The "concentration" of telephone lines outside the central office is an old concept but a comparatively new art. Development of this idea has resulted in a device that can save operating telephone companies millions of dollars in capital expenses.

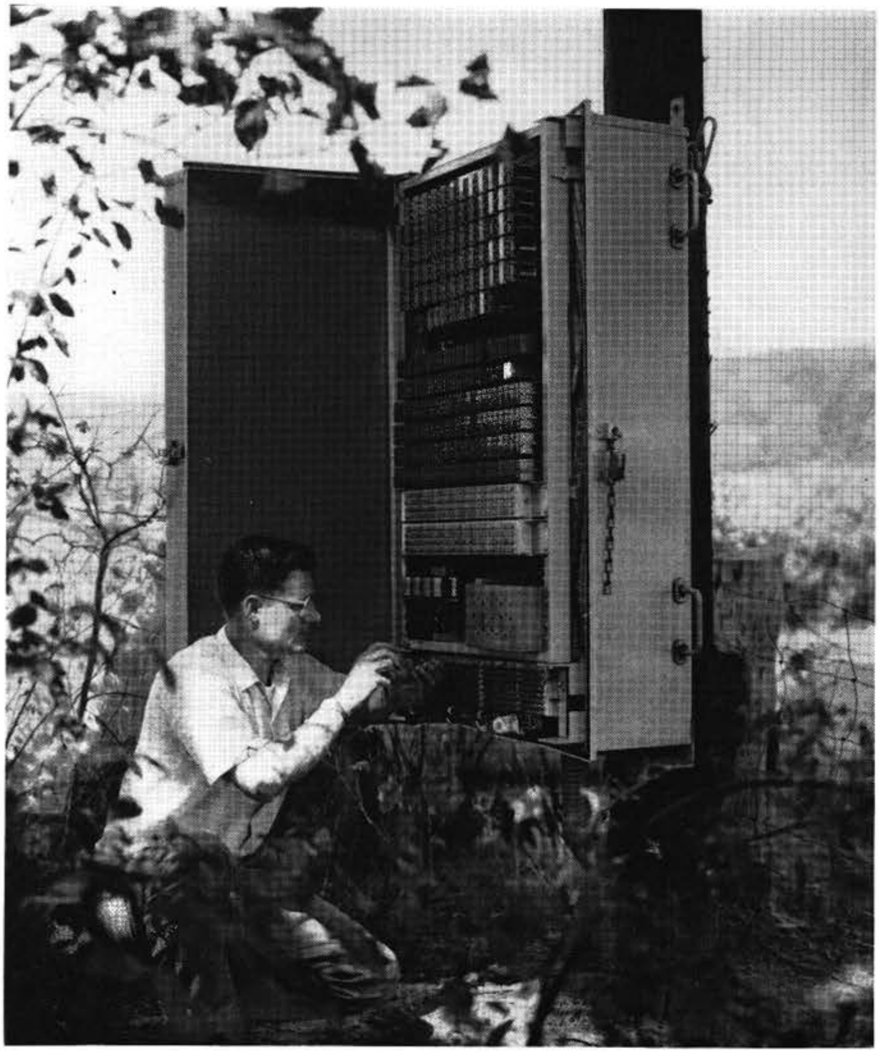
M. E. Krom

The 1A Line Concentrator

The telephone plant is in a large measure designed with the knowledge that only a small percentage of telephone customers want service at the same time. This is a broad concept relating to the over-all system, but here we will apply it specifically to the method of connecting telephone customers with a central office. In recent years, the cost of customer lines in the outside plant has increased rapidly, while the cost of central-office equipment has remained relatively constant. This is basically attributable to the increasing size of telephone exchanges, and the greater distance that their customers live from a central office. The result of the increase is manifest economically in terms of such things as more telephone poles, more wire, and more maintenance.

As early as 1908, and perhaps earlier, development engineers tried to devise a method of reducing the number of paths between telephone customers and the switching plant without affecting service. But not until recently has telephony advanced to the point where this concept could be put into practice. Three developments underlie its success: (1) mechanically or magnetically latching switches and relays which use power only during the set-up and disconnect intervals, (2) new power stores, such as large capacitors or nickel-cadmium batteries, and (3) better metal finishes which permit electromechanical apparatus to be installed outdoors in housings.

