after the Great Kano earthquake of 1923 had destroyed much of their network.

Long before the cutover, the Grover subscribers cable pairs had been connected to both the manual switchboard and the SXS equipment. When a Grover subscriber made a manual call, it was necessary to prevent the SXS equipment form being activated. This was accomplished by placing insulators between a pair of line switch contacts on each subscriber's SXS line switch. The insulators in each vertical column of line switches were strung together with a cord so that pulling on the cord would remove the insulators from a number of line switches simultaneously.

On July 19th 1924 at precisely 11:52 p.m., four men equipped with large shears began cutting the cables to the manual switchboard. As soon as they were done, thirteen men began removing the line switch insulators. Within minutes, the clickety-clacking of the SXS switches could be heard throughout the switch room. Everything was completed before the clock struck midnight and some 3000 Grover subscribers now had dial service. The transition went very smoothly with virtually no problems with the SXS equipment and only a few dialing errors by subscribers.

Dial desk stand and dial wall telephone used by Grover subscribers after cutover
(COURTESY BELL CANADA'S HISTORICAL COLLECTION)

Tonight at midnight

The new "Grover" automatic exchange will be put into operation. From that time on, all "Grover" subscribers will use the dial instrument in making telephone calls.

If you are a "Grover" subscriber and have not yet been shown how the new dial telephone is operated, why not—

1. Call at our Demonstration Room, 2202 Danforth Ave., or at our office, 76 Adelaide St. West, and let us show you how to dial telephone numbers, or
2. Telephone "Grover Repair Clerk" and ask to have a representative call on you, or
3. Consult the white pages at the front of the latest telephone directory (Pages 3 and 4).

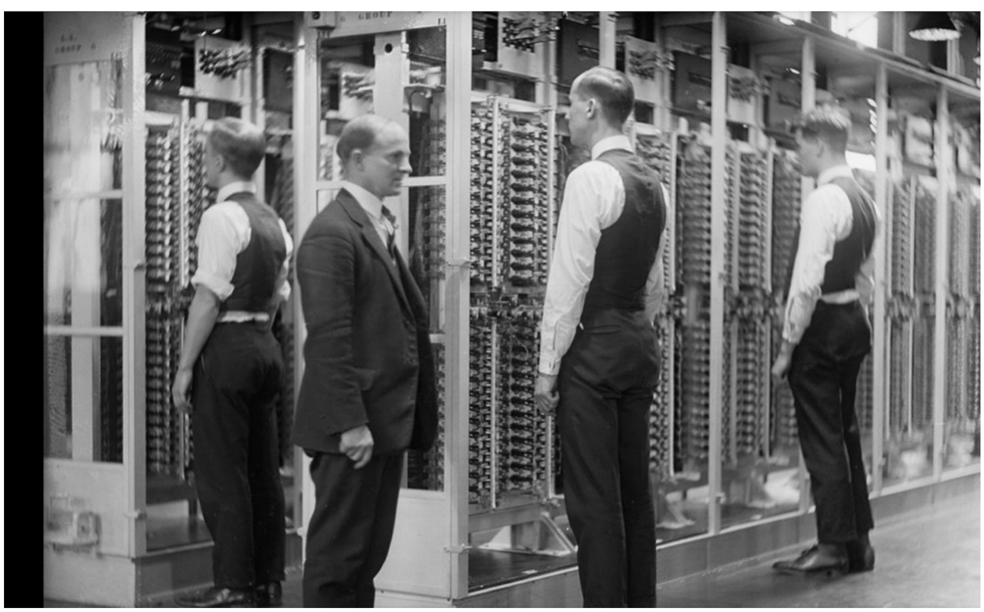
All subscribers outside of "Grover" area should continue to use the telephone in calling "Grover" numbers as heretofore.

FRANK KENNEDY, MANAGER

THE BELL TELEPHONE COMPANY OF CANADA

BTCO Notice: "GRover" First Dial Conversion (July 1924)

Ladies calling Grover subscribers just prior to cutover. New SXS equipment in background
(COURTESY BELL CANADA'S HISTORICAL COLLECTION)



Technicians preparing to activate the SXS line switches at a cutover
(this photo was not the actual Grover cutover, but the process was the same)
(COURTESY BELL CANADA'S HISTORICAL COLLECTION)

Grover Automatic Office is Now in Operation

OUR new "Grover" Central office was put into operation Saturday night at 12.00 o'clock. From present indications it would seem that the equipment is working satisfactorily and "Grover" subscribers are quickly adapting themselves to the new type of apparatus.

The opening of the "Grover" exchange is the first step in the program, which will extend over a number of years, of gradually converting Toronto's telephone service from manual to automatic operation.

If you are a "Grover" subscriber and have not yet been shown how to use the new dial telephone, will you please call at 76 Adelaide Street West? We will be glad to give you a demonstration.

Subscribers served from other City exchanges should continue to call "Grover" numbers exactly as heretofore.

FRANK KENNEDY, Manager.

THE BELL TELEPHONE COMPANY of CANADA

Newspaper notice after the cutover

As with many exchange names in those days, the public began to use the name Grover to denote the area in which a person or business was located. Some new businesses opening up in the exchange area used the word Grover in their business names. Examples include:

Grover Fish Market	GR 4369
Grover Hardware Company	GR 4367
Grover Lunch	GR 9405
Grover Tire Shop	GR 6134
Grover Real Estate	GR 1760
Grover Cast Stone	GR 7268
Grover Furniture Store	GR 0066

However, the most prominent business to use the Grover name was the Grover Theatre, established in 1928 and located at 2714 Danforth Avenue. Its huge hanging sign extending out in front of the theatre could be seen from quite some distance along the Danforth. Unfortunately, it seems that no Grover numbers were available when the theatre opened and the business had to settle for HOward 9245. However, the Grover Theatre name outlasted the Grover exchange name, finally closing its doors in 1957.

The Grover Theatre in the late 1920's

The Grover exchange area experienced rapid growth after the cutover, such that by the end of December 1924 there were already 7783 subscribers and it became apparent that another exchange would soon be required. Accordingly, in 1925 a two-story extension was added to the Grover building at a cost of $85,811. Another automatic switching system was installed on the 3rd and 4th floors and on December 19th 1925, the Hargrave exchange was cutover to automatic service. Hargrave was a pre-existing manual exchange located at the 97 Lee Avenue exchange building (along with Gladstone). A few days after Hargrave went into service, a new exchange name, Howard, was also put into service to handle growth in the area. Howard and Hargrave shared the same SXS switching system. Hargrave was never intended to be a permanent exchange at Main Street and it only remained there for 10 months. It was transferred to its own new building at 184 Simpson Avenue in October 1926.

The Grover building with its 1925 two-story extension (photo taken in 1937)

(COURTESY BELL CANADA'S HISTORICAL COLLECTION)

On December 21, 1942, a new exchange name “Oxford” went into service and was assigned to a SXS system in the Main Street building (joining “Grover” and “Howard”).

In the early 1950’s, a seven-year phase-in to 7-character telephone numbers began, using a 2-letter, 5-numeral format. This change was part of a new North American wide standard telephone numbering plan driven by the introduction of Nationwide Operator Toll Dialing and the upcoming introduction of Direct Distance Dialing. The change to the new format came to telephone numbers in the Grover area on March 20, 1955. The exchange name “Howard” was replaced by “Oxford 1”; the exchange name “Oxford” was replaced by “Oxford 9”; and the exchange name “Grover” was replaced by “Oxford 4”. After more than thirty years, the Grover exchange name ceased to exist. This was the last change to the exchange names before All Number Calling (ANC) was introduced, which was phased in between 1960 and 1966.

BTCO Notice: 8 More Exchange Names Change & Convert To The 2-Letter, 5-Figure Format (March 1955)

In 1969 the Main Street building had a major overhaul. Additional land had been puchased on the south side of the existing Main Street property in 1967 at a cost of $120,000. A two-story wing was added to the south side (another $908,721) and the entire building was encased in an aluminum cladding. The purpose of this was to help reduce outside electrical interference. As of 2023, the buiding still stands and remains under the ownership of Bell Canada.

