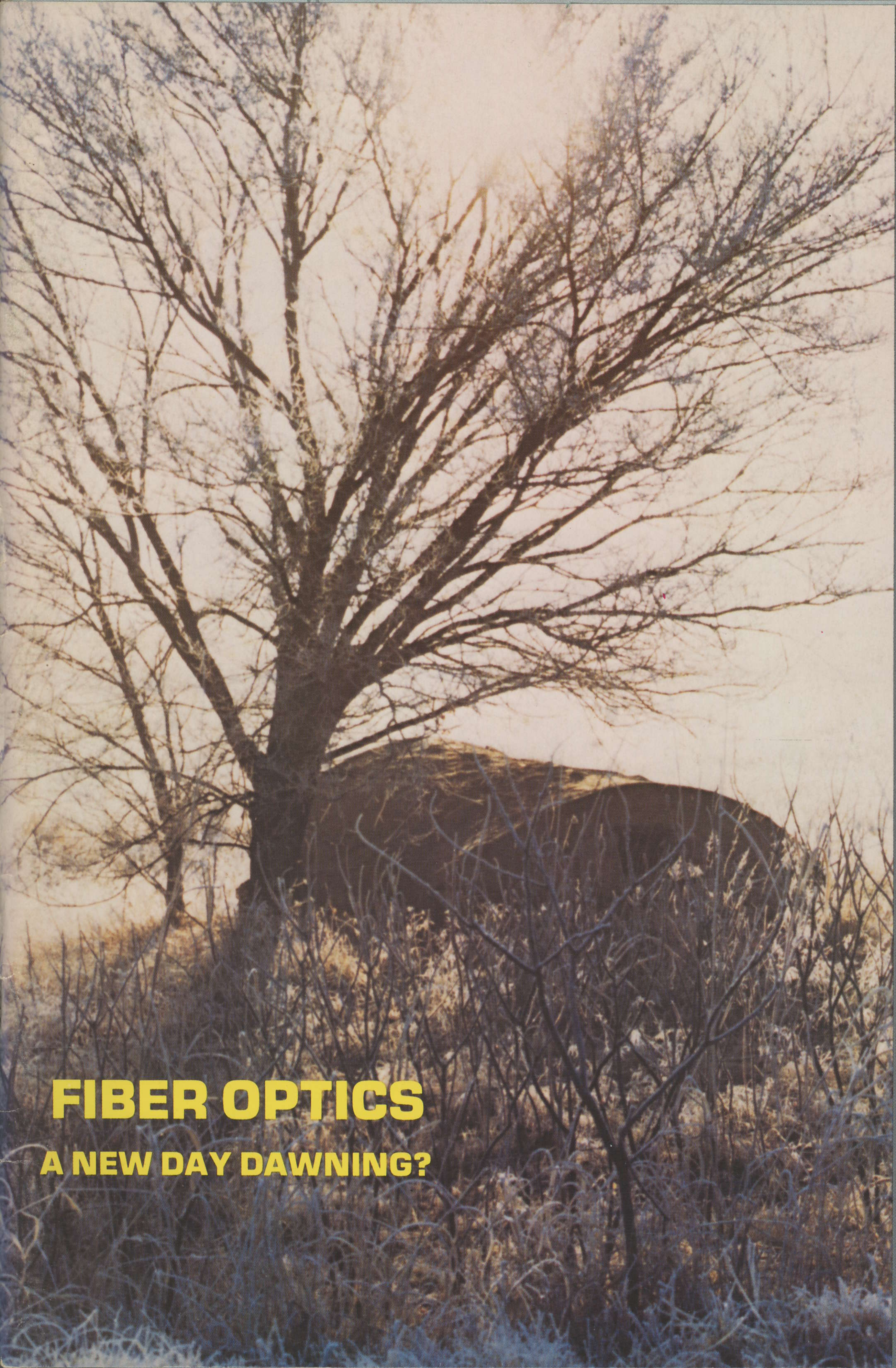
CATJ

APRIL 1977

OFFICIAL JOURNAL
OF THE
COMMUNITY ANTENNA
TELEVISION ASSOCIATION



FIBER OPTICS

A NEW DAY DAWNING?

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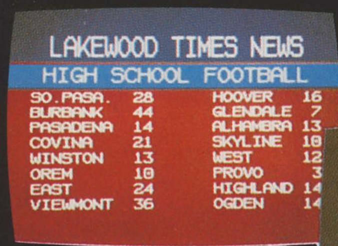

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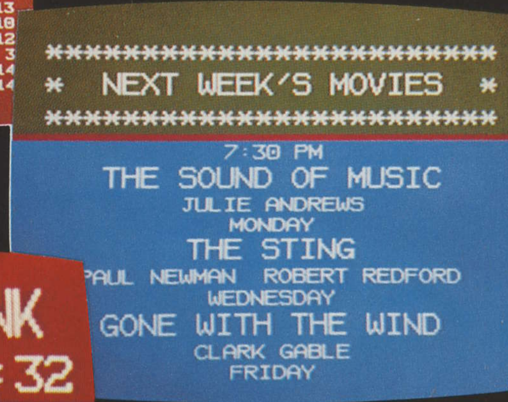

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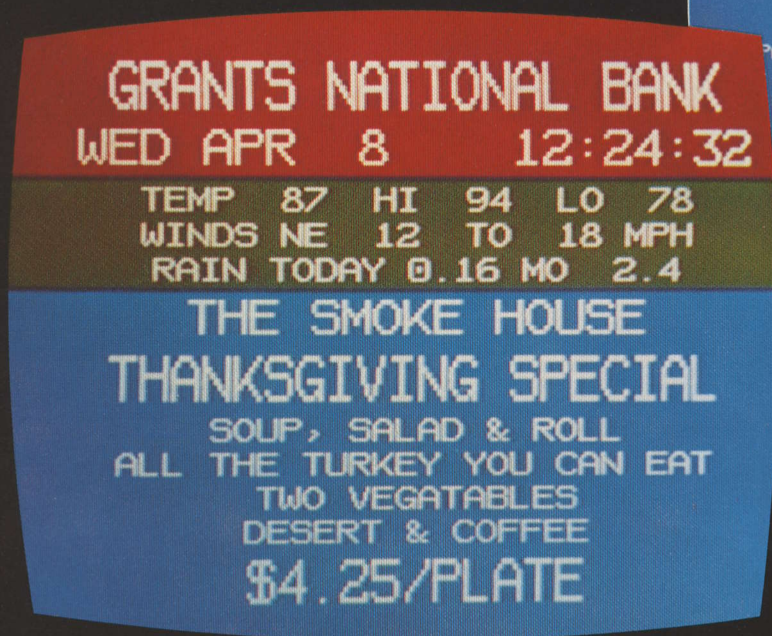

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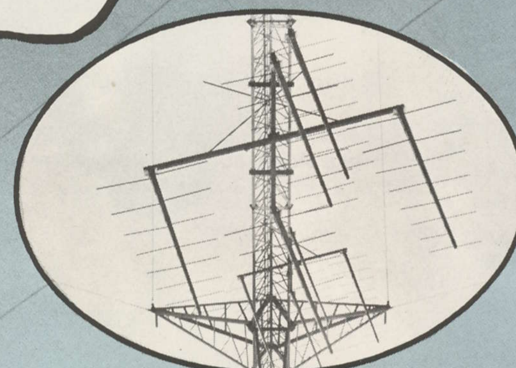

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VOLUME 4 – NUMBER 4

PUBLISHED MONTHLY, AS ITS OFFICIAL JOURNAL, BY THE COMMUNITY ANTENNA TELEVISION ASSOCIATION, INC. OKLAHOMA CITY, OKLAHOMA AS A SERVICE TO ITS MEMBERS AND OTHERS PROVIDING CATV/MATV SERVICE TO THE TELEVISION VIEWING PUBLIC LOCATED THROUGHOUT THE WORLD.

OFFICES

CATA/CATJ
4209 NW 23rd, Suite 106
Oklahoma City, Oklahoma 73107
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CATJ subscription rates $12.00 per year for non-CATA members, $8.00 per year for CATA member-systems; $9.00 per year for industry employed personnel for at-home delivery. In Canada, $13.00 per year for CATV systems, $10.00 per year for system employees. Foreign rates upon request.

Third class postage rates paid in Oklahoma City, Oklahoma, U.S.A.

The Community Antenna Television Association Inc. is a nonprofit organization formed under Chapter 19, Title 18 of the Statutes of the State of Oklahoma. As such, no part of its assets or income shall be the property of its members; such assets and income shall be devoted exclusively to the purposes of the Corporation.

—CONTENTS—

DEPARTMENTS

— OUR COVER —

Fiber optics. Is there really a new day dawning? Is the sky blue or golden? Is there gold at the end of the rainbow? When will it all happen? We try to put the fiber optic question into the proper perspective, and into the proper time-frame, starting on page 16 here this month.

CATA ~ TORIAL

KYLE D. MOORE, President of CATA, Inc.

Fiber Prologue

As a trade association, CATA has always been extremely skeptical of any new "ingredient" which seems to have 'blue-sky' leanings. There is a time and a place for any new technology, and often the time comes far after the initial announcement of a 'major technological breakthrough'. The transistor is good case in point. The transistor was announced in the 40's (late 40's to be sure, but still the 40's). **It was going to** revolutionize the world of electronics, **and sure enough it did.** But it took more than a decade for the transistor to make significant inroads in the electronics world and the change away from tubes is still far from complete.

Fiber optics reminds us of the transistor. It is a great concept, and it will undoubtedly **one day** revolutionize the way many things are done. Cable TV may or may not be one of those things affected. In this issue of CATJ we take two detached views of fiber optics and lay them before you. Our primary look is the studious report of a Canadian with great credentials; Dr. K.Y. Chang. It begins on page 16 here. It says that fiber optics offers interesting new **alternatives** to conventional cable TV. **It also says that it is not here yet,** and when it comes, it appears that it will come in a totally different format than today's trunk and feeder solid sheathed cable systems. Our second look at fiber optics is through the eyes and mouth of Irving Kahn; a man known to most of the industry as an individual with keen vision and great capacity to promote his concepts.

The truth in fiber optics remains elusive. In our own investigation for this special issue, we turned up dozens of conflicting reports and hundreds of conflicting statements by people actually doing work with fiber optics. Much of what we learned about the 'technical problems' is not revealed here, at this time. Dr. Chang says it better than we could, in his own paper.

Still, inspite of the warnings and signs that fiber optics may be headed for a long, **slow road** to realization, we see other signs around that fiber optics may in fact be **helping** some of us conduct our business in a very short period of time. Lee Holmes, owner and operator of Guam Cable TV (on the island of Guam) is apparently going to be one of the very first cable operators to add fiber optics to his system. The Guam situation is unique. Guam lacks broadband communications capacity and Lee Holmes sees fiber optics as an important and cost-effective answer to the need for broadband communications on his island. It may well be owned and operated and maintained by a cable television system. . .but the Guam use of fiber optics will be largely **communications-oriented,** not cable TV (distribution) oriented. We suspect other system operators, perhaps closer to the mainland than Guam, will find similar one-way or two-way applications **in their communities.** They will investigate, as Lee Holmes has for many years now, the most cost effective way to provide broadband communications capability between remote points. They will probably find fiber optics to be a cost effective answer.

But like Lee Holmes, **we doubt they will find fiber optics a cost effective answer to providing cable television.** At least not today, and probably not for many years to come. Not in the conventional 'cable television' format anyhow.

Poles and Fines

The fiasco of last fall, before last year's 94th Congress, is heading for a replay. It was a bad show the first time around, and the audience on hand to view it at that point should make a conscientous effort to avoid having a re-run.

It all began when NCTA and NARUC (the National Association of Regulatory Utility Commissioners) inked a private agreement to take to Congressman Lionel Van Deerlin; an agreement which NCTA and NARUC represented as "speaking for the cable television industry" and "the regulatory bodies which oversee public utilities in the various states". The agreement did **not** speak for the **full** cable television industry; and by **claiming** it did, NCTA stumbled into the same type of tactical blunder which caused this industry so much grief last fall.

Congressman Van Deerlin has been widely quoted as saying, privately and publicly that his paramount concern in the 95th Congress is that his House Subcommittee on Communications began the massive task of re-writing the 1934 Communications Act. The same Congressman has shown understandable reluctance to circumvent this most laudable project or to weaken it before it begins to breath by enacting piece-meal legislation that weakens the full re-write concept. With that basic policy from Van Deerlin, the whole of the Communications world has shown understanding and a willingness to leave special pieces of legislation alone.

Now comes the NCTA/NARUC request for a special bill, to empower the states and/or the federal government to regulate pole attachments between cable and the utlity companies. This places Van Deerlin on the spot. The pole attachment problem **is** acute in many areas; **there is no arguing that fact.** But if he reacts to **this** request for special legislation, how might that endanger the willingness of his Subcommittee to deal with the much larger rewrite? Would not "this special case" (as meritorious as it may seem) open the flood gates for other "special cases"?

The March 28th issue of **Television Digest** carries this news item:

'Pole attachment legislation shouldn't be considered by House Communications Subcommitee unless forfeiture bill is also included, NAB Senior VP Donald Zeifang wrote Chairman Van Deerlin. "That would seem to be the only fair and equitable way to handle these issues after the way forfeiture was killed by cable last session" '.

The April 4th issue of **Television Digest** reports on the NAB convention held in Washington the end of March:

'. . .All FCC Commissioners said FCC power to fine CATV systems is much needed'.

The FCC wants to fine us. The NAB wants the FCC to be able to fine us. And Congressman Van Deerlin, if he reads his mail, has been told that IF the Communications Subcommitee deals with "special" pole legislation, it should also deal with "special cable fines and forfeiture legislation". Given that sort of situation, and given the reluctance of the good Congressman to deal with any "special" legislation that might endanger his massive rewrite of the 1934 Communications Act, we find it very difficult to be supportive of the NCTA/NARUC agreement. We don't have to and will not oppose it. . .although we do find serious flaws in the suggested language of the bill submitted to Congressman Van Deerlin by NCTA and NARUC. We simply hope it won't see the light of day **unless** there is a total commitment by all parties involved that this singular piece of legislation is just that; a singular piece of legislation which will **not** signal the opening of the flood gates for other special pieces of cable related legislation in the 95th Congress.

It happened every time I did a "measurement by comparison" check on the Test Bench. I'd hook together the most expensive gear in the lab, put the display on a scope, and there it'd be... tilt, notches and lumps! Generally about .5 to 1 dB worth.

Then I learned that Wavetek has put together a complete system for making measurements by comparison. It costs less than $1,250, plus another $545 for the 12" scope. But the best news is that Wavetek's system lets me eliminate enough RF tilt to get a correlation of 0.1 dB.

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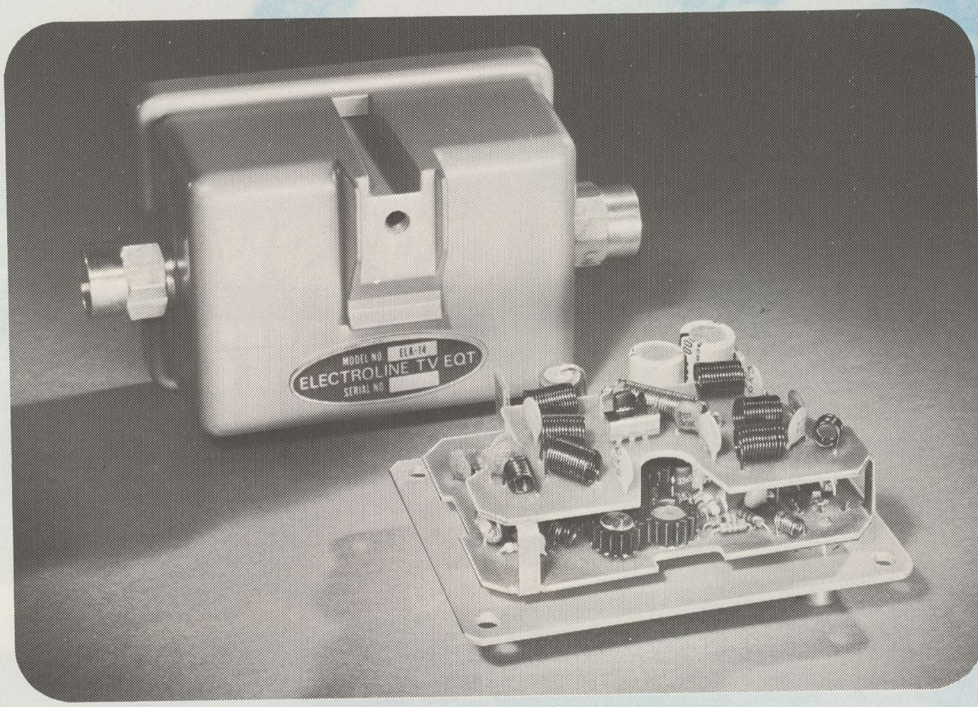

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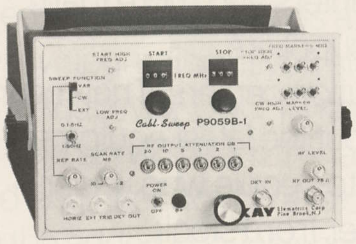

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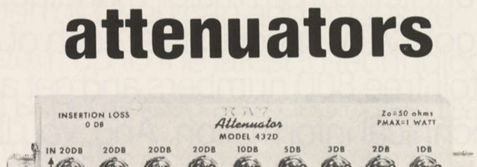

