Only a very few engineers who are fascinated not only by the future development of telephony, but also by its past history, still find it worth while to contemplate and try to understand the vestiges of the early days of electromechanics.

No museum has so far engaged in the systematic collection of these souvenirs of the past, except for a few parts or models which have been saved from destruction and are scattered among various national telecommunication museums. Nor is there any detailed monograph on the subject which would show the diversity of designs. Such a work would require long and patient research and, if it were ever undertaken, it would certainly have to mention three fundamental references[4]:
–the article by P.C. Smith which appeared in 1929 [11],
–the article by R.B. Hill, already mentioned [5], which appeared in 1953,
–the detailed bibliography annexed to the chapter on automatic telephony of reference [1].

1.5. For anyone who wishes to philosophize, what a vast difference there is between this era of the late nineteenth century and the times in which this book has been written!

1.5.1. In our days, the process of designing and developing a switching system is measured in:
–hundreds of engineer/years,
–and, in monetary values, tens, if not hundreds, of millions of dollars.

Whatever the merits of this approach may be, all individuality has now been completely flattened out, drowned in the anonymous mass of fellow-engineers. There is no longer any question of anyone leaving a personal stamp on a product or system, which will be known only by a trade name or even by a mere symbol followed by a serial number.

1.5.2. Things were different in the 1890s. In an area which was as yet unexplored and had no precedents, an inventor could give free rein to his imagination and could dream of success. Relatively small resources were required, but a great deal of ingenuity and very often cooperation which began within the family itself:

"Brothers and other relatives working together were not unusual. The brothers Connolly are only one example. There were the early switching brothers: the Erickson brothers, the Lorimer brothers. Almon B. Strowger was the uncle of Walter Strowger, an important early contributor to the development of the step-by-step system" [12].

2. A.B. Strowger's invention: at last, a breakthrough to success in automatic telephony

2.1. None of the inventions mentioned in Section 1 above were followed up.

It was not until Almon B. Strowger (1839–1902) produced his invention or, more accurately, the inventions developed by him and his collaborators, that the step-by-step system which bears his name saw the light of day and the first automatic switching system was installed on an industrial basis.

A long time, from 1889 to 1907, had to elapse before the STROWGER automatic equipment could compete with manual telephony which, in the United States at least, had reached a high degree of perfection.

This result was largely due to the energy and tenacity of A.B. Strowger and of the collaborators around him. The commercial dynamism of his nephew Walter S. Strowger, the first to believe in his uncle's ideas, certainly also played an important part in solving the

[4] I hope I am not being indiscreet if I also mention the very extensive documentation collected over long years of patient personal research by Amos E. Joel, the author of the preface to this book. This preface, moreover, refers (... "everything from moving balls in slots and miniature roller coasters to robot operators" ...) to the very wide variety of solutions proposed, some of which will remind us of children's games and others of such games for adults as the Japanese 'pachinko.'

innumerable material problems with which the very modest A.B. Strowger Company was confronted in its early days.

Strowger's achievements are undeniable and his name is and will continue to be known by every telecommunication engineer. Section 9 annexed to this chapter contains a brief biography of A.B. Strowger, with a description of the circumstances – as picturesque as they are legendary – which led him to invent an automatic system in order to avoid the inopportune intervention of operators.

2.2. Without in any way wishing to minimize the inventor's own achievements, in a historical analysis of the emergence of switching, stress must nevertheless be laid on the remarkable conjunction of timing and social factors which favoured the penetration and success of Strowger's ideas.

2.2.1. Timing

The installation of the first STROWGER prototype at the exchange in La Porte, IL, coincided almost exactly with the establishment in the United States of 'independent' telephone companies not affiliated to the BELL System (see Chapter III-3).

2.2.2. Social and technical environment

The Middle West was where Strowger lived (in Kansas City, MO), his first exchanges were to be installed in Indiana and his company and its workshops were to be established in Chicago. The Middle West was a land of pioneers, undergoing a period of full economic expansion in the late nineteenth century, a land in which initiative flourished and which, in particular, the 'independent' telephone companies had chosen as the centre of their activities.

In this region, the great city of Chicago, with its renowned machine shops and as the headquarters of Western Electric (belonging to AT & T), was then the unrivalled world capital of the telephone equipment industry and contained the largest existing concentration of qualified personnel in that industrial sector. It was from this pool of engineers and skilled technicians that A.B. Strowger drew his collaborators who, with experience far greater than his own, were to ensure the success of the company he had founded.

3. The first switching equipments of the Strowger Company [1, 13]

3.1. Almon B. Strowger's original patent dates back to 1889.[5] Among other features, the patent comprises his now well-known selector, with two movements, horizontal and vertical, and banks of contacts arranged semicylindrically.

3.2. The first operational automatic telephone exchange was installed at *La Porte*, IN, near Chicago, by the firm that A.B. Strowger established in this latter town in 1890, the Strowger Automatic Telephone Exchange Company.[6] This exchange, which was put into service on 3 November 1892, had 80 selectors with 100 positions; these were, however, not yet selectors of the 2-motion horizontal and vertical type, since this solution had been only one among several in the original patent applied for by Strowger.