The Main Street building in May 2021

In 1982, the Grover name underwent a bit of a revival when a new pub in the area opened its doors. The pub was named The Grover Exchange (later The Grover Pub & Grub). The name was chosen in recognition of BTCO's first dial exchange, which in part was due to the pub's location at 676 Kingston Road. From the back yard of the pub, you can see the BTCO Main Street exchange building, just two lots over. Downstairs in the pub, a series of framed photos and articles detailed the 1924 Grover cutover. The pub lasted for 40 years but closed in December 2022, another victim of the Covid-19 pandemic.

The Grover Pub & Grub September 2021

In North America, nearly all of the SXS switching systems were removed in the 1980's and 1990's, replaced mostly by the digital switching systems of Nortel and Lucent. The last SXS switch was removed from the Public Switched Telephone Network (PSTN) in 2002. This was a remarkable endurance record for such a technology, having lasted more than a century.

In 1963, Dual-Tone Multi-Frequency (DTMF) push-button telephones were introduced, which initiated the slow demise of the rotary dial. This decline was hastened from the late 1990's up to the present day due to the rapidly increasing use of the cell phone as a replacement for landline telephone service. However, even after more than a hundred and twenty years, the rotary dial still survives. If you are interested in owning a vintage rotary dial telephone, they can be found in antique stores, flea markets and online. If you'd like to hook one up and use it to make calls, there are a few options. For landline users, some telcos stiill permit calls to be made with rotary dial phones. If the telco doesn't allow it, there are devices available that convert dial pulses to DTMF. If you have Voice Over Internet Protocol (VOIP) telephone service, there are VOIP analog adaptors on the market that enable the use of rotary dials. If you have a Bluetooth capable smartphone, there is a Bluetooth adaptor that allows you to use your rotary dial phone to originate and receive calls via your smartphone. An enterprising engineer in New York City even produced and marketed a cell phone that uses a physical, functional rotary dial.

Pulse to DTMF converter

VOIP analog adaptor

Bluetooth adaptor

Rotary dial cell phone

This concludes my “GRover 1924” narrative. I hope you found it an interesting and enjoyable read. Should you wish to contact me regarding any of the content, you can email me at lhicken@gmail.com.

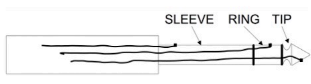
Many of the photographs seen in this narrative are from the archives of the Bell Canada Historical Collection. A grateful thank you to Bell Canada for providing and allowing me to use these photographs and other documentation.

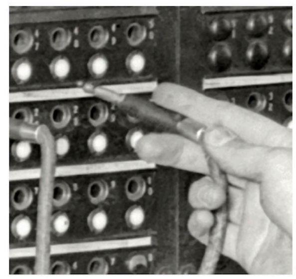
Below are three appendices that provide more detailed information on the SXS switching system in general and its arrangement and use in the Grover exchange.

Appendix 1

A Short Guide to the Grover Exchange Step-By-Step Telephone Switching System of 1924

Each telephone line has two wires that connect it to the exchange. These two wires handle the voice transmission and all signalling (dial pulses, ringing, off-hook, on-hook) and are designated as the “tip” and “ring” wires. At the exchange, each telephone line adds a third wire designated as the “sleeve” wire. The sleeve wire provides a number of control and busy/idle status functions. The connection path of a call through the SXS switch train contains the 3 wires, tip, ring and sleeve, which are generally shortened in references and diagrams to T, R and S. The names for these wires originated in manual switching systems and was based on the termination points of the wires inside a switchboard plug. The male plug

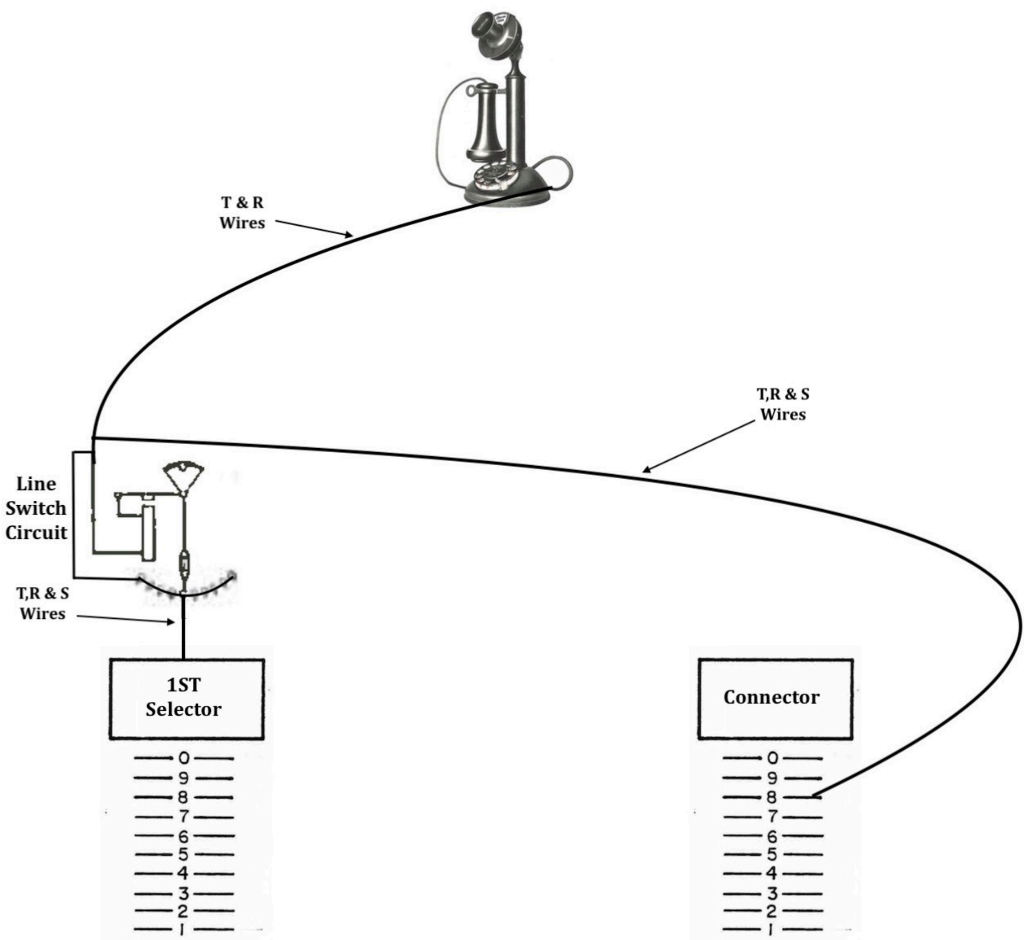




on the end of each cord was a 3-wire plug. So, the metallic portion of the plug that fitted into a jack had 3 insulated sections. One wire was connected to the section at the very end or "tip"of the plug. Another wire was connected to a short circular band or "ring" section behind the tip. The last wire was connected to a long cylindrical section that enclosed all three wires like a "sleeve".