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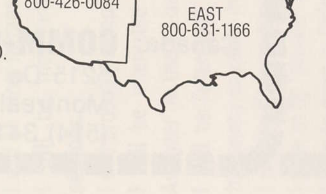

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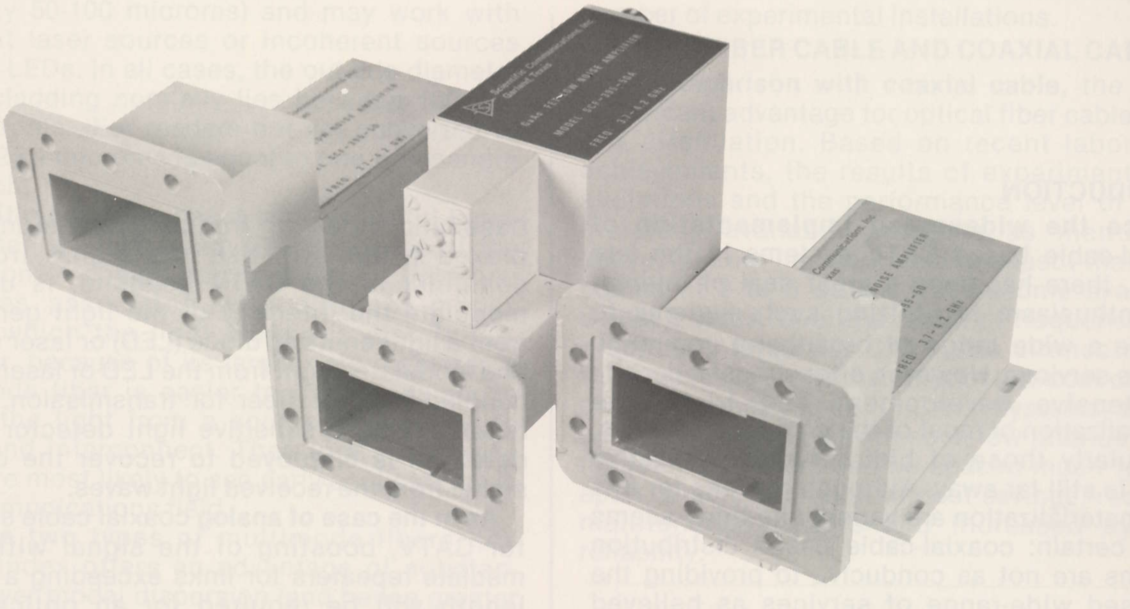

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INTRODUCTION

Since the widespread implementation of coaxial-cable based CATV systems in the late 1960's, there has been a great deal of interest and enthusiasm in utilizing such systems to provide a wide range of broadband communications services. However, after almost a decade of intensive development and trials, the materialization of most of the proposed services, particularly those of bidirectional interactive types, is still far away. Although reasons for this slow materialization are varied, one thing seems to be certain: coaxial-cable based distribution systems are not as conducive to providing the proposed wide-range of services as believed originally. This is due in part to economic factors and in good part to the technical limitations associated with the use of coaxial cable. Optical fiber technology has been the object of intensive research and development efforts around the world during recent years and is now on the verge of finding applications in various areas of telecommunications.

Although much of the emphasis in the R & D of optical fiber communications to date has been on digital transmission, there has also been some interest in the potential use of optical fibers for analog broadband communications[1-5]. In this paper, we shall discuss the current state-of-the-art of fiber optic technology, in particular as it relates to CATV and other analog broadband communications. Also, suitable network configuration concepts and system design methods will be examined.

BASIC ELEMENTS OF FIBER OPTIC TRANSMISSION SYSTEMS

The basic elements required in fiber optic transmission systems are shown in Figure 1. The input signal at the transmitter, which may be baseband video or frequency-division multiplexed (FDM) RF, like the signal from the combiner at the CATV headend, is used to modulate the intensity of the light generated from a light emitting diode (LED) or laser source. The modulated light from the LED or laser is then coupled into the fiber for transmission. At the receiver end, a sensitive light detector (photo detector) is employed to recover the original signal from the received light waves.

As in the case of analog coaxial cable systems for CATV, boosting of the signal with intermediate repeaters for links exceeding a certain length will be required for an optical fiber system. An optical repeater for analog video signals is basically similar to those used in coaxial cable CATV systems, with the addition of a photodetector at the input and a laser or LED at the output.

Although not shown in Figure 1, it should be noted that certain elements, such as fiber splices and connectors and, in some cases, directional couplers, also form an important part of an optical fiber system. In what follows, the basic elements of fiber optic systems will be briefly described and their state-of-the-art discussed.

THE OPTICAL FIBER

The most common form of optical fiber is composed of a central core of high-purity glass surrounded by a coaxial cladding of glass which has a slightly lower index of refraction. The light waves are propagated along the core by total internal reflection at the core-cladding boundary when the refractive index of the core is uniform (step-index), or by periodic diverging and self-focusing when it is graded (graded-index). Depending upon the relative diameters of the core and cladding, fibers are usually categorized into two types: multimode and single mode. A further distinction is made between graded-index and step-index multimode. A single-mode fiber has a very small core diameter (usually 3-5 microms) and will only efficiently propagate

Dr. K. Y. Chang
Manager, Fiber Optic Systems Planning
Bell-Northern Research
Verdun, Quebec
Canada H3E 1H6

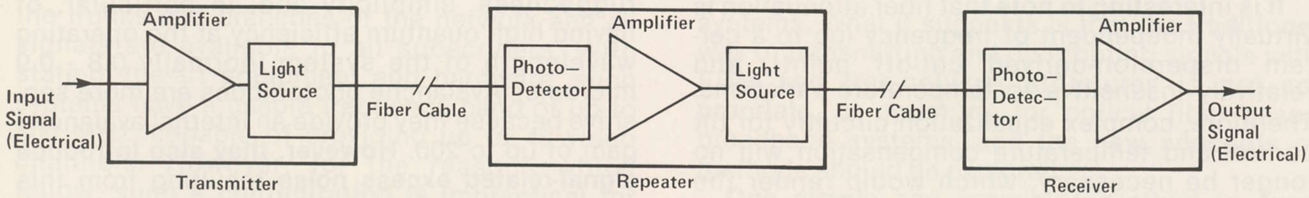

Figure 1 A Simplified Fiber Optic Link

coherent light from a laser. A multimode fiber, on the other hand, has a much larger core diameter (typically 50-100 microms) and may work with coherent laser sources or incoherent sources such as LEDs. In all cases, the outside diameter of the cladding normally lies between 100 and 150 microms. (For readers not yet converted to metric, 25.4 microms is equal to one thousandth of an inch).

A multimode fiber has a smaller useful bandwidth than a single-mode fiber, because of the dispersion of energy due to different travelling velocities associated with different modes among which the light energy is distributed. However, because of its larger core diameter, a multimode fiber is easier to handle, easier to couple the light from a source, and easier to splice and interconnect. Therefore, multimode fibers are most likely to see early applications in the communications field.

Of the two types of multimode fibers, the graded-index offers an advantage of substantially lower modal dispersion (and hence greater bandwidth), and is therefore considered as a prime candidate for telecommunications applications.

The most important parameter for an optical fiber is, of course, the attenuation. It is a result of such things as impurities, refractive index fluctuations, composition inhomogeneities, and physical imperfections existing in the glass guide. Due to the rapid advancement in glass purification techniques and fiber fabrication processes, fiber attenuation has been steadily decreasing in recent years. From a few hundred dB/km prior to 1970, fiber losses **of less than 0.5** dB/km have recently been achieved in the laboratory.[6]. Currently, fibers of 6 dB/km, both step-index and graded-index, are commercially available.

For field applications, optical fibers must be appropriately coated for protection, grouped into suitable numbers and sheathed in a cable form. To increase the durability of the cable, strength members are often incorporated in the cable, either at the center or in the cable sheath. Fiber cabling is presently in a very active state of development. Various small size fiber cables, ranging from 1 to 12 fibers per cable, are now available from several manufacturers, although most of these are developmental or prototype designs. At the other extreme, Bell Labs have experimentally fabricated, installed and tested cables incorporating 144 fibers.

It is notable that fiber cables of approximately 5 dB/km loss have been reported recently in a number of experimental installations.

OPTICAL FIBER CABLE AND COAXIAL CABLE

In comparison with coaxial cable, the most significant advantage for optical fiber cable is its low attenuation. Based on recent laboratory achievements, the results of experimental installations and the performance level of commercially available products as mentioned above, it is not unreasonable to expect that fiber cables of 2 to 5 dB/km will become available **within 5 years.** Over the range of frequencies of practical interest for CATV, the attenuation of fiber cables is lower than that of low-cost coaxial cables presently used for CATV systems; as can be seen in Figure 2. With such low attenuations, repeater amplifiers can be spaced much further apart, which will result in cost savings, reduced maintenance efforts and increased system reliability.

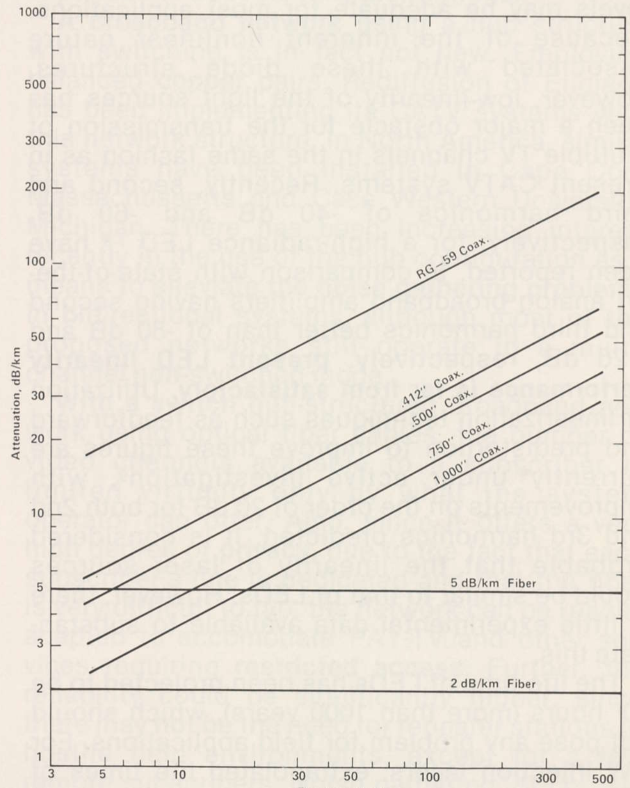

Figure 2 Attenuations of Optical Fiber and Coaxial Cables (Effect of Dispersion on Fiber Cable Attenuation not Included).

It is interesting to note that fiber attenuation is virtually independent of frequency (up to a certain dispersion-derived cut-off point), and relatively insensitive to temperature variations. Therefore, complex equalization circuitry for tilt control and temperature compensation will no longer be necessary, which would render the design and operation of repeater amplifiers simpler.

Further, since optical fibers are non-inductive and non-conductive, electro-magnetic interferences, RF leakages, and lightning inductions will cease to be a problem. In addition being light in weight and small in size, fiber cables should prove to be more convenient for storage, transportation and installation.

LIGHT SOURCES

Two types of light sources appear to be suitable for analog broadband fiber optic transmissions: high-radiance LEDs and continuous-wave (CW) semiconductor injection lasers, both of a Gallium Arsenide (GaAs) diode structure. These devices are compatible with fibers in terms of size and wavelength. Parameters of greatest interest, in the context of analog broadband applications, are power output, linearity, life time, and bandwidth.

LEDs capable of launching more than 0.4 mW of power into a multimode fiber, and laser diodes with power output in excess of 10 mW are now commercially available. Such power output levels may be adequate for most applications. Because of the inherent nonlinear nature associated with these diode structures, however, low-linearity of the light sources has been a major obstacle for the transmission of multiple TV channels in the same fashion as in present CATV systems. Recently, second and third harmonics of -40 dB and -60 dB, respectively, for a high-radiance LED [7-8] have been reported. In comparison with state-of-the-art analog broadband amplifiers having second and third harmonics better than of -80 dB and -120 dB, respectively, **present LED linearity performance is far from satisfactory.** Utilization of linearization techniques such as feedforward and predistortion to improve these figures are currently under active investigation[9], with improvements on the order of 20 dB for both 2nd and 3rd harmonics predicted. It is considered probable that the linearity of laser sources would be similar to that of LEDs. However, there is little experimental data available to substantiate this.

The life-time of LEDs has been projected to be 10^7 hours (more than 1000 years), which should not pose any problem for field applications. For CW injection lasers, extrapolated life times of 10^5 hours (approx. 12 years) have been reported.[10]

PHOTODETECTORS

Both PIN and avalanche photodetectors are being considered for optical fiber systems. They meet general requirements of compactness, ruggedness, simplicity and, in particular, of having high quantum efficiency at the operating wavelength of the system (normally 0.8 - 0.9 microms). Avalanche photodiodes are more sensitive because they provide an internal avalanche gain of up to 200. **However, they also introduce signal-related excess noise** resulting from this avalanche processes. For applications where high signal-to-noise ratios are required, as in the case of analog video transmissions, this excess noise tends to **cancel** the advantages derived from the avalanche gain. Also, avalanche photodiodes require bias-voltages substantially higher than PIN diodes (**in excess of** 130 volts) and therefore would be less convenient for use in the field.

Being well developed, the photodetector is considered to be the strongest link in a fiber optic system. Because of the relative low-power operation, linearity and lifetime are more adequate for most applications. Many photodetectors suitable for use in fiber optic systems are commercially available.

SPLICES AND CONNECTORS

Both permanent fiber-to-fiber splices and detachable fiber-to-fiber connectors are necessary to join the cables during installation, to connect fibers to terminal equipment and to provide flexibility for repair and rearrangement. Various techniques are currently under active investigation, including inserting fibers in a sleeve (or tube), aligning fibers with a Vee groove, fusion by flame or electric arc. Splicing or connecting losses as low as 0.1 dB have been achieved in the laboratory with almost all of these techniques, although 0.5 dB per connection is considered as being more realistic for field implementations in the near future (within 5 years). **At present, most splices and connectors suitable for use in the field are still in the prototype or developmental stages.** However, considerable progress has been made in this area in recent years and some components are commercially available.

Directional couplers

For certain network configurations, as the tree-structured network commonly practiced in present CATV systems, the directional coupler is an essential component. Many types of fiber optic directional couplers, employing virtually all aspects of optics, have been proposed or investigated. One simple technique that appears to be very promising uses two fibers placed side by side.[11] **In general,** however, **directional couplers are still in early stages of laboratory development.**

BROADBAND NETWORKS SUITABLE FOR FIBER OPTICS

Currently, coaxial-cable based analog broadband systems such as those providing CATV and PAY-TV are implemented with the tree-structure configuration. All the signals are frequency division multiplexed (FDM) and transmitted onto the trunks and branches of the network and all signals are available to all subscribers. With state-of-the-art equipment and hardware, such systems have a usable frequency band of up to 300 MHz, capable of providing **up to 40** video channels. However, for the reasons which follow, **such a configuration is impractical** for fiber optics.

BANDWIDTH OF FIBER OPTIC SYSTEMS

In principle, an optical transmission system **may** have a **flat** frequency response extending from dc to optical frequencies (on the order of 100,000 GHz). Even though the dispersion phenomena will limit the actual usable bandwidth of a fiber system, a **bandwidth of 1 GHz-km***is attainable under **controlled** conditions. Unfortunately, the effective utilization of this bandwidth, particularly for analog transmission, has not been without technical difficulties, and potential users would be wiser to think **in terms of 100 MHz-km**. Further, light sources operating in a continuous mode become inefficient if designed for high frequency operation.

LIMITATIONS DUE TO DEVICE LINEARITY

As is well known to CATV systems engineers, one of the main concerns associated with the design of a CATV system, particularly one requiring the provision of more than 12 standard NTSC video channels, is the inter-modulation and cross-modulation interferences resulting from the nonlinearity of the analog broadband amplifiers. We have already pointed out the comparatively **poor linearity of light sources** for fiber optic systems, and it should be obvious to any systems engineer that if one attempted to implement CATV distribution **by simply replacing** coax cable by fiber and replacing the CATV amplifiers by suitable amplifiers onto which one had stuck a photodetector at one end and a light source at the other, **one would be in bad trouble.** In fact, with state-of-the-art devices and a 5 dB/km loss fiber cable, it is found that[12] to cover a distance of, say, 20 km while meeting the NCTA performance requirements, **only 3 to 5 channels can be provided per fiber** on a FDM basis. So much for the "thousand channels per fiber" so enthusiastically predicted in early reportings on fiber optics!

SWITCHED, HUB-STRUCTURED NETWORK CONFIGURATION

The fact that fiber systems **cannot** operate, at least in the foreseeable future, in a fashion analogous to conventional CATV systems, though, **in no way implies** that optical fibers are **not** a suitable medium for analog broadband systems. What it suggests is that the **traditional** way of transmitting and distributing signals with FDM and tree-network structures is **not appropriate,** or optimum, for optical fiber based broadband systems, and the **new concepts** or methods should be explored.

One simple and promising method to overcome the problems imposed by the **severe linearity limitation** of light sources calls for the alteration of the traditional concept of network configuration; i.e. from a tree-shaped structure to a hub-(or star-) shaped structure **with switching facilities at the hub.** With a hub-structured network, **each** subscriber is provided with a fiber **from** the hub. The fiber carries a light signal modulated with the video signal(s) of the television channel(s) that the subscriber selects. **In this case,** each fiber would not normally carry any more than **one or two** television channels, and linearity would not become a problem. Obviously, with this network, a return path from each subscriber to the hub for channel request and a video switch at the hub for channel assignment would be required (see Figure 3). The return path can be either an **extra** fiber, a separate copper pair similar to ordinary telephone wires, **or** the **same** fiber used in a **bi**directional manner. If an extra fiber is used, the return path can readily accommodate the transmission of video and/or data from the subscriber to the hub, and **the network** can be easily expanded to become **fully bi**directional.