A model of the La Porte selector was presented at the International Exhibition of

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[5] A.B. Strowger, U.S. Patent *447 918*, applied for on 12 March 1889, granted on 10 May 1891. Patents also applied for in the United Kingdom (6 May 1891) and in Germany (27 June 1892).

[6] The La Porte exchange was installed by the Cushman Telephone Company [1, pp. 411–412]. This Independent Company replaced an affiliate of Bell, which had previously installed an exchange in the same town. In 1890, there was a lawsuit between the two companies, and the judge ruled that the telephone equipments of the Cushman Company infringed the Bell patents (then still valid) and should be incinerated. They had to be hastily removed to avoid this fate. In July 1892, the municipal authorities of La Porte, which had been deprived of telephones by this judicial ruling, allowed the Cushman Telephone Company to install another exchange, this time provided by the Strowger Automatic Telephone Exchange Company, being the first automatic exchange in public service in the world.

Chicago in 1893 and, like the La Porte exchange, aroused great interest, particularly among foreign visitors. In this selector, a search in a horizontal plane was conducted in a system of polar coordinates, with two movements:

(1) orientation following a certain angle of rotation of a selecting arm in the horizontal plane;

(2) thereafter, a shift in amplitude – with a sliding movement along the selecting arm – correctly oriented during the first movement.

This selection device, duly mentioned in Strowger's original patent, may to a certain extent be regarded as a forerunner of the LME 500-point selector which appeared around 1920.

3.3. A second, 90-line, experimental exchange was installed in 1894, again at La Porte. It was quite different in type from the first and was the result of research carried out by Frank A. Lundquist and two brothers, John and Charles J. Erickson,[7] of Scandinavian origin, who, after an attempt to set up in business on their own, joined the Strowger Company. Their system, known as the 'piano wire board' and sometimes as the 'zither,' comprised a horizontal arrangement of bare parallel metal wires which were stretched over a wooden frame like piano wires and replaced the contact studs.

A number of shafts, also arranged in a horizontal plane, constituted the selecting arms and these moved above the bank wires and at right angles to them. Each shaft carried 10 wipers arranged spirally around it. To establish a connection, the selecting arm had to perform two movements, first rectilinear to bring the wiper into position above the required wire, and second rotary to establish the contact.

The Erickson brothers' automatic device is interesting in that it may be seen as an antecedent for the use of bare contact wires, which

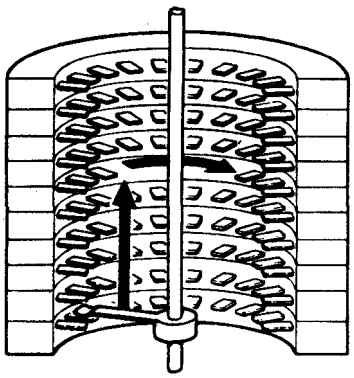

Fig. 2

was to be one of the fundamental features (developed by Hultman) of the LME 500-point system of 1920 (see Chapter IV-5).

Owing to crosstalk between the parallel contact wires and the large number of relays required which limited its capacity to a very small number of lines, this design was abandoned.

3.4. In the above system, only one contact could be established by the rotation of one of the selecting arms, and it was clearly greatly preferable for this rotation to be able to explore a whole series of contacts placed side by side in a semi-circular arrangement. This soon led back to one of the ideas of Strowger's original patent, that of having for each connecting wire:

–a semi-circular row or 'bank' of ten contacts hunted by the rotation of a selecting arm, or 'wiper';

–a vertical arrangement of ten of these rows, one above the other; and

–a selecting arm choosing first one of these ten rows of contacts (a 'level') by an upward movement and then one of the ten contacts in a row by a horizontal rotary movement (Fig. 2).

This device was developed by the engineer A.E. Keith, one of Strowger's closest collaborators, and by the Erickson brothers.[8] A

[7] Not to be confused, if only by the spelling of their surname, with L.M. Ericsson, the founder of the Swedish firm which bears his name.

[8] U.S. Patent of 16 December 1895 by A.E. Keith and J. and C.J. Erickson, engineers of the Strowger Automatic Telephone Exchange Company.

No. 638,249. Patented Dec. 5, 1899.

A. E. KEITH & J. & C. J. ERICKSON.

ELECTRICAL EXCHANGE.

(Application filed Dec. 16, 1896.)

(No Model.) 5 Sheets—Sheet 1.