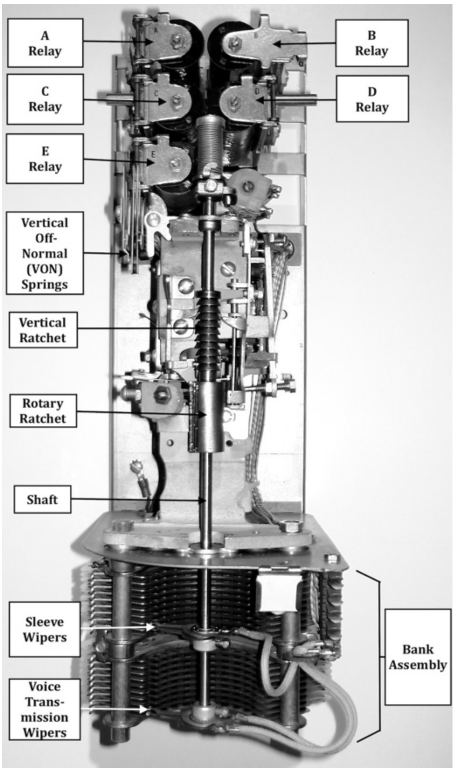
Each telephone line is attached to the SXS system in a way that allows it to both originate and receive incoming telephone calls. Every originating call requires attachment to a 1st selector switch and every incoming call requires attachment to a connector switch. Selectors and connectors are expensive pieces of hardware and it would be economically prohibitive to provide one of each of these switches for each telephone line. In the golden era of SXS switching, the average telephone subscriber only used the telephone line for about 5 minutes in the busiest hour of the day. So, if the lines were permanently attached to switches, these switches would be idle for all but a few minutes of the busiest hour, a very expensive inefficiency. In general, it was found that a very good level of service would be given if just enough switching equipment was provided to allow about 10% of the telephone lines to have simultaneous calls in progress. The SXS system is designed so that telephone lines are only attached to 1st selectors when originating calls are initiated and only remain attached for the duration of the calls. Similarly, connector switches are only attached to telephone lines when incoming calls are received and only remain attached for the duration of the calls. When the calls end, the selectors and connectors are released and become available to serve other calls. The attachment of telephone lines to 1st selectors is accomplished by using a switchable shared access arrangement controlled by Line Switch circuitry. In a typical setup, 1000 telephone lines are given shared access to 100 1st selectors. Without getting into a lot of detail, let’s just say that the action of lifting a telephone receiver off its switchhook activates its Line Switch circuitry which automatically connects the telephone line to a waiting (preselected) 1st selector. For incoming calls, telephone lines are divided into groups of 100. Each group is connected to a bank assembly, with each bank having capacity to terminate 100 sets of tip, ring and sleeve wires. These wires are multipled to 9 other banks. Ten connector switches are mounted on top of these banks, which through their wipers, give the 10 connectors shared acces to 100 telephone lines. The 10 connectors in a group are available for selection through a shared access arrangement from the preceding selectors. In addition to the 1st selectors and connectors, the Grover SXS system also has 2nd, 3rd and 4th selectors that are necessary to process the dialed numerals. These switches constitute the distribution stages of the switching network. They provide the wired logic that, step-by-step, gradually directs calls to their intended destination. Access to each stage of these selectors is on a shared basis from previous selectors. Sufficient quantities are provided to maintain the ability for about 10% of the telephone lines to to have simultaneous calls in progress in the busy hour. Below are some pictures, diagrams and explanatory notes to help in the understanding of the Grover exchange SXS switching system.

Telephone Line Connections to SXS Switching System

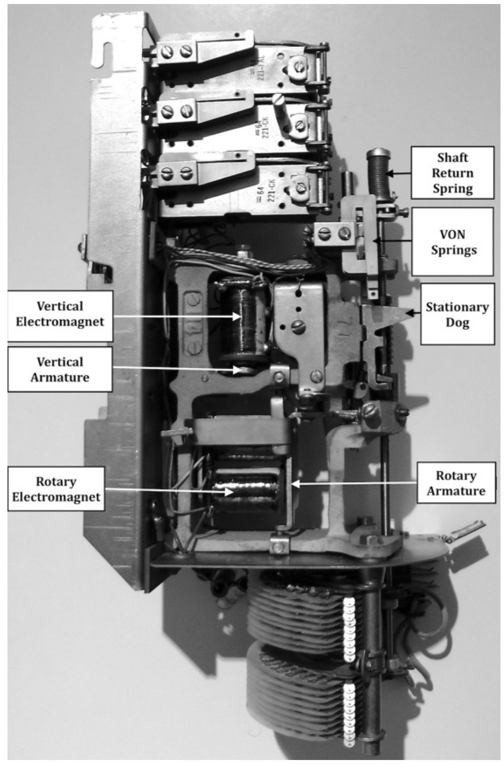


Each telephone line has two wires, designated as the tip and ring, connecting the telephone set to the exchange. At the exchange, the telephone line branches off to two connection points. The first connection point is to the Line Switch Circuit. Within a Line Switch circuit, each telephone line has a dedicated Primary Line Circuit which is activated on originating calls to initiate connection to a 1st selector. It is at this circuit that the 3rd wire, called the sleeve wire, is picked up to become part of the 3-wire call switching path through the SXS system. The second connection point is the is to a T, R & S contact set on the bank assembly of a connector switch. On an incoming call, a connector switch's wipers will come to rest on this contact set, thereby completing the connection to a called telephone.

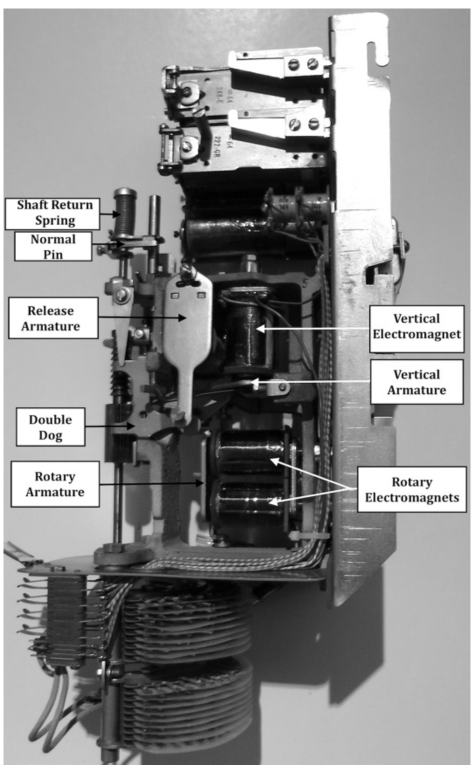
The Main Parts of a Typical SXS Switch (with bank assembly attached)



Front View



Left View

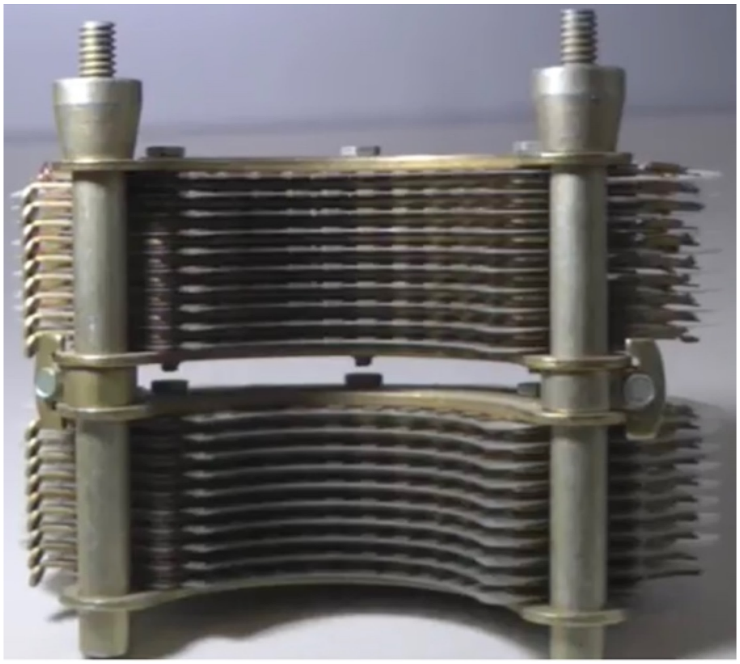


Right View

The relay assembly contains the relays for operating the stepping magnets, and contolling supervisory and operating circuit conditions. Depending on the switch function, relays also contol the application of dial tone, busy signals, overflow signals, talk battery and ringing current.

The stepping mechanism contains the vertical shaft equipped with contact brushes (wipers), ratchets, pawls and electromagnets by which vertical and rotary stepping motions are enabled. The shaft can be stepped vertically, one step at a time for up to 10 steps. Each vertical step aligns the wipers with a level on the bank assembly. The shaft can also be rotated, one step at a time for up to 10 steps. Each rotary step aligns the wipers with a contact position on a level of the bank assembly. This arrangement allows the wipers to access all 100 contact sets (T,R,S) on the bank assembly.

