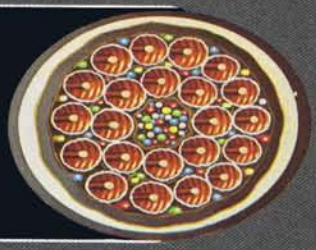
Western Electric



Transmission systems

L5

COAXIAL CABLE CARRIER SYSTEM

The ULTIMATE
In Analog Cable Carrier Systems

Extended Circuit Cross-section
High Reliability
Lowest per circuit cost

L CARRIER SYSTEMS

. . . A History of Bell System Service

Time has proven the effectiveness of the L Carrier family as a large cross-section, high quality, long distance coaxial cable facility.

The basic designs of all Western Electric L Carrier systems lend themselves to updating as the state of the art changes, in order to improve the performance and extend their usefulness as long as possible. This approach has made L Carrier a symbol of economy and transmission excellence.

COAXIAL CARRIER EVOLUTION

Coaxial System	L1	L3	L4	L5
First commercial service	1941	1953	1967	1974
Two-way 4kHz message channels per coaxial pair	600	1,860	3,600	10,800
Nominal repeater spacing (miles)	8	4	2	1
Number of coaxial pairs per sheath	4	6	10	11
a. working pairs	3	5	9	10
b. protection pairs	1	1	1	1
Total two-way 4kHz message channels per sheath	1,800	9,300	32,400	108,000

Now L5 ...starts with a distinguished genealogy ...continues in the established tradition

The L5 Coaxial Cable Carrier System extends the L Carrier capability to 108,000 total channels. Intended for long haul communications over routes with heavy traffic loads. It is a fourth generation of L Carrier making full use of experience and modern technology to provide the most dependable, flexible and economical carrier system yet offered to the Bell System.

The system provides the following advantages:

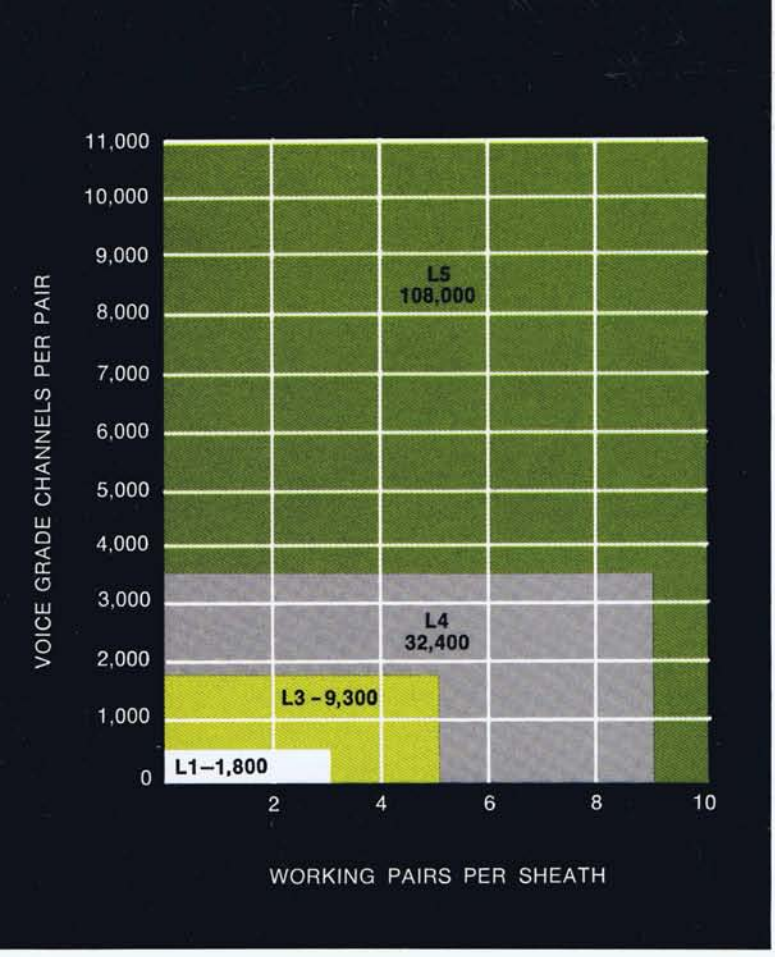
- 10,800 two-way voice circuits on a coax pair
- 40 dBrnc0 noise level for a 4000 mile circuit
- High reliability through duplication of critical circuits
- Programmed semi-automated fault location