A broadband network using a hub structure with switching is in fact not new. Employing balanced **copper** pairs, Rediffusion of England has been implementing its CATV systems with this network structure. In North America, similar systems have been installed in Cape Cod, Massachussetts and Case Western University, Michigan. There has been increasing interest recently in the use of the hub configuration as a means to alleviate the **noise gathering problems** in **bi**directional systems, although most of the proposed networks still operate in a multichannel **non**-switched mode.

With a switch hub-structured broadband network using optical fiber cables, the number of video channels available to a subscriber is limited virtually only by what the system operator can offer. Also, since it offers a very high degree of **privacy,** due to the fact that each subscriber's line is dedicated and that the fiber is very difficult to tap, the network can be readily adapted to accomodate PAY-TV and other services requiring **restricted access.** Further, the reliability could be significantly higher, since there may **not be** the need for repeater stations in hostile field environments, except for a few remote subscribers. Noise gathering, of course, will cease to be a problem even if all subscribers are equipped with the "up-stream" video and/or data option.

From the technological viewpoint, all the elements required for a switch, hub-structured

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***The notation "X" Hz-km means if one has a bandwidth of X Hz over 1 km, one has X/2 Hz over 2 km, X/3 Hz over 3 km, etc. In fact, fibers do not always follow this rule. In many cases, the frequency response only falls off as the square root of length.**

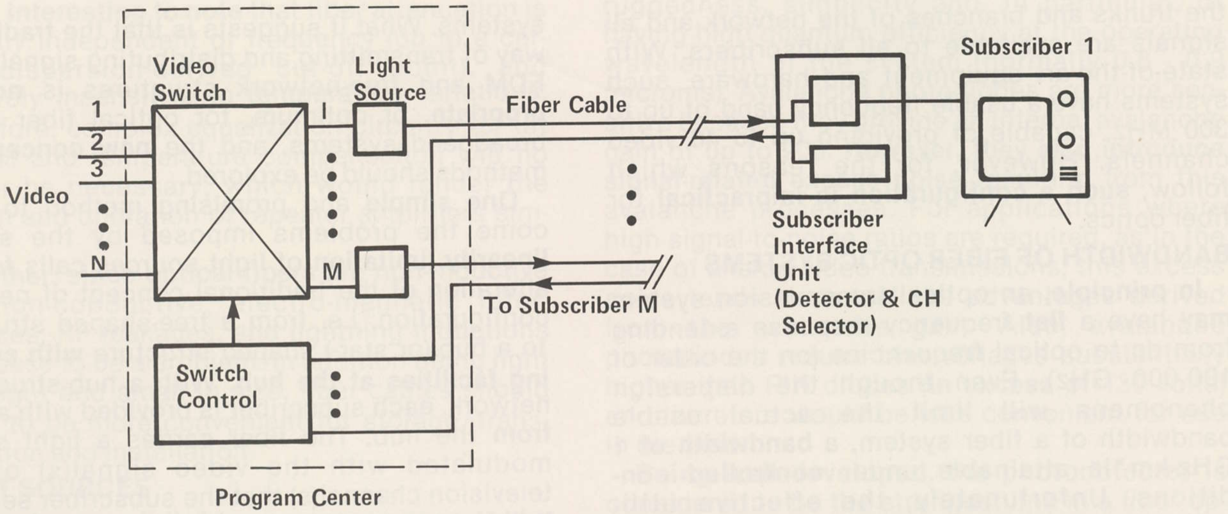

Figure 3 A Switched Hub—Structured Broadband Network

fiber optic broadband network **are** at, or close to, **a mature stage of development**. If the implementation of an analog broadband network is being considered for the **near** future, a serious systems engineering and economic study of such an optical fiber based network configuration is certainly worthwhile.

WAVELENGTH DIVISION MULTIPLEXED TREE CONFIGURATION

The switched hub network configuration discussed above **overcomes the problems** imposed by opto-electronic device non-linearity. However, the system **still** does **not** fully utilize the bandwidth capability of the fiber. One technique to take advantage of the wide bandwidth capability of the fiber, while at the same time avoiding the linearity limitations of the devices, is the use of **wavelength division multiplexing** (WDM).* With WDM, one could implement the network in much the same way as present coaxial cable CATV systems; i.e. tree structured, as shown in Figure 4. Note that in this case, at the headend, N lasers of narrow spectral width, each having its intensity peak at a different wavelength, are individually intensity modulated by N video channels. The N light beams are comined optically and launched into the "trunk" fiber. Through trunk, feeder and drop fiber cables, the signals are then distributed in the same way as present-day coaxial cable systems. At the subscriber end, the signals are optically split, filtered and detected. **One** of the N video channels delivered **to the subscriber** can then be **selected** at the input to the television set.

Note that at each amplifier station, the signals must also be split, filtered, detected, then individually amplified, modulated, and finally combined for transmission onto the next cable section.

With lasers of narrow spectral widths (half power width of, say, less than 2 nm), it should be **possible** to transmit more than 30 television channels **through** a single fiber. The quantity of fiber required to serve a given area would be less than that with the switched hub network and would therefore be attractive when the fiber price is at a relatively high level. Unfortunately, many of the optical and electro-optical **compo-**

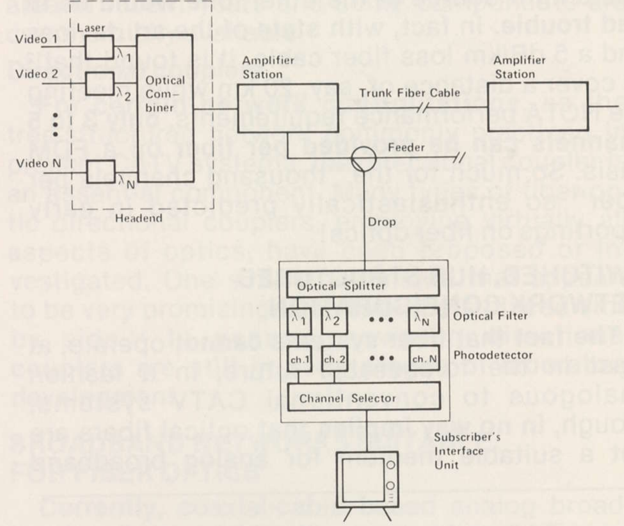

Figure 4 Wavelength Division Multiplexed, Tree–Structured Broadband Network

***Since wavelength and frequency are, obviously, related, some workers object to the term WDM instead of FDM. However, we make the distinction that, semantically, one talks of the wavelength of light more often than its frequency, and of the frequency of an electrical signal more often than its wavelength. Thus, we elect to use WDM to mean multiplexing of several light sources of different optical wavelength, and FDM to mean multiplexing of several electrical signals of different frequencies.**

nents required for a WDM network, including laser sources of different wavelengths but with fine spectral resolution, optical combiner and splitter, directional coupler, etc. **are still in early laboratory development stages.** Further, this system suffers in service and operational limitations currently experienced by the tree-structured CATV networks, notable the difficulty in evolving the network towards a **fully bi**directional one.

For the WDM and hub-type systems, it would be advantageous to transmit video signals **at baseband.** The development of commercial TV sets with baseband inputs for such systems of the future is deemed to be highly desirable. If such sets are **not** available, an up-converter (**or modulator**) would be required **at the subscriber's** interface unit.

There are other approaches to the provision of broadband communications with optical fibers. These include for example, non-switched space-division multiplexing, hybrid frequency/-space division multiplexing (similar to Ameco's Discade system), and hybrid FDM/WDM. Studies are being carried out now to evaluate the relative merits of **all** these competing system approaches from technical, operational and economic standpoints. **Whatever the outcome, it is certain that the optimum fiber-based CATV sysstem will not simply be a present-day coaxial cable system, with the coaxial cable replaced by optical fiber.**

DESIGN OF AN ANALOG FIBER OPTIC LINE

The basic design of an analog fiber optic line is no different from that of an analog coaxial cable line. For economic and reliability reasons, it is necessary that the repeaters be spaced as far apart as possible, while meeting, in the mean time, the requirements on system performance, overall length to be covered, channel capacity, etc. In **maximizing** the repeater spacing for fiber optic systems, **one proceeds as with coaxial cable systems.** First, the signal level output from the repeater (light source) is set to the **maximum level where non-linearity induced distortions** (principally intermodulation, cross-modulation, differential gain and differential phase) are still within the performance specifications allocated to that repeater. Second, the signal level input to the next repeater (photodetector) is allowed to be attenuated **to the minimum level** where the signal-to-noise ratio is still within the signal-to-noise requirement allocated for that repeater. The allocation of performance requirements to each repeater is such that the furthest subscriber receives a signal whose quality meets the standard specified for the system.

SIGNAL-TO-NOISE RATIO

The noise of a fiber-optic line is generated principally by the photodetectors and amplifiers of its intermediate repeaters and receiver. In converting optical power to electrical current, one has, in addition to the thermal noise familiar to all CATV engineers, **new sources of noise unique to optical communications.** Photodetectors contribute signal-related noise (referred to as **quantum noise**) and dark-current quantum noise. The signal related nature of the former introduces new mathematical problems in optimizing detector design which have been studied in many laboratories.

In a simplified general form, the signal-to-noise ratio (SNR) can be expressed as follows:

$$SNR = \frac{P_r}{N(N_t + N_d + F_q P_{av})}$$

where **N** is the number of repeaters cascaded, N_t and N_d are thermal and dark-current noise powers respectively, F_q is the "quantum noise" factor equal to the ratio of quantum noise power to average signal power P_{av}, and P_r is the received signal power. Due to the limited space, the precise relationships of these factors to system parameters will not be elaborated on here. Interested readers are referred to, for example, reference **13**. As always in the CATV world, care is needed in matching the definition of SNR in the literature to the definition needed for designing a specific system.

NON-LINEAR DISTORTIONS

Given the nonlinear characteristics of the light source (normally given by specifying the second and third harmonics at a certain power level of the fundamental), one can determine the intermodulation and crossmodulation for multi-channel transmission **in much the same way** as with coaxial cable systems. Because of the relatively poor linearity of the source device, as compared to conventional amplifiers, however, differential gain and differential phase should **also** be examined. This is particularly important for single channel per fiber transmission, where intermodulation and cross-modulation are not a problem. It is these considerations which define the maximum power, P_t, which can be transmitted by the light source while still meeting the requirements for signal quality allocated to that light source.

REPEATER SPACING

The repeater spacing (S) in kilometers is simply related to the transmitted optical signal power (P_t) dBm, received optical signal power (P_r) dBm, and fiber attenuation (**L** dB/Km) as follows:

$$S = \frac{P_t - P_r}{(L + L_s)}$$

where L_s (dB/km) is included to account for extra cable losses due to splices. By determining the allowable maximum transmitted and minimum received powers as described above, one can then readily determine the maximum repeater spacing. Using this method, we have determined the **spacing** for fiber optic links of various system parameters. With state-of-the-art LEDs, PIN photodiodes and graded index fibers of less than 5 dB/km, for example, it is found that **repeater spacing of greater than 7 km for single-channel transmission can be readily achieved.**

OTHER CONSIDERATIONS

The non-conductive and non-inductive characteristics of optical fibers offer very significant advantages as mentioned earlier. Unfortunately, this very property **also** poses some **problems. Remote powering of field** repeaters through the **same** transmission line as that which carries the signal will **no longer be possible** with optical fibers. However, since the repeater spacing will be substantially longer, there will **not** be the need for a large number of field repeaters. In fact, with a switched hub configuration, in urban or suburban environments field repeaters **may** not be required at all, **except at the hub.**

For situations where field repeaters are required, they can be powered with the use of: a) local small power stations, which may derive their power from hydro lines in the vicinity or, in a world increasingly conscious of energy shortage, charge batteries from solar or wind power, b) **composite optical fiber/copper pair cable** with the copper pair carrying the power and possible doubling as the "strength" member discussed earlier, and c) a separate power-carrying copper-pair cable. The approach which will be most attractive would depend on the relative economics in particular situations.

In addition to remote powering, another area of major concern in considering the implementation of a fiber optic system is fault location, of both the repeaters and the cable. Fault location of optical repeaters should not be more difficult than fault location of amplifiers of coaxial cable systems. Similar techniques to status monitoring can also be used in optical fiber systems. For the detection of cable faults, the traditional method of sectionalization and isolation still applies. **Pressurization is a possibility** for detecting cable breaks and its feasibility **is under investigation** by many fiber cable manufacturers. To pin-point the precise location of the fault, the time-domain reflectometry technique, **can also be used** for optical fiber systems. **Test equipment employing this technique,** however, **has yet to be developed.**

CONCLUDING THOUGHTS

We have discussed in this article the **state-of-the-art** of fiber optic technology, particularly in relation to broadband communications. The advantages and limitations relative to coaxial cable based broadband systems have been examined and suitable approaches to the implementation of a broadband network with optical fibers are suggested. General rules for designing a fiber optic system have been noted.

In summary, with an appropriate network configuration the optical fiber is considered as an attractive medium for providing broadband communications services. **Although design and developmental efforts** on certain devices, hardware and equipment **are still required** to obtain an economical and reliable operational fiber optic broadband system, there does not appear to be any **technical barrier** hindering its eventual full-fledged development.

Initial application of optical fibers to CATV is likely to be in transportation trunks. Such an application has recently been successfully field tested by TelePrompter, N.Y. and Rediffusion, England. Currently, with a much broader scope, Japan is conducting the trial of a fully integrated optical fiber broadband system in an entire new development covering an area of about 2 square km. Many other field trials have been successfully conducted by various organizations around the world over the past year, and many more with expanded scope and in many cases operating under real operating environment and carrying real customers' services, are being planned in the coming years. Judging from the rapid speed at which the technology is advancing, it is therefore reasonable to expect that we shall have commercial fiber optic broadband distribution systems, both ananolg and digital, in the near future*.

***Editor's Note: See announcement of just such a 'first system' for CATV by Guam Cable TV elsewhere here.**

ACKNOWLEDGEMENTS

The author wishes to thank his colleague, Dr. N. Toms. for careful reading of the manuscript and for many useful comments.

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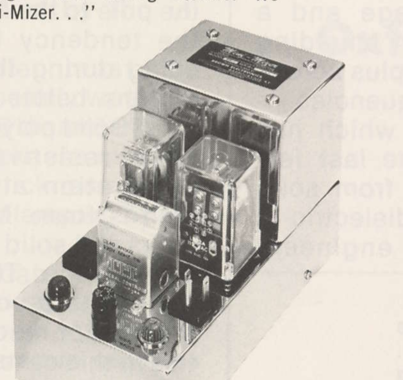

Better Drop Cable?
WHEN YOU ARE READY . . . IT'S READY FOR YOU!

During the recent "Second Annual System Reliability Conference" held in Atlanta, jointly by the SCTE and IEEE, complaints lodged against cable and connectors led one or two of the operator panelists to declare these items to be CATV's biggest problems. Particular attention was paid to the need for an improved subscriber drop cable, both from quality control and final product reliability.

Developing a modern CATV/pay drop wire is not a new or novel idea to the manufacturers of CATV cables. The need for am improved drop wire has been discussed by R&D and Engineering staffs for some time. With the advent of Pay-TV and additional channel capacity requirements, a better drop wire has been under constant consideration by the manufacturers.

Much of the research and development in developing and producing maximum shielded, easy-to-connect, high strength drop cables has been completed. These drop cables could be produced for the CATV industry almost immediately.

If these cables can be produced and the market exists, why are these improved products **not** on the market today? Perhaps the best answer is **the need exists but the market does not!** In explanation, we have found that operators are not willing to pay the costs for the improvements in drop wire.

In 1968, the average cost for a 150' drop was approximately $5.25. Today, the average cost for the same length of drop wire is approximately $4.00. It is true the $5.25 drop was covered by a 96% copper braid instead of todays' aluminum braid over aluminum tape, but it must be remembered that the same 96% copper braid did not offer the isolation of the aluminum braid over tape. The tape is really two aluminum tapes sandwiched over a film of polypropelene or mylar, offers 100% coverage and a specified minimum shielding efficiency of 80 dB plus across the spectrum of frequencies.

Another change which has occurred during the last few years is the move from solid dielectric to foam dielectric in drop wires. Many engineers and technicians feel the **lowest loss** drop wire will be the **best** buy because they will have added signal at the set. Since the average drop length is 150', the signal strength is improved by less than 1.5 dB at channel 13, by going from solid to foam. This **might** be considered a worthwhile improvement **until** the difference in strength and dielectric resistance to moisture is considered. Solid dielectric drop wire will hold up considerably better than foam due to its density of material. It has much less tendency to **stretch** during hanging from the pole to the house and it has the tendency to resist stretching during the hot summer months better than the foam drop. Solid polyethelene is also more resistive to moisture penetration at the junctions than is foam. Most cable suppliers sell solid and foam at the same price. The attenuation savings is a poor trade-off for the loss of mechanical properties in this case.

