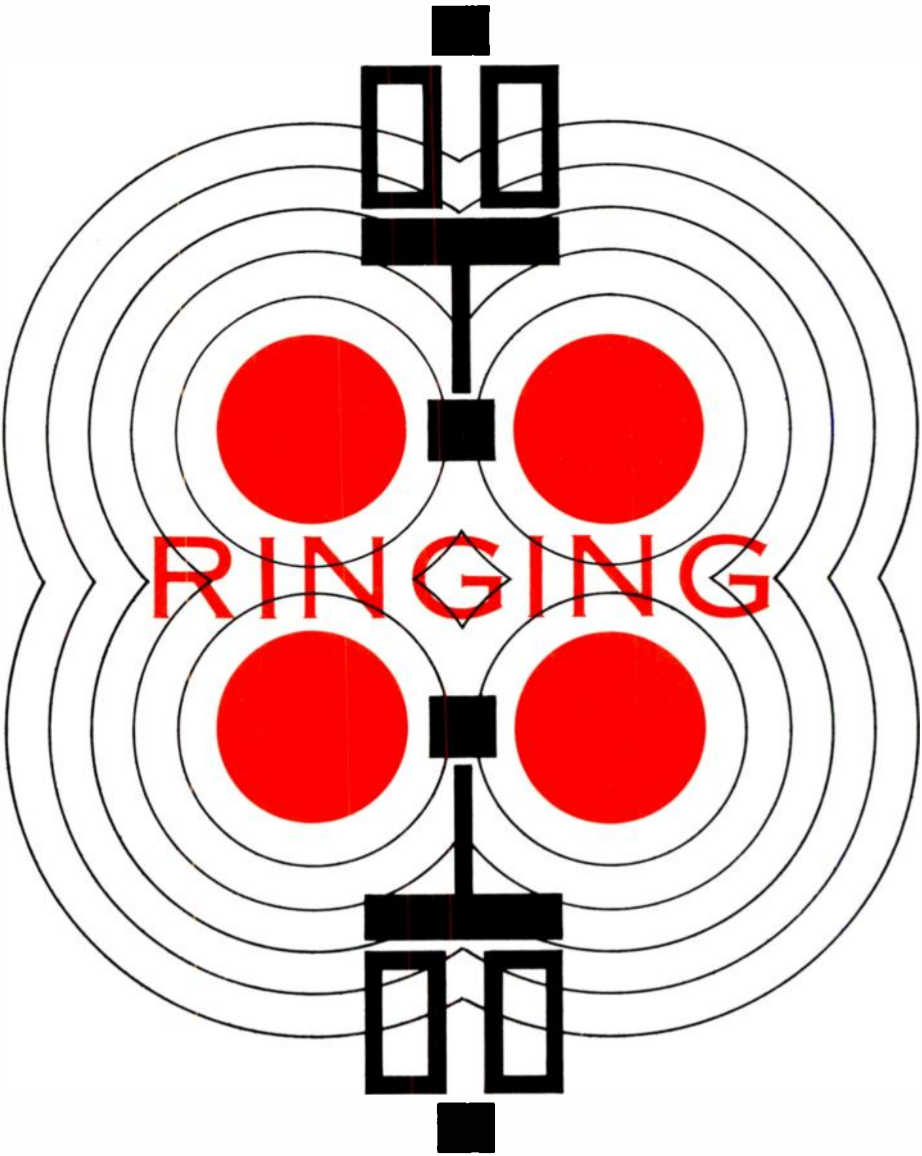
The Lenkurt DEMODULATOR

JUNE 1968



Multiparty service through ringing.

The modern telephone system provides a pleasant and functional means of communication over literally any distance. But for the service to be efficient and convenient, a number of functions beyond just the conveyance of the voice must be performed.

By dialing ten digits, most subscribers in the United States can call any other telephone in the country. Soon direct dialing all over the world will be possible.

