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INSTITUTE OF ELECTRICAL AND ELECTRONICS ENGINEERS, INC.

1974

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JUNE 17 – 19, 1974

HOTEL LEAMINGTON

MINNEAPOLIS, MINNESOTA

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FOREWORD

This ICC'74 Conference Record contains the papers presented at the tenth annual IEEE International Conference on Communications. More than 90 percent of the papers appear in complete form, and most of the remainder, which were not available for publication for various reasons, are represented by author-prepared abstracts.

The full Technical Program is tabulated at the beginning of this volume, and an author index is provided at the end. In addition, a listing of ICC'74 exhibitors and patron firms is included for permanent reference.

We on the ICC'74 Executive Committee hope that this Record will, in the tradition of its predecessors in the series, prove to be a valuable reference document both during the Conference and afterward.

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Sponsor: Radio Communications Committee, Communications Society

27A: An Overview of Underground Communications
R. F. Linfield, Westinghouse

27B: An Ultrasonic Personnel Location System
C. R. Kraus, Consulting Communications Engineers

27C: An Automated Facility for a National Warning Network
N. B. Tharp, Westinghouse

27D: Multiple Beam Communication Satellite Antenna Systems
R. B. Dybdal, Aerospace Corp.

27E: Design of the Bell Laboratories 19 and 28 GHz Satellite Beacon Propagation Experiment
D. C. Cox, Bell Laboratories

27F: Communications and Propagation Ground Receiving Station for the ATS-F Millimeter Wave Experiment
T. L. Duffield, Martin Marietta Aerospace

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Organizer: G. B. Thompson, Bell-Northern Research, Canada
Chairman: G. B. Thompson, Bell-Northern Research, Canada
Sponsor: ICC'74

PANEL DISCUSSION

Panelists:
J. Limb, Bell Laboratories
D. M. Atkinson, Bell Canada
E. Joseph, Sperry Univac
A. Seyler, Australian Post Office Research Laboratory
A. Reid, G. P. O., England (Participation via Trans-Atlantic Telephone Link)

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Organizer: L. C. Pollack, COMSAT
Chairman: E. J. Martin, COMSAT General
Sponsor: Space Communications Committee, Communications Society

29A: Experimental Evaluation of Satellite Links to Aid Ship Operations
J. Furick, EXXON, R. E. Anderson, H. Hoffman, General Electric

29B: Communications System Planning for Marisat
D. W. Lipke, D. W. Swearingen, COMSAT General

29C: A Maritime Mobile Terminal for Commercial Communications Satellite Application
F. Giorgio, I. Knight, R. Matthews, COMSAT General

29D: The Marisat Spacecraft
L. M. Keane, E. R. Martin, COMSAT General

29E: Maritime Satellite Experiments
H. A. Feigleson, U.S. Dept. of Commerce

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Organizer: R. A. Scholtz, University of Southern California
Chairman: R. M. Gray, Stanford University
Sponsor: Communication Theory Committee, Communications Society

30A: Optimum Resolution Filter with Constrained Detection and Estimation Performance
L. A. Thurman, MIT Lincoln Laboratories, C. D. McGillem, Purdue University

30B: Analysis of Digital AGC Amplifiers Using the Discrete-Time Volterra Series
D. R. Morgan, General Electric

30C: Optimum Spatial Processing of Passive Sonar Signals
S. Pasupathy, University of Toronto, Canada

30D: A Class of Direct Detection Receivers for Optical Communications
S. Prasad, A. K. Mahalanabis, Indian Institute of Technology, India

30E: Performance Evaluation in Digital Transmission Systems with Nonlinearities
S. Benedetto, E. Biglieri, V. Castellani, Istituto Di Elettronica E Telecommunicazioni Politecnico, Italy

30F: Performance of Selected Linear and Nonlinear Receivers in ELF Noise
J. W. Modestino, B. Sankur, Rensselaer Polytechnic Institute