During the reliability conference, one MSO engineer remarked at the close of the session that he would be willing to sacrifice some signal strength for an improvement in mechanical strength, handling ease, reliability and ease in connector installation. This sacrifice must be made to insure the very best drop wire for

ABOUT THE AUTHOR

Rex Porter is National Sales Manager for Times Wire & Cable Company (Wallingford, Connecticut). **Rex has come into his present position by working his way up through the ranks within the industry. He began his CATV industry career in Decatur, Alabama; he left Decatur as Chief Engineer and moved onto Waco, Texas and then to Kansas City, Missouri as Chief Engineer for United Video Systems. He became General Manager for all United Video Systems in 1967 and became associated with Times in 1968 when United was sold to ATC. Rex knows cable because he has worked with cable, on the poles and in the trenches as it were. His understanding of 'your cable problems' is unique in the industry, and his thoughts here about 'a better drop cable' reflect that understanding.**

today's market (although the loss should not be very great.)

However, the biggest sacrifice to be made will be in the area of price. Each speaker who called for an improved drop cable prefaced their remarks with the requirement that the price of the cable **not** be greatly increased. **This is impossible!** The ideal drop wire will not be low-cost in comparison to the prices available to the market today. **A quality drop wire** for todays' market and future reliability will solve problems in the following areas:

1. The drop wire will have to be **strong enough** to insure reliability from the tap to the house. It must exhibit long life capabilities in ice-loading and heavy wind areas. Where conditions require messengers, the engineers must be willing to specify messenger use.

2. It will have to insure **maximum shielding efficiency** from 0 to 300 MHz, not in a test lab, under controlled conditions, but **in the field** under various climates. It must resist cracking of shields from wind movements, expansion and contractions.

3. The cable must be reasonably **low-loss** and tolerance will have to be met.

4. Application of connectors must be **almost fool-proof** with reasonable effort by the installer.

5. The cable must be **flexible** and hopefully would be of RG/59 or RG/6 diameters.

6. Jacket thickness must be of sufficient thickness to insure maximum clamping by the connector.

CATV drop cables **can** be manufactured today to meet **all** of these requirements. However, **CATV operators must be prepared to pay** for these improvements.

A 150' drop to a home will more likely cost up to $10.00, compared to todays' average cost of $4.00. Can the CATV industry afford this cost increase? We believe the industry cannot afford **not** to pay the cost of an ideal drop cable.

The $4.00 drop cable is costing the CATV operator **more** than the difference in many cases. One MSO engineer stated his company had to staff for incoming inspection of drop cables and gave examples of faults discovered in drop wire which could lead to problems **after** the drops were installed. Prior to the Reliability Conference, a large MSO produced records to prove that over sixty percent of their service calls were directly attributable to drop wire failure!

Systems are investing in earth stations, Pay-TV and other auxiliary service every day. When an operator is willing to invest in the installation of earth stations and purchases expensive conversion devices for Pay-TV, he should remember that the additional transportation of these auxiliary services changes his position in relation to customer satisfaction. A network signal may appear on three or four **different** channels on the system. If there is interference or loss of signal on one channel, the customer will probably switch to another channel and watch the network program, without calling to complain. However, Pay-TV is generally carried on **one** channel, most often in the low or mid-bands and **if** there is interference or degradation on **that particular channel,** the customer can**not** switch and watch Pay-TV on another channel. Most likely, he will disconnect from both Pay-TV **and** the regular CATV service. The operator has now lost a monthly income of around 17 or 18 dollars every month from one drop. **Even if the customer doesn't disconnect, a service call will result and service calls cost the operator much more than the difference in the price of the 150' drops.**

Most operators have already proven their willingness to pay more for added services and improvements in test equipment. I hope our next stage in maturing as an industry will be the recognition and demand for an ideal drop to improve the **"weak link"** in our CATV systems.

THE PRICE IS RIGHT

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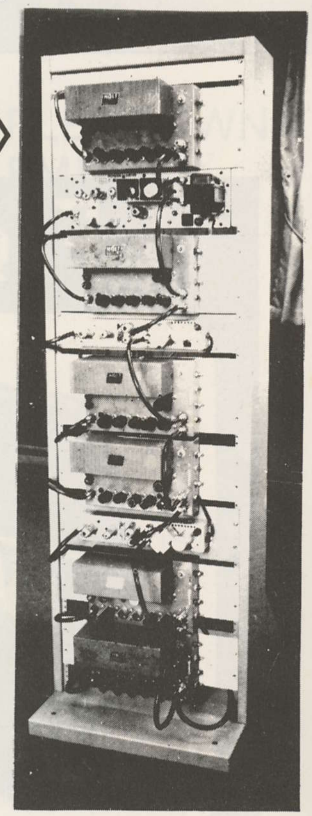

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State—Of—The—Art

RICHEY FINALLY DESIGNS A FREQUENCY COUNTER FOR CATV SYSTEMS

Back in the September 1976 CATJ we began a series on "do-it-yourself" CATV system test equipment. In the September issue we described a 'modulation stripper' or signal processor/limiter device with which a system could prepare a carrier for frequency counting with an external frequency counter. This is the 'other shoe' for that project; a newly developed (state-of-the-art) frequency counter designed to allow the system operator to make system carrier frequency measurements for perhaps less cost than would otherwise be possible.

The FCC rules, when we began this series, required *all* cable systems of any size (50 subscribers up) to perform *annual* measurements of the on-cable carrier frequencies for any carrier signals which have been frequency translated (i.e. converted) between the off-air frequency received and the cable frequency carried. To measure the frequency of a cable signal, one modulated with video information, requires that the system strip or eliminate the video modulation information from the carrier before measurement. The box or device to do the modulation-eliminating was described in the September CATJ (page 46). It was our intent at the time to come back in December with the designed-for-CATV frequency counter unit. As we got close to the point of buttoning up the counter along about early November, we were advised by parts suppliers of a whole new generation of counter/pre-scaler devices. The pre-scaler is the device that allows you to take a basically low(er) frequency frequency counter and drive it with higher (or VHF) frequency signals. The new "chip" looked so good we decided to start all over again with the counter; it simply meant that we would be eliminating about half the cost and an equivalent amount of circuit. That translates to dollars saved and time saved in the construction of the unit. *The opportunity was too good to pass up.*

And, in the interim the FCC has re-evaluated who must make annual frequency measurements and who could get by with "on-demand" frequency measurements. So maybe it is just as well we got sidetracked with new technology because now perhaps many CATV systems who would otherwise have felt compelled by FCC rules to acquire frequency measurement capabilities will have second thoughts about spending the dollars for a tool that may only be required once per year.

A Nifty Device

The counter described here is very much state-of-the-art. It utilizes the latest chip technology, which means that we have fewer parts and more counting capability for fewer dollars invested. Anyone who remembers the ten-year-ago frequency counters (they weighed about 150 pounds and required daily maintenance!) can appreciate just how small, compact, and relatively speaking component-simple the newest generation counters are. Perhaps someday the ultimate state-of-the-art frequency counter will read and display to 7 places (or 8) with a single "chip" and the whole device will fit into the palm of your hand. For now, the unit to be described here this month and next is about as compact and simple to construct as the art today allows.

The heart of a digital frequency counter is a decade counter. The decade counter takes an input signal and counts the signal pulses present. A signal pulse is one complete cycle or 1 Hz. One kilohertz is 1,000 complete cycles and one megahertz is 1,000,000 complete cycles. The basic decade counter counts to ten complete cycles (or 10 Hz) and then it "outputs" a 1 (i.e. it says "the 1 I am outputting tells you, the user, that I have just seen ten complete cycles go by"). As shown in diagram one, if we input to the decade counter a 16 Hz signal the first decade counter watches the first ten cycles zip by and then it kicks out a "1". This one goes to the next decade counter in line which says "Ok. . .there is '1 hertz/cycle to me'", and it displays a 1. Meanwhile back at the input decade counter the remaining 6 cycles zip by and

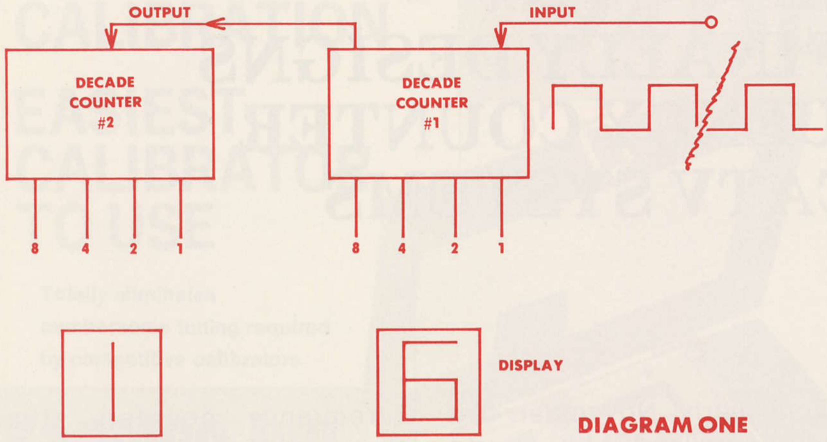


DIAGRAM ONE

there being no more cycles passing by, the first decade counter displays a 'partial count' of 6. With two decade counters and displays we can count cycles or hertz up to 99. If we want to go higher than this, we need to add another decade counter (to the left of the unit displaying a "1" in diagram 1). That would take us to 999. And so on, adding a new decade counter each time we want to increase the count capacity by ten times.

In a typical counter useful for CATV we would have an 8 decade count that would take us up to 99,999,999 hertz (or 99.999999 megahertz). This is an interesting exercise but it is not getting us to our goal. For if we kept feeding the hertz to the input of the unit, it would count up to its full capacity (whether 99, or 99,999,999) and then like your car speedometer it would return to 00 (or 00,000,000). So we are only part way to a frequency counter. What we have at this point is an "events counter" and while it may count very far and very fast. . .we need to do some more work to allow us to count and display frequency.

Remember that a carrier wave is self-calibrating at so-many cycles or hertz per second. So if we want to count the number of hertz or cycles represented by the carrier wave we need to develop a timing circuit that turns on the count mechanism at one point, keeps the counter-counting for a pre-determined period of time, and then turns off the mechanism. Well, if you think back into your theory, the carrier wave frequency is self-calibrating at so many hertz or cycles *per second.* In other words, when we glibly say channel two is 55.25 megahertz, what we are really saying is that *in one second of time* the channel two visual carrier signal will go through 55,250,000 complete cycles of RF. So it follows that if we want to count how many hertz are going through our counter and then translate that number into the *actual frequency* involved, we need to measure or open up our counter for *one second time.* So at the input to the counter device (i.e. the decade counters) we install a very fast and precisely controlled time "switch". We call this "switch" a gate and we call the signal that drives this switch a "gating signal". The gating switch *could be* controlled by internally looking at the 60 cycle AC power source and turning itself on for one complete cycle of AC (remember there are 60 cycles of AC per second). Therefore the AC cycle would provide the gating signal or time base for our "switch" (see diagram 2).

However, this is not such a good system (it has been found) so a better system has been developed, using a (typically) one megahertz *crystal* oscillator. If you take a 1 MHz precise-frequency oscillator and feed it into a series of dividers you can divide 1,000,000 hertz by 10 and get 100,000; and then divide that by 10 and get 100, and then divide that by 10 and get 10; and finally divide that by 10 and get the reference 1 Hz signal. One advantage to using a 1 MHz oscillator crystal for our reference signal is that we can feed the output of the 1 MHz oscillator to a shortwave communications receiver which we have tuned to the National Bureau of Standards signal at 5 or 10 or 15 MHz. By adjusting the 1 MHz oscillator circuit trimmer, we can bring the counter master gating oscillator into excact *"zero beat"* with the NBS precision shortwave signals and thereby *"calibrate"* our own counter gating oscillator signal.

Pre-Scaling

Most available decade counters will not work high enough in frequency to allow us to count much beyond 5 MHz or so (yes, there are high priced exceptions but we are trying to hold the cost down) so you have to put another electronic box *in front of* the basic counter unit to bring the frequency down to some range which the counter *will* accept. This box is called a "pre-scaler" and it is a cross between a frequency converter and a divider system.

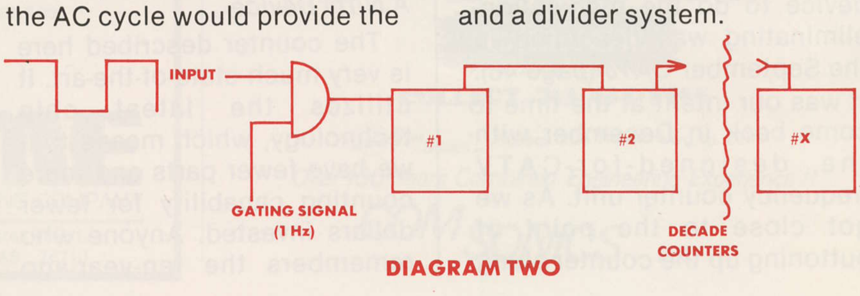


DIAGRAM TWO

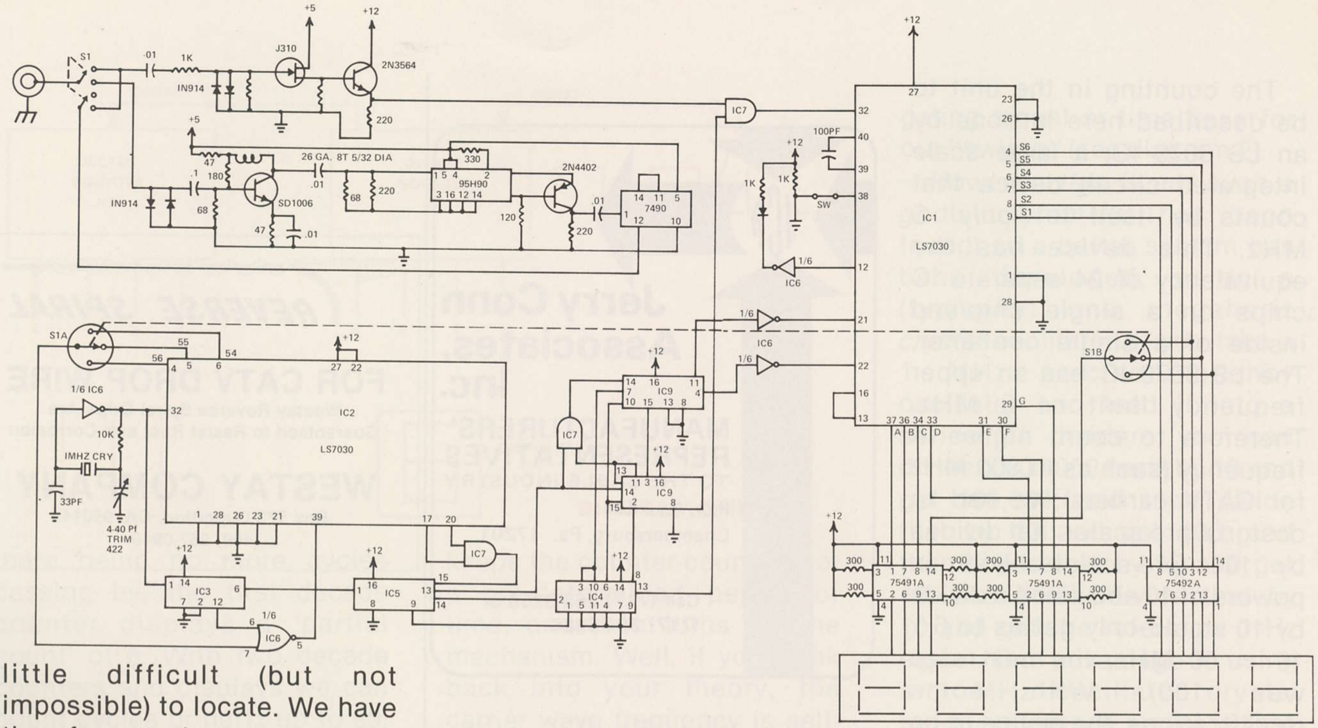
The counting in the unit to be described here is done by an LS 3070 IC; a large scale integrated circuit device that counts by itself to *"only"* 5 MHz. This device has the equivalency of 24 separate IC chips on a single chip/and inside of a single container. The LS 3070 IC has an upper frequency limit of 5 MHz. Therefore to count higher in frequency (such as to 300 MHz for CATV carriers) we had to design a pre-scaler that divides by 100 (pre-scalers work in powers of 10 and since a divide by 10 would only get us to 5 x 10 = 50 MHz, the next step was 100). With some modifications, the device to be described *might* well count to 450 MHz.

The pre-scaling is done by something called an *emitter coupled logic* (ECL) *chip*. This device accepts a signal up to 300 MHz at the input and then it outputs to exactly 1/10th of the input frequency. Which means that 300 MHz goes in and 30 MHz comes out. This is a 95H90 pre-scaler chip. The 30 MHz output from the 95H90 is then fed into a 7490 pre-scaler IC which *again* divides by 10, resulting in 30 MHz in and 3 MHz out.

Two Parts

The general discussion here is intended to acquaint you with the basic design problems associated with constructing a counter for CATV signal carriage measurements. The full schematic is also presented and the parts list. You can begin to gather parts and otherwise get oriented so that next month when we come back with the step-by-step construction of the unit you will be ready to roll. If you have no problem working directly from schematics, you are off and running at this point.

Because of the nature of the state-of-the-art approach, some of the parts may be a



little difficult (but not impossible) to locate. We have therefore made arrangements with a local outfit called Electronic Research and Development (see parts list) to supply those parts marked with an (a) as well as a complete circuit board for the unit. It is our belief, having priced all of the parts, that the total cost should come to between $100 and $115 for the complete package (including the PC board). If you have priced 300 megahertz counters recently, we think you will agree this is a pretty decent price, even if you do have to put it together in your own system shop.