But before the caller gets his party, the telephone system must somehow alert the called party. This important information, called *ringing*, begins when the connection is made and remains until the called party answers or until the calling party hangs up.

The first telephones had no signaling device at all, and the lines between a number of phones were simply connected together. There was no central office or switching equipment, and service was strictly local.

Hallo!

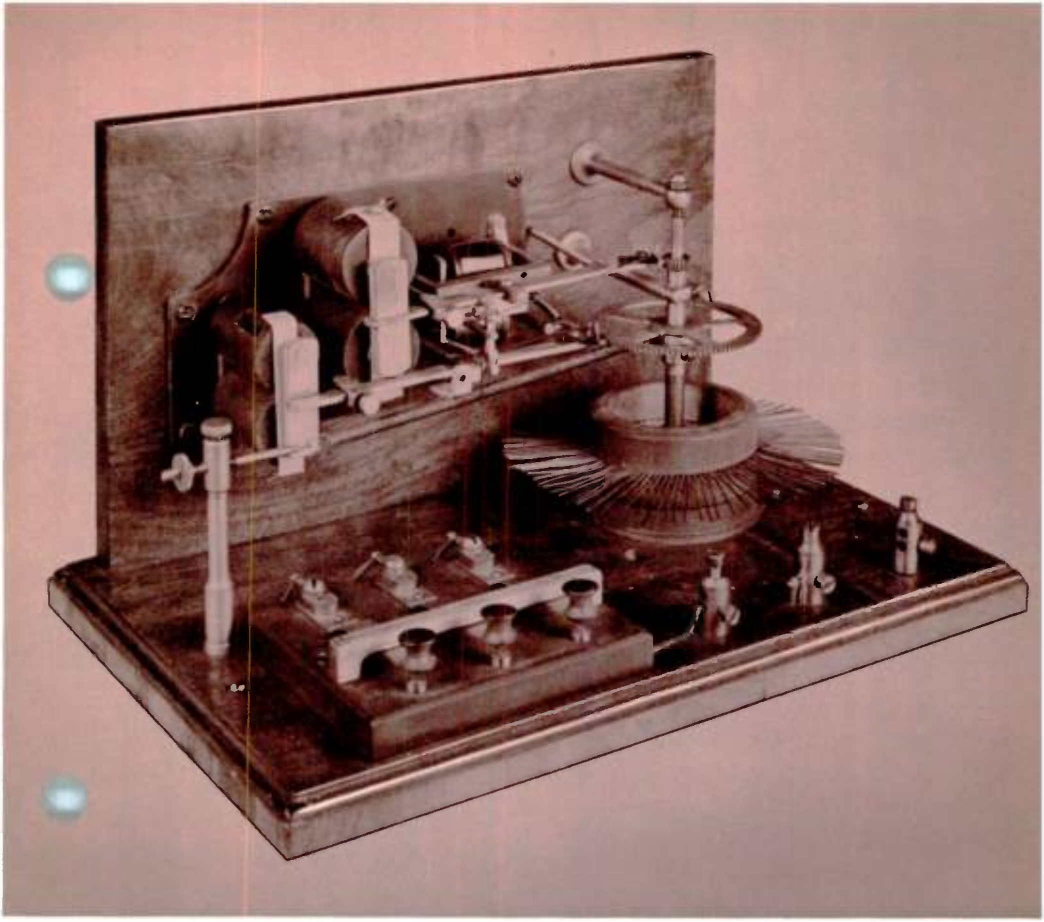
To attract attention the caller shouted into the mouthpiece. One of the common exhortations was "Hallo!", originally an exclamation to incite hunting dogs. With much usage, it became "Hello!", and one of the words contributed to our language by the telephone industry.

Callers soon learned to strike the mouthpiece diaphragm with a pencil to arouse attention. But this caused the diaphragm to become damaged, and a hammer-like device was designed to perform the same function.

A buzzer was added later, but its offensive sound was not popular with customers. This brought forth the two-gong bell, which still exists today as the most common form of signaling or ringing.