Session 31: PCM AND ANALOG TRANSMISSION

Organizer: J. M. Thorson, Jr., Control Data Corp.
Chairman: F. S. Hird, Northwestern Bell Telephone
Sponsor: Wire Communications Committee, Communications Society

31A: Crosstalk Considerations for a 48 Channel PCM Repeatered Line
S. D. Bradley, GTE Lenkurt

31B: An Automatic Protection System for Digital Lines
A. H. Erlund, VICOM

31C: A Simplified High-Speed Regenerative Repeater for a Long Haul Digital Coaxial System
T. Matsuoka, N. Chiba, S. Hamao, H. Kimura, NTT, Japan

31D: New Translating Procedure for the 60MHz System
Y. Nomura, E. Iwahashi, NTT, Japan

31E: A New Analog Group Bank Using the Cascaded Filter Principle
G. Gotz, E. Koob, Siemens AG, Germany

Session 32: EARTH RESOURCES TECHNOLOGY SATELLITE: APPLICATIONS I

Organizer: J. Deskevich, Operations Research
Chairman: W. E. Scull, NASA
Sponsor: Aerospace and Electronic Systems Society

32A: The Earth Resources Technology Satellite Program: An Overview
E. P. Mercanti, NASA

32B: Recent Advancements in Information Extraction Methodology and Hardware for Earth Resources Survey Systems
J. D. Erickson, F. J. Thomson, Environmental Research Institute of Michigan

32C: Computer Processing of Earth Resources Technology Satellite Sensor Data
R. Bernstein, IBM

32D: Using ERTS-1 Data Systems to Predict Wheat Disease Severities and to Estimate Crop Growth
E. T. Kanemasu, Kansas State University

32E: Application of ERTS Multispectral Imagery to Agricultural Research
B. E. Dethier, W. W. Knapp, Cornell University
M. D. Ashley, University of Maine

Session 33: DIGITAL COMMUNICATION SYSTEMS

Organizer: C. A. Strom, Jr., Rome Air Development Center
Chairman: C. A. Strom, Jr., Rome Air Development Center
Sponsor: Communication System Disciplines Committee, Communications Society

33A: Data Above Voice (DAV) and Data Under Voice (DUV) Hybrid Microwave Systems
K. Feher, RCA Limited, Canada; R. Goulet, S. Morisette, University of Sherbrooke, Canada

33B: Data Above Video Transmission in Microwave Systems
K. Feher, M. Morris, RCA Limited, Canada

33C: A Method of PCM Transmission Over 2-GHz Microwave Radio
J. D. Olson, GTE Lenkurt

33D Narrowband Modem Performance Over DCDM and PCM Channels
S. Russell, Rome Air Development Center

33E: Integrated Services Digital Network for an Urban Environment
A. B. Glenn, Page Communications Engineers

33F: More Communications for the Public
C. R. Kraus, Consulting Communications Engineers

Session 34: SWITCHING SYSTEMS III

Organizer: F. K. Becker, Bell Laboratories
Chairman: F. K. Becker, Bell Laboratories
Sponsor: Communications Switching Committee, Communications Society

34A: Some Considerations on Application of SPC System to Small-Size Electronic Switching System
T. Kataoka, T. Uchida, M. Suzuki, OKI, Japan

34B: KC 250 EPBX
S. Sugo, OKI, Japan

34C: Business Communications Services from ESS Central Offices
J. J. Horenkamp, H. Oehring, Bell Laboratories

34D: Selection of an Optimum Digital PCM Switching Configuration Based on a Set of System Considerations
S. G. Pitroda, GTE Automatic Electric

34E: Methodology for Isolating a Set of Near Optimum PCM Digital Network Configurations
A. W. Kobylar, GTE Automatic Electric

