CATJ

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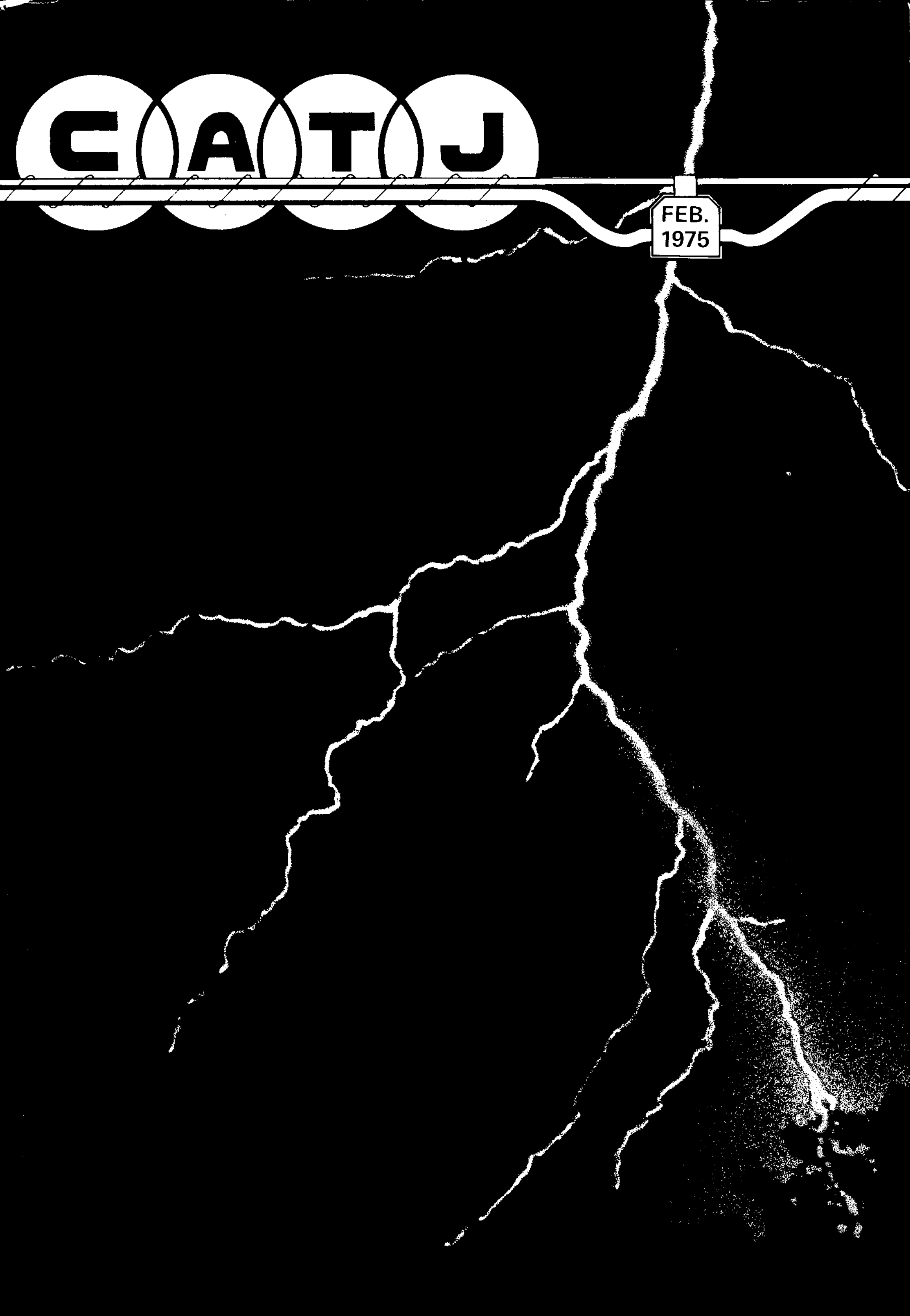
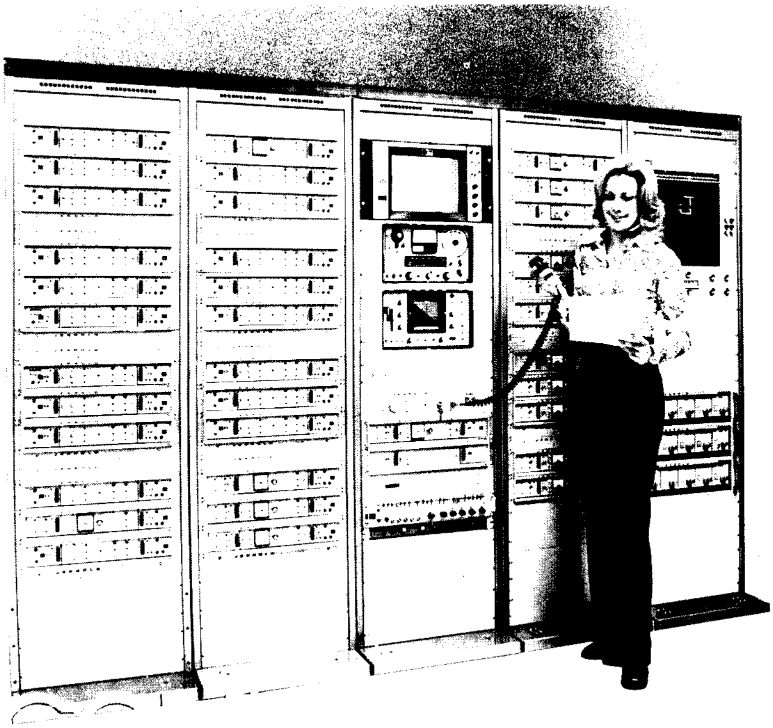
1975



COMMUNITY ANTENNA TELEVISION JOURNAL



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OFFICES

4209 N.W. 23rd St., Suite 106
Oklahoma City, Ok. 73107
Telephone (405) 947-4717

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–CONTENTS–

OUR COVER

Everyone has lightning problems. Virtually this entire issue of CATJ is devoted to the problem and its cures. Hopefully you will learn a few new things about the solutions this month!

CATA-TORIAL

KYLE D. MOORE, President of CATA, INC.

CATA ASSOCIATE MEMBERS

Early in January the Community Antenna Television Association (CATA) announced an "Associate Member Program" for the industry's suppliers. The program is an important one, and deserves some explanation because we all (operators and suppliers alike) have a very vital stake in the coming events of the new year.

When CATA was initially formed, there was some discussion of bringing the manufacturing and supply portions of our industry into the activities of CATA. We were told by several influential people in the industry "NCTA has an associate group. You should too." But at that time, the CATA Board of Directors thought otherwise. The NCTA had a lot of things of which CATA wanted no part, and the many hundreds of dollars which they charge for an "Associate Member Plaque" is one of those things.

The CATA Associate Program is tailored exclusively for suppliers to the industry, and was announced in a brochure mailed to all known suppliers in early January. It will work in this manner:

(1) Industry suppliers have goals similar to those you have, as a supplier of television signals from your community-master antenna. They strive to supply one or more pieces of equipment, or one or more services, which result in a profit to them.

(2) Any associate program by CATA, NCTA, or anyone else (including state or regional associations) has to recognize that **without profits, the supplier is dead,** just as you would be if your community antenna turned unprofitable for you.

An associate program at any level that charges suppliers for the **privilege** of belonging to an organization must make some tangible returns **possible** for the supplier. A tangible return means a profitable return.

A wall plaque is not a tangible return, nor is making "Associate Membership" a prerequisite to renting display space at an association gathering really fair, unless the "Associate Membership" is in truth nothing more than a thinly disguised "entry fee" to the gathering's display floor. If that is what it is, then why should one company pay $350 for an entry fee, and another company pay two or three times as much simply because the second company has more employees, or sells more dollars of equipment per year to the industry? Yet, that is what the NCTA does to suppliers. They **require** "Associate Membership" before a firm can display at the NCTA annual show (or at previous EXPO shows). The annual "associate member fee" is based upon company size; the bigger you are, the more you pay to "belong". In addition to this, everyone who "belongs" pays very large fees for the rental of "floor display space" at the NCTA shows.

The CATA Associate Member Program differs in these respects:

(1) The annual fee is the same for all companies, regardless of size.

(2) It is a reasonable fee—$150 per year.

(3) Membership is for 365 days, beginning on the date the membership application is received, **not** for a calendar year.

(4) There are **direct** returns to the supplier:

(A) He receives an advertising rate reduction for all advertising space he utilizes in CATJ.

(B) He is listed monthly in a new "CATA ASSOCIATE MEMBER ROSTER" which will appear in CATJ in March, and thereafter. Need we suggest that when you are considering dealing with suppliers, that you check the Membership Roster for a list of firms that support CATA?

(C) He receives the use of a new section to begin in CATJ in March entitled "ASSOCIATE'S SHOWCASE", where we will report on new pieces of equipment and services offered by CATA Associate Members.

(D) He receives many more direct benefits, the yearly total of which far outweigh the modest annual associate membership fee.

In short, **the supplier gets a return on his money.** This means he makes a profit on his associate membership investment.

If this industry is to regain its strength, **it must have strong suppliers.** The CATA Associate Member Program is our way of helping our suppliers **regain** some strength, and remain that way. If we are to stay in business as operators, **we need to keep them in business** as suppliers. Yes, their profits come from us as operators, **but our profits as operators come from their equipment and services.**

CABLE CAPTIONS

Thanks a lot FCC! There is a growing amount of concern on the part of system operators over the "instructions" community leaders are receiving from the FCC about "how to handle CATV franchisees and applicants". Many system operators have gone (and are going) to their cities to ask for modifications in their franchises, so the franchise instrument "complies" with FCC requirements in advance of 1977. Many cities, understandably, are confused and a little leary of a whole new set of unfamiliar Washington mandated regulations, when they are delivered to the City by the CATV operator. So, they do the natural thing—they instruct the City Attorney to "look into the matter". The rub comes when the City Attorney contacts the FCC (Cable Bureau) and ends up getting reams of data, "instructions", and lists of things his city can and can't do. He also gets a bushel basket of "free advice" from reform-minded Cable Bureau attorneys trying to make **their** mark on the world. The cities end up **very** confused, and many operators report relations with City Hall have fallen to an all time low because FCC attorneys and "instructions" plant the "suggestion" that the CATV operator needs to be closely regulated and watched. One operator became so disgusted after operating in his town twenty years, he withdrew his application for franchise amendment and told his city, "To hell with everyone but my customers. They deserve good service and they will get it, but as far as the FCC is concerned, they can go climb a pole!"

What about re-regulations? Can we expect any meaningful changes, relaxation, or improvements in the FCC's hell-bent-on-destruction-of-CATV regulatory climate? Most observers feel that Chairman Wiley's brash statements about re-regulation, and wanting to "free up" needless regulations and paperwork for small systems will turn out to be **just political bunk.** Dozens of operators have commented recently, "If we are going to turn this stinken mess around, it will have to be through Congress." There is an all time low confidence level by CATV in the FCC's ability to do anything for anyone but broadcasters, and as long as the higher (Federal District) courts continually acquiesce to the "expertise on the FCC", when you drag the FCC into court to question their authority in an area such as CATV, the courts (**below the high court**) don't hold much hope.

Canadian court holds U.S. TV signals public property. Justice Arthur Thurlow of the Federal Court of Appeals (Ottawa) has ruled that U.S. TV signals (or radio signals) "intruding on the Canadian airwaves" have no rights in Canada. In a case brought against Rogers Cable TV Ltd. of Toronto, U.S. stations WGR, WBEN, and WKBW (Buffalo) sought to end the Rogers practice of "deleting commercials on the station signals before distribution in Toronto, and substituting local messages in their place". The Canadian version of the FCC, the CRTC, had ruled in 1972 that Canadian CATV systems could and should delete U.S. commercial messages "where they were equipped to do so", and either substitute local public service messages, or arrange with Canadian TV broadcasters for the latter to sell replacement commercial time. Canadian broadcasters have been concerned that as CATV expands in Canada (something like 30% of all Canadian homes now have CATV) that large advertisers, such as Coca-Cola, would cut back Canadian station advertising on the theory that U.S. stations already carrying the advertising would reach the audiences anyhow. The Canadian court ruling has drawn mixed reviews, from broadcasters in Canada who welcome the decision, to Canadian CATV operators who fear that commercial deletion may now become mandatory for them with the attendant rise in their costs.

One man can turn the tide! If you ever get the feeling that endless writing of letters to Congressmen, FCC officials, the President, and so on is a useless function, **think again.** One letter, written by CATV pioneer Jim Y. Davidson of Little Rock to the FTC (Federal Trade Commission) chairman, found its mark. Based upon Davidson's letter and his booklet, "The Injustice Of A Distorted Image", the FTC has decided that CATV is getting a bad deal at the FCC! The Chairman of the FTC has directed his people to investigate the FCC's handling of CATV, and make recommendations on how the FTC can help our struggling industry. **Well done, Jim!**

Check out those rumors! Ever since Dolphin folded in December, virtually every day brings a new rumor about CATV manufacturers "going under". Virtually all **have had** big shake-ups; many key personnel have been moved or replaced. Even the big boys have pulled way back, shut down production lines, and a couple have replaced their entire sales staffs from top to bottom. Let's face it, **times are bad** for equipment suppliers. But most are in the business to stay, and just because you hear that personnel have left, or a production facility has been shut down, **don't** immediately assume the company is folding. Any smart businessman makes adjustments in his operation when things get rough. He looks for a **new** key to turn sales around, or for a better sales team. Let's **not** turn the industry into a rumor mill. Before you pass a story on, check it out!

Late word on 35 Mile Rule. When Chairman Wiley's Commission did not vote on the relaxation of the Grade B contour non-duplication protection requirements January 10th, as they had agreed to do back in December, many CATV observers felt that the Chairman had knuckled under to the broadcasters one more time. It now appears that this is exactly what happened, that in fact the Rocky Mountain Broadcasters Association was successful in a last minute effort to talk the Chairman into holding a new round of ''Oral Arguments'' on the matter. Word from the Commission is that the original December informal Commission agreement (knock back non-dup requirements to 35 miles, allow simultaneous showing of priority stations on blacked out channels, and raise the exemption from non-dup system size from 500 to 750 subscribers) is **not** dead, but that it will not be approved in **that** form. It is believed that a new round of ''number games'' is likely, and at press time the **best guess** is that we **may** see the following happen: (1) The Rocky Mountain area will still be singled out for special treatment; (2) in the top 50 markets, the non-dup requirement will be cut back to 35 miles; (3) in the next 50 markets, the non-dup requirement will be cut back to 45 miles; (4) beyond the top 100 markets, it is anyone's guess, although a ''70 mile protection contour'' is being bantered about; (5) the system-size exemption now being talked about would be 1,000 subs, rather than the present 500 subs; (6) and systems would be allowed to run the priority channel, on the blacked out channel, during non-dup protection periods. Keep in mind nothing is final until the gun sounds. . .and at the minute, the gun is not even loaded!

IT'S NOT NICE TO FOOL WITH MOTHER NATURE!!

DANGER – 200,000 amps!

If you or your CATV receiving tower lived long enough, you *might* experience a lightning strike that would produce an instantaneous surge current of 200,000 amps. If you lived long enough to encounter the mathematical probability of such an unusual lightning strike (*0.5% of all strikes* to a single point), you probably couldn't find the pieces of your tower and antennas after it happened. And if you or a fellow worker were at the head end when this awesome energy struck . . . well, your pieces also would be difficult to locate.

The mysteries of lightning-induced voltages (and the currents these voltages produce) are not well understood by scientists; and within the CATV industry, we are patent ignoramuses. As the old adage goes, it is *what you don't know* that will kill you, or cripple you, or put you out of business in a hurry!

It is not our purpose here to scare you. Any half-smart person already knows the inevitable fear that crawls up the back when a man is caught at or near a CATV tower in a local thunderstorm. Those unfortunate enough to be "ordered onto the poles" in a storm should check their life insurance and the line at the unemployment office, in that order, before undertaking such a venture.

If industry mail to CATJ is any indication of industry concerns, and we believe it is, lightning protection for CATV equipment rates within the top five concerns in our industry. So, we set out last Fall to start gathering data on lightning as it relates to communication system tower structures, and cable communications systems. We went to all of the places you might expect us to go, starting with the people at Bell Labs, the National Fire Protection Association, and manufacturers of lightnning protection equipment. The data we found available in the form of published papers, handbooks, and the like, barely numbered twenty, and one of these dated back to 1913! Purely, lightning is *not* something people say very much about, *if they know anything to say.*

Protection from lightning damage takes on a bit of black-science, because most people who practice the "art" (and you can number such people on a single hand), deal in "before and after" numerical summaries of their work.

For example, "Before system 7894 was installed at a Bell Labs TD-2 site in Texas, the site experienced an average of seven lightning related outages per year." However, "After installing system 7894, the TD-2 site experienced an average of two lightning outages per year." Clearly system 7894, *whatever it was*, improved the odds considerably for that particular TD-2 site.

So, just when you think you have found something worthwhile, you learn that system 7894 turns out to be a lost equation whose documentation has disappeared in the intervening fifteen years. Very disappointing!

Then, there is the problem of simulating lightning strikes within the laboratory. Virtually everyone (those fewer than five who practice the art) agrees that something called a 10 X 600 microsecond impulse test wave is the proper way to test protection devices or circuits for lightning-induced transients entering a "communication system" *via* the power lines. *Nobody agrees on anything* when it comes to simulating direct strokes to a tower.

Still for all that is not known, much-much more about lightning is known, than we as an industry know. And that is the purpose of this special emphasis in CATJ: To transcribe *into the language and art of CATV* what *others* know about lightning, its damaging effects, and the preventive steps we can take to avoid it.

The Nature of The Beast

To combat the enemy, it is wise to know something about him. You chase and flail at fewer paper tigers that way. The best data around on the true nature of lightning is referenced in footnotes to this report. Particular short-form credit, however, goes to a gentleman named David W. Bodle, a private consultant to Joslyn Electronic Systems. Mr. Bodle's book, *"Electrical Protection Guide for Land-Based Radio Facilities"*, is the closest thing to a single-source handbook on the subject we uncovered in our six month trek into the mysteries of lightning (1). It is with the permission of Joslyn Electronic Systems, that we have lifted passages and illustrations from Mr. Bodle's handbook for use in this report.