At first none of these signaling methods proved to be practical, mainly because they did not *selectively* identify the called party. Any number of parties could answer the phone or even listen in.

But along came "Central", a manual switchboard which helped the problem. This method of terminating lines at jacks and interconnecting them with patch cords still finds use in many small telephone companies.



Courtesy Automatic Electric Co.

Figure 1. Strowger's Automatic Switch, patented in 1891, provided automatic party selection without the aid of an operator. This first model had two ratchet wheels. The smaller wheel selected the tens numbers, and the larger, the ones, to give a total of 100 combinations or 100 lines.

The magneto phone introduced about the same time fit well into the scheme and provided acceptable service even when the transmission path was a system of barbed wire fence. To make a call, the customer would crank the magneto to release a flag at the central office. When the operator answered, the customer would ask for the desired number – or in most cases, just the name of a neighbor down the road. The operator then patched the lines together, signaled the called party, and announced to both to "go ahead".

Strowger Switch

To Almon B. Strowger, a Kansas City undertaker, this intervention was suspect, for he was losing valuable business through the partiality of an operator. Because the operator was diverting calls to a competitor, he reacted by inventing the first automatic switch. The Strowger Automatic System was publicized as the "girl-less, cuss-less, out-of-order-less, wait-less telephone".

It accomplished automatic party selection by means of an electromechanical pawl-and-ratchet mechanism that moved a wiper over a bank of contacts, each connected to a different telephone (Figure 1). The calling telephone was permanently attached to the wiper, and by sending the proper number of pulses, the caller automatically guided the wiper to the correct contact, and as a result, the desired phone.

At first, pushbuttons were used for "dialing", but were followed by the

Courtesy Automatic Electric Co.

Figure 2. Typical two-gong, straight-line ringer pictured above is used on single-party lines where there is no need to distinguish between one ringing frequency and another.

rotary finger-wheel dial similar to those used today.

As the number of customers increased, party-line service was established with many phones sharing the same pair of wires. Now even more selectivity was required to satisfy customer needs. This was done by developing methods of identifying each customer by ringing.

In the beginning special codes were established in conjunction with the number of cranks of a magneto. But this did not provide full selectivity. Two or more phones would ring, and each customer would recognize the code assigned to him before answering his phone.

Later, more sophisticated methods provided fully selective signaling for each customer, and the job of ringing was transferred to a specialized section of the central office. Of the several different schemes developed through the years, only a few are still in general use.

The Ringing Circuit

All schemes share the same telephone ringing circuit, which is made up of a ringing generator and interrupter, a connector, and the customer's station ringing device. Their purpose is to direct a ringing signal to a desired party and to alert the party that he is being called.

The ringing voltage is either ac or a composite of ac and dc. The ac is supplied by the ringing generator, and the dc by the office battery. Types of generators include vibrating-reed, rotary, static-magnetic (sub-cycle), and electronic tube or transistor. Each fulfills a specific purpose in a central office depending on its frequency and capacity.

The first system rang the customer's bell continuously. But this was found to be irritating, and the interrupter was added. The interrupter is a mechanical device consisting of rotating cams whose peripheral lengths control the on/off timing of the ringing cycle. The standard interrupter ringing cycle for single-party service is 6 seconds – a 1.2-second ring followed by a 4.8-second period of silence. To equalize the load capacity of the ringing generator, the interrupter consists of five ringing groups sequentially connected to the generator for 1.2 seconds, or a total of 6 seconds.

In most exchanges ringing equipment is part of the station signaling rack. It usually operates continuously except in some small offices where the unit is on only when a call is made.

In response to digit dialing information, the central office connector or equivalent circuit used to complete a call checks whether the called line is idle. If so, a ringing voltage is applied to the called telephone. Simultaneously, a ring-back tone with the same on/off cycle as the distant end ringing lets the caller know that the phone is being rung. If the line is in use, a busy tone is sent back to the caller. Both the ring-back and busy tones are merely a subjective means to give the caller full control over the telephone connection.