Session 35: INTER-SYSTEM INTERFERENCE COORDINATION IN THE MICROWAVE BANDS

Organizer: R. F. White, GTE Lenkurt
Chairman: R. F. White, GTE Lenkurt
Sponsor: Radio Communications Committee, Communications Society

35A: Microwave Interference Coordination — 1974 and Beyond
R. F. White, GTE Lenkurt

35B: Interference Objectives for the Microwave Radio Network
M. J. Pagones, Bell Laboratories

35C: Estimation of Tropospheric Propagation Loss on Terrestrial Interference Paths
H. J. Weiss, COMSAT

35D: X-Band Pit-Shielding Measurements at an Earth-Station Site
D. Davidson, J. Elkan, GTE Laboratories

35E: Rainfall Attenuation Statistics with Application to Satellite-Terrestrial Sharing
P. Rice, J. Edwards, MCI Tele-Communications

Session 36: DIGITAL SATELLITE COMMUNICATION

Organizer: R. K. Kwan, Telesat Canada
Chairman: R. K. Kwan, Telesat Canada
Sponsor: Space Communication Committee, Communications Society

36A: Transponder Multipath Effects on Digital Satellite Communications
L. S. Golding, COMSAT

36B: Effects of PSK Spectral Spreading in a Satellite Transponder
R. G. Lyons, Telesat Canada

36C: A Constant-Envelope Digital Modulation Technique for Millimeter-Wave Satellite Systems
D. M. Brady, Bell Laboratories

36D: PSK Transmission Over a Non-Linear Satellite Channel
D. A. Lombard, D. R. Duponteil, Centre National D'Etudes des Telecommunications, France

36E: A TDMA Terminal for the Spot-Beam Satellite and its Field Test Results
A. Ogawa, Y. Hirata, M. Ohkawa, H. Saitoh, Kokusai Denshin Denwa, Japan

Session 37: THE VITERBI ALGORITHM IN DIGITAL COMMUNICATION

Organizer: D. D. Falconer, Bell Laboratories
Chairman: R. D. Gitlin, Bell Laboratories
Sponsor: Communication Theory Committee, Communications Society

37A: Performance and Implementation of the Viterbi Decoding Algorithm for Satellite and Space Communication
J. A. Heller, Linkabit

37B: Reduced State Viterbi Decoders for Channels with Intersymbol Interference
F. L. Vermeulen, M. E. Hellman, Stanford University

37C: Joint Optimization of Transmitter and Receiver Filters in Digital PAM-Systems with a Viterbi Detector
S. Fredricsson, Royal Institute of Technology, Sweden

37D: Design of a Finite Impulse Response for the Viterbi Algorithm and Decision-Feedback Equalizer
D. G. Messerschmitt, Bell Laboratories

Session 38: EARTH RESOURCES TECHNOLOGY SATELLITE: APPLICATIONS II

Organizer: J. Deskevich, Operations Research
Chairman: J. H. Voeckel, NASA
Sponsor: Aerospace and Electronic Systems Society

38A: Earthquake Prediction Proposed Utilizing Instrumentation of Large Pipelines with Telemetry to DCS Satellites
I. C. Bechtold, Consultant, N. D. Nelson, Hughes Aircraft

38B: Interdisciplinary Analysis and Interpretation of Earth Resources Technology Satellite (ERTS) Data
G. J. McMurtry, Pennsylvania State University

38C: Withdrawn

38D: Water Resources: Applications of ERTS Imagery to the Lake Champlain Basin
A. O. Lind, University of Vermont

38E: Geologic Uses and Non-Uses of ERTS-1 — Northern Rocky Mountains and Similar Areas
R. M. Weidman, S. S. Alt, University of Montana

Session 39: DIGITAL COMMUNICATION TECHNIQUES

Organizer: B. R. Saltzberg, Bell Laboratories
Chairman: E. K. Peterson, GTE Lenkurt
Sponsor: Data Communication Systems Committee, Communications Society