Lightning is an electrical discharge which occurs *between* clouds, and/or from a cloud (or clouds) to earth. *The latter type of discharge is the one which concerns us the most.*

Generally the *impedance* (2) of an object, such as a CATV tower which inadvertently *becomes a part of the electrical discharge path* of the lightning, is appreciably lower than the total path impedance. Thus, it is possible to presume for discussion that a lightning stroke originates at a constant current source (i.e. the clouds). The magnitude or intensity of the current will vary, however, from one stroke to another stroke, *due largely to meteorological considerations.*

There are generally three things most people want to know about the internal workings of a single stroke: (1) How often will a single point (i.e. one tower) be struck, (2) how large are the voltages/currents produced, and (3) what is the waveform of a typical stroke? Answers to these three questions are considered essential and basic *to the design of any system* that is likely to assist in protecting CATV equipment from the harmful effects of lightning.

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1) David W. Bodle, Senior Member, IEEE, consultant to Joslyn Electronic Systems, P.O. Box 817, Goleta, California 93017.

(2) When a path of current flow (i.e. circuit) contains both reactance and resistance elements, the combined effort is known as impedance. Reactance and resistance can combine in a series, or parallel path. The reactance can be capacitive, (i.e. like a capacitor) or resistive (i.e. like a resistor). The phase relation between current and voltage in a circuit may be from 0 degrees (when resistive) to 90 degrees (when highly reactive). The exact phase relationship, therefore, depends upon the relative amounts of resistance and reactance in the circuit. The tower grounding system represents phase imbalances to the lightning stroke current, and it is the fine tuning of these phase imbalances which is of interest to us here.

How Often?

We are dealing with the odds of probability; not unlike the chance one takes at a table in Vegas. It has been said about lightning, *"There is nothing perfect about lightning, or the charge-center it comes from. It is more strongly under the influence of chance than anything of equal frequency of occurence with which the engineer must contend. Consequently, we can only deal with a statistical function."*

First of all, where is the tower? Reference is made to Diagram 1, a map of the United States and Canada which depicts the "Mean Annual Number of Days With Thunderstorms" from data supplied by the United States Weather Bureau. The definition of a "day with thunderstorms" is a *little* loose. Generally it means a day when an observer will "hear thunderstorm activity" from a single spot on the map, and the assumption is made that where you hear thunder, there is accompanying lightning. Still, the exact number of days is not important-only the relative number of days since the map was prepared from a twenty year period; and averages tend to be of less concern than the current year anyhow.

Okay, so central Florida is a *bad spot*, and the Pacific Coast is a pretty good spot (the difference is striking, a 10:1 ratio!). How does that translate into the "statistical probability" of lightning strikes on *your tower*? Through suitably well engineered field studies, something called the "stroke factor" has evolved, which is the approximate *number of strokes to ground per square mile per thunderstorm day*. Now, we are getting a little closer to home.

The "stroke factor" depends upon the type of storms you encounter. If *your* storm is basically a convection storm (i.e. the type of storm that arises late in the day due to the earth's heating in the Spring/Summer sun, and hot

How Often / How Potent?

Crest magnitudes of lightning strikes vary widely, chiefly as a function of meteorological conditions creating the lightning. Diagram 2A shows the percentage of time that various crest magnitudes are exceeded by lightning strikes. For example, 10% of all strikes have a crest current of 60 kiloamperes, and 1% of all strikes have a crest current of 120 (or more) kiloamperes. The most potent crest current ever measured exceeded 200 kiloamperes.

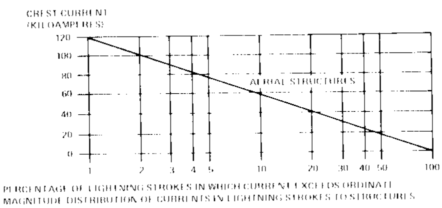


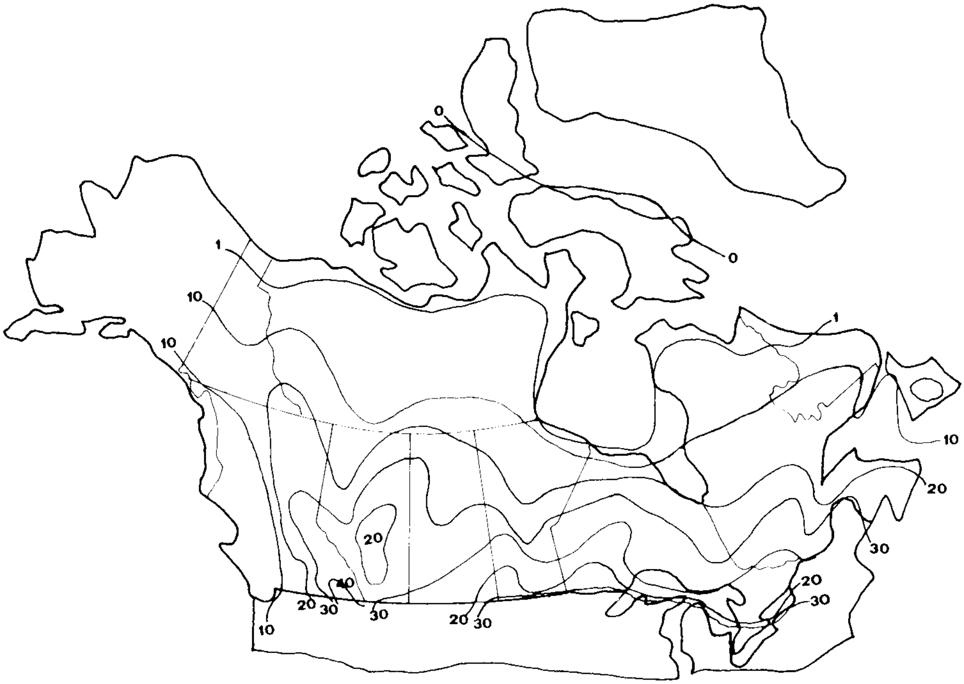
DIAGRAM 2-A

air rising), then your chances are better. Better than what? Better than if *your* storm is a storm produced along a frontal line (i.e. a boundary line between warm/moist and cool/dry air masses). The difference in "stroke factor" is this:

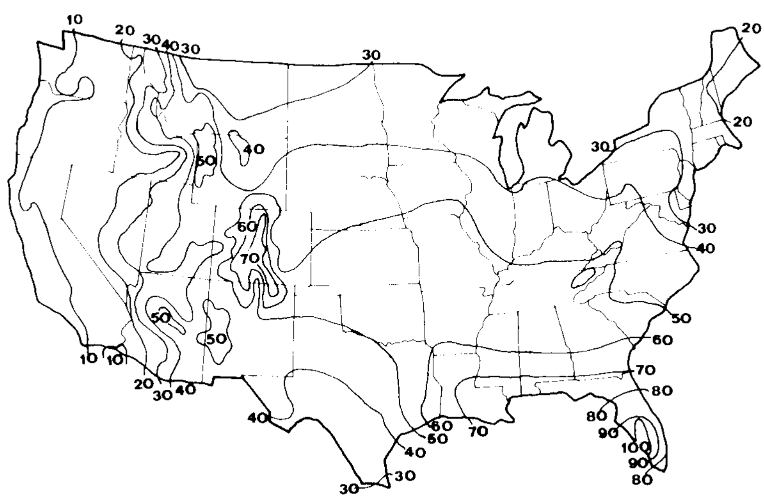
(A) *Frontal type storms*—a stroke factor of 0.37

(B) *Convection type storms*—a stroke factor of 0.28

Now let's put that into real numbers, using Diagram 1. If your area has fifty Annual Days With Thunderstorms (as much of the Mid-west and Mid-south does), you have a stroke factor of 50 x 0.28 or 14 strikes per square mile for convection type storms; or, 50 x 0.37 or 18.5 strikes per square mile (per year) for frontal type storms. Since the fifty days per year is an annual average of both convection and frontal type storms, you would end up with someplace between 14 and 18.5 strikes per year per square mile. Now, let's further refine that to the *area of zone of influence for your tower.*



ANNUAL AVERAGE NUMBER OF DAYS WITH THUNDERSTORMS IN CANADA
(BASED ON PERIOD 1941-1960)



MEAN ANNUAL NUMBER OF DAYS WITH THUNDERSTORMS IN THE UNITED STATES

DIAGRAM 1

The Tower As A Lightning Rod

The structure, such as a tower, does not effect the mechanism of the thunderstorm. But, they do provide favorable discharge points for strokes *that would otherwise strike the earth in the vicinity of the tower,* if the tower was not present. In other words, the tower does *not* draw strikes to it, if the

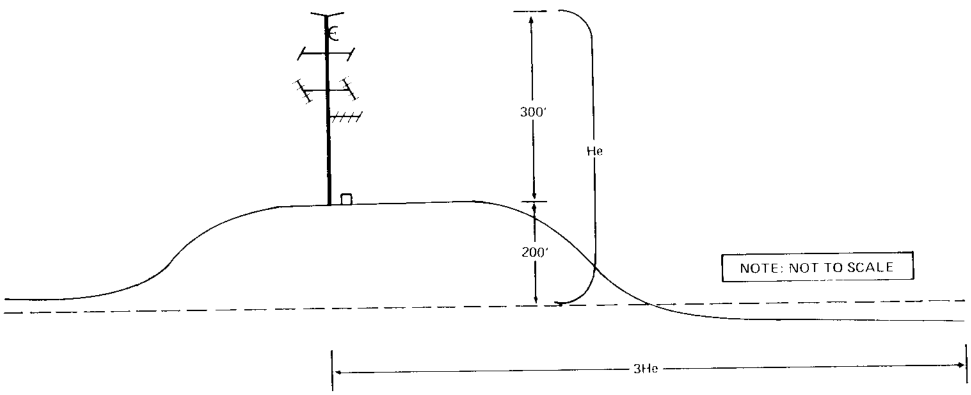


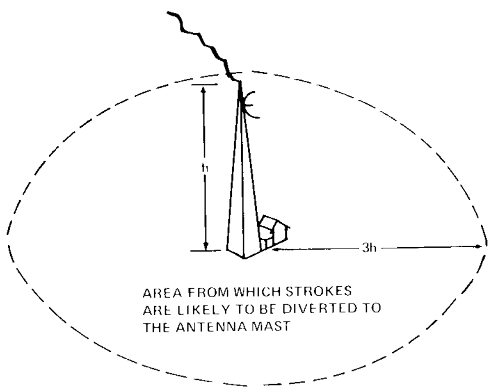
DIAGRAM 1–A

strikes are not going to discharge from storm to earth *in the general vicinity* anyhow.

The strokes are, however, *diverted* in their normal paths to ground *by the presence* of the tower structure. In effect, the steel tower represents an attractive strike point for the discharge. The height of the tower creates a "strike-influence zone", and for towers 100 to 500 feet in height, the "strike-influence zone" is roughly three to four times the height of the tower, represented by a radius drawn around the tower base. This is for a tower mounted on relatively flat terrain.

If the tower is mounted on a hill, the actual "strike-influence zone" *is the height of the tower plus the height of the hill* above average (surrounding) terrain. The effect of the tower height becomes particularly critical when the tower is installed on a prominent, or "lone" elevated hill.

Now, let's put that into real numbers. The number of strikes you can expect per average thunderstorm year depends upon (1) the number of thunderstorms your area experiences in a year, (2) the nature of the storms (i.e. convection or frontal associated storms), and (3) the effective height of your tower above ground and/or average nearby terrain (say a half mile in all directions). Since we know the number of thunderstorms on the average for all areas of the U.S. and Canada, and we know the "stroke factor" (i.e. convection storms are 0.28 strikes per square mile per thunderstorm day, and frontal storms average 0.37 strikes per square mile per thunderstorm day), we need only apply the "strike-influence



STROKES TO A STRUCTURE ON LEVEL TERRAIN - AREA OF INFLUENCE OF MAST

The following example illustrates a method for estimating the annual incidence of strokes to a 200-foot radio mast situated on a hill which has an elevation of 200 feet. Representative values assumed for the problem are:

	Effective height (h_e) of mast	= 400 feet or 0.0758 mi
	Annual incidence of thunderstorm days	= 50
	Stroke factor	= 0.37/sq mi/thunderstorm day.
Now:	Area of influence of mast	= $(3h_e)^2$
		= 3.14 $(0.227)^2$
		= 0.162 sq mi
	The probable number of strokes per year to the mast	= 0.37 (50) (0.162)
		= 3.0.

DIAGRAM 2

Number of Days of Local Thunderstorms/ Storm Types	Number of Lightning Strikes Per Year 100' He	200' He	300' He	400' He	500' He	600' He	700' He
10 Days/Convection	.02	.11	.25	.45	.71	1.02	1.39
10 Days/Frontal	**.04**	**.15**	**.34**	**.60**	**.94**	**1.35**	**1.84**
20 Days/Convection	.05	.23	.51	.91	1.42	2.04	2.78
20 Days/Frontal	**.07**	**.30**	**.67**	**1.20**	**1.87**	**2.70**	**3.68**
30 Days/Convection	.08	.34	.76	1.36	2.13	3.06	4.17
30 Days/Frontal	**.11**	**.46**	**1.01**	**1.80**	**2.80**	**4.05**	**5.52**
40 Days/Convection	.11	.46	1.02	1.81	2.83	4.09	5.57
40 Days/Frontal	**.15**	**.61**	**1.35**	**2.40**	**3.74**	**5.40**	**7.36**
50 Days/Convection	.14	.57	1.27	2.27	3.54	5.11	6.96
50 Days/Frontal	**.19**	**.76**	**1.68**	**3.00**	**4.68**	**6.75**	**9.19**
60 Days/Convection	.17	.69	1.53	2.72	4.25	6.13	8.35
60 Days/Frontal	**.22**	**.91**	**2.02**	**3.60**	**5.62**	**8.32**	**11.03**
70 Days/Convection	.20	.80	1.78	3.18	4.96	7.15	9.74
70 Days/Frontal	**.26**	**1.10**	**2.36**	**4.20**	**6.55**	**9.45**	**12.87**
80 Days/Convection	.23	.91	2.04	3.63	5.67	8.18	11.13
80 Days/Frontal	**.30**	**1.21**	**2.69**	**4.80**	**7.49**	**10.80**	**14.71**
90 Days/Convection	.26	1.03	2.29	4.08	6.38	9.20	12.52
90 Days/Frontal	**.34**	**1.37**	**3.03**	**5.39**	**8.42**	**12.15**	**16.55**
100 Days/Convection	.28	1.15	2.55	4.54	7.08	10.22	13.92
100 Days/Frontal	**.38**	**1.52**	**3.37**	**5.99**	**9.36**	**13.51**	**18.39**

Locate **number** of days for your area from Diagram 1. Apply to **left** hand column here, reading **right** until you find the height of your tower above average terrain (including hill, if so located). The tabular number **is the number of lightning strikes your tower will experience** in an average year.

TABLE 1

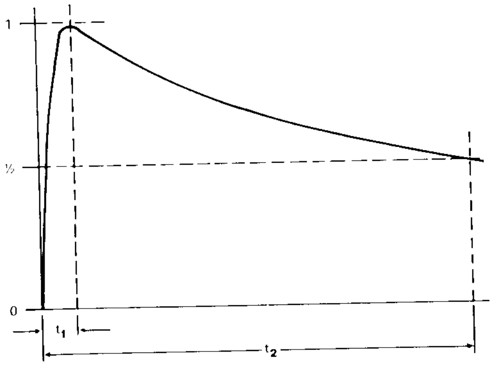
zone" for your tower to determine how many strikes you can anticipate per year. Diagram 2 illustrates the mathematics behind the computation, and Table 1 provides a handy stepped reference chart for determining what your "annual lightning liability" should be.

A good portion of the United States receives fifty days of thunderstorms per year, and a good portion of the CATV systems in the Mid-west and Mid-south have at least 300 foot sticks. Table 1 shows that even on flat ground, the tower will be directly struck an average of three times per

Lightning Waveshape

The waveshape of lightning stroke current at, or very near, the stroke point is essentially unidirectional. It has a very rapid rise time, and a tail which decays exponentially at a considerably slower rate. The customary way to define such a strike is 1.2 x 50 microseconds. See Diagram 3A. The 1.2 represents the **rise time** in microseconds, from zero value to crest current value. The 50 represents the time interval from zero (start of rise) until the **decayed level** reaches fifty percent of its crest current value.

For purposes of standardization, the 1.2 x 50 impulse voltage wave is customarily used for testing of insulation and the sparkover of gaps, insulators, and arresters. Another test, 8 x 20, is utilized extensively for testing of lightning arresters used on power lines.



WAVE SHAPE DESIGNATION OF AN IMPULSE $(t_1 \times t_2)$

DIAGRAM 3–A

year for frontal type storms in this region.

Obviously, the taller the stick, the more apt it is to be a "lightning rod" for *your square mile.* There is some evidence in lightning discharge studies that when several tall towers are grouped together (*i.e. antenna farm*), that the lightning frequency becomes something *approaching* the *sum* of all of the towers stacked one atop another, *for the area surrounding the towers.* Thus, a tiny 300 foot stick, dwarfed by nearby 600 foot or 1,000 footers, is *not* necessarily shielded by the presence of the taller towers. It may in fact receive a *larger* number of strikes than if it were sitting all by itself.

Protecting the Tower

Metal antennas are inherently *self-protected* for lightning, *provided* they are well bonded to the tower, and the tower is well grounded. Lightning almost always discharges to the tip-top of the tower, and for this reason any antenna that mounts above the top of the tower *itself* becomes "the lightning rod" for the entire tower.

Proper design of towers calls for a "cone of protection" located above the top of the tower-mounted antennas. If the top of the tower (i.e. the *very* top) has a beacon light, *it becomes the lightning rod* for the tower array. This is not necessarily good practice, as we shall see.

Metallic towers, guyed or self supporting, provide an excellent conducting path for stroke currents, *provided the base of the tower*, the footings, and the guy anchors are *properly* designed with suitable grounding electrodes. Wooden antenna support structures present unique problems, and will be covered separately.

There are two common antenna types in CATV: the log, and the yagi. The log is designed so that at frequency components present in lightning strikes (i.e. the frequency of the devastating current in a strike), the booms and elements all look like *a short circuit to ground* for the strike voltage. This is because with the whole antenna array (booms and elements) at tower DC ground, or within a few tens of ohms worst case to DC ground at lightning frequencies, the lightning strike voltage discharge path is from the antenna (if directly struck) to the tower, and then to physical ground (and hopefully earth-ground) through the tower structure.

The yagi antennas commonly utilized in CATV have the same advantage. The dipole element, if it is a 300 ohm balanced type with a built-in 300 to 75 ohm balun of some type, looks like a short circuit to the carrier wave frequency of the lightning discharge. This is because the balanced 300 ohm dipole is normally operated at boom DC ground at one point.

