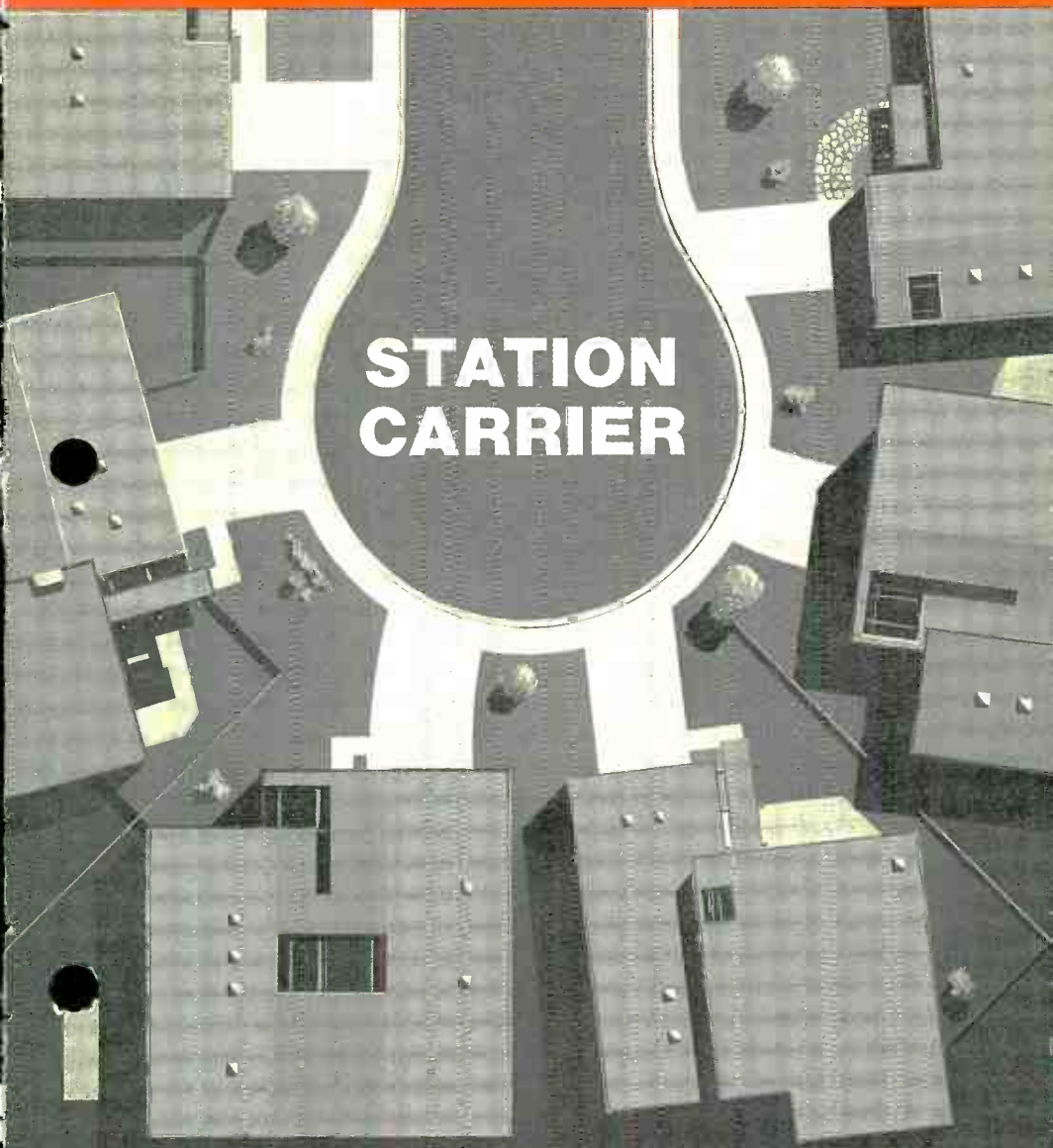
SEPTEMBER, 1967
VOL. 16, NO. 9

The Lenkurt® DEMODULATOR



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The use of carrier equipment has been valuable in medium and long circuits for many years. Now advances in manufacturing make carrier feasible for subscriber loops.

