The Lenkurt® Demodulator

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Novel Uses of datatel*

Data transmission has become one of the most dynamic efforts in the field of telecommunications. Because of growing industrial and military requirements, each month sees the introduction of new equipment for transmitting and handling data. Yet, the needs and new applications continue to grow at such a pace that even the equipment manufacturers are sometimes taken aback at the diverse uses to which their products are put. While much publicity has been given the new, special-purpose systems, little mention has been made of the ingenious ways in which similar needs have been satisfied by more conventional data systems. This article describes some of these new uses for standard telegraph carrier.

There is a growing tendency to identify *data transmission* almost exclusively with information for business machines and computers. However, data transmission takes in a much broader spectrum which includes telemetry and remote control, as well as digital data for business machines.

Telemetry enables a train dispatcher to "observe" the location of distant trains; it reports on the electrical load at an outlying power substation; it may state the pressure developed by a remote pump or monitor the viscosity of the fluid being pumped.

Remote control adds a new dimension by allowing a central operator to alter the distant conditions reported by telemetry. When telemetry and remote control are used together, complex "organisms" of vast efficiency can be created. The central control point becomes the "brain" of the organism, receiving reports from the telemetry "senses" and performing distant operations with the

**Trademark registration applied for.*

remote control "muscles." The essential key to such an industrial organism is found in the nerves which link central brain with distant limbs — the data communication system.

Tremendous efficiency can be gained by such an operation. Centralized control provides superior coordination, and decision-making is speeded. It becomes possible to harness the speed and accuracy of electronic computers to achieve a quality of management not previously available.

In many industries, such centralized control must be approached in gradual steps. Although the concept is old, the means for accomplishing it are new and change rapidly as refinements upon refinements appear. By planning carefully and using familiar, proven equipment, many such systems have been started, modestly at first, then expanded as better techniques and equipment prove themselves particularly suitable.

This philosophy is particularly valid in the field of data transmission itself. Many industries making heavy use of data processing in their normal operations are meeting their transmission requirements adequately and economically with conventional telegraph systems. By planning their operations carefully, they have avoided the need for expensive, highly-specialized transmission equipment.

This is less surprising than it might seem. From a transmission viewpoint there is no difference between telegraph signals and the digital data generated by computers and punched card machines. Although the new machines operate at high speeds within themselves, they don't have to be supplied with data at these speeds. Most industrial operations do not require high speed or "real time" handling of data as in some military systems—air defense, for instance — in which large

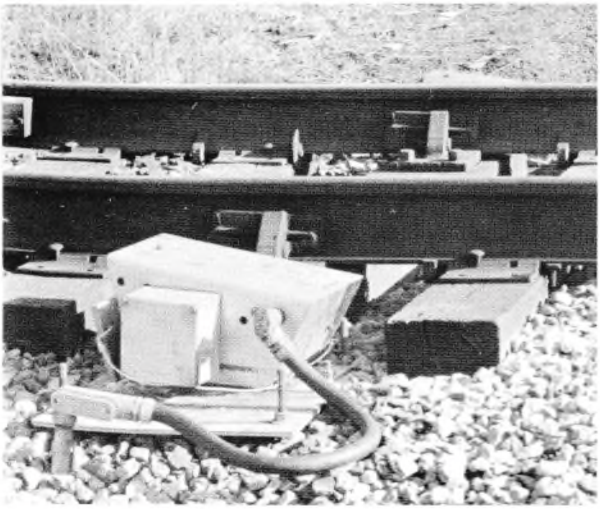


Figure 1. Typical hot-box detectors alongside railroad track. Separate units are required on each side. Detectors are sensitive enough to detect glowing cigarette several yards away.

quantities of data must be transmitted and processed very quickly before they become obsolete. Most of the data handled by industrial systems—payroll, inventories, and similar statistics—do not