Where we run into trouble with antennas and lightning, normally, is where an antenna is insulated (i.e. its boom *and* elements) from the tower DC ground system, through an antenna mounting arrangement that "*floats*" the antenna *away from the tower DC ground.* In this case, if the lightning *should strike directly on the antenna array* as it "floats" off of the tower (from a DC connection standpoint), the lightning discharge then chooses the only to DC ground path open to it, which is down the transmission line.

However, even with the antenna "floating" off of the tower DC ground, normally there is a DC continuity path to the tower structure through the aluminum jacketed down lines as they are strapped or bonded to the tower in the run down the tower to the head end building (although this is very tough on downlines!). If you have a "floating" antenna mounted at the very top of your tower (i.e. where it plays lightning rod), and you feed the signal down the tower in *jacketed* aluminum down line (or jacketed RG-59, RG-11, etc), which insulates the downline from DC ground of the tower, then you have an excellent possibility that a discharge will *follow the path* from floating antenna to insulated down line to your head end equipment building. Even in this situation, there *is* one more chance to *save yourself* at the building entry point, as we shall see shortly.

The key to keeping antennas whole on the tower is to operate their booms as close to DC ground as possible (i.e. a very low impedance path to ground). One way to do this is to pointedly provide as many common-bonded DC paths to ground as possible. Each leg of the tower (three or four legs) represents an opportunity to "bond" the array to ground; so too does each down line on its run down the tower, if it is bare aluminum.

Lightning likes to follow the lowest impedance path to ground. Paralleled resistances (i.e. the resistance of all individual tower legs and down guys to DC ground from the top of the tower) create a lower overall impedance to the lightning strike to ground. Therefore, towers which are well engineered for lightning protection provide as many (i.e. multiple) direct, low impedance paths to DC earth ground as possible, thereby *distributing* the discharge currents through as many paths as possible.

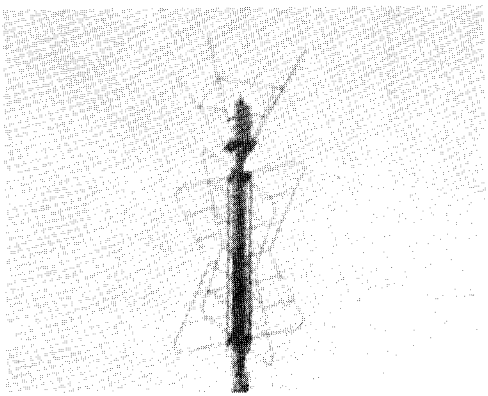
The Top Of The Tower

The *top* of the tower is the point *most likely to take the stroke.* Anything *above* the top of the *real* tower becomes the "top" *as far as the stroke is concerned,* and it becomes the "strikee".

(1) Do *not* place lights (beacons, etc.) or antennas (including search) *above* the top of the tower.

(2) If you *do* mount something other than the tower itself at the highest point, further protect the item on top with still another item—a lightning rod or a "Top Hat" as shown in Diagram 3.

Note: An antenna at the top of the tower, protruding above the light fixture, provides a "Top Hat" or "cone of protection" for the light fixture, provided the antenna does *not*



Early television broadcast tower antenna with grid-work of lightning rods surrounding light.

"float", as previously discussed. Light fixtures are especially vulnerable to strikes, as is their associated 110/220 volt wiring apparatus.

(3) Antennas mounted directly *to the tower* in the top 10 percent of the tower's effective height must be *securely bonded* from antenna mount to the tower leg or cross arm where it is attached. Simply tightening the "U" bolts to the point where the *the antenna-to-tower clamp* does not allow the antenna to move is *not* enough. Antennas mounted in this critical strike region need to be *well bonded* in a way that insures that tower paint, grease, etc. does not create a higher impedance path from the antenna to the tower than can be measured from the tower to the tower.

(4) Conduit carrying power to the lights, and the light fixture, must be well bonded to the steel tower. Again, merely clamping the fixture or the conduit to the tower is *not* adequate if the end result is a higher path impedance between the fixture and the tower. Metal (light/power) conduit must be bonded *directly* to the tower at several points in the critical top 10 percent region.

(5) Any coaxial feedlines must be likewise bonded to the tower, especially if they are in the top 10 percent region. Merely wrap-locking the lines to the tower leg may not be adequate. Aluminum or steel straps from the feedline outer shields to the tower are recommended, if they cut through tower paint and grease.

(6) If you have an antenna rotor for a search antenna, be certain it is *direct metal bonded* from its mount to the tower. Next, the power and control wiring for the rotor, which seldom if ever is available in a *shielded* format, should be installed *inside conduit* for at least the run from the rotor power inlet down the first 10 percent of the tower itself. Do *not* run it inside the same conduit as the light (beacon, etc.) power wiring.

At the point of lightning strike, and for some distance down the tower thereafter, very large voltages and currents from the lightning are present. The secondary danger, after the impact of the strike (and there is con-

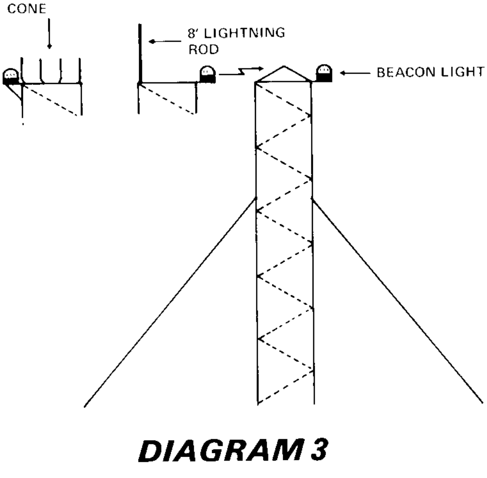


DIAGRAM 3

siderable physical power there), is *arcing.* Loosely bonded lines, conduit, mounts, and the like invite the voltages from the strike, once into the tower structure, *to arc to other physically nearby low impedance* to ground *points.* This arcing can and does burn cables as large as .500 to a crisp, melting clamps, and otherwise solid typical tower-top objects in their path. By properly bonding everything mounted on the tower top to the low impedance to ground tower structure, the *arcing possibilities are greatly curtailed.*

Down The Tower

Once the lightning voltage and current is into the tower proper and heading for DC (earth) ground, the best thing to do is to stay out of its way! The lower portion of the tower presents no particular challenges to good engineering practices. About all that is required is *keeping an eye out* for potential *arcing points* where in its flight to ground the voltage and current might want to "jump track" to something along the way that also presents an earth DC ground potential. Feedline bonding to the tower is important at the top and bottom of the tower, but along the way its value has never been proven.

At The Tower Base

As important as the correct procedures are for top of tower, the base of the tower is where the real protection is located. There are two areas where grounding techniques apply at the base of the tower:

(1) Tower legs
(2) Building entry point for all cables

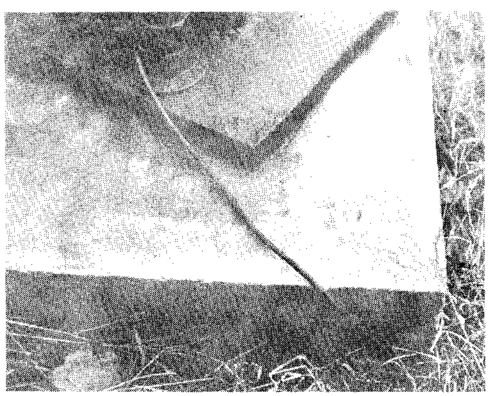
Most CATV towers are constructed by digging a modest size hole, placing a steel cage in the hole, and filling the hole with concrete. Based upon evidence "unearthed" by CATJ for this report, this cannot always be considered an adequate system for protection against lightning strikes.

There are, admittedly, half-hearted attempts at providing a tower to ground system bond. Most are similar to that shown in the photograph here; a number 6, 8, or even 10 copper wire is wired to the base of the tower just above the concrete pier and "disappears into the ground" along side of the pier. It *may* be connected to the following:

(1) Nothing—simply laying half in the ground and half in the concrete foundation or pier;
(2) The steel foundation cage;
(3) A metal (unknown composition) rod or stake set in the hole adjacent to the pier before the concrete was poured.

Professional lightning protection people would at best discount this as a source of adequate protection.

The argument is *made* that the tower bolts to a steel cage, which sets in concrete, which sets in the ground. *Therefore,* there is ground continuity from the steel tower to the rebar cage, to the concrete, and to the ground. What is overlooked is that the DC resistance (or impedance) of the steel tower to DC earth ground in this situation is usually quite high, which is another way of saying that there is not a



But is it really grounded? Copper wire bolted to the tower leg disappears into who knows what!

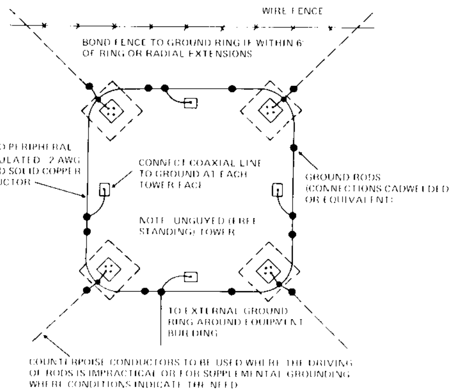
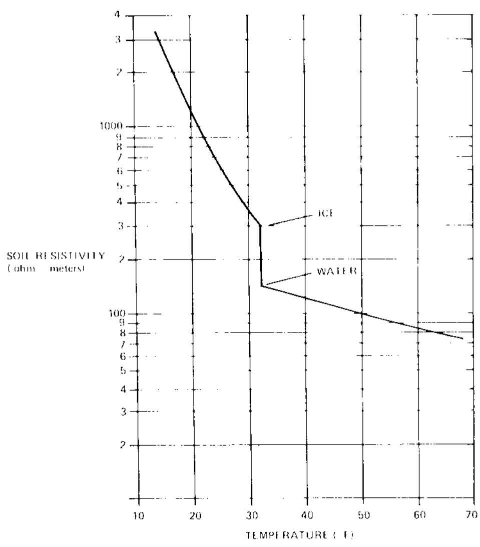


DIAGRAM 4

true low impedance path to earth ground present.

If the tower base bolts to other bolts that are welded on the steel cage, we are depending upon the pier bolts *connected* to the steel cage to conduct through the paint on the base of the tower. If the steel cage is *welded* to a short tower stub which is in turn set into the concrete pier, then the first (real) tower section *bolts* to the tower stub. Again, we are depending upon the galvanized bolts that *bolt* tower section to tower section to provide a low resistance (i.e. impedance) connection to the pier ground.



VARIATION OF SOIL RESISTIVITY WITH TEMPERATURE

TABLE 2

It is possible to provide very good immunity from lightning damage with steel reinforced concrete tower footings (and guy anchors, as will be discussed separately), *provided that* the steel cage reinforcing bars are *welded* together to ensure good electrical continuity, and *welded to the anchor bolts or short base stub tower section.* The big danger with reinforced cages sunk in concrete is that a *poor* weld or a deliberate design to *bolt* a tower stub to the steel cage before the concrete is poured will leave a *poor* DC connection. Even *within* the concrete pier, arcing can develop as the lightning charge seeks earth ground. The combination of arcing *within the pier,* plus the chemistry of concrete, can create a true explosion that could materially weaken the concrete pier, allowing the tower to fall.

Consequently, it is advisable to follow the procedure outlined in Diagram 4 for each tower leg on a free-standing tower, or Diagram 5 for the mounting plate for a guyed tower.

How Deep?

It is not unusual for a tower to be situated in an area where ground excavation is difficult. The tendency under such circumstances is for the grounding system *designer* to lay out a well-planned grounding arrangement, and for the personnel *installing it* to take shortcuts (i.e. driving an *8 foot* rod 3 feet in the ground and *cutting it off!*).

As D.W. Bodle points out in "Electrical Protection Guide . . .", the resistivity of soil changes rather dramatically *when the ground freezes.* In northern latitudes, ground freeze depths of 18 inches or more are not uncommon. Table 2 illustrates what happens to the resistance of soil when it freezes. From a ground temperature of 70 degrees F and a resistance per square meter of earth of 72 ohms, to a ground temperature of 20 degrees the resistance per square meter of earth of approximately 1200 ohms is quite a change in the effectiveness of a grounding system! Naturally, the frequency of thunderstorms *diminishes* in cold winter weather, but *when* they do occur, if your grounding system is relegated to a very poor protection system as a result of frozen ground, your chances for sustained damage *rise sharply.*

Note in Table 2 that the ground does *not* have to freeze; that it will typically freeze close to the surface and be progressively warmer as you go deeper. Even with a freeze to 18 inches, frost-type temperatures to 3 feet and more are not uncommon. Staying close to the surface with *ring ground* wires or driven rods is *dangerous* if you live in a region where ground freezes are common.

However, recognizing that some soil conditions simply do *not* lend themselves to 8 foot driven rods, the designer must *still* provide adequate protection. If he is in an area where ground

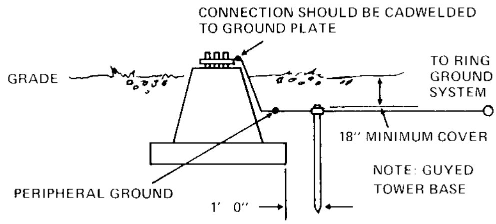


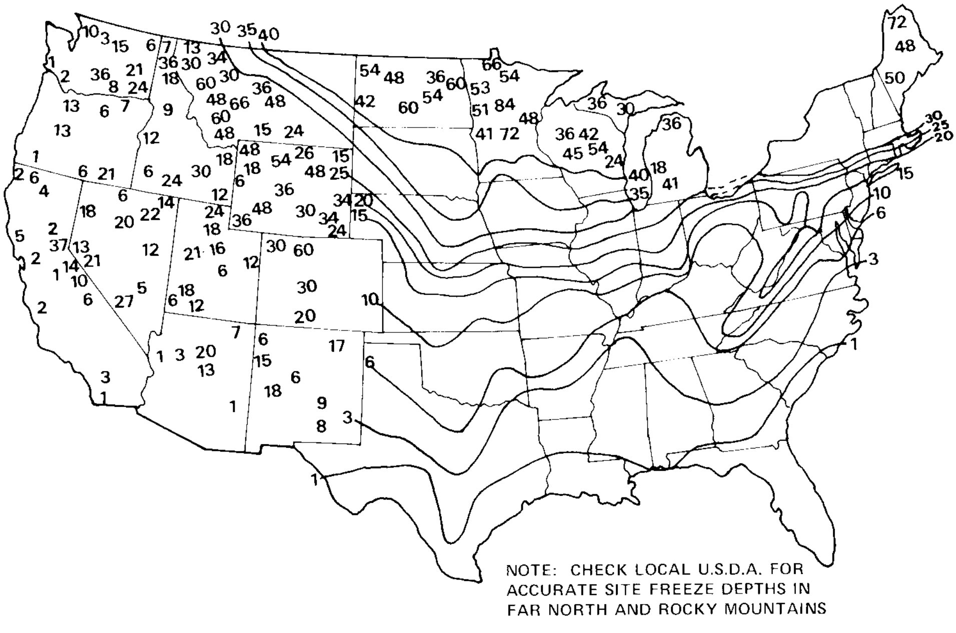
DIAGRAM 5

freezes are common, the general consensus seems to be that if he constructs a *ring ground* arrangement, to be described shortly, and encases the *ring ground* wire in a concrete footing, he has done about everything he can do.

Barring this, a *ring ground* system with numerous 8 foot ground rods *welded* to the *ring ground* (not clamped!) utilizing bare copper wire buried to a depth of 18 to 24 inches will suffice.

Ring Ground System

The heart of all lightning protection systems is the ground afforded, and



AVERAGE DEPTH OF FROST PENETRATION (INCHES)

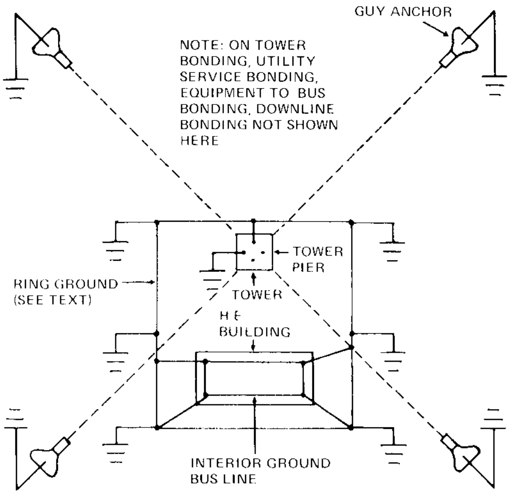


DIAGRAM 6

the path to ground for the lightning stroke or charge. By getting the strike to the base of the tower through the tower members itself, we are half way to a successful installation. In other words, by confining the most attractive to-ground paths for the lightning *to the tower* itself, we keep the damage of the strikes away from the more sensitive down lines and control wires.

Because the tower pier is seldom an adequate ground system, we must think about supplementing that system with one designed especially for lightning protection. This can usually be incorporated into a similar common ground system for the equipment building (i.e. head end) which will have advantages to additional protection requirements relating to the building itself.

The *ring ground* system consists of a buried network of highly conductive cables or wires that distribute the resistive load of the ring over a large ground (earth) area. By combining the tower *ring ground* and the building *ring ground* into either a single large ring, or into an interconnected pair of rings, we establish a *commonality* of ground (earth) potential for *all equipment on the premises.* In addition to providing superior protection against lightning discharges, the common ground greatly improves stray RF signal radiation and stray pick up within the head end facility. Many a head end suddenly looses its "touchy tuning" and "pruning" when everything in the building is connected to a common ground (earth).

The *ring ground* shown in Diagram 6 is an expansion of the *ring ground* of Diagram 5, which was for the tower only.

(1) In areas with light or no ground freezes, the #2 AWG uninsulated tinned solid copper ring conductor should be *18 to 24 inches below the grade* (ground surface) level;
(2) In areas where deep freezes are common, the same copper wire material should be buried *approximately 4 feet* in a concrete footing;
(3) In both situations, the *ring ground* wire is augmented by earth driven ground rods, 8 foot long by ¾ inch diameter, with one ground rod for every 10 feet of lineal buried ring ground wire.
(4) All connections, from *ring ground* to ground rods, to external connections such as the tower legs, to feedline grounding plate on the exterior of the head end building, should be welded, cadwelded, or otherwise affixed one to the other. *Clamps*, which cause arcing, *are not recommended under any circumstances.*

Under all circumstances, we want to keep the lightning discharge *out of the head end building,* where it is dangerous to both equipment and personnel. Normally, the only outer-to-inner path the discharge can follow is (1) the down lines, (2) the tower light power cables, (3) miscellaneous control cables such as search antenna rotor and weather instrument sensors, (4) the power mains (AC) providing operating power to the building, and (5) the trunk line leaving the building.