Multiplex technology, which allows transmission of two or more speech signals over the same telephone circuit simultaneously, has been a valuable part of the telephone industry since the early 1900's. The first uses of multiplexing or carrier technique were made in long and medium haul toll circuits where the expense of electronics equipment could be justified.

As electronics manufacturing methods improved—along with advances in circuit design—it became economical to use multiplexing on shorter circuits. Not only did the circuit capacity increase, but circuit quality was also improved. Open wire facilities, previously limited to one conversation, could now carry up to 16 channels; multipair cable was expanded to 24 channels. (For a more detailed review of multiplexing theory and history, see the *Demodulator,* December 1965.)

Gradually multiplexing found its way to the shorter exchange circuits and eventually to subscriber loops. This trend was accentuated with the availability of semiconductor devices—equipment could be made smaller, required less power, and cost less. Today there are basically three types of subscriber carrier systems, each designed to satisfy certain requirements, each offering individual economic advantages.

One class of subscriber or station carrier is generally used for long distances and may carry 20 channels or more. A second type, limited to six channels, serves to expand cable facilities closer to the central office. The third is a single channel system specifically designed to add one additional subscriber to a cable pair easily and cheaply.

Suitable Upgrade

Station carrier first proved suitable for expanding cable and wire routes to rural or sparsely-populated areas. Customers in these locals were accustomed to multiparty service and shared a circuit with perhaps eight neighbors. But in recent years ambitious upgrading programs have begun. Industry-wide objectives are to establish one-party service for all customers within the next decade. However, upgrading service by adding new physical lines to remote areas is not always profitable.

With the introduction of carrier systems such as the Lenkurt XU, it became possible to carry up to 20 voice channels over two cable pairs (one for each direction of transmission). The carrier derived circuits can be used to establish

any class of new service or upgrade present customers. Each of the 20 channels can provide 8-party service if necessary.

The XU subscriber carrier system effectively extends the reach of the central office to outlying areas. The subscriber terminal can be placed up to 30 miles from the central office. From this point, subscriber loops with a 1000-ohm loop resistance capability distribute service to a group of customers.

A distinct advantage of the XU type equipment occurs when the area grows to the point of rating its own exchange office. At that time the subscriber carrier system can easily be converted to exchange carrier to provide trunk service between offices.

Carrier equipment of the XU type has been typically used in areas 12 to 14 miles or more from the central office. While prove-in distances can be much less in specific cases, the usual installation serves to extend a number of channels over medium distances.

Recently two new types of carrier systems have been developed for use specifically on exchange loop cable plant. These systems—a multichannel and a single channel version—add versatility and convenience to the station carrier field. Both allow station terminals to be placed anywhere along the cable by regular telephone installers. No adjustments are necessary in the field, and maintenance is limited to the replacement of defective units. The systems are economical for new service or for upgrading programs—and both accept Schedule 4 data.

Economics

Several factors have changed the attitude of exchange plant engineers toward laying out new systems and planning the company's approach to growth areas.

As the economy of the established rural population has changed, demands for service equal to that of urban areas have increased. The migration of urban workers—long accustomed to single or two party service—to rural areas has added pressure for better telephone service. Other factors, such as the need for automatic toll ticketing and the increased cost of copper and labor also

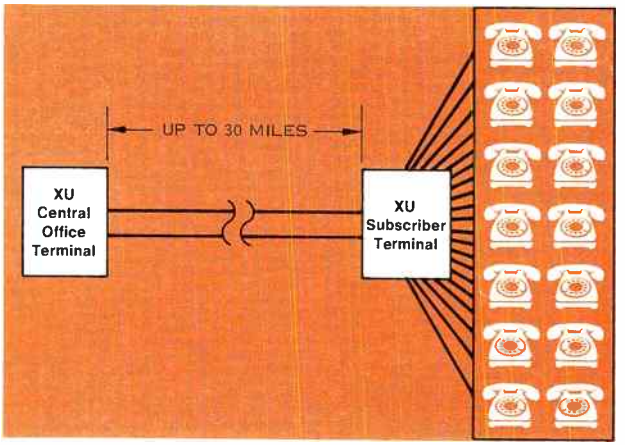

Figure 1. The Lenkurt XU subscriber carrier system expands telephone capability into outlying areas. Subscriber terminal may be up to 30 miles from the central office.