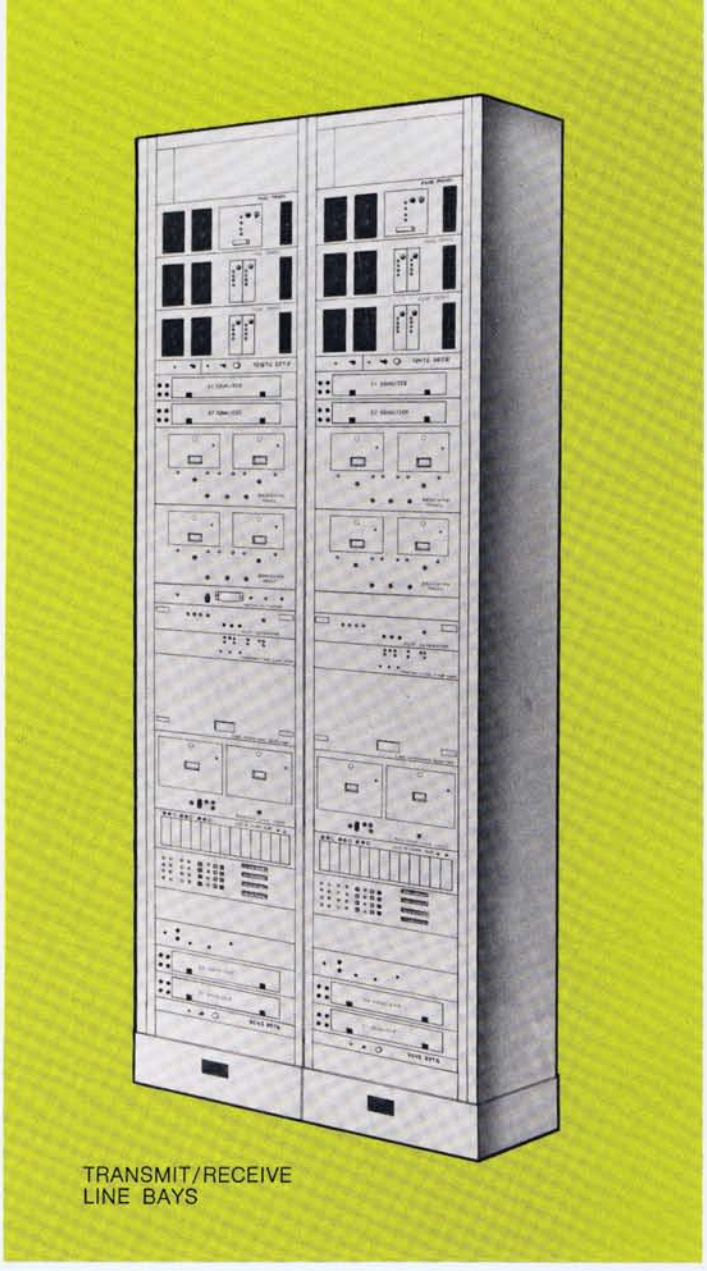
The L5 system has been designed to accept mastergroup or multimastergroup (maximum of six mastergroups) from radio, terminal equipment or other systems. Six mastergroups (600 voice channels each) are multiplexed to form a basic jumbogroup. Three basic jumbogroups are translated to different frequency spectrums to form the L5 signal in the frequency range of 3.124 MHz to 60.556 MHz. Provisions are included for adding, dropping or branching any jumbogroup at any main station.

The L5 has three times the L4 message capacity, the transmission media is more efficiently utilized and the resultant cost of a message-circuit on L5 is less than that of a message-circuit on L4 (when cost per channel mile of fully equipped systems are compared). It is possible to convert existing L1, L3 or L4 systems to L5 by adding the required number of new repeater sites between existing sites. This will result in a substantial increase in message capacity at modest cost.

The L5 system is composed of main stations and repeatered coaxial lines. Main stations include line protection switching equipment, transmission surveillance equipment (to insure reliable system performance) and a wide range of other equipment to support line operation and provide multiplex capabilities.

A mode of digital transmission is planned for the future to provide facilities to be used mainly for PICTUREPHONE® trunks.





