

In connection with the cylindrical bank, as an alternative to the original principle whereby the upward movement precedes the translation movement, reference should also be made to the old North Electric Company equipment,<sup>3)</sup> in which a rotary motion comes first, followed by the vertical translation movement.

1.3. In fact, the different versions referred to under Section 1.2 above had met with little or no success. The only ones to survive into the 1960s were the XY and HASLER types, while virtually all the STROWGER or STROWGER-derived equipments used cylindrical banks swept by a vertical translation movement followed by a horizontal rotary movement.

1.4. The different types of step-by-step systems developed from the STROWGER may be divided into three main families: American, British, German.

This classification must of course be headed by the original, American version. It is followed by the British version, since Great Britain became from the 1920s the bastion of the STROWGER system which had no competitor within the country. In Britain, it kept the name Strowger, whereas in the United States it gradually gave way to the term 'step-by-step system' often abbreviated to S x S. In Germany, the STROWGER system underwent a number of radical modifications, with regard both to the hardware and the 'software' of the electrical circuits, gradually becoming known under its official title of the German Administration system, and then the SIEMENS system, in view of the leading role played by this company in construction and development.

In the following detailed classification of

<sup>3)</sup> cf. Chapter III-4 for its use in the semi-automatic Automannual system. This version of the step-by-step selector was also employed at the beginnings of the British STROWGER system, by the Peel-Conner Telephone works of General Electric in Manchester.

the various step-by-step STROWGER systems in relation to the major industrial groups which controlled their manufacture, we shall take as a basis A. Jouty's study of 1953 [1], a year which was to an extent the high mark of the production of exchange lines based on step-by-step systems developed from Strowger.

## 2. American step-by-step systems

### 2.1. Automatic Electric Co., Chicago

2.1.1. In the United States, the STROWGER equipment was manufactured in the first place by the companies using the 'AUTELCO' trade mark of the firm Automatic Electric of Chicago. This firm was the direct successor of the one originally founded by Strowger and adopted its new company name in 1901<sup>4)</sup> [3].

The line production, in *millions* of subscriber lines, of step-by-step switching equipment by the Chicago plants of Automatic Electric (now in North Lake, IL, near Chicago) is given by Table 1.

Table 1  
Line production of step-by-step switching equipment at the Chicago-North Lake plants of Automatic Electric, Chicago (in millions of lines)

	1920-1929:	1.7
	1930-1939:	1
	1940-1949:	0.8
	1950-1959:	2.6
	1960-1969:	5.3
	1970-1979:	3.1
Total lines	1920-1979:	14.6

In 1978 (the end of the period covered by this book), the production of step-by-step STROWGER equipment by the North Lake

<sup>4)</sup> The Automatic Electric of Chicago was merged in 1955 in the General Telephone and Electronics (GTE) Corporation.

factories was important and was expected to continue for several years.

2.1.2. In addition to the Automatic Electric Company of Chicago, the following subsidiaries outside the U.S.A. also manufactured the STROWGER equipment:

—Phillips Electrical Works (Brockville, Ont., Canada), a name later changed to Automatic Electric (Canada) Ltd.,

—l'Automatique Electrique (Antwerp and later Herentals, Belgium), abbreviated to ATEA,<sup>5)</sup>

—'Autelco Mediterranea' (Milan, Italy).<sup>6)</sup>

2.1.3. The British firm Automatic Telephone Manufacturing Company, Ltd., of Liverpool (cf. Section 3) was also closely associated with the Automatic Electric of Chicago.

2.1.4. In the beginning of the 1920's, Automatic Electric Co., Chicago, designed the STROWGER Automatic Director System to meet several complicated interoffice trunking problems in the Havana, Cuba, network and the first exchange in this system was brought into service in 1924 in this town [4].

A year earlier, this Director system had been officially adopted by the British Post Office for the automatization of the telephone network of London.

2.1.5. In the middle of the 1920's, Automatic Electric Co., Chicago, took patents for an Automatic Toll Ticketing System (ATTS). After several developments for a ticket printer, which recorded on a paper tape the dial impulses and the minutes of elapsed time after a connection had been set up, the ATTS system was implemented:

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<sup>5)</sup> Various official denominations, changing with the time but with always the same acronym ATEA: Ateliers de Téléphonie et d'Electricité d'Anvers, in 1890; The Antwerp Telephone and Electric Works, in 1922; Automatique Electrique de Belgique, in 1931; Automatic Electric in 1962, and now GTE-ATEA ...