39A: Multilevel DCPSK Over Real Channels
V. Castellani, L. Lo Presti, M. Pent, Istituo Di Elettronica E Telecomunicazioni Politecnico, Italy

39B: Selected Topics in Adaptive Data Modems
E. D. Gibson, Rockwell International

39C: On the Design of All-Digital Components for Low-Speed and High-Speed Modems Using MOS Technology
W. K. Giloi, K. D. Kammeyer, Heinrich Hertz Institute, Germany

39D: PCM Receiving Equipment of a 640 Mbits/s Waveguide Transmission System Using Integrated Circuits
G. Hanke, Forschungsinstitut der Deutschen Bundespost, Germany

39E: Characteristics of an Experimental 200 Mb/s High Speed Regenerative Repeater for Various Code Types
T. Ohira, K. Ono, M. Niiro, T. Ogawa, OKI, Japan

Session 40: INFORMATION THEORY: RESULTS OF INTEREST TO THE COMMUNICATION ENGINEER

Organizer: M. E. Hellman, Stanford University
Chairman: M. E. Hellman, Stanford University
Sponsor: Information Theory Group

40A: A Mathematical Theory of Data Compression?
L. D. Davisson, University of Southern California, R. M. Gray, Stanford University

40B: Many User Channel Capacities
T. M. Cover, Stanford University

40C: Remarks on the Shifting Foundations of Communication Theory
T. L. Fine, Cornell University

40D: The Mathematical Theory of Secrecy Systems
M. E. Hellman, Stanford University

40E: Robustness of Convolutional Coding — Viterbi Decoding
I. M. Jacobs, Linkabit

Session 41: NO. 4 ESS SWITCHING TECHNIQUES

Organizer: H. E. Vaughan, Bell Laboratories
Chairman: H. E. Vaughan, Bell Laboratories
Sponsor: Communications Switching Committee, Communications Society

41A: System Aspects of the Network
G. D. Johnson, T. J. Cieslak, Bell Laboratories

41B: 1A Technology
H. A. Hilsinger, S. M. Neville, Bell Laboratories

41C: Voiceband Interface
C. L. Dammann, J. H. Davis, Bell Laboratories

41D: The No. 4 ESS Switching Network
J. Janik, Jr., M. F. Slana, Bell Laboratories

41E: Network Clock for the No. 4 ESS Time-Division Network
J. H. Huttenhoff, W. R. Schleicher, Bell Laboratories

41F: No. 4 ESS Signal Processor
F. H. Tendick, Jr., G. W. Kinder, Bell Laboratories

Session 42: DIGITAL PERFORMANCE DC TO LIGHT

Organizer: A. C. Walker, VICOM
Chairman: A. C. Walker, VICOM
Sponsor: Radio Communications Committee, Communications Society

42A: A 250 Mb/s EHF Data Transmission System — Radio Set AN/GRC-173 (XW-1)
C. K. H. Tsao, W. J. Connor, Raytheon

The two lectures which follow are tutorial in character. The duration of each is approximately one hour.

42B: Digital Transmission from D.C. to Light — Part I
R. H. Fish, A. C. Walker, VICOM

42C: Digital Transmission from D.C. to Light — Part II
R. H. Fish, A. C. Walker, VICOM

Session 43: SYNCHRONIZATION IN DIGITAL SATELLITE COMMUNICATIONS

Organizer: W. G. Schmidt, Computer Sciences Corporation
Chairman: W. G. Schmidt, Computer Sciences Corporation
Sponsor: Space Communication Committee, Communications Society

43A: Optimizing a TDMA Channel Including Synchronization
L. Lundquist, European Space Research Organization, Netherlands

43B Comparison of QPSK Carrier Regenerator Circuits for TDMA Application
F. M. Gardner, Consulting Engineer

43C: TDMA Synchronization for Future Multitransponder Satellite Communication
H. Ganssmantel, B. Ekstrom, AEG-Telefunken, Germany

