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The Early Years of the Strowger System

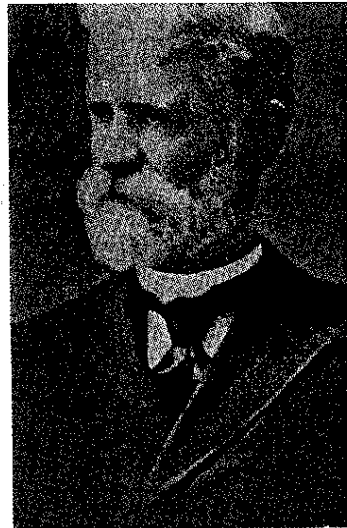
R. B. HILL
General Staff

Some of the early attempts to devise automatic telephone systems were described briefly in a previous article*, and it was stated that, while some of the early inventions embodied ideas that were later developed into important features of the modern automatic art, none of the systems themselves went into commercial use. It remained for Almon B. Strowger, an undertaker of Kansas City, Mo., to devise the first automatic telephone system to be used commercially. The important feature of this invention was that of imparting to the switch arm first a vertical movement, and then a rotary motion in a horizontal plane. Strowger is said to have constructed the first crude model of his switch from a cardboard collar box and a paper of pins. He stuck the pins from the outside of the box toward the center until he had ten horizontal rows of ten pins each, one row above the other, to represent the line terminals. The vertical shaft for carrying the switch arm was represented by a lead pencil through the center of the box.

Strowger filed his patent application on March 12, 1889, and it was issued on March 10, 1891 as patent No. 447,918. The mechanism of Strowger's patent is shown in Figure 1. While this particular arrangement was never used commercially, it illustrates the inventor's original ideas. As may be seen, an individual switch was required at

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Almon B. Strowger in his later years, from "Telephony" for October 15, 1949.

the central office for each subscriber line. The switch consisted essentially of a hollow cylinder with a shaft capable of both vertical and rotary motion. This shaft carried a wiper arm capable of wiping over all the horizontal rows of contacts on the inside of the cylinder. All of the subscriber lines were multiplied to the rows of terminals around the cylinder of every switch, while one of the subscriber lines was connected to the wiper of each switch. Strowger did not specify in his patent the maximum number of lines which could be terminated in his switch, but in a circular issued in April, 1891, he claimed that it would "connect telephones in a system from two to ten thousand." In describing its method of operation, however, most writers have assumed ten horizontal rows of 100 contacts each. (Even this number would have required a switch prohibitive in size and cost.) The vertical and rotary motions of the shaft were controlled by electromagnets actuated by impulses sent from the subscriber station. Four push buttons on the subscriber telephone box each controlled a wire to the central office, while the fifth wire was for talking.

To call the number 315, Strowger states in his patent, the subscriber pressed his "hundreds" button (C') three times, thus lifting the shaft of his switch three notches and bringing the wiper opposite the third row of terminals. He then pressed his "tens"

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button (H') once, which gave a single rotation to a 10-toothed ratchet wheel (E') attached to the shaft and moved the wiper arm to 310. Pressing the "units" button (I') five times operated a 100-toothed ratchet wheel (E) attached to the shaft and moved the wiper arm five more points to 315.

Ringling was done with a magneto or battery. When through talking, the calling subscriber pressed the (P') button, which energized the release magnets and brought the shaft and wiper arm back to their normal positions. The use of five wires and ground was, of course, an impractical feature, but Strowger planned to later reduce the number of wires. A heavy battery was to be employed at each sub-station for operating the central office switch. There was no provision against the calling subscriber being connected to a busy line.

The first company was incorporated on October 30, 1891, under the name of the Strowger Automatic Telephone Exchange. Early in 1892, A. E. Keith, who had previously been employed by the Brush Electric Company, of Baltimore, entered the service of the Strowger company and was for many years thereafter one of its leading technicians and inventors.

On November 3, 1892, the first Strowger exchange was opened for public service at La Porte, Ind., with about seventy-five subscribers. This was the first automatic telephone exchange to be installed anywhere, and a considerable amount of ceremony was attached to the affair, with a special train run from Chicago and a brass band on hand to greet the guests. Since this system was designed for less than 100 lines, there was no need for a switch with a two-way movement, and a flat rubber disc type of switch was employed, with but one (rotary) movement for the wiper arm and one circular row of contacts. There were still five line wires, as in Strowger's patent, and each telephone was equipped with four push buttons, although the hundreds button was not used. The battery for operating the switches was now located at the central office. There was still no provision against a subscriber being connected to a busy line. The system worked with reasonable accuracy when the subscribers operated their push buttons correctly and remembered to press the release

button after a conversation was finished.