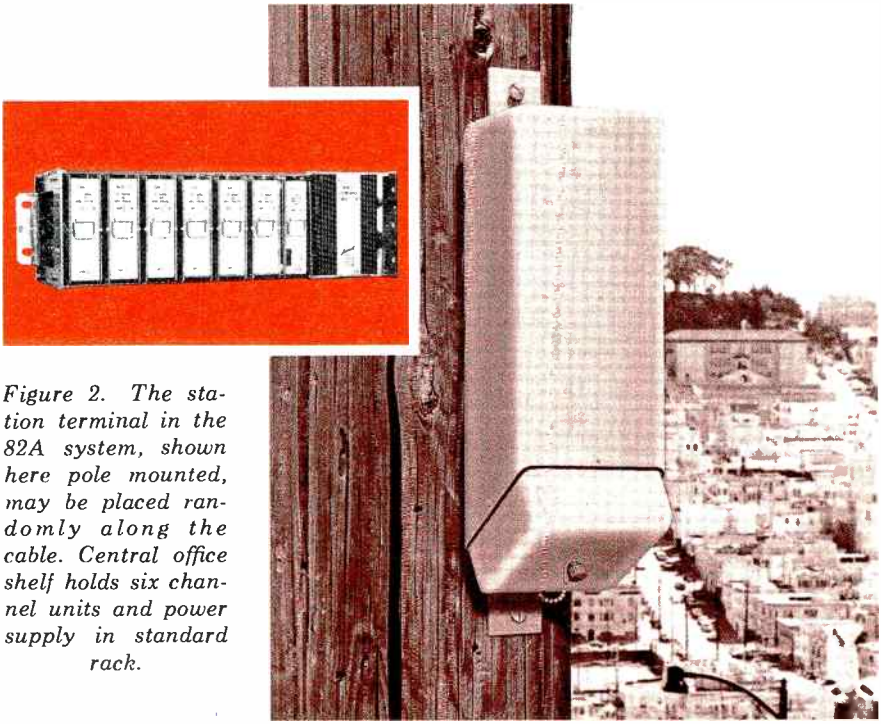

Figure 2. The station terminal in the 82A system, shown here pole mounted, may be placed randomly along the cable. Central office shelf holds six channel units and power supply in standard rack.

influence the decisions of exchange plant engineers.

The general need to upgrade service, obtain cable relief and provide growth margins in new developments has enhanced the advantage of integrating carrier equipment into the exchange loop plant. Station carrier is an obvious answer for upgrading service and providing new service in areas where spare cable pairs do not exist. Additional benefits are realized in the planning of new cable plant.

In a typical exercise to determine cable size for new exchange loop plant, an operating company will first review the expected five year circuit requirements for the area to be served. This figure may be revised to reflect personal experience of local engineers. Based on the results, a cable size is selected. But, since cable is supplied in standard numbers of pairs, it is the usual practice to choose the next larger size cable to ensure adequate facilities. This method usually results in the installation of a cable that is oversized by as much as 50 percent.

If, for example, the cable is actually oversized by 25 percent, it must be accepted that the cost per mile will also be increased by 25 percent. This condition becomes especially critical at longer distances from the central office.

By using a station carrier system, the plant engineer can realistically size his new cable to the nearest *smaller* cable instead of the next larger size. Extra

Maximum system lengths with all 19 gauge cable is 20 miles, but most applications will be from 3 to 12 miles.

The equipment will operate with any combination of 19, 22, 24, or 26 gauge cable. Without repeaters, the maximum system length is 40 dB, measured at 112 kHz. Up to three repeaters may be added at approximately the 20 to 40 dB loss points along the cable. Repeaters extend the maximum length out to 140 dB.

Loop Resistance

The length of subscriber loops on physical circuits is limited by loop resistance, usually set at a maximum of 1200 ohms dc resistance. Beyond this point the signaling on the loop begins to suffer serious degradation.

