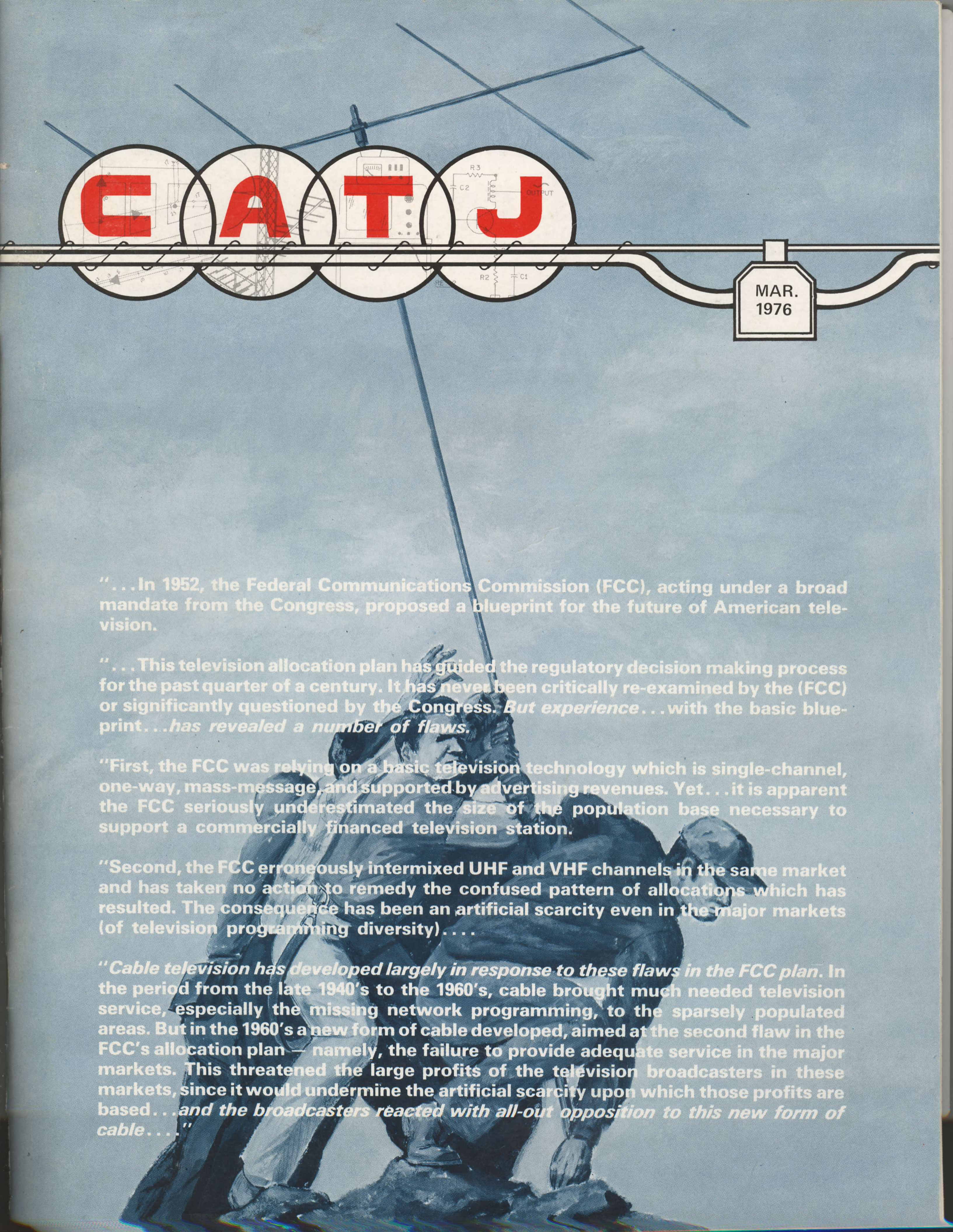
CATJ

MAR.
1976



"...In 1952, the Federal Communications Commission (FCC), acting under a broad mandate from the Congress, proposed a blueprint for the future of American television.

"...This television allocation plan has guided the regulatory decision making process for the past quarter of a century. It has never been critically re-examined by the (FCC) or significantly questioned by the Congress. *But experience*...with the basic blueprint...*has revealed a number of flaws.*

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"*Cable television has developed largely in response to these flaws in the FCC plan.* In the period from the late 1940's to the 1960's, cable brought much needed television service, especially the missing network programming, to the sparsely populated areas. But in the 1960's a new form of cable developed, aimed at the second flaw in the FCC's allocation plan — namely, the failure to provide adequate service in the major markets. This threatened the large profits of the television broadcasters in these markets, since it would undermine the artificial scarcity upon which those profits are based...*and the broadcasters reacted with all-out opposition to this new form of cable*...."

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CATJ

MARCH 1976

VOLUME 3 - NUMBER 3

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

OFFICES
CATA/CATJ
4209 NW 23rd, Suite 106
Oklahoma City, Oklahoma 73107
(405) 947-7664

CATJ subscription rates $12.00 per year for non-CATA members, $8.00 per year for CATA member-systems; $9.00 per year for industry employed personnel for at-home delivery. In Canada, $13.00 per year for CATV systems, $10.00 per year for system employees. Foreign rates upon request.

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

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DEPARTMENTS

OUR COVER

ONE YEAR AGO — In the March 1975 CATJ, we began a special two-issue report on the tragic history of FCC bungling of television allocations. Now the Subcommittee on Communications of the Committee on Interstate and Foreign Commerce (U.S. House of Representatives) has issued a blistering 110 page report entitled **"Cable Television: Promise Versus Regulatory Performance"** and this report echoes almost word for word CATJ charges of one year ago. Our front cover quotation comes from that report, which is must reading for all CATV people. Copies are $5.00 each from Television Digest, 1836 Jefferson Place NW, Washington, D.C. 20036.

CATA -TORIAL

KYLE D. MOORE, President of CATA, Inc.

March 31, 1976

What's in a date?

Say December 25, and most people instantly reply "Christmas." Or say July 4th, and most Americans respond "Independence Day." If you say April 15th to anyone over 18, you will probably get a scowl and a sarcastic remark about "tax deadline day."

March 31st.

What is your response?

For roughly one reader in 365, it is your birthday. Happy returns. For roughly one reader in 91, it is the birthday of someone in your immediate family.

Here's a hint. It has something to do with the cable industry.

If you are a system manager or a system technical type, you already know the answer. March 31 is the date when the current year FCC Compliance Testing must be completed. Sort of like an April 15th **reserved just for the cable industry.** It is a two Excedrin day, especially if you don't decide to get around to your own testing liability until March 30th.

The federal government is a wondrous creation. Each "agency" seems to believe it is a fiefdom unto itself, answerable only to itself. The popular news media of late has been filled with examples of how some agencies seem to believe they, and they alone, know what is best for America.

Take the IRS as one small example. Recently a group of casino employees in Nevada decided that the IRS had no business making them report on their "tip" income and pay taxes on same. The group organized, took the IRS to a federal court and pled their case. And wonders of wonders, the federal court decided in favor of the employees and directed the IRS to stop making casino employees report "tips" as regular income and requiring tax payments for same. The IRS reacted by issuing a statement that said in effect **"We don't care what the court said, until we get good and ready, we are still going to require casino employees and others receiving additional 'income' from 'tips' to report it and pay taxes on it."** The IRS, in case you haven't discovered this previously, believes it is bigger than the federal courts. Or, if not bigger, more capable of determining what is "right for America."

Enough of the IRS example; I have to pay my own taxes and I don't need them mad at me!

And perhaps that is the point; the fear the agency itself creates. I was in a neighbor's home one Sunday night in January and Tony Curtis in his McCoy creation was playing on the tube. The plot involved the usual caper where McCoy was doing his best to recover a large sum of money ($300,000.00) bilked away from a children's home. One of the sub-plots involved a McCoy henchman who was playing the part of an IRS agent. A six year old child in the home watched the first fifteen minutes with the rest of us, and finally after hearing someone say "IRS man" for the umpteenth time, the child turned to his father and asked out loud, "Dad, what is an IRS man?"

The father grimmaced noticeably, stammered for a minute, and finally said very quietly, "That is an internal revenue man—a tax man." Satisfied, the child went back to McCoy.

And that is how much power one federal agency has been able to build in its own super structure. Just mention three little letters...and watch the reaction.

Now mention FCC. Most cable operators react either blandly (no outward sign of emotion) or with anger. But never with fear. The FCC is simply **not an awesome, fear producing agency**. At least not to the cable industry.

Many consider the FCC a minor annoyance; an agency to pat on the head, feed with an occasional form or two, and send on its way. The FCC has simply failed to show us its muscle to date. When we don't like some particular rule, we simply ignore it. When we don't like all of the rules, we simply ignore them. And I wonder how long this can be kept up.

I am too young to remember, but I am sure my father and his friends probably looked upon the IRS in much the same way; feed them a form or two, pat them on the head, and send them on their way.

That was probably before the IRS got muscle and teeth. Or, as they say in Washington, a tool or weapon to police their wards. Well, our own FCC is just about ready to get their own tool. It is called monetary fines for CATV. During January, Senate Hearings were held on a new Senate bill (S.2343) which is designed to broaden the powers of the FCC in the area of levying monetary fines for "rule infractions." Unfortunately, the Senate hearings slid by **almost** unnoticed. NCTA President Bob Schmidt had been invited to testify, but he backed out at the last minute reportedly because he felt the bill was going to sail through the Senate with very little or no opposition and he felt "it would look bad for the cable industry to oppose the bill." I wonder if the general populace reacted in the same way when the youngster-IRS first sought the power to attach personal banking accounts. I suspect they did, unaware of what was up, or at best sure such a lunatic idea would never be signed into law.

Our own FCC is plainly not satisfied with the role we as an industry have cast them in. They don't like being told, 'No, you can't do that to me.' They don't like being told 'Take me to court if you want to push the issue,' and they plainly are unhappy when they are required to 'justify their actions' before a review body such as a court. We recall that when the NCTA took the FCC to court and won the **annual CATV-viewer fee** case, that the FCC did not rush right out and send refund checks to the CATV companies they had illegally collected from in the past. Rather, they dragged their feet, and dragged their feet (not dis-similar to the IRS telling the Nevada federal court "go to hell; when we get good and ready, then, maybe, we will change our rules for reporting tips....") until a young attorney in Washington went to **another** court and obtained an order forcing the FCC to turn back the money the higher court had already told them once to give back.

Now if the present monetary fines (they call them forfeitures) bill does pass both houses of Congress, and is signed into law by the President this year (it seems likely this **will** happen unless a lot of people get mad in a hurry), what about next year, when March 31 (1977) rolls around?

For one thing, it will no longer **be possible** to ignore the March 31 annual date. It is one thing to thumb your nose at a policeman with an empty gun and no citations in his pouch. It is quite another thing to wave a red flag in front of a mad bull pawing the ground before you. And, like it or not, we have been waving red flags at this "mad bull" for several years now.

With monetary fines added to their arsenal, the Commission, like the IRS, doesn't **have to be** right. With a brand new book of citations and a $1,000.00 fine for every test you have not made "in compliance with the rules," they can drive you right out of business with just a single visit to your town.

Today we can thumb our nose because we are in the process of grinding out a court suit or two in which we question whether or not the Commission **really does have** the authority to regulate us **at all**. It is, for now, an **even** 'fight' because we are arguing black vs. white, right vs. wrong. We can't harrass **them**, and without any clever weapons such as fines at their disposal, they can't harrass **us** either. When the court finally decides Gridley, Kansas, we will either win or lose. And that will be that.

But with monetary fines added to the weaponry, the FCC suddenly has the tool to police us with harrassment and nit-picking. One visit, and we get a citation. With the citation comes an optional fine. Now we are **forced** to negotiate with them. We may find it is 'easier' to agree to do what they ask (regardless of right and wrong) than face the inevitability of paying a fine and court costs should we choose to fight the levy.

But this is 'backdoor cable regulation.' Lacking a clear mandate from Congress that says the FCC **can** regulate cable, the Commission is up to another of its old tricks—**ancillary** regulation. We tire of repeating it, but the Communications Act of 1934, from which the FCC draws authority to issue rules and regulations, does **not** say one word about **cable**. In fact, and this is the important point, the 1934 act even expressly **prohibits** regulation of receivers. For many years, since cable came along, we have been told we were being regulated because we were 'reasonably ancillary' to the FCC regulation of broadcasting. But because of the 1934 Act, which forbids the Commission regulating receivers **or** licensing receivers, we have made it hot for the Commission, in cases like Gridley, to enforce **all** of the rules they would **like** to enforce.

Now while the matter is still up in the air, and still heading for the courts for a final interpretation, we find the FCC asking for the power to issue monetary fines against any (CATV) receiving system operator that violates the rules.

CATA has filed a strong protest with the the good Senator from Rhode Island, Mr. Pastore, regarding **this** blatant attempt at backdoor regulation by the Commission. We fail to see how giving **self-**proclaimed vigilante squads (i.e. the FCC) the **guise** of legality at this point in time will serve justice, especially when Congress has so far seen fit not to codify the Commission's claims to power in the cable area.