<sup>6)</sup> Which, in 1978, is G.T.E. Telecomunicazioni S.p.A., Milan.

—in 1937 (Mons exchange) in Belgian STROWGER networks by the associated Automatique Electrique S.A., Antwerp, Belgium manufacturing company;

—in 1944, in the Los Angeles metropolitan area, in a Director Strowger network; in addition to the automatic short-haul ticketing system, the system provided several facilities, e.g. for alternate routing, class of service discrimination, station identification on party lines.

## 2.2. *Western Electric*

2.2.1. However great the output of Automatic Electric, an equally high production of step-by-step exchanges was achieved by Western Electric at its Hawthorne Works, Chicago, the vast solid-brick elderly structure, the grandfather of all Western Electric Plants, to meet the requirements of the companies within the BELL system: this output was therefore exclusively intended for an American market formed by the AT & T companies. In 1958, the Hawthorne plant was producing almost equal proportions of crossbar and STROWGER equipment, with about one million lines manufactured for each of these systems.

The BELL system adopted STROWGER equipment in 1916. When various independent operating companies were taken over by Bell companies belonging to AT & T, the latter found in 1915 that it was serving nearly 90 000 subscribers with STROWGER exchanges. In 1916, AT & T concluded a patent licence agreement for the manufacture of STROWGER exchanges by Western Electric.<sup>7)</sup> Until the advent of the crossbar system and even long afterwards, the operating companies in the BELL system used STROWGER equipment, then known as the 'step-by-step system,' for the automatic servicing of medium- or

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<sup>7)</sup> The first step-by-step exchange installed by a Bell Company was that of Norfolk, open to service in 1919. The exchange was manufactured by Automatic Electric.

small-town subscribers (single office areas), while the big American cities in the BELL system used the PANEL equipment [5].

An agreement between AT & T (Western Electric) and Automatic Electric (then known as the Theodore Gary Group) took place in 1919 for the provision by Automatic Electric of step-by-step exchanges to Bell Companies of AT & T. For many years, the majority of step-by-step exchanges for Bell Companies were manufactured by Automatic Electric according to this contract.

2.2.2. The number of step-by-step lines in service in the AT & T companies (BELL System) in 1978 was in the range of 10 millions.

### 2.3. Other productions of 'American' step-by-step systems

2.3.1. Despite its small output compared with that of the firms referred to under Sections 2.1 and 2.2, the Federal Telephone and Radio Corporation, New York (abbreviated to FTR), one of the numerous subsidiaries of the International Telegraph and Telephone Company, also manufactured 'American' STROWGER equipment in the United States.

2.3.2. In Britain, the Automatic Telephone Manufacturing Company, Liverpool (abbreviated to ATM), whose leading part in the domestic promotion of the STROWGER system will be discussed below, manufactured both 'American' STROWGER equipment for export and the British version of STROWGER for the home market.

2.3.3. In Canada, until the middle of the 1950s, the 'American' step-by-step equipment was (just about) the only automatic system upon which Canadian telephone companies relied. The equipment was produced in Chicago, in Britain (Liverpool, mainly) and later in Canada by Northern Electric (now Northern Telecom).

## 2.4. The evolution of the American step-by-step system

In regard to the British and German step-by-step systems, the one which we call 'American' is that whose mechanical concept remained closest to that of the 1910 STROWGER equipment. However, it should be pointed out that, for instance, FTR frequently used PANEL or ROTARY relays instead of STROWGER relays.

Considerable improvements were introduced in the electrical circuits of exchanges, specially for exchanges designed for the main networks (i.e. mainly for exchanges other than those of the BELL system), for example, in the use of the DIRECTOR (register-translator) system (see Sections 2.1.4 and 2.1.5) or for identification of the calling subscriber for the use of ticket printers (see Section 2.1.5).