TRANSMIT/RECEIVE
LINE BAYS

MAIN STATIONS

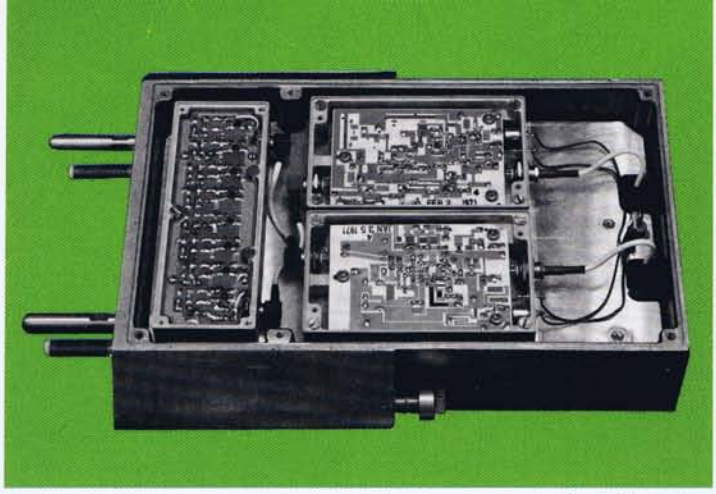
Main Stations are of three types as follows:

1. Power Feed Main Stations
2. Switching Power Feed Main Stations
3. Terminal Stations/Terminal Main Stations

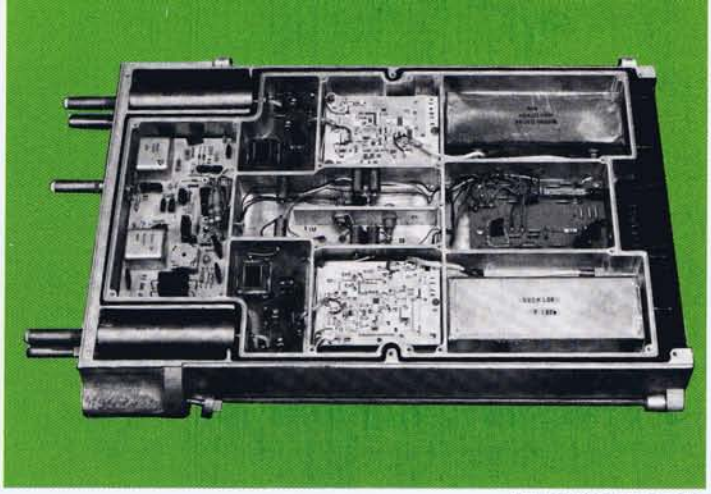
The Power Feed Main Station supplies the necessary power for the repeaters from the battery plant through high voltage converters. The high voltage converters supply a maximum of 1150 volts d.c. at approximately 910 milliamperes to the line. In addition, this station contains receiving and transmitting circuitry to provide level adjustment and maintenance access. The equipment provides amplification, regulation and equalization of the L5 line signals. These stations are spaced at intervals not exceeding 75 miles from another main station. The Power Feed Main Station receives and transmits signals on a "thru" basis only.

The Switching Power Feed Main Station contains the same equipment with the addition of a line protection switching system. In the event of a transmission deviation beyond the functional limits, the line protection switching system diverts the signals to the spare coax tube until the problem is corrected. These stations are located at intervals not exceeding 150 miles.

At Terminal Main Stations and Terminal Stations, the equipment required for signal administration is divided into receiving and transmitting classifications. The receiving equipment consists of the Line Interconnect Pilot Detector and the Receiving Line Connecting Circuit. The transmitting equipment consists of the Pilot Generator and Combining Circuit and the Transmitting Line Connecting Circuit. Terminal Main Stations always have at least one jumbogroup being routed on a "thru" basis. Line branching is permitted at Terminal Main Stations and jumbogroups may be multiplexed to and from other systems such as L4, radio etc. Terminal Stations are the only stations where all jumbogroups are "dropped" to jumbogroup multiplex and "added" from jumbogroup multiplex. Terminal Main Stations are typically spaced approximately 300 miles apart. Terminal stations are located at the terminus of an L5 system, generally in metropolitan areas.



Basic Repeater



Regulating Repeater

REPEATERS

HIGHLIGHTS — Remote testing
Automatic gain correction
No routine adjustments required

The repeatered line design is centered on use of a pair of 0.375 "coaxials" in cables containing up to twenty-two coaxial units. A twenty-two unit coaxial cable will provide ten working pairs and one protection pair.

Three types of repeaters are used in the L5 line. They are as follows:

Basic repeaters at one mile intervals.
Regulating repeater at seven mile intervals max.
Equalizing repeater at thirty-eight mile intervals max.