Ringing current to the customer's phone uses the same physical wire pair or carrier-derived circuit as used for voice transmission. Some of the earlier systems, however, used a separate third wire for ringing only.

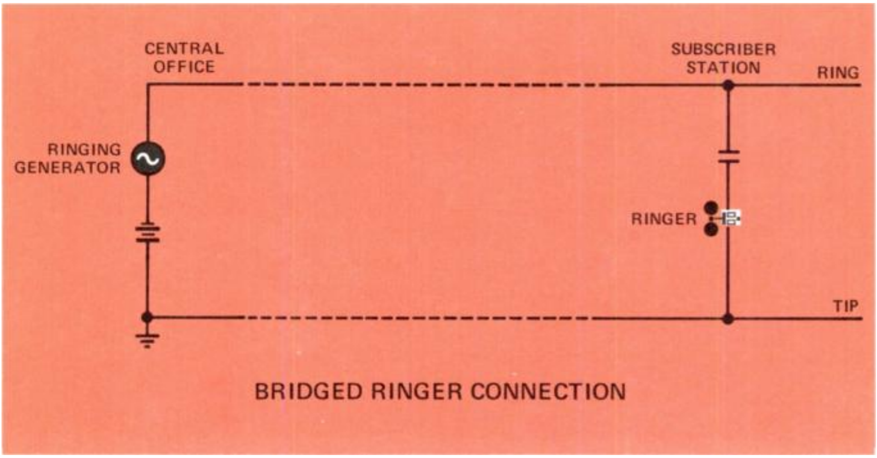


Figure 3. The connection for the bridged ringer is across the tip and ring transmission pair.

In order to signal a called party it is necessary to provide a ringing device at the customer's premises. It normally consists of a two-gong mechanical ringer.

The common two-gong mechanical ringer (Figure 2) is variously referred to as a polarized, biased, or straight-line ringer. All are the same device. Functioning parts include a two-coil electromagnet, an armature supporting a bell clapper, a bias spring, and two gongs. The armature is held to one side by spring tension to prevent bell tapping during dialing or accidental jarring.

One polarity of ac current causes the clapper to oppose the bias spring and strike one gong. The opposite polarity aids the clapper in returning to the other gong in the same direction as the spring.

In series with the ringer is a capacitor to prevent flow of direct current through the ringer coils. The capacitor coupled with ringer inductance resonates at about the ringing frequency (nominally 16-2/3 to 66-2/3 Hz) to increase ac current through the ringer coils and, thus, improve efficiency.

Ringer Connections

In general use are two types of connections for the ringer: *bridged* and *divided.* The bridged connection (Figure 3) has the ringer across the tip and ring transmission pair.

Divided ringing (Figure 4), also known as ground return ringing, uses either the tip or ring wire to ground. With one ringer connected tip to ground, and another connected ring to ground, two-party service in its simplest form is provided. The number of stations which may be served by divided ringing is double that for bridged ringing. And only one ringing frequency (usually 20 Hz) is needed to provide full-selective service to two customers over the same loop.

For multiparty service to four or more customers, there are a number of ringing schemes. Among the standard techniques are *frequency selective*, *superimposed* and *coded*. Frequency selective is commonly found in Independent telephone systems, whereas superimposed (or biased) ringing is used by the Bell System. Coded ringing, the simplest of all three, is employed by both.

Frequency Selective

Frequency selective, also called multifrequency ringing, makes use of five different frequencies to provide five-party service with a bridged connection, or ten-party service with a divided connection (Figure 5). Single-party and up to four-party frequency selective service almost always uses the bridged ringer connection.

Each station set is equipped with a mechanically tuned ringer whose reeds respond to a particular frequency. The three most common sets or groups of frequencies applied at the central office are *decimonic*, *harmonic*, and *synchromonic* (or anharmonic).