## 3. The British STROWGER system

3.1. On 1st January 1912, the United Kingdom Post Office took over the telephone networks of the National Telephone Company, thus acquiring the monopoly of telephone operations in the United Kingdom.<sup>8)</sup>

From 1912 to 1923, despite the economic difficulties encountered in the aftermath of the World War, 18 automatic exchanges were installed in Britain by the Post Office, using an entire range of types representing practically all the systems known at the time (Table 2). With the exception of that at Leeds, however, these relatively low-capacity exchanges served only populated areas corresponding to medium-sized towns.

After World War I, the crucial problem in Britain was to handle the traffic of London and the other main British towns. "Britain was lamentably undertelephoned. Much of the country — including London and other big cities — was more than inefficiently served,

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<sup>8)</sup> With the exception of the Hull network.

Table 2

Automatic telephone exchanges established by the British Post Office, 1912–1924

	Exchange	Type of equipment	Date opened	Capacity	
				Of present equipment (1924)	Ultimate
1	Epsom	A.T.M. Co.	13 March 1915	1 100	1 500
2	Official, London	A.T.M. Co.	13 July 1912	900	1 500
3	Hereford	Lorimer	1 Aug. 1914	500	900
4	Darlington	W.E. Co., Rotary	10 Oct. 1914	1 100	2 260
5	Accrington	A.T.M. Co.	13 March 1915	1 100	1 500
6	Chepstow	A.T.M. Co.	7 July 1915	190	200
7	Newport, Mon.	A.T.M. Co.	14 Aug. 1915	2 000	3 500
8	Portsmouth	A.T.M. Co.	29 April 1916	5 200	7 000
9	Paisley	A.T.M. Co.	15 July 1916	1 700	2 150
10	Dudley	W.E. Co., Rotary	9 Sept. 1916	500	1 600
11	Blackburn	A.T.M. Co.	14 Oct. 1916	2 400	4 400
12	Leeds	A.T.M. Co.	18 May 1918	9 600	15 000
13	Grimsby	Siemens	14 Sept. 1918	1 860	4 000
14	Stockport	Siemens	23 Aug. 1919	1 300	2 260
15	Ramsey	Siemens Village	21 Oct. 1921	40	80
16	Hurley	Siemens Village	20 Dec. 1921	40	80
17	Fleetwood	Relay Auto. Co.	15 July 1922	480	700
18	Southampton	Siemens	30 June 1923	3 200	5 500

Source: [6, p. 669].

the quality of the service being only the rather dismal complement of the fewness of the telephones," according to Robertson [7, p. 127].

3.2. The years 1921–1922 marked a turning point in the history of British telephony, and the decisions then adopted rank among the most far-sighted ever taken from the standpoint of the coherent development of a national network.

3.3. At that time, the British automatic switching equipment industry, a piecemeal structure of fairly recent creation,<sup>9)</sup> did not begin to gather way until the years immediately preceding the World War. At the end of the war, there were five main manufacturers:

<sup>9)</sup> "The National Telephone Company had been in the habit of buying all its exchange equipment and accessories in America and in Sweden" [9].

(1) Standard Telephone and Cables Ltd. (abbreviated to STC) which represented the interests of Western Electric, Chicago, in Britain and had its plant at North Woolwich and New Southgate in the Greater London area.

(2) The General Electric Company, Ltd.,<sup>10)</sup>

<sup>10)</sup> Name adopted in 1889, three years before the same title was taken by the American company General Electric in 1892 after the amalgamation of the Edison and Thomson–Houston companies. These two firms had no direct relationship and were engaged in quite different areas of activity. This similarity of names has often given rise to confusion among the uninitiated, particularly in the non-English speaking world. The German company Allgemeine Elektrizitäts Gesellschaft (A.E.G.) was so named after its President Mr. Rathenau had paid a visit to England and discovered the popularity of the initials G.E.C. [8]. In the same manner, La Compagnie Générale d'Electricité was set up in France under the same denomination, a company also completely independent from its British, American and German homonyms.

which had a subsidiary, the 'Peel-Conner Telephone Works' which, specializing in the construction of manual exchanges and originally set up in Manchester, had at the end of World War I transferred its operations to a much bigger factory in Coventry [8].

The technical general staff of the GEC consisted of a glittering array of engineers enjoying an international reputation, some of whom had come from the North Electric Company, Galion, OH; the chief personalities were Mr. Charles North, Mr. Frank R. McBerty, the inventor of what subsequently was known as the ROTARY system, and Mr. Kempster B. Miller, at that time the best known author of books and publications on automatic telephony.