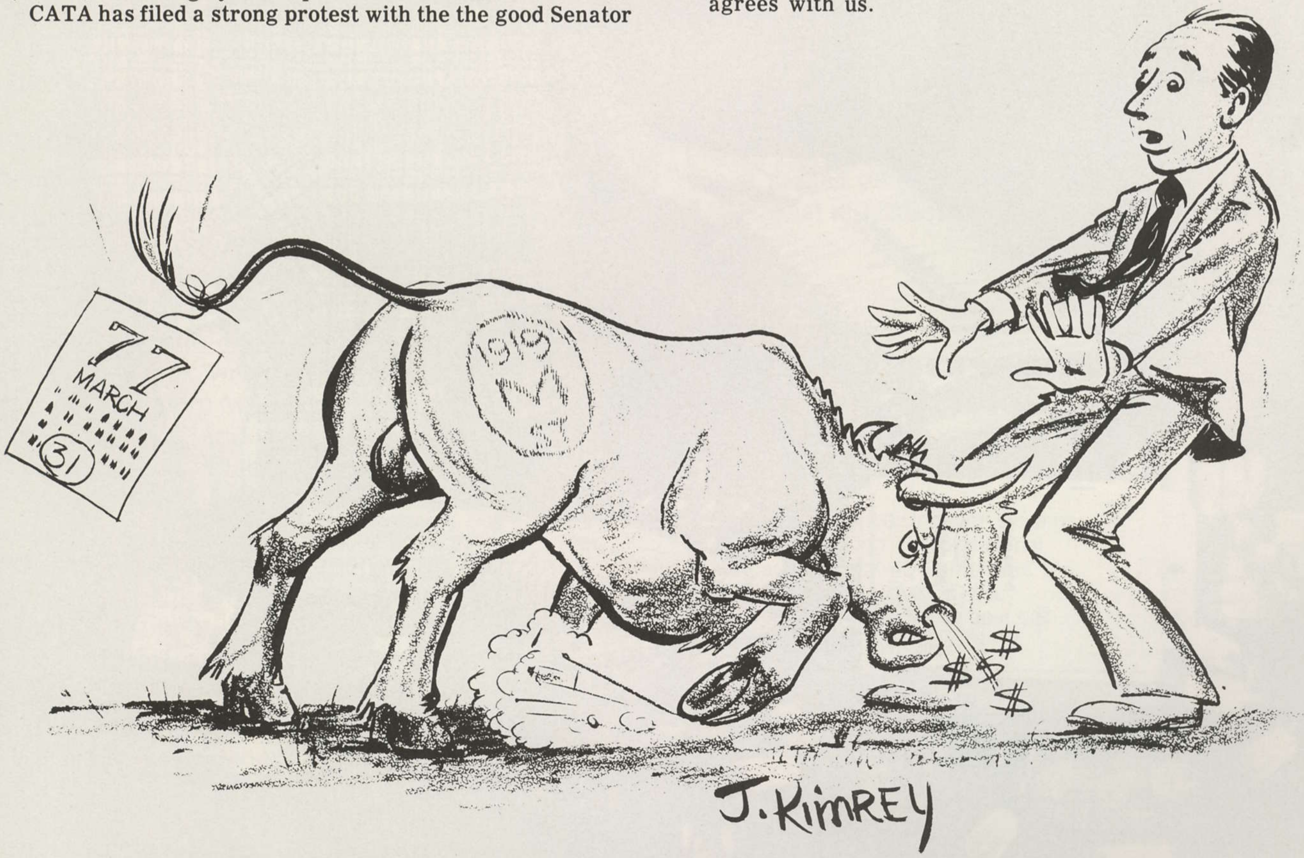
We do not question the Commission's authority to impose fines on **broadcasters** of any form. They routinely slap fines of up to $10,000.00 on broadcast stations and up to $1,000.00 on CB operators. When one is fooling with the public's airwaves, that makes good sense. If the policeman does not have the authority to issue a citation and make it stick, chaos is the inevitable result.

But we are **not** dealing with the public's airwaves with cable. Rather we are dealing with a **privately owned** piece of coaxial cable. A piece of cable (with attached electronic apparatus) which does not utilize **any** of the public's airwaves.

IF the FCC really wants to regulate transmission **and** reception, let **them** go to Congress and get a wholesale **revision** of the 1934 Communications Act adopted. Let them address the regulation of receiving apparatus in an aboveboard, open manner, not through **subversive**, underhanded tactics like this.

On January **26** the House Subcommittee on Communications, for the House Committee on Interstate and Foreign Commerce issued a 95 page report entitled "Cable Television: Promise versus Regulatory Performance." In that study, this Subcommittee said **"The Communications Act of 1934 should be amended specifically to encompass cable television. . . ."** Until the FCC **does** have an amended 'Act' to justify their actions in the cable arena, there should be **no new** 'exploratory trips into backdoor regulation' by the FCC. In fact, until Congress **does** give the FCC the specific authority to regulate CATV, any and all new 'ancillary' trips into the world of regulation should and must come to a halt.

S.2343 should be modified **at once** to **strike cable** from its list of affected 'wards of the Commission.' We are indeed sorry the NCTA feels "this bill is inevitable." **We carry** no such feelings, and we hope the majority of the industry agrees with us.



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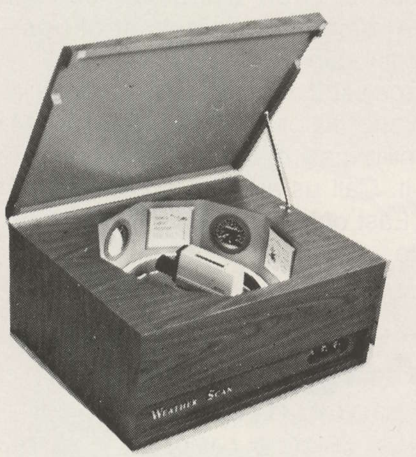

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WHERE ARE WE WITH MULTI-MODE?
(An Honest Phase II Report)

The October (1975) issue of CATJ presented a nine page feature entitled "Multi-Mode Receiving Antenna Arrays Reduce Scatter Region Signal Fading". The long and short of it all was that research indicates that on over-the-horizon paths (i.e. beyond the visual horizon area or roughly after the *first 70%* of the station's combined A and B contour areas), the original sacred horizontally polarized wave front is no longer likely to be horizontal a large percentage of the time. And if it is not horizontal, it is likely to be at some other wid^ly varying 'descrete' polarization such as vertical, half way between vertical and horizontal, or any of some 357 other "one degree increments" between the three.

This thesis has been borne out in tests that have now extended into a time period of nearly two years; tests set up at the CATJ Lab Site near Oklahoma City, and monitored through chart recording equipment, suitable detection devices (SLM's with chart recording drives) and numerous antenna arrays.

In our October 1975 report, we reviewed some of the basic data developed to date, and included several example chart recordings depicting what happens to some long haul scatter-range signals during various combinations of weather patterns and/or time of day. The charts published indicated that when horizontally polarized antennas were exhibiting wildly fluctuating received signal levels (i.e. fading abruptly over 20-30 dB fade 'windows'), a circular polarized receiving antenna looking at the same signal at the same time was exhibiting much tamer signal levels, seldom fading beyond 3 dB 'window' ranges. In a sense, the use of circular polarization seemed to be a technique that produced *an antenna with AGC;* that is, an antenna that compensated for wide fade ranges all by itself, thereby allowing the electronic AGC to do less work and in the end the customers would have better looking pictures.

And that is about where we left the project in the October CATJ, with one exception. We noted that the standard format circular polarization antenna, the helical or helix antenna, had one bad dis-advantage going for it; that being its not-quite-as-good-as-a-Yagi rejection of rear of antenna and side of antenna non-desired co or adjacent channel sources. We noted that we felt it was doubtful that CATV customers would appreciate distant signals that faded less if at the same time the signals picked up new signs of co-channel interference.

Which left us wondering, in print as it were, whether the circular polarization approach was going to function for CATV *unless* the antenna directivity problem could be licked.

When the October feature was prepared, we were already well down the road to solving the pattern-problem. In fact, we anticipated being able to bring you the net results of the solution no later than the subsequent December issue. By the time the October issue was being circulated from coast-to-coast, we knew we had struck a 'cord of interest'. One operator south of San Francisco told us "I am having trouble with KGO on channel 7 in San Francisco. This is about a 100 mile path, and the signal comes down the back of a mountain range, crosses over some water and low lands, and then winds down a valley to our elevated headend site. We have fading just as the CATJ Lab Site charts shows. I know this should help us; how do we build one?"

Another operator in Florida had a different problem. "We are bringing a distant UHF channel into the suburbs of Miami because the distant U carries the Dolphin football games. We have excellent signals even over the 150 mile path in the early mornings and evenings, but the Dolphins play football in the afternoons. When they play football is the exact time signals have their worst fade rates. So we took your tip and built a couple of Helix antennas. They do work, and now we want to build a big array of say 8 antennas."

The operator of a chain of radio and television stations in a mountain state advised us "We began experimenting with a circular polarized antenna array for a 140 mile FM band path last spring. I expected it would help our fade problems just as you suggested. But our experience to date has been unhappy; we find there is less average signal with the array (not a helix, but rather an array of crossed Yagis phased so the array thinks it is a circular antenna) than with a standard horizontal array."

Then we heard from the people at SITCO in Portland, Oregon who told us "we have been experimenting with an array of crossed Yagis, phased for circular polarization, at a location down the coast here in Oregon. We are convinced, as you are, that the circular mode reduces the fade rate substantially. We expect to be marketing a line of circular polarized Yagi antennas under our SITCO CATV antenna line sometime in 1976."

CATJ also received several dozen other letters from systems that "wanted to know more" and these ran the gamut from "tell us where we can buy a circular polarized antenna" to "tell us how to build an array."

As noted, we felt confident back in October that by December we would be in a position to move ahead with the editorial and research project by December. Our December cover even displayed U.S. Tower Company President Stormy Weathers hanging on a CATJ Lab Site tower putting the finishing touches on a pair of cross-polarized log antennas, part of the research this program has looked at to date.

Then we ran into a couple of snags. One minor, the other potentially major. The minor one involved the antennas shown on the December cover. It works this way. Someplace between the ARRL Antenna Handbook (the ham's general guidebook to building and tuning antennas) and Kraus (the noted expert on helical antennas) we overlooked the fact that *one* helical antenna is fine, *but two are bad.*

To explain. A circular polarization antenna has usefulness for our particular beyond-horizon receiving problems because it responds equally well to any sort of polarized wave that happens to come along. Vertical, horizontal, in between. . .it matters not to the circular antenna. Because all wave polarizations look "in-phase" to the circular antenna; that is why we are using it for this particular problem. So, if one works good, two *should* work better. Except two works worse. We proved it several dozen times by connecting the first stand-alone array to the chart recorder via the SLM detector, looking at it, and then connecting both (via a combiner) to the chart recorder. After much head scratching and climbing up and down the test tower, it finally occured to someone to go back and read Kraus. And there the answer was found, after suitable interpretation.

It seems that when you have been brought up thinking of antennas in a single dimension linear-polarization-format, it takes more than a little time and experience to adapt to thinking of antennas in three dimensional formats. To most of us, an antenna has gain, some particular polarization format, and, phase coherency. But the phase coherency we think about is the phase coherency of keeping identical arrays so spaced and looped together that wave fronts appearing at the driven element of one antenna in an array are fed in phase into a combining network with the same wave fronts arriving at the driven element of the other antenna(s) in the array. Circular polarization takes more concentration than that.

The "antenna field" surrounding a circular polarized antenna is *circular,* just like the antenna polarization. The "antenna field" surrounding a linear polarized antenna, such as a horizontal Yagi or log, is *egg shaped.* See diagram 1 here.

When two Yagis, for example, are stacked vert-

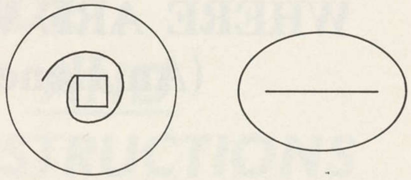


DIAGRAM 1

cally, or one above the other, *they* maintain polarization purity. But when two circular polarized antennas are stacked in the same configuration, the field of one, being circular and therefore round in shape, runs smack dab into the field of the second antenna. The effect is that what *was* a circular polarized receiving pattern becomes a linear polarized receiving pattern. If you are lucky, it may be horizontal; if you are not so lucky, it could end up being most anything else. *But it is no longer circular.* In fact, antenna genius Kraus points out that if you stack two circular polarized helix antennas side by side, one wound for right hand circular and the other wound for right hand circular, you *produce* an antenna with linear polarization (diagram 2). Why anyone would want to do that is beyond us, but it apparently has some application someplace.

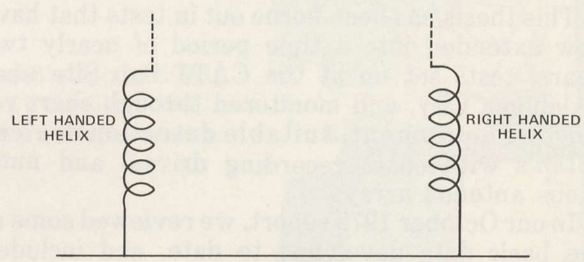


DIAGRAM 2

Like we said, *this* was the minor problem; one we figured out for ourselves pretty quickly, but not quickly enough to make the December issue of CATJ with our promised part two of this series. The bottom line of stacking circular antennas by the way is that you do it in *multiples of four.* That is, move from one antenna to four antennas, and then from four antennas to sixteen antennas if you want to *maintain* the integrity of the circular polarization. There is one other way to do it with a lesser number of antennas, but that technique (called 'ring-configuration') is probably beyond any CATV system for the time being.

The major problem turned out to be no problem at all, but it contributed to our delay problems. Along about the time we began measuring the results with the two U.S. Tower Company circular logs shown here, we also made a significant change in our chart recording system. For more than a year we have been operating with a pair of older tube-type Heath chart recorders. Lacking the ability to *simultaneously* record two channels of data on *one* chart roll (i.e not having an adequate *two-channel* recorder), we had been time-slaving a pair of identical Heath units and then physically time marking each chart as it began so that the chart from machine "A" could be laid beside the chart from machine "B" at the end of a run, and with time-marks atop one another, directly compare the two charts. One chart would have the circular antenna on it, for example, while the second chart would have the linear antenna on it. There was (and is) nothing wrong with this system, but it means running two machines at a time, keeping both in "sync" and making sure the recording process is operating properly. It left no time to do anything else when the charts were running but monitor and maintain the integrity of the two independent machines.