One caution: Remember that as you start to accumulate parts that most of the IC devices are CMOS. *This means they must be handled with extreme care.* They come to you in protective cases. . . *leave them there* until you are ready to install them in the IC sockets. They are easily damaged when 'out in the open' by stray static charges, such as your body carries.

CATV COUNTER - PARTS LIST

Qty.	Item	Identification	Note
2	**LS7030**	IC # 1,2	(a)
1	4013	IC # 4	
1	4017	IC # 8	
1	4022	IC # 9	
1	4024	IC # 3	
1	4081	IC # 7	(a)
1	4572	IC # 6	
1	7490	IC # 10	
2	**75491A**	IC # 13,14	
1	75492A	IC # 12	
1	95H90	IC # 11	
1	7805UC	regulator	
1	7812UC	regulator	
1	2N3564	transistor	
1	2N4402	transistor	
1	SD1006	transistor	(a)
1	J310	FET	(a)
6	**FND500**	**LED display**	
1	1 MHz Xtal .01%		(a)
2	**47 ohm**	**resistors**	
2	**68 ohm**	**resistors**	
1	120 ohm	resistor	
1	180 ohm	resistor	
3	**220 ohm**	**resistors**	
8	**300 ohm**	**resistors**	
1	330 ohm	resistor	
3	**1K**	**resistors**	
1	4.7K	resistor	
1	10K	resistor	
1	1M	resistor	
4	**.01 MFD**	**capacitors**	
1	.1 MFD	capacitor	
1	33 pF	capacitor	
1	100 pF	capacitor	
1	422	trimmer cap	
1	SPST	switch	
1	DPST	switch	
1	2 pole, 3 pos. rotary switch		
1	PC board	main	(a)
1	PC board	display	(a)
2	**IC sockets 40 pin**		
4	**IC sockets 16 pin**		
4	**IC sockets 14 pin**		
1	enclosure	5.25 x 9.5 x 6.75 (")	
1	transformer		(a)
4	**2 amp diodes**		
1	line cord		
1	fuse holder		
1	5500 MFD, 25 v capacitor		

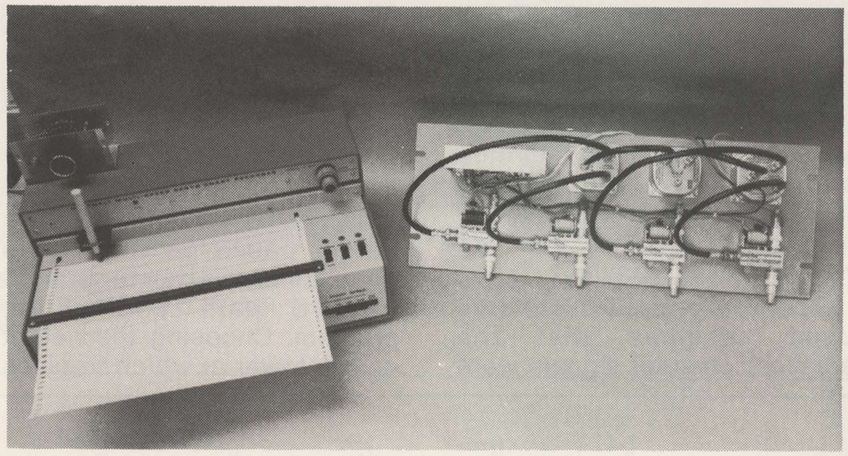
(a - a source for these parts is **Electronic Research & Development,** 5611 NW 37th, Oklahoma City, Oklahoma 73122.)

Is The Top Always Best?
SELECTING THE TOWER LOCATION FOR A UHF RECEIVING ANTENNA

In the process of engineering a four hop microwave system designed for the purpose of importing WTCG Atlanta into three Alabama cable communities, a combination signal-pick-up/microwave transmissions site was needed.

Economic considerations prevented the use of more than one microwave hop into the nearest system and, as a result, some compromises had to be made with respect of site selection. The resulting tower location was therefore selected primarily upon microwave path considerations, although a nearby cable operator indicated that reasonable quality reception of Channel 17 could be obtained. None-the-less, the pick up point was far from ideal since it was **90 miles** for channel 17 transmitter, and because there was an **adjacent channel 18** approximately 70 miles distant, and a two-removed channel 19-54 miles away.

Past experience had shown several things about long distance reception of UHF signals.



INEXPENSIVE HEATH IR-18M single channel recorder (kit) is turned into four channel recording device with analog read-out of recording channel using package shown right of recorder.

1. **Reception** at a distance of 80 miles or greater **can result in deep fading** under certain conditions.
2. **Adjacent channels** with signal strengths in the same order of magnitude of the desired signal can create interference that is sometimes **difficult to eliminate.**
3. **The height** of the receiving antenna is in some cases **critical.**

Note that the three statements are hedged considerably. The facts are that prediction of the result is difficult, thus no invariant statements have been made.

In the case at hand, the receive site was located as shown in diagram 1, with respect to the three signals noted.

Fortunately, for microwave purposes, it was possible to find a mountain top site. The site was about 10 feet below the crest of the mountain on the east side. A 160 foot tower was installed for the microwave and Channel 17 receiving antenna. Removal of adjacent channel interference was the first step after the tower was in place. Diagram 2 shows the technique that was used. The antenna signal was amplified by a low noise Channel 17 preamplifier. Following the preamp was a specially designed UHF band pass filter which attenuated the adjacent

William H. Ellis
TECHNICAL DIRECTOR
Telesis Corporation
Evansville, Indiana
47714

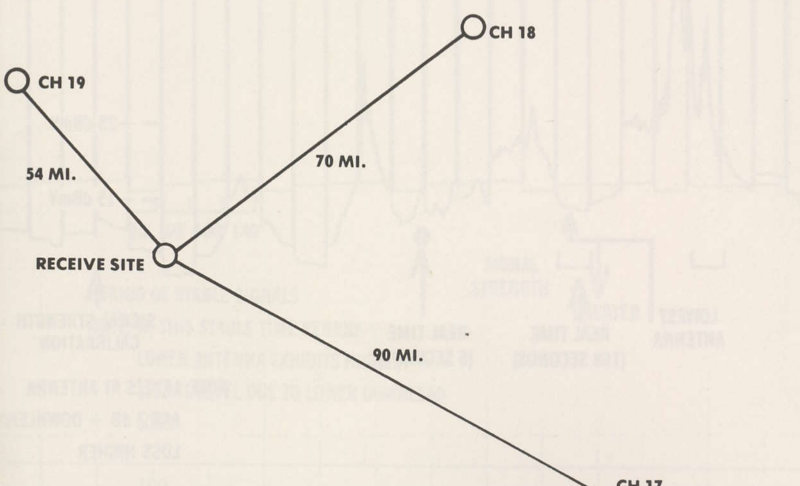


DIAGRAM ONE

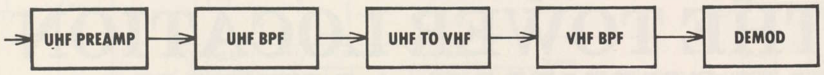


DIAGRAM TWO

channel carrier by 25 dB. The band pass filter fed a UHF and VHF converter which also had some selectivity. In turn the converter was followed by a VHF band pass filter and a demodulator. Virtually no adjacent channel signals remained at the output of the VHF band pass filter. Although it was not measured, **appreciable group delay might be present** due to the filtering requirements. However, picture quality from an observer viewpoint was excellent.

The processing scheme used assumed that the adjacent channel signals were not sufficiently strong to overload the preamplifier. If overload had been a problem, the UHF band pass filter could have been placed ahead of the preamplifier with some degradation in system noise performance, since the filter had an insertion loss of 5 dB.

Once the adjacent channel interference problem was eliminated the problem of antenna location was approached. Choosing the tower height based on microwave consideration was a straight forward path engineering problem. Choosing the height on the tower at which to place the Channel 17 antenna was not so straight forward. In most cases it would appear **logical** to locate it at the **top** of the tower. However, under the reception conditions outlined it seemed advisable to further investigate the problem.

Investigating the problem initially sounded relatively simple, however, prior experience showed that significant changes in signal level could occur over a relatively long time span. Since it was not possible to monitor the signal personally over a long time period, a chart recorder was pressed into service to provide a permanent record of the signal strength over a period of several weeks. The recorder was a single channel

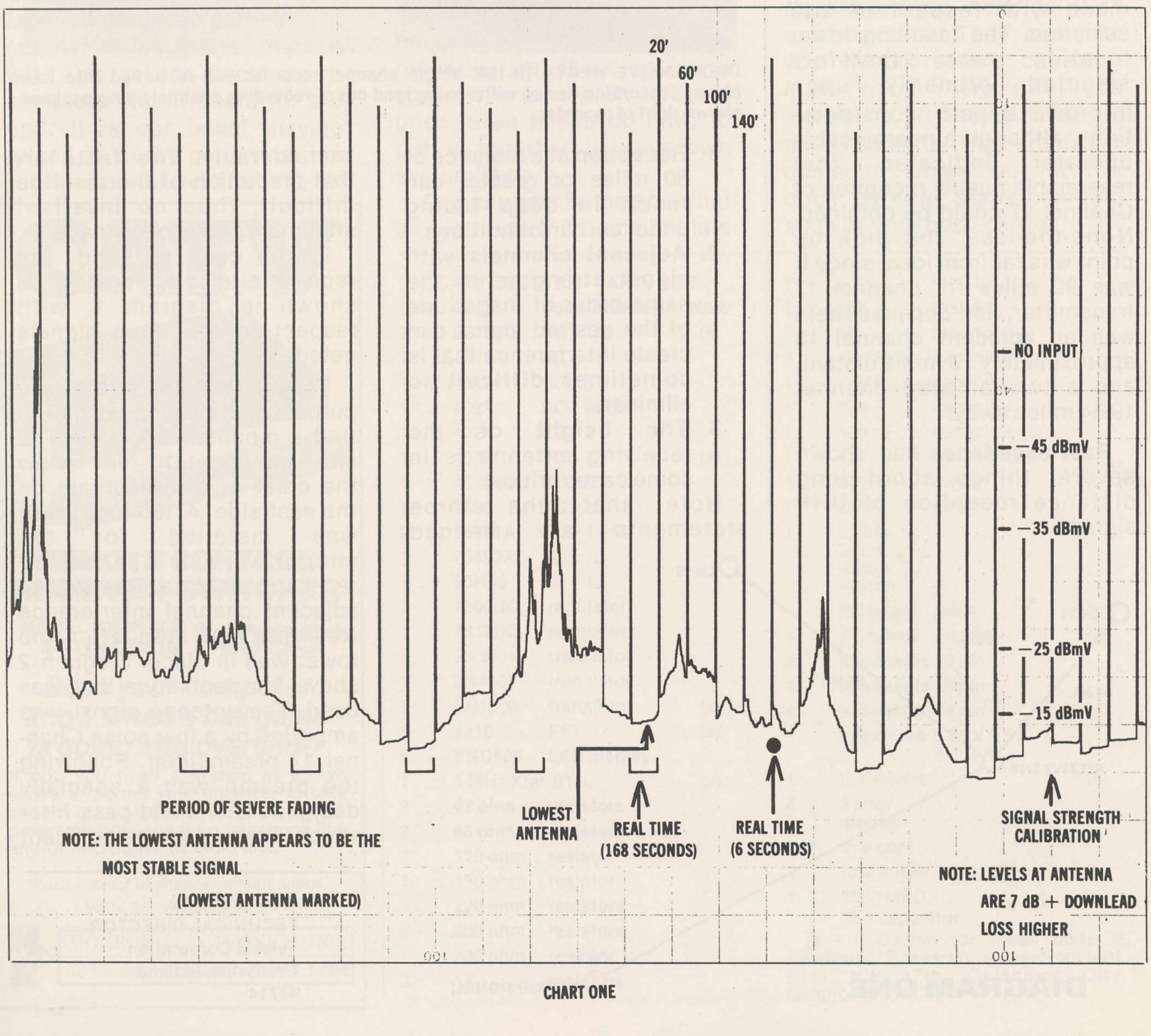
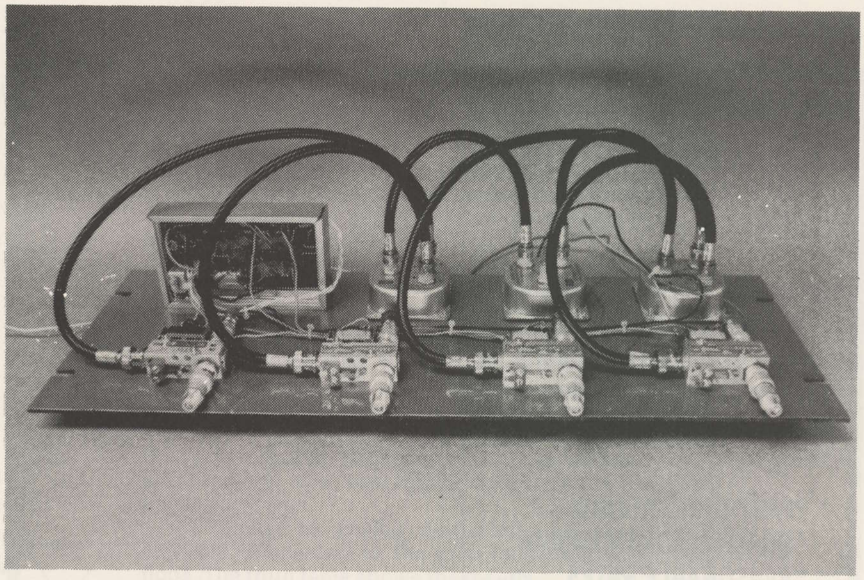


CHART ONE

device and as such could monitor only one location at a time. Although it would have been possible to place the antenna at one location, look at it for a few days, move the antenna and monitor for a few more days, etc., the results would **not** have been too meaningful since the antenna signal levels at various locations were not measured during the **same** relative time period.

To solve that problem, four identical inexpensive UHF log periodic antennas were puchased and mounted at 20, 60, 100 and 140 feet on the tower. Down leads were run into the headend building and signals were combined as shown in diagram 3. A circuit



PANEL CONTAINS SWITCHING CIRCUIT plus analog display voltage, four DOW-KEY (DK-77 family) 75 ohm 'F' fitting relays and UHF splitters used in combining mode.

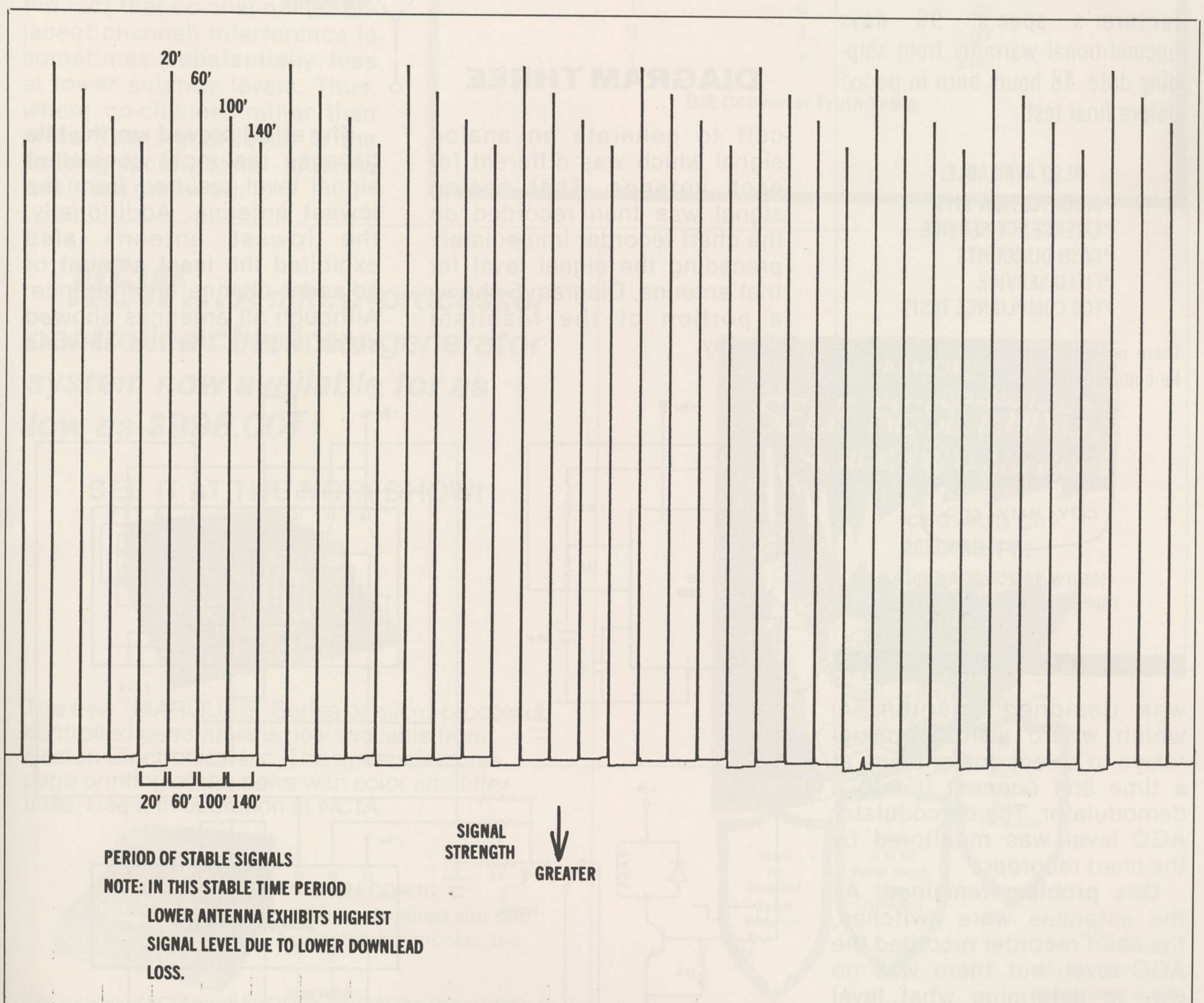


CHART TWO

SAMPLE OF DISPLAY (reduced to 50% of actual size) **shows combination of analog reference signals and off-antenna signal levels recorded during antenna monitoring session at Alabama headend site.**

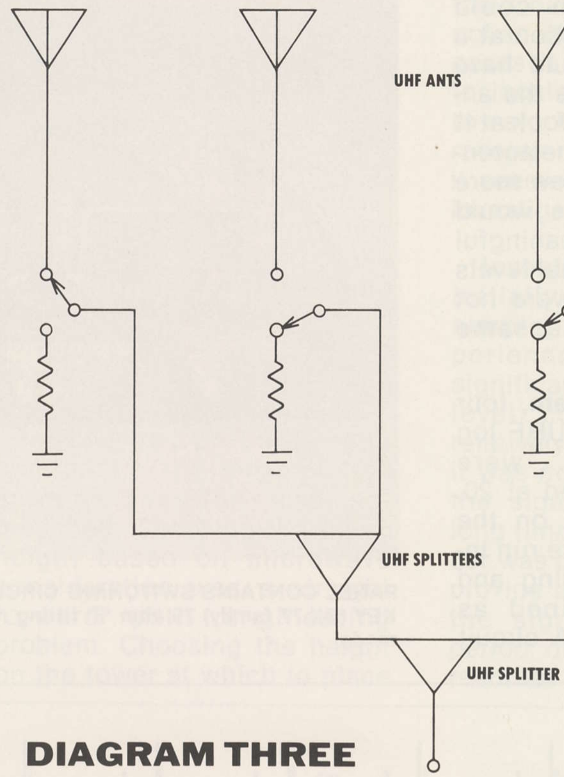


DIAGRAM THREE

was designed (diagram 4) which would switch coaxial relays to select one antenna at a time and connect it into a demodulator. The demodulator AGC level was monitored by the chart recorder.