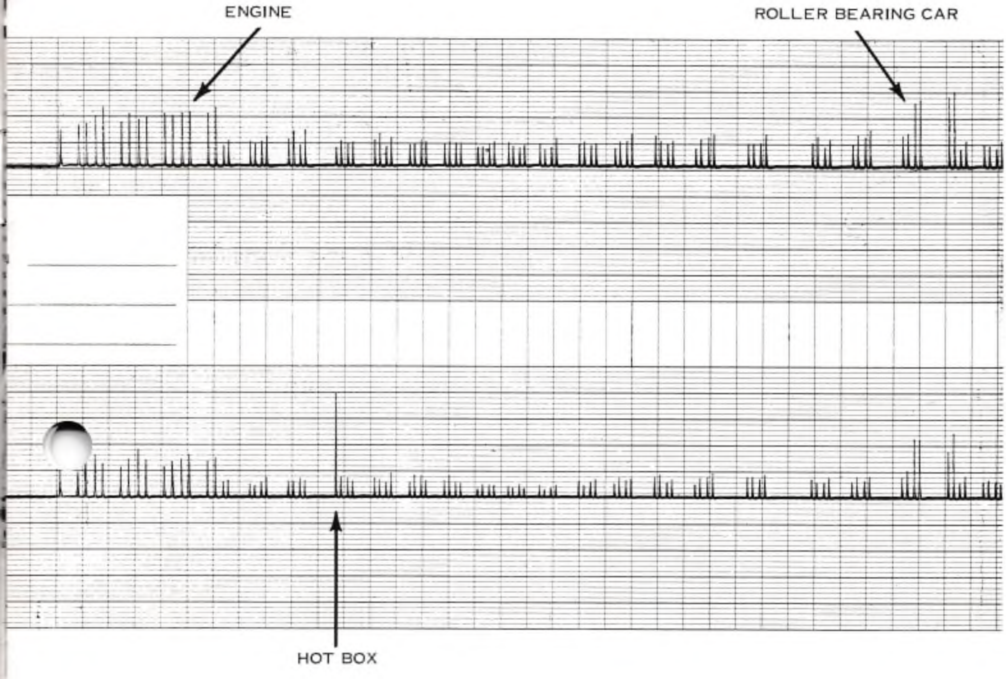


Figure 2. Typical hot-box detector transmission. Each pip shown represents a single wheel. Two recordings are made simultaneously, one for each side. Engine driver wheels, shown at left, and roller bearings always operate at higher temperatures than ordinary solid or plug-bearing journals. Note hot-box indication.

change very rapidly. The same is true of operating functions which may be monitored and controlled over data links. Almost all of these are adaptable to the 50-75 bits-per-second rate of ordinary telegraph transmission.

Lenkurt's basic telegraph carrier equipment, the 23A Datatel system, provides several excellent examples of its versatility in satisfying communications needs quite different from those for which it was designed. One of the important industries in which 23A systems have demonstrated remarkable versatility is the railroad industry. Modern railroads use the full spectrum of industrial communications facilities: telemetry, remote control, conventional voice circuits, facsimile, business machine data, and even closed circuit television. Confronted by stiff competition and rising costs, railroads have had to exercise extreme diligence in making the most of existing facilities.

Hot-box Detection

One of the persistent problems of railroading is the detection of so-called "hot boxes". On cars equipped with solid bearings, overheated wheel journals can cause derailment by shearing an axle or locking the wheels of a car. If a wheel bearing becomes seriously overheated, the lint packing in a journal box will ignite, causing smoke to issue from the overheated journal box. Before the advent of automatic detection systems, the detection of hot boxes was the responsibility of train crews and personnel along the track. But visual spotting, with its universal signal of thumb and forefinger clasped over the nose, poses many problems. Considerable damage is done to the bearing before the journal box begins to smoke. On some lines with many twists and curves, the train crew is limited in the number of times that they can see the full length of a long train, and hot boxes may go undetected even after the journal box has begun to smoke.

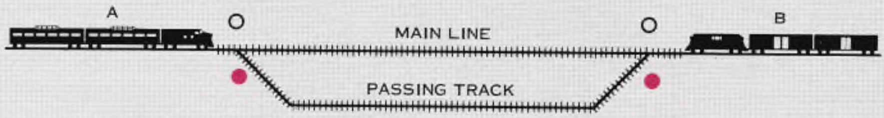
In the past few years, efficient infrared detectors have been developed which can sense the heat radiated by the passing journal boxes. When these are installed along the track, they can detect hotter-than-average journal boxes and signal an alarm before the journal reaches damaging temperature. With the development of these systems has come the need to transmit their data somehow to the train engineer. Since various factors such as train speed, type of bearings, or air temperature do affect the temperature of the journals, in many systems the information is sent to a central location for evaluation. If a hot box is indicated, the train is halted.