43D: Precision Synchronization to a Switching Satellite Using PSK Signals
C. R. Carter, S. S. Haykin, McMaster University, Canada

43E: Synchronization and Acquisition in SDMA Satellite Communication System
M. Asahara, Y. Tsuji, M. Fukui, Y. Sohma, T. Hara, Fujitsu Laboratories, Y. Sakamoto, Fujitsu, Japan

43F: Generalized Frank-Heimiller Signals for Multiple Access Satellite Communications Systems
N. C. Mohanty, State University of New York at Buffalo

Session 44: COMMUNICATION SYSTEM THEORY

Organizer: R. A. Scholtz, University of Southern California
Chairman: J. A. Heller, Linkabit
Sponsor: Communication Theory Committee, Communications Society

44A: Comparison Detection of Hard-Limited Digital PM Signals
D. D. Falconer, J. J. Werner, Bell Laboratories

44B: Effect of a Soft-Limiter on the Error Rate of an M-ary CPSK System
P. Hetrakul, D. P. Taylor, S. S. Haykin, McMaster University, Canada

44C: Phase-Locked Loop Performance in the Presence of Fading Communication Channels
W. C. Lindsey, W. J. Weber, University of Southern California

44D: Performance of a Threshold Unlock Detector for a Digital Delay Locked Loop
J. L. Lewis, TRW

44E: An Adaptive Discrete Phase Lock Loop-Acquisition Behavior
R. H. Pyle, Analytic Sciences

44F: A Technique for Correcting Transmission Errors in Delta Modulation Channels
M. Z. Ali, I. Paz, N. R. Scheinberg, D. L. Schilling, The City College of The City University of New York

TRENDS IN DESIGN OF TELEPHONE CABLES
INTENDED FOR DIRECT BURIED APPLICATIONS

Eugene W. Riley
Anaconda Wire and Cable Company
Sycamore, Illinois 60178

ABSTRACT

The introduction of coated aluminum shielding tapes and filled cable cores has resulted in major changes in the makeup of telephone cables intended for direct buried applications. In this paper current trends in cable design are discussed. A test program initiated to compare various cable designs under identical environmental conditions is described and measured results are presented. Some problems which have been encountered with buried distribution wire are reviewed. An experiment carried out to investigate some aspects of these problems is reported upon and test results are presented.

INTRODUCTION

Following the development, in the mid 1950's, of plastic insulation, various configurations of double-jacketed cables for direct burial application evolved.[1,2] In the Independent Telephone Industry, concern for possible corrosion problems associated with the direct burial of aluminum led to the adoption of double-jacketed cables with copper shields.

During the subsequent 10 to 12 years a minimum of development effort was devoted to sheath design. The major emphasis throughout that period was on core design and manufacturing techniques. Two events which led to a renewed interest in development of a single-jacketed sheath with aluminum shield suitable for direct burial were the introduction in the middle and late 1960's of coated aluminum tapes [3,4] and "jelly" filled cores.[5]

The filling compound increases the mutual capacitance of the pairs for a fixed insulation thickness. To maintain the standard of 0.083 microfarads per mile it was necessary to increase the diameter of the cable for a given number of pairs. The obvious next step is the development of cellular plastic insulation and manufacturing techniques for applying it economically to small wires. Although filled-core cables with cellular insulation are not yet available in the United States, results of some activity in this area already have been reported upon in the literature.[6,7]

Simultaneously, equipment manufacturers were hard at work reducing the cost of applying electronic devices to the cable pairs. Digital trunk carrier systems and analog station carrier systems were experiencing ever-wider acceptance in the industry due to reductions in cost and improved versatility and flexibility.

At the same time a proliferation of improved, low-cost voice frequency electronic devices brought about a shift in emphasis on conductor sizes. The use of coarse gauge pairs gave way to finer gauge pairs with electronics.