Decimonic frequencies are 20 Hz, 30 Hz, 40 Hz, 50 Hz, and 60 Hz (multiples of 10 Hz). Harmonic frequencies are multiples of 8-1/3 Hz: 16-2/3 Hz, 25 Hz, 33-1/3 Hz, 50 Hz, and 66-2/3 Hz. Non-multiple, synchromonic frequencies are 20 Hz, 30 Hz, 42 Hz, 54 Hz, and 66 Hz.

Decimonic and harmonic frequencies simplify the design of the ringing generator. However, "cross-ring" problems are sometimes encountered. For example, a 16-2/3-Hz ringing signal rich in third harmonics could give a weak ring or tinkle on a 50-Hz ringer. Additionally, power line interference could cause cross ringing

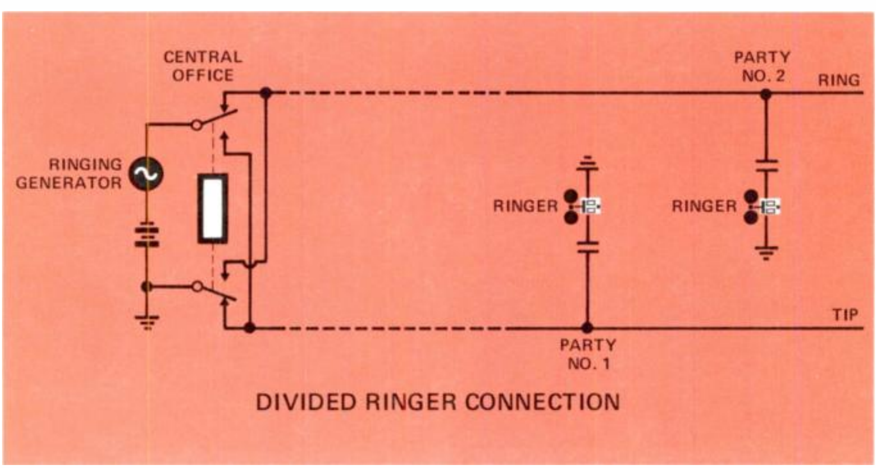


Figure 4. Divided ringing connects the ringer between either the tip or ring wire and ground.

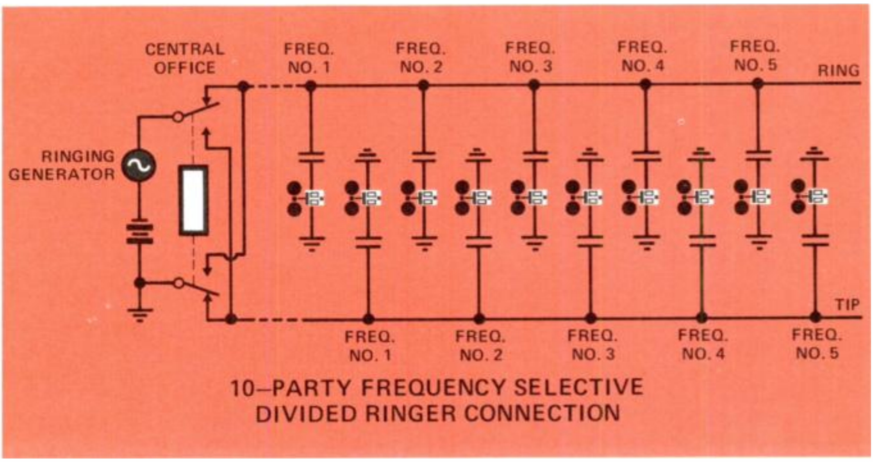


Figure 5. For ten-party frequency-selective service two sets of frequencies, either decimonic, harmonic or synchromonic, are used with divided ringer connections.

with the 60-Hz ringer of the decimonic frequency set.

Frequency selective ringing offers the greatest amount of fully-selective customer signaling. However, it does have one shortcoming – this is the requirement for five ringing generator frequencies and five station ringers.