At least one railroad uses 23A Data-tel to carry the digital output of hot box detectors. Since the 23A system is restricted to handling binary information, only two conditions can be transmitted. In this case, the tone representing "hot" is transmitted only when an arbitrary temperature threshold has been exceeded.

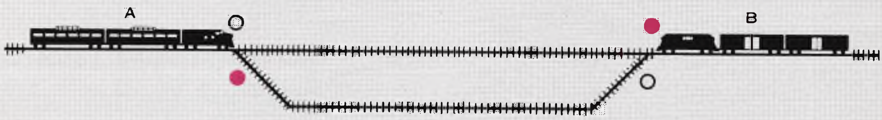
Another system, which has so far only been proposed, would dispense with transmission to a central point, but broadcast directly to the train crew by VHF radio. In this case, the detector would be connected to a logic network which would count the number of wheels (and thus the cars) *following* a hotbox, and on the basis of count, would select a suitable pre-recorded message for the engineer, telling him the exact location of the hot box. Since the broadcast message would be made up of several portions, code signals at the beginning and end of each would identify individual portions, and these would be matched with the combination ordered by the logic circuit. The identification codes would be detected by a 23A receiver and passed on to the logic circuit. In this case, the railroad already uses 23A for conventional communications, and by using it for this application, would not have to maintain a new type of equipment.

Centralized Traffic Control

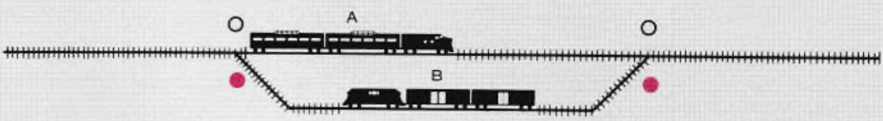
Centralized Traffic Control, or *CTC,* is the most important control function in railroad data transmission systems.



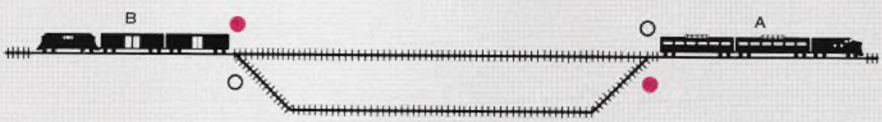
An eastbound passenger train (A) and a westbound freight train (B) approach each other on a single-track main line. The CTC dispatcher must set up a meeting of the two trains and route one of them to the passing track.



The CTC dispatcher throws the east switch of the passing track from the central control board. The new switch positions are indicated to the train crews by the track signals. This step permits the westbound freight train (B) to enter the passing track without stopping.



The westbound freight train (B) has entered the switch and proceeds on the passing track. The eastbound passenger train (A) proceeds on the main line without stopping. Trackside telemetry, such as relays, display the positions of the two trains on the control board. Based upon this information, the CTC dispatcher throws the east switch back to its mainline position to permit the eastbound passenger train (A) to proceed.



The CTC dispatcher throws the west switch of the passing track to permit the freight train (B) to re-enter the main line and proceed. When the freight train clears the switch, the dispatcher will re-set it to main line position. Both trains have met and passed without stopping.

Figure 3. The use of Centralized Traffic Control has enabled railroads to achieve great economies by better coordination af all traffic from a central point. A typical train "meet" controlled from distant CTC board is shown here.

From a central control panel, a CTC dispatcher can throw switches at remote points along the line, re-set signals, if needed, follow the movement of trains across his district, and monitor the results of his actions. The steps of a CTC "meet" are illustrated and described in Figure 3. CTC has become one of the most important tools used by the railroads to cut operating costs and improve service and safety.