Basic Repeaters

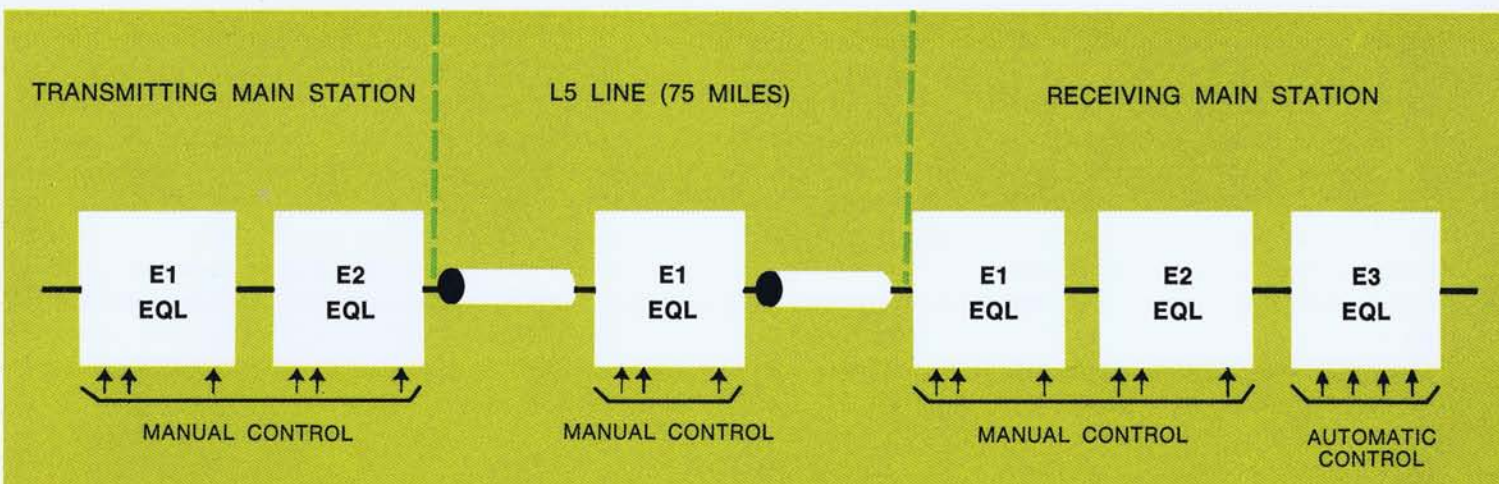
The basic repeater is the simplest form of repeater. The gain is fixed to compensate for one mile of coaxial cable at a temperature of 55°F. Fixed line buildout networks are provided in increments of one-tenth mile for repeater spacings of less than the nominal one mile. The line buildout networks are permanently wired into the repeater at the time of manufacture. This necessitates six different codes of basic repeaters which must be selected to fulfill the requirements of the cable span.

Regulating Repeater

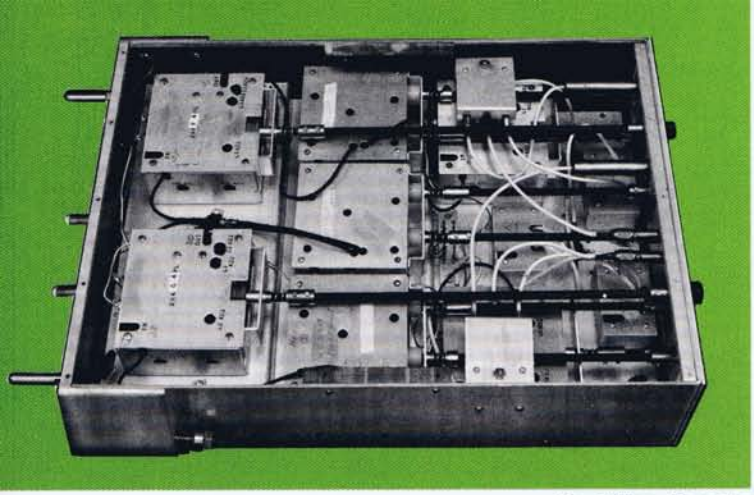
The regulating repeater is a basic repeater with plug-in line buildout networks and the addition of two automatic gain correcting networks. One network is automatically adjusted based on changes in amplitude of the 42.800 MHz regulating pilot signal due to changes of cable temperature. This compensation takes place at the end of the cable span. The other network is automatically adjusted based on changes in ground temperature in the vicinity of the repeater. This adjustment compensates for one half the gain change required at the beginning of the next cable span. Thus the two networks each compensate for half the loss change at each end of the cable span. This method is referred to as post and pre-regulation.