Seeking to update that system, a military surplus two channel recorder was obtained in October and after suitable check out pressed into service. After more than 18 months of recording data on two separate slaved machines, this seemed like the big time! For the first week or so the charts were superb. Then, gradually, something began to change so that without our knowledge one of the two data channels was lagging the second one by up to a couple of seconds. In the innards of the two-channel recorder one of the channels decided it was going to be lazy. And this happened just at the time the two new antennas from U.S. Tower were being readied for test.

So between the "two is *not* better than one" problem, and the mis-readings displayed on the newly acquired (but not newly produced) dual-channel chart recorder (i.e. one channel was sluggish with a dampened response), the project ground to a problem-solving halt along about late November.

We present this explanation for several reasons. Primarily, the interest shown in the initial October report was as high as most anything published in CATJ to date; and we feel we owe you an adequate explanation for our delay. Secondly, perhaps our mistakes and mis-fortunes will keep some others from falling into the same traps if they too get into the business of experimenting with circular polarization.

Some good did come out of the whole delay business. For one thing we had a long talk with two leading consumer (i.e. home) antenna manufacturers (they *also* read CATJ closely) and they seemed to be in unanimous accord that they won't touch circular polarized antennas with a ten foot pole. Bandwidth seems to be their problem. We'll have more to say about that shortly. It's nice to know that we won't be seeing multi-mode antennas on would-be-subscriber rooftops soon. And then, we were able to make arrangements with the people at the Heath Company to gain possession of one of their brand new SR-206 *dual* channel solid state recorders which (take our word for it) is some kind of extra nice machine. The dampened response military surplus machine ended back up in the amateur surplus market from whence it came and with good riddance!

Roll Your Own

Inspite of the time lag between last October and now, there is *still* no commercial source for circular polarized CATV antennas. SITCO should be there soon with some cross-polarized Yagis and U.S. Tower might pop with the sixteenth generation of the cross-polarized log shown in the photos here. But you will have a hard time getting delivery on either right off the shelf.

So if you have a wildly fluctuating off-air distant signal on your system and you want to tame the beast, you will probably have to do like the fellow in South Florida did, and roll your own.

Thus, we'll cover the basics here because it seems likely that many systems will want to try 'rolling their own' this spring as the weather clears and the memory of bad winter-time reception still lingers fresh in your mind.

We in fact *recommend* building at *least one antenna* before you even consider buying a new array; at least at this stage of the game. Build it, put it up on the tower, and put a pre-amp on it. Then run it on your system, *against* your *regular* antenna with a time clock, or on alternating days (i.e. change it manually) and compare the results long term. That is the only way you are going to know whether the circular polarized format is *your* answer to deep signal fades and signal dropouts on your long haul, difficult channels.

We will cover the helical antenna, the cross polarized Yagis and another design at this point. The helical you have to build up from scratch. The cross polarized Yagi approach, with phasing lines, is something you can perhaps make up from out of service Yagis you have laying around the headend.

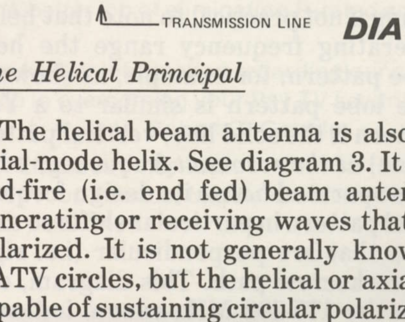


DIAGRAM 3

The Helical Principal

The helical beam antenna is also known as the axial-mode helix. See diagram 3. It operates as an end-fire (i.e. end fed) beam antenna capable of generating or receiving waves that are circularly polarized. It is not generally known, at least in CATV circles, but the helical or axial-mode helix is capable of sustaining circular polarization over a 1.7 to 1 frequency range. So an antenna designed for frequency of say 100 MHz will retain its circular properties over the frequency span of 100 MHz to 170 MHz. Or, a Helical antenna with a design frequency of 175 MHz will cover a range from 175 MHz to 297.5 MHz. Obviously, our high band TV range (174-216 MHz) fits right into that range very nicely with no pushing or crowding. And a Helical antenna designed with a center frequency of 55 MHz can cover the range 55 to 93.5 MHz with the same ease. This is not unlike the log-periodic antenna (see CATJ for September 1975, page 25), although the *realizable frequency spread* with the Helical is *less* expansive than the log.

The helix produces a 'natural adjustment of the phase velocity of the wave propagation' along its entire length, sort of automatically adjusting to each frequency within its capabilities (range). One result is that for *its size* (i.e. length in particular) the helix has the *sharpest* forward lobe (i.e. best defined frontal lobe) of any antenna design known. The key phrase is "for its size"; obviously there are Yagi antennas with narrower beamwidths, but they are considerably longer than the boom of the typical helix device.

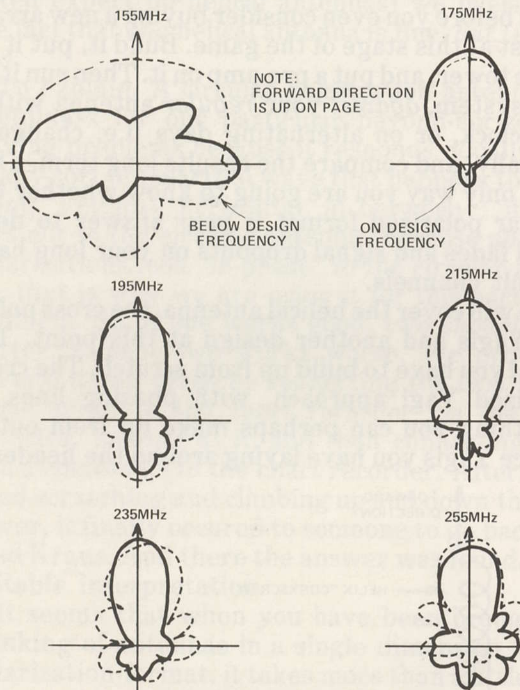


DIAGRAM 4

It is interesting if not practical to note that below the design operating frequency range the helix changes its lobe pattern; for example, as shown in diagram 4, the lobe pattern is similar to a Yagi (horizontal pattern is the solid line, vertical pattern is the dashed line) *at the resonant frequency;* while if the antenna is operated *below* its design frequency the horizontal pattern in particular shifts so as to favor directions that are perpendicular (i.e. right angles) to the corkscrew path. This diagram, of a test antenna in the 175-298 MHz range, indicates that horizontal patterns do change even within the frequency design range of the antenna; and the *actual* pattern rejection of *rear* and *side* lobe signals depends to a large extent on the segment of the design range the antenna is functioning within. The general rule of thumb is that if you utilize the antenna on the actual design *frequency* (which is at the low end of the design *range*; remember the 1.7 number works from the design frequency up), this is where you will have the cleanest possible pattern. A clean pattern means maximum rejection of side and rear lobes. Note in our example that this antenna, designed for 175.25 MHz, has an extremely clean pattern at the design frequency, and while the gain remains *useful* and the match *good* up through 298 MHz, the pattern begins to go to pot as the operating frequency shifts upward in the design range.

So design for the *intended* channel, if you have co-channel sources around. If that happens to be channel 7, the antenna will be good well beyond channel 13, but as you go higher and away from 7 the *pattern* will pick up some minor *side* and *rear* lobes that can*not* be avoided.

There are several ways to build a helix; each has its merits if you are after different results. We'll stick with one technique and one set of parameters which can be duplicated by most and with which we have already had satisfactory results.

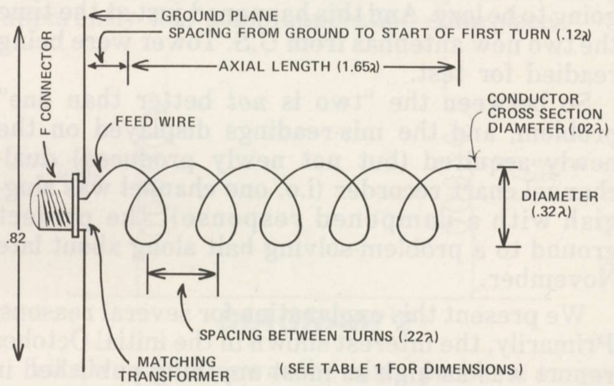


DIAGRAM 5

Here are some basic facts (see diagram 5):

(1) Our helix has an axial length of 1.65 wavelength (wavelength is a free-space function);
(2) The overall length of 1.65 wavelengths is at the design frequency of operation (i.e. channel 7 for a broadbanded channel 7-13 unit);
(3) The diameter of the spacing between top and bottom of the helix turns is .32 wavelength (again in free space, at channel 7);
(4) The spacing, between turns is .22 wavelength (free space, at channel 7);
(5) The diameter of the rear reflector (called ground plane surface) is .8 wavelengths (again, at channel 7);
(6) The spacing from the ground plane surface to the first turn (top or highest point) is .12 wavelength (at channel 7);
(7) The helix or axial twist is constructed from material that is approximately .02 wavelength in diameter (not all that critical, but at channel 7).

That leaves us only with "how many turns" on the helix. The more turns you add, up to both design and practical limits, the narrower the antenna beamwidth and therefore the greater the forward gain. You can't wind yourself into infinity because you run into both practical problems (i.e. how do you support it) and sooner or later some operational abnormalities. There is nothing *magic* about six turns, except that it is a convenient 1.65 wavelength long antenna. You could go further (longer) if you wish, but we won't cover that here at this time.

TABLE 1 (see diagram five)

Measurement	Ch. 2	Ch. 7
Ground Plane (.8 wave)	171.75″	54″
Spacing GP to 1st turn (.12)	25.75″	8.1″
Axial Length (1.65)	354″ (29.5′)	111.4″ (9.25′)
Turn Spacing (.22)	47.2″	14.9″
Turn-Diameter (.32)	68.7″	21.6″
Conductor-Diameter cross section (*) (.02)	4.4″	1.35″
Number Turns	6	6

*—This is quite large material, especially at channel 2, to be 'bending' into a spiral. CATJ test models have been constructed from number 10 copper-clad steel wire and our experience is that our loss has largely been in large bandwidths (i.e. 1.7 x design frequency is ideal spec).

There is one other concern in a helix design, and that is something called *"pitch angle."* The pitch angle is the handle around which many fairly *complex* (and inter-active) design computations are made. Helix diameter, spacing and turn length are all inter-related and *pitch angle* is the glue that holds them all together. For our purposes, a pitch angle of 14 degrees has been selected. That is not a transit measurement you make or something you scribe with a compass, it is merely a *design* function which you may run into if you do your own reference reading on the helix. We wanted you to know what our standard was just in case you like to sleuth. If you are simply going to follow the instructions and build the thing, forget all about pitch angle, it is of no further concern to you.

Our original test antenna was constructed on a piece of redwood 2 x 4, topped with several coats of plastic shellac to keep the redwood from rotting (We know, redwood is not *supposed* to rot . . . but). Following the instructions in diagram 5 and the photos shown here, you should be able to construct your own duplicate high band antenna.

Now the basic axial-mode helical antenna (helix) is *not* a good match to 75 ohm cable. In fact it exhibits a VSWR of 2:1 or better, with a 140/150 ohm load match. Fortunately, and this is a plus, the load match on a properly designed helix is very resistive. In fact, it is about as resistive as any antenna can be (i.e. there is virtually no distributed capacity so antenna 'reactance' is minimal). In our first CATJ Lab Site antenna, we *ignored* the mismatch from the unbalanced 140/150 ohm helix to the 75 ohm cable and gave away some signal. Subsequently we took an RMS model CA1002 two-way customer type splitter apart and scavaged a core out of it. From this we made up a 150 ohm unbalanced to 75 ohms unbalanced matching transformer (see diagram 6). If you do the same thing, you can match the helix with a VSWR of under 1.1 : 1 (we measured ours at just over 1.05 : 1 using the *CATV Match Box* described elsewhere in this issue of CATJ). The broadband nature of the matching transformer means the match is good through the antenna's frequency range.

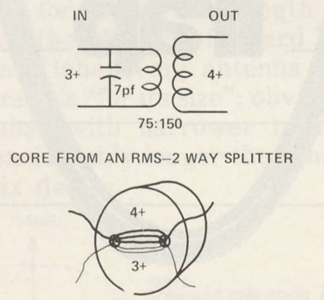


DIAGRAM 6

Then you can hang a chassis-mounting "F" series fitting on the screen ground plane on the back of the antenna (see diagram 7) and you are in business; the "feed wire" connects the center conductor pin of the "F" fitting to the helix turn and the screen (ground plane surface) makes up the shield side of the antenna feed. You *might* want to cut a 3 inch by 3 inch solid aluminum (or better yet copper if you can find it) plate to mount the chassis "F" fitting onto, that will be more structurally sound than trying to lash the chassis "F" fitting to the screen mesh used for the ground plane on the rear.