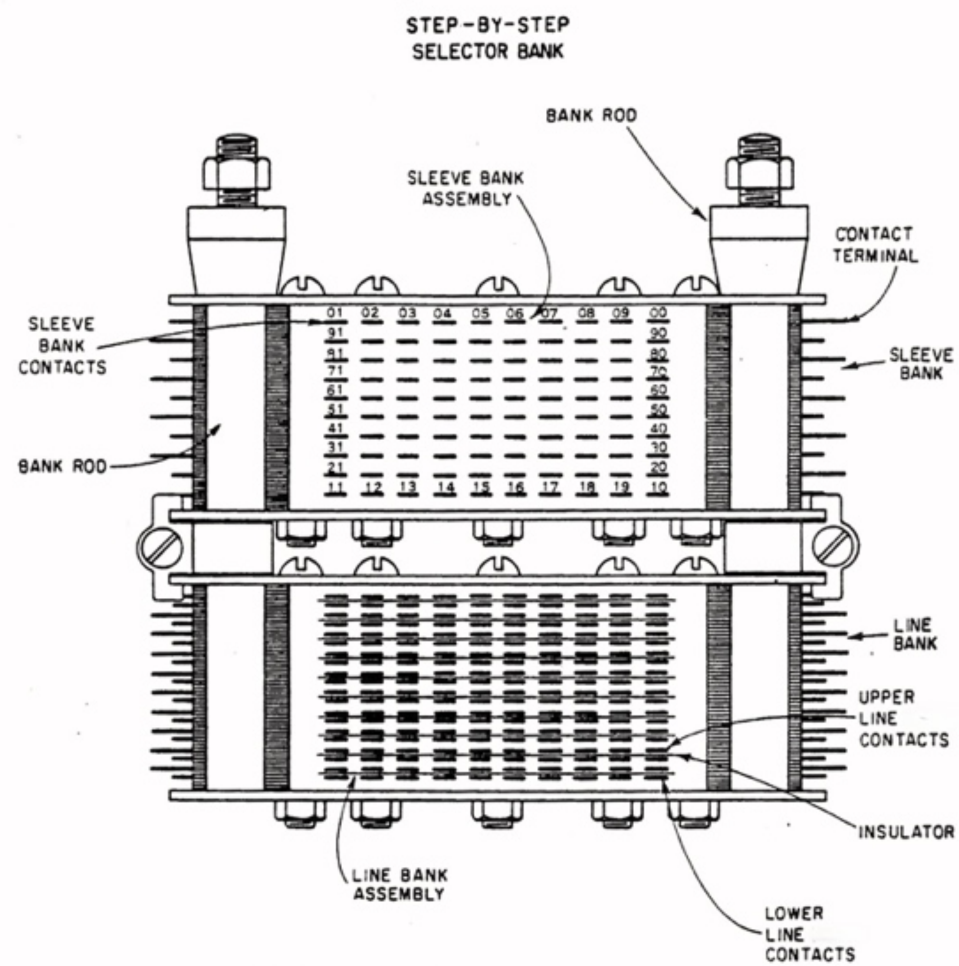
A SXS Bank Assembly



Front View

Bottom View

Numbering of the Terminal Contacts on the Selector and Connector Bank Assemblies

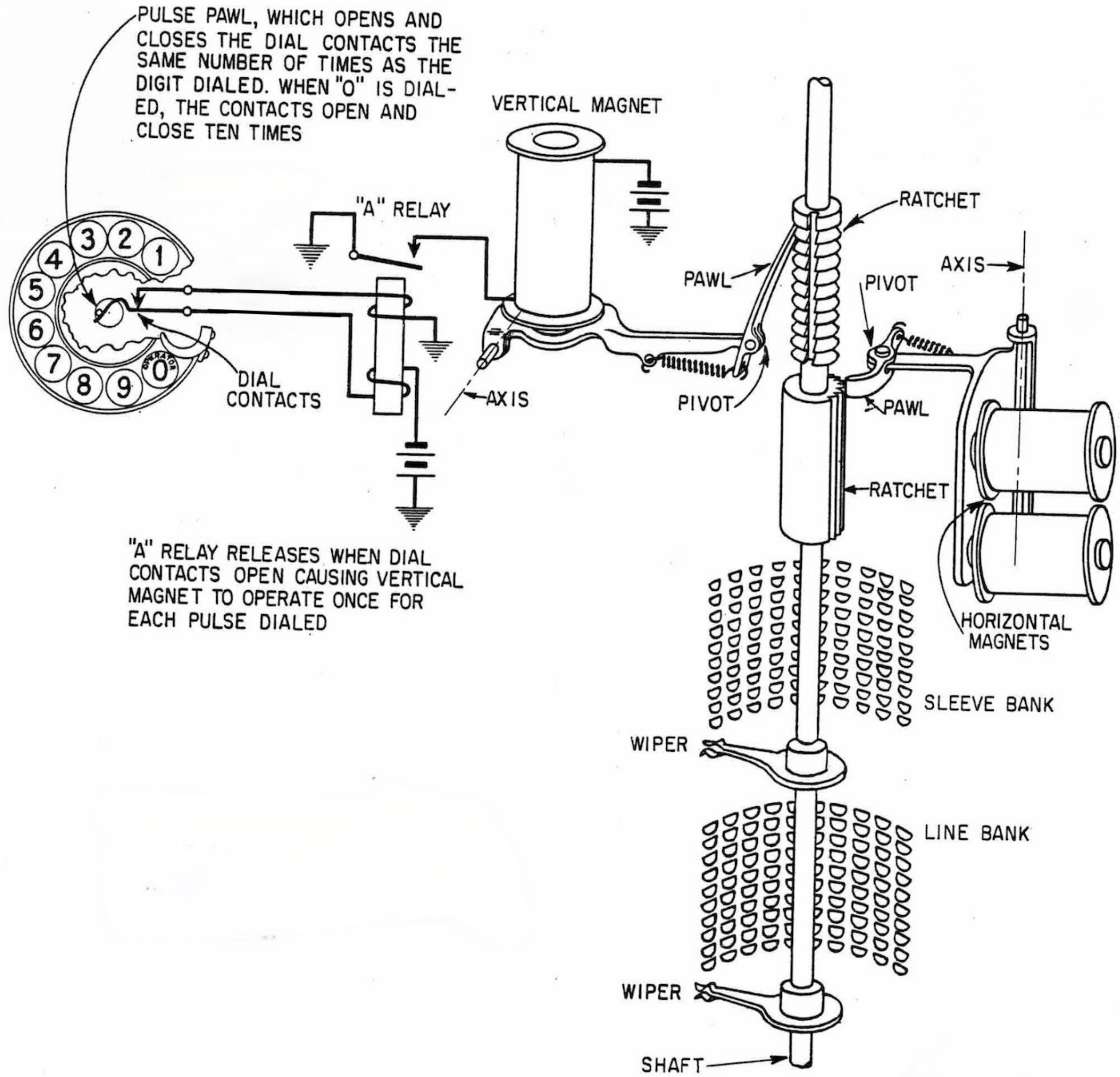


NOTE: BOTH SLEEVE AND LINE BANKS EMPLOY THE SAME NUMBERING ARRANGEMENT.

The banks of contacts (or terminals) are in horizontal semi-circular levels of ten contacts each and there are two tiers of ten levels. The lower tier contains the voice transmission path contacts. On this tier, each level has an upper and lower contact set, with the upper contacts being the Ring (upper line) contacts and the lower contacts being the Tip (lower line) contacts. The upper tier contains the Sleeve contacts which are used for switch control and busy/idle status indications. The contact numbering shown on the upper tier also applies to the lower tier. For banks associated with selectors, these contact numbers identify the trunk numbers to succeeding switches. The T, R and S wires for 100 trunks are connected to the rear side of selector bank contacts. Bank assemblies are generally equipped in units of 10, horizontally mounted side by side on an equipment shelf. The 100 T, R and S trunk paths are multipled in parallel to all 10 bank assemblies on a shelf so that there are only 100 trunk outputs from the 10 banks. Ten selectors mounted onto these banks would share access to the same 100 trunks. A unit of 10 banks and selectors is called a "division". For banks associated with connectors, the contact numbers identify the last two digits (tens and units) of the telephone numbers. The T, R and S wiring for 100 telephone lines is connected to the rear side of connector bank contacts. The 100 T, R and S line wiring is multipled in parallel to all 10 bank assemblies on a shelf so that there are only 100 line outputs from the 10 banks. Ten connectors mounted onto these banks would share access to the same 100 telephone lines.