In the 82A carrier system, repeaters can extend the signal loss limitation, but dc loop resistance remains a factor—all power is fed to the repeaters and subscriber terminals over the cable. Shelf equipment common to the channel units converts the standard —48 Vdc office supply power to 260 Vdc. At this voltage the system works satisfactorily with loop resistances up to 1600 ohms. The equipment may also be strapped for 340 Vdc for longer loops, if necessary. For safety reasons, this power is fed to the cable on a balanced arrangement between the tip and ring conductors.

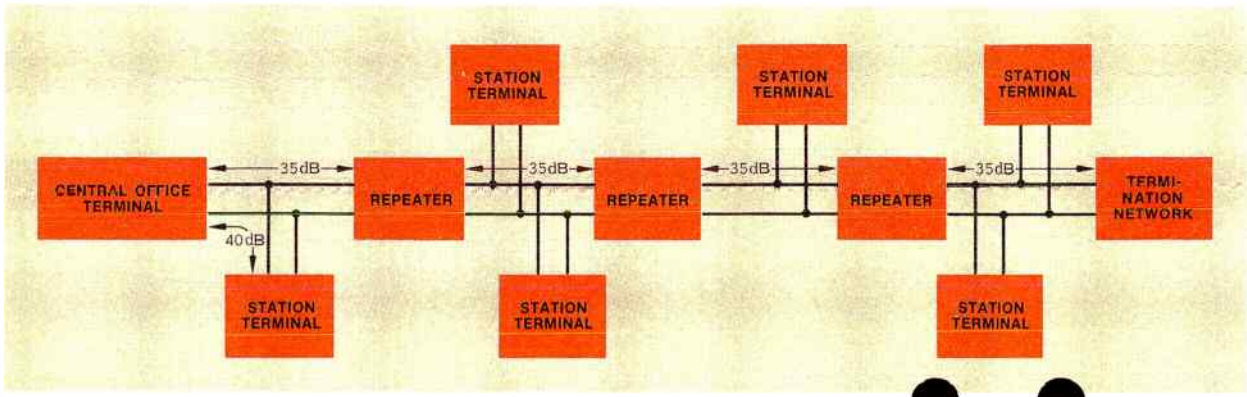

Figure 4. Typical 82A system illustrates maximum attenuation for first terminal and approximate repeater spacing. Automatic level control allows terminal placement anywhere on cable, even immediately next to repeater.

Once preliminary engineering is completed and a cable has been designated for carrier use, installation by plant personnel is routine. Subscriber equipment will be installed at the same time as the house instrument, and can be placed at any point along the cable. No adjustments need be made in the field—automatic level controls in the station terminal will compensate for cable loss. A unit that is malfunctioning will simply be replaced by the installer.

Automatic regulation of levels at the station terminal greatly simplifies installation. At the same time this regulation reduces far-end crosstalk between systems by maintaining similar levels for all systems, regardless of channel terminal location. Crosstalk coupling is increased between channels of unequal level.

In operation, all signals leaving the central office are fixed at essentially the same level. When they reach the station terminal, the received level is detected. The signal from the station terminal back to the central office is then automatically preadjusted to compensate for the cable loss. In this way the central office will see the incoming signal from a station unit at the same level, regardless of its distance from the central office. This unique method of regulation would allow the cable to be sampled at any length, revealing the levels at a given carrier frequency on any of the carrier pairs to be the same.

The station terminals and repeaters — identical in appearance — can be mounted on pole (Fig. 2), crossarm, strand or pedestal. They are hermetically sealed at the factory to keep out moisture.

Because repeater and station unit powering is supplied over the cable, voice frequency transmission is no longer possible. It is necessary to remove from the cable all load coils and build-out capacitors, and all bridged taps should be either terminated or removed. In addition, the cable should be properly terminated at the distant end to eliminate reflections.

Transmission from the central office to subscriber is in the frequency range of 72 to 140 kHz. The subscriber to central office transmission is spaced in the 8 to 56 kHz range. Compandors are used in both directions to reduce noise.

Add One

A third type of station carrier system adds one new channel to a cable pair, leaving the existing physical circuit in operation. This system, known as the Lenkurt 83A, is designed primarily for shorter cable lengths than the multichannel system. With prove-in at a little over a mile the 83A is an ideal unit for providing a second private line where service is already established, or for initiating new service near an existing installation.