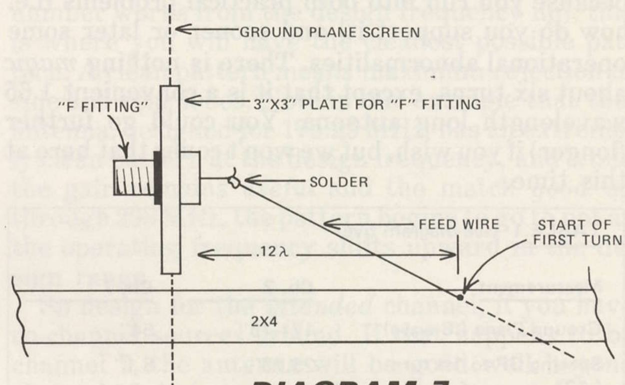
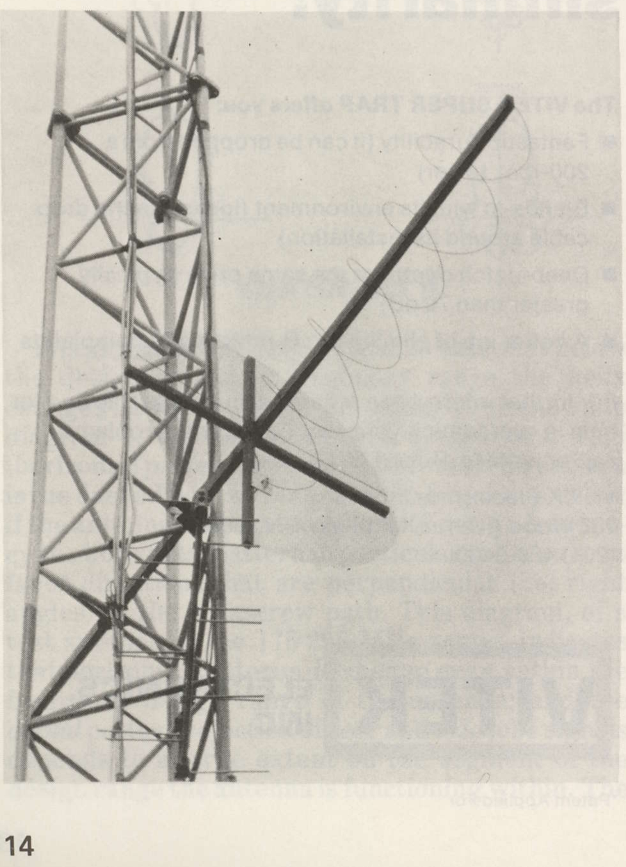
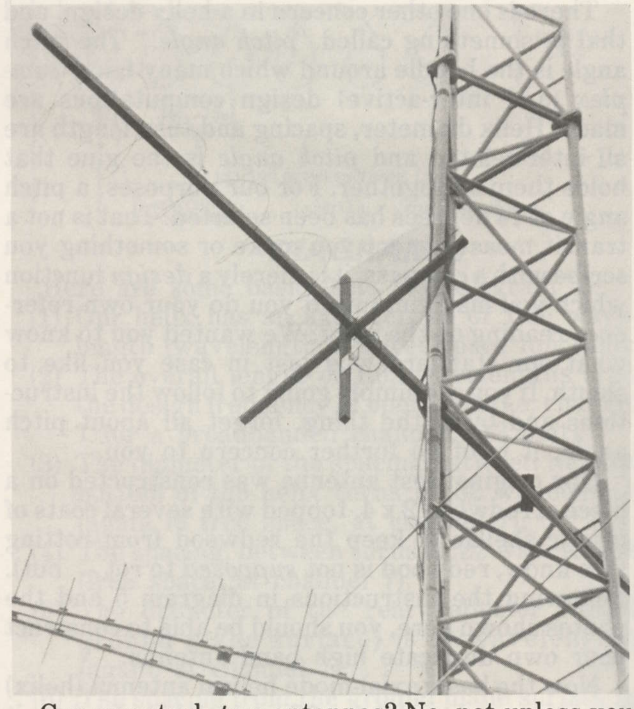


DIAGRAM 7

There is no antenna tuning possible, once constructed; you can mount it from the rear to a vertical or horizontal tower member. We found that with all of that "sail" out there that the wind really likes to whip the helix around so you should tie it across *two* different tower members to maintain it from swinging like a wind vane in the breeze. If you chose good redwood, or tough weathered cedar, the 2 x 4 should take whatever winds you have. Our winds in Oklahoma are not exactly kind and the test antenna is now into its third year of operation.

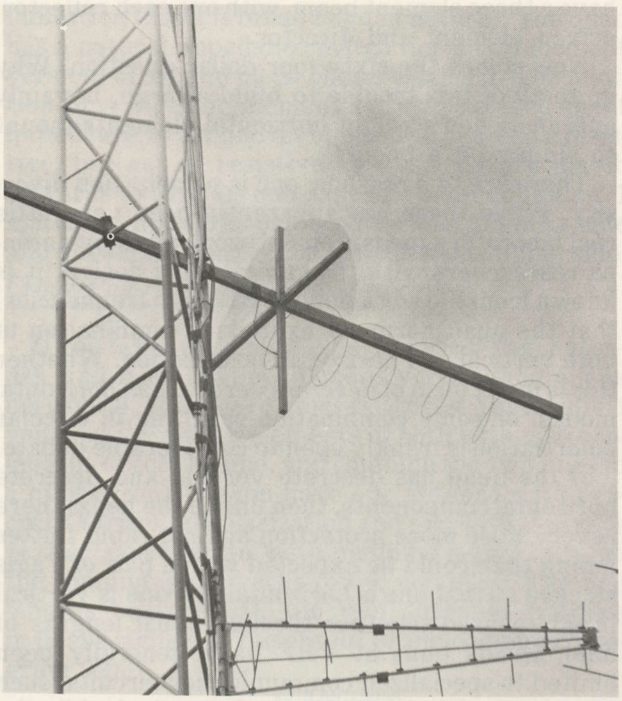




Can you stack *two* antennas? No, not unless you want to give up the circular polarization. Can you stack *four* antennas? Yes, and we suggest the best way to do it is to follow common log or yagi stacking practices and use equal-length coaxial phasing lines with a hybrid combiner.

What about UHF?

Our original intent with the original Lab Tests



was to get into UHF very quickly. Experience has shown that the scatter-fade rate (i.e. the rapid flutter fading that is caused by polarization shift or skewing) is from 2-5 times more pronounced on UHF than at high band VHF (see Page 13, January 1975 CATJ). It is our theory that a properly-designed (i.e. proper number of turns) UHF helix used as a focal point (i.e. feed point) antenna on a 20 foot (or larger) UHF parabolic antenna (see CATJ for July 1974) would be a hard antenna to beat. The 20 foot parabolic reflector would scoop up the microvolts, while the helical feed would *even out* the rapid fading by following the multi-mode polarization regardless of where it went.

What about low band VHF?

Chances are the antenna is too large for the average kind of installation, especially when the antenna must get several hundred feet into the air to be clear of local noise and terrain. At channel 2, 1.65 wavelength (just as an axial-mode length number) is 29.5 feet long. That is alot of 2 x 4 (it had better be 4 x 8!), much too much to hang out in front of a tower and expect to stay up. On the other hand, because of its wooden support design, you could space two or even three 20-30 foot wooden telephone poles *in a line* pointing at the desired station and construct a helix for channel 2, hanging it on the poles, if you were on top of a mountain or had natural elevation height at your headend (see diagram 8). We plan to build such a channel 2 antenna this spring ourselves at the CATJ Lab. Design dimensions for channels 2 and 7 are given for reference.

There is one other consideration concerning low band use. Our CATJ experience is that after nearly two years of measuring (and chart-recording) off-air distant (i.e. far grade B and beyond) signals, we believe the rapid flutter fading is only fractionally a

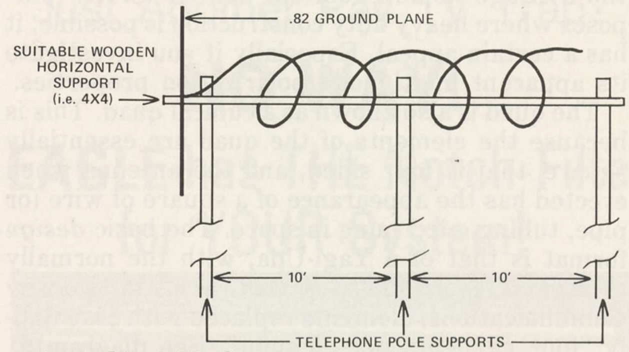


DIAGRAM 8

problem at low band. To put that another way, the low band signals just don't exhibit that same rapid pumping motion that high band and UHF signals do, most of the time. However, we *have seen* occasions during periods of propagation abnormalities when a just-beyond-Grade B low band signal goes into a deep fade; a signal that *averages* near perfect 99.9 percent of the time. For that .1 percent of the time when it drops down or almost *out*, we have found it comes *up* on a vertically polarized antenna; suggesting that during the formation of a "duct" the low band signals may be going through an axial-mode transition of their own. In other words, they seem to drop out on a horizontally polarized antenna, but are at the same time much stronger than normal on a vertically polarized antenna. This suggests the low band helix may have some applications afterall.

Finally there is the matter of man made noise. Most of us are aware that ignition noise from vehicular engines and some forms of electrical noise are *largely vertically polarized.* Thus our normally horizontally polarized CATV antennas have from 20 dB up discrimination *against* these local noise sources and that is an advantage in shutting the noise pulses out. However, the helix antenna is *equally responsive* to horizontal *and* vertical wavefronts. And this simply means that vertically polarized local noise sources may become quite abit stronger in level on the helix than they are on the horizontally polarized antennas. This is more theory than observation with us because the CATJ Lab Site test system is blessed with what is normally a very quiet location, and noise is seldom measureable. But you should be warned before you start out building a helix that *if* you have a locally noisey location, you *might* want to think twice *before* you experiment with a helix.

At this point you are on your own, for the moment.

The Lesser Known Quad

Although popular with high frequency (3-30 MHz) types, the Quad Antenna has never amounted to much (if in fact anything) with the VHF-UHF set. There are a number of *structural* reasons why this antenna might not be an appropriate choice for the average home's rooftop, but for CATV purposes where heavy duty construction is possible, it has a certain appeal. Especially if you investigate its apparent multi-mode polarization properties.

The quad is also known as a cubical quad. This is because the elements of the quad are essentially square, that is four sided, and the antenna when erected has the appearance of a square of wire (or pipe, tubing, etc.) hung in space. The basic *design* format is that of a Yagi-Uda, with the normally horizontal (as in CATV) or vertical (as in two-way communications) elements replaced with essentially "four elements per element". See diagram 9.

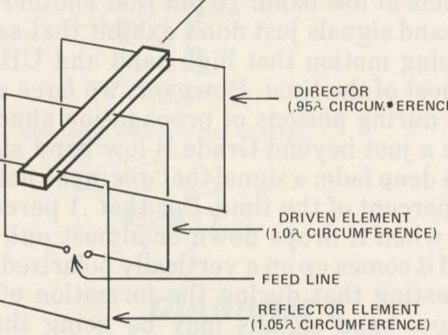


DIAGRAM 9

For the moment let's look *only* at the driven element, or coaxial line fed element. As shown in diagram 10, it is a frame of four sides. Each side is approximately 1/4th wavelength long which means the starting-out length is 1 wavelength of tubing, wire, rod or whatever the material happens to be. The driven element is broken in our example on the bottom side in the middle where the transmission line is connected. We'll come back to the matching problems shortly.

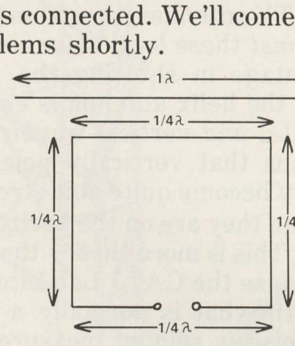


DIAGRAM 10

If the dipole is expanded with a suitable "reflector" element, we have a directional 'beam' antenna. The reflector is constructed in the exact same manner, only it is 5% *longer* than one full wavelength to begin with (while straight). That makes each of the four sides approximately .2625 wavelength long for the reflector. And the reflector is *not* broken in the center of the bottom side (or any other side) because it does not have a transmission line connection.

Now to go off in the opposite direction, if a third cubical element is added in *front* of the driven element, one .95 of a wavelength long *overall,* we have a three element beam, with one each reflector, driven element and director.

Now comes the sixty four dollar question. Why go to all of this trouble to build a large, ungainly antenna when straight horizontal elements mount so simply on a boom?

There are two reasons; one is polarization diversity. While there has apparently been very little real laboratory measurement work done by antenna researchers with the cubical quad design, it is known from the work done at HF (high frequencies) that the quad normally exhibits a combination of both vertical and horizontal polarization. Whether this is in the form of *descrete* vertical *and* horizontal modes, or some combination resulting in circular polarization is frankly open to considerable debate.

If the quad has descrete vertical and descrete horizontal components, then unlike the helix, there is very little more protection against rapid flutter fading than could be expected with a pair of Yagis stacked so that one is horizontal and one is vertical (Yagis phased together through equal lengths of line). Quads built at VHF have generally been limited to specialized communication circuits, such as amateur (ham) 144 MHz systems. And while the documentation is nil, the results do suggest that fade rates *are markedly lower* with a quad than with descrete horizontal *or* vertical arrays. Therefore the quad deserves some mention, and, additional experimentation for CATV purposes.

To do the construction practices of the quad justice would require more space here than it is worth at this point in time. Suffice to say the antenna can be constructed from any conducting material and the high band version (see diagram 11) is not very difficult to construct or large. A 2 x 4 for support is adequate if the element materials are aluminum tubing or rod. For low band, the elements could be tubing, rod, or #10 or 12 wire fixed to spreaders.

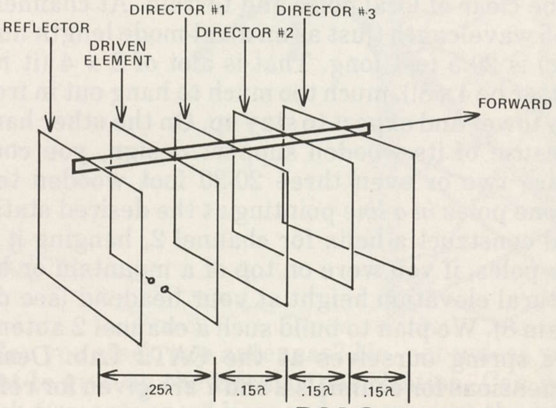


DIAGRAM 11

The quad is reputed to be broadband, but defining what is broadband *in this application* is difficult. It *will* cover *one* TV channel with no trouble, especially at high band, and the match is not critical (an indication that it is broad band in nature). The quad has a natural impedance match (for a two element version) of around 50-55 ohms, balanced. The addition of a director element lowers the feed point impedance to around 40 ohms. The match *is* resistive, but *not as* resistive as the helix. To match upwards to 75 ohms unbalanced would require a 2:1 matching network, balanced on the antenna side and unbalanced on the coax (75 ohm downline) side.