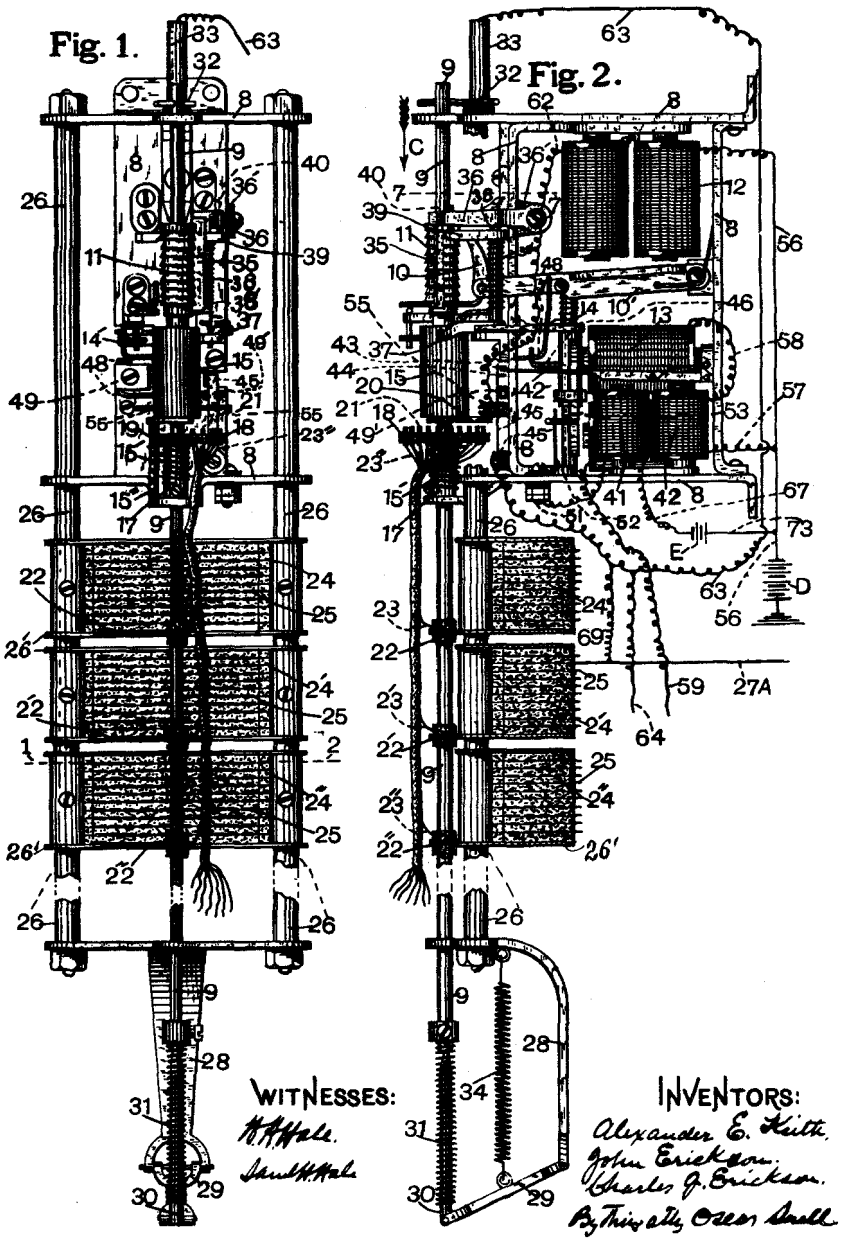

Fig. 3

patent for the equipment was applied for in 1895 and its configuration (Fig. 3), so frequently reproduced, is one of the best-known illustrations in the whole history of telecommunications. It is indeed striking that in our times, 80 years later, switching equipments are still being made which practically follow this model.

3.5. In June 1895, another experimental exchange was brought into service, again at La Porte, making the third prototype of an automatic STROWGER exchange,[9] which now comprised the 2-motion STROWGER selector. Various other exchanges of this kind were installed immediately afterwards,[10] with capacities varying between 200 and 400 lines.

These first models of automatic systems were somewhat rudimentary. They were still powered by local battery, and a double battery was necessary at the subscriber end, one for speaking and the other for ringing. Five wires, in addition to the earth return, were needed between the subscriber station and the exchange – three for signalling, one for call release and one for speaking. The dial did not yet exist and the calling subscriber had to press buttons (one for the hundreds digit, one for the tens and one for the units digit) as many times as was necessary for each of the digits to be registered.

4. Use of the dial in automatic telephony

4.1. The *dial*, a mechanism based on devices used in telegraphy, particularly for alarm systems, fire brigades, etc., was patented[11] in 1896 (see Fig. 4).

4.2. In the first model of a dial, there were projecting vanes instead of finger holes. The dial had three wires, one for the hundreds digit, one for the tens digit and the third for the units digit [14].

4.3. The replacement of push buttons by the calling dial now made it unnecessary for the subscriber to perform the time-consuming and rather difficult task of counting, very accurately and for several operations, the number of times that the buttons had to be pushed.

4.4. In 1896, the subscribers connected to the private exchange of Milwaukee Town Hall had the honour to be the first in the world to be equipped with dial-telephone. Next, also in 1896, came the subscribers to the public exchange of Amsterdam in New York State, but their enjoyment of the new system was short-lived. Two years after their exchange had been brought into service, it was completely destroyed by fire, thus constituting one of the first examples of the vulnerability of these installations to fire [1, p. 423].

4.5. Over the years, a large number of improvements were introduced to dials (or 'call transmitting discs').[12] For nearly a decade, they had to compete with 'lever' systems. By the early 1910s the simplicity of its design (pointing the way to mass production) and, even more, the ease with which it could be used ensured the supremacy of the dial over all other calling devices, and the word 'dial' thereafter became synonymous with 'automatic telephony.'