Simplicity of use and installation, along with an economic advantage over new physical cable, mark the 83A for many applications. It might be used for upgrading from multi-party service, to add new business lines, for PABX extensions, and temporary phone installations.

The 83A also operates on most standard cables provided they are not loaded. The single station terminal may be added at any point on the cable out to the 37 dB loss point measured at 64 kHz. This corresponds to a maximum system length of about 42,000 feet on 19 gauge cable. Cable loss can be calculated from the curves in Fig. 5.

Installation

When calculating the maximum length of a system, certain considerations must be given to losses attributed to bridged taps and drop wires. Bridged

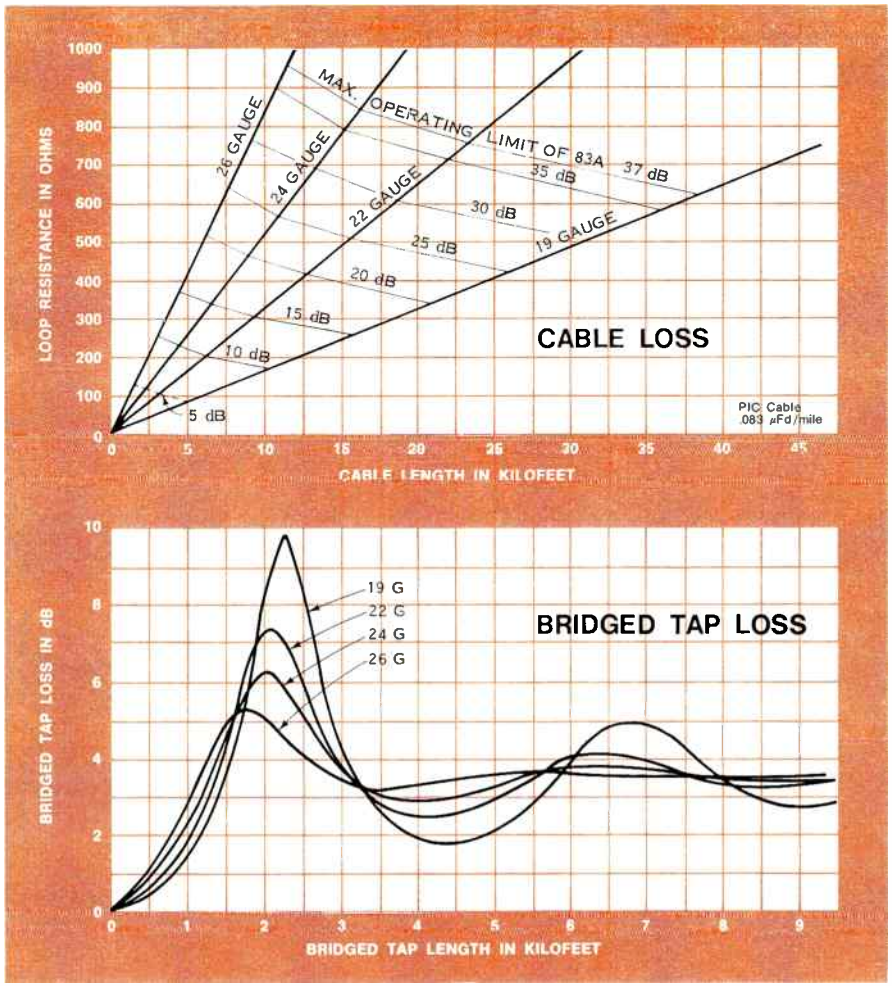

Figure 5. Cable and bridged tap losses must be calculated for 83A station carrier. Drop wire loss, if over 250 feet, must be added to total attenuation.

taps do not have to be terminated. However, they do cause attenuation at carrier frequencies, and must be considered in the maximum loss calculations. Bridged tap losses can be roughly calculated from the curves in Fig. 5. Note that this type of loss is particularly critical if the bridged tap is about 2,000 feet long. In some cases, nearly 10 dB loss is added to the carrier circuit.