Down lines, tower light power cables, and miscellaneous control cables are on the *tower side* of the ledger, and are protected in the following manner:

(1) All downlines should be bonded to a *metal* plate mounted on the *exterior* of the building. The plate in turn should be bonded (*not* connector affixed) to the ring ground system through a short length of #2 copper wire.

(2) If the control cables from the weather sensors and/or the rotor control cables are *not* solid metal sheath covered, the run from the tower into the building *via the exterior located metal plate*, should be in metal conduit. The conduit should start 6 feet (or more) up the tower from the horizontal run to the building plate and be bonded to the tower. Where possible, the conduit should start 6 feet above ground, and then carry the cables to the building *underground*. It is proper to bundle weather sensors *and* rotor control wires into a *single* conduit, but do *not* combine them with the tower light power wiring, either above ground or below ground. The conduit must be attached to the metal plate on the exterior of the building, through bonding, even if it runs underground from the tower to the building.

(3) The tower light power wiring should come from the tower base to the building in conduit bonded to the tower. This wiring begins 6 feet above the tower take off point and continues to the exterior metal plate on the building, where it is bonded.

LIGHTNING DAMAGE REPORTS

As lengthy as this report on lightning damage to CATV facilities is, we believe there is more to be said. Accordingly, we are soliciting from readers the following information, for future expansion of this discussion:

(1) Photographs of lightning damage to CATV equipment, showing the extent of damage.

(2) Reports of damage, including an analysis by the reporter of where the strike apparently occurred, and **where it traveled** and did damage, before being dissipated.

(3) Summary reports on how often each year you have had to replace tower mounted electronics (pre-amplifiers, etc.), and of the extent of damage to the tower mounted gear (transistors blown, whole unit fried, power wiring burned, etc.).

A simple letter will do. We intend to collect this data in report form for later use in CATJ. All contributions will be appreciated.

Many CATV systems like to keep their downline cables *high* above ground on the entry into the building. This makes some sense from a vandalism point of view, but it also creates a long, *exposed* ground wire run from the metal exterior plate to the ring ground. It is *preferable* to locate the head end building entry point at ground level or below ground level, so the exterior metal plate is at or in the ground itself. This still *requires tieing the exterior plate to the ring ground system*, but it eliminates the dangers of *exposed* lightning voltage carrying cables and conduits at or above ground level.

If you select this method, which is the preferable one, it is permissible to place the downlines in plastic PVC (if they are not jacketed cables). Keep in mind the bonding between the downline cables must take place between the outer aluminum jacket and the exterior metal plate. There is no *good* way to bond aluminum cable jackets to steel (or aluminum) exterior plates without running the risk of damaging the relatively fragile aluminum jacket on the downline. Perhaps the best technique is to install .412, .500, .750, etc. bulkhead fittings on the plate, making very sure that the bulk head fitting *bites into the plate* when it is installed. Remember that a poor DC (high impedance) connection *will create arcing* if the lightning voltage gets that far, and that with arcing there is heat, fire, and the *possibility* of explosion. Metal plates used for this exterior building entry point should not be painted, or weather or moisture protected, until *after* the bulk head fittings have been installed and *tightened* to within a micron of their life. If the plate is painted beforehand, the effectiveness of your bond to the plate, and to (earth) ground, is diminished. The chances for arcing goes up dramatically *as the effective resistance between the two materials increases.*

Inside the Head End

With the ring ground system installed, all that remains to be protected within the building, aside from the trunk line out and power line in, is the internal grounding system for the equipment. Be certain this is effectively tied to the ring ground.

If you are building a *new* head end, it should be planned so that all equipment racks mount directly *over* bolts set into the concrete floor, which are *welded* to a reinforcing cage under the floor, that is *welded* to the ring ground system. Then, when the racks are installed to the pre-placed bolts set into the concrete, be sure that the racks are *free of paint* at the point of connection. Real purists urge you to *weld* the bolts to the racks. While that insures that no arcing is likely to take place between *pressure-bonded connections,* it may be more than the average CATV system designer is willing to do (*until* he has a head end rack *explode!*).

As a check list, here are the items within the head end which must be directly connected to the ring ground system, preferably through two or four grounding paths (see Diagram 6):

(1) Equipment racks
(2) Any equipment cases not mounted in racks
(3) All internal building wiring, through both the metal conduit which carries the wiring and the ground wire on the three wire (ground) system
(4) The metal door frame to the metal door (if one is used)
(5) The shell, case, and/or mounting frame for the air conditioner
(6) Any metal (copper or galvanized) screening used for equipment shielding, or partitions between units of equipment or racks
(7) All metal encased multiple outlet power (AC) boxes, when they are mounted so as not to be directly tied to a rack, etc.
(8) The building itself, if you use a metal building

The Trunk Line Out

There is a technique common in CATV which should send shivers and chills up and down your back. That practice is *utilizing the tower to attach the messenger strand* as you make your trunk run from the building to the first system owned or joint pole.

When you anchor one end of the messenger strand (or figure eight cable strand) to the tower, you are just *begging* the lightning stroke to travel *down the tower and into the whole system through the messenger strand.* Needless to say, this places not only your head end, but your first section of trunk plant, in a high danger area. If you are on joint poles with *proper grounding* at every end pole, plus every tenth pole, and all amplifier locations between your strand and the telco/power grounds, you have just created one very large incentive for the down stroke of lightning to *follow your messenger* straight into town, or at least as far as the first joint guy (ground)! The trunk can then carry lightning voltages in two directions. If it is *connected to the tower,* (shudder) it can send lightning voltages and currents into the plant when the strike point is to the tower. Or, if the lightning strikes on *the power/utility* or your trunk line, it can carry the damaging voltages and currents not *only on towards town,* but *right back to the head end.* If the messenger is anchored to the tower, it can feed the stuff all over your head end. So, if you fall into this category, *run,* don't walk, to the head end and get the messenger off the tower.

On the assumption that you do not feed your trunk out of the head end via the tower, the main problem with the trunk line is seeing that lightning that strikes along the trunk or utility pole run(s) does not get back into the head via the trunk line. The simplest way to do this is to take an *extra* measure of precaution with the trunk run as it leaves the building:

(1) Make sure that the trunk run is bonded to a metal plate, just as the antenna down lines were, as it leaves the building. Be certain that the metal plate is properly tied *to* the ring ground system. You may want to utilize a *separate* metal plate (not the input down line plate) for this purpose, just to be extra safe.

(2) In a new system situation, burying the trunk as it leaves the building for 20 feet or more is advisable:

(A) If you install the trunk cable in metal (conduit) pipe run a #6 AWG copper bond between the messenger strand and the metal (conduit) pipe on the aerial end of the run, and between the metal (conduit) pipe and the metal plate at building entry on the building end.

(B) If you place the trunk cable in PVC, or use jacketed cable, run a #6 AWG copper wire from a bonding point on the aerial strand *underground with the trunk cable* to the metal entry plate, where it is bonded again.

It is important to keep as close as possible to the DC potential (i.e. resistance) between the messenger strand and the ring ground system. By using 20-25 feet of #6 AWG copper to tie or bond the strand to the ring ground, you will accomplish this.

(3) With an aerial strand take off from a pole you set or have set or have set on a joint basis near the building, the aerial strand *must be connected to your ring ground* via a #6 (or larger) AWG copper wire. This is in *addition* to bonding the aluminum jacket on the trunk cable to the metal plate (and the ring ground) as you exit the building.

(4) If your trunk cable runs across an elevated hill top site for several spans before it gets down off the hill and into relatively protected low lands, and if this pole line is one of your own construction, you should consider carefully the effective "capture

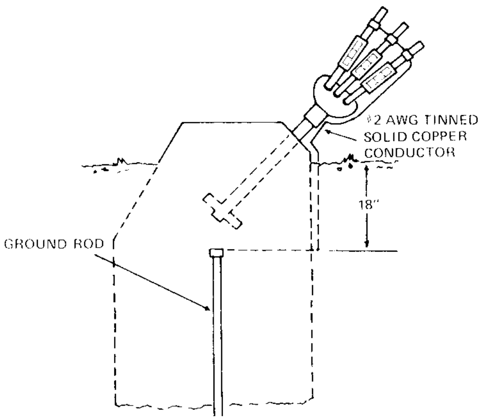


DIAGRAM 7

area" of the pole line as it meanders across the hillside to the low lands. We will investigate the "zone of influence" for pole lines later, but suffice to say at this point that the exposed pole line run presents an attractive lightning discharge point to the menace overhead. The best solution to this is to ground at every pole through an 8 foot earth-driven ground rod (8' x ¾") from strand to ground.

(5) If you are on joint poles for the run out of the head end (i.e. rural power), perhaps you should inspect how *often* they are running earth grounds along the exposed run to your head end site. A half mile run (2500 feet) of rural power line, 25-30 feet above ground, makes a very attractive discharge point for lightning. If it is grounded infrequently or not at all, as many rural lines seem to be, the "lightning antenna" draws discharges to your trunk line which hangs below.

The Guy Anchor

Grounding of the guy anchor is essentially the same as grounding of the tower base, except there is less to it. See Diagram 7. Note that the individual guy wires are bonded through a (common) #2 AWG tinned solid copper conductor that ends up in a driven 8 foot earth ground. The ground rod can be set inside of the concrete pier for the guy anchor, *provided* it is top-ended 18 inches or more below the ground level in areas where freezing is likely. In areas where freezing is not a problem, the top of the earth-driven rod can be at ground level.

Side Flashing

Some special mention should be made of the effect known as side flashing. When two side by side racks, pieces of equipment, down lines, etc. are not equal with respect to DC earth ground, a *potential* can and does build up *between* the two (or more) units. This arcing is a good way to destroy delicate connectors, and equipment.

If all lines, equipment, etc. are connected to the *same* common ring ground system, the problem is usually cured. However, in tall metal racks, it is also advisable to bond across the *top* of the racks (on the theory that the common grounding is at the base of the rack) with #6 AWG copper wire. Keep in mind that when any painted equipment (racks, etc.) or anodized equipment housings are connected together for bonding purposes, the bond must be between metal and metal.

Pole (Wooden) Mounted Installations

When antennas are mounted on wooden poles or platforms, the antennas attract the discharge, which passes to ground down the outer shell of the feedline. This is obviously *a poor choice*.

Protection requires that a *cone of protection* be provided for the antennas, and the feedlines and equipment connected thereto. By installing an 8 foot copper ground rod as a lightning rod *above the top antennas,* the discharge can be intercepted and taken to ground *around* the antenna system. See Diagram 8. The down lines should be routed down one side of the wooden pole, and the ground wire run (#6 AWG copper) should run down the *opposite* side of the pole. All antenna booms, and downlines, and other metal encased equipment housings on the pole *should be bonded to the #6 AWG copper ground wire.* If the pole is well separated from the building, it may be necessary to create a *mini-ring ground* system around the pole to bring the equivalent resistance of the grounding system down low enough to present a low impedance "load" to the lightning stroke charge. Such a ring ground system can be created following instructions given previously for a single tower, although a total circumference of 20 feet should be adequate for a 40/50 foot wooden pole. If several poles are grouped to form a platform, *standard* ring ground principals apply. A *single* 8 foot ground rod may *not* be adequate for a single pole.

If the wooden pole(s) is located near the head end building, the ring ground for the building can be designed to include the location of the pole(s), and the #6 AWG ground down lead can be bonded (welded) to the ring ground.

Wire Fences

Wire fences around the perimeter of the property or head end building are potential discharge points for lightning. If the fences run close to guy wires, buried ground rings, or other CATV system metal parts, they need to be bonded to the ring ground, guy wire anchors, etc. whenever they come within 6 feet of any metal part of your system.

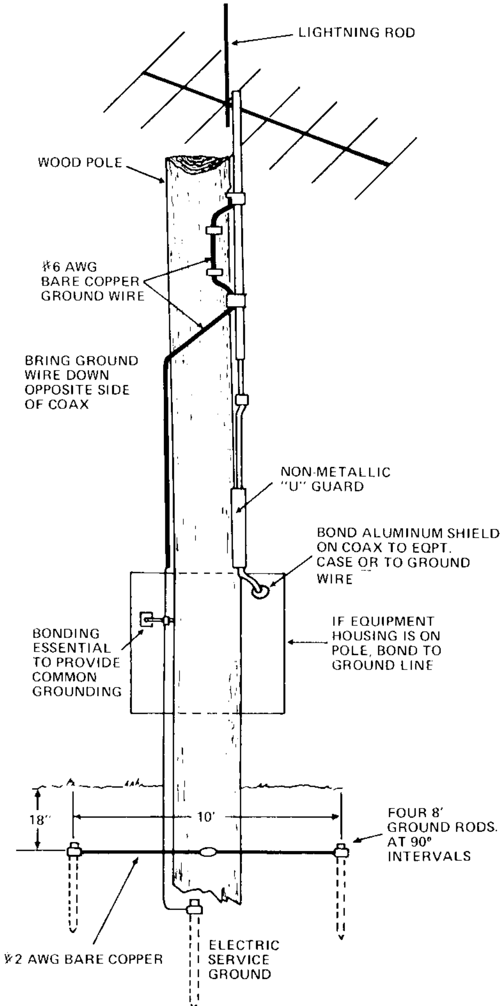


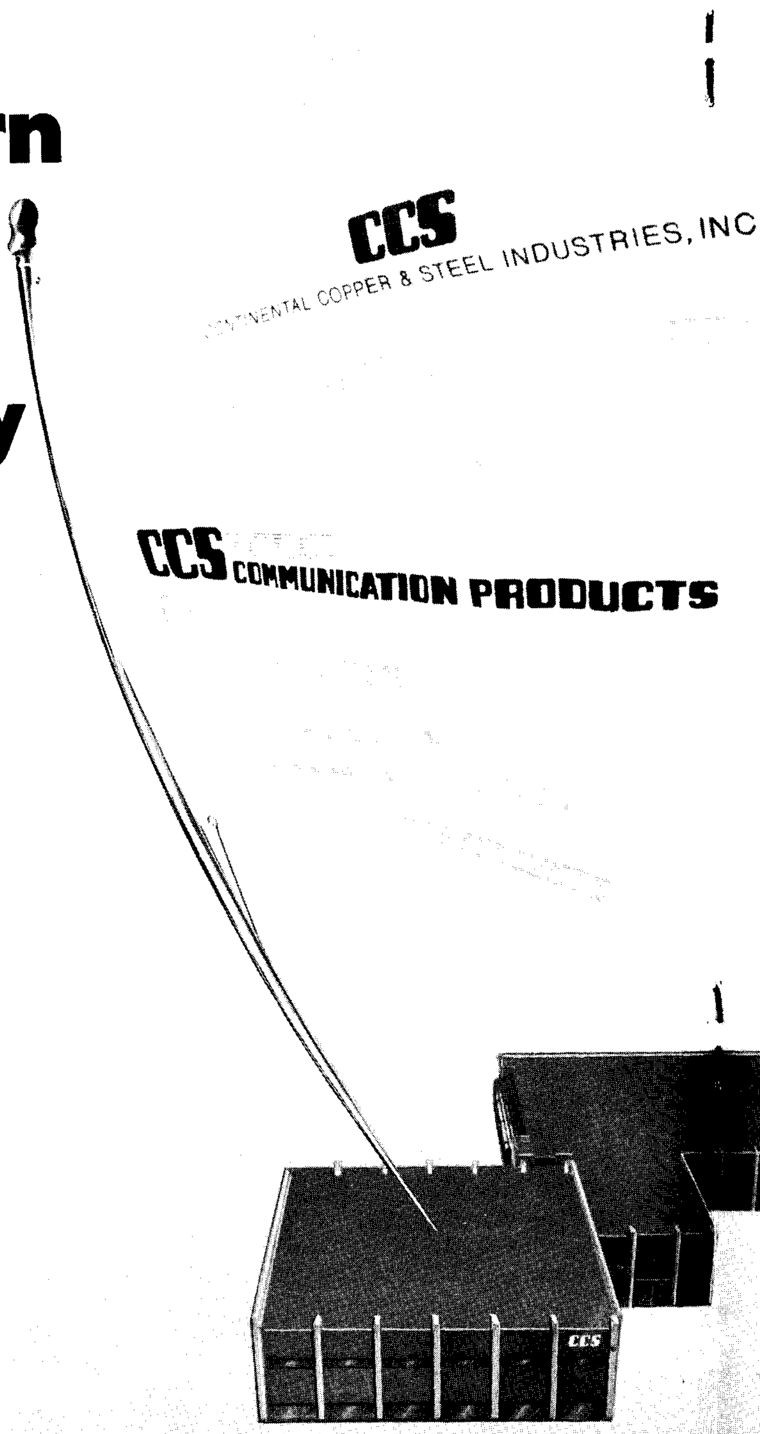
DIAGRAM 8

Protecting the AC Service Side

The design of a station grounding electrode system is very important, since this "dumping ground" for lightning strokes is in reality the only protection you have against lightning entering your building from one of several directions.

Table 2 illustrates the difference in earth resistance when temperature changes. A single 8 foot x ¾ inch diameter copper ground rod has similar

A modern banner for a mature company



... Leadership through marketing

Recognizing that leadership can only be sustained by new dynamics, new techniques, and a modern image, Continental Copper & Steel is continuing its dedication to an aggressive marketing concept.

No matter which division of **CCS** serves your market, it serves with a dedication to distribution, service, product responsibility and technical expertise that will assure our mutual opportunities.

... Since 1898

From the founding of our first division in 1898 to the restructuring of our company today, **CCS** has served each of its markets with distinction.

As we move forward we cannot forget the names Hatfield, Braeburn, Hanover, Safeguard and Continental Rubber Works which combined to form Continental Copper & Steel Industries, Inc.

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Now it is appropriate that we continue our progress with a single logo "**CCS**", to identify our singleness of purpose – to continue to distinguish ourselves in all of the markets we serve. To this end, each of our divisions has modernization and expansion programs underway to which our Board of Directors has committed millions of dollars.

It is appropriate that the **CCS** banner lead your parade for progress and greater profits.