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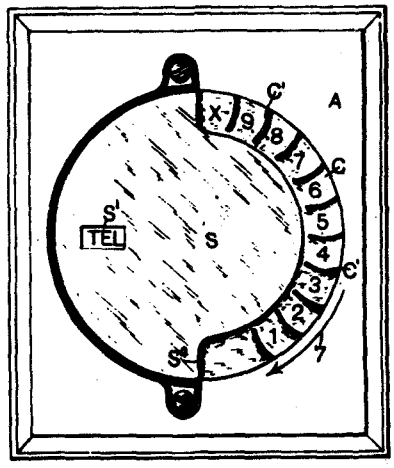
[9] The patience of the long-suffering inhabitants of this town in waiting for a telephone service can only be admired. This was (see Footnote 6 in Section 3.2) the fifth exchange to be installed in 5–6 years!

[10] Michigan City (IN), Albuquerque (NM), Trinidad (CO) [1, 13], Rochester (MN) [1], Manchester (IA), Alber Lea (MN), Albion (NY) and Milwaukee (WI) [13].

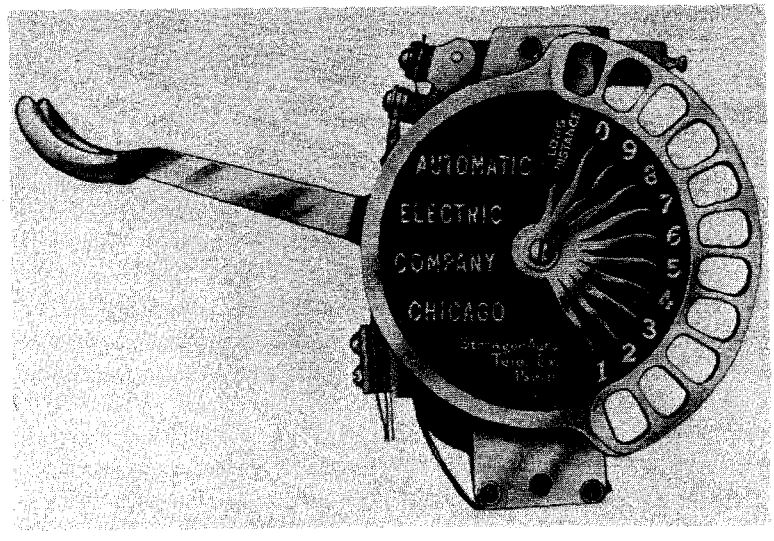
[11] U.S. Patent No. *597 062* applied for on 20 August 1896 and granted on 11 January 1898 [1, p. 424].

[12] In the early 1920s, Milhaud [15] noted that there were as many different types of dials as systems and manufacturers, each designer jealously defending his own ideas.

One of the first tasks in automating national networks was to bring order into this situation and to standardize the characteristics – electrical and mechanical – of telephone dials (rotation speed, pulse ratio, etc.).



(a)



(b)

Fig. 4. First telephone dials (Automatic Electric Co.); (a) first form of station-set dial, (b) dial with fingerholes and 11 positions, circa 1900–1905.

5. 1897–1907, a period of technical innovations developed by the Automatic Electric Company [1, 13]

5.1. In 1896, less than 10 years after his invention, A.B. Strowger retired for reasons of health from the company he had founded.

In 1901 the name of the firm was changed to Automatic Electric Company, with Alexander E. Keith as its technical director. From its brilliant beginnings, the company went on from one technical achievement to another.

1897–1907 was an extremely active period in the development of automatic switching: practically every year witnessed the bringing into service of one or more new exchanges constructed by the Automatic Electric Company, several of them introducing important innovations in the design of switching systems.

5.2. The first of the events that stand out in the uninterrupted progress during this decade was the bringing into service of an exchange in *Augusta,* GA, in 1897 [15].

This exchange has often served as a reference point in subsequent years. When it was brought into service, it was the largest automatic exchange in the world, although it comprised only 900 lines. Its subscribers all had dials, but the principal innovation in the actual exchange was the use of *two selection levels*.

Until then, automatic systems were designed for a capacity corresponding to the number of subscribers to be connected. The STROWGER selector successfully met this requirement provided the number of subscribers to be connected was below 100. Instead of pursuing the current trend of research and trying to design a single switching device for 1 000 subscribers, Keith went back to the practices which had prevailed before the adoption of multiplying on manual positions, i.e. the method where two operators in tandem, connected by a junction line, were required for the setting up of certain calls.

The AUGUSTA exchange had a trunking arrangement with two selection levels (the equivalent of two operators in tandem), comprising two types of selectors:
—a primary stage with *'group selectors'* giving access to a group of a hundred subscribers;
—a secondary stage also with 100-point selectors, known as 'line selectors,' *'final selectors'* or 'connectors,' selecting the required subscriber in the hundred group.

Each subscriber had his own group selector. The ten group selectors of ten subscribers formed a unit. Their outlets corresponding to the level of each hundred final selector were multipled and served one and only one final selector belonging to that hundred. For each group of ten subscribers, there were therefore as many final selectors as there were hundreds.