In 1893, a small Strowger equipment was exhibited at the Chicago World's Fair.

About the beginning of the year 1894, Frank A. Lundquist and the Erickson brothers, John and Charles J., entered the service of the Strowger company, and, with A. E. Keith, started work on an improved system employing the so-called "piano wire" terminal banks with a flat-faced multiple and a switch arm capable of both a rotary and a longitudinal movement. Switches of this type, which were covered by patent No. 540,168, were installed at La Porte, Ind., in the fall of 1894 to replace the original equipment, and at Michigan City, Ind., in the same year. These new installations employed a simple form of busy signal. When the calling subscriber rang, both bells responded if the called line was free. If it was busy, the calling subscriber bell remained silent. They also utilized the first automatic release arrangement, invented by A. E. Keith in 1893 and covered by patent No. 573,884, embodying a mercury switch connected with the subscriber switchhook, which restored the central office switch to its normal position upon the hanging up of the receiver.

The "piano wire" form of switch did not prove successful, and in 1895 a return was made to the principle of Strowger's original patent. Patent No. 638,249, issued to A. E. Keith and the Erickson brothers, covered a switch which more nearly resembled the modern step-by-step switch. Two views of it in the patent are shown in Figure 2. It employed semi-circular banks and the familiar "up-and-around" motion of the selector rod and wipers. One-hundred-line switches of this type replaced the "piano wire" switches at La Porte in June, 1895. In August, 1895, a similar system, with 200-line switches, was installed at Michigan City.

At this time, the Strowger system employed, between a subscriber's premises and the central office, two hard drawn copper line wires, and a soft copper battery wire which branched into all the stations to supply signaling current. This arrangement continued in use until about the year 1900.

In the summer of 1896, an important forward step was made with the introduction of the finger-wheel dial to replace the push buttons. It was covered by patent No. 597,-

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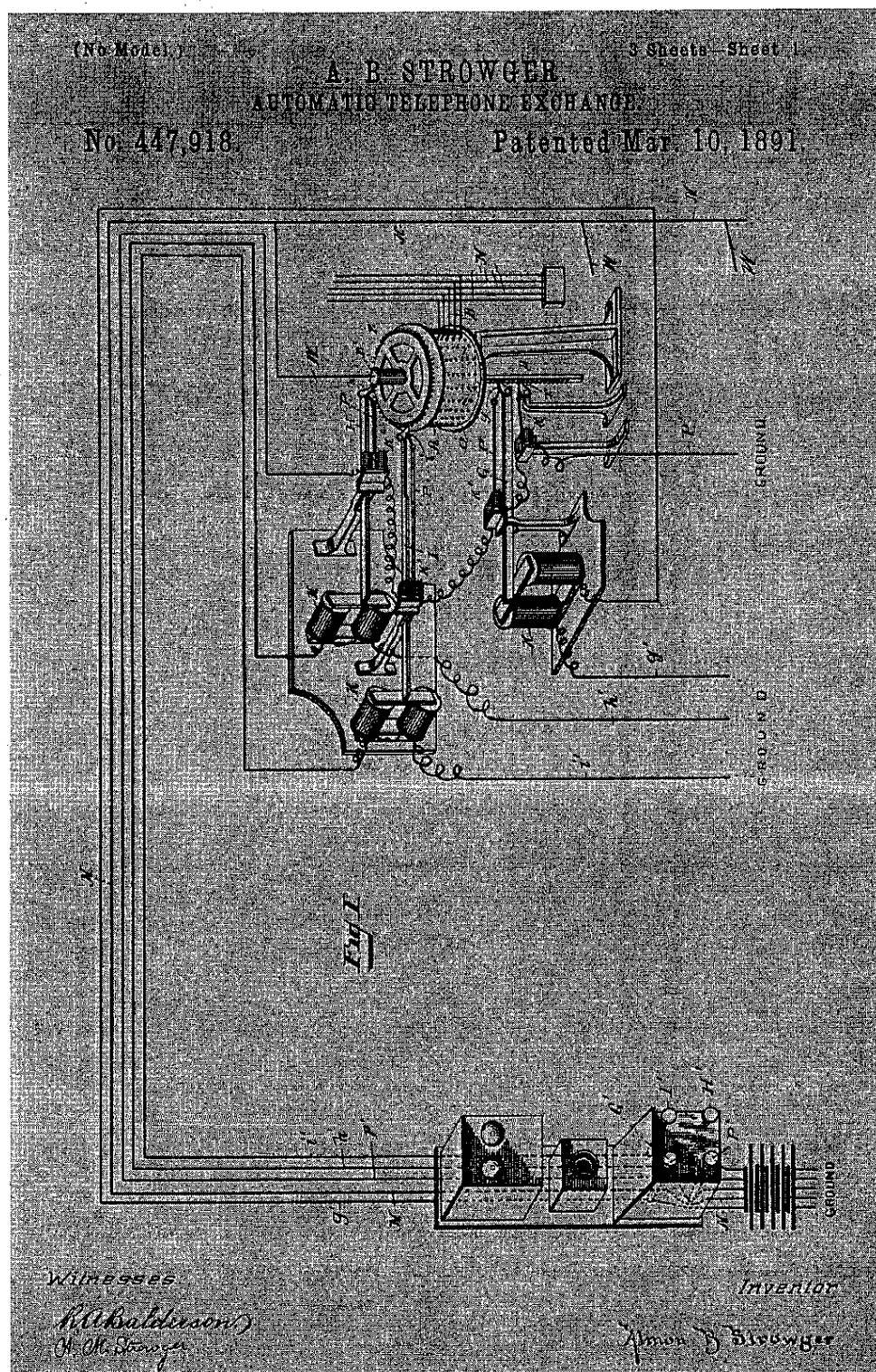