One problem remained. As the antennas were switched, the chart recorder recorded the AGC level, but there was no way to determine what level belonged to which antenna. That problem was solved by using the antenna switcher circuit to generate an analog signal which was different for each antenna. That analog signal was then recorded on the chart recorder immediately preceding the signal level for that antenna. Diagram 5 shows a portion of the resultant display.

The effort proved worthwhile because the most consistant signal level resulted from the **lowest** antenna. Additionally, the lowest antenna **also** exhibited the **least amount** of adjacent channel interference. Although all antennas showed **some** fading, the top antenna

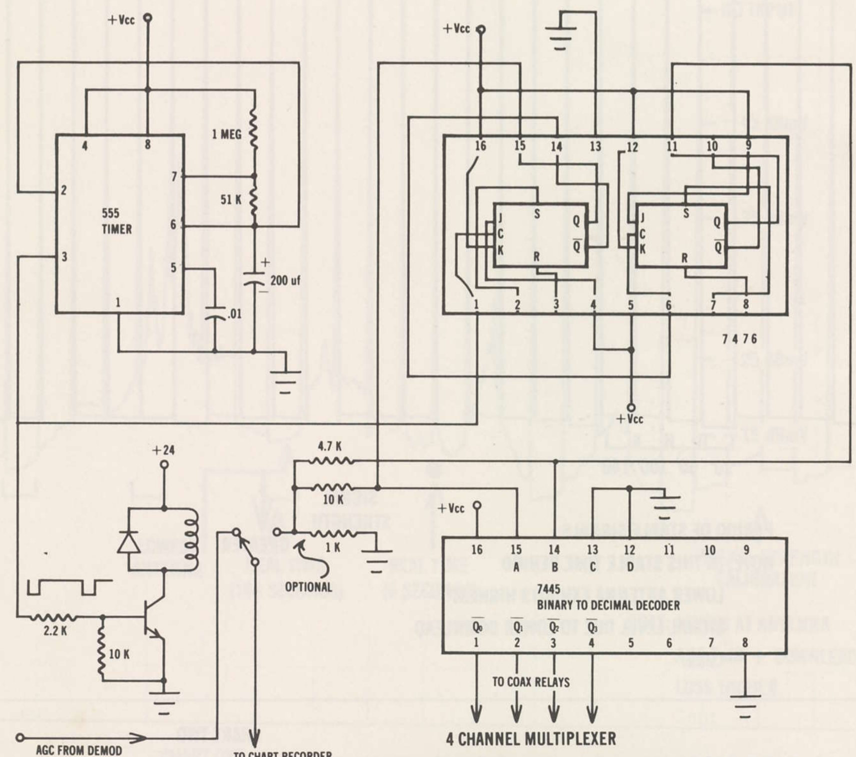


DIAGRAM FOUR

was generally **the most** erratic. It can also be seen on the chart that the bottom antenna exhibited the least down lead loss and as a result, during stable signal level periods, the bottom antenna generally should be the strongest signal followed by the other three in order of height "upwards".

Identical results should **not** be expected when the same technique is used on relatively **flat** terrain. Under those conditions the higher antenna should show higher signal levels than lower antennas, although fading characteristics might still show that a **lower** antenna **is** a better choice. But, perhaps equally important is the fact that co-channel (or adjacent channel) interference is sometimes **substantially less** at lower antenna levels. Thus, where co-channel rather than noise (low signal level) is the limiting factor, lower antenna levels are preferred.

Circuit description of four channel switcher.

A 555 timer was used as the basic clock for the circuit. The waveform was adjusted to be **on** for 300 seconds and **off** for 15 seconds. The timer output was used to drive a 2 bit counter and a transistor. The transistor via a SPDT relay switched the input to the chart recorder alternately to the output of a digital to analog converter and to the demodulator AGC signal.

The two bit counter output drove a binary to decimal decoder that provided as an output, a **single** output for **each** counter state. Since the counter consisted of two flip flops in tandem the resultant count was four before the cycle repeated. Thus, one of four coaxial relays were activated one at a time by the output of the binary to decimal decoder.

The digital to analog converter was simply two resistors connected to the Q outputs of the two flip flops. The truth table shows the results.

A	B	VOLTAGE
0	0	0
1	0	.92
0	1	2.07
1	1	3.00

D/A Converter Truth Table

FULL THIRTY TWO ISSUE INDEX for CATJ

Last year in our January **CATJ**, we ran a full listing of all past **CATJ** editorial features, and those briefs and letters which directly related to the matter presented in prior issues. What follows is a thirty-two issue index, showing all that has been published by **CATJ** on a number of different subject matters.

Where one editorial feature crosses over into more than one editorial category, there is a modest amount of cross (or multi) listing; just to assist you in finding your own way around the more than 1500 pages of **CATJ** material printed to date. Just in case you have failed to notice, by direction of the Board of Directors of CATA, **CATJ** continues to run a much higher percentage of editorial material to advertising than any other CATV publication. This simply means you get more material per issue and more material per year in **CATJ**; a fact we are exceedingly proud of, and a traditional which shall continue in 1977!

ANTENNAS

CATA-torial Subjects

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FIELD STRENGTH METERS / AND RELATED TECHNOLOGY

HEADENDS — MISCELLANEOUS

HEADEND RECEIVING SITUATIONS

MEASUREMENTS

OPERATIONS AND TV STATION INTERFACE

SATELLITES / CATV

SYSTEM LAYOUT & DESIGN

Irving Kahn On Fiber Optics. . .
FIBER OPTICS IS LARGELY SAND AND THE SAME PEOPLE WHO CONTROL THE OIL. . .ALSO HAVE A LARGE STOCKPILE OF (you guessed it) SAND

EDITOR'S NOTE:

If there has ever been a prophet in the TV industry, Irving B. Kahn is that man. Kahn's history in CATV began in the very early 1960's when he created the first major national MSO (Multiple system Owner) company; **TelePrompTer.** Kahn has always been ahead of his time. He has been severely criticized and for many years his influence on our industry has been minimal if at all. Still, it was Kahn who first saw pay cable (in 1960) and it was Kahn who first saw big city systems (1961). It was Kahn who dared to be different and it was Kahn who perhaps more than any other single individual (with the possible exception of Bill Daniels) attracted the investment world to the cable world.

Fiber optics is the latest Kahn 'crusade'. In true Kahn fashion, the industry is either soundly behind the vision of Kahn or soundly skeptical of the vision. At the moment, it appears that the skeptics may outnumber the visionaries. In true Kahn form, on March 15 Kahn delivered a 'pep talk' to the CATV Analysts Group in New York City. . .on. . .fiber optics. The talk, aptly entitled "a grain of sand, a grain of salt" painted the rosey future Kahn sees coming for 'broadband communication systems' which themselves dare to be different by tieing their own destiny to the emerging fiber optics transportation mode.

CATJ feels that an edited amount of this Kahn-ese is worth sharing with the industry this month because for the next few weeks (at least) you will be hearing a great deal about the fiber optics phenominon. Kahn would like to see that what you hear in the next few weeks will go on and on and on. That fiber optics will not be another 'flash in the pan'; such as bi-directional two-way or locally programmed full color local origination studios.

Kahn has a product to sell; fiber optics. **And he's selling hard.**

"A funny thing happened to me on the way to this forum. Since last we met en masse, about two years ago next month, I have ambled down several curving roads searching for some of the answers to some of the questions that hang like storm clouds over the broadband communications industry. Then one day last summer, I turned a corner, came face to face with two gentlemen from New Jersey, and said to myself, "Here comes the sun."

This serendipitous encounter took place in the unlikely town of Orange, New Jersey, where, at that time, ensconced in what best can be described as a loft, these two scientists were quietly and without pretension laying the foundation for what would undoubtedly be a towering achievement in the field of broadband communications.

In just 500 square feet of space, two young Ph.D.'s, still, it seemed to me, too young to be so smart, were manufacturing a new product so startlingly revolutionary that its incandescence was matched only by the light bulb that, like a cartoon balloon, began to glow in my own head.

Fibers! Optical fibers. Long thin pieces of glass, drawn so fine as to be no thicker than a strand of hair. Optical fibers of such technical purity, of such strength and endurance, and with capabilities so dramatic that it didn't require a third Ph.D. to immediately recognize that these hair-like strands of glass could shatter all existing limitations in communications-and could, in proper combination with ancillary devices, revolutionize the communications and information industries.

Well, what followed was a long, hot summer and then a long, cold winter. There were the proverbial sleepless nights, the round-the-clock business negotiations, the high-level technical briefings, and the endless hours of research and study. I got thinner, and several attorneys got fatter. But by the time the last snows had melted, an excited group of businessmen, engineers and scientists emerged from the board room to announce the formation of our industry's newest corporation: Times Fiber Communications, Inc., a joint venture bringing the Times Wire and Cable division of the Insilco Corporation into cohabitation with Fiber Communications, that prodigal child of Doctors Frank Dabby and Ronald Chesler, my two young friends from Orange.

As a shareholder of the original Fiber Communications, a position I assumed shortly after meeting the good Doctors, and as a shareholder and director of the new parent corporation, I have had both the obligation and the privilege of throwing myself into this new world of optical fiber communications with a gusto one enjoys only a few times in his lifetime.

After digesting literally thousands of pages of literature in the field, and after rubbing shoulders with and picking the brains of some of the foremost experts in this area, I feel like a young man with a new love.

And what's it all about, this new technology that makes grown men giddy? Perhaps more to the point, what is Irving Kahn doing all wrapped up in fiber?

Well, two immediate answers come to mind. First and foremost, the fact of the matter is that fiber is the master key that will at last open the gateway to broadband communications, and heaven knows that broadband communications is something with which I have been concerned for most of my adult life. Secondly, as Paul Kagan's **Cablecast** so aptly stated when our venture was first announced last December- -and I quote- -"In fiber optics Kahn has selected a vehicle with the ability to light up the investment community." Close quote and amen.

On the latter point, I am so confident that this will be a self-fulfilling prophecy that I will merely add that if fiber doesn't set you on fire, then your Brooks Brothers suits are asbestos.

On the matter of broadband communications- -which is, after all, why I am knee-deep in this adventure of a venture- -I am equally confident of the role of optical fibers. I feel, however, that the complexity of this technology warrants further discussion. As **New York Times** columnist Tom Wicker wrote earlier this month in an article about fiber optics and other new technologies, quote, "when Gutenberg invented the printing press, farseeing men of his day wondered what would be the consequences of a device that could actually put a Bible in the hands of every man. Now," Wicker continued, "the experts say there's about to be a communications revolution to rival or surpass the one Gutenberg wrought, and once again mere mortals can't quite conceive what the consequences might be." Close quote. Lest any "mere mortals" in this room today leave the premises unconvinced about fiber optics and its ability to alter our lives, it is worth our while to further explore its applications.

It was pointed out in a recent **TV Guide** article on the subject that "in the entire history of long-distance communications. . .from the telegraph to television, electricity has been the medium used to convey information. . ." Now, for the first time, all of that can and will change, with the advent of optical fiber communications, for these tiny glass hairs are the conductors not of electricity but rather of something as simple and as plentiful and as cost effective as plain, old light.

By converting electrical signals and information into pulses of light- -a technique accomplished more or less by the flicking on and off of a light source- -the original signal is converted into a pulsed code, and this coded beam of light is then entered into the glass fiber, carried on its journey along straight or curving routes with no detrimental effect, and then "captured" at the other end by a photodetecting device which converts the light signal back into electrical energy.

The effect is to create a mode of communications which completely changes the characteristics of a cable television plant- -and all for the better.

Fiber optics technology brings a far greater bandwidth capability than ever before economically feasible- -a point illuminated by the fact that today one thin fiber can carry 30 different channels. The extensive difference in cost between one or even a handful of fibers encased in a cable no larger than a typical RG-59U drop cable now used throughout the CATV industry is reason enough to be excited. Adding to this excitement is the fact that fiber optics brings with it exceptional strength, extra-ordinary crush resistance and flexibility, a total insensitivity to temperature variations, a high resistance to all electrical interference, and a total absence of signal leakage.

Then, consider the fact that the extreme low-loss characteristics make it possible for the optical signal to travel for great distances before amplification is required, thereby again dramatically lowering the costs of system design, equipment, installation and maintenance. And just to cap this all off, picture in your head a fiber optic cable, no wider around than the conventional piece of Bell wire now attached to your telephone, versus a standard coaxial trunk line; now imagine how easy it's going to be to snake these thin cables through the overcrowded ducts in our urban areas, where underground construction is such a significant factor. With optical fibers, it's possible, even, to feed the cables through existing gas ducts, for, since the signal is non-electrical, there is no danger of fire or explosion.

Even if fiber optic systems promised nothing more than the above- -even if there were no new capabilities and blue-sky services to be had from this technology, the cable television industry would **still** be receiving a better, cheaper, more easily constructed plant today, right now, than anything ever before available through conventional CATV equipment.

That's a very important point to be made before an audience of CATV investment analysts. What I am saying is that if I were asking an entrepreneur to consider fiber optics because of its **future** capabilities, he would have every right to hold back and hesitate before making any investment. However, I am asking, instead, that he consider fiber optics because of its **present** ability to enhance the delivery of the signal to the home, and to do so better, cheaper and with far less risk of signal loss or system downtime.

Let me return, now to discuss the light source for these coded beams that will travel these incredible fibers and make all of these wonders come to pass. The two sources most commonly used today are the Light Emitting Diode, better known as LED, and the laser. The choice between the two is mainly determined by particular system requirements.

For purposes of definition, an LED is just what it sounds like: a diode which, with proper stimulation, can be caused to emit light. A diode, to carry it one step further, is a device containing both a positive and a negative element. The light emitted from an LED is more diffused than that of a laser, and therefore not as useful in certain applications.

The laser, which we all know is an acronym for Light Amplification by Stimulated Emission of Radiation, is a device which produces an intense beam of visible or infrared coherent light by pumping atoms to ever higher energy levels and allowing them to oscillate in an optical resonator until the energy level is high enough that a constant stream of photons is emitted. Now that we've got that cleared up, suffice it to say that there are both LED's and lasers available to us today which have already proven their capabilities for use as light sources in the most sophisticated optical fiber systems.

So, from the viewpoint of pure equipment, let's take a look at where Times Fiber Communications now stands as it positions itself to lead the cable television and related broadband industries in the use of optical fiber communications.

First, we have the fiber—and the fiber we have is, without qualification, the finest now being produced in this or any other country, and getting even better with every production run. Less than a year ago, the first fiber installed for commercial CATV use had a loss of 15 decibels or dB—and considering that the loss in conventional 3/4" coax of the same length is about 62 dB, that was pretty good! Today, however, we are routinely producing fiber of well below 10 dB loss, and it works! It's for real. And it's for sale and being sold right now.

This isn't hard to comprehend when you remember that the two gentlemen who are responsible for the manufacture of our fiber are the very same gentlement who, as research scientists with Bell Labs, were responsible for the manufacture and testing of the fibers, lasers and related optical devices and materials now being demonstrated by Bell in several test applications.