CCS HATFIELD COMMUNICATION PRODUCTS

5707 WEST BUCKEYE ROAD, P.O. BOX 14970, PHOENIX, ARIZONA 85063

problems when the earth's temperature changes:

Soil Temp (F)	Soil Resistance	Rod Resistance
60 degrees	82 ohm-meters	32 ohms
33 degrees	135 ohm-meters	51 ohms
31 degrees	330 ohm-meters	128 ohms

Where frost penetrates below the depth of the ring ground counterpoise conductor, the effectiveness of the total ground system falls onto the earth driven ground rods. Even when the frost does not penetrate, the lowering earth temperature greatly diminishes the effectiveness of the nominally low impedance grounding system.

Thus, the tendency to start out with an 8 foot ground rod, but to "give up early" when driving it home, should be tempered by the realization that *the depth of the driven rod may be the only saving factor in winter weather.* The rise in head end "potential" (relative to DC earth ground) can be quite dramatic in cold weather.

When you start out to construct a new head end, and have the option of placing a welded steel reinforcing cage below the floor, connecting to the ring ground outside of the building, and all equipment bays, electrical conduit, etc. inside of the building, you at least are presented with the chance to do it right. However, when the head end is already installed, digging up the concrete floor to place a reinforcing cage below is infeasible.

An "after construction" system can be put together utilizing #2 AWG copper conductor attached directly to the inside wall of the building and running around the full inside circumference of the building. It should attach directly to the metal door frame, to any electrical conduit on the walls, and by way of "branch runs" tie to all equipment bays and racks. The internal ground bus must be connected to the exterior buried ring ground at several points. Buildings that measure 100 feet inside perimeter (rare in CATV) require no fewer than four interconnections (i.e. each corner) to the ring ground buried system. The connection points to the exterior ring ground need not be totally symmetrical, but where cables enter and leave the building, there should be a direct run from the interior ground bus to the exterior ring ground. This keeps leads as short as possible (thereby keeping impedances down in the ground system) at points where lightning strikes are likely to enter the facility.

It cannot be over emphasized that bonding, inspite of its simplicity, is a very effective way to protect against the hazards of surge voltages. There are two methods of reducing inductive voltages associated with surges. One is to reduce the length of the conductor (i.e. cut the length of the wire into which the surge voltage is being induced). The other is to distribute the induced current (which is inevitable) over a multiplicity of paths to ground.

Bare copper wire has long been utilized, along with copper-clad ground rods, for the construction of ground systems. The durability of such metals has been proven by long experience. However, the cost of this metal has risen dramatically and there has been some use of more passive (i.e. higher resistance) metals. One acceptable step in that direction, which also contributes to a lower longer term corrosion (stability) for the grounding system, is the use of stainless steel ground rods (alloy #304 or higher) and interconnecting the rods with bare tinned copper wire.

When installed indoors, or outdoors where protection is afforded, #6 AWG copper wire is electrically adequate for bonding and grounding. For *direct* burial, #2 AWG solid copper is preferable because it holds up well to mechanical stresses. A solid conductor is preferable to stranded conductors for burial because it holds up better to corrosion.

For the *interior* ground bus, *stranded* #2 AWG copper is acceptable since corrosion should not be a problem.

Some form of metal fusing, such as cadwelding, provides an effective and durable means of connecting the components of a grounding system together. *Pressure connectors are not recommended* because they tend to loosen in time, and corrode. Once they loosen, the resistance of the connection rises sharply, even more sharply as corrosion sets in. This diminishes the overall low resistance (impedance) of the ground system and creates a point where arcing can occur and possibly create an explosion.

Any lines entering the head end can bring lightning surges *into* the building, *or* act as an outward bound path for strikes to the tower array. Normally, lines coming in are power and telephone. Rightfully, we are more concerned about surges coming into our head end from strikes on the power or telephone lines, than we are with surges passing through the head end into the inward bound power and telco lines. Still, if a strike hits our tower, flows through the head end and knocks out the inbound power and/or telco service, *we stand the loss of service just the same* (even if not the direct cost of repair). So, it behooves us to protect our system for both inbound and outbound surges that travel along the utility lines.

The utility pole lines and/or your trunk line out of the head end represent the same type of hazardous source as your tower, only it is lower to the ground and has some protection by virtue of its low provile. Still, on runs across rural country, the pole line is often the tallest thing around and it takes its lumps. Based upon frontal type storms (0.37 strikes per square mile per storm) and fifty thunderstorm days per year, the odds shape up like this for 30 foot poles:

Total Pole Run Length	Strikes For Run/Per Year
10 poles	0.17
20 poles	0.34
30 poles	0.68
40 poles	0.84
50 poles	1.01

Thus, if you have an exposed fifty pole run into town, where we theoretically have better "shielding" protection for the poles, and are located in an area where fifty thunderstorms per year occur, you can count on the pole run of fifty poles to get zapped at least once each year. If your pole run is on one set of poles, and power is on another pole run, then your total exposure is the sum of all of the poles around you leading to or from the head end.

Keep in mind that the "strikes per year" are calculated upon square miles of area, and that within the immediate square mile of your tower, your tower is probably the dominant feature. It will take *all or most all* of the strikes, unless it is "shielded" by other nearby taller towers. The poles close to the head end, or those within a radius of the tower base equal to 3 to 4 times the height of the tower, will seldom be struck *directly*. Once you get beyond a distance of 3 to 4 times the tower height from the tower base, any poles so located are prime targets for lightning, if they are not shielded by other (numerous) tall objects.

The Run To Your Head End

How the utility brings service to your head end effects the type of lightning protection required. Elevated sites, which are common in CATV, are generally on rocky soil which presents a much higher resistivity than a low lying marsh area, or flat area with moist soil.

Open wire utility plants have substantially higher insulation strength than paired cables. The likelihood of lightning *damaging an open wire sys-*

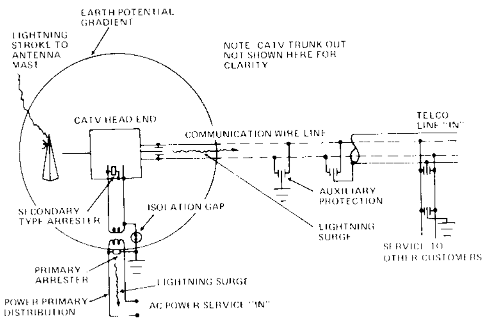


DIAGRAM 9

tem is not great, because they can support higher voltage surges than lines constructed from paper insulated cables. Consequently, where open wire utility lines interface with paired or covered cables, special protection measures should be taken.

Wire plant serving a CATV head end (see Diagram 9) should be terminated on the outside of the building, permitting the ground lead from the protectors to be run directly to the external buried ring ground. The duty on these protectors will be severe, deeming it advisable to use *gas-tube protection* to reduce the possibility of permanent (i.e. shorted) grounding. Gas-tube protection may be applied in either of two ways:

(1) Combination of fail-safe gas tubes in a fuse-type mounting, listed by UL for this purpose;
(2) Gas tubes in parallel with the carbon blocks in a UL listed fuse-type mounting.

In the case of telephone protector mountings, connector blocks, and terminals, a dual element gas tube can be conveniently mounted.

Where the open wire plant junctions with plastic insulated cables (PIC), protectors should be applied to all wires entering the PIC cable. This is another situation where gas tubes, rather than carbon blocks, are preferable because they are *less apt to fuse* and become permanently grounded. Paper shielded cables should be avoided at the CATV head end, as they are especially vulnerable to flash-thru.

Another means of reducing surges on open wire transmission systems is to provide auxiliary protection by installing protectors between each line wire and a ground electrode (8 foot x ¾ inch ground rod) within a quarter to half mile of the CATV head end. Where possible, selecting the ground electrode point by virtue of superior, less rocky, more moist soil, will increase the grounding protection. Gas tube protectors are recommended in this situation.

When the CATV head end is fed by telco lines with a metallic sheath cable, the diameter of the metallic sheath cable is usually quite small. This means the shield resistance of that cable is quite high. Consequently, very large voltages can be produced *between the inner conductors and the shield* by surge currents of even moderate intensity. Because of the severe nature of the exposure around a CATV tower, metallic and paper sheathed cables are simply not advised for service runs to the CATV head end. It behooves the cable operator to point this out to the telco personnel planning your installation, and to ask for PIC in the installation.

Above Ground Entry

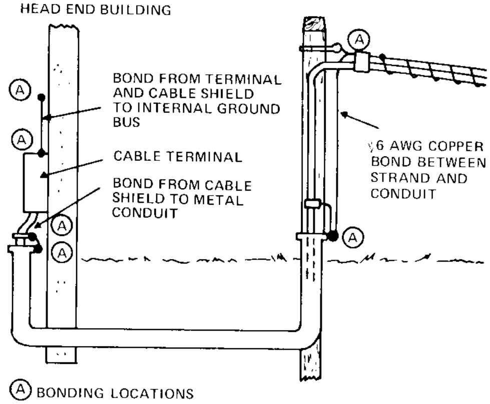
The above ground entry comes to your head end in much the same way you will probably leave your head end with your trunk cable—utilizing a messenger cable to support the utility cable. See Diagram 10. The messenger (or neutral) power service cable should be connected directly to your exterior ring ground system.

Below Ground Entry

Lines brought *into your head end below ground* have several advantages, although the initial expense is higher than aerial construction.

The actual distance (from the head end to the building) you bury the incoming lines is not critical unless you are able to get the utilities to bury for a distance equal to, or more than, 3 to 4 times the tower height. This is the preferable method, since it eliminates any opportunity for "flashing" from the above ground tower to the incoming utility lines. It also reduces the amount of "metal hanging in the area" around the head end, thereby reducing the overall liability.

Barring this, if the utility service lines can be brought in for the last 20 feet underground, there are some advantages to be realized. Diagram 11 shows how the utility strand, the metal conduit (if such conduit is used), the cable shield (if there is one), and the cable terminal are commonly bonded not only together, but to the exterior ring ground system and the interior ground bus system.



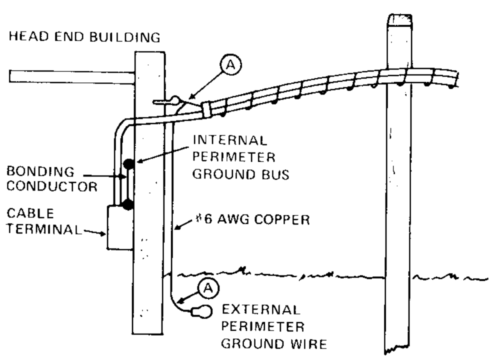
GROUNDING OF CABLE, SUPPORT STRAND, CABLE SHIELD, AND TERMINAL (BELOW EARTH BUILDING ENTRY)

NOTE: IF NON-METALIC CONDUIT IS USED, OMIT BONDS TO CONDUIT AND CONTINUE THE 6 COPPER CONDUCTOR THROUGH THE CONDUIT WITH THE CABLE AND TERMINATE IT ON THE GROUND LUG IN THE CABLE TERMINAL.

DIAGRAM 11

Protection of Equipment

Everything thus far has been related to providing protection to the building; that is, equalizing all potentials inside and outside of the building so that high resistance paths do not develop dangerous voltages. Naturally, if there is any way to keep the strike voltage out of the building, we want to do it. Following the guidelines given here, you will be able to provide the maximum extent of protection CATV head ends can realistically afford.



GROUNDING OF CABLE SUPPORT STRAND, CABLE SHIELD AND TERMINAL (ABOVE EARTH BUILDING ENTRY) INDENTIFIED AS (A)

DIAGRAM 10

Still, the danger of surges and transients for head end equipment remains. The unique low voltage ratings of solid state CATV gear employed at most head ends presents unusual protection problems for head end gear. For economic reasons, CATV head end equipment is frequently designed with small inverse voltage safety factors. Even transients, created by the switching of AC power sources (i.e. at the sub stations or power sources), are dangerous to semi-conductor rectifier devices.

It is generally recognized that while a typical CATV head end may be treated to a direct lightning strike only a few times per year, the frequency of lightning-induced surges along and through the AC power mains *may be from 2 to 5 times as great.*

Such surges, in addition to normal switching transients encountered in many rural areas on a daily or weekly basis, often exceed the capacity of solid state protection devices normally built into CATV head end gear. Naturally, if the ratings are exceeded for a sufficient length of time, the solid state components fail. However, it should be noted that there are two basic approaches to surge protection:

(1) *Detect and shut down* — Through the use of very fast switching circuits, the presence of a voltage surge is detected and the AC power circuit is disconnected from the load for either a timed period, or until the surge has leveled off at the normal voltage level.

(2) *Swamping*—By employing very large inductors in the AC power circuit, the sudden surge voltages are "swamped" by the natural action of a large transformer-inductor. In effect, the surge is dissipated in the constant voltage transformer.

Lightning potentials in communication plant systems are primarily longitudinal (i.e. *conductor to earth* in flow), but metallic voltages (*conductor to conductor*) develop because of resistance (impedance) imbalances. These imbalances can develop at a multitude of locations within a head end, and *even within* a discrete piece of processing equipment. One study of a remote communication facility found that in a total of ten thunderstorms, there were 249 surges ranging from 40 volts to 550 peak volts across a pair of discrete wires located inside a metallic sheath cable. The range 40 volts to 550 volts is important because there is a "window region" here where normal air gap and line protectors do not perform (they normally start to function at some voltage in excess of 500 volts), and where solid state devices fail. Generally, voltages from the operating voltage up to approximately 100 volts are protected by available solid state diodes. Between 100 volts and 500/550 volts there is an area for some concern, especially in older solid state gear produced before the latest advances in diode technology.

Diodes are chiefly employed for protection from metallic voltages, since most head end equipment is transformer operated, and transformers, *assuming* they have adequate swamping capacity, interrupt longitudinal path surges. Generally, the dielectric strength of transformers, with respect to DC ground, will exceed 500-600 volts, and discharge gaps (i.e. external lightning protection devices on the AC line) will provide adequate voltage limitation above the rating of the dielectric protection or break down value for voltages that exceed this value.

The first step in reducing the magnitude of power line surges entering a CATV head end is by the use of lightning arresters on the AC secondary service conductors. The preferred location for these arresters is the service weather head. See Diagram 12-A and 12-B.

Experience has shown that a 175 volt secondary arrester will provide dependable protection for equipment such as tower lamps (motors, heaters, etc.). However, such arresters are *not* adequate for protecting solid state equipment.

For protection of solid state equipment, low voltage arresters are required. They are usually installed on the AC distribution circuits within the head end, or on AC power strips mounted on each rack. When an AC voltage regulator, such as a SOLA CONSTANT VOLTAGE TRANSFORMER, is installed between the AC secondary service power box and the AC distribution lines within the head end, this will normally protect against surges in the low voltage range elimi-

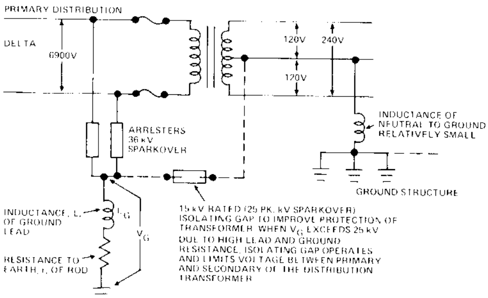


DIAGRAM 12-A

nating the need for a low voltage arrester circuit.

When the entire head end operates continuously from a battery bank, the batteries provide an excellent "dumping ground" for surges. However, the use of a battery bank does *not* negate the need for arresters across the secondary service (i.e. at the weather head or service entrance). The batteries operate through a typically solid state diode trickle charging system, and the rectifier diodes *still require* some large value surge protection, even if they are looking at the AC power mains through a transformer.

Myths About Protection

Some effort at definitions is desirable because of the many myths which have developed through the years about lightning protection:

An *arrester* is a discharge device used on power circuits to limit abnormal surge and transient voltages. The *arresters* in use for equipment protection are normally rated for 600 volts or less.

A *protector* is a simple discharge (air) gap device used on communication circuit equipment.

Arresters are utilized on circuits having appreciable, steady state voltage (i.e. 117 VAC). Therefore, a simple discharge gap (i.e. protector) would continue to conduct steady state current, after the abnormal surge which initially operated the gap has attenuated to a safe or normal value. The steady state current flowing through an arrester, after the surge has attenuated, is referred to as "power-follow current". It cannot be tolerated for any appreciable time because current disconnect devices will operate and deenergize the circuit, and the arrester will be damaged. It is necessary, therefore, that arresters incorporate some type of "clearing mechanism" in addition to the discharge gap to promptly interrupt the flow of power-follow current. Clearing on DC circuits is much more difficult than on 60 Hz circuits. Consequently, typical clearing voltages for one given type of arrester are usually given as "50 V dc, or 175 V rms, 60 Hz".

The arresters which the power utility installs on its primary circuits adjacent to a transformer (i.e. service step down transformer) are intended to protect the transformer *exclusively.* They do not provide protection for the secondary circuits and the associated CATV head end equipment. Diagrams 12-A and 12-B show the location of such a benevolent gift from the power utility, and the location of additional protection which you, the user, must install. In this diagram, if a primary voltage of 7.2 kV is assumed, the arrester would have a sparkover value of 24.0 kV (crest) on a 1.2 x 50 microsecond wave. These protection values do not offer any protection to the secondary voltage user.