Another loss must be calculated if more than 250 feet of drop wire is used. A convenient figure for drop wire loss is 0.3 dB per one hundred feet *in excess* of 250 feet. Drop wire loss in excess of 250 feet and bridged tap loss

circuits can be added with carrier equipment as actually required—a reduction in both initial cost and annual cost.

Transmission Advantages

Advantages of carrier derived circuits include signal consistency and stability. Long physical circuits generally contribute to increased noise, delay distortion, and degraded frequency response. These are major considerations especially when data is to be transmitted. And each of these parameters varies continuously along the length of the cable.

With a properly engineered carrier system, the quality of the signal should be almost identical at any length. In addition, net loss can be carefully controlled, and environmental conditions will have little effect on the stability of the circuits.

Multichannel station carrier, such as the Lenkurt 82A, provides an economical method of extending the capability of subscriber cable. Operating on a single cable pair, the 82A has six channels, each of which can be utilized for up to 4-party service—a maximum of 24 subscribers on each pair.

Use of multichannel station carrier becomes competitive with wire at about 3 or 4 miles from the central office—up to that point it would usually be less expensive to install new physical plant.

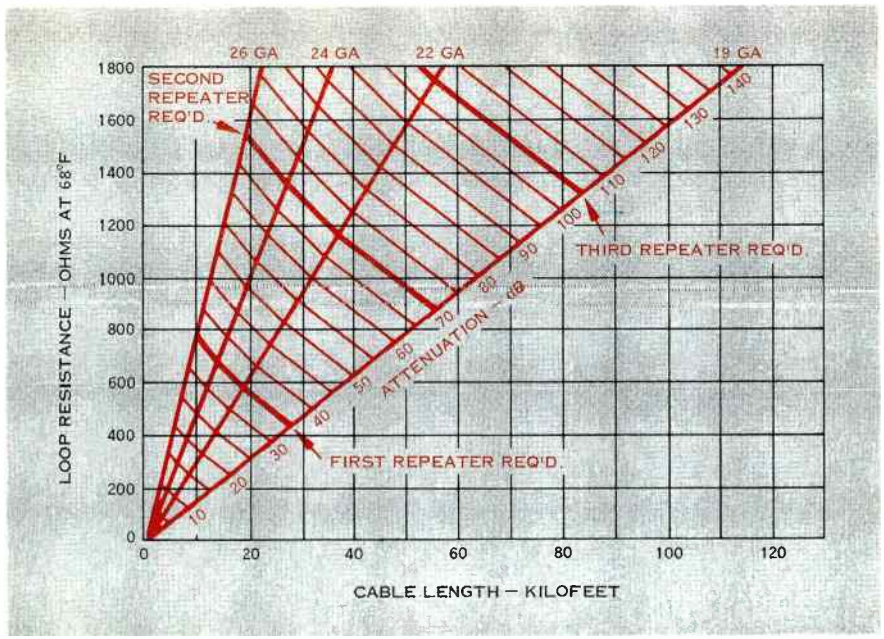

Figure 3. Cable design chart for 82A station carrier indicates repeater spacing requirements for various cable sizes. Also, loop resistance limitation of 1600 ohms sets maximum system length with 260 Vdc repeater power.