CTC systems require rather extensive communication facilities. Coded control signals for throwing switches and setting signals must be transmitted from the control board to points along the line. When these actions are performed, centralized traffic control "telemetry" signals a verification to the control board that the function was actually performed. This same telemetry reports on the location and movement of trains over the line.

Datatel systems are used by a number of railroads in their CTC operations. The application made by one large railroad is typical of the use of carrier telegraph to consolidate data and control functions. A 600-mile mainline section of this railroad was operated with CTC dispatching. As in most of the earlier CTC systems, the 600-mile dispatching zone was broken down into five CTC districts, each having a control panel within its boundaries. Each CTC district was, in effect, a large number of d-c loops closed at the control board, and with data transmitted as coded direct-current pulses. For most of the earlier systems, the poor transmission qualities of on-off d-c pulses and the required high safety factors limited the length of a single CTC district to approximately 100 miles of line.

A few years ago, as the railroad's requirements for data transmission grew with the installation of business machine and car reporting centers, Datatel channels were added to its communications plant to provide increased capacity. A number of factors, among which were long-distance transmission reliability, ease of adding channels and compact terminal equipment, led to testing the Datatel channels for long-distance transmission of CTC data.

In the testing program, a single CTC district served in much the same fashion as a number of d-c teleprinter loops. From a control point located outside the district, frequency-shift tone signals were translated to d-c pulses and transmitted over the signaling circuits of the test district.

The tests proved successful. Subsequently, all CTC dispatching over the 600-mile section was consolidated in a central dispatching office affording greater speed, safety and economy of operations. A CTC dispatcher can establish a train meet and perform all control functions at sidings more than 500 miles away. Data requirements for this particular railroad have continued to grow. Telegraph channels at any one point in the system may carry a broad range of information including telemetry and control functions of CTC, data for business machines and computers and hot box alarm telemetry.

Pipeline Communications

Pipeline transmission systems are called upon to handle massive amounts of data because of extensive use of automation and remote control. Illustrating the industrial trend toward long-distance remote control, pipeline automation has developed from control of nearby "satellite" pump stations and tank farms, to centralized remote control of points hundreds of miles away. The dispatcher's control panel of a modern pipeline is almost identical to the CTC board of a modern railroad.

Unlike railroads, the "freight trains" of the pipelines are not under the immediate control of a crew. For this reason, pipelines were among the first industries to make extensive use of telemetry, even in short-distance "satellite" operations. Effective remote control of a booster pumping station, for example, requires knowing the suction,