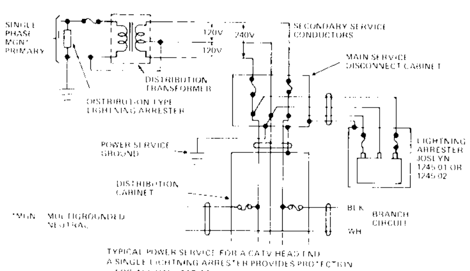


DIAGRAM 12-B

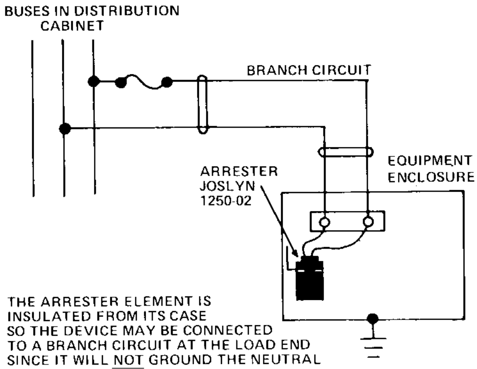
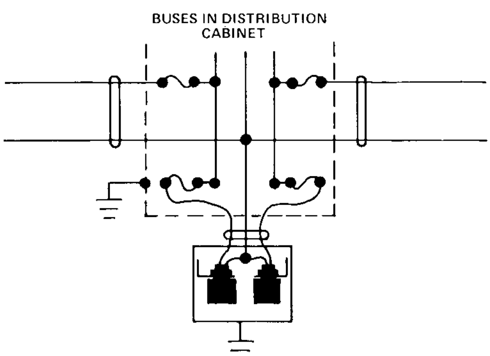


DIAGRAM 13

Get After the Power Company

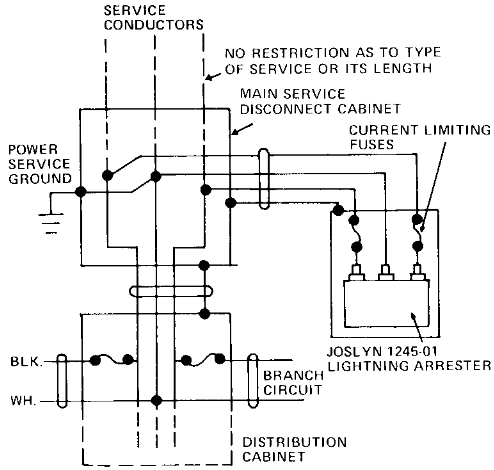
In Diagram 12-A, we have a scheme to provide increased reliability *for the service transformer* feeding your head end. This technique places 36 kV sparkover arresters on each leg of the delta distribution system primary, and an isolating gap (sparkover device), properly rated, from the neutral of the MGN system back to the grounding electrode lead on the primary side.

Most power company grounds depend upon a single earth driven rod (8 feet if the installation crew isn't lazy!). On the other hand, your CATV system head end ring ground system, if you follow the suggestions here, has a much lower resistance with respect to ground than the power company single rod. Naturally, it behooves you to *ask them to connect their ground* on their service pole *to your ring ground system.* Normally, the power utility will cooperate with you on a *common ground connection,* since they know all too well the grief they can have with *their* power line into *your* head end location if adequate ground precautions are not followed.



JOSLYN 1250-02 ARRESTERS MOUNTED IN A METAL ENCLOSURE AND CONNECTED THROUGH FUSES TO DISTRIBUTION BUSES

DIAGRAM 14



SINGLE ARRESTER PROTECTS ALL STATION UTILIZATION EQUIPMENT

DIAGRAM 15

Three Simple Secondary Arrester Schemes

Diagram 13 shows how to prevent surge damage to a single piece of equipment through the use of a Joslyn Model 1250-02 arrester installed at the load end, with the arrester floating above ground.

Diagram 14 expands the single unit/single arrester concept to the commonly found AC power bus found wired into CATV head end racks.

Diagram 15 takes the single arrester approach to service for the entire head end, by placing the arrester across the AC input line(s) in the main service disconnect box.

TRANSIENT CLIPPER FOR CATV POWER SUPPLIES

SELECTING "PAPERS" FOR PUBLICATION

The publication of this paper by Bob O'Hara, of Theta-Com, marks a departure from the CATJ format of nearly one year. Our format has called for internal generation of articles, reports, and papers for publication. Material submitted has been handled through our Technical Topics column, or through melding into other similar material, by our staff, into a complete report.

In the future, articles or papers prepared by readers will be considered for publication provided (1) you make inquiry as to our needs, and for our suggestions on particular slants or depth we feel might be required for a topic, and (2) that commercialization for particular products or concepts be avoided.

To be considered for publication, all material must detail not **only** a solution to a problem, but the problem itself. Solutions (often disguised as products) are useful to CATJ readers only when all facets of the problem itself are covered by the author.

Product mention is certainly not taboo, but thinly disguised product data sheets prepared as "articles" are not likely to find space in CATJ.

Address inquiries concerning publication material to Editor-in-Chief, Bob Cooper.

TRANSIENT CLIPPER

By:
Bob O'Hara,
Product Sales Manager-CATV
THETA-COM Subsidiary of
Hughes Aircraft Company

Transient caused outages and equipment damage in the CATV industry has been, and continues to be, a very costly factor to the CATV systems operator. An extensive investigation of protective devices aimed at preventing transient damage has resulted in the development of the *Transient Clipper* by Theta-Com. The *Transient Clipper* is intended to prevent damage from one source of transients. For discussion, we may categorize transients into two types:

A. Transients that are caused due to power line faults, power line load changes, and lightning effects transmitted from the power lines into the CATV power system.
B. Transients caused by power line disturbances and direct lightning or atmospheric effects coupled into the strand or coax of the CATV system.

The key point in diagnosing and treating the transient ills is knowing where they enter the cable system (see Diagram 1).

1. The Transient Clipper will protect against those transients ("A"

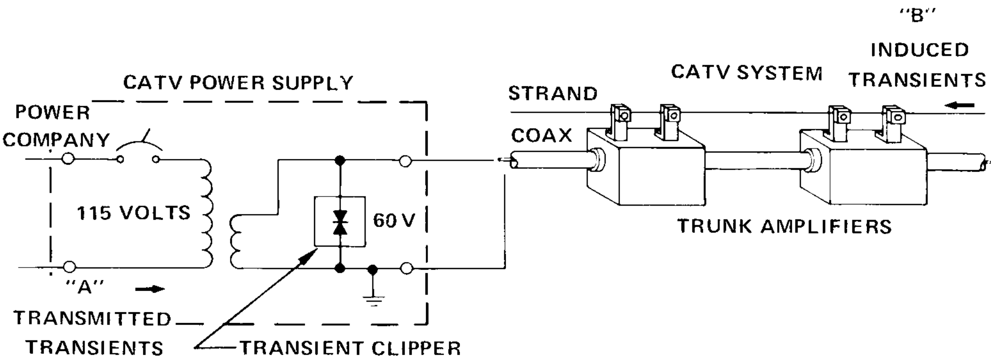


DIAGRAM 1

type) coming through the CATV 60 Hz power supply. It will *not* protect against the "B" type transients entering from the coax and strand direction. These will be discussed in the latter part of this report.

2. The difficulty in handling transients is clarified if we look at the nature of transients, i.e. rise time, duration, and particularly the magnitude of the currents and voltages.

Direct lightning strikes have had the following recorded:

Current:
 10,000 amps avg. to 160,000 amps max.
Rise time:
 12,000 V/usec
Voltage:
 72,000 V
Waveform Definition:
 6 x 20 is a standard test waveform for typical lightning strikes. The first number (6) is the rise time, the second (20) is the time to decay to ½ amplitude, as shown in Diagram 2.

Power line surges resulting from switching load transients can range from one usec to the larger part of a second. Currents of 2,000 amps and voltages of 15,000 volts are not uncommon. Higher and lower values for transients can be cited, and *when compared to the 24 volt transistors we use,* the magnitudes are formidable!

The lack of adequate transient protection (assuming you are in an area of high transient activity) can be expensive in maintenance cost, equipment damage, and most serious, loss of customers. Equipment damage includes expensive R.F. transistors, power supplies, and passive devices.

This damage will occur from transients coming either through the power supply, or from the other direction down the coax. Let's look at how the Transient Clipper protects the system from transients which enter through the power supply. The typical waveform from a ferro-resonant supply is shown in Diagram 3. The peak value is 62 to 72 at full load and no load respectively. The Transient Clipper is connected across the 60 volt (rms.) terminals and will conduct when the peak voltage exceeds 91+/—% in either a positive or negative direction. This is done by a network of avalanche (zener) diodes. The voltage and current waves of the Transient Clipper and two other devices are shown in Diagram 4.

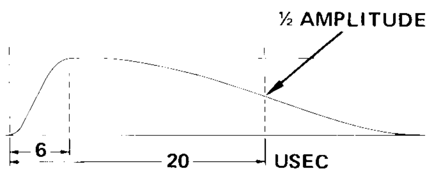


DIAGRAM 2

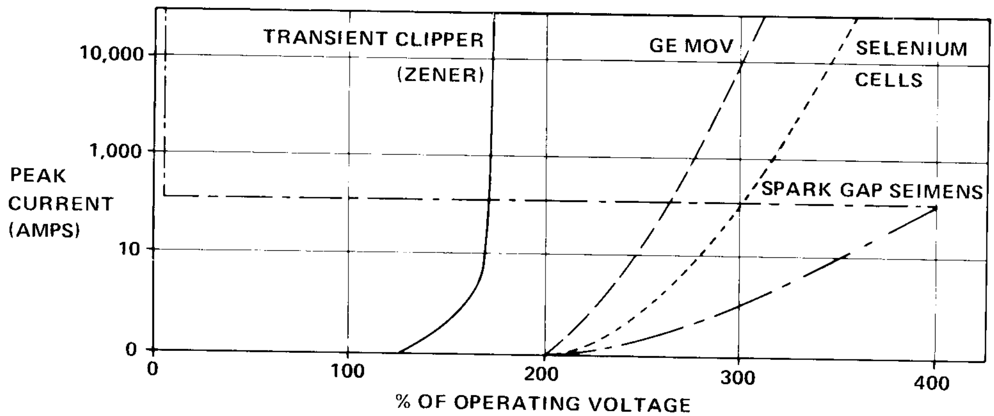


DIAGRAM 3

Characteristics of the Transient Clipper—

The sharp curve (zener characteristic) allows the breakdown voltage to be set reasonably close (130%) to the operating voltage. Other devices used start at 200%, and some go to 400% voltage, before complete breakdown. When the Transient Clipper conducts, *it clips above 91 volts*, but does not present a low impedance or short circuit, as does the spark gap device. The turn on and off time is very fast at 10-12 seconds (*one millionth of one microsecond*). It has a peak power dissipation rating of 15,000 watts and a peak pulse current rating of 300 amps. The small size of the Transient Clipper allows it to be easily mounted in the power supply housing.

Problems Cured by the Transient Clipper

Ferro-resonant type power supplies (which are used by the majority of CATV systems) produce a voltage transient of *2 to 3 times rated output voltage* when turned *on*. This will decay to normal voltage in 2 or 3 *cycles* of the 60 Hz frequency. The Transient Clipper will clamp these at a lower voltage than the spark gap type devices. The spark gap units at times would not turn off due to the power supply short circuit current. When they do not turn off, they will destroy themselves by melting leads or solder joints in the associated circuitry. The Transient Clipper does not have this problem as it turns off at approximately 91 volts peak.

Experience with Transient Clipper

The basic circuit device in the Transcient Clipper has been used in airborne electronics equipment to protect voltage sensitive components from large voltage transients. The device was tested in the Theta-Com Engineering Laboratory and subsequently in-

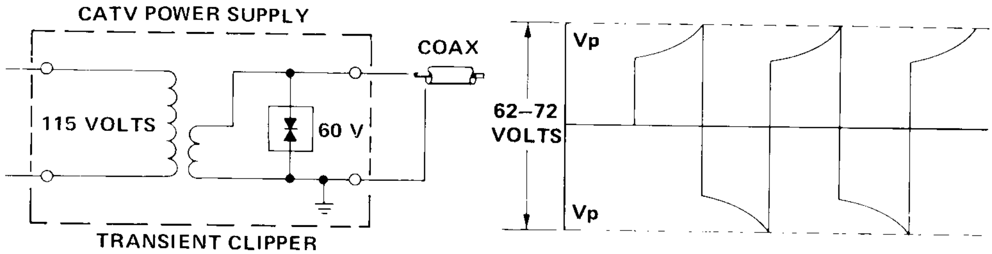


DIAGRAM 4

AEL HAS CLIPPER

Transient clipper Model TZ-1 has recently been announced by AEL. Model TZ-1 connects to the output winding of the cable system power supply and can be used with either 30 or 60 VAC systems. The specs are as follows:

(1) **Peak pulse power dissipation**—15,000 watts at 70 degrees F
(2) **Clamping time**—10^{-12} seconds
(3) **Max Peak Pulse Current**—300 amps
(4) **Peak Clipping Voltage**—91 volts, +/— 9 volts
(5) **Net Price**—$29.50

A copy of a data sheet on the TZ-1 is available from AEL Communications Corporation, P.O. Box 507, Lansdale, Pa. 19446.

stalled in several systems that were experiencing severe transient problems. The resulting reduction in transient damage and outages has been dramatic in most cases.

Category "B"—Induced Transients

Coax Sheath & Strand

There still remains trouble areas in these systems that continue to experience blown fuses and transistors. These problems typically were from transients entering the cable system *via the coaxial cable and strand.* Theoretically, the Transient Clipper could be used at the *individual* amplifier *power supplies*, and would provide *some* protection in these situations. However, it has not been evaluated in this use; it would only be a band-aid type fix, and not the proper cure for this type of transient.

Other protective devices presently in use include fuses, spark gaps, etc. and they prove useful. Many times they create a secondary problem by doing their job of protecting equipment, but creating a system outage in the process. The most important consideration for system protection from this type of transient is a good grounding system. To understand what a "good" grounding system is, let's look at a simplified example of how the transients are produced (see Diagram 5). Surge currents in the power strand and lines produce a magnetic field which, by fundamental principles of inductive coupling, *produces a voltage in the CATV strand and coax sheath.* This voltage produces current which flows toward the best ground point, as does the surge current in the power strand.

There are three grounding situations shown in Diagrams 6A, 6B, and 6C which are significant. In all three situations it has been assumed that the surge current in the power strand is

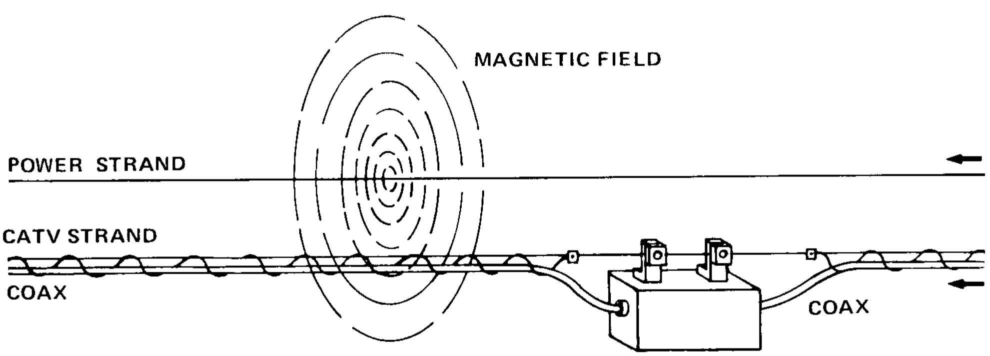
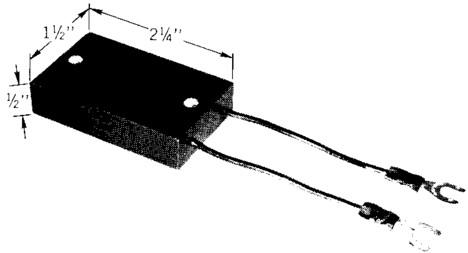


DIAGRAM 5



Theta-Com Transient Clipper is totally encapsulated, simple to install.

5,000 amps, and a surge has been coupled into the CATV strand and coax sheath of 1,000 amps. A ground resistance of 5 ohms has also been assumed.

Diagram 6A, the CATV strand is "strapped" to the power strand, and the sum of 5,000 and 1,000 amps flows through the common ground resistance of 5 ohms, producing a voltage at the amplifier case of 30,000 volts.

In Diagram 6B, a separate ground lead and rod have been installed on the CATV strand which is still strapped to the power strand. The total surge current of 6,000 amps divides equally between the two grounds, and produces 15,000 volts (3,000 amps x 5 ohms) at the amplifier housing. This is a 2 to 1 improvement over Diagram 6A.

In Diagram 6C, the strap has been removed from the power strand, allowing the surge current in each strand to follow the separate grounds installed on each system. The 1,000 amps in the CATV strand will produce 5,000 volts (1,000 amps x 5 ohms) at the amplifier housing. This is a 6 to 1 improvement over Diagram 6A.

The above is intended to illustrate the problems that can be encountered in grounding systems, and the importance of low ground resistance. There are "attachment" requirements, in many instances, necessitating strapping to power grounds. However, many systems having consistent transient problems are able to cure them *only by removing the strap.* This was done after all other remedies had been tried. A good grounding system is necessary to reduce the high transients to a minimum before they reach the equipment. If this is done, then various protective devices stand a better chance of protecting the equipment.

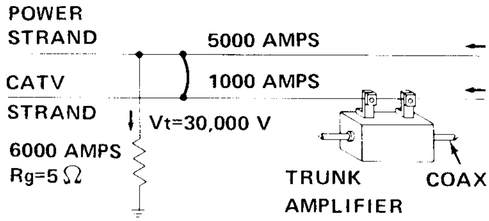


DIAGRAM 6-A

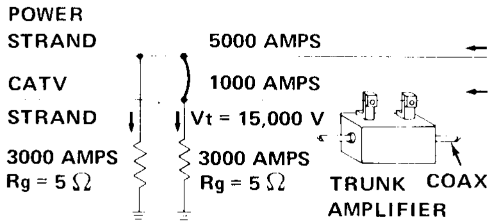


DIAGRAM 6-B

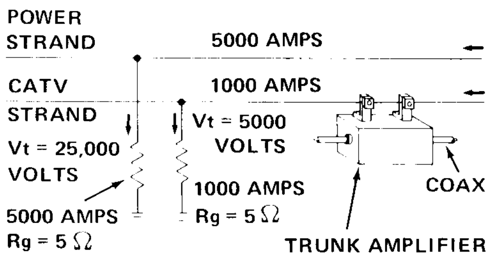


DIAGRAM 6-C

Transistor protection is provided by the spark gap (Siemens) devices. They are the *only devices* in use that have a suffieiently *low* capacitance to attach directly to the center conductor, *without* effecting the RF signals significantly. In the future, a low capacitance device having a zener-type characteristic would provide a significant improvement, and reduce the number of R.F. transistor losses. Use of the Transient Clipper and a good grounding system have proven to be a satisfactory solution for many systems that have been plagued with transient outages.

CATJ REVIEWS ARVIN 500B SLM

Basically Different

In our four month series on field strength meters (October/November/December 1974 and January 1975) CATJ looked at the design criteria and basic meter operating habits of five popular CATV SLM/FSM devices. In the course of that series, we developed some basic operating data about virtually all instruments on the market, and found a number of areas where even the most expensive instruments had potential, if not real problems.

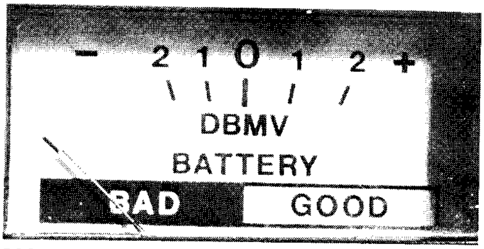
Our primary continuing concern as we developed that series was the *accuracy of absolute calibration* to make real *FSM* test measurements in hard numbers. We found meter scale linearity and detector efficiency were two criteria that continually caused problems for meter designers. Readers who have not reviewed that four part series are well advised to do so at this time.