Equalizing Repeater

The equalizing repeater is a regulating repeater with an equalizing network. The equalizing network contains adjustments to compensate for static gain deviations across the frequency band. An E1 equalizer with ten manual adjustments is part of the equalizing repeater located at mid-span between the two main stations. The mid-span E1 equalizer is similar to the main station E1 equalizer except for physical design and manner of powering.



BLOCK DIAGRAM OF



Equalizing Repeater

Surveillance System Center Console

EQUALIZERS

HIGHLIGHTS — Infrequent re-adjustment required
Temperature compensating

The L5 repeatered line utilizes both static and dynamic equalizers to compensate for transmission deviations. The static equalizers compensate for the design and manufacturing limitations of the repeaters. The dynamic equalizers correct for the variations due to temperature changes.

There are two types of static equalizers designated as E1 and E2. These equalizers are installed at both ends of a line section. In addition, the E1 equalizer is used at the midspan point of the line section. The E1 equalizer has ten manual adjustments while the E2 equalizer contains eighteen manual adjustments. The manual adjustments are performed at the time of installation of the cable section and are not expected to change except at infrequent intervals.

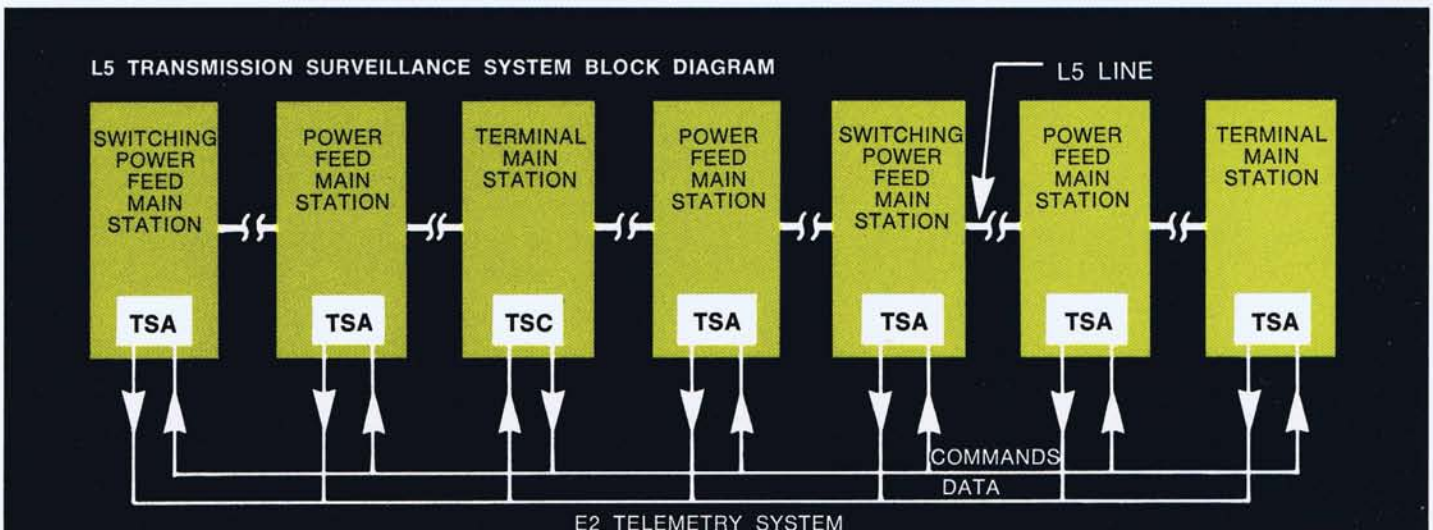
The E3 equalizer is the only type of dynamic equalizer used in the L5 system. This equalizer appears only at the receiving end of a line section. Four pilot frequencies spread across the L5 frequency spectrum are monitored. Four electronically controlled networks in the equalizer provide the required changes to correct for deviations from the nominal pilot levels due to temperature changes and other time-variant effects.