Fig. 1—Strowger's first automatic telephone system, as disclosed in his patent No. 447,918.
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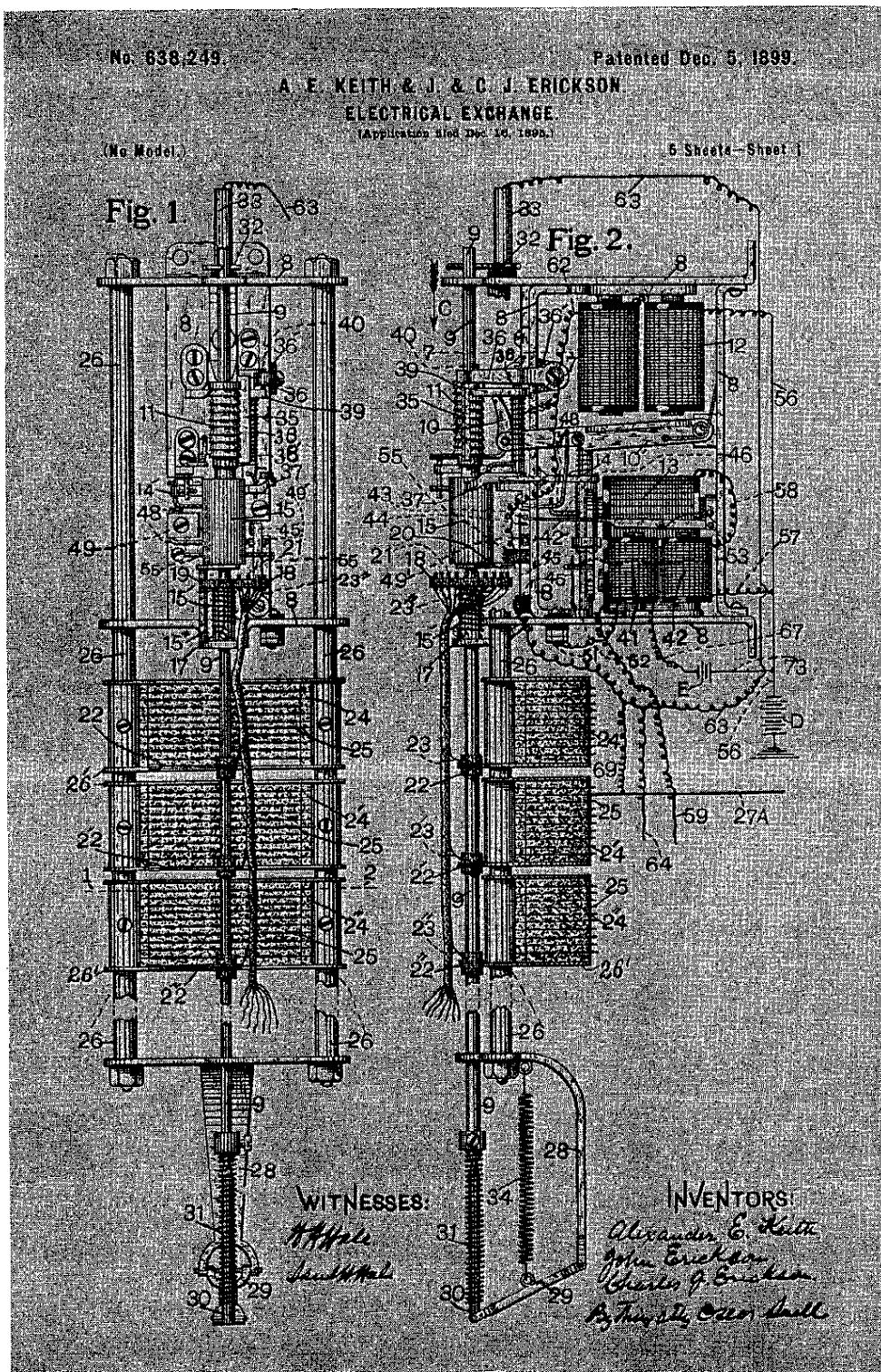