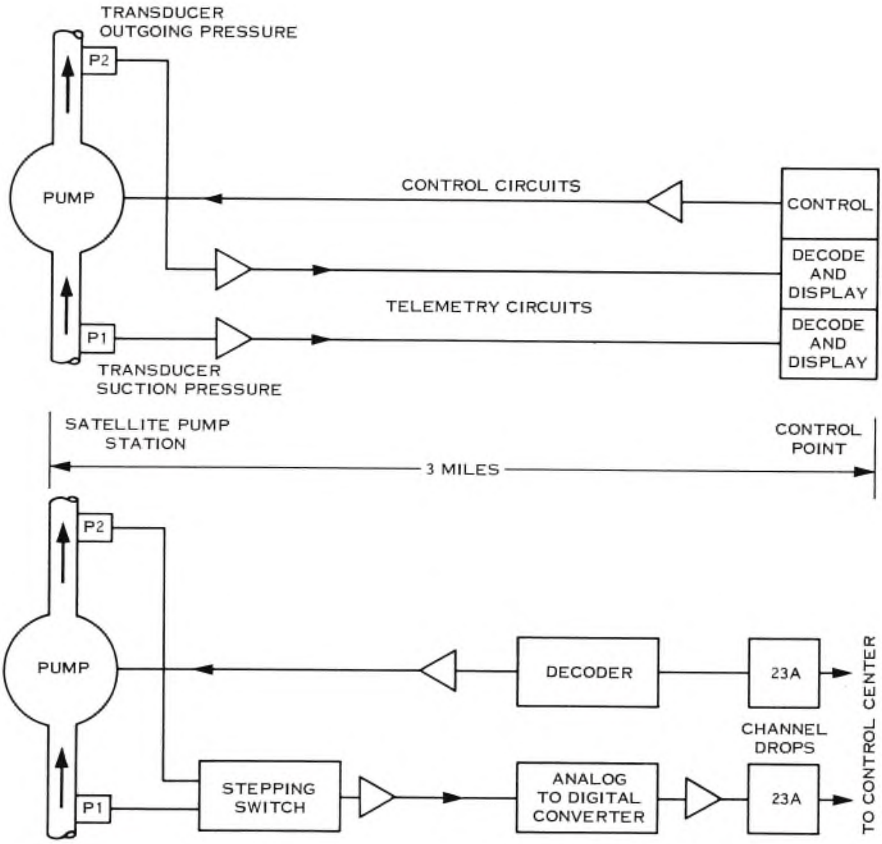


Figure 4. Oil and gas producing units and pipelines have long used relatively short-range direct-current telemetry to monitor and control satellite operations. Direct current transmission impairs accuracy of telemetry beyond a few miles. Judicious use of analog-to digital converters and modern telegraph carrier permits centralized control over far greater distances without obsoleting existing short-range equipment.

outgoing, and differential line pressures, the most critical of these being differential pressure. The conversion to automation and long-distance remote control calls for a greater amount of telemetry, and places an even greater reliance upon the accuracy of telemetering systems.

In changing to centralized control, pipelines have been faced with the problem of using analog telemetering systems which are adequate for satellite operations, but not so suitable for long-distance transmission. The analog equipment frequently represented a substantial capital outlay in its own right. The problem has been solved by using analog-to-digital converters and pulse-duration translators, thus permitting binary transmission via Datatel channels. Thus, pipelines have achieved centralized control without having to discard existing telemetering equipment.

In one particular example, a satellite booster pump station was controlled and monitored by analog telemetry from a tank farm office three miles away. With conversion to centralized control, it was necessary to transmit pump station telemetry over Datatel channels in the company microwave system to a control point 155 miles distant. A number of channel drops were installed for this purpose in a repeater terminal at the pump station.

With the short-haul satellite operation, pressure data were supplied by an analog telemetering system (Figure 4) consisting of two pressure transducers mounted in the pipe on either side of

Figure 5. A typical centralized control station for a pipeline. From this location are monitored such operational details as flow rate, pump pressure and suction, fluid viscosity, and the like. Distant operations can be adjusted in response to changing loads and other variables. Panels in background show profile of terrain which pipeline traverses, and which has important bearing on operating parameters. Centralization is made possible by efficient digital transmission.

the pump; two potentiometer amplifiers to raise the output current of the transducers; display equipment at the control point; and two physical circuits. One transducer indicated suction pressure and the other outgoing line pressure. The operator at the control point obtained the differential pressure by reading the difference between the two.

The continuously variable voltage signals of the analog system could not be transmitted over suitable long-distance channels and the factor of distance in centralized control placed a premium on the accuracy of the information. Yet, this problem was solved with maximum use of existing equipment in a manner that provided improved accuracy of information, as shown in Figure 4.

The signal leads from the two pressure transducers were coupled to a slow-speed stepping (or sampling) switch, the output of which is fed to an amplifier for transmission over a short physical circuit to the tank farm repeater station. At this point, voltage signals are translated into coded pulses by an analog-to-digital converter, and the digital output of the converter is transmitted to the control center over a Datatel channel. At the control center, the digital signals are restored to analog form and connected to suitable meters which show the suction, outgoing, and differential pressures.

Similar arrangements, using existing analog equipment at other booster stations, have yielded substantial savings in new telemetering equipment. The accuracy of the telemetry was improved. The effects of calibration drift on the critical differential pressure were minimized with the use of the common circuits, amplifiers, coding and read-out equipment. Other Datatel channels on the pipeline carry the necessary control signals for centralized operation.

TASI Signaling

The telecommunications industry itself provides an interesting example of how telegraph carrier equipment can be adapted to still another type of control function. In this application, the 23A equipment is used to provide dialing and supervision for the voice circuits handled by the TASI systems in the California-Hawaii and Florida-Puerto Rico submarine cables. Here, the cost of the cable—$37 million in the case of the Hawaiian cable—is so high, that even very expensive means of increasing circuit capacity provide great savings.