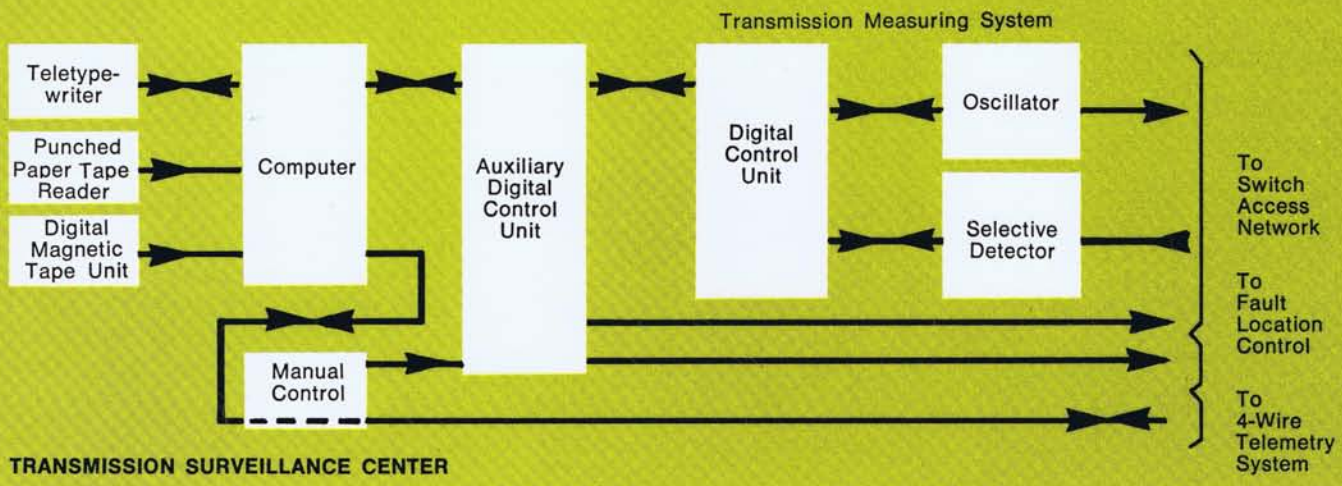
TRANSMISSION SURVEILLANCE SYSTEM

HIGHLIGHTS — Computer Diagnosis
Automatic or manual operation
Remote control via E2 telemetry
Teletypewriter printout
Economically enhanced service reliability

A new type of testing and maintenance system has been developed as an integral part of the L5 carrier to provide automatic measurement of system efficiency. Included in the system are Transmission Surveillance Centers, Transmission Surveillance Auxiliaries, Coaxial Access Networks (in Line Access and Distributing bays) and Fault Locating Oscillators (in manholes with repeater equipment).

The repeater stations contain four fault locating oscillators. Two of the oscillators generate frequencies at the low end of the L5 frequency spectrum and two at the high end of the spectrum. One low frequency and one high frequency oscillator is connected to the input of the repeater via a switching network and the other two are similarly connected to the output. At the time of installation, the four oscillator levels are adjusted for approximately the same readings at the measuring location and readings are recorded. Any future deviation from the recorded readings indicates an abnormality in the repeater or line section that should be corrected before catastrophic failure occurs. A





remotely operated switched access network provides the necessary connections to perform the measurements.

The Transmission Surveillance Center is located at a major manned terminal station. The center consists of test equipment, a digital computer to initiate automatic measurement and a teletypewriter equipped with a data set to provide a printout of readings. The teletypewriter also permits a craftsman to command the desired tests. All remote control commands and measured data at a remote location are transmitted in digital format via a four-wire telemetry system on the interstitial wires of the cable. The line protection switching equipment prevents interruption of traffic on the line by blocking test signals until the line is in an out-of-service condition. The Center may also be operated on a manual basis. One Transmission Surveillance Center originates local and remote automatic operations over a significant part of an L5 route.

The Transmission Surveillance Auxiliary contains the same equipment as the Transmission Surveillance Center except for the computer and teletypewriter and may be located at manned or unmanned main stations. Although the auxiliary is normally remotely controlled by a center via the four-wire telemetry system, it has provisions for local manual operation. The measurement equipment used with a Transmission Surveillance Auxiliary is mounted in a rolling console and may be temporarily disconnected to be used elsewhere in the station.