Fig. 2—Front and side views of the first Strowger switch to bear a general resemblance to the modern step-by-step switch.

062, issued to the brothers. As with this first form holds mounted on a circular plate up a spring which was withdrawn from its normal position limited to a moment mechanism the required number took place to connect central office and

In the fall of 1897, Strowger Company's health. He took the development of his name, and he died in May, 1899.

It was also A. E. Keith who started work on the trunking order to remove an automatic exchange of necessity of multiple lines to each switch of course, but he had produced a commercial use of switches which lines would each have their own lines, and enough switches would handle various hundred lines preceded by a selector switch. The selector would handle hundreds of digits the call to a connection the latter would handle digits and Two switches would handle but they might be more than a single line.

The Keith-Erickson system, covered by this character of Strowger exchange in March, 1897, this installation of terminals at which it could

* RECORD, January

062, issued to A. E. Keith and the Erickson brothers. As will be seen from Figure 3, this first form employed numbered finger holds mounted on the periphery of a rotatable circular plate. Dialing a number wound up a spring whose tension, when the finger was withdrawn, caused the dial to return to its normal position. The return rotation was limited to a moderate speed by an escapement mechanism, and, during the return, the required number of circuit interruptions took place to control the movement of the central office apparatus.

In the fall of 1896, A. B. Strowger left the Strowger Company and went to Florida for his health. He took no part thereafter in the development of the system which bore his name, and he died in St. Petersburg, Florida, in May, 1902.

It was also during the year 1896 that A. E. Keith and the Erickson brothers started work on a 1,000-line system employing the trunking or transfer principle in order to remove the limitation on the size of an automatic exchange imposed by the necessity of multiplying all of the subscriber lines to each switch. The idea was not new*, of course, but none of the previous workers had produced an arrangement suitable for commercial use. Under such a plan the switches which make connection to called lines would each be limited to reaching 100 lines, and enough groups of such connector switches would be provided to serve the various hundreds of lines. They would be preceded by a stage of selector switches. The selector would respond to the initial or hundreds digit of the number and extend the call to a connector in the proper group; the latter would respond to the tens and units digits and connect to the desired line. Two switches would be used on each call, but they might be made smaller and cheaper than a single large switch.

The Keith-Erickson 1,000-line trunking system, covered by patent No. 672,942 was of this character. It was employed in the Strowger exchange installed at Augusta, Ga., in March, 1897, to serve some 400 lines. In this installation the selector had only one set of terminals at each of the ten positions to which it could be dialed, and thus each

group of selectors had only one trunk to each group of connectors. Because of the inefficiency of these one-trunk groups, the system although operable was not commercially practicable.

In the summer of 1897, however, the Strowger engineers started work on the problem of a 1000-line trunking system employing automatic trunk selection. Under this plan the selector would have several sets of contacts in each row, leading to the several connectors serving a group of 100 lines, and would be arranged to connect with the first idle trunk it found in rotating over these contacts. In the first arrangement designed for this purpose, the pulses for

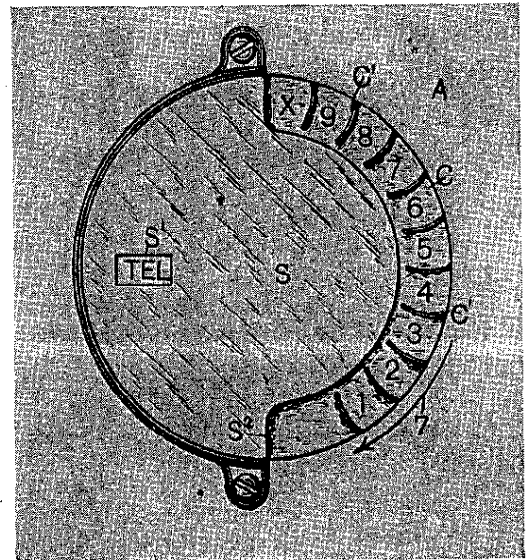


Fig. 3—First form of Strowger finger-wheel substation dial, which replaced the push buttons previously used.

rotating the selector were provided by the calling subscriber, through the device of inserting a dummy "O" in the directory number following the hundreds digit. The selector was designed to rotate in response to the pulses of the dummy digit until an idle trunk was encountered, after which the remaining pulses were disregarded. This plan was soon superseded by one in which the pulses were furnished by a continuously operating interrupter in the central office. The plan could be extended to exchanges of 10,000 lines by inserting another stage of selectors in the train.