In the TASI system (which means "*T*ime *A*ssignment *S*peech *I*nterpolation"), extra channel capacity is obtained by using the idle time present in the speech messages transmitted over the cable. All telephone conversations have pauses, listening periods and the like, and in ordinary practice this transmission time is wasted. By salvaging these silent periods and using them to transmit additional conversations—which have their own idle periods—twice as many conversations can be accommodated as there are carrier channels to transmit them.

To accomplish this remarkable juggling feat, TASI monitors each carrier channel to determine when it is active or idle. When an "excess" circuit is connected to the system, it is instantly switched to a cable channel which is idle at that moment. When the displaced circuit becomes active, it is, in turn,

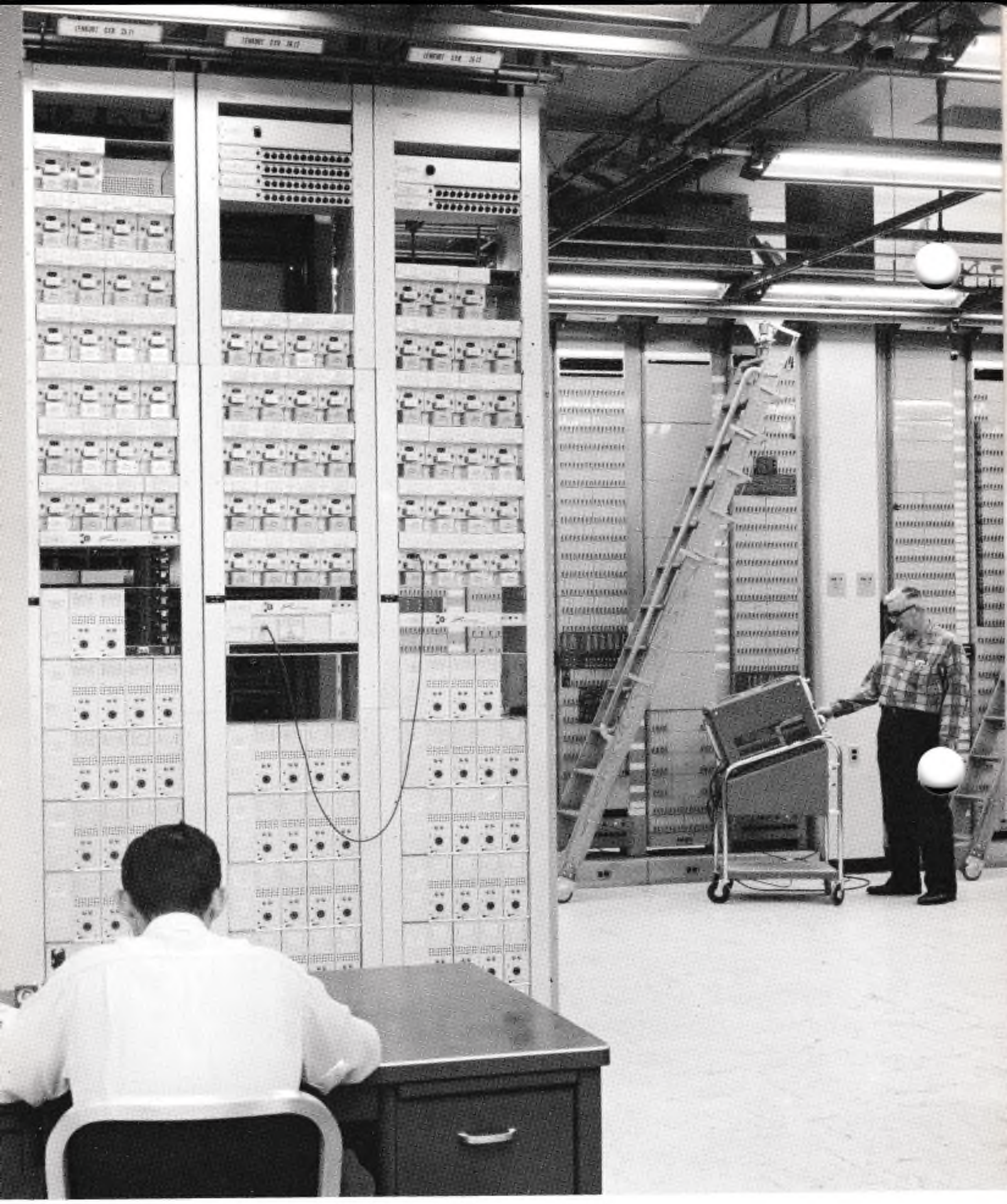


Figure 6. California end of Hawaii-mainland submarine cable. In background are some of the racks for TASI system which squeezes waste time out of conversations to obtain additional voice circuits from the limited cable bandwidth. In left foreground is the Lenkurt 23A Telegraph Carrier system which provides signaling and supervision for the TASI voice circuits. The 120-cycle channel filters permit 22 to 26 signaling channels or 100-speed telegraph channels to be sent through each voice channel.

connected to another channel which has become idle.

Obviously, if this were attempted with only a few circuits, there would be many moments of conflict in which all circuits would be active simultaneously, leaving no room for an additional circuit. When several dozens of conversations are used, however, the probability becomes quite high that some circuit will be idle at any given instant.

Although the high-speed switching and monitoring equipment required for this job is complicated and expensive, the extra circuits obtained in this way cost less than additional channels obtained without TASI.