LINE PROTECTION SWITCHING SYSTEM

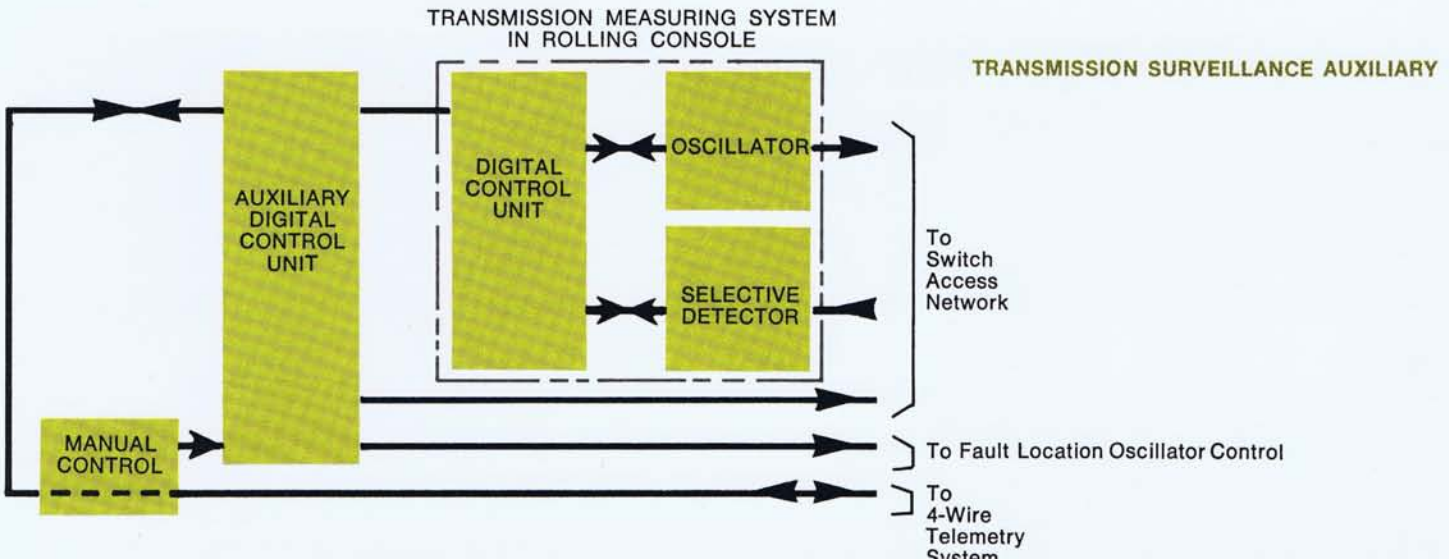
HIGHLIGHTS — Reliable
1 for 10 protection

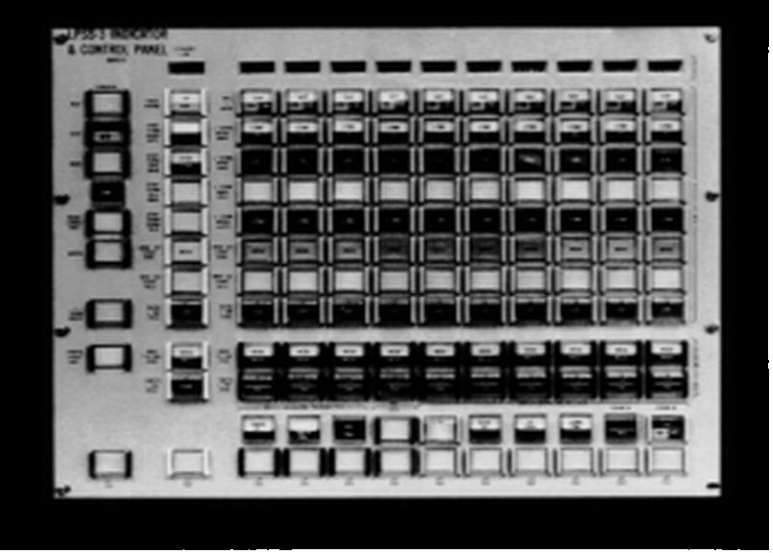
A new 1 for 10 line protection switching system, the LPSS-3 has been developed for L5 coaxial systems. The system control is primarily by integrated circuit logic. Switching is originated when the total energy of the L5 system increases 9 dB above nominal or when the temperature pilot signals deviate ± 5 dB from nominal.

The main features of the LPSS-3 are:

- solid state switches
- convenient means of removing message load
- automatic blocking of non-failed section switches
- differential switching based on pilot tone and system energy limits
- a high reliability signaling system
- assignable key line which has priority over all lines
- modular expansion as the L5 system grows

A new signaling scheme has been devised for LPSS-3 commands. In the past, protection switching systems have used single tones or a combination of tones for commands. The LPSS-3 system uses a frequency shift keying signaling system supplemented by a noise detector to overcome the





problem of noise in the switching signal band. Further, the eight-bit signal format includes parity bit protection. Positive replies are required to action request signals. Hence, reliable communications are assured.

The LPSS-3 can perform many different switching operations some of which are listed below:

1. Automatic switching of signals to standby line when trouble is detected and return to regular line when clear.
2. Manual switching for maintenance and testing of line with manual return only.
3. Lockout of spare line during maintenance or when line is in use.