Cross Polarized Yagi-Uda Antennas

If you take two separate *but identical* Yagi antennas, and mount them so one is vertical and one is horizontal, you have a *cross-polarized* Yagi. Now if you feed the driven elements of both with *identical* lengths of coaxial line, and combine the two lines in a hybrid coupler, you have *one* antenna with *descrete horizontal* polarization and *one* with *descrete vertical* polarization, both pumping signal through the combining networks to the downline. The line lengths being equal, the two antennas produce in-phase signals at the output of the combiner (diagram 12).

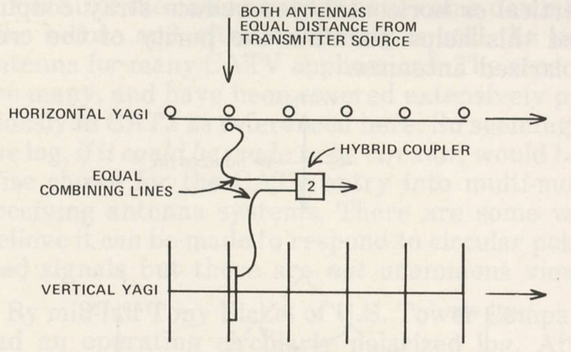


DIAGRAM 12

This is not the best way to do it, simply because you end up with two descrete forms of polarization (i.e. one each horizontal and vertical). That is no protection against the in-between modes such as a 45 degree canted wavefront.

Now, if you take the same two Yagis and connect them together with *unequal* lengths of coaxial line between the antenna(s) and the input to the hybrid combiner, and if the line lengths are of a *special* length, you can make the two descrete polarization antennas function together (as a pair) *as if they were in fact a single circularly polarized antenna,* such as helix. See diagram 13.

This works out this way because if one antenna driven element drives signal through a section of coaxial line that is 90 degrees (in phase, or 1/4 wavelength in coax with the coax propagation factor included) longer than the opposite antenna-to hybrid coupler coax, at the combiner end the two signals are no longer phase-equal. You would think this would lead to partial cancellation of the out of phase component of the second antenna; but in fact it leads to creating circular polarization.

For this ploy to function (i.e. for there to be circular polarization when you get all done), both

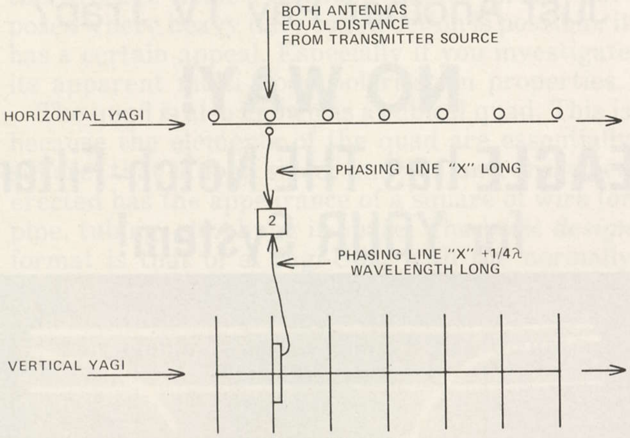


DIAGRAM 13

antenna driven elements need to be at the same point in space (i.e. in time or *the same distance from* the transmission source). There are mechanical problems associated with taking *one piece* of boom material and mounting two sets of elements on the same boom; when both sets have to run through the boom at the exact same point on the boom. (If one set of elements is offset ahead or behind the other, that means the forward set is *slightly* closer to the transmitter source and will in effect receive the signal first; this is a form of phase non-coherency all by itself.)

Therefore most approaches to cross-polarized Yagis utilize two separate, identical antennas, with one of the two following procedures:

(1) The two antennas are so mounted that they are the exact same distance from the transmitter source, to maintain phase coherency (just as you do now when you stack two or more antennas for the same signal), and, the antennas are joined together with two different lengths of coaxial cable, one being 90 degrees of phase or 1/4th wavelength longer than the other.

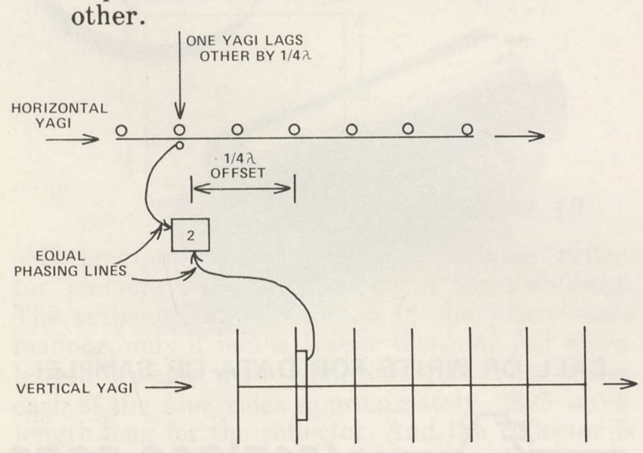


DIAGRAM 14

(2) The two antennas are mounted 90 degrees in phase or 1/4th wavelength apart in space, so that one antenna's nose *leads the other antenna's nose* by 90 degrees of phase or 1/4th wavelength in space (diagram 14). Then the two antennas are fed with two *equal*, identical lengths of coaxial cable, to the hybrid combiner. The 1/4th wavelength in space lead of one antenna creates the same polarization skewing as the extra 1/4th wavelength of line would do.

No cross polarized yagi approach requires that one antenna be *exactly* horizontal (in relation to the earth's flat plane) and the other *exactly* vertical. What *is required* is that the two antennas be so mounted that the respective individual antenna elements are at *right angles to one another*. They could be vertical, and horizontal, or they could be slanted from 135 to 315 degrees for one antenna and 45 to 225 degrees for the second antenna (see diagram 15). The reason this *may be* better than straight horizontal and straight vertical is that the balance of your tower mounted antennas are horizontal (this means coupling between horizontal elements on *different* antenna arrays) and the largest sections of your tower are vertical (again, coupling). By slanting the two antennas off of *either* vertical *or* horizontal, you reduce stray coupling and this helps maintain the purity of the cross polarized antennas.

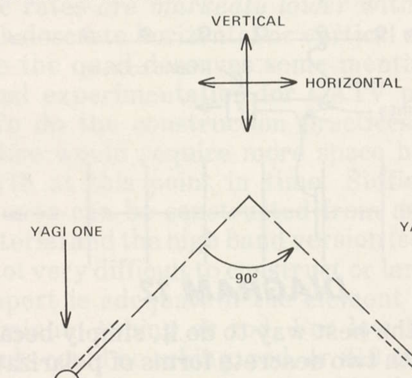


DIAGRAM 15

Thus you can conduct your own experiments *with circular polarization* by creating circular polarization using two identical on-hand Yagi antennas. Any of the techniques discussed and shown here will function; the actual choice you make should largely depend on the area you have available to mount the antennas.

The Cross Polarized Log

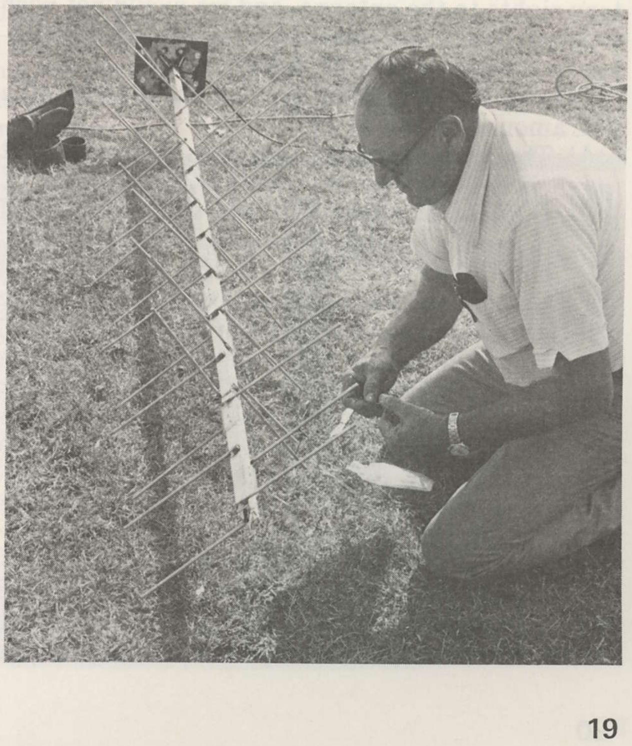
Either the helix or the quad have simple single point feeds. The helix has a broad frequency response, good match if the 2:1 unbalanced transformer shown here is employed, but it is still cumbersome. And except on the *design* frequency, the side and rear lobe rejection *could be* a problem if you have some co-channel sources in the area. Even at the design frequency, the rear and side lobe rejection is not nearly as decent as with a log (20 dB typically best case vs. 30 dB best case with a log).

The cross polarized Yagi has the advantage that it is a fairly simple approach, and chances are you have the parts or antennas laying around to conduct your own tests. However, mounting *two antennas* to get one antenna performance is somewhat wasteful and it cannot be carried very far before available tower space is gone. The primary disadvantage is that you need to be careful with your feedline lengths and/or antenna spacing (i.e. one ahead of the other 1/4th wave) if you want to end up with something approaching true circular polarization. One other disadvantage is that the 1/4th wavelength in space, coax or both is very frequency sensitive. That is, what is 1/4th wavelength at channel 7 visual will *not be* 1/4th wavelength at channel 7 aural so you *may* end up with some *minor* amount of polarization non-linearity as you move across even a single high band channel. At low band, this is not a "may", it is a definite. And since the color sub-carrier is nestled just below the audio on the high end of the 6 MHz channel passband, you *could* create some strange looking color with such an arrangement (you may *not* do that also, it is merely conjecture on our part).

For all of the antennas that have come down the pike before and after it, the log is still the best antenna for many CATV applications. The reasons are many, and have been covered extensively previously in CATJ as referenced here. So seemingly, the log, *if it could be made to be circular*, would be a wise choice for the CATV entry into multi-mode receiving antenna systems. There are some who believe it can be made to respond to circular polarized signals but these are *not* unaminous views.

By mid-fall Tony Bickel of U.S. Tower Company had an operating circularly polarized log. After tests at their Afton, Oklahoma facility, a pair of the high band units were brought to the CATJ Test Site north of Oklahoma City. As depicted on the December (1975) CATJ cover, the antennas were installed and have been operating since that time. After the previously mentioned difficulties with two antennas and a new-to-us chart recorder, things settled down and tests have been underway ever since. Unfortunately, without four antennas to play with, we have been forced to make measurements with only a *single* antenna. The single antenna, mounted at the same height as a single horizontal log antenna, is on a rotor so that we can work with and measure signals that are respectively 65 miles (mid to far range B), 103 miles (beyond B or scatter range), and some really distant signals in the 150-200 mile region. For CATV purposes, because we have to have something approaching 99.9% reliability, the signals beyond the 100-110 mile range are not *really useful* except for measurement purposes (we do have one 200 mile UHF station on our mini-lab system, but that is another project and story).

Unlike the cubical quad and the crossed Yagis, no design data is available on the circular log although several photos of its construction are shown here.



shield to the other boom-nose. The feedline runs back through (inside of) one of the booms to the rear of the log, in typical "decoupling" fashion.

To summarize the multi-mode log (i.e. with built-in circular polarization), we *believe* it provides a worthwhile improvement over a straight horizontal antenna. It does *not*, in our measurements, compare *totally* with a helical antenna; it lacks some degree of circular concentricity in its *present* form. Designer Tony Bickel believes this can be cured, and that is why for the moment the antenna is not yet on the market at U.S. Tower.

The reasons for this are not difficult to understand; U.S. Tower believes they *may* have some proprietary rights to the antenna, and we would not wish to jeopardize those rights by prematurely publishing any construction or design *details*.

We can say this much, because the photos tell a fair amount of the story.

(A) The circular log has two sets of elements, at right angles to one another.

(B) One set of elements *leads* the other set of elements by 90 degrees of phase (1/4th wavelength) which means (as the photos show) that one set starts out at the very front of the twin-log (insulated from one another) boom(s) while the second set of elements (90 degrees displaced in polarization) begins further back on the boom. The set of elements that begins further *back* from the front *also* ends 1/4th wavelength further *back* on the boom.

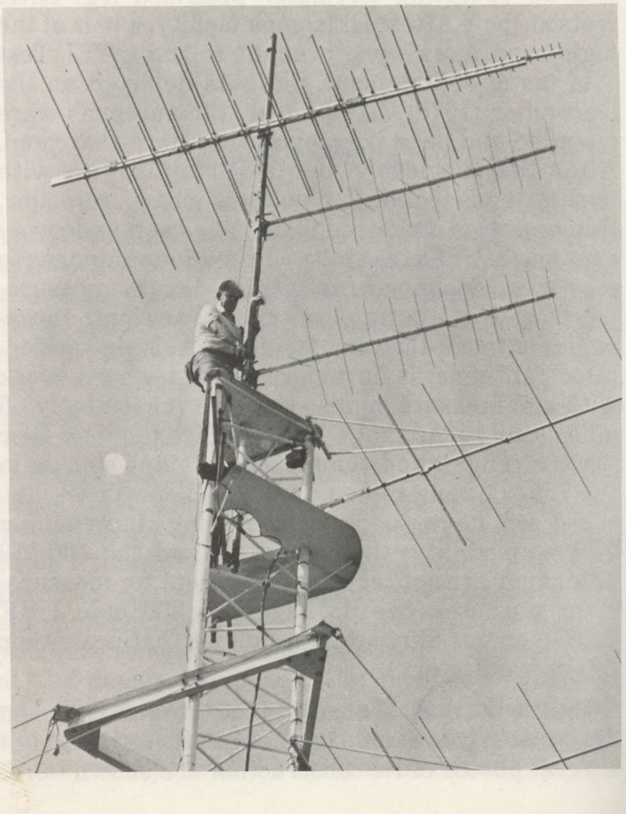
(C) This means that circular polarization is created by the same space-offset technique discussed with the cross polarized Yagis.