Secondly, in the area of equipment, our own experiments indicate to us that we will have available before the end of this year a laser with a life of better than 100,000 hours. For those who left their pocket calculators back in the office, that translates into more than 10 years of continuous laser life, a most impressive span. Anyone who has followed the development of lasers—and for those who are technically oriented, we are talking here about something called a gallium aluminum arsenide laser—knows that when a 10,000-hour laser was announced, **that** was considered a breakthrough. Imagine the quantum leap to 100,000 hours and you'll have an idea of how fast this technology is advancing.

Consider, too, that even if we have to build our first systems with 10,000-hour lasers, these will last over a year, and it will be no great technical problem at the end of that time to replace those lasers with the more advanced model.

This piece of glass fiber that starts out as little more than a grain of sand, and this microscopic laser no bigger than a grain of salt—together they are going to change us and everything around us. And as if that weren't terrific enough, I have the added delight of knowing that all of what I've been talking about today came about as the result of extensive research by one of the CATV industry's foremost adversaries: none other than Bell Tel. For once, the cable television industry is going to be a total beneficiary of Ma Bell.

So, to repeat a question, what is Irving Kahn doing all wrapped up in fiber? He's helping to put together a new, important company which will ultimately offer the first and only investment opportunity in this new technology and at terms too good to be true even in **good** times. He's taking the best that Ma Bell has to offer—both in research and, in the form of Doctors Dabby and Chesler, in talented people—and running with it at a pace that even the telephone company won't be able to maintain. He's taking a new technology and, with more than a little help from his friends, using that technology to make an "honest man" of himself by at last making possible those blue-sky broadband marvels so often pooh-poohed throughout the industry. And, for the immediate present, he's offering to the cable television industry right here and now, a chance to update and upgrade its physical plant while whittling down its costs in major areas of system development.

That seems to me like enough good reasons, for starters, to justify my involvement and account for my good humor.

Let me tell you a favorite story that circulates in the automotive industry, concerning one Mr. Firestone and one Mr. Ford. It was Firestone who once approached Ford with a pitch to sell tires, only to be told, in no uncertain terms, that when it came to tires there were three very firm specifications that must be met.

"They must be round, they must be black, and they must be cheap," Ford said, "and we'll waive the first two if you meet the third."

Ladies and gentlemen, I've seen our price list and "we meet the third." "Now, just for good measure, we'll make our cables round and black."

CARS BAND MICROWAVE PATH ALIGNMENT

by
John Schuble / William Ellis
Telesis Corporation
Evansville, Indiana
47714

Microwave path alignment (especially at CARS band) has been considered "black magic" or at best a tedious time consuming "art". And, it is just that, if it is not approached with a specific plan of attack in mind. Experience has shown that if alignment of even a relatively straight forward CARS band path is approached in a haphazard manner, many hours or even days may be consumed before acceptable results are obtained. Since contract tower personnel are quite expensive and not always readily available, it behooves the CARS band operator to achieve path alignment as rapidly as possible. **Although tower personnel** are skilled in their work, path alignment cannot be left to the contract tower crew, but must be supervised by a competent technician who knows what must be done and has a plan set out to accomplish the effort. During the past four years a technique has been developed which has proved itself on nearly 100 CARS band paths. It is a technique which is straight forward and lends itself to a step by step alignment procedure that can achieve optimum path alignment in the shortest period of time.

The approach does require good planning and many of the preparations can and must be completed before the tower crew is even on site. Before alignment is attempted the following information and equipment should be available:

1. **Path calculation sheet showing theoretical receive carrier level.**
2. Receiver AGC level vs. receive carrier level curve (for the receiver being used).
3. **Topographic maps with transmit and receive points located and a line representing the microwave path connecting the points.**
4. Field strength meter or large meter movement. (See procedure.)
5. **Angle finder.**
6. Three foot carpenter level.
7. **Two twenty foot pieces of nylon twine.**
8. Four two-way radios, sound powered telephones, etc.
9. **Two ground plane antennas.**
10. Video monitor.
11. **Compass**
12. Binoculars (optional).

After the necessary items have been assembled the following procedure should be read and throughly understood by the supervisor before the actual work is started.

PATH ALIGNMENT PROCEDURE

Path alignment is the process of adjusting transmitting and receiving antenna systems so that the maximum power is transferred between the transmit and receive site. It can involve direct radiators, reflectors, or both. If periscope systems are used at both the transmit and receive ends of the path, two antennas, two reflectors, and the antenna feedhorn polarizations will need adjustment. In some cases it may also be necessary to adjust the position of the antenna feedhorns. Where adjustable face reflectors are utilized, they may also require adjustment. Listed is a recommended sequence of events, which the authors have determined is the quickest and most reliable means of path alignment. Appropriate explanations are given with each step. The instructions apply to the typical microwave path shown in **figure 1.**

Step 1: Appoint a Supervisor. Because the beamwidth of the transmitted energy will probably be less than 1°, the alignment of antenna system components is very critical at CARS band frequencies. Therefore, it is very important that only one component be

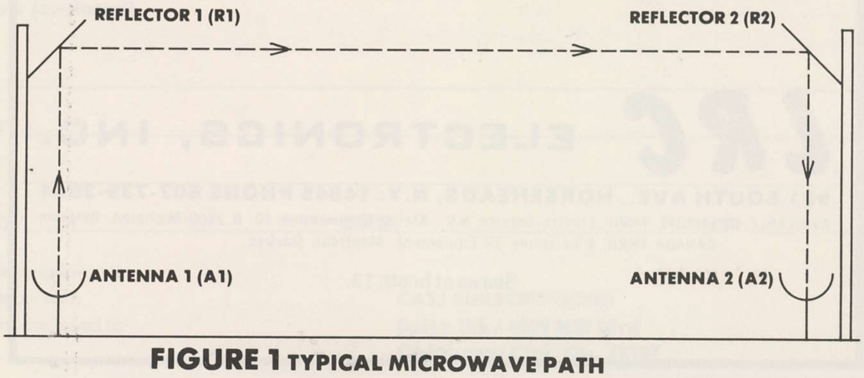


FIGURE 1 TYPICAL MICROWAVE PATH

moved at a time if there is to be hope of receiving a signal. As a result it is essential that **a** supervisor be appointed to direct adjustment of **each** antenna system component. Absolutely no adjustments should be attempted without his explicit instructions.

Step 2: Establish Communications. Appointing a supervisor and extablishing reliable communications will save hours or even days in the alignment process. The supervisor should have a direct communications link with all four points of adjustment. It is neither essential **nor desirable** that all four points communicate with each other. The supervisor will normally locate himself at the receive antenna (A2). From there he can communicate with R2 via sound powered telephones or hand held transceivers. He will communicate with A1 and R1 via hand held transceivers. (It may be necessary to install a temporary ground plane two-way antenna 75 to 100 feet on the receive tower.) It is possible to use telephones to communicate with A1, but this has the disadvantage of having to extent the telephone line at A1 to the area outside the building where the dish is located, or having to use two persons at A1 (one to man the telephone/relay information outside and one to adjust the dish). It may be necessary for the personnel at R1 and/or R2 to move their transceiver antenna from behind the reflector(s) before communications can be established.

Step 3: Level A1 and A2. If the dishes are located directly beneath the reflectors they may be set to a starting point with a three foot carpenter's level. This may be done by placing the carpenters level on the underside of the dish and adjusting the mounting legs until the dish is level. An angle finder, as shown in **figure 2**, will be used later to set the angle of the reflector. Angle finders are used by carpenters to set the "pitch" of roofs,

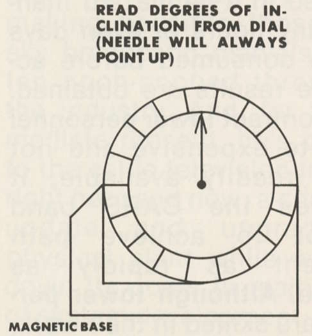


FIGURE 2 ANGLE FINDER

etc., and can be purchased at most hardware stores. If the dish does not lie directly beneath the reflector, refer to **figure 3** to determine the tilt angle of the dish and reflector.

Step 4: Preset Polarization. Although waveguide is rectangular in shape, the mounting holes which allow two pieces of waveguide to be connected together may be arranged in a square configuration, which will allow the waveguide to be "crossed". If the waveguides are crossed, signal rejection will occur on the order of 30dB. It is therefore **imperative** that waveguide installation be undertaken with care **to avoid cross polarization.** Energy leaving the transmitting anten-

Assume that the dish must be moved away from the tower by distance "d" and the reflector is distance "h" above the dish. Calculate the tilt angles required for the dish and reflector. See Figure A.

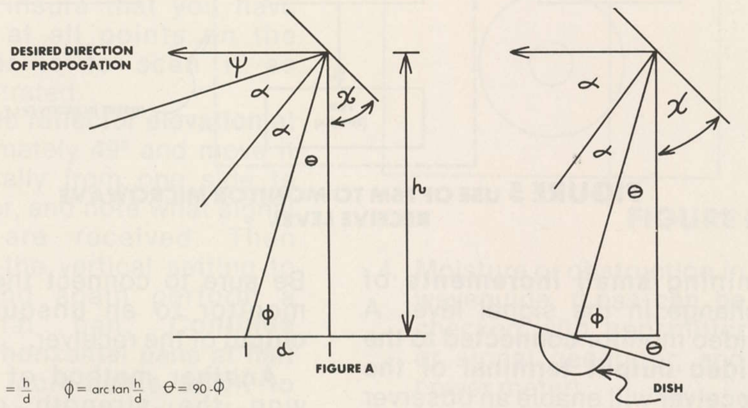


FIGURE A

$\tan \phi = \frac{h}{d}$ $\phi = \arctan \frac{h}{d}$ $\theta = 90 - \phi$

Angle of incidence (α) = angle of reflection (α)
For proper reflection Ψ must not exist.
We can therefore write $2\alpha + \theta = 90°$
and $\chi + \alpha + \theta + 90°$
Thus $2\alpha + \theta = \chi + \alpha + \theta$
or $\chi = \alpha$

The angle of the reflector must be set to the angle of incidence.

The reflector angle is reduced by one half of the tilt angle of the dish.
An example will demonstrate that fact. $2\alpha + \theta = 90°$
Assume $\theta = 20°$
$2\alpha = 70$
$\alpha = 35$ which is $\frac{\theta}{2}$ degrees less than 45°

FIGURE 3

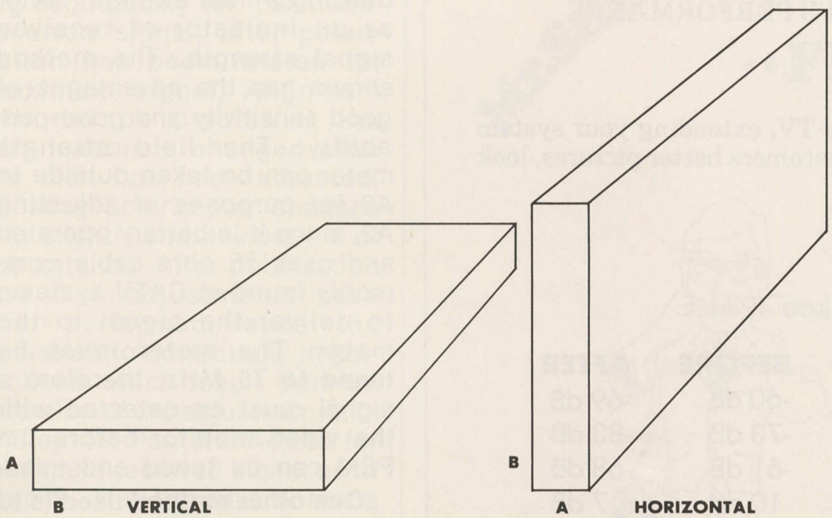


FIGURE 4 **WAVEGUIDE POLARIZATION**

na system on one polarization must be received on the same polarization, just as if the transmitting and receiving antenna systems were two pieces of waveguide which had to be matched. The transmitting antenna polarization must also be set as specified by the station license (or construction permit, usually either vertical or horizontal).

To set the transmitting antenna polarization to vertical, position yourself behind the feedhorn and face the receive tower (underneath the dish). Turn the feedhorn until side B faces you **(figure 4).** For horizontal polarization, turn the feedhorn until side A faces you. You will only be able to turn the polarization about 120° with some antennas, because the feedhorn inside the dish employs guywires (spring loaded and adjustable) which are used to position and hold the feedhorn. The transmit polarization must remain in this position (as licensed) and the two ends (transmit and receive) are "matched" by adjusting the receive polarization only. As a starting point for the receive polarization, position the feedhorn just as you did the transmit feedhorn, by looking at the other tower and point Side B toward you for vertical polarization. This will usually be close to the final setting unless your antennas have circular feedhorns. With circular feedhorns the receive polarization may have to be turned anywhere from 0° to 90° to match the transmit polarization, since the energy may spiral in the circular feedhorns.

Step 5: Adjust Feedhorn. This step should be performed only by competent technicians who are qualified in antenna work, and should only be performed, or checked, when the technician has reason to suspect an antenna to be faulty. If new antennas are being used, this step may be skipped.

First, adjust the focal length of the feedhorn by moving it in or out of the dish; then adjust the spring tension on each of the feedhorn guywires until the feedhorn is centered in the dish.

Step 6 Preset R1. Using the angle finder described in Step 3, adjust the reflector to 45°. If A1 has been set to any angle other than 0° (level), R1 must be set by 1/2 of this difference. For example, if the dish was tilted in toward the tower from level by 20°, the reflector must be raised from 45° by 10° (see figure 3). Set R1 on azimuth (aimed toward the receive tower). Use topographical maps and landmarks, pocket compass and calculated azimuth, and visual sighting of the receive tower to set R1 on azimuth. Be precise with the setting of R1, since **it** is the component most likely to prevent signal reception during the first alignment attempt of R2.

Verify that the face of R1 is flat by stretching a piece of string across it's surface. (Some reflectors have an option whereby adjustments are available to curve the face of the reflector to achieve more gain as a result of a specific distance between A1 and R1 and a specific size of A1 and R1.)

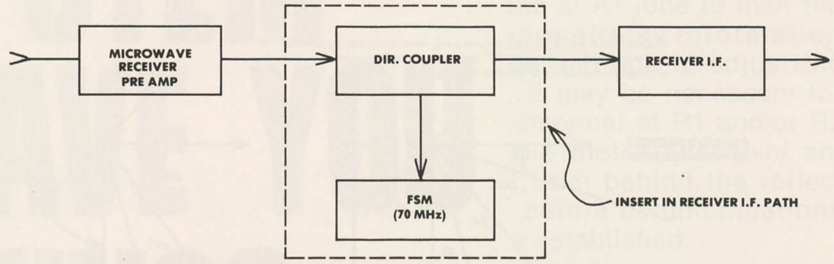


FIGURE 5 USE OF FSM TO MONITOR MICROWAVE RECEIVE LEVEL

Step 7: Set up to monitor received signal strength. The receiver AGC meter can be read to obtain an indication of the strength of the received signal, but **this method** does **not** provide the needed sensitivity for either picking up a signal **initially** or for determining **small increments** of change in the signal level. A video monitor **connected to the video output terminal of the receiver** will enable an observer to detect signals which would be too weak to cause a indication on the AGC meter. Be sure to connect the video monitor to an **unsquelched output** of the receiver.

Another method of observing the strength of the received signal is to monitor the noise level out of the receiver. This method is preferable to the AGC meter, because of it's better sensitivity; however, it is seldom used with CARS band microwave when field strength meters are available. Shown in **figure 5** is a configuration utilizing a field strength meter as an indicator of received signal strength. The method shown has the advantages of good sensitivity and good portability. The field strength meter can be taken outside to A2 for purposes of adjusting A2, since it is battery operated and uses 75 ohm cable commonly found at CATV systems to deliver the signal to the meter. **The meter must be tuned to 70 MHz,** therefore a signal must be detected **with the video monitor before** the FSM can be tuned and used.

One other method used is to simply purchase a large meter movement and temporarily wire it in the place of the smaller AGC meter. This will provide increased sensitivity and portability, since the meter can be extended to A2 with any suitable pair of wires.

Step 8: Verify and monitor transmitter operation.

Step 9: Pan R2 to receive signal. The most common error made when aligning reflectors is demonstrated in figure 6. The main lobe of the reflector is shown as a small circle with side lobes shown as a larger circle. It is easily seen that mere vertical and horizontal adjustments will not necessarily cross the main lobe. The **only way** to insure that you have looked at all points on the reflector is to scan it as demonstrated.

Set the reflector elevation at approximately **49º** and move it horizontally from one side to the other, and note what signal levels are received. Then change the vertical setting to **48.5º** and again perform a horizontal pan. **Continue making horizontal pans at half degree increments down to 41º.** (Use the angle finder described in step 3.) Return the reflector to the point where the highest level of signal was received.

If no signal is received, return to Step 6.

Step 10: Adjust A2. Most antennas are mounted on 3 or 4 adjustable legs which rest on a pylon or outrigger. Adjust **each** leg sequentially for maximum received signal, **after polarization has been rotated for maximum signal.** Alignment will **not** be precise **if** the polarization is **changed after** the dish has been adjusted, because polarization changes may slightly alter the pattern of the antenna. After polarization and dish adjustments have been performed, repeat the operation to correct any imperfections which result from interaction of the adjustments.

Step 11: Pan R1. Adjust for maximum received signal as in Step 9. The transmit antenna system is independent of the receive antenna system. No adjustment performed in this step or Step 12 below, will change the settings of Step 9 or Step 10.

Step 12: Adjust A1. Follow procedure described in Step 10.