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Incidentally, after protracted Patent Office interference proceedings, the patent (No. 776,524) covering the automatic selection of an idle trunk was awarded to Frank A. Lundquist, who had left the Strowger Company in 1896.

The Strowger exchange at New Bedford, Mass. — the first automatic exchange to employ a practicable form of trunking system — was opened for service in November, 1900. It employed first and second selectors, and was equipped for some 3,600 lines.

Other improvements were also made in this installation. The common battery supply wire was discarded, only the two line wires being carried back to the central office. However, the telephone had a third wire connected to ground, which served as a common return, the call being made by grounding one line or the other the required

number of times. For this reason, this arrangement, which was standard until 1907, was usually referred to as a three-wire system. Local batteries still furnished the talking current, and the subscriber rang by operating a push button which connected a central office ringing generator into the circuit.

In September, 1901, a Strowger exchange very similar to the New Bedford installation was opened for service at Fall River, Mass., with about 400 subscribers.

During the year 1901, the Automatic Electric Company was organized and acquired the United States rights to manufacture and sell Strowger equipment. The Strowger Automatic Exchange remained only a patent holding company until 1908, when its stock was acquired by Automatic Electric.

The New Bedford and Fall River installations may be said to mark the beginning of the work which eventually led to the development of a Strowger system suitable for use in large single-office cities. There were still many improvements to be made, the most important of which were: bridging the switch-controlling relays across the line, instead of placing them in series with the line; common battery talking; automatic ringing; the provision of practical forms of measured rate and selective party-line service; means for eliminating the need of an expensive first selector for each subscriber line; and the replacement of the three-wire (two-wire and ground) system with a straight two-wire system. Until these improvements were introduced, there was no prospect of the Strowger system competing on anything like even terms with the manual common battery system.

What some of the apparatus of the Automatic Electric Company looked like at this period (about the year 1902) is shown in accompanying illustrations. Figure 4 shows a wall set equipped with a finger-wheel dial. Figure 5 shows front and side views of the selector switch, of which there was one for each subscriber line. In the upper half were the electromagnets and their associated equipment. The lower half consisted of three banks of terminals, with a wiper for each bank. The upper, or "busy," bank was used to show whether a trunk was busy, and the two lower, or "line," banks provided the

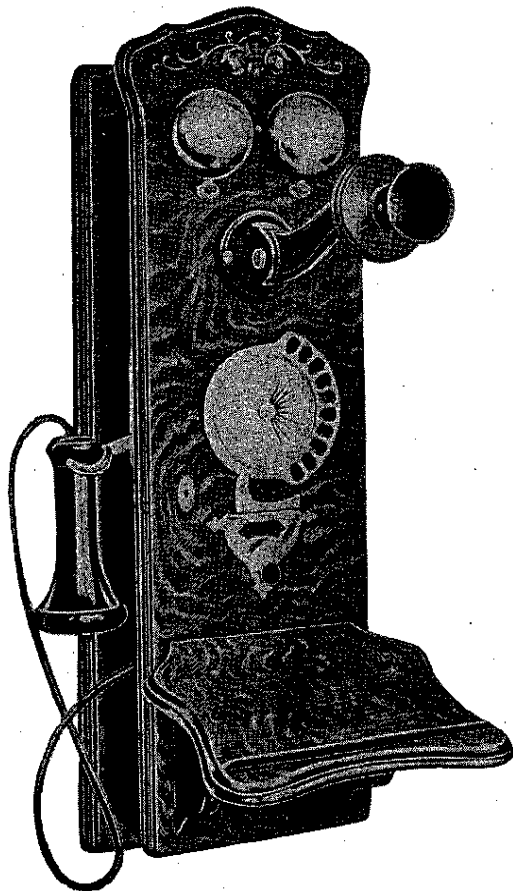


Fig. 4—Strowger wall set with finger-wheel dial about the year 1902.

Fig. 5—Front and side views of the selector switch.

talking connection. The first selector employed first and second selectors. Later, the first selector was made it possible to connect terminals into a selector switch.