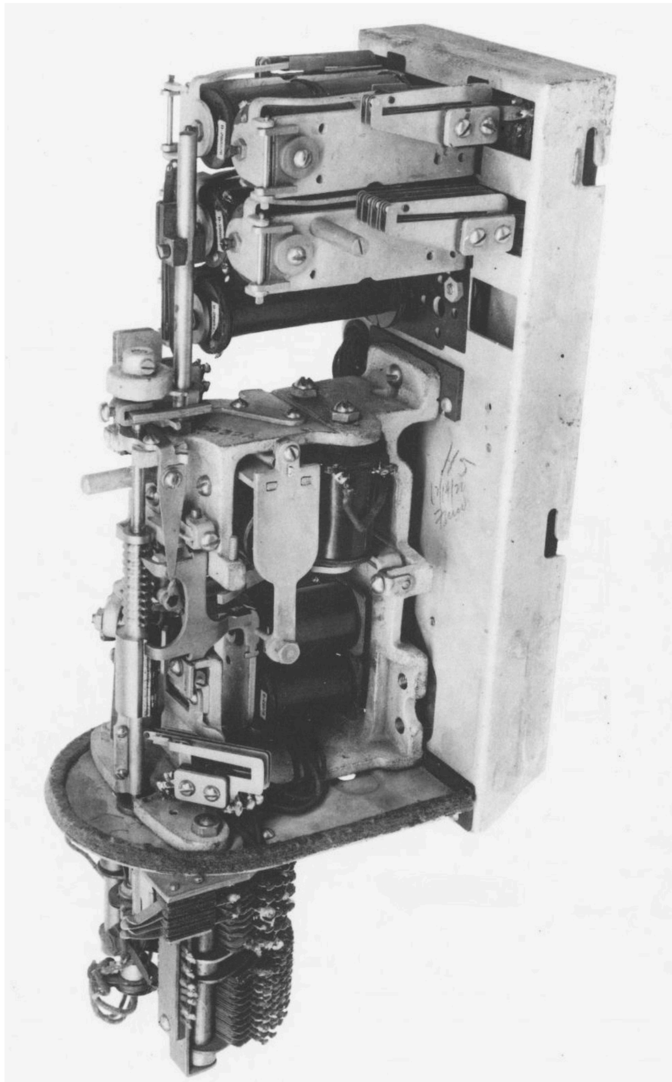
STEP - BY - STEP

STEP - BY - STEP SELECTOR
(OPERATION)



The vertical operation of the switch is under direct control of the subscriber's dial which causes the switch to step to a level corresponding to the digit dialed. The rotary movement of the selector is entirely automatic, thus the selector will "cut in" on the level dialed and hunt left to right in order to select the first idle terminal on that particular level. For example, dialing "zero" opens and closes the circuit ten times and will cause the selector to raise 10 levels (to 0 level), then automatically hunt for an idle terminal on that particular level.

Selector Switch



Selector switches constitute the distribution stages of the SXS switch train. In the Grover exchange, selectors process the first four characters of the called telephone number, which are the first 2 letters of the exchange name and the thousands and hundreds digits of the station number. Because selectors don't actually recognize letters, it is best to just say that they process the first 4 digits of the called telephone number (the last 2 are processed by connector switches). Any given selector only processes one of the four digits. Selectors are partitioned into four large groups designated as 1sts, 2nds, 3rds and 4ths, the designation reflecting whether they process the 1st, 2nd, 3rd or 4th digit dialed. Within a group, there may be one or more "ranks" of selectors, the rank being defined by the particular digit dialed to reach it. For example, the Grover exchange has 7 ranks of 2nd selectors because there are 7 different digits, 2 through 8, dialed in order to reach 2nd selectors (see the Appendix 2 Switching Diagram).

The 1st selectors process the first digit of all originating calls. The telephone lines get access to the 1st selectors on a shared and concentrating basis performed by the Line Switch circuitry. In a typical arrangement, the lines are divided into groups of 1000, each having access to 100 1st selectors. So, a full exchange would consist of 10 such groups, providing a total of 1000 1st selectors.

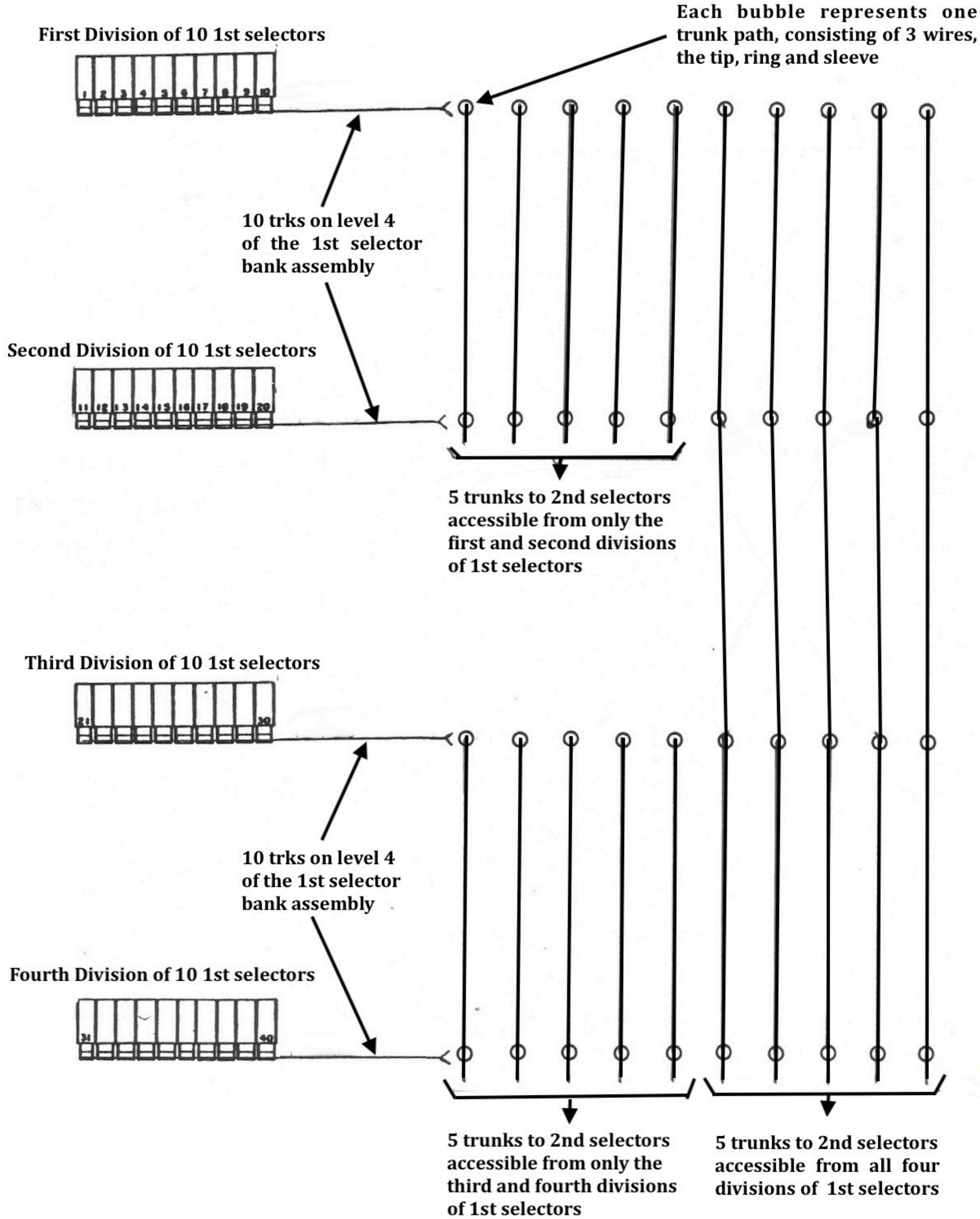
Selector bank assemblies are equipped in units of 10, which are called divisions, and are mounted side by side on a selctor shelf. The T, R and S wires of the 100 bank contact sets are multipled in parallel across all 10 banks so that the division of banks only has 100 trunk outputs. The 10 selectors mounted on these banks are also called a division of selectors. The selectors in a division all have access to the same 100 trunks. On any given level of a bank division, the selectors in that division all have access to the same 10 trunks.

It should be understood that for any given level of a selector bank, the trunks on that level are going to be available to one or more divisions of selectors on a shared access basis. Let's look at a hypothetical example. In the Grover exchange, let's say there were 1000 1st selectors installed that were spread over 100 divisions. Let's also say that there was a requirement for 10 trunks to the Assistance Operator switchboard from level zero of these 1st selectors. There are 10 trunk outputs on level zero from each division of 1st selectors. Each trunk output would be multipled to its like numbered output across all 100 divisions, so that all 1000 1st selectors would have shared access to the same set of 10 trunks to the Assistance Operator switchboard.