A LOOK AT THE TRENDS

The trends seen in our markets during the period of transition, based upon records furnished by our Sales Department, are illustrated in Figures 1 and 2. Figure 1 shows the shift in emphasis on conductor size. The number of mcf (million conductor feet) of 19 gauge conductor shipped dropped from 30% of the total in 1964 to less than 5% of the total in 1972. Simultaneously, 24 gauge rose from a level of less than 20% to over 40%. The relative usage of 26 gauge conductor also has shown a modest increase during the period while that of 22 gauge has decreased slightly.

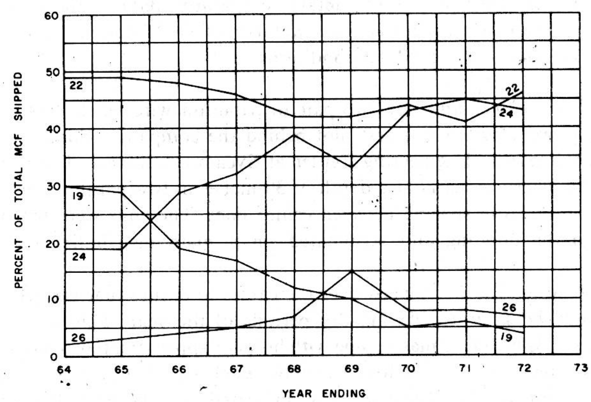

Figure 1 Trends In Conductor Size Usage

The trends in cable usage are shown in Figure 2. The reference is the total mcf of conductor allocated to aerial (single-jacketed) non-filled cables, buried (double-jacketed) non-filled cables and filled core cables. The number of mcf of conductor allocated to each per year is expressed as a percentage of the total mcf allocated to all types included in the group. Between 1964 and 1970 the number of mcf of conductor shipped in single-jacketed cables dropped from 70% to 43% of the total. During the same period the number of mcf of conductor shipped in double-jacketed cables rose from 30% to 52% of the total. Manufacture of filled cables, at least for our company, started in 1969; however, 1970 saw the first measurable quantities of filled cable produced. During the period from 1969 to 1971 the relative quantity of double-jacketed cables continued to rise along with the filled core cables while aerial constructions continued to decline. A definite reversal of the trend in double-jacketed cables was seen in 1972; early 1973 figures show a continued sharp decline along with a continued rise in filled core cables. The trend toward standardization of single-jacketed filled cables for direct burial appears well underway.

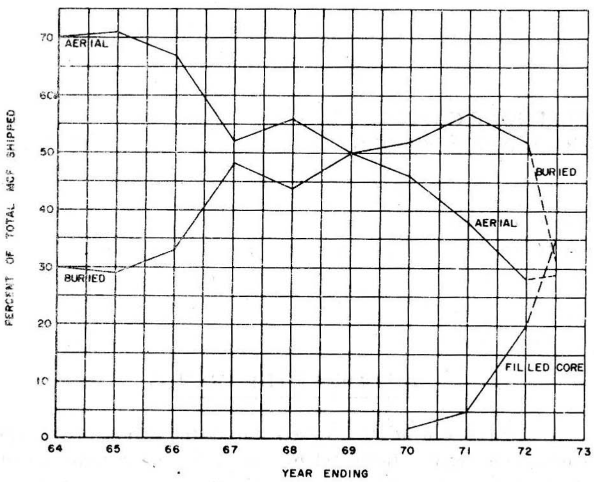

Figure 2 Trends In Cable Type Usage

ENVIRONMENTAL TESTS

Anaconda Wire and Cable Company, in September 1972, initiated a long-term test program to obtain comparative data on the stability of transmission properties of a number of cable designs subjected to identical environmental conditions.

Eight cables and one two-pair distribution wire, each 1000 feet long were buried in a test plot behind the company's Communication Products Engineering Center at Sycamore, Illinois. The cables were placed by hand at a depth of 30 inches in two parallel trenches with four foot spacing between center lines. The ends were brought into the building and terminated on a main distributing frame.