Because TASI depends on interruptions or pauses in the individual messages, the presently-used single-frequency signaling tones cannot be transmitted with the individual circuits in the normal way. Since the signaling tone is present on the line when there is no connection or during dialing, TASI would interpret this idle-condition tone as "activity" and would connect it to the first available cable channel. This, of course, would result in idle circuits competing with the active circuits for the limited number of cable channels.

To get around this difficulty, signaling and supervision is separated from the message circuits and transmitted through non-TASI channels, using 23A telegraph carrier. In order to make the fullest use of the limited bandwidth available, 120-cycle spacing is used, thus permitting 23 or more telegraph (or signaling) channels to be sent over a single 3-kc voice channel, instead of the 16 possible with the more commonly-used 170-cycle spacing. This saves one of the expensive cable channels, since the cable has a capacity of only 48 three-kc channels at this time, and some of these must be reserved for data transmission, private-wire service, and the signaling channels for TASI.

Conclusions

Many of the uses made of carrier telegraph equipment have taken it far afield of the application envisioned by its designers. For Datatel systems in particular, one of the newest applications suggested involves parallel transmission with a number of channels for increased speed and direct read-out to and from the parallel characters of tape.

A review of the applications made or proposed for various types of carrier telegraph equipment suggests that users, rather than manufacturers are contributing the greater amount of imaginative applications engineering. ●

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Lenkurt Electric Co., Inc.
San Carlos, California

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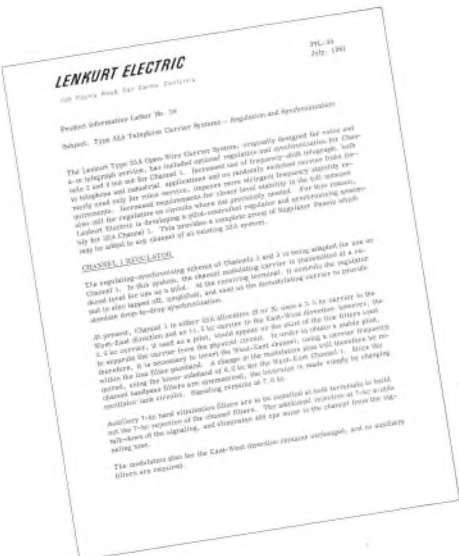

New Channel 1 Regulator Described

Regulation and synchronization of Channels 2 and 3 of Lenkurt's classic 33A Carrier System have long been available, but not Channel 1. This has been corrected by a new regulator described in *Product Information Letter No. 34,* now available by writing

EDITOR
The Lenkurt Demodulator
San Carlos, California

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