The *Arvin Systems, Inc.* Model 500B signal level meter is very new on the CATV scene. Attendants of recent CATV trade shows have had the opportunity to see this meter and discuss its design philosophy with Arvin's Jack Cauldwell, but very few operators have had this new instrument in the field.

When the previous four part series on SLM/FSM devices began, Arvin contacted CATJ and asked if they could provide us a meter for evaluation. We said, "*Sure*, send it down." In mid-December Jack Cauldwell, accompanied by engineer Paul Buddendeck, *brought* a meter to Oklahoma City for a one-day evaluation and learning session.

The 500B meter approaches the measurement question from a new direction. The premise behind the unusual approach is to "eliminate meter scale non-linearities and detector efficiency problems" that translate into errors on the meter-scale display.

ARVIN SYSTEMS, INC. Model 500B covers 5-300 MHz with 36 pre-programmed push buttons for channel selection



500B meter scale reads over 4 db range; you zero level to "0" point and read real level on calibrated attenuator

500B calibrated attenuator "windows" read out level of signal after user "zeros meter"

Most meters have a mechanical/electrical display range, via a meter movement, of from 20 to 30 db *per range.* The 500B does not; its display range is 4 db. The designers of the 500B have limited the meter display range to a very narrow segment of the dbmv scale on the theory that by operating the whole unit (*including* detector) within a range of +/— 2 db, the errors that creep into 20 or 30 db scale width meters are eliminated, or greatly curtailed.

The "heart" of the 500B then becomes the front end switchable attenuators, a system of 10 db and 1 db step attenuators in a rotary configuration that allows the user to sum the 10 db range with the 1 db range to have 1 db steps from -30 dbmv (-32) to +60 dbmv (+62).

You *operate* the meter differently than other meters, because your scale-window in your display is limited to +/— 2 db. On the assumption you have *some* idea what the signal range is, you "crank in" the appropriate amount of 10 db attenuators to be the ball park. Then you "fine tune" with the 1 db step attenuator until the meter reads *zero* on the +/— 2 db window shown on the meter face. When the meter reads zero (see photo) the true signal level is determined by looking at the calibrated scale on the attenuators. What they read out, while the meter scale is "zeroed", is the level you have.

With that *basic description* of how the 500B differs in operation from other meters, let's see what is inside of the "black box".

As Diagram 1 shows, the input signal (over any range from 5 to 300 MHz) first sees a set of precision rotary attenuators, 10 db per step and 1 db per step, as previously explained. Following the step attenuator is a broadband RF pre-amplifier, which has circuit *temperature compensation* for high (frequency) end equalization.

Following the pre-amplifier is a double balanced mixer (Mini-Circuits SRA-1). The double balanced mixer sees the RF input from the input F connector, plus, it *also sees* a variable carrier frequency oscillator (i.e. local oscillator) that operates at some adjustable frequency between 205 and 355 MHz. The product of the input signal (say 50 MHz) and the VCO (say 305 MHz) is the first i.f. at 355 MHz. How the local oscillator is derived will be covered shortly.

Following the 355 MHz output mixer is an i.f. filter, at 355 MHz, and then a *second* mixer/conversion stage. This one sees the 355 MHz i.f. input and a 335 MHz oscillator which produces a 20 MHz i.f. output. The 20 MHz i.f. is the basic gain i.f. in the unit.

Following this 20 MHz output from the second mixer (also an SRA-1 double balanced type) is a variable attenuator; +/— 3 db through a pin diode (voltage controlled) system.

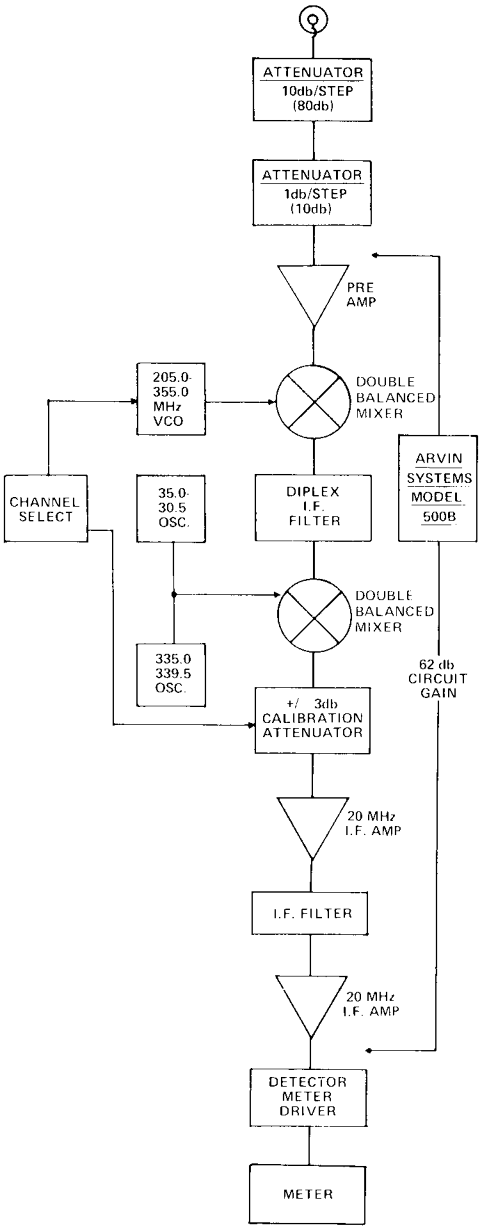


DIAGRAM 1

Then the signal encounters its first "gain" since the broadband RF pre-amplifier (ahead of the first mixer), a bi-polar 20 MHz i.f. stage. This is followed by a 20 MHz i.f. filter network and then a second bi-polar 20 MHz i.f. amplifier.

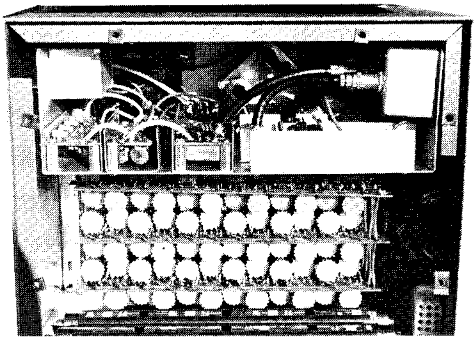
Finally the signal sees a fairly conventional diode detector/high impedance DC amplifier that drives the meter element.

Total gain through the package, from input to the front-end RF pre-amplifier, to the meter amplifier, is 62 db according to Arvin.

Now actually the 355 MHz i.f. is *only* for low band signals. The VCO operates in the 205-350 MHz range for *both* low and high band. It works out like this:

Input Frequency	VCO/LO	I.F. Output
5 MHz	350 MHz	355 MHz
50 MHz	305 MHz	355 MHz
100 MHz	255 MHz	355 MHz
150 MHz	205 MHz	355 MHz
— — —	— — —	— — —
150 MHz	205 MHz	55 MHz
200 MHz	255 MHz	55 MHz
250 MHz	305 MHz	55 MHz
300 MHz	355 MHz	55 MHz

Recall that there are *no active* (i.e. amplified) stages between the input (RF) broadband pre-amplifier and the first 20 MHz i.f. amplifier. What is there are two mixers—a diplex filter, and the pin diode fine-adjustment attenuator. The diplex filter has two sections: *one that passes 355 MHz* (for *low band* signals converted to the high frequency i.f.) *and one that passes 55 MHz* (for *high band* signals converted to the low frequency i.f.).



A total of 72 pots (trimmable resistors) operate calibrate controls (2 per push button frequency); CATJ suggested the pots be labeled for quick reference

No Manual Tuning

The 500B is tuned *exclusively* by push buttons, thirty-six in all. The push buttons activate a fairly straight forward set of switching diodes that (1) set the oscillator tuning for conversion to the first i.f. (for low band or high band), (2) select the *proper second oscillator* for conversion to the second i.f., and (3) select the proper amount of individual channel compensation so that the level you read on the meter is within the specification of the unit (+/ — 1 db).

The push buttons can be programmed for any frequency in the 5-300 MHz region, with eighteen buttons *normally* set aside for low band (5-150 MHz) and eighteen buttons set aside for high band (150-300 MHz).

Visual or Aural Carriers

Selection of the visual carrier level or aural carrier level is a front-panel slide switch which selects one of two oscillators in the second mixer stage. For example, if you are tuned to channel 6 video (i.e. have channel 6 button pushed in) and are reading video level, the first VCO (programmed via a control voltage on the push button switch) is tuned to 271.75 MHz. This LO voltage, plus the 83.25 MHz channel 6 video carrier signal voltage results in a mixer output of 355.0 MHz (see Diagram 2-A). Then by mixing the 355 MHz i.f. with a 335 MHz crystal oscillator in the second LO, we have the basic 20 MHz i.f. output from the second mixer.

Now, *to get audio out of this,* Arvin leaves the front end tuned 271.75 MHz VCO/LO alone and switches the second crystal oscillator from a 335.0 MHz unit to a 339.5 MHz unit (see Diagram 2-B and the mathematical analysis along the right hand edge). This produces a 20 MHz i.f. from the 87.75 MHz channel 6 aural carrier. To make

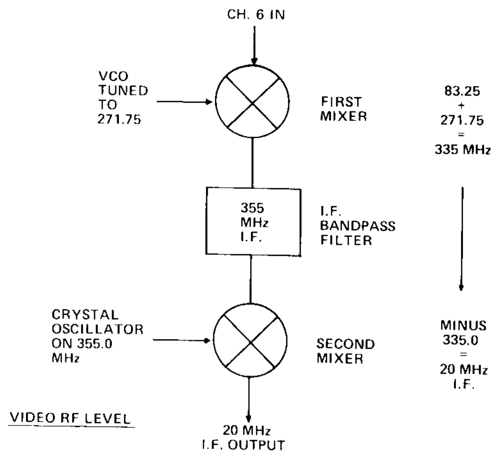


DIAGRAM 2-A

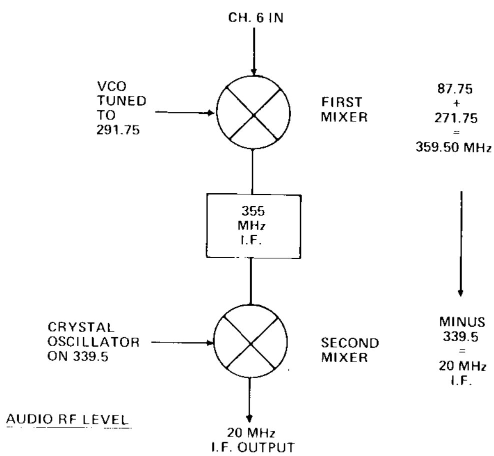


DIAGRAM 2-B

this scheme fly, Arvin must keep its 355 MHz diplexed i.f. filter quite *flat* over at least the 355-359.5 MHz region, or the aural carrier would be filter-sloped down (or perhaps peaked upward) out of proportion to its associated video carrier.

All of this "magic" is accomplished by simply sliding the front panel switch from video to aural.

The 335 and 339.5 MHz oscillators are shown in Diagram 3; they begin at 111.667 and 113.167 respectively and triple to 335 and 339.5 MHz (tripler section not shown). Note that selection of the respective oscillator is through a

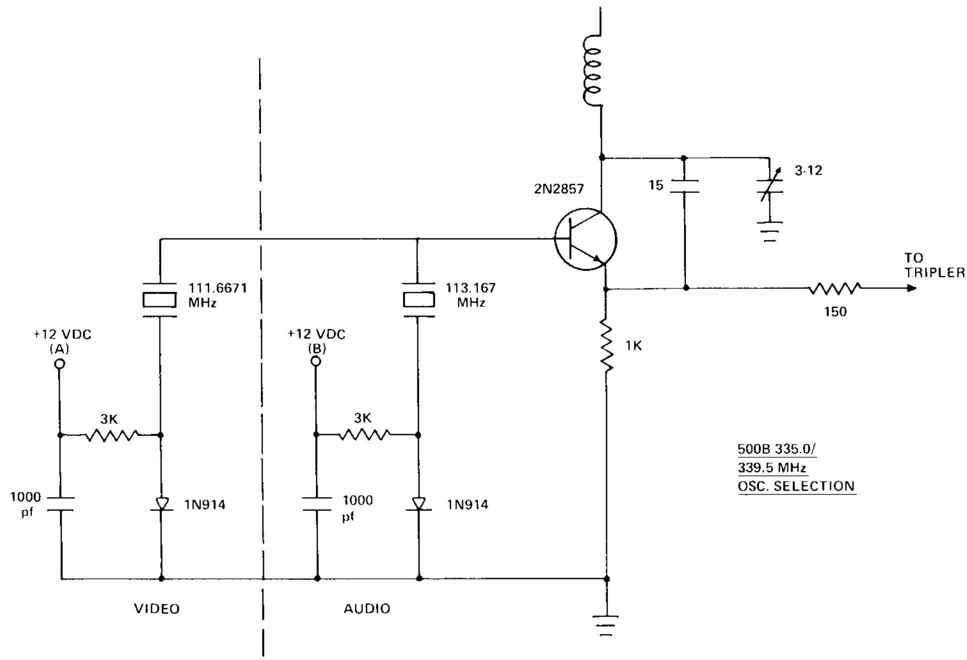


DIAGRAM 3

panel slide switch, via a 12 VDC supply line.

Individual Channel Compensation

Diagram 4 typifies an individual channel push button switch. Compensation is individual to each channel, and it appears that between 5 and 300 MHz there may be as much as 5 db of individual push-button-channel compensation available.

There are two adjustment pots (see photo) per channel 1 to set the VCO frequency so that when the push button switch selects the channel, the proper voltage appears at the VCO, which produces the proper tuning of the voltage variable capacitor (thereby putting you on the chosen frequency). The other is a compensation adjustment for that channel, via the pin diode attenuator.

There is also a vernier (electronic) fine tuning on the i.f., to compensate *via a front panel knob* for small changes in VCO action. Arvin originally showed the 500B with an AFC system to *eliminate* operator tuning of *any* kind. However, in the final form in which the meter is now being shipped, the AFC system has been replaced with a manual fine-tuning adjust knob (see photo). This fine tuning allows you to "peak" the meter reading on any single channel. The tuning range of the fine tuning is approximately +/—1.0 MHz.

Powering System

The 500B always operates from the batteries, even when operating from AC. That is, the power supply is for DC operation and even when the unit is plugged into AC outlet (for charge cycle) the unit draws current through the battery supply.

The basic supply is an 18 volt DC supply (full charge) which shuts down (i.e. refuses to supply regulated output voltage) when the current drain reduces the supply potential to 15 volts DC.

The unit draws 120 mA of current while operating and has a 1.2 amp capacity. The recharge time according to

Arvin is 12 hours at 100 mA per hour. *Seemingly* if you operated the unit *while it was plugged in and charging* (i.e. at the head end, shop, etc.) you would be drawing out *120 mA per hour* and replacing only *100 mA per hour,* thereby losing 20 mA of charge for each hour operated. Apparently for full time operation from 110 VAC (i.e. through the charger) you have to start out with at least a *modest* charge to offset the differential between going out and coming in! For full time bench operation, the 500B *might* need some modifications in the power supply *if* it were going to be used constantly on the bench. Arvin does advise that a 12 VDC external source jack will be available shortly on the back apron, so the unit could be operated from an *external* 12 VDC supply such as a battery.

In addition to the basic 18 volt DC supply (regulated to 12) there is also a very small (i.e. small in current load) 23 volt supply for operation of the channel selector system; 1 mA load is all that is utilized here. In the unit which CATJ saw, this was supplied via a secondary battery system; Arvin advises newer units have a multi-vibrator system operating off of the 18 volt DC supply. See Diagram 5.

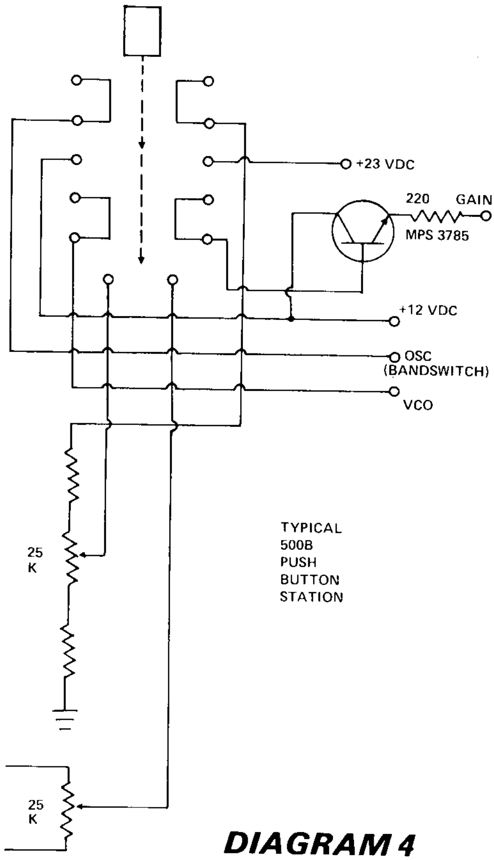


DIAGRAM 4

General Impressions

In the October and November issues of CATJ, five separate FSM/SLM products were reviewed and evaluated for absolute and scale-linearity readings. All five instruments were checked simultaneously on the same CATJ bench, and there were cross checks possible between different units because of the testing system utilized. Because the Arvin 500B arrived by itself, *no such cross checks were possible* (several of the other units tested and reported on in October and November had been returned to their respective manufacturers by mid-December's visit from Arvin).