(3) The Automatic Telephone Manufacturing Company, Ltd., Liverpool (referred to below as ATM). ATM had been established on 1 January 1912 by an automatic telephony enthusiast, Mr. Dane Sinclair<sup>11)</sup> of the British Insulated and Helsby Cable Company, Ltd. [7, p. 106] with a view to acquiring licences on Strowger patents for the United Kingdom and colonies.

(4) Siemens Brothers Ltd. which, before becoming completely independent, had been a subsidiary of the German parent company and had been established in Britain for nearly half a century, having started by producing submarine cables. Siemens Brothers used Siemens patents, those concerned with automatic telephony being themselves derived from Strowger patents [9].

(5) Finally, a number of other companies, such as the Relay Automatic Telephone Com-

pany, London, belonging to the Marconi Group, and Ericssons Telephones Ltd.

3.4. During World War I, far from the sound of battle and the economic toils of the European belligerents, the telephone equipment industry of the United States had made giant strides within the space of a few years.

In 1919, AT & T opted for the automatic PANEL system for use in serving large towns. An ambitious plan had been mapped out providing for the conversion to PANEL automatic of 750 000 lines in 16 American towns within less than 8 years.

The main innovations offered by the PANEL system were as follows:

- its register-translator,
- its numbering system, with three letters and four digits on the subscriber's dial to identify the subscribers of a large town,
- 'call number indicators' to enable the subscribers to switch over from automatic operation to operator intervention to reach subscribers still connected to manual exchanges, etc.

These novelties were extremely appealing and produced a considerable impact on the British Post Office authorities. In fact, the PANEL system was very nearly adopted in Britain, as it had already been in the United States, for serving large towns, in the first place London. A PANEL exchange was even ordered for field trials in London.

3.5. The energy and enterprise of the British captains of industry and particularly the head of ATM, coupled with a deliberate national industrial policy pursued by the British Government, completely altered the course of events.

After the war, the United Kingdom was in the throes of a financial crisis, and the adoption of the PANEL system would have meant importing, for some years to come, equipment either of American origin or supplied by European subsidiaries of Western Electric, especially the BTM in Antwerp. The production of switching equipment by British com-

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The object of the British G.E.C. was stated to embrace "the manufacture and sale of dynamos, motors, telephones, bells, electroliers, arc lamps, electric light fittings, heating, cooking and medical apparatus, and all apparatus and fittings required for being used in connection with the generation, distribution, supply, accumulation, and employment of electricity ..." [8].

<sup>11)</sup> Dane Sinclair in 1883 was the first British engineer to design an automatic system, while working for the National Telephone Company in Glasgow (see Chapter II-2).

panies became a clear national priority.

After consultation with their opposite numbers in Chicago, the ATM engineers, advocates of the STROWGER system, proposed a solution based on a development of STROWGER. A register-translator (storing and translating device) would be built into the system to provide the advantages claimed by the PANEL system with regard to the necessary flexibility in inter-exchange routing and to maintain a constant, consistent and practical plan for subscriber numbering. This was the 'DIRECTOR' system.

3.6. The engineer-in-chief at the Post Office, Colonel Purves, a man of vision, then decided in November 1922 on the all-out introduction of a single automatic system to become the British national system. His choice was STROWGER:

- with 'DIRECTOR' in the major towns,
- without 'DIRECTOR' elsewhere.

It was also decided to standardize the system. Patents were pooled and the conversion of the various British factories using either American patents (of Automatic Electric, Western Electric or North Electric trade marks) or German or Swedish patents was immediately set in motion.

The priority in standardization related, needless to say, to the basic characteristics of the equipment:

- standardization of subscriber sets and the characteristics of the pulse trains delivered by the dial,
- pulses transmitted on the subscriber loop, without an earth return,
- standardized battery voltage,
- subscribers served by 25-position rotary pre-selectors for traffic concentration,
- etc.

3.7. What stands out most in Colonel Purves's achievement? It is clearly his success in focussing all the efforts of the British telephone industry on a single automatic system and in getting it adopted as a national system despite its foreign origin. As a result of this

coordination, Great Britain, which in 1923 had no more reason than any other European country to take pride of place in automatic telephony (since at the time, it was Germany that was very clearly leading the field in Europe), nevertheless, for nearly half a century, remained at the head of the European countries in the production of automatic equipments.