(D) However, like any log, this log takes its feed at the front or nose of the antenna with the center conductor to one boom-nose and the shield to the other boom-nose. The feedline runs back through (inside of) one of the booms to the rear of the log, in typical "decoupling" fashion.

<u>*Summary*</u>

The broadcasting tests with VHF channel 7 in Chicago and UHF channel 19 in Modesto, California continue. The broadcasters are piling up reams of data which will undoubtedly show that in certain situations *their use* of circular polarization is very beneficial to *their own* operations.

But the real advantages to circular polarization would seem to be at the receiving end of the circuit. When this series continues in a future issue of CATJ, we will discuss that further, especially as it relates to cancellation of reflection path signals and co-channel sources.



FREEING UP TIRED HANDS

ComSonics ACM-20 Automatic Test Recording System

You have probably already tired of the repetition; but *this is* the year of FCC tests. If you have not tired of the endless technical reports on tests, testing procedures and testing apparatus, you have probably been *too busy* conducting tests to keep up with the printed material currently being devoted to the topic. Which means you are probably a prime candidate for the Automatic Channel Monitor; a do-many-things-for-you automatic kind of machine that takes much of the drudgery and fatigue out of making system tests.

Some tests are complicated and fraught with error (i.e. in-channel response tests); other tests are tiresome and at best a drag. The requirement that you make "24 hour period tests" (76.605/[a5]) for all Class I channels (i.e. broadcast signal channels) is one of the latter.

It is not with a great deal of surprise then, that you learn that some clever people have devised a "box" to conduct certain tests for you, automatically, and provide you with a written record of the test results. The clever people are located at Com Sonics, Inc. (P.O. Box 1106, Harrisonburg, Va. 22801) and the clever box is the Automatic Channel Monitor (ACM).

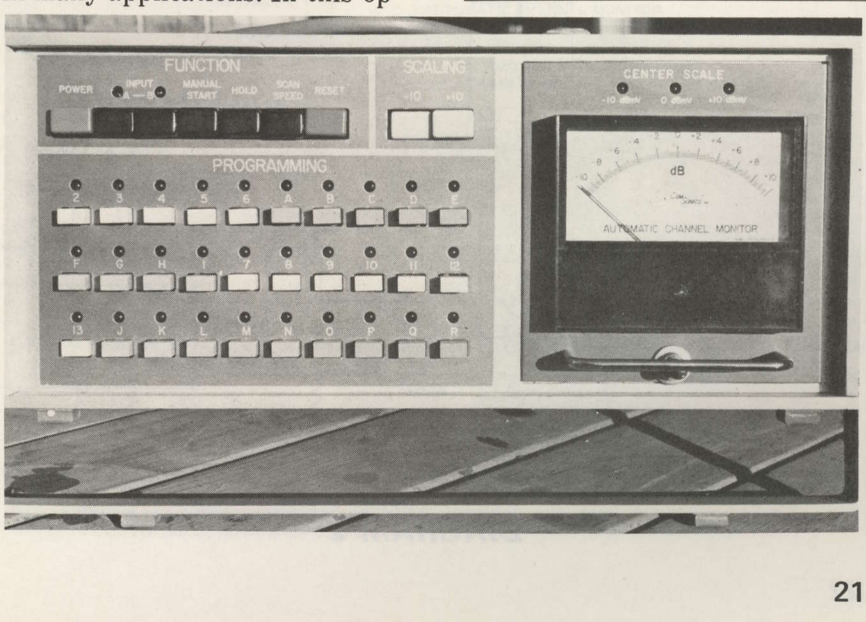
The ACM is a CATV test instrument capable of measuring *and recording* RF signal levels of standard television carrier frequencies. In a sense, it is a programmable SLM (programmable in the sense that it will scan or look at each of the channels on the system, either on manual command or on *programmed* command), that happens to be tied to a hard-copy machine (i.e. a chart recorder). All of the functions are housed in the single container, and other than AC power to operate the unit and the drop cable to plug into the unit (with the CATV RF signals), there are no extra boxes to lug around or patch cords to connect descrete boxes together.

The ACM has a pair of input connectors; one each for "A" and "B" inputs. A and B could be separate CATV feeder lines (for dual-cable systems), or they could be respectively the input and outputs of (for example) a headend rack of processors, through appropriate test points of course.

The ACM is, in CATV circles, a very sophisticated field strength or signal level meter with what promises to be an above average amount of accuracy and scale readout correctness going for it. In fact the unit can be utilized minus the recorder function as a standard SLM in many applications. In this op-

ACM SPECIFICATIONS

Purpose—30 channel SLM with built-in chart recording function
Frequency Range—Channels 2-13, A-R
Dynamic Range— —10 dBmV to +20 dBmV (3 ranges centered on —10, 0, +10 dBmV)
Input—75 ohms, "F" fittings (two input ports)
Match—15 dB RTL (operating port)
Accuracy—+/— 0.75 dB in —10 dBmV range; +/— 1.0 dB in 0 and +10 dBmV ranges
Tuning—Varactor tuned, push-buttons for pre-set channels
Scale Linearity—+/— 0.35 dB
Scale Markings—Numbers 1 dB steps, 0.2 dB step markings
Chart Recorder Speed—1" per hour
Usable Recording Time—100 hours (30 channels;) 12.5 hours continuous
Channel Read Period—Once per hour for 15 seconds per channel
Reference Oscillator Accuracy—+/— 0.5 dB
Operating Temp Range—+23 to +122 degrees F
Dimensions—13.25" x 12.75" x 5.5"
Weight—20 pounds
Price—$2395.00
Manufacturer—
Com Sonics, Inc.
P.O. Box 1106
Harrisonburg, Va. 22801
(703/434-5965)



erating mode the unit will read a single channel for as long as you wish, or two or more channels in sequence based upon the way you have programmed the unit to "read" the levels present (determined by which buttons you push). The unit will switch channels *automatically*, as a function of time, going through the sequence and coming back to the "rest point", or by pushing the proper push buttons you tell it which channels to look at manually. If all of this seems complicated, it is not. The unit is about as difficult to operate as your dashboard AM/FM car radio.

Reference is made to Diagram 1; the approximate block diagram of the ACM.

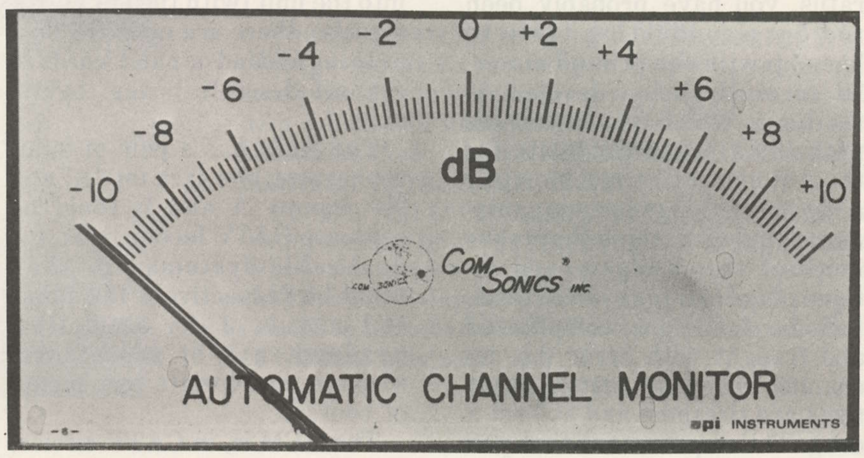
Low To High

At the input on the back apron there are two F fittings, for connection of two separate RF signal sources. A manual "A"/"B" switch, or a programmable "A"/"B" switching system selects which input the meter will provide to the measurement guts of the box.

After the input source port has been selected, the ACM operator selects a meter scale range (see photo here). There are three (push button) meter ranges, with 20 dB *linear* scales for each. One is centered on —10 dBmV (meter range is —20 to 0 dBmV); another is centered on 0 dBmV (meter range is —10 to +10 dBmV); and the third is centered on +10 dBmV (meter range is 0 dBmV to +20 dBmV). If that seems less than adequate for typical SLM functions, remember that this is *not* a basic SLM; it is intended to be a cable-line recording device, and typically will find wide (st) applications at the tag end of a house drop, where levels in the —20 to +20 dBmV region are definitely in order. The push button meter range chosen tells you it has been chosen with a front panel red LED that identifies the range chosen; should you forget.

The range chosen actually selects the amount of attenuation in the front end of the unit ahead of the meter amplifier/conversion stages. In the ACM all attenuation functions are handled by the newest arrival on the attenuation scene; pin diode attenuators. Pushing a range "up" selects the appropriate pin diodes to calibrate the range chosen.