This arrangement required a fairly large number of selectors. Internal blocking could occur when two subscribers in the same group of ten each wished to call a subscriber belonging to the same hundred.

5.3. Keith then developed a new design for an exchange, known as the 'improved AUGUSTA system.'

The group selectors were still assigned to each subscriber, but did not stop at mere selection of a 'hundred' level. They carried out by their second rotary movement, a 'one out of ten' search for an idle trunk to gain access to the secondary stage. The group's selectors no longer consisted of sets of ten, but of sets of 100, and each set had ten trunks serving the second selection stage ('final selectors'). This arrangement led to a spectacular reduction of the number of selectors needed for the exchange.

The *hunting* carried out by the group selector was at first effected by the insertion of an additional digit, a zero, which the subscriber had to insert between the 1000s and the 100s digits (hardly a practical proposition); this operation was later carried out by the exchange itself.

5.4. The principle of automatic hunting by the exchange itself for an idle trunk among the selection stages was first applied at the four-digit exchange in *New Bedford*, MA, commissioned in 1900. This large exchange, designed for a final capacity of 10 000 lines, already comprised four groups of a thousand lines when it was brought into service.

5.5. In 1903, the *Chicago* automatic exchange with an ultimate capacity of 10 000 lines was brought into service with striking success. This was an exchange with three successive selection stages and was the largest installation then in existence, its capacity exceeding that of any manual telephone exchange. Automatic hunting by the exchange of an idle trunk among the selection stages was of course one of the characteristics of this exchange but it introduced also a new feature — *call metering.*

5.6. This exchange was followed by many others in subsequent years. Without listing them all, reference should be made to the exchange installed in Los Angeles in 1904, outstanding both for its size and the introduction of automatic trunk release.

Although the following exchanges had smal-

ler capacities, they marked new and important stages in the progress of switching.

5.7. Preselection[13] first made its appearance in 1904 at the *Wilmington*, DE, exchange.

With the preselection system a new stage was introduced before the selection stages proper, to concentrate subscriber traffic with a view to achieving a substantial reduction in the number of selectors.

Keith's inventive genius was again the source of the preselection mechanism in STROWGER exchanges, the *'plunger' preselector*. The operation of this device, long to be regarded as one of the keystones of the STROWGER system, is described in Section 8 (Annex 1) below.

Preselection must operate unknown to the subscriber, from the moment he picks up the receiver and he begins to dial. The preselection device must therefore operate with exceptional speed. "Keith's plunger preselector proved to operate efficiently and to provide satisfactory service," [18].

The obvious purpose of preselection was to reduce the total number of selection devices and in the case of the Wilmington exchange, this reduction led to a decrease of over 20% in the overall costs.

5.8. In May 1905, the first automatic exchange operated entirely from a central battery (power supply for speech current) was installed at *South Bend*, IN. The battery intended solely for selection and initially installed at the subscriber's home had been eliminated as early as 1892 when the second experimental exchange at La Porte was established. The South Bend exchange thus marked the elimination of one of the last handicaps which kept the automatic exchange behind its competitor, the manual exchange, in which the central battery had become common practice a number of years previously.

5.9. In 1907, E.A. Mellinger who, with Keith, had already introduced the preselection technique referred to in Section 5.7 in the Automatic Electric Company, developed the 'two wire system,' which was introduced at the *Pontiac*, IL, exchange in 1908. Dial pulses now corresponded to intermittent interruptions of the subscriber line, which served for battery supply, transmission of speech current and the sending of dialling pulses.

6. The STROWGER system comes of age

6.1. With group selection, the line-finder (preselection stage) and central battery power supply, the modern automatic exchange really came into being in 1907. In the 1905 edition of his book American Telephone Practice, then regarded as an authoritative work, Kempster Miller wrote that in the preceding few years, and especially in 1903 and 1904, there had been a considerable development in techniques. Thanks to the efforts of its engineers and promoters, the 'automatic exchange' had made such spectacular inroads that it definitely appeared to be an important phenomenon of the time and to have an increasingly important future.

6.2. In 1910, there were 200 000 subscribers to the automatic telephone in the United States, divided among 131 exchanges, nearly all of them STROWGER exchanges.

All of them belonged to 'independent' companies. The companies of the BELL system were allergic to the automatic telephone: the AT & T representatives' rebuttal of arguments in favour of automatic telephone working at the Paris Conference of 1910 is described in Chapter II-3, Section 6.3.

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[13] According to Lawson [17], preselection was invented by Romaine Callender for the system he designed in 1893, although A.E. Keith is responsible for the practical application of the idea.

The idea of reducing the number of selectors by concentrating the random traffic from subscriber lines is fundamental and was in the air during the years when Keith introduced it. In Germany (see Chapter V-1, Section 4.3), preselection was introduced in 1909, with a different kind of preselector than Keith's.

6.3. Around the turn of the century in Europe – rather cautiously – automatic telephony began to take root, on the basis of the STROWGER system or through imports of STROWGER equipment (see Chapter V-1 and V-2). In the United Kingdom, for instance, an exchange of the Automatic Electric Company imported from Chicago was installed in Epsom in 1912 and the same procedure was followed in France for the Nice exchange (October 1913).