All the circuits required to serve one end of the 22 tube coaxial cable are located in a single bay. The bays are completely shop wired and tested. All equipment is contained on plug-in circuit boards on a per-line basis. This permits plugging in the appropriate boards to add a line to the system when all lines are not utilized in the original installation.

For More Information refer to:

BSP 354-444-100	Jumbogroup Frequency Supply — Description
356-042-100	Basic Jumbogroup Trunk Bay — Description
356-600-100	Jumbogroup Multiplex — General Description
356-600-101	Jumbogroup Multiplex — Transmitting and Receiving Circuits — Description
356-600-102	Jumbogroup Multiplex — Transmission Switch and Alarm Circuits — General Description
356-600-103	Jumbogroup Multiplex — Carrier Supply and Pilot Supply — Description
359-300-100	L5 Carrier System — General Description
359-300-101	L5 Carrier System — Basic, Regulating, and Equalizing Repeaters — Description
359-300-102	L5 Carrier System — Main Station Repeaters and Equalizers — Description
359-300-103	L5 Carrier System — Line Protection Switching System — Description
359-300-104	L5 Carrier System — Line Connecting Circuits Pilot Generation and Distribution Circuits — Description
359-300-105	L5 Carrier System — Transmission Surveillance System — Description
359-300-106	L5 Carrier System — J68937A Order Wire Bay — Description
E.L. 1879	L5 Coaxial System — Transmission Surveillance System
E.L. 2087	L5 Carrier — Line Protection Switching Systems
E.L. 2088	Basic Jumbogroup Trunk Bay for L5 Carrier Systems
E.L. 2089	Jumbogroup Multiplex for L5 Coaxial Systems
E.L. 2090	L5 Carrier — Jumbogroup Frequency Supply

TECHNICAL DATA

Capacity per Coaxial tube	
Telephone Circuits	10,800
PICTUREPHONE®	36 LMD
Digits	240 MBits/Sec
Coaxial Cable Size	0.375"
Frequency Spectrum	
Analog	3-60 MHz
Regulation Range	± 6dB per 7 mile section
Maximum System Length	4000 miles
Protection Switching	1 x 10
Repeater Spacing	
Basic	1 mile
Regulating	7 miles (max.)
Equalizing	38 miles (max.)
Station Spacing	
Power Feed	75 miles (max.)
Switching Power Feed	150 miles (max.)
Noise (worst channel)	40 dBrn c0
Test Equipment	Programmable and Remote Control
Test Access	Local and Remote
Power Requirements	— 24V dc, 124A 117V ac, 2A

Western Electric continues to stand ready to assist you in meeting your requirements for transmission systems of all types. For assistance, please contact the Service Consultant, Transmission Products, serving your State or Region:

Central Region 3800 Golf Road Rolling Meadows, Ill. 60008 Ill., Ind., Mich., Wisc.	Al Bayer 312-956-2059 John LaCost 312-956-2024
Eastern Region 225 Schilling Circle Cockeysville, Md. 21030 Del., Md., Ohio, Pa., Va., W. Va.	Frank Koenig 301-666-6104 Marty Rosen 301-666-4225
Mountain-Northwestern Region 111 Havana Street Aurora, Colo. 80010 Ariz., Colo., Iowa, Ida., Minn., Mont., Nebr., N.D., N. Mex., S .D., Utah, Wyo.	Tom Devereux 303-343-2320 D. D. McCullick 303-343-5453
Northeastern Region Gateway II Newark, N. J. 07102 Conn., Maine, Mass., N. H., N. J., N. Y., R. I., Vt.	Paul Bergelson 201-468-7133
Pacific Region 898 Stewart Drive Sunnyvale, Calif. 94086 Calif., Nev., Ore., Wash.	Frank Heinisch 408-745-4596 Lewis Kaufman 408-745-4049
Southern Region 6701 Roswell Rd., N.E. Atlanta, Ga. 30328 Ala., Fla., Ga., Ky., La., Miss., N. C., S. C., Tenn.	Frank Cipolla 404-266-7059 Charles Hatcher 404-266-6382
Southwestern Region 1111 Woods Mill Road Ballwin, Mo. 63011 Ark., Kan., Mo., Okla., Tex.	Ed Strauss 314-391-4359

PRODUCT INFORMATION ORGANIZATION

PECC AND MANUFACTURING
MERRIMACK VALLEY

0091BWRD 10M 4/73