After the first exchanges were installed in the district of Chicago about 1,500 subscribers in July 1903, with Grand Rapids having 5,300 subscribers. The Chicago exchange

reason, this standard until 1907, a three-wire system furnished the talker-subscriber rang by which connected generator into the

Strowger exchange at Fall River, Mass.,

the Automatic Electric Company manufactured and acquired the Strowger Automatic only a patent in 1898, when its stock was sold to the Electric.

The Fall River installation was the beginning of a system suitable for cities. There were many things to be made, the first were: bridging the gap across the line, in series with the talking; automatic practical forms of party-line serving the need of an operator each subscriber of the three-wire system with a switch. Until these improvements were made, there was no system competing with the manual

apparatus of the Automatic (which looked like at this time) is shown in Figure 4 shows a finger-wheel dial. The side views of the dial were one for the upper half were their associated half consisted of a wiper for "busy," bank was busy, and banks provided the

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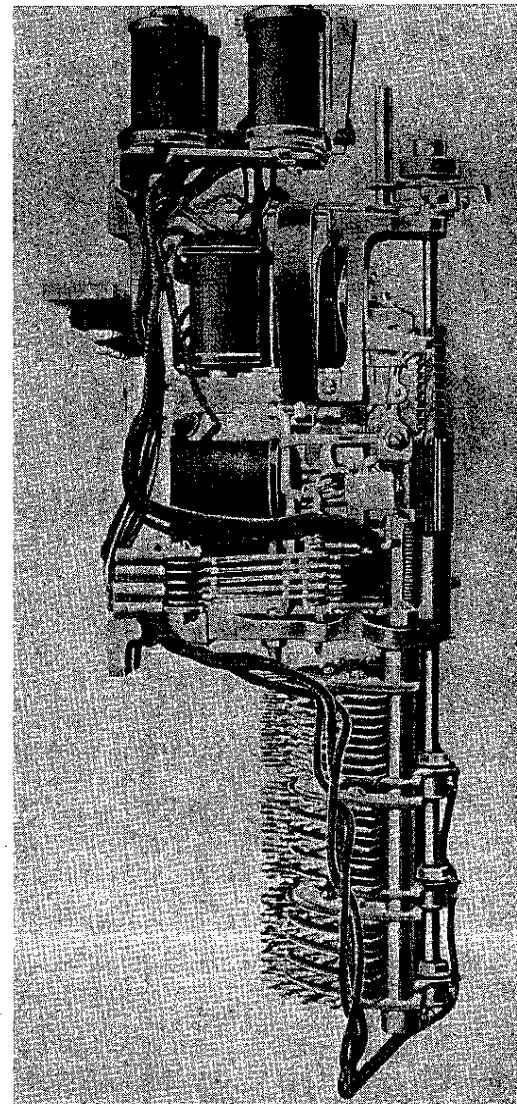
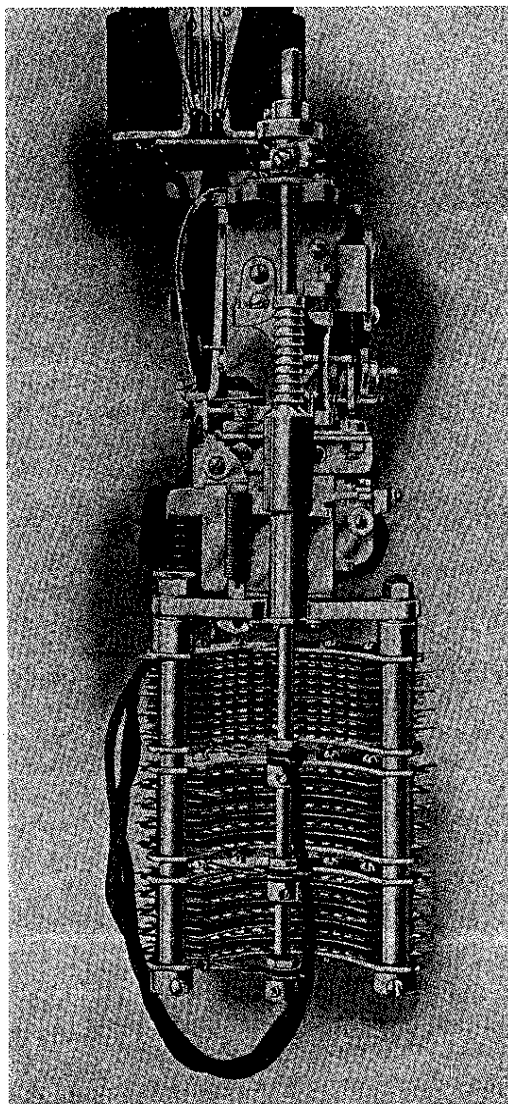


Fig. 5—Front and side views of Strowger selector switch about the year 1902.

talking connections. Three-digit systems employed first selectors and connectors, while four-digit systems employed first selectors, second selectors and connectors. The latter were very similar in appearance to the selectors. Later, mechanical improvements made it possible to incorporate the 200 line terminals into a single line bank, and resulted in a shorter two-bank switch.