Now let's examine the trunking requirements on level 4 of the 1st selectors. The calls on this level are destined for the GHI rank of 2nd selectors, which handle traffic to the Grover, Gladstone, Hillcrest and Gerrard exchanges. There is going to be a lot of traffic to this level, enough to require hundreds of trunks to the GHI 2nd selectors. But no individual 1st selector division can access any more than 10 trunks on level 4 because the bank assembly only has 10 contact sets on each level. When the trunk requirements on a level exceed 10 trunks, not every selector division can be given access to all the trunks. Therefore, it is necessary to split the 100 divisions of 1st selectors into equally sized subgroups, such that each subgroup would be given access to an equal portion of the trunks. It was found that 10 trunks would be able to handle the traffic from 2 divisions. So, the simplest arrangement would be 50 subgroups of 2 divisions, with each subgroup having access to its own subset of 10 trunks. The total trunk requirement to the GHI 2nds would be 500 trunks. However, this arrangement is inefficient due to the low capacity of small trunk group sizes, such as a trunk group of 10 trunks. Mathematicians determined that the larger the trunk group size, the greater would be the traffic carrying capacity of each trunk in the group. Trunks between 1st and 2nd selectors are engineered to provide 1% blockage on offered calls in the busy hour. This means that 99% of the offered calls would find an idle trunk and 1% would not. To meet this blockage service level, each trunk in a group of 10 trunks could only be in use for 24.6 minutes of the busy hour. If the trunk group size could be increased to 15 trunks, each trunk in the group could be in use for 32.4 minutes of the busy hour. In the example we are looking at, it was determined that providing 25 subgroups of 4 divisions, each accessing 15 trunks would provide about the same traffic capacity as the 50 subgroups of 2 divisions, each accessing 10 trunks. This arrangement reduces the trunks to GHI 2nd selectors from 500 down to 375. But if a division is limited to 10 trunk access, how can a trunk group size of 15 trunks be provided? Well, in this setup, 5 of the 15 trunks in each subgroup are multipled so that all 4 divisions have access to them; another 5 of the 15 trunks are only multipled to the first 2 of the 4 divisions; and the remaining 5 trunks are only multipled to the last 2 of the 4 divisions. This arrangement, in which some trunks in a subgroup are accessible to all divisions in the subgroup while other trunks are only accessible from part of the divisions, is called "graded multiple trunking". A diagram of this arrangement is shown below. Such arrangements had been under continuous development since 1907 and weren't completely finalized until 1949, when subgroups were given access to up to 45 trunks. A particular subgrouping and trunking pattern configuration has to be determined for every level of every group and rank of selectors based on projected traffic loads. This work is performed during the engineering phase of every SXS initial installation and extension job.

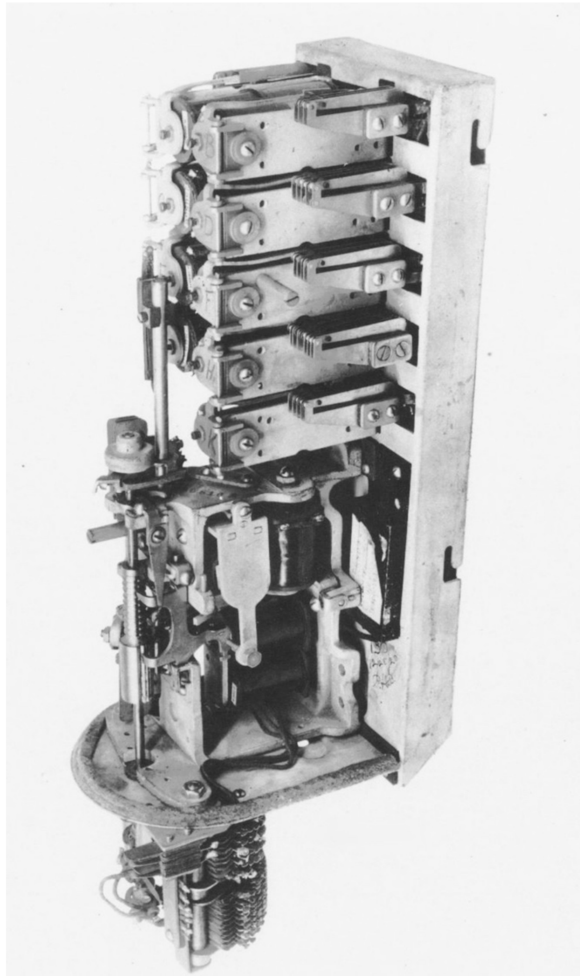
Graded Multiple Trunking

One Subgroup of 40 1st Selectors Accessing 15 Trunks To 2nd Selectors



This diagram depicts the graded multiple trunking pattern on level 4 of the bank assembly for one of the 25 subgroups of 4 divisions of 1st selectors. There are a total of 40 trunk path (10 per division) outputs from these 1st selector banks, but by bridging these ouputs in the manner shown, the total trunk path outputs to the 2nd selectors are pared down to 15 trunks. The remaining 24 subgroups would be wired in exactly the same manner.