Superimposed

Superimposed ringing uses both direct and alternating current to provide fully selective two-party bridged ringing or four-party divided ringing (Figure 6). The bridged connection is not generally used, however.

With superimposed ringing two sets of dc potentials of opposite polarities (± 38 to ± 48 Vdc) are applied to the tip and ring conductors for station selection. Telephones respond to only one of the two polarities.

Unlike frequency selective ringers, all superimposed telephone ringers are the same, but in series they have a three- or four-element, cold-cathode, gas-filled rectifier tube rather than the usual capacitor. For station selection the gas tubes are polarized for a particular polarity of ringing potential. The gas tube will pass the signal only if the 20-Hz ringing is superimposed on the proper dc voltage.

Superimposed ringing requires only a single-frequency ringing generator, which is a distinct advantage over frequency selective. However, it can only supply selective signaling to four customers.

Coded

Another form of multiparty signaling is coded ringing. It is nonselective since two or more phones on a party line are rung at the same time. Party identification is based on the number and duration of rings. Five ringing codes have been established consisting of combinations of shorts and longs.

Coded ringing requires only a single frequency ringing generator with the interrupter providing the codes. It can supply five-party service with the bridged ringer connection or ten-party service with the divided ringer connection. Combined with either frequency selective or superimposed schemes, it can provide semiselective service for up to ten parties.

Table A compares the different ringing schemes in general use, standard ringer connections for these schemes, the number of stations per line, and selectivity.

Revertive Ringing

Party lines do impose some special considerations when one customer desires to call another customer on the same line. A customer cannot make a call in the normal manner because once the call is initiated, the line is made busy. The term *reverting call* describes such a call on a party line, and there are several methods of revertive ringing depending on the ringer connection, ringing scheme, and number of parties on the line.

Two of the more common types are simultaneous revertive and alternate revertive ringing. Simultaneous revertive is normally used for coded ringing systems with either the bridged or divided ringer connection. The central office applies the called party's ringing code to the line and all ringers respond. When the called party answers his code, the ringing stops, and the calling party then picks up his receiver.

Alternate revertive finds use in bridged and divided frequency selec-

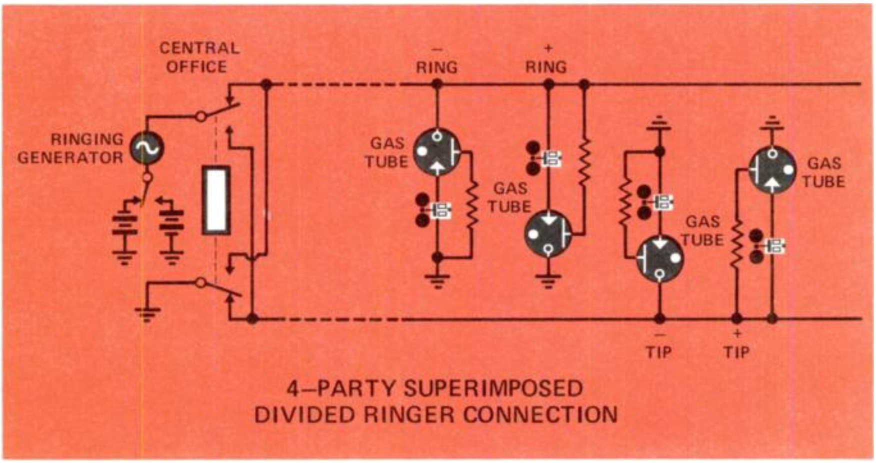


Figure 6. Four-party superimposed ringing uses a gas tube in series with each ringer, and a divided connection for the ringers. Each gas tube conducts the ringing current only if the applied superimposed dc voltage is of the correct polarity.

Table A.
Ringing schemes in general use.