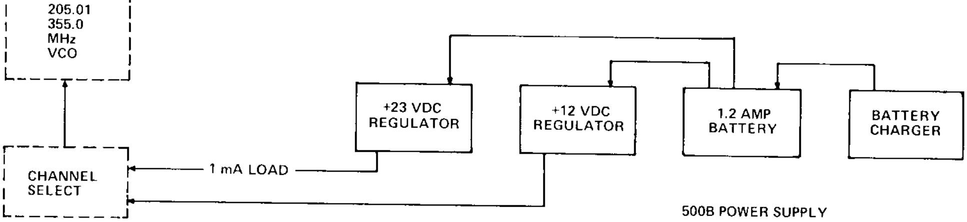


DIAGRAM 5

ARVIN 500B

Frequency Range: 5-300 MHz
Measurement Range: -32 to +62 dbmv
Input Impedance: 75 ohms
Selectivity:
  at 3 db points, +/— 400 kHz
  at 30 db points, +/— 1.5 MHz
Accuracy: +/— 1.0 db, -20/+120 F
Temperature Range:
  -40 F to +140 F (storage)
Power Requirements:
  Rechargeable NiKad battery, 110 VAC (through battery on charge cycle), 12.6 VDC
Weight: 15 pounds
Size: 8½" high x 10½" wide x 7¾" deep
Battery Drain: 120 mA
Minimum Battery Voltage Required: 15 volts for regulator to function
Price Range: $895.00

Thus we *cannot* present an absolute level evaluation of the 500B. We have managed to talk Arvin out of a temperature compensation chart, however, and it is shown here as Diagram 6. This chart depicts the amount of compensation *they must design into the unit* for various frequencies between 5 and 300 MHz, at various environmental temperatures. This is *not* an out-of-spec report; it merely shows what "tricks" the factory has to play with the circuit to make it "flat" to within their +/— 1 db spec. Given these numbers for an uncompensated meter, Arvin was able to tackle the range of individual channel compensation adjustments and design the final parameters for the pin diode attenuator located between the second mixer and the input to the 20 MHz i.f. amplifier.

The construction approach to the 500B is modular; the photo shows (although not too clearly) that small slide-in "U" channel trays hold the various circuit sections. What does not show too clearly is the fact that the circuitry of the 500B is really *very straight forward.* A full set of schematics, which Arvin left with CATJ, indicates that (1) cautious use of temperature compensation is found in the broadband input pre- amp, in the 20 MHz i.f. amplifier and in the detector circuit; (2) there is not an over abundance of parts (i.e. circuits seem to have been reduced to their *practical minimums*); (3) common parts-house type parts are used throughout (i.e. given a full set of schematics and an electronics parts house in a city of 50,000 or more, *you* could probably duplicate the meter on your own); (4) the only complexity in the unit is in the 36 sets of switches, with their attendant pots, diodes, resistors, etc. to make the unit change

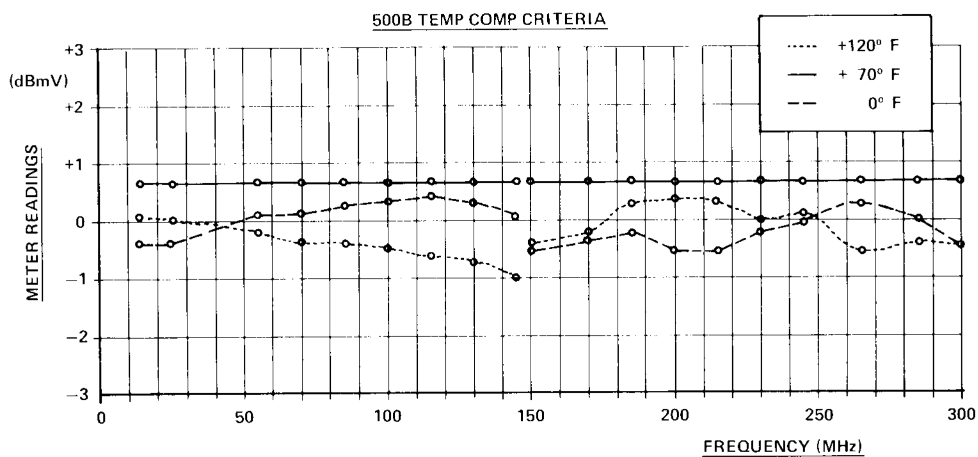
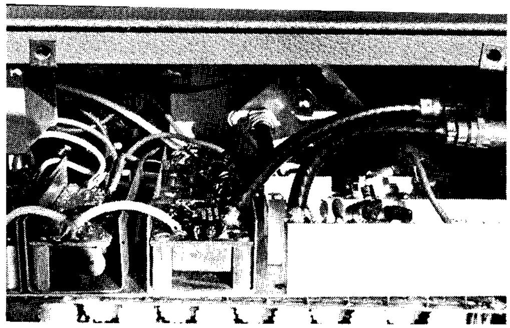


DIAGRAM 6

channels, tune accurately, and compensate.

Arvin's history in electronics is heavily weighted in the oscillator field. For many years they participated in the military electronics rat race supplying complex, highly stable oscillators to manufacturers of complete military communication systems. Arvin's Jack Cauldwell mentions this history frequently, seemingly to illustrate the company's ability to produce a high quality SLM/FSM *that is highly dependent* upon oscillators for its accuracy and usefulness.


Internal electronics, aside from large array of pots, is basically on individual "trays" for discrete circuit boards.

The 500B does *not* have an aural output (i.e. speaker) although they do have a no-cost option of providing a detected video output to drive a scope of chart recorder display. The video (detected) output option provides 0.8 volts peak to peak with an input (RF) level of +10 dbmv or greater.

The "battery check" switch on the front panel checks the actual state of the battery charge (i.e. *it is ahead* of the regulator). It is marked "Bad" and "Good". Seemingly, with a known battery-supply capacity and a reasonably linear meter, this "Bad" and "Good" battery indicator *could be re-scaled* from "0%" to "100%" to indicate, with appropriate marks along the way, the exact amount of charge remaining in the cells. The meter has a 1 mA movement.

While CATJ had the unit here for test, we took a look at the method by which the input "F" connector is mounted on the panel. Our analysis is that you *could* change it out in about one hour's time with only modest finger pinching.

The argument Arvin makes for absolute accuracy is an interesting one. "Meter inaccuracies are primarily due to (1) detector efficiency changes, (2) meter-element non-linearities, (3) meter (DC) amplifier non-linearities, and (4) temperature (environment)." they theorize. "The 500B eliminates all but the temperature portion, by doing away with the 20 (or 30) db meter range, and operating the detector at one level (+/— 2 db) where efficiency can be accurately determined." Then they build in individual (push button connected) channel compensation so that, as the alignment tech sets the unit up, he can "tweek" upon the compensating control(s) and set the unit dead on for each channel.

Seemingly, with that type of approach (which is similar to the Mid-State Communications SLIM, except SLIM employs AFC as well), there is only one way a meter can get out of spec, *and that is environment.*

Even though Arvin supplied us with a temp comp chart from their design notebook (Diagram 6), we would *prefer* to see an *end-user temp comp chart* that tells the *user* how many parts of a db to comp up or down when the temperature is this side or that side of a normal 70 degree F environment.

Things to Consider

We didn't have the meter itself long enough to develop any personal feelings about how well it might perform for us in normal useage.

Arvin makes the point in their data sheet that measurement time is reduced with the 500B because you merely "push the button and read the level" for each channel. Truthfully, we found we had to re-adjust the fine-tuning compensation for most of the channels to peak the carrier in the center of the passband; and this *slows you down* from push-read-push-read just a tad.

When we went from reading visual carriers to the same channel aural carriers, very little (if any) retuning was required. This suggested to us that the "drift" was taking place *in the VCO in the front end,* since, once we had stabilized on the video carrier within the 355 MHz i.f., shifting to the audio carrier *seldom* required retuning.

We did check the accuracy of the 1 db and 10 db step attenuators, and not surprisingly they were every bit as accurate as our reference step attenuators. Small wonder—the 500B uses some very expensive, first quality rotary attenuators in the front of the instrument!

The "narrow range" of the level-zero -meter takes some getting used to, and there may be some built-in limitations for *some users.* We can't imagine trying to track the depth of widely varying signal level (i.e. one fading over a range more than the 4 db "window of the meter") with the 500B. Many 20 db meter-scale instruments are not "wide enough" for tracking some beyond-grade-B signals and the 4 db range seems altogether too tight for this exercise.

Still, as we said in the first part in our four part FSM/SLM meter series, *nobody has yet built a perfect, do everything meter,* because to do so would require a housing so large that you probably could not transport it! So if you find yourself studying the 500B for maintaining plant and head end output levels only, and disregarding time-term measurements of widely varying input to head end levels, you probably are thinking with your head screwed on correctly.

NACOGDOCHES, TEXAS vs. MOTHER NATURE

HIDDEN SURGE COSTS

Surges in the CATV system plant powering complex, regardless of the origin of the surge, usually result in damage and/or outage to some portion of the signal transportation network. AC power supplies, line amplifiers, and DC power supplies located within the line powered amplifiers are often partially or totally destroyed by surges. The obvious damage to equipment costs money and time to repair, but it *can* be put back into working order.

This may not be so evident when you consider the "hidden damage" to the system's operation. Specifically, a system that suffers more surge damage than it should has an on-going problem with existing subscriber good will. It also has a problem with potential system subscribers who "hear" that the cable is unreliable and who never try the service as a result. Finally, there is the potential problem of outages being so frequent that the local franchising authority feels obliged, under pressure of subscriber complaints, to call the system on the carpet for an explanation of the outages.

IT HAPPENED IN NACOGDOCHES

Texas Community Antennas (TCA) of Tyler, Texas owns and operates systems in Texas, Louisiana, and Arkansas. One of the TCA systems is located in Nacogdoches, Texas. It was rebuilt in 1972 using all solid state equipment. The system has approximately 125 plant miles and is located in an area of Texas (200 miles inland from the Gulf) where thunderstorm activity is very high (from 80 to 90 thunderstorm days per year, and many days with multiple storms).

In the rebuilding process, Nacogdoches Cable TV incorporated some system grounding procedures which should prove interesting to other operators plagued with system outages related to surges. The key points to their program were as follows:

(1) A 6 foot grounding rod was installed at *every* active device location;

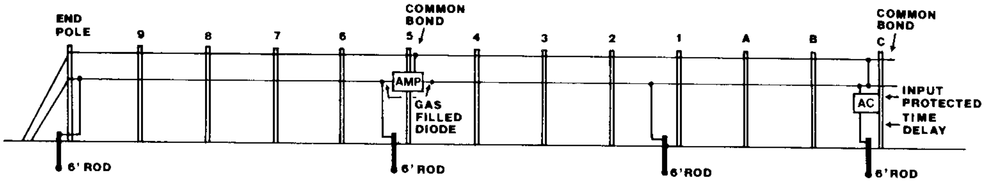
(2) A 6 foot grounding rod was installed at *every* AC power supply location;

(3) A 6 foot grounding rod was installed at *every* first, last, and tenth pole (per run) throughout the system;

(4) At these ground-rod locations, all of the CATV facilities located at these locations were common-bonded to all adjacent (same pole) utility grounds or strands;

(5) The inputs to all AC power supplies were surge protected with GE (General Electric) pellet-type lightning arresters;

(6) At each AC power supply location, a time delay (relay) sys-



NACOGDOCHES GROUNDING

DIAGRAM 1

tem was installed to disconnect the power supply AC input mains from the AC (CATV) supply when a surge was detected, resetting after the surge time had passed;

(7) Gas-filled diodes were installed on the ports of all amplifiers in the system.

CHECKING THE SYSTEM

The rebuilding program was completed at the beginning of the peak thunderstorm period for the area. During these storms, the system experienced trunk, bridger, and line extender amplifier failures, *in spite of the numerous precautions.* Because the system had recently rebuilt, and the "improved level of service" promised by the system to the city was being destroyed by the frequency of surge outages, the City Council called TCA on the carpet and asked for some indication that the problem would be resolved.

Wayne McKinney, TCA Chief Engineer, and Fred Dempsey, then Nacogdoches system engineer, established a system behavior monitoring system. The system's operation was closely monitored for 30 days, at the end of which it was found that:

(1) 32 DC power supplies in the amplifiers had sustained circuit, component, or board damage during the 30 days;

(2) 29 "fuses" were blown at *other* amplifier locations, resulting in outages and some minor circuit cremation;

(3) 90% of the outages occurred on 5 of the system AC powering sections, and all 5 AC powering locations were located on terrain which was "above" (relatively speaking) the terrain in the general CATV area.

ENTER SURGE PROTECTION MODULE

In spite of the protection measures taken by the system designers/planners/rebuilders in the solid-state reconstruction of the system, something else was needed to correct the problem.

The TCA people took their problem to the industry and found a solution. It turned out to be the installation of a newly developed (then) surge protection device (1).

Willard Truckenmiller of C-COR recommended to TCA that they (1) install a surge protection device on the secondary of the power transformer in each trunk and bridger amplifier, and (2) install a transient protection device on each of the AC power supply loca-

(1) In Nacogdoches, TCA installed the C-COR Model SPM-53 at trunk and bridger amplifier locations, and the Model TSM-93 at power supply locations. C-COR's address is 60 Decibel Road, State College, Pa. 16801.

SPM DEVICES—HOW EFFECTIVE?

As related in this report, the Surge Protection Module device (in this case C-COR SPM-53 and TSM-93) installed by Nacogdoches Cable TV, has proven to be an important part of the "mix" of system surge protection techniques. But, **just how effective** is the "SPM"? Another feature in this issue of CATJ suggests it has certain applications.

CATJ asked C-COR just how effective they felt the SPM type unit would be. We were told:

(1) **An SPM unit protects by voltage fold back phenomena which limits power dissipation. It automatically extinguishes itself and resets at the zero crossover of each one-half cycle of AC voltage.**

(2) **An SPM is NOT a substitute for good system practices. It should be considered a "mop-up" unit for severe conditions. Systems must still practice good grounding techniques, lightning arresters at the input to power stations, gas diodes at amplifier ports, and time delay relays on AC power supply stations.**

CATJ then asked C-COR how a system goes about selecting an SPM unit for their particular system and amplifiers:

(1) **Select an SPM which will not fire under normal AC power conditions. The SPM firing voltage must be above the AC voltage maximum.**

(2) **Mount the SPM in the amplifier so that it utilizes the metal amplifier housing as a heat sink. Connect the leads across the secondary of the power transformer, or in the AC power input circuitry** (as a second choice).

(3) **Adjust the amplifier "main fuse", if there is one, to prevent the nuisance tripping of the fuse when a surge causes the SPM to fire. This should be determined on the bench before the units are installed wholesale in the field.**

Are SPM's all alike? Apparently different manufacturers have slightly different approaches to the SPM design problem, but the principal appears very similar between units. Because of the difference in amplifier operating voltages, there are specific SPM units for different amplifiers (brands), **at least at C-COR.** For example, the C-COR Model SPM-53 (which handles a maximum voltage of 53 volts AC, a recommended operating range of 30-48 volts AC, and a clipping voltage [peak] spec of [+/—] 75 volts) is designed for the Jerrold Starline 1, Starline 20, Starline 20 push-pull, and C-COR 400 series amplifiers.

The long and the **short** (pardon the pun!) of it is that you need to check the specific requirements of your own plant amplifiers, and pay particular attention to your existing grounding techniques, **before** you talk with an SPM supplier about protecting your own system for the coming barrage of Mother Nature.

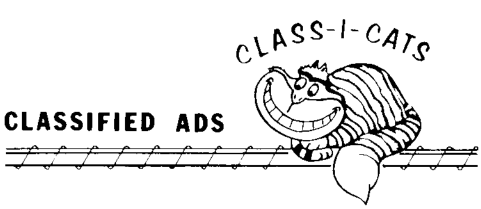
tions (on secondary of AC supply). In all, 50 trunks and 59 bridgers were protected in this manner.

For a 2 week period immediately following the installation of the protective devices, the system monitored system performance. The system reported that the thunderstorm activity during that 2 week period was comparable to the previous month when the large number of outages occurred. During this monitored period, the system experienced only one episode of equipment failure (at a bridger amplifier location). It turned out later that the bridger module was *probably* defective prior to installation.

SUMMARY

Approximately 2½ years have gone by since the TCA system in Nacogdoches rebuilt and went through an anxious post-improvement period. TCA's Wayne McKinney reported, "As far as we can tell, the SPM units have continued to work for us since they were installed." McKinney added, "For the price of the SPM type unit, it is hard not to put them in, because just going out and replacing a fuse one time can cost you more as an operator than the one-time cost of the SPM."

The SPM, like the Siemen's device, is sort of a "trust me...I'm working" device. Unless they short (in failure), you have a difficult time checking them while they are installed in the air. They can be checked, but the procedure is usually done in the shop.



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TECHNICAL TOPICS

MID-STATE RESPONDS

Your series of articles on Signal Level Meters has been super. As the designer and manufacturer of SLIM, we are listening very carefully to your comments and criticisms on what is available and what needs to be available to the CATV market.

I would like to make a few comments about the "What We Did Not Like" portion of the Mid-State SLIM review.

1) **Regarding the briefness of our theory of operation section of the owner's manual;** this is a point well taken, and we will soon have a more complete manual, which among other things will include a replacement parts list and functional schematic diagram.

2) **Regarding our stripped attenuator knob;** this is a very good quality plastic knob with brass bushing insert. However, when you returned the meter, that knob was stripped, a quality inspection oversight that should not have occurred.

3) **Regarding the leather carrying case cover;** the case cover is designed to swivel around out of the way and there are two snaps to which the cover is secured while in an operating position. This feature was apparently over-looked (**It was - Editor**). This is a feature that will be explained in our (new) manual. We will be offering very soon an optional meter case, metal, with a piano-type hinged cover that does open upward as you suggest. It will have a strand hook and be a more conventional (727) type housing, for those systems that prefer this type of case.

4) **Lastly on meter tracking;** I personally unpacked and inspected the evaluation unit that you had and indeed there was a 1.0 db tracking error on the left edge of the meter face. I wish you had attempted to correct this with the internal control in the meter, as you stated in the article you were "tempted to do". I followed the owner's manual procedure to the letter and got the meter tracking to with 0.15 db over the entire 20 db range and it is dead-on (i.e. perfect) in the center 10 db.

We are appreciative of your excellent criticisms and very grateful for your praise. Thank you.

Doyle T. Haywood
Vice President/Dir. Engineering
Mid-State Communications, Inc.

CABLE DROP

MISSING VALUE

The December CATJ contained a report on elementary bandpass filters (Pages 11-18). The schematic drawing at the top of Page 16 (Diagram 6) for low band/high band splits neglected to give the value of the fixed capacitor connected in series from L3 to ground (low band out leg). The correct value for that capacitor is 10 pF.

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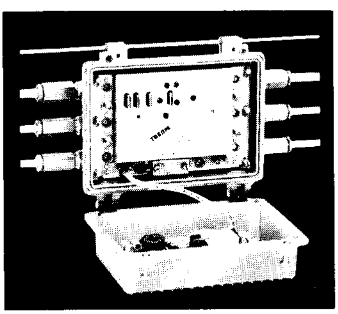

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