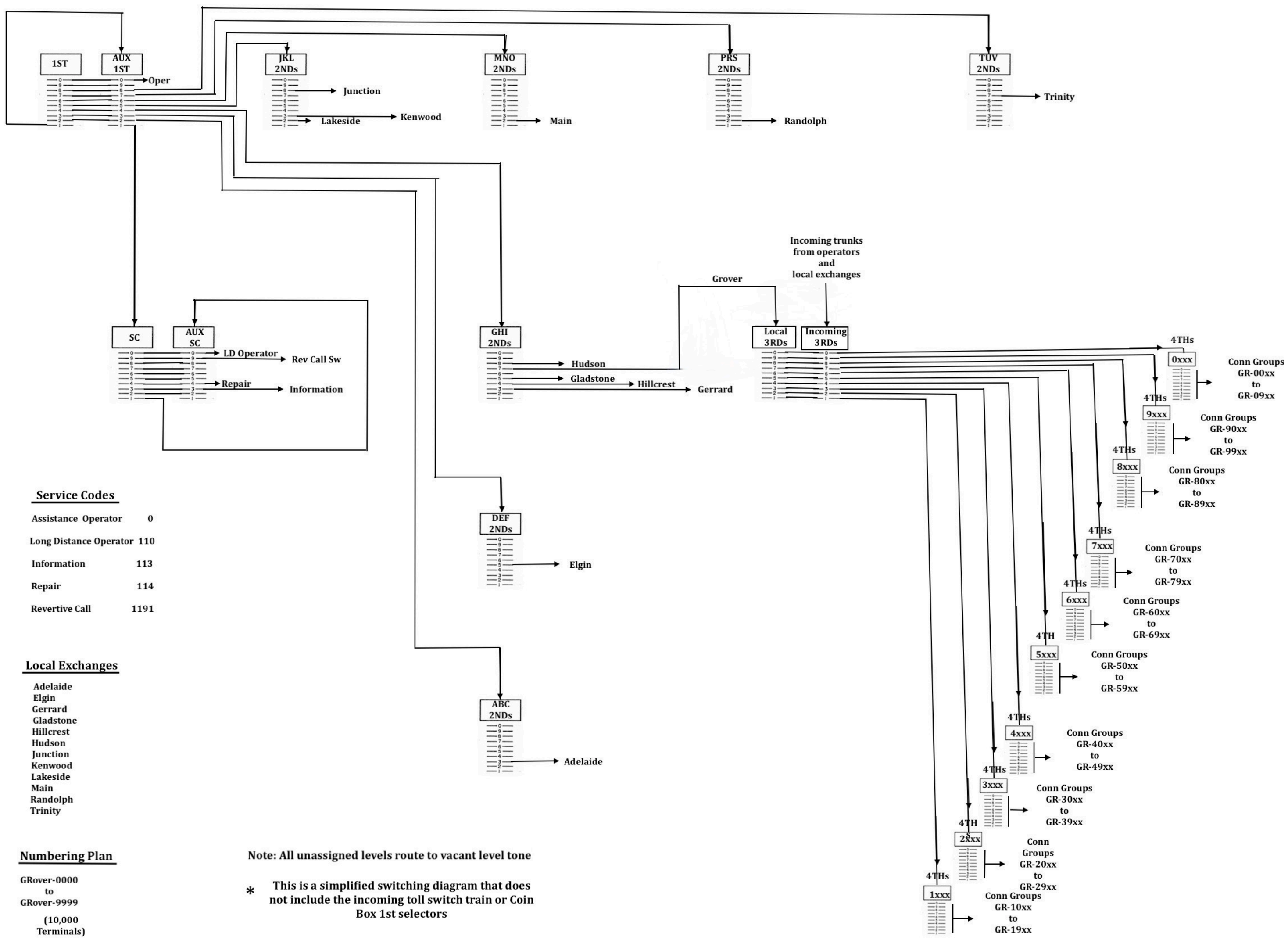
Connector Switch



The connector switch processes the last two (tens and units) digits of the called telephone number. It has several more relays than a selector because it has more functions to perform. When the tens digit is dialed, the connector responds by stepping the shaft and wipers vertically in the same way that a selector does. However, it does not proceed to perform an automatic rotary hunt because it is not seeking an idle succeeding trunk. Instead, it waits for the units digit to be dialed and then rotary steps in accordance with the number of pulses received. This is because the bank assembly terminates 100 telephone lines and it is one particular bank contact set that the wipers need to come to rest on, which is the contact set associated with the dialed tens and units digits. The connector switch also performs the following tasks: tests the called line for busy/idle status; if the called line is busy, sends busy tone to the calling line; if the called line is idle, connects ringing current to the called line and audible ringing tone to the calling line; trips the ring upon call answer; stops the called line from initiating a dial tone request upon call answer; connects the calling and called parties together and provides talk battery; makes the called line appear busy to other incoming calls; maintains the switch train connection; monitors for the end of the call and then releases the switch train.

Appendix 2

Grover Exchange Switching Diagram *



Service Codes

Assistance Operator	0
Long Distance Operator	110
Information	113
Repair	114
Revertive Call	1191

Local Exchanges

Adelaide
Elgin
Gerrard
Gladstone
Hillcrest
Hudson
Junction
Kenwood
Lakeside
Main
Randolph
Trinity

Numbering Plan

GRover-0000
to
GRover-9999

(10,000 Terminals)

Note: All unassigned levels route to vacant level tone

* This is a simplified switching diagram that does not include the incoming toll switch train or Coin Box 1st selectors

Appendix 3

Call Progression for an Intraoffice Call to GRover – 5789

When the SXS telephone switching system was introduced to Toronto in 1924, the telephone numbers were 6 characters long and were made up of two letters (the first two letters of the exchange name) and 4 numerals (the 4-digit station number). The exchange name was Grover, so let's examine a call from one Grover subscriber to another Grover subscriber. For this example, we'll let the called number be GR-5789 (Note: As you read through this, follow the call path using the diagram on the last page).

The caller lifts the receiver of the calling telephone off the switchhook. This closes a loop on the line, which activates its Line Switch circuitry at the exchange. The Line Switch performs the task of connecting the calling telephone line to a 1st selector. The chosen 1st selector's "A" relay operates over the closed loop at the telephone set and the selector prepares itself to receive dial pulses. When the 1st selector is ready, it sends dial tone to the calling line, which can be heard through the receiver of the telephone as an indicator that the switching system is ready for the caller to begin dialing.

Only dial fingerwheel holes 2 through 9 contain letters, with 3 letters per fingerwheel hole for a maximum of 24 choices for the first exchange name letter to be dialed. The SXS system does not recognize letters. It only recognizes numerals on the basis of the pulses received from a returning dial. So, for the first exchange name letter, there are only 8 achievable different inputs to the SXS equipment, those being from 2 pulses to 9 pulses. Again, for the second exchange name letter to be dialed, only fingerwheel holes 2 through 9 may be used and so there are only 8 possible inputs to the SXS system. The first two letters dialed would produce 576 (24 x 24) possible letter combinations, but only 64 (8 x 8) possible pulse combination inputs to the SXS equipment. This means the subscribers could reach a maximum of 64 exchanges, each having a maximum of 10,000 station numbers for an overall total maximum of 640,000 telephone numbers. The process that follows explains how the SXS equipment narrows a call down to one of those 640,000 possibilities.

The caller begins to dial the first letter of the exchange name (GRover) by inserting a finger into the finger-wheel hole of the dial position for the letters "GHI", which is also numerical position "4". The caller rotates the dial clockwise to the finger stop position. This activity has no affect on the SXS system at the exchange. The finger is removed from the dial and the dial automatically rotates anticlockwise towards its normal resting position. As it does this, it pulses (opens and closes) the line loop four times, which corresponds to the numeric value of the digit that was dialed. At the SXS exchange, the 1st selector "A" relay reacts to these pulses by releasing and re-operating four times. This causes the 1st selector's vertical magnet to operate and release four times, which, through the actions of the vertical pawl and ratchet, steps the shaft with its wipers upwards four steps so that the wipers are aligned with the fourth level of the bank assembly. The selector recognizes that vertical motion has stopped and automatically, through the actions of the rotary magnet, pawl and ratchet, begins rotating the shaft and wipers across the contacts on level 4 of the bank assembly, hunting for an idle trunk to a 2nd selector. The rotating line (tip and ring) wipers and the sleeve wipers brush against the tip, ring and sleeve contact sets on level 4, one set at a time. The sleeve wiper is looking for an idle trunk condition, which means there should not be any electrical potential (either battery or ground) on the sleeve contact of the trunk. A busy trunk (one that is being used) will have a ground condition on the sleeve contact of the bank multiple. In this application, a trunk is merely a set of three wires (tip, ring and sleeve) joining two selectors. When an idle trunk is found, the rotary motion stops, with the wipers coming to rest in a holding position on the contacts of the chosen trunk. The far end of the trunk terminates on a 2nd selector. The 2nd selector chosen is one out of a large rank of 2nd selectors all assigned to level 4 of 1st selector banks. The key factor to be noted here is that every selector in this particular rank of 2nd selectors only ever gets chosen if the first numeral dialed is 4. Because exchange names are being used, you could also say that this rank of 2nd selectors is only ever chosen if the first letter dialed is in the GHI combination (sometimes the end panel on an equipment bay of such selectors would be labelled to indicate that this bay contained the "GHI 2nds"). The list of possible exchanges to connect to on this call has been reduced from 64 to 8 (because first numeral choices 2, 3, 5, 6, 7, 8 and 9 have been eliminated as possibilities), and the list of possible telephone numbers that can be reached has been reduced from 640,000 to 80,000. The 1st selector resets itself as a passive pass-through selector in which the calling telephone and the tip, ring and sleeve leads from its line switch circuit are connected through the 1st selector relay contacts, wipers and bank contacts to the tip, ring and sleeve wires of the trunk to the 2nd selector. The 2nd selector is now seized by virtue of the closed loop at the telephone set and its "A" relay operates. The 2nd selector assumes control of the switch train and grounds the sleeve wire to keep the 1st selector and the line switch held up in their off-normal positions. Since the detailed actions of the selectors are similar for each selector stage, the descriptions are abbreviated for the rest of the switch train.

The caller dials the second letter of the exchange name, which is the letter "R" (numerical position "7"). The returning dial sends 7 pulses to the 2nd selector, which responds by establishing a connection to a trunk to a 3rd selector on level 7 of its bank assembly. The 3rd selector chosen is one out of a large group of 3rd selectors all assigned to level 7 of the 2nd selector banks. The key factor to be noted here is that every selector in this particular group of 3rd selectors only ever gets chosen if the two preceding numerals dialed are "47". The list of possible exchanges to connect to on this call has again been reduced from 8 to 1 (because second character numerals 2, 3, 4, 5, 6, 8 and 9 have been eliminated as possibilities), and the list of possible telephone numbers that can be reached has been reduced from 80,000 to 10,000 (GR-0000 to GR-9999). From purely a letter aspect there are actually nine letter combination that could have been dialed to reach this same point of connection. These are: GP, GR, GS, HP, HR, HS, IP, IR and IS. The BTCO planners had to ensure that only one of these combinations, GR, would be used in the entire local calling area for the City of Toronto. In fact, 5 exchange names in Toronto had to be changed before automatic service was introduced to avoid such conflicts. The 2nd selector connects the calling telephone line through to the 3rd selector, which is now activated by virtue of the closed loop at the telephone set. The 3rd selector assumes control of the switch train and grounds the sleeve wire to keep the line switch, 1st and 2nd selectors held up in their off-normal positions.