After the Fall River exchange, Strowger exchanges were installed in the "Loop" district of Chicago in February, 1903, with about 1,500 subscribers; at Dayton, Ohio, in July 1903, with 1,300 subscribers; and at Grand Rapids, Mich., in January 1904, with 5,300 subscribers, replacing a manual board. The Chicago installation was the first Strow-

ger exchange to furnish any type of message rate service, the first selectors being equipped with a commercial form of meter (Veeder meters). These did not register a busy call, but did register all completed calls, whether answered or not. The Dayton exchange was the first in which the controlling magnets were bridged across the line, instead of being in series with it, thus effecting a considerable improvement in transmission characteristics.

The first of several Strowger branch offices, designed to connect with and supplement the Main (independent) manual exchange at Los Angeles, was completed in July, 1904. Several years later, the Main exchange was cut over to dial operation.

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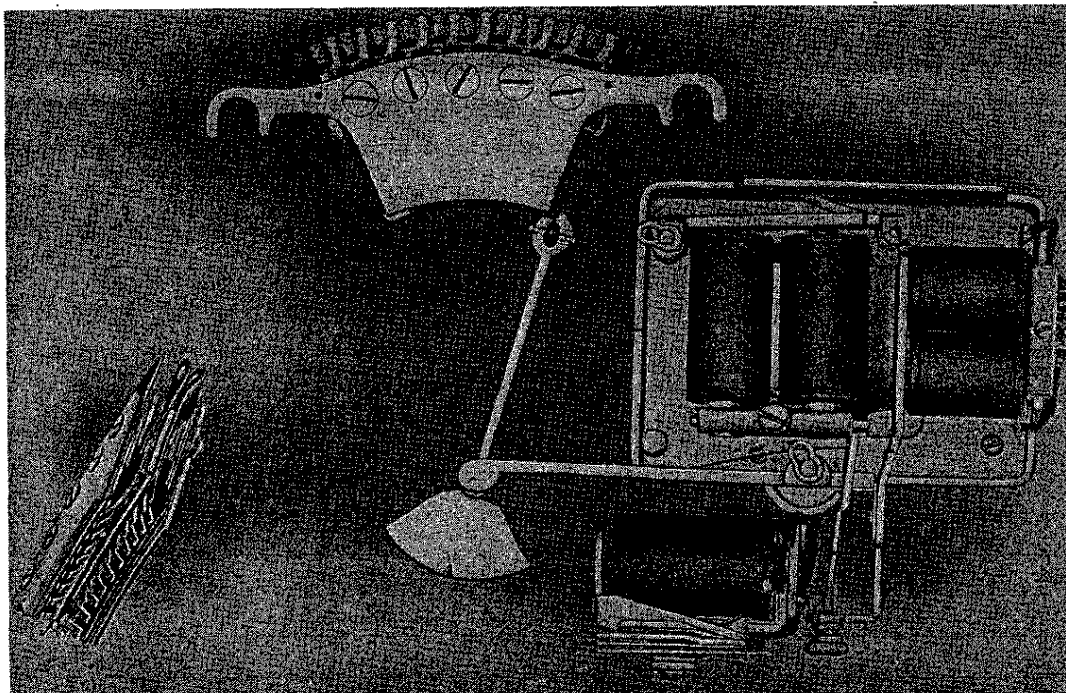


Fig. 6—Early form of Keith line switch.

The first Strowger exchange with common battery talking was installed at South Bend, Ind., in May, 1905, to operate jointly with a manual common battery board in the same building. It served about 700 subscribers. With the advent of common battery operation, it became possible to employ automatic (machine) ringing, whereby the called subscriber bell was rung automatically as soon as the connection was made to his line. Common battery operation and machine ringing were, of course, old in manual switchboard practice at this time. The Hayes repeating coil system of common battery supply had been developed by the Bell System in the 1890's and was widely used in their exchanges, while the Hibbard machine ringing system had been standard in Bell exchanges for many years. The early Strowger common battery exchanges used a bridged impedance type of circuit.