By connecting say, 100 telephone lines in a specific area to a remote switching unit, we can reduce the number of lines from customers to the central office. Such a switching center operates on the principle that only a few of these customers use their telephone at the same time. This means



The 1A Line Concentrator is a compact switching system designed to decrease the number of lines between a given area and a central office.

that only a few lines between the line switching center and the central office assure all customers of regular service whenever they pick up the phone. These lines, which now become trunks, are used first for one call and then for another.

The 1A Line Concentrator, developed by Bell Laboratories, does precisely this: it takes a relatively large number of lines, and, in effect, "concentrates" them on to a few lines or, more correctly, trunks. Of course, the practicality of installing a line concentrator depends on telephone usage, the distance of telephones from each other and from a central office, and the rate of increase of telephones in an area. When these factors indicate that a 1A Line Concentrator should be installed, annual savings in capital can be considerable. For example, the installation of 1000 line concentrators results in potential savings of four million dollars in capital expenditure.

The 1A Line Concentrator consists of a control unit within a central office, and a remote unit, which connects customer's lines to trunks. A block diagram of the system is shown on page 299. The remote unit can be mounted on a pole or on the wall of a building. Twenty trunks and two control pairs connect the remote unit to the control unit in the central office. Although the concentrator does not reduce the amount of equipment within a central office, it does allow a relatively large number of customers to share a small number of trunks to the central office. In other words, it affords a considerable reduction in outside-plant facilities.

The control portion of the concentrator is made up of two items of equipment. One is an inexpensive steel framework with associated fuse panels, terminal strips, and local wiring. This item may be ordered and installed before the concentrators are actually needed, thereby postponing capital expenditures until the equipment is put to use. The other item is the switching apparatus. This is an integral unit which can easily be attached to the central-office framework. This unit is installed by making simple cross connections on matching terminal strips.

Laboratories engineers designed the concentrator for virtually all types of central offices with very few modifications to existing central-office equipment. The concentrator is arranged for direct connection to lines having sleeve leads that are at negative 48-volt potential when the lines are idle and at ground potential when the lines are busy. Other types of lines require minor auxiliary apparatus to provide a compatible sleeve condition.

The transmission characteristics of a line will be unaffected by the concentrator. Standard tones, ringing voltages, pulsing arrangements, and data sets are accommodated. In fact, the unit can handle all types of lines except PBX and ground-start coin lines, which would normally be excluded anyway because of the high number of calls they handle.

The 1A Line Concentrator was designed to meet standard working limits of the connecting offices and to operate with standard message-charging equipment. Outside-plant facilities may consist either of loaded or non-loaded cable. Conventional electromagnetic apparatus—relays and crossbar switches—constitute the majority of the apparatus and assure long life, quality performance and minimum maintenance.

Power Supplied From Central Office

One of the most difficult problems encountered in designing the concentrator was that of supplying power to the remote unit. For reliability, it was decided that the power should be supplied from the central office via cable pairs. This means that the average current drain must be kept very small (actually about 0.1 ampere). This amount of current, however, is insufficient to hold as many as 20 hold magnets and 20 cut-off relays in the operated position. This problem was solved by developing a magnetic-latching crossbar switch and a magnetic-latching cut-off relay. Both devices are actuated by a pulse of current in one direction, released by a pulse of current of opposite polarity, and held in the operated position without any current flow. The switch is a conventional crossbar switch in which the standard hold-magnet core is replaced by a core having a high residual flux density. The standard armature of the hold magnet is replaced by a nickel-plated armature to improve magnetic properties. Some reed-type relays in the remote unit contain a small