6.4. In Canada, quite near the Chicago plant of the Automatic Electric Company, STROWGER automatic exchanges were introduced very early on. As early as 1893, there were STROWGER exchanges, or rather private automatic equipments, in London (Ont.), Terrebonne (Que.), and Seaforth, Mitchell and Arnprior (Ont.). Unfortunately, history relates that none of these devices remained in operation for longer than several weeks. The first STROWGER exchange really to operate in Canada was the one at Whitehorse (Yukon), brought into service in 1901.

Bell Telephone of Canada, whose methods of operation were based on those of companies of the BELL System, later introduced the automatic system in the large cities it served, commencing with STROWGER exchanges in Toronto in 1924.

7. The basic principles of the STROWGER system

7.1. The STROWGER system constitutes the prototype of so-called step-by-step systems.

The STROWGER system is universally known and has been described a thousand times. The brief account of its basic principles as given below will doubtless be regarded as superfluous by any switching engineer. But for a work that is not exclusively intended for that class of reader, it may be useful to draw attention to some of the essential characteristics of the STROWGER system.

Indeed, it would be impossible to do less for a system which has played a leading role in the development of automatic switching. During the first 50 years or so of our century, it was the most widely utilized of all the automatic systems. In 1978, the year in which our account closes, though it had lost its absolute supremacy and had fallen behind the crossbar systems, the STROWGER system continued to be one of the most extensively used exchange systems throughout the world.

Although the design of the system and its present form date back to around 1900, the industries of certain countries continue imperturbably to manufacture STROWGER equipment. The history of technology knows hardly any examples of comparable longevity of a widely-used product.

7.2. STROWGER is a direct control system, control being applied by the calling subscriber. The switching mechanisms of the various selection stages are set in motion by the pulses (momentary interruptions in the current of the subscriber line) imparted by the caller's dial. Calls are set up gradually, passing successively from the switching device of one selection stage to that of the next stage: hence the generic name of 'step-by-step system,' with the classical abbreviation, mainly used in the American terminology, of 'S x S system.'

7.3. The basic STROWGER switch, the '*selector*', has *two* selection *movements*:
–an *upward vertical movement*; and
–a *rotary horizontal movement*.

Both these movements are caused by *pawl* mechanisms plus:
–a vertical ratchet for the initial upward movement; and
–a ratchet wheel for the subsequent rotary movement.

For each of the two movements, the pawl is itself activated by the armature of a relay (vertical or horizontal magnet), operated in turn by the dialling pulses generated for each of the various digits by the caller's dial.

7.4. The STROWGER is a *decimal system.* The banks of fixed contacts in the selector are arranged in *ten levels*, one above the other. There are *ten contact positions* in each level arranged in an arc which is swept by a wiper mounted on a carriage. The wiper describes a rotary movement once the carriage has brought it to the desired level by the initial movement (see Fig. 2 above).

Thus the capacity (number of subscribers) of a STROWGER exchange is expressed in powers of ten:
—100 lines, served by a single selection stage, with the STROWGER selector directly serving a field of 10 x 10 subscriber numbers defined by the two vertical and horizontal coordinates. The selector is then called a 'final selector';
—1 000 lines, served by two selection stages: hundreds selectors and final selectors;
—10 000 lines, served by three selection stages: thousands selectors, hundreds selectors and final selectors.

7.5. In the thousands or hundreds selectors, the second (horizontal rotary) selection movement corresponds to the search for a free selector at the next selection stage. This process, known as *hunting*, is set off by the mechanism itself as soon as the wiper has been positioned at the vertical level corresponding to the thousands (or hundreds) digit dialled by the caller. If, during hunting, none of the ten lines of access to the following selection stage is free, the call is lost and the caller receives the busy tone. The STROWGER system is a *lost call system.*

This 'lost call' characteristic of the system is a direct consequence of the fact that it is a direct control system. The time available for hunting cannot exceed the time available before the arrival of the first of the pulses corresponding to the next digit dialled by the caller. This interval of time, which is shortest when the next digit to be dialled is a 1, is of the order of 3/10ths of a second.

8 (Annex 1). Description of the Keith plunger preselector of the STROWGER system [17]

8.1. When a subscriber calls (i.e. when he removes the handset), the plunger preselector is designed to set up a direct connection between:
—the subscriber's loop, and
—a free selection unit in the exchange. (This unit will be a first selector or, if there is a second preselection stage, a 'secondary preselector.' To avoid differentiating between these two cases, we shall simplify by calling this unit, the 'B unit,' the subscriber's loop being the 'A side.')

8.2. There is one plunger for each subscriber line (see Fig. 5). The plungers, each situated on a different horizontal plane, are mounted one above the other on a rack holding 25 or 50 preselectors[14]) and can be controlled by a common vertical shaft K. As soon as a plunger is actuated by a subscriber call, the shaft K rotates, thus placing the *plungers of the other subscriber lines* which are *not yet engaged* by a call, in an azimuthal position *opposite a line* serving a *free* B unit.