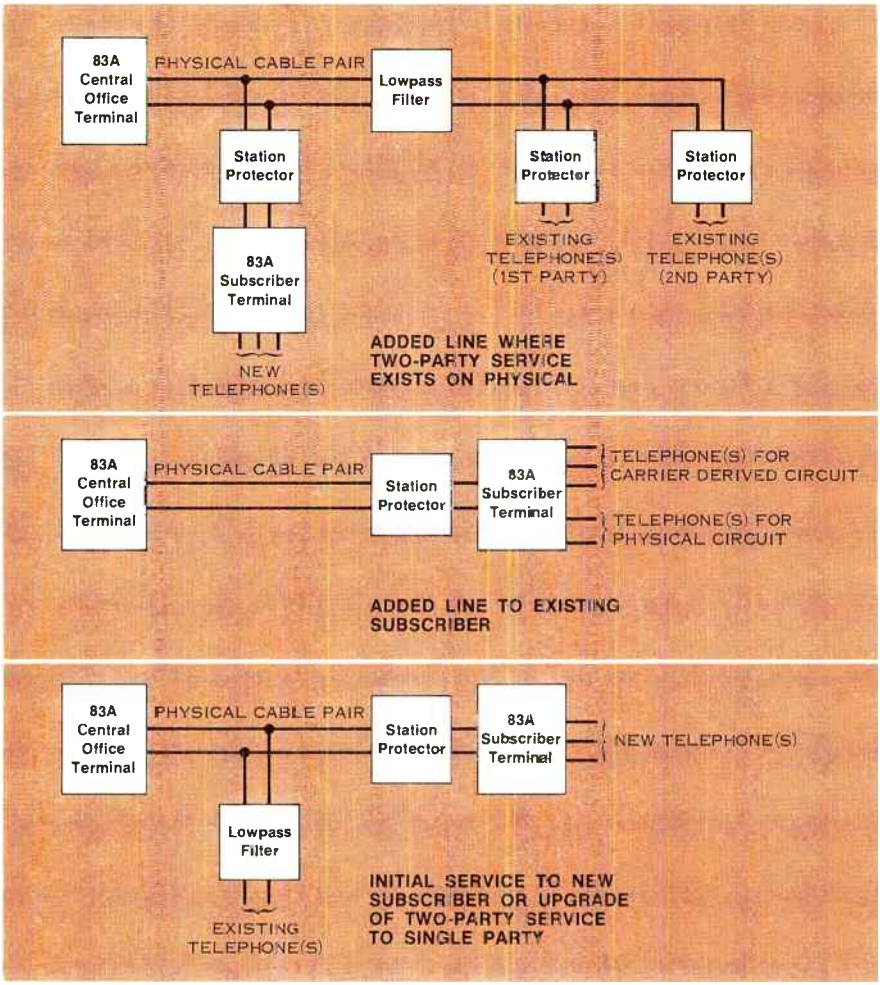

Figure 6. Typical applications of 83A station carrier equipment show the many ways additional service can be added to existing physical circuits.

must be added to cable attenuation loss to calculate the total attenuation of the cable.

Once plant records have been reviewed and cables assigned for carrier use, assignment of 83A to particular cables becomes routine. The engineering department can set an average maximum loop length for each cable, determined from the average pair makeup in the same manner used for "zoning" telephone instruments. Assignment personnel then can easily allocate the 83A terminal anywhere within the area in the same way that regular telephone installations are assigned.

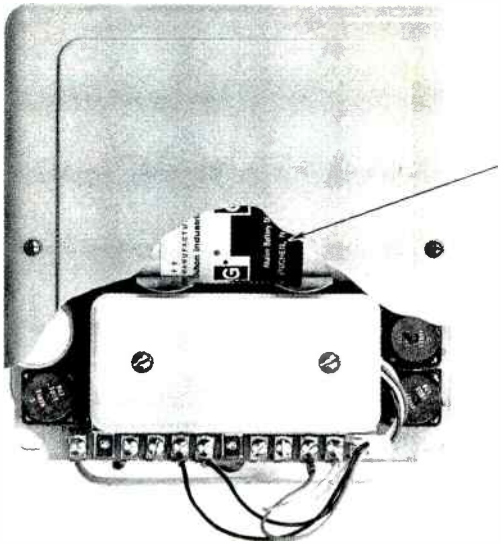

Figure 7. Attractive 83A subscriber terminal mounts inside customer's premises. Power transformer attaches to wall outlet.

Power

Station unit installation is relatively simple and straightforward. The station channel unit is mounted inside the customer's premises, probably in an out-of-the-way location such as the garage. Power for the unit comes from a nearby ac wall outlet. A small transformer reduces the voltage to 19 Vac at the plug, and standard inside wire is used to connect to the channel unit.

In the 83A, an optional nickel-cadmium battery is available for protection from commercial power failure and will keep the phone in operation up to 12 hours. Battery protection is particularly advisable if there is no other telephone on the premises. The battery is automatically trickle charged during normal operation.

It would be possible to power the station unit from the central office, but a number of tradeoffs in performance must be accepted.