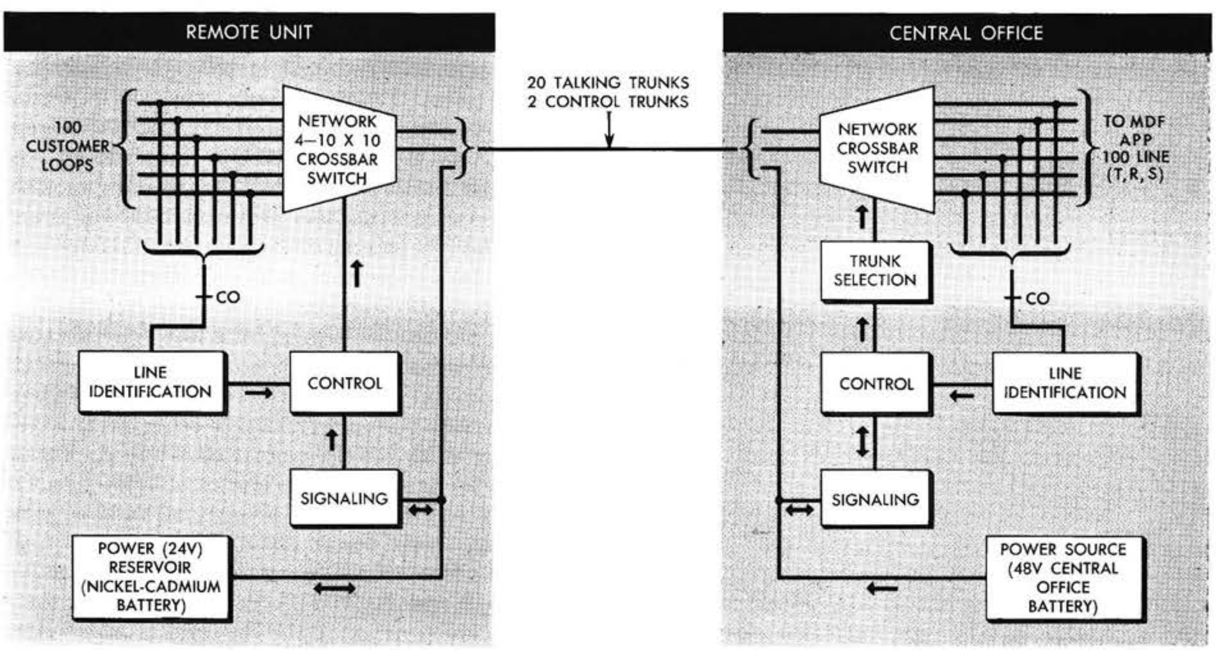


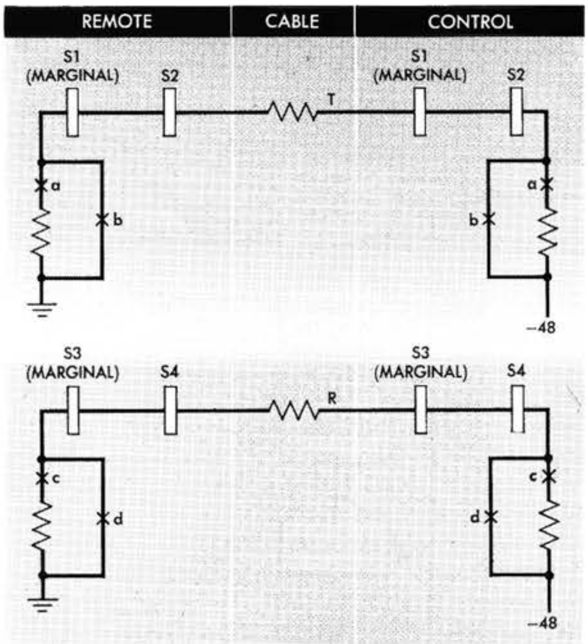
Diagram of the 1A Line Concentrator. Remote unit "concentrates" a number of calls on to a few lines. Central-office equipment "expands" incoming lines and routes them to called party.

permanent magnet. This magnet provides a flux insufficient for operating the relay but sufficient to hold the contacts closed after the relay is operated by a current pulse of proper polarity.

The use of these two new components means that the only local power needed is that required to connect or disconnect a line and to compensate for line leakage. Since a call can be set up or disconnected in less than ½-second, the power requirements for this use are small. Normal limitations on line insulation resistance (combined resistance of all lines shall not be less than 400 ohms) result in only a small current drain, thus permitting the remote unit to be powered by a small 24-volt battery. This battery is "trickle-charged" (over idle trunks) from the negative 48-volt battery in the central office. These are the only voltages required by the concentrator.

The crosspoint network used to associate lines and trunks in the remote unit consists of four six-wire, 100-point crossbar switches, having three lines (two leads each) per crosspoint. Lines appear on the switch horizontals and trunks on the verticals. Three steering levels serve to select one of the three lines in a crosspoint. The lines are divided into two groups of 50 lines each, with each group having full access to an individual group of ten trunks.

The control circuit in the central office requires



The signaling circuit uses two wires for transmission of line and trunk number information and two to control the sequence of transmission.

three leads per line, thus limiting the number of lines per crosspoint to two. Three 200-point, six-wire switches are required. Lines appear on the horizontals of these switches also.