3.8. The first demonstration of the STROWGER DIRECTOR system was given at the British Empire Exhibition in 1924. In addition to the arrangements at the automatic exchange, this demonstration included a complete model of the Coded Call Indicator (C.C.I.) system, which could be installed at existing manual exchanges to provide a visual display of the required subscriber's number to operators on calls incoming from automatic exchanges. The C.C.I. equipment was designed expressly to require a minimum of floor space and the lowest possible power requirements, so that it could be installed at existing exchanges where, in many instances, accommodation was very restricted.

During 1926–1927, all London manual exchanges were provided with C.C.I. equipment in readiness for the opening of the first automatic exchange [10].

3.9. The first DIRECTOR exchange in the United Kingdom was Holborn, opened in 1927. Nine other DIRECTOR STROWGER exchanges were brought into service in 1928 and 1929 and thereafter the system was extended throughout London and 5 other large cities: Birmingham, Edinburgh, Glasgow, Liverpool and Manchester.

3.10. The standardization of the STROWGER system in Britain was a long-term undertaking.

It was about 1930 that the British STROWGER equipment started to diverge considerably from the parent design. Although most of the existing electrical circuits were maintained, the hardware and the relays were



completely redesigned in order to reduce costs:

- the British relay (3 000-type) was simpler, with its knife-edge pivot, than the original STROWGER relay; twin contacts were employed to minimize the number of circuit failures caused by dirty contacts;

- the number of mechanically actuated electrical contacts was considerably reduced in favour of purely electrical switches;

- the release magnet was dispensed with, the wiper assembly being returned to the idle position not by retracing its path, but by free rotation to the 12th position, followed by vertical drop at the end of the bank, and completed by rotation below the bank;

- finally, the mechanism was rendered much more accessible, so that it could be entirely removed without any need to touch the bank; double-sided racks were abandoned and replaced from 1931 by standard single-sided racks;

- the British exchange was about 40% more compact than the initial standard STROWGER version.

The equipment was strictly standardized in 1936. Until then, the various British companies manufactured two-motion selectors based on the same general design, but displaying nevertheless differences in construction with non-interchangeable components. The STROWGER selector which was then standardized was designated the '2 000-type selector'.<sup>12)</sup> The English technical literature makes wide use of this designation, distinguishing previous models by the term 'pre-2 000 type.' This standardization led to a reduction of some 30% in the number of piece parts, and in the weight and size of the selector, at the same time concentrating the mechanically operated springs together in an accessible position [2, pp. 99–100].

3.11. Strict standardization was likewise imposed for low-capacity exchanges designed for

<sup>12)</sup> First installation of an exchange with 2 000-type switch (Rugby, 1936).

rural areas or small towns. These exchanges consisted of a number of standardized units and were known as Unit Automatic Exchanges (abbreviated to U.A.X.), with 3 types [2, pp. 405–526].

- U.A.X. No. 12 (capacity limited to 100 lines),

- U.A.X. No. 13 (capacity limited to 200 lines),

- U.A.X. No. 14 (capacity limited to 800 lines).

These types of units were designed in 1935–1936 and were preceded by a series of other types of rural automatic exchange<sup>13)</sup> equipment for large-scale application of automatic telephony to rural areas which began in 1929. Between 1929 and 1934, 1 100 such exchanges were opened for service.

3.12. The British STROWGER equipment was largely used in the Commonwealth countries. It was also exported in many Latin American countries.

#### 4. The German step-by-step, or SIEMENS system

4.1. Just before the beginning of this century, the German Administration warmly received the representatives of the Strowger Company (with Alexander E. Keith himself travelling throughout Europe) when they came to display their automatic switching system.

In June 1901, the Strowger Company granted a concession for the use of its patents<sup>14)</sup> throughout Europe, excluding France and Britain, to a German industrial group consisting of the Ludwig Loewe Company's

<sup>13)</sup> "The designation Unit Automatic Exchange (U.A.X.) superseded the Rural Automatic Exchange one, to avoid any possible objection from communities who did not consider themselves rural! ..." [10].

<sup>14)</sup> German patents filed at the Imperial Patent Office in 1898 and granted on 26 June 1900 under No. 111 478.