We have now finished with the exchange name portion of the dialing and are beginning the station number portion of the dialing. The caller dials the thousands digit of the called number, which is a “5”. The returning dial sends 5 pulses to the 3rd selector, which responds by establishing a connection to a trunk to a 4th selector on level 5 of its bank assembly. The 4th selector chosen is one out of a large rank of 4th selectors all assigned to level 5 of the 3rd selector banks. The key factor to be noted here is that every selector in this particular rank of 4th selectors only ever gets chosen if the three preceding numerals dialed are “475” (or GR-5). The list of possible numbers to be reached has been reduced from 10,000 to 1,000 (because thousands digits 1,2, 3, 4, 6, 7, 8, 9 and 0 have been eliminated as possibilities). The only possible telephone numbers that can be reached are GR-5000 to GR-5999. The 3rd selector connects the calling telephone line through to the 4th selector, which is now activated by virtue of the closed loop at the telephone set. The 4th selector assumes control of the switch train and grounds the sleeve wire to keep the line switch, 1st, 2nd and 3rd selectors held up in their off-normal positions.

The caller dials the hundreds digit of the called number, which is a “7”. The returning dial sends 7 pulses to the 4th selector, which responds by establishing a connection to a trunk to a connector switch on level 7 of its bank assembly. The connector chosen belongs to a group of connectors that only ever gets chosen if the preceding numerals dialed are 4757 (or GR-57). The list of possible numbers to be reached has been reduced from 1,000 to 100 (because hundreds digits 1, 2, 3, 4, 5, 6, 8, 9 and 0 have been eliminated as possibilities). The only possible telephone numbers that can be reached are GR-5700 to GR-5799. The 4th selector connects the calling telephone line through to the connector, which is now activated by virtue of the closed loop at the telephone set. The connector assumes control of the switch train and grounds the sleeve wire to keep the line switch, 1st, 2nd, 3rd and 4th selectors held up in their off-normal positions.

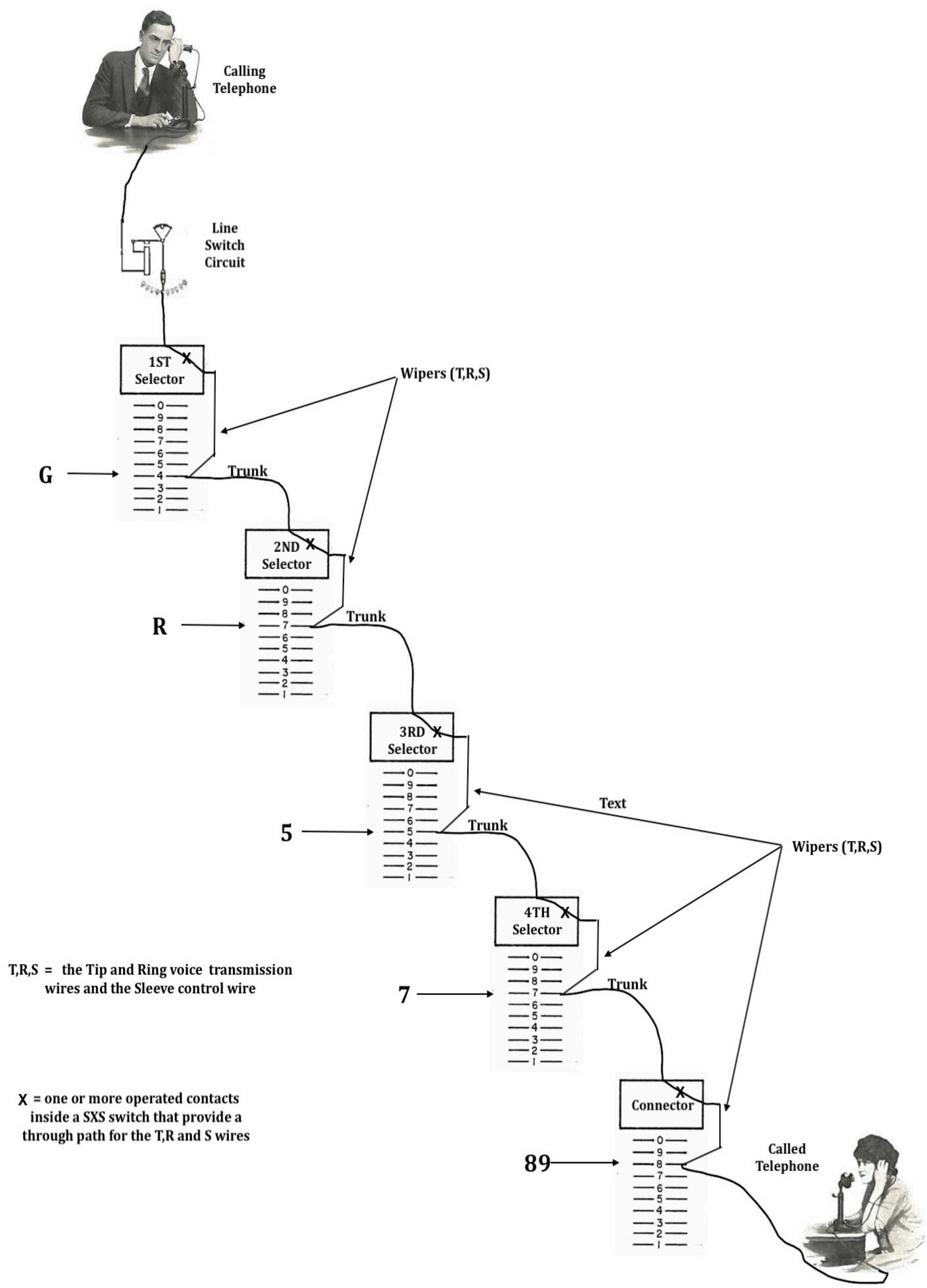
Unlike the selectors, which only process one numeral, connectors process two numerals, those being the tens and units digits of the called telephone number. The first numeral to be processed is the tens digit.

The caller dials the tens digit of the called number, which is an “8”. The returning dial sends 8 pulses to the connector, which responds by stepping the shaft with its wipers upwards eight steps so that the wipers are aligned with the eighth level of the bank assembly. The connector recognizes that vertical motion has stopped and prepares the connector shaft for rotary motion and awaits the last number to be dialed. At this point, the list of possible telephone numbers to be reached has been reduced from 100 to 10 (GR-5780 to GR-5789). The caller dials the units digit of the called number, which is a “9”. The connector responds by rotating the shaft with its wipers horizontally nine steps. When the 9th contact set is reached, rotary motion stops since there are no more pulses being received. This reduces the list of possible telephone numbers to be reached from 10 to 1 (GR-5789). The connector’s T, R and S wipers are now resting on the connector bank contacts assigned to the called party’s telephone number. These T, R and S contacts are wired to the called party’s line circuit, and from there, the T and R wires extend out to the called telephone set. Since the called telephone is idle (on-hook), there will be battery on the sleeve contact of the bank assembly supplied from the called telephone’s line switch circuit. When the connector recognizes battery on the sleeve, it connects ringing current to the called line. A small portion of ringing current is also sent back to the calling telephone to provide an audible ringing signal in the receiver. The **GR**over – 5789 telephone set now begins to ring. When the called party answers, it closes the loop on the called line. This is recognized by the connector and it removes ringing current from the line and connects the incoming tip, ring and sleeve from the 4th selector, through itself, to the outgoing tip, ring, and sleeve of the called line. The calling and called parties are now connected and may begin their conversation.

If the called party was already busy when this call came through, there would be ground on the sleeve instead of battery. When the connector recognizes ground on the sleeve, it connects busy tone (a 60 interruptions per minute buzzing sound) to the calling line.

The entire switch train is held up for the duration of the call by a ground on the sleeve wire supplied from the connector. When the call has ended, the loop on the line opens, which causes the "A" relay in the connector to release and all other connector relays follow suit. This removes the ground from the sleeve and all the switches release to their normal (idle) position.

Call Path Through The Grover SXS Switching System



This switching diagram shows the connected call path through the SXS system of an intraoffice call to **GR**over – 5789.