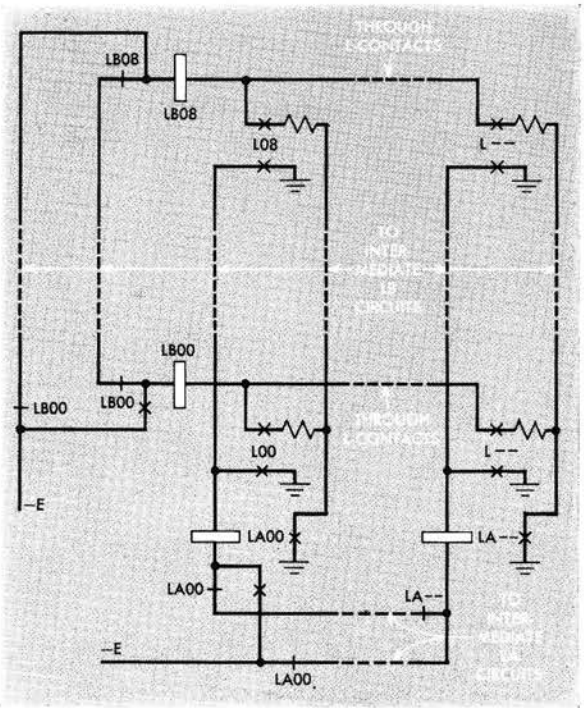
The concentrator control circuit monitors both originating and terminating traffic and controls the process of establishing and disconnecting calls. In the remote unit, switching is controlled by signals sent between the two units over two control pairs. One of these pairs transmits information for identifying line and trunk numbers. A simplified form of this signal pair is shown below, at left.

This is a symmetrical circuit, permitting signals to be sent in either direction. The circuit operates in this way: a, b, c and d represent contacts on many relays that control the sending of information. Now, assume that contact b is closed at the control end; it will be seen that three signals can be sent over the tip (T) conductor under control of contacts a and b at the remote end. When neither contact is closed, all relays are normal. When contact b is closed, all relays will operate; when contact a is closed, both S2 relays will operate. When two circuits are combined as shown above, nine different signal combinations can be derived. The second control pair provides sequence control, checking and release functions, and also an indication as to whether trunk 0 or 9 is to be chosen.

The manner in which information is sent over the first control pair is indicated on page 302. There are four successive steps used to send the information and establish a connection between the two units. There are four types of information transmitted: (1) class of call and line group number, (2) B part of the line number. (3) A part of the line number and (4) trunk number. The second pair controls the progress between these steps. The left column in this figure indicates the signal relays that operate in each step to provide the desired information.

When a customer served by a line concentrator lifts his handset, the line relay for his line (in the remote unit) operates. The concentrator then identifies his line and locks out other service requests by means of the circuit shown in the lower drawing on page 301. This circuit subdivides each 50-line group into six A groups, all having nine lines each except for the last which has only five. Each of these nine lines is assigned a B-number between 0 and 8.

The identification of the line and transmission of the information to the central office is accomplished as follows, using line 08 as an example:



The remote unit of the 1A Line Concentrator identifies a customer's line and locks out other requests for service with circuit shown above.

Operation of line relay 08 operated LA00 relay and LB08 relay. No other LA- or LB-relay can operate. The line group number and the line number (A and B information) are then transmitted to the central office over the signal circuit.

The information sent in each step is recorded in registers and checked both in the control and the remote units before proceeding to the next step. Finally, the information in the remote register is checked to see that it matches the information in the line lockout circuit before the circuit proceeds.

While the above information is being recorded and checked, the control circuit selects an idle trunk in the proper group and then transmits the number of the trunk to the remote unit in step four. When this information is registered and checked at each location, the hold magnets operate and the cutoff relay is released at the central office. The same sequence of operations occurs at the remote unit. When these operations are checked, the circuit releases, leaving only the magnetic-latching hold magnets operated at each end of the connection.

A call incoming to the concentrator operates a relay connected to the central-office line sleeve and proceeds in a way similar to a service request except that all information signals emanate from the control unit. A line lockout circuit, similar to that at the remote unit, identifies the number of the called line.