From this point on the ACM



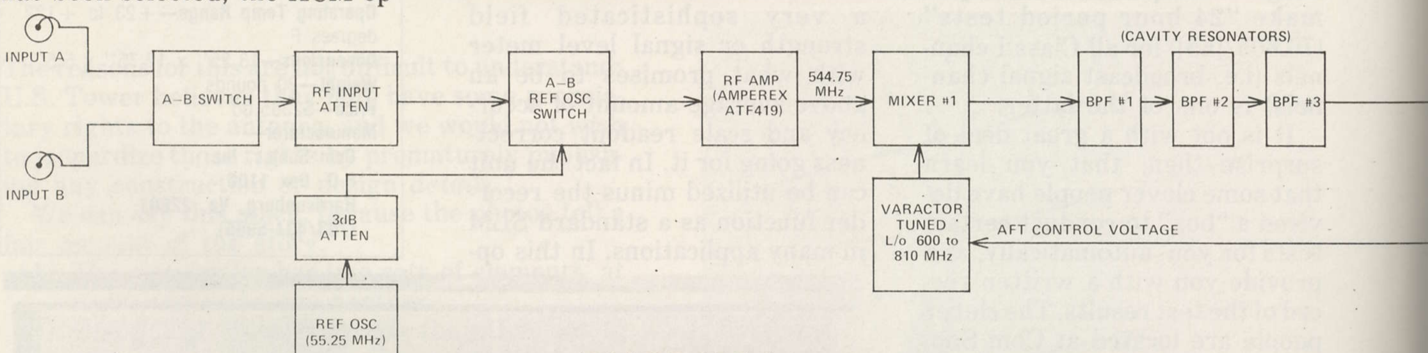


DIAGRAM 1

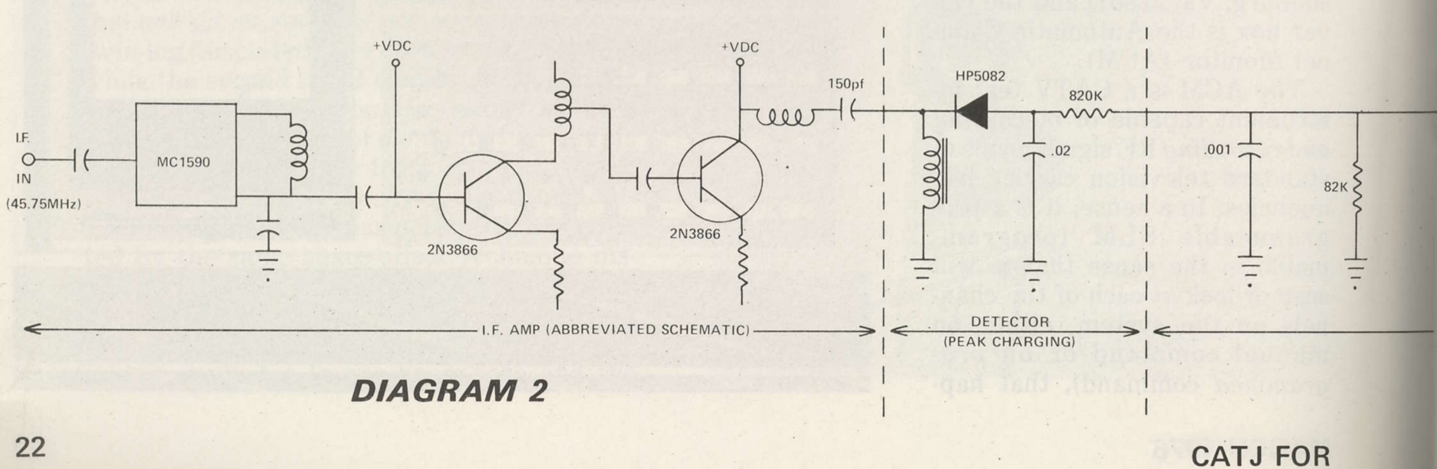


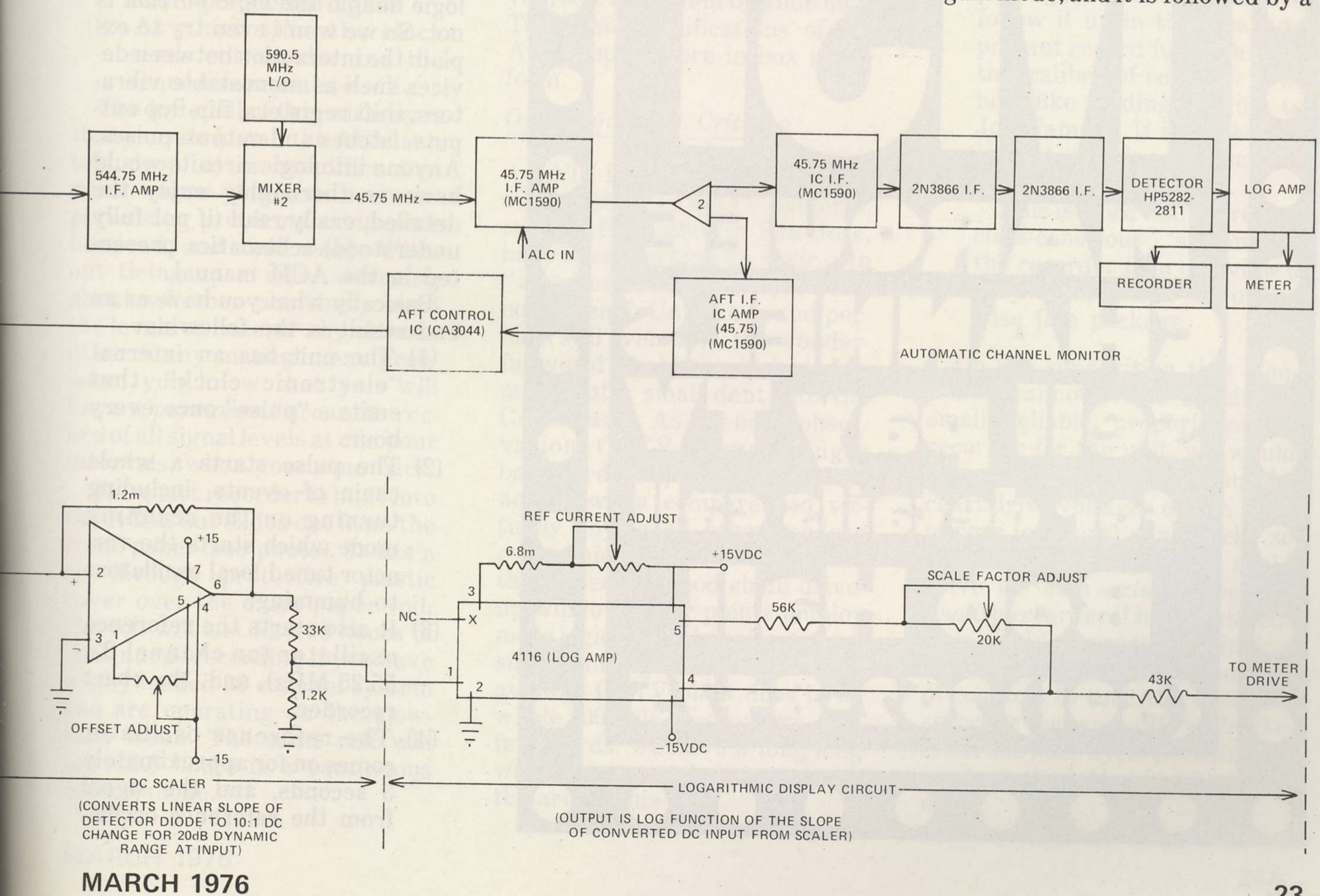
DIAGRAM 2

begins to deviate in large amounts from standard SLM design practice. First of all there is the reference oscillator. The ACM provides a built-in reference oscillator (on channel 2 visual carrier; 55.25 MHz), which does double duty. It not only allows instant calibration of the meter scale, but it also provides a reference signal for the SLM to detect and put into hard copy on the paper strip chart recorder. More about that shortly.

Following the reference oscillator switch, which is sandwiched between the RF input attenuator block (pin diodes) and an RF amplifier, *is the RF amplifier.* This is perhaps the only present-day useage of a true (VHF) RF amplifier in an SLM. The device chosen for this function is an ATF-419, a very flat broadbanded chip-amplifier imported from Europe (Amperex) and found in a number or more recent CATV amplifier devices in low level applications. The (VHF) RF output from the ATF-419 is fed into one port of a mixer; the other input port is driven by a varactor tuned local oscillator operating in the 600-810 MHz region. The i.f. output of the (first) mixer is high; in the UHF region, or 544.75 MHz to be exact. This is a practice followed generally by at least two other CATV SLM units. (See page 36, December 1974 and page 42, February 1975 CATJ). The 544.75 MHz "i.f." passes through three resonant cavity type bandpass filters and is then amplified by a 544.75 MHz i.f. amplifier. At this point the signal has level and some i.f. shaping, and it is ready for re-mixing from the high i.f. back down to a lower frequency. A second mixer is driven on one input port by the 544.75 MHz signal, and at the second input port with a 590.5 MHz single frequency local oscillator. The resulting output is a 45.75 MHz i.f. which immediately drives an IC amplifier (MC1590).

Following the first IC 45.75 MHz i.f., there is a two-way splitter which provides signal to loop backwards to the first mixer for AFT control (automatic fine tune/tracking). The AFT system is comprised of an additional 45.75 MHz gain stage (another IC). This relatively high level i.f. signal drives yet another IC where signal detection takes place. The detected voltage is proportional to the input frequency into the IC. This proportional voltage becomes a control voltage or signal to drive a DC reference regulator. The output of the regulator (which provides a tuning voltage) is applied to the initial varactor tuned local oscillator for the *first* mixer. In this way the frequency stability of the system is assured; it tracks itself as it were and comes back to the proper 45.75 MHz i.f. output frequency of the second mixer.

Going on through the "other" output of the two-way splitter at the aft end of the first 45.75 MHz regular i.f. amplifier, the i.f. signal then sees a second IC i.f. (another MC1590). This MC1590 is operated in an extremely linear gain mode, and it is followed by a



pair of bipolar descrete amplifier stages also tuned to 45.75 MHz.

The voltage developed by the second 2N3866 (i.e. the last i.f. gain stage) is sufficient to drive at high level the Hewlett-Packard 5082-2811 detector diode. The detector is a linear peak charging circuit. The output of the detector is linear (at DC) with respect to the i.f. (RF) input level changes. However the "scaling" of the DC voltage at this point is not proper for display purposes, so the DC voltage is fed to a "DC Scaler" which converts the linear slope of the detector diode to a 10:1 DC change for a 20 dB dynamic range input level change.

The front panel meter of the ACM unit is evenly divided into equal increments of meter-scale-face-space (say that fast!) for equal amounts or increments of decibels. The 20 dB meter face scale is broken up with marks that are 1 dB apart, and in between the 1 dB calibrated points are 0.2 dB marks or steps.

Between the DC Scaler and the meter movement is a log amplifier. This log amplifier develops the log-ratio-current (voltage) which is actually read by the meter, and this interesting innovation ends low-end scale bunch-up commonly found on SLM instruments.

Automatic Operation

Up to this point we have a number of novel if not downright clever approaches to the basic signal level reading problems normally associated with any frequency selective voltmeter.

As noted, if you want to read the level on say channel 3, you simply push the "manual" button followed by the "channel 3 select" button. At this point you have an accurate SLM, push button operated, not totally unlike a happy mixture of several of the other high quality SLM's on the market today.

But this is *not* basically an SLM; it is a *remote meter-recording device* designed for unattended operation.

If the "logic" behind the RF section, as described to this point, is fairly easy to grasp for the average CATV person, the logic behind the *logic portion* is not. So we won't even try to explain the interaction between devices such as monostable vibrators, shift registers, flip-flop outputs, latches and output- pulses. Anyone into logic circuits would however thoroughly enjoy the detailed, easily read (if not fully understood) schematics presented in the ACM manual.

Basically what you have as an end result is the following:

(1) The unit has an internal "electronic clock" that emits a "pulse" once every hour;

(2) The pulse starts a whole chain of events, including turning on the scanning mode which starts the varactor tuned local oscillators to humming;

(3) It also starts the reference oscillator (on channel 2's 55.25 MHz), and, the chart recorder;

(4) The reference oscillator comes on for approximately 5 seconds, and the signal from the reference oscilla-

tor is "read" by the SLM and recorded by the hard copy paper chart recorder;

(5) Then the scanner starts the varactor tuned local oscillators operating, and in sequence starting with the lowest channel for which you have previously preset a push button, the SLM automatically reads out the signal level present on the first channel for some 10 seconds time. This level is recorded on the chart paper immediately after the local reference oscillator.

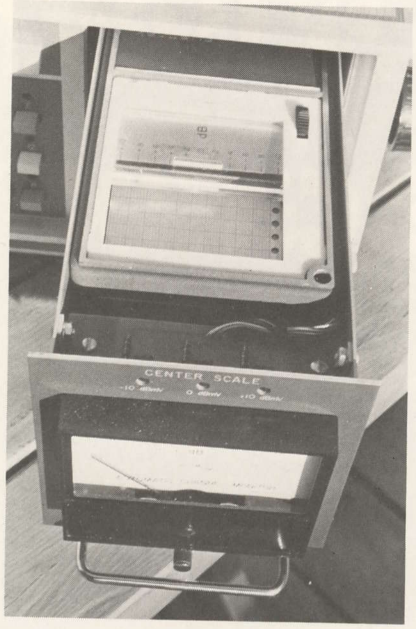
(6) Then in a scanning/switching function, the SLM *moves* to the next *higher* channel which you have preset a push button for and reads (and records) that level also. This process is repeated until the last channel has been measured (channels 2-13 and A through R are accommodated).

(7) Then the unit shuts down and the electric clock does its slow trickle job until an hour has passed again.

(8) At which time the clock sends out a pulse and the sequence repeats itself.

The joy of all of this wizardry is that you can install the ACM at a test drop, at an amplifier test point where you have been experiencing problems, or in your headend, *and walk away.* Without tieing up a man, worrying about whether somebody read the levels on time, or any of those other funny management problems, you know that you will have a *permanent accurate record* of all signal levels at one hour intervals, when you come back.

The chart recorder is built into the ACM, but slides out from the front panel (see photo). It has a see-through protective plastic cover over the chart paper roll; the roll will last for 100 hours of continuous recording if you have a fully loaded 30 channel system and are operating on the slow-scan mode. The same roll will last 12.6 hours in a continuous record mode.



The ACM has a host of override, manual select, reset, channel hold and scan speed options built-in. Each could be discussed, but if you are the type who finds the basic functions of interest and follow up with a request to Com Sonics that your system inspect an ACM, you will have adequate opportunity to acquaint yourself with them on your own. The basic specifications of the ACM appear here in box insert form.

Operations and Critique

CATJ is aware that a number of sophisticated CATV systems, such as Gill Cable in San Jose, have been working on their own "automatic test/recording equipment". Until now, and perhaps still even now, the wonderful world of electronic *logic* has made but a small dent into the CATV camp. As a general observation, CATV is exceedingly backward in *applied logic* technology when compared to virtually any or all other modern communication industries. Even the newer fast-food chain drive-up window order points employ more logic technology for processing hamburger orders than the average CATV plant does in its whole 100 mile plus system. In a few words, we have a long-long ways to go to catch up to state-of-the-art in this field.

Therefore, we are extremely reluctant to offer more than a couple of "observed-criticisms" of the ACM unit for fear that this first new start into automated logic technology may be set back even a small step before it gets moving.

We had the ACM unit in the CATJ Lab for a long 60 days (*long* in the sense that we were supposed to keep it around for a much shorter period of time). It ran almost continuously for that full period. It ran well, did not stop running, and that speaks well for its reliability. However....

(1) *We* do not care for the *chart recorder* chosen for incorporation into the unit. We are well aware that within the chart recorder industry, there are very few options open when you go out to select a unit that must be small, reliable *and* relatively (speaking) inexpensive. But for what our observation is worth, to build such a superbly operating electronic package like the ACM, and to follow it up in the most important record function with this caliber of recorder is at best like feeding Pablum to Joe Namath. It is almost an insult to the class of electronics in the ACM itself.

This is more than a price or class-conscious statement; the recorder is in our view a very weak link in the otherwise fine package.

On the supposition that Com Sonics cannot locate a suitable small, reliable, properly priced recorder for the unit, we would at least like to see them bring the chart drive voltages out on a set of rear (or front) panel jacks so that the cable operator could drive his *own external better-quality recorder* if he so desired. This would also require bringing out a relay or switching diode set of contacts to turn the external recorder on and off with the ACM one hour cycle periods, but we don't think that is asking too much.