8.3. A plunger consists of a rod terminating at one end in an insulating head and at the other in a fan-shaped extension notched in the centre.

Each plunger (corresponding to a subscriber line) can move in two ways:

(a) the so-called *'plunging'* movement: this is a horizontal movement controlled by the lever constituting the armature of an electromagnet E (itself actuated by the subscriber line relay), which drives the plunger into a set of springs. This movement is the equivalent of inserting a plug into a jack.

By means of the contact springs, this insertion movement connects together the wires of the subscriber line, on the A side, and those of a free B unit, for selection. For each subscriber line and each preselector there are three wires connected by the contact springs: two line wires and an auxiliary wire;

(b) the rotary movement produced by the action of the vertical shaft K. This rotary movement, with *ten azimuthal directions*, places all the plungers on the rack which are not yet engaged with their contact springs (i.e. all the plungers which are not seized by a call or conversation in progress) opposite a line to a free B unit.

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[14]) Two racks of 50 preselectors can be coupled by means of a connecting rod which locks together the two vertical control shafts K, thus forming groups of 100 preselectors.

8.4. When a plunger is seized and makes a horizontal plunging movement giving access to a free B unit, it is disconnected from the shaft K and is no longer subject to the rotary movement described in (b) above.

The connection of the plunger with and its disconnection from the common vertical control shaft K are effected by means of:
—a protruding tooth S on the shaft K, and
—a notch in the back of the plunger; the tooth S engages in the notch when the plunger and its controlling electromagnet E are at rest. The plunging movement releases the notch from the tooth S so that the plunger is then no longer controlled by the rotation movement of the vertical control shaft K (see Fig. 5).

8.5. The rotary movement of the shaft K is controlled by a 'main switch' which acts as soon as a plunger is engaged in the contact springs and has seized a free B unit. The main switch has a wiper arm F which is rigidly fixed to the shaft K. This arm brushes against the ten bank contacts of a rotary switch, each of which is linked to a wire f connected to a B unit; an earth potential on a wire f indicates the busy condition of this unit.

The wiper arm F is normally in an azimuthal position corresponding to the bank contact of a wire f connected to a free B unit. When a plunger is actuated, an earth potential is placed on the wire f serving the B unit owing to the plunger's insertion between the