Conventional relays and switches are released by opening the operating circuit, but the magnetic-latching equipment in the line concentrator must be released by means of a current pulse having a polarity opposite to that of the operate pulse. Therefore, when a call is to be disconnected, that line and its associated trunk must be identified and this information outpulsed to the remote unit.

A trunk may be disconnected at any time when it is not actually being used by a customer. The idle condition is indicated by the release of a relay (normally held operated under control of the customer or the central-office equipment) when the associated trunk hold magnet is in the operated position. Release of this relay activates the disconnect circuit. The disconnect operation is similar to that for an incoming call, except that a disconnect instead of a connect indication is set up in Step 1 (page 302). This causes a reversal of current to the cutoff relay and hold magnet. These devices are respectively operated and released. After these operations are checked at the remote unit, similar functions are performed in the control unit. Both units then return to the normal state, awaiting other calls.

Minimum of Six Lines Connected

A minimum of six concentrator lines in the 100-line concentrator will always be cut through the concentrator to the central office. This is accomplished by means of a trunk load control circuit which disables the disconnect circuit when three or less lines per group are cut through to trunk circuits. This feature insures that some lines can always obtain service even if the control circuit becomes disabled. This means that the line will remain cut through even though not in use. It also prevents repeated connect and disconnect of trunks to lines having low insulation resistance. The latter condition can occur when the resistance is low enough to engage the concentrator but too high to engage the central-office equipment.

The remote unit is housed in a weather-tight, hardened-aluminum casing. Ventilation holes, covered with filters, guard against dust and insects. These holes in the bottom and back of the casing provide enough air circulation to prevent the accumulation of moisture in the housing.

The apparatus in the remote unit is mounted on two gates which open forward, thus making all wiring available from the front of the cabinet. The rear gate contains the four crossbar switches: the front gate contains relays, power equipment and terminal strips. The front gate also contains carbon protectors for protection of lines and trunks against high, foreign potentials and lightning surges. Connection to the outside lines and trunks is made through a connecting block in the bottom of the cabinet.

The concentrator underwent field trials in Gulfport, Miss. and Eau Claire, Wis. These geographic areas represent the near extremes of climatic conditions in the United States. The trials were conducted for extensive periods to ascertain the effect of climatic variations, to check circuit performance thoroughly, and to accumulate traffic information that will assist in installing line concentrators. The results of the trial were very gratifying in view of the limited laboratory testing that preceded installation. Only minor circuit modifications were found to be necessary, performance met all expectations, and much useful traffic information was obtained.

Today, the concentrator is the first of a new type of switching system. Tomorrow, it may be the prototype of a new line of systems that take advantage of new concepts and provide more economical telephone communication.

STEP →	1	2	3	4
Signal Relay Operated	Class of Call and Grp. No.	B Part of Line No.	A Part of Line No.	*Trunk No.
None		0		0 or 9
S4	Disc. Grp. 1	1	0	1
S3, 4		2	1	2
S2	Disc. Grp. 0	3	2	3
S2, 4		4	3	4
S2, 3, 4	Conn. Grp.1	5	4	5
S1, 2		6	5	6
S1, 2, 4	Conn. Grp. 0	7		7
S1, 2, 3, 4		8		8

*This number in combination with G0 selects trunks 0 to 9, and in combination with G1 selects trunks 10 to 19.

Information is transmitted from the remote unit to the central office in four successive steps.

Bell Laboratories scientists have developed a "traveling-wave" optical maser which amplifies light directly. The device has a net gain of 13 db—amplification of twenty times.

Optical Maser Amplifier Announced By Bell Laboratories

A solid-state optical maser amplifier has been designed with techniques that are similar to those used in microwave maser amplifiers. The Laboratories announced recently that it has constructed a "traveling-wave" pulsed ruby optical maser which can amplify the intensity of light directly. The device has a net gain of 13 db—an amplification of 20 times.

This optical maser amplifier preserves the spatial relationships of an input image. If a suitably illuminated object is placed at the input of the amplifier, its intensified image will appear at the output. This property was demonstrated with a small transparency whose intensified image was recorded photographically.

The experiments were carried out by the Laboratories with support from a contract with the U. S. Army Signal Research and Development Laboratory. They are described in the July, 1962 issue of the Bell System Technical Journal in an article by J. E. Geusic and H. E. D. Scovil of the Solid State Device Laboratory.

The new device is composed of two maser amplifying sections with an "isolator" between them.