An arrangement aimed at convenience and economy in the grouping of the apparatus was covered by A. E. Keith's patent No. 831,876, filed on March 9, 1905. It called for ten rows of ten frames each, every frame containing the switches for serving 100 subscribers, and consisting of 100 first selectors,

10 second selectors and 10 connectors. This arrangement provided for 10,000 lines, each row serving a particular 1,000 lines. This patent also covered the important feature known as "bank slip," wherein the trunk multiples are wired or "slipped" in such a way that if ten selectors start at the same time to test the same trunk group, they will all at their first step test a different trunk. This arrangement shortened the time necessary for a selector to find an idle trunk, reduced the possibility of two selectors seizing the same trunk, and equalized the wear on the switches.

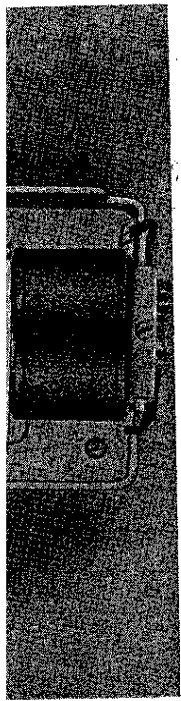
About the year 1905, the Automatic Electric Company developed a four-party selective signaling system for use with their common battery equipment. This feature, of course, was also old in Bell System manual exchanges, the Hibbard system, employing oppositely biased polarized bells, having been in use for many years. The Strowger exchanges used harmonic ringing.

The earliest Strowger exchanges had all been equipped with a first selector for each subscriber line, and this practice had continued when the larger exchanges, employing trunking, had come into use. It involved

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a great waste of equipment, since only about ten per cent of the first selectors would be in use at any one time. This very serious limitation on the economy of the Strowger system was removed by A. E. Keith's patent No. 1,304,324, covering a line switch of the plunger type, filed on April 29, 1905, but not issued until many years later. With this arrangement, which went into general use around the year 1907, and eliminated about 90 per cent of the first selector switches, each subscriber line terminated in a line switch, much smaller and cheaper than a first selector, whose function was to connect his line automatically to an idle first selector as soon as he removed his receiver from the hook. The first selector then received the initial dialing impulses in the usual manner. This line switch, shown in Figure 6, consisted essentially of a magnet and a lever carrying on its end a plunger. The latter, when actuated through the lever by the magnet, pressed together certain springs that connected the subscriber line to one of ten trunks leading to first selectors. One hundred line switches were controlled mechanically by a common "master switch," which kept the plungers of the idle line switches directed toward idle trunks.

Early in 1908, the first Strowger straight two-wire system, in which the ground was eliminated, was installed at Pontiac, Ill. This was accomplished by the use of a sluggish, or slow-release, relay which, when energized by a current, held its contacts closed for a short period after the circuit through its winding had been broken. In the two-wire system, the pulses were sent by opening the line a certain number of times, in-

stead of grounding one side of it. The vertical and rotary relays of the previous three-wire system were replaced, respectively, by a quick-acting relay and a sluggish relay. When a series of pulses (one dialing operation) had been received, the pause before a second series could be sent in allowed the sluggish relay, which was held up during the dialing, to fall off, giving the signal for the switch arm to rotate and choose an idle trunk. The two-wire system simplified the central office wiring, eliminated, during dialing, the disturbing influences due to differences in earth potential, and permitted a considerable simplification of the substation dial itself.

With the two-wire common battery system, provision was made for measured service by employing a differential or polarized service meter associated with the line switch and operated by the reversal of the current through the line of the calling subscriber at the time the called subscriber answered his telephone.

The advent of the two-wire system, with its basic simplification of the method of signaling from the station to the central office, marks the beginning of the modern phase of the Strowger (or "step-by-step") system. The engineers of the Automatic Electric Company continued to make improvements in the step-by-step system, while the Bell engineers developed the panel type of machine switching system. These parallel developments and the far-reaching effects of World War I led to the adoption by the Bell System after the war of step-by-step equipment for small and medium size cities and panel in the largest ones.

THE AUTHOR: ROGER B. HILL received a B.S. degree from Harvard University in 1911 and entered the Engineering Department of the American Telephone and Telegraph Company in August of that year. For several years thereafter he was engaged principally in appraisal and depreciation studies. When the Department of Development and Research was formed in 1919, he transferred to it, and since then, until his retirement in 1951, had been largely concerned with studies of the economic phases of development and operation. He had been a member of the staff of Bell Telephone Laboratories since 1934, first in the Outside Plant Development Department and later in the Staff Department.

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