A water line was placed over the cables to ensure that the ground would be saturated during dry periods of the year. This line consists of ¾ inch I.D. plastic pipe with holes of approximately 0.080 inch diameter spaced at 10 foot intervals. Each trench has its own line and control valve. Measurements indicated that the pipes free flow over 2000 gallons per hour. The pipes are "energized" for 7 hours each week: two hours on Monday and Friday, one hour on Tuesday, Wednesday and Thursday. A cross-section view of the trench is shown in Figure 3.

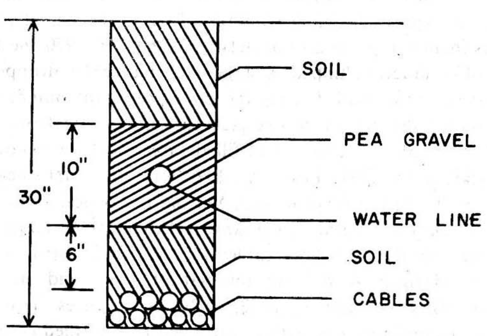

Figure 3 Cross-Sectional View of Trench

The samples included in the study are listed in Table I. Sample No. 8 has controlled damage in the form of two-inch sections wherein the jacket, shield and core tape have been removed from one-half the circumference of the cable. These openings are spaced 30 feet apart over approximately 800 feet of cable.

Stability of mutual capacitance and conductance (or lack of it) is a good indicator of whether or not moisture is affecting the transmission properties of a cable. We therefore selected three pairs in each cable sample — one in the center, one near the shield and one almost midway into the core — and monitored their mutual capacitance and conductance at 1000 Hertz. The two pairs in the distribution wire sample were monitored in the same way. Measurements were made on the selected pairs every week for the first two months and every four weeks thereafter. The first measurements were taken on September 25, 1972.

Only three of the samples have shown a definite increase in capacitance and conductance at the time of this writing; these are the ALP and PCP cables and the buried distribution wire.

Table I

Description of Cables in Test Plot

Sample No.	1	2	3	4	5	6	7	8	9
Code Name	ALP	PCP	SLM	ALP-TF	SLM-F	ALP-TF	BDW	ALP-TF	SLM-LP
Pair Count	50	50	25	25	25	25	2	25	50
Insulation	PP	PP	PP	PP	PP	CPP	HDPE	PP	LP
Core	NF	NF	NF	TF	F	TF	NF	TF	NF
Shield	A	C	SA	CA	SA	CA	B	CA	SA
Jacket	S	D	S	S	S	S	D	S	S

PP: Solid polypropylene; CPP: Cellular polypropylene; HDPE: High density polyethylene; LP: Longitudinal paper

NF: Non-filled; F: Filled core; TF: Filled core plus filling compound over core tape and shield

A: 8 mil corrugated bare aluminum; C: 5 mil corrugated bare copper; SA: 8 mil smooth aluminum coated both sides with polyethylene copolymer, bonded to sheath, sealed at overlap; CA: 8 mil corrugated aluminum, coated both sides with polyethylene copolymer; B: 5 mil helical bronze

S: Single jacket; D: Double jacket

1. All samples: 22 gauge solid annealed copper; high molecular weight polyethylene jackets
2. All samples except No. 9: Non hygroscopic core wrap
3. Sample No. 9: Paper core wrap
4. Filling compound: Petrolatum-Polyethylene
5. Sample No. 8: Controlled damage (See Text)

Variations in 1000 Hertz conductance are shown in Figure 4. It has been shown [8] that at frequencies below about 50 kHz very small amounts of water in a cable — for example, just enough to moisten the conductors or become suspended in a vapor state — are more detrimental to conductance than larger amounts in the liquid state. Since these samples have no apparent sheath damage we suspect that moisture has entered the core by permeation through the plastic jacket.