This completes the steps required to align the antenna of the typical microwave hop described. In the event that a signal cannot be received, the problem may be one of the common causes listed below:

1. **Insensitive receiver.**
2. Low transmitter power.
3. **R1 not pre-set properly.**

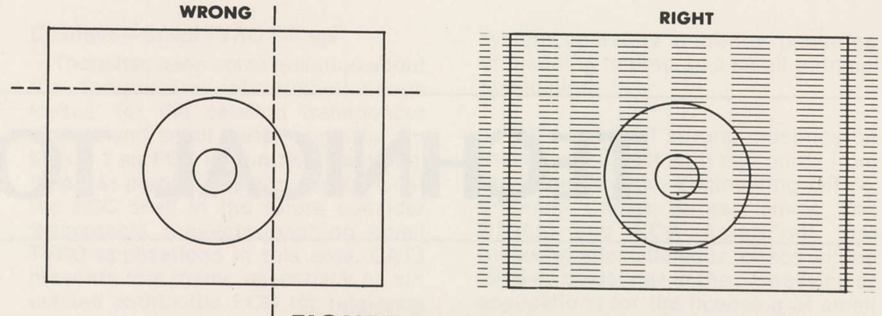


FIGURE 6 **REFLECTOR SCANNING PATTERN**

4. Moisture or obstruction in waveguide. (Loss can be checked with transmitter or signal generator, and power meter).
5. **Crossed waveguide in path.** (Also, a **choke-type connector** connected **directly** with another **choke-type connector** can cause appreciable signal loss.)
6. Receive polarization improperly pre-set.
7. **Obstacle in path, not reported on field survey.**
8. Defective antenna.

TECHNICAL TOPICS

FIRST OPERATING 4.5 METER

The assault on the '9 meter TVRO standard' began in earnest in April, 1976 (see **CATJ** for **January,** page 45 and **CATJ** for **February,** full issue). On April 1, 1977, at Kalispell, Montana the TelePrompTer company, with the able assist of Prodelin's Jerry Pell, a receiver from Scientific Atlanta and a 120 degree kelvin noise temperature LNA from Scientific Communications, Inc. turned on the first 'legal' (i.e. FCC authorized) small earth terminal.

The 'victory' for Prodelin and the others who labored so hard **(if not so long in terms of how long these things often take)** was particularly sweet. The first installation delivered pictures by Pell and the others at 3 PM on April fools day. While final adjustments were being made as we closed this issue of **CATJ** for the presses, it appears the system will have 51.5 to 52 dB signal to noise at video when it has been finally adjusted.

The TelePrompTer 'support' for the small terminals is particularily significant simply because of the cost savings which the giant MSO is able to effect with the 'smaller-than-9-meter' terminals. While TelePrompTer's 5,300 plus subscriber system might well have stood the cost of a larger terminal, the savings with the smaller terminal (which is certainly delivering satisfactory pictures at the 51.5-52 dB video signal to noise region) can obviously be put to good corporate use elsewhere.

The Kalispell terminal will initially deliver HBO programming to Kalispell.

A Question of Gain

"I read with interest your February 1977 issue of CATJ which was devoted almost exclusively to small aperture earth station antennas. In general, the issue covered all of the important aspects of this new and emerging market. However, on page 43 the listing of the various antenna sizes had some errors. Andrew has opted, in both the 10-meter and 4.5-meter sizes, to go with a double reflector feed system. We feel that the higher efficiency afforded by this kind of feed system is very important in delivering the required carrier-to-noise level to the receiver. Calculations indicate that a dB gained at the antenna yields a dB in carrier-to-noise level. The Andrew 4.5 meter receive-only earth station antenna has a gain at 4 GHz of 44.0 dBi. Other aspects of the antenna are covered in our Bulletin 1094A. On page 44 for February CATJ also indicates that the Prodelin antenna, incorporating a prime focus feed, has a gain of 43.7 dBi. Specifications published by Prodelin and on file with the FCC indicate that their prime focus feed has a gain of 42.9 dBi. A gain of 43.7 dBi in this size relector would almost surely require a double reflector feed system. In small aperture earth station antennas the gain is a critical parameter. The Andrew 4.5-meter receive-only antenna delivers high gain while meeting the necessary FCC pattern requirements. We feel that this combination provides the optimum solution to the CATV operator considering the small aperture station."

Carl Van Hecke
Product Planning Manager
Earth Station Antennas
Andrew Corporation
Orland Park, Illinois

Buzz-

Prodelin advises that they have a 'new' feed system which is indeed a prime focus type of feed, but which has additional gain above their earlier version. They also tell us it has 'patent possibilities'. For our readers' enlightenment, there is going to be some confusion in the antenna size versus feed versus gain statements one sees in print for probably as long as there are two or more manufacturers offering competitive products. Lacking the test range ability and years of experience required to make direct verifications of these printed numbers, CATJ cannot be expected to act as a referee in these "word battles"**. It is the game of** specmanship, **personified. About the best we can do is to provide a completely open forum for all comers who have creditability and who have something to say or offer. That we are doing.**

TVRO Up-Date

Following up on the heels of CATJ's special full-issue report on the status of newly available "small earth" terminals, we have the following to report:

(1) **Microdyne Corporation** (Box 1527, Rockville, Maryland 20850) has announced a new satellite TV receiver which they claim is an "important break through" in demodulator design. The important improvement, with patented techniques, involves a new circuit which **lowers** the FM threshold **to 7 dB carrier-to-noise.** Microdyne's new model 1100-TER(VT) receiver includes the "improved threshold extension" as standard equipment according to the company.

(2) **U.S. Tower Company** (P.O. Drawer 'S', Afton, Oklahoma 74331) has completed antenna pattern tests with their six meter dish antenna. According to a schedule released late in March, the first operating six meter terminal was scheduled to be installed at Rockville, Texas shortly after the first of April. The installation will operate as a **"test facility"** until the CATV system there can obtain the FCC approval for the use of the facility for the cable customers.

(3) **Several readers,** including some in Canada, have drawn to our attention the "plain fact" that reception of satellite signals is **not** exactly what you might call "broadcast reception". One Canadian reader was particularly concerned with our photographs on pages 37 and 44 of the February 1977 issue of CATJ (showing off-screen ID photos of the Anik channels utiltzed for TV distribution in Canada). **"The satellite relay of signals is not in the same category as sticking up an antenna and simply picking up broadcast signals; these are private, common carrier signals and they are not intended for the general public's use. The penalties are the same for illegal interception of these signals as they are for unauthorized interception of point to point** (microwave) **transmissions".** Our Canadian reader is of course correct. **Any** reception of common carrier signals, **regardless of where** they come from (i.e. a bird or a nearby Bell relay tower) **is forbidden** unless the recipient has the authorization of the common carrier. There are severe penalties for the misappropriation of such signals, even for test or experimental purposes. **You have been warned.**

Cablecasting Manager Sought

One of the most interesting cablecasting operations in CATV has an opening **at the top**. The present cablecasting manager has a Ph. D. in Communications and he has built up a solid following for special events telecasting and two local 30 minute full color newscasts per day. This system makes extensive use of videotape and in this particular market the cablecast system news is a consistent winner in ratings against the local television broadcast station. These are tough shoes to fill (the present cablecasting manager is leaving to become a professor in communications at a leading state university) and the salary is "open". If you are a professional who knows how to make a first class operation consistently turn in top ratings, we'd like to hear from you. Send resume and your availability date to:

Box C-1 c/o CATJ, Suite 106, 4209 N.W. 23rd, Oklahoma City, Oklahoma 73107.

Changes—Small TVRO Filings

There has been some question about the computation of 'miscellaneous losses' for the satellite transponder signals and small earth terminals. On March 1 an FCC **inter-office memorandum** was prepared as a 'guide' for what the FCC shall in the future consider 'acceptable presentations' on small TVRO applications in this area. CATJ presents this memo essentially as circulated within the FCC for reference and for the assistance it may provide system operators currently preparing or planning to prepare a small terminal application.

"As a result of several meetings on the above subject with personnel from the Cable Bureau, Engineering Office, Common Carrier Bureau, Home Box Office, and RCA Americom, the following miscellaneous losses will be used as guidelines in the processing of applications for the licensing of small earth stations.

	Nominal dB	Random (RSS) dB
Satellite EIRP	— (1)	-0.15 (2)
Atmospheric	-0.10	-0.10
Polarization	-0.10	-0.10
Rain Attenuation	—	-0.20 (3)
Earth Station Pointing	-0.30 (4)	—
Wind Effects	—	-0.40 (5)
Antenna Gain	—	-0.20 (6)
LNA Temperature	—	-0.35 (7)
Long Term Degradation:		
Satellite EIRP	-0.40 (8)	-0.40 (8)
Earth Station LNA	— (9)	—
Interference Degradation	-1.0 (10)	—
FM Threshold	-1.0 (11)	—
Back-up Satellite	— (12)	—
Subtotal	2.90 dB	0.75 dB (13)
Total Losses	3.65 dB	

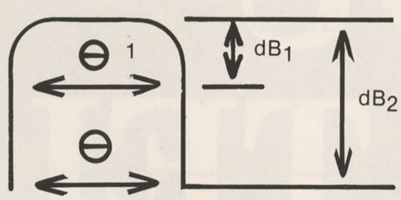
Notes

(1) Services from the same satellite provide different EIRPs. For example, the HBO transponder has approximately 1.0 dB more transmitted power than the transponder providing channel 17 (Southern Satellite) service. Therefore, an applicant should declare the types of services that he intends to participate in.

(2) Daily variation—per RCA.

(3) Heavy rainfall areas should increase attenuation up to -0.5 dB.

(4) Calculation based on ± 0.1° orbit stability of satellite or total of 0.2° for 4.5 meter antenna. Other antenna sizes may use the following model:



$$\frac{dB_1}{dB_2} = \left(\frac{\Theta_1}{\Theta_2}\right)^2$$

(5) Calculation based on an additional pointing error of 0.1° or a total pointing error of 0.7°. Use model in (4).

(6) Antenna gain tolerances. A ± 0.2 dB variation is used based on 4.5 meter antenna data.

(7) LNA temperature tolerances. LNA temperature is given as a typical noise temperature and a maximum specified limit. For this example, a maximum of 130°K is specified (21.14 dB°K) and typically operates at 120°K (20.79 dB°K). This tolerance is sensitive to the LNA type selected and will vary with the model and type of LNA used.

(8) RCA suggests a 0.4 dB degradation loss. Comsat experiences 0.5 dB average degradation loss on Intelsat IVs. Comsat and Government satellites define an EIRP failure when power output drops -1.0 dBw. Hence, it was agreed to assign 0.4 dB nominal and 0.4 dB random.

(9) LNA degradation is assigned 0 dB for it can be repaired and/or replaced to correct degradation.

(10) Interference degradation is assigned 1.0 dB as discussed in the Small Earth Station Order, FCC 76-1169. However, detailed calculations are encouraged.

(11) Data on file at the Commission shows that impulse noise begins at 1.0 dB above FM threshold of the receiver type used. Impulse noise appears as bright sparkling noise (called "sparkles") in the video and as clicks in the audio.

(12) Loss characteristic to earth station location resulting from loss of EIRP from satellite and additional space loss. Each assigned loss is thus peculiar to each applicant's location. For the RCA satellite, locations east of the Mississippi River are particularly affected by these additional losses.

(13) RSS of the random losses."

WHAT HAS CATA DONE FOR YOU LATELY?

1) **Small earth terminals.** CATA saw the problem with large, expensive terminals (they cost alot of money) and the engineering ability of smaller terminals to do the job we require. CATA got the job done. In record time.

2) **FCC rule relaxation.** From the very beginning of CATA **this trade association** has refused to roll over and play dead before the FCC and Congress. We told it like we believed it to be. Now the FCC is beginning to agree with us. Systems with fewer than 500 subscribers now have minimal federal regulation. Systems with fewer than 1,000 subscribers can hope they too will soon enjoy such "freedoms".

3) **Operating seminars.** Big trade shows are fine. And expensive. But CATA saw another need. A need for down-to-earth, practical trade **seminars.** Learning sessions, bringing together the people who have to make their living actually building and operating CATV systems and the people who design and equip the systems we utilize in cable TV. CCOS (CATA Cable Operators Seminar) was the result. It was "all sold out" in 1976. It will be all sold out in 1977.

4) **Regional seminars.** CATA recognized that smaller system operators could not afford the expense nor the time away to attend a far-distant national meeting. So CATA conceived and put on 9 regional "CCOS" meetings this past fall and winter. More than 300 system operators attended these sessions. And there will be at least nine additional sessions in 1977.

5) **Copyright reality.** The record speaks for itself. **Without CATA,** small and medium sized systems would be scheduled to pay as much as 1,000% MORE for copyright than they are now responsible for, starting in 1978.

6) **Ongoing practical technical excellence.** The willingness and the ability to be of assistance to member systems when they have technical and operational problems. A commitment to provide member systems with hundreds of carefully researched and carefully prepared "technical reports" every year, through the 'Official Journal' of the Community Antenna Television Association. . .**CATJ.** Many members report "my CATA membership is returned many times over each year by having CATJ to assist me in my operations. . .I know I am supporting a very useful and much needed service. . .".

Does this sound like your kind of organization? A down-to-earth, practical group of CATV system operators (perhaps just like yourself) working together to improve the state of the art? CATA invites your inquiry concerning membership. Direct your requests to: CATA Membership Services, Community Antenna Television Association, Suite 106, 4209 NW 23rd, Oklahoma City, Oklahoma 73107. Or telephone CATA at (405) 947-7664.

cata

ASSOCIATE MEMBER ROSTER

In recognition of the untiring support given to the nation's CATV operators, and their never-ending quest for advancement of the CATV art, the COMMUNITY ANTENNA TELEVISION ASSOCIATION recognizes with gratitude the efforts of the following equipment and service suppliers to the cable television industry, who have been accorded ASSOCIATE MEMBER STATUS in CATA, INC.

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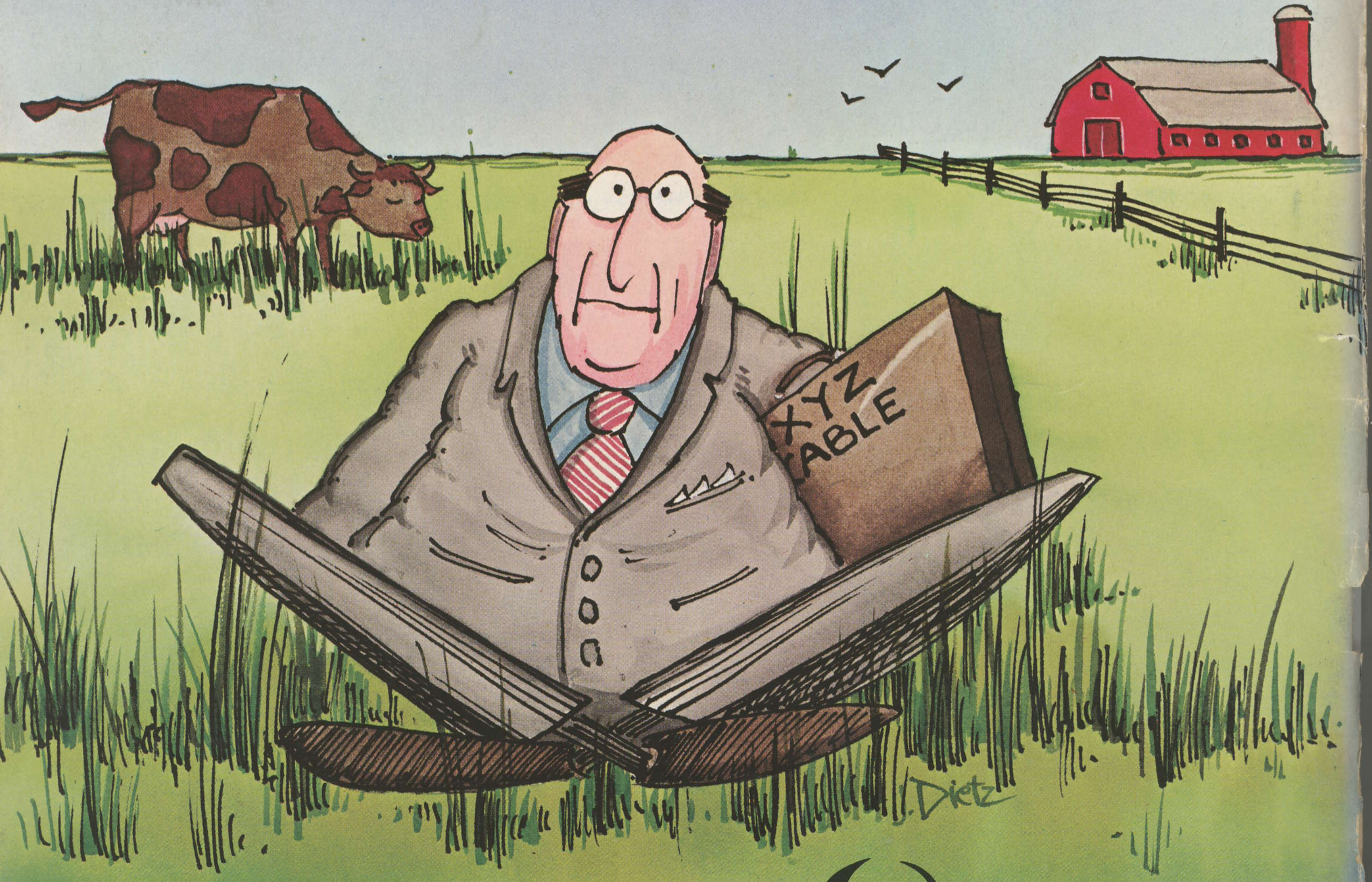

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