In such a system, a battery is still necessary at the station unit. When the physical circuit is in use, there simply would not be enough power available on the cable to power the carrier equipment also.

The battery would obviously have to be charged from power taken off the cable—and then only when the physical circuit was not in use. These restrictions dictate that the battery charge rate would have to be set at several times normal, providing a source of maintenance trouble.

Even at this accelerated charge rate, the battery would have about a 1 to 10 work cycle: ten hours of continuous charge would provide stored power for about one hour of conversation.

Ringing would be powered by the battery also, and could become unpredictable at low voltage levels. And ringing itself draws heavily on the battery storage.

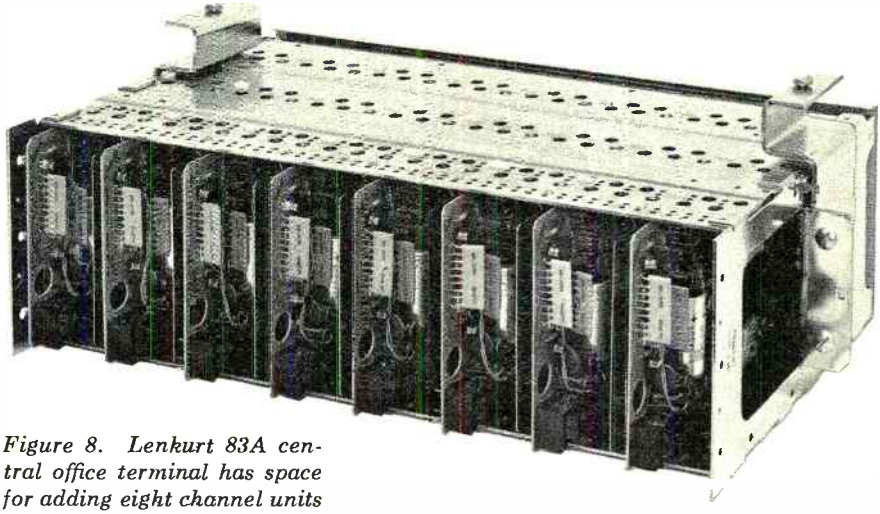

Figure 8. Lenkurt 83A central office terminal has space for adding eight channel units as needed. No common equipment is used.

Maybe a Filter

The only additional equipment to be installed in the field is an external filter, if needed. The filter is normally housed in the same wall box with the channel unit, but some systems necessitate installation on the pole or wall outside the physical drop. The filter's function is to separate the carrier signal from the telephone instrument on the physical pair.

Like the multichannel station carrier, the 83A has automatic level control at the station terminal and requires no adjustment.

The subscriber may have up to three ringing telephone subsets (extensions) operating from the carrier derived circuit. And normal dial or tone signaling will operate with the 83A without modification.

Since the physical circuit is not affected by the addition of carrier equipment, previous party lines or other service continues uninterrupted.

Carrier equipment in the exchange loop plant has added to the alternatives available in solving immediate cable shortages, and ensures more economical planning for future plant expansion. The use of carrier on these relatively short distances has only recently become feasible with advances in solid state electronics and improved manufacturing techniques. Now for the first time, carrier is competing with copper wire down to 1½ miles from the central office. This is a new concept for most plant engineers, and many in the field are not accustomed to some of the unique features of this equipment. But as open wire has given way to cable, it is felt that station carrier will begin to take its place as a standard in exchange loop plant.

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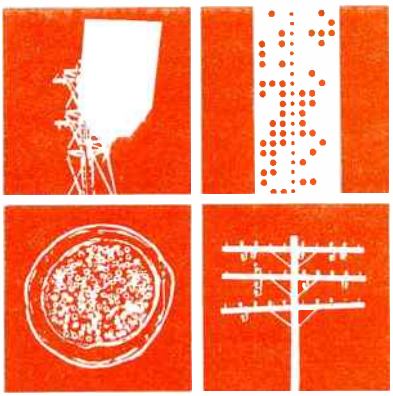

For information and descriptive literature on Lenkurt station carrier equipment or any of our complete line of voice, video or data transmission systems, contact the district sales office near you — or write Lenkurt, Dept. B720.

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