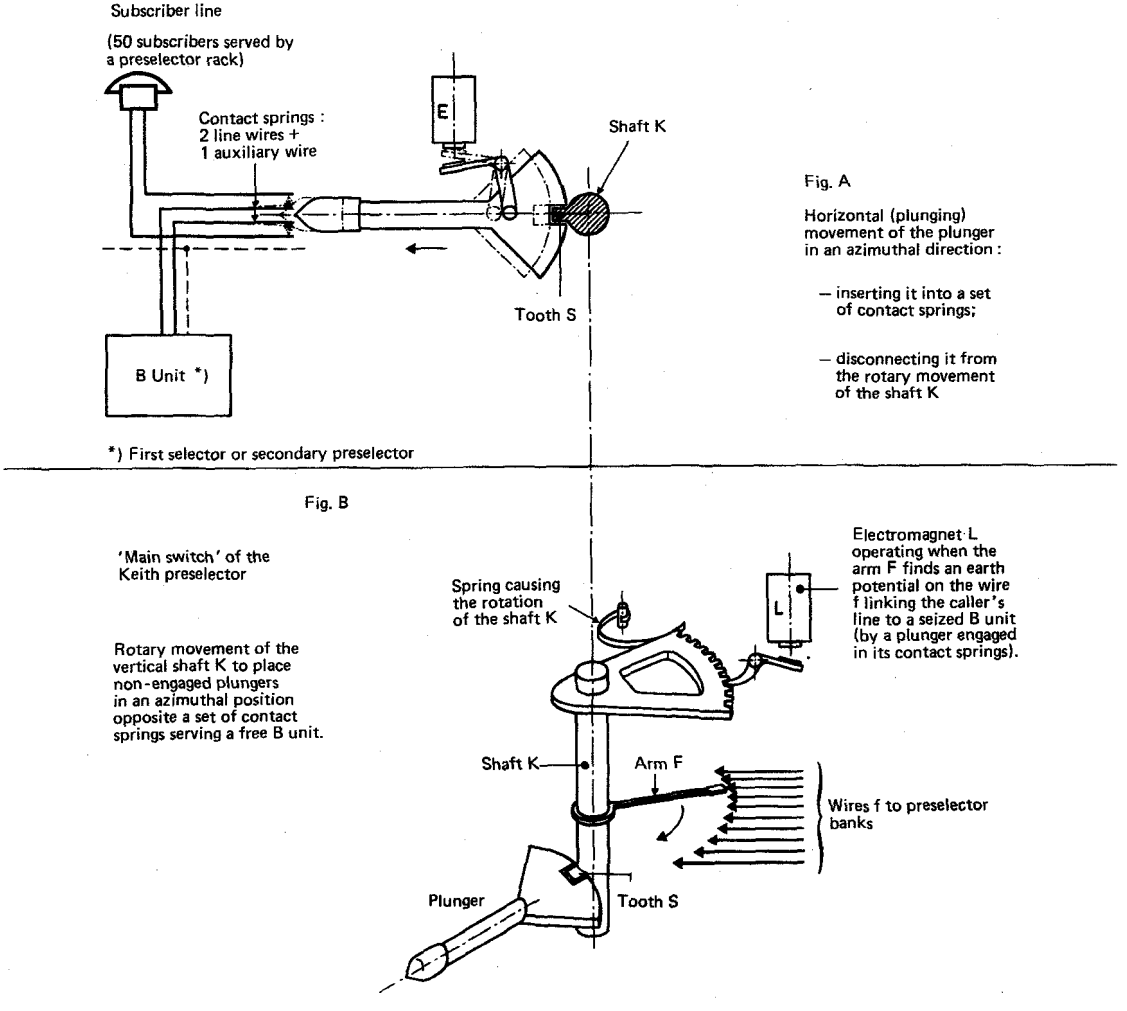


Fig. 5. KEITH preselection plunger.

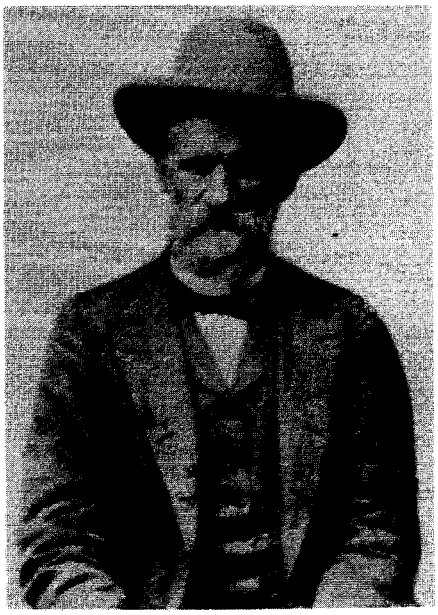
contact springs corresponding to the auxiliary wire. An electromagnet L, which controls the rotary movement of the shaft K, then comes into play. The shaft K rotates, driving its arm F. As soon as the arm touches a bank contact corresponding to a wire serving a free B unit (i.e. an unearthed wire f), it stops in this new azimuthal position.

9 (Annex 2). A.B. Strowger – a neglected figure

9.1. A pioneer of telephone history, whose name is illustrious to every telecommunication expert, Almon B. Strowger nevertheless seems to be somewhat neglected by historians of telecommunications.

As far as the author is aware, no book exists describing Strowger's life and work.

There is no portrait of Strowger in the famous collection of great telecommunication personalities which the ITU published faithfully until 1968. This is a most regrettable omission. Is it due to lack of initiative on the part of his compatriots or to some hesitation because Strowger's name is still being used for the marketing of automatic equipments? The answer matters little. At least the presence of these few lines and Strowger's portrait will do something to fill this gap in this series of engraved portraits (Fig. 6).



Almon B. Strowger (1839–1902).

9.2. After schoolmastering, A.B. Strowger (1839–1902) took up what was presumably a more profitable line of business, becoming a funeral undertaker in Kansas City, MO. The manner in which he conceived the idea of a telephone without operators, i.e. a fully automatic device, has become a classical story in the history of inventions.

One day he heard that one of his friends had died, and was very put out by the family's failure to turn to him to make the funeral arrangements. He conceived a strong animosity to telephone operators, suspecting them of having diverted the calls of the bereaved family to one of his competitors, and he decided on a drastic remedy, to do away with telephone operators altogether. According to the legend, after much thought and investigation at the local manual exchange, A.B. Strowger devised a model of his famous switching equipment, assembling it in his home out of makeshift materials, namely:

–two pencils;

–some pins;

–and, above all, stiff collars, the genuine stiff collars of the time, high, hard and starched, such as all respectable men in those days used to wear.

The collars were stacked one on top of the other. The pins were inserted at regular intervals on the semi-cylinder of each collar. A first pencil was used as the vertical axis of rotation. A second, at right angles to the first, swept the circular row of pins at the level which it had reached. Thus the STROWGER switching equipment was born.

This story of how the model was made seems too good to be entirely true and is no doubt merely an apocryphal legend. The first patent applied for by Strowger did in fact include the principle of the two-motion selector which made his name, but it was only one of the features which he claimed as innovations.

9.3. The first patent dated from 1889 and A.B. Strowger then had great difficulty in making a model of his mechanism and in marketing his invention. He knocked unsuccessfully on dozens of doors (including that of Western Electric). With the help of an enterprising nephew, W.S. Strowger, he finally decided to launch his own company in Chicago in 1891. But he then had no less difficulty in getting an order for an exchange.

These difficulties, however, were overcome by Strowger's tenacity and energy.

9.4. Apart from these qualities and his innovatory ideas, yet another of the merits of Strowger was his excellent choice of collaborators. Among these, there

are many whose names deserve to be remembered in the history of switching: in particular, A.E. Keith, the brothers J. and C.J. Erickson and Frank A. Lundquist.

9.5. In 1896, A.B. Strowger ceased to take an active part in his company's business. He retired to Florida and died there in May 1902.

His collaborators carried on with his work and ensured the success of the system which bears his name.

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