TYPE OF RINGING	RINGER CONNECTION	STATIONS PER LINE MAXIMUM	RINGING SELECTIVITY
Single Party	Bridged	1	—
Single Party	Divided	2	Fully Selective
Frequency Selective	Bridged	5	Fully Selective
Frequency Selective	Divided	10	Fully Selective
Superimposed	Divided	4	Fully Selective
Coded	Bridged	5	Nonselective
Coded	Divided	10	Nonselective
Coded Frequency Selective	Bridged	10	Semiselective
Coded Superimposed	Divided	10	Semiselective

tive and superimposed ringing schemes. With this method the central office alternately applies ringing to the called party, then the calling party, etc. When the called party answers, the ringing stops.

TPL and TPS

For party-line systems, the central office linefinder is common to all circuits, but the connector has the option of being arranged on a terminal-per-line (TPL) basis or on a terminal-per-station (TPS) basis.

The TPL arrangement has one set of terminals for each party line. A final digit of the directory number identifies each party on the line.

The TPS arrangement, on the other hand, uses a separate set of terminals for each station on the party line, with unrelated directory numbers assigned to each customer. Generally used in expanding localities, it makes the most efficient use of office name codes and aids in providing full intercepting service. Also with TPS, a customer may be changed to a different transmission pair or moved from one party line to another without changing directory numbers.

Ringing on Carrier Systems

With all the combinations of ringer connections and schemes to signal customers on a party line, it is imperative that subscriber carrier systems such as Lenkurt's 82A, 83A, TFM and XU systems, accurately reproduce central office ringing. But with carrier systems, it is not possible to actually send the ringing frequency, the correct polarity, and separate the bridged or divided connection without special circuitry. And this circuitry must adhere to industry standards of reliability and ease of maintenance. Therefore, it must be straightforward and simple.

For example, the six-channel 82A Station Carrier System responds to ringing from the central office by turning the carrier on and off at the ringing frequency rate. A transistor switch at the subscriber unit detects the change in the carrier and applies about 80 Vac to the customer's ringer.

The ringing frequency applied to the 83A Single Channel Station Carrier System FM modulates the system's 64-kHz carrier. At the customer's station the signal is demodulated and applied as an accurate ringing signal.

Lenkurt's TFM Carrier System, like the 82A, turns the carrier on and off at the ringing frequency rate. Two in-band frequencies identify positive or negative superimposed ringing, and whether it is applied to the tip or ring wire.

The XU system operates similarly to the TFM but uses a 4-kHz out-of-band tone. All provide the widest flexibility without the need to make any changes to existing central office equipment.

Destiny

Specialized ringing schemes have provided important benefits by making possible the expansion of our nationwide telephone network and by aiding communications in general. The industry objective of one hundred percent single-party service in the next ten to fifteen years should eliminate the need for all of these special ringing schemes. The associated equipment will then perhaps become museum pieces along with the old magneto telephones and switchboards.

LENKURT ELECTRIC CO., INC.
SAN CARLOS, CALIFORNIA 94070

Bulk Rate
U.S. Postage
Paid
San Carlos, Calif.
Permit No. 37

RETURN REQUESTED

MR. LEONARD D. POOR R1266
BELL TEL. LABS. ROOM-1F314
HOLMDEL, N.J. 07733

- •••• Telegraph, data, and three-frequency (telemetry) models
- •••• Most economical use of standard voice channel bandwidth
- •••• Universal application at speeds from 75 b/s to 600 b/s
- •••• Conforms to EIA Standards
- •••• Compatible with Western Electric 43B
- •••• Plus much more

For brochure, write Lenkurt, Dept. B720

LENKURT ELECTRIC

Subsidiary of
GENERAL TELEPHONE & ELECTRONICS

SAN CARLOS, CALIFORNIA, U.S.A.

VOICE, VIDEO & DATA
TRANSMISSION SYSTEMS

Lenkurt Offices

San Carlos	Chicago
Stamford, Conn.	Atlanta
Falls Church, Va.	Dallas

The Lenkurt Demodulator is circulated monthly to technicians, engineers and managers employed by companies or government agencies who use and operate communications systems, and to educational institutions. Permission to reprint granted on request.