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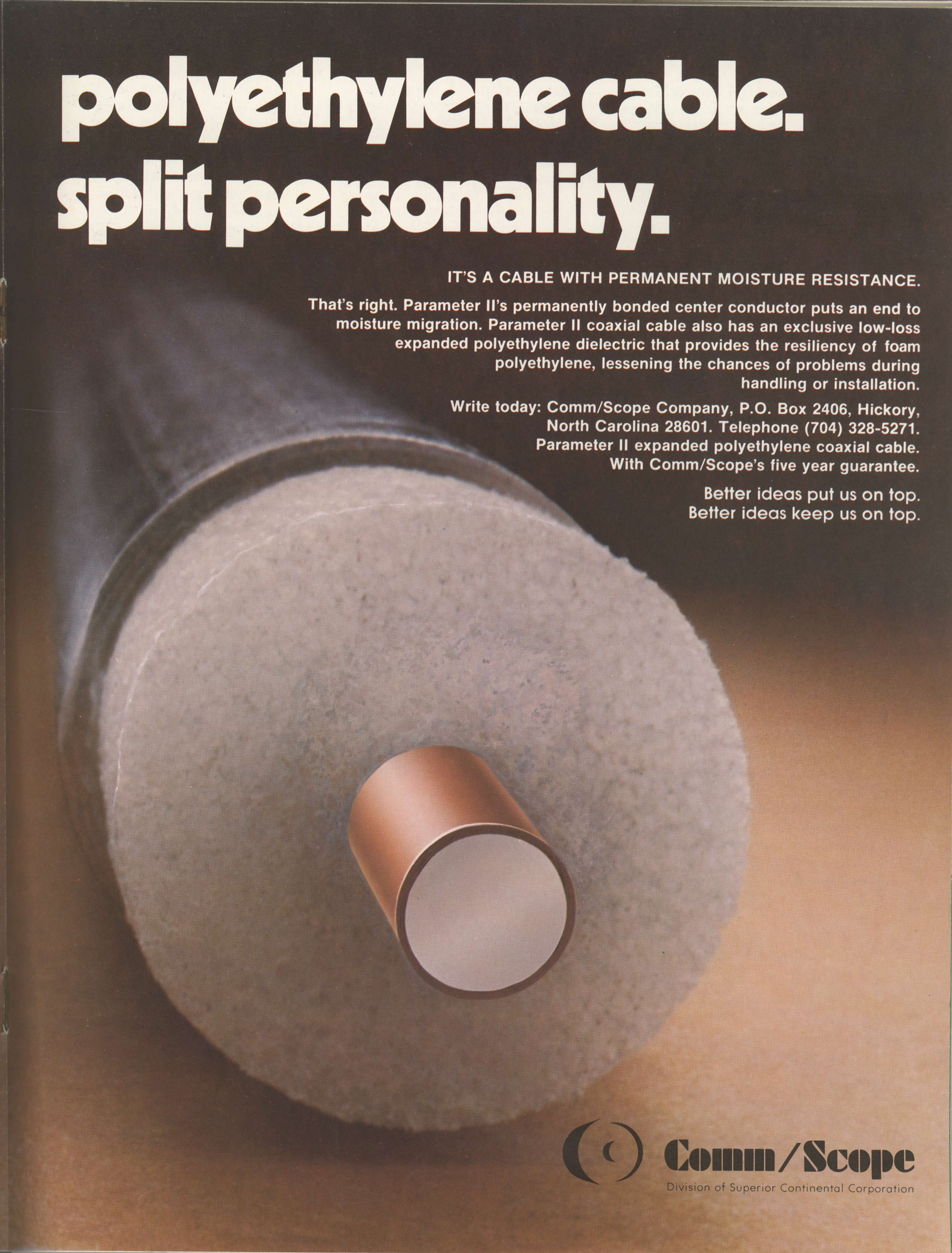
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(2) *Audio*—the ACM ignores the audio carrier measurement criteria. Now we can think of several reasons why it might do this (cost is one important criteria), but we are also mindful of 76.605 (a) (6) which tells us that aural carriers shall be down 13 to 17 dB from the associated visual carrier. As CATJ discussed in the December and January issues most recent, if your headend aural AGC is functioning (assuming your processors have aural AGC), about the only way your aural/visual carrier relationship can be disturbed *after* the signals exit the headend is when there is a strange plant introduced hump, bump or hole in the overall CATV trunk or feeder bandpass response. And truthfully, such bumps, humps or holes are almost always passive-created *and therefore static*, not subject to variation with short term time passage. Therefore, if you measure the aural idiosyncrasy at point "A" one hour, the chances are good that you will find it at point "A" a week later as well.

All of this suggests that if you *once* measure plant aural levels at a test point, and determine they are staying in the minus 13 to 17 dB range relative to the associated visual carrier, you probably do not have any *real need* to look at it again, in repetitive same-test-point measurements. This is one of those areas where the rules say one thing, but probably mean or interpret another way.

And all of this boils down to the *probable lack of a requirement* that when you set up a test point to monitor or measure signals, that you *actually* look at *both* aural and visual *each time* you measure one or the other. This says "why would you need aural measurement capability at all" with a device such as the ACM?

The answer is *you may not;* especially if adding it would be as costly as we suspect it might be after looking at the circuit of the unit. Still, when you are paying this kind of money for a stellar SLM, it would be nice to be able to read aural carriers with it.

(3) *The input level range*—The "window" you select is 20 dB wide. This is the meter scale window range, and, it is not surprisingly the adjusted recording paper window range for the chart recorder.

Of course higher levels can be measured very simply; by sticking a fixed or adjustable pad in front of the ACM. As long as you know the value of the pad or external attenuation, your meter scale readings and your chart recorder readings would adjust accordingly.

And it may be that below levels of —20 dBmV only fools tread; if you read enough CATV literature, you sooner or later come to the conclusion that many system *planners* will not even *consider* an off-air signal that is not at least —20 dBmV in antenna level (before pre-amplification).

Still, again, there is the nagging feeling that if you are going to spend this much money for a unit such as the ACM, you would like it to be as versatile as possible. This means that you would like to be able to utilize it for as many purposes as possible, and not feel you have *dedicated* approximately $2,000.00 to a box that replaces a $2.50 an hour meter reader once per year for a three day stretch. If the ACM had a more conventional range of input levels, switch selectable from the front panel, this would help overcome that "purchasing agent's demand" that you "justify" the expense of the unit!

Summary

When the FCC announced the new rules and regulations for Cable in 1972, it *should have* signaled a new awakening in test equipment techniques and system responsibilities for running "clean ships". It did neither of these things, for reasons largely political.

The Automatic Channel Monitor (recorder) just *may* be the first in a series of new approaches to CATV test technology. It may well be too narrow in its application, too expensive, or it may be neither of these things. But *it is* a new approach, and one based upon sound logic that has as its basis a crying need for whole new families of CATV test equipment. The industry has been coasting along on 1960's test equipment technology for the better part of the 70's; and it is perhaps time we came out of our cocoon!

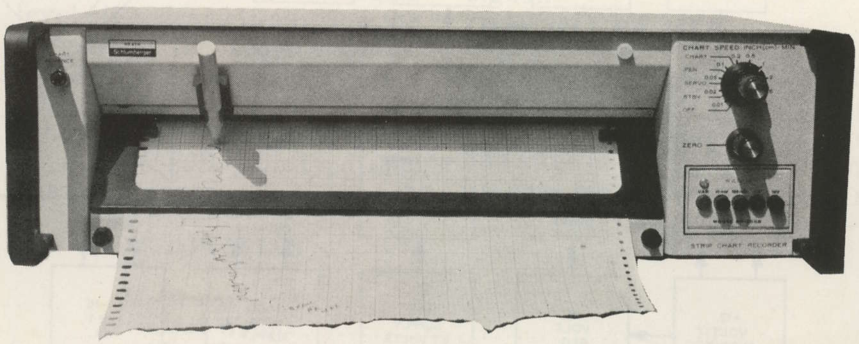
ARE YOU A HAM?

In the January CATJ, we asked readers who are ''Ham'' or amateur radio operators to register with us utilizing a card supplied in the magazine. For all who did (and did not) register with us, and who will be in attendance at the Dallas, Texas industry convention April 4-7, we invite you to stop by the **TOMCO** booth to pick up your free ''**I Am A Ham in CATV**'' 3 inch badge that identifies you to fellow hams. The badges, created by CATJ, will help you spot fellow enthusiasts at the show.

CATJ is appreciative to Tom Olson and Vince Borelli (neither of whom are licensed hams) for allowing us to ''park'' the badges and the small card display in their booth!

A VERY INTERESTING BOX

Solid State Chart Recorder From The Folks At Heath



Heath/Schlumberger SR-255B chart recorder recording at 1 inch per minute.

SR-255B RECORDER

In the May 1975 issue of *CATJ* we began a series on recording techniques for CATV system tests; utilizing commonly available strip chart recorder devices (see Pages 21-30, *May CATJ*). Part of that introductory segment of this series on Chart recording apparatus discussed at some length an older (tube type) servo driven chart recorder no longer manufactured; the Heath EU-20B recorder.

We noted in that report "Although the (EU-20B) recorder is no longer available from Heath, several newer, solid state versions are available; and they will be discussed in future issues of CATJ".

The SR-255B unit comes about as close to being a Heath successor to the tried and true (with us) EU-20B as any unit currently in the Heath/Schlumberger equipment line. The Heath literature (they have a *separate catalogue* for their instrumentation line, under the joint Heath/Schlumberger banner) describes the SR-255B as "(our) best recorder value". It is also the lowest priced unit in the full function recorder family currently offered by Schlumberger, which makes it particularly attractive for CATV systems of virtually any size.

The arguments in favor of having chart (or strip-chart) recording capabilities were made at some length in the May 1975 *CATJ* report. Briefly, virtually any SLM/FSM produces an output voltage (DC) through the detector output jack which can be utilized to "drive" a chart recorder. Therefore *any* signal that can be tuned in on an SLM/FSM *can be recorded permanently* on strip chart paper on a strip chart recorder. The advantages to permanent records are many and varied. First of all, strip charts are like having several extra sets of hands. Anyplace you can stow an SLM and a companion recorder and plug into your system, an antenna, or any other signal source for your SLM, you can make a permanent record of the variation in off-air or off-plant signal levels. If the chart recorder you choose has a selection of chart paper speeds, it is possible to accumulate as much as several months unattended recording time for later analysis. In effect, the dedicated SLM and the chart recorder are "slaves" to your signal recording whim; freeing you or your system personnel from laboriously sitting tight and making written records of signal level (or plant line voltage) variations. The advantages to that type of freedom, and accurate, permanent data should be obvious.

Additionally, when a system must perform annual FCC compliance tests, having a strip chart recorder to "log the data" is extremely helpful. Not only does it free up personnel who would otherwise have to spend time watching signal levels move around (and recording same on logging forms), but the strip chart itself, filed away with the balance of the test evidence, becomes the best kind of permenent record material for FCC inspection.

In May we lamented the fact that to date there has been very little CATV industry utilization of paper recording techniques for data keeping purposes. Our position has not changed. We feel strongly that anyone who spends time checking levels and monitoring system performance would find his hands, mind and body considerably freed-up if he made a modest investment in a versatile chart recorder. And, we feel his system would run better for the investment because the data recorded on the strip chart is extremely accurate and not subject to coffee breaks or attention diversion as human help tends to be.

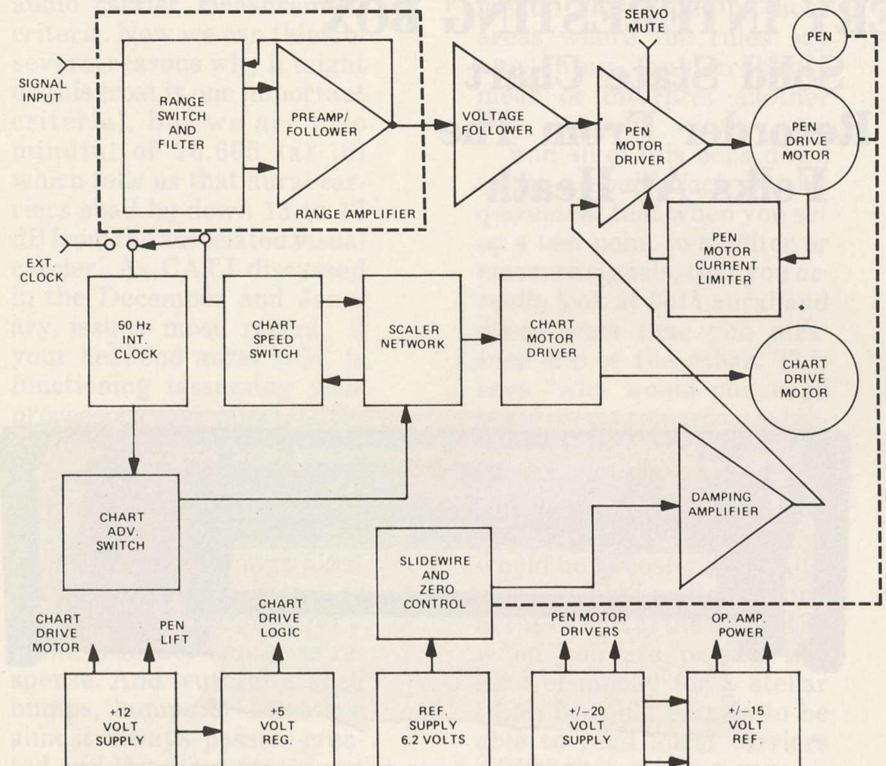


DIAGRAM 1

A Basic Recorder

The SR-255B is not unlike the May "reviewed" EU-20B unit in function; although it has complete solid state design going for it.

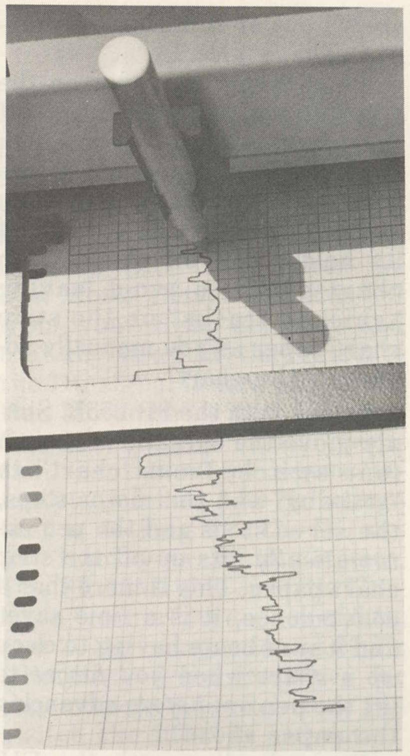
You are referred to block diagram one which depicts the functions of the various stages of the SR-255B. The *input signal* (in *our* case a DC voltage as detected by the SLM) goes into a range amplifier. This stage consists of a 60 Hz filter (to block out 60 cycle noise effects) and a voltage range selection switch. The SR-255B will accept input voltages from 10 millivolts to 10 volts and produce full strip-chart scale recordings. Additionally, there is a voltage divider network in the range amplifier which allows the user to turn a small screw-driven pot (front panel mounted) and *multiply* the selected full scale range by a factor of *up to* 10. This is extremely useful in CATV recording since it allows the user to make the full scale range of his SLM (typically 20 dB although Sadelco meters have 34 dB full scale range) *track with* the full 10 inch wide paper width of the SR-255B. Or, alternately, set the SR-255B to correspond to some SLM attenuator set minimum level, and then adjust the voltage divider control on the SR-255B to correspond to something greater than the 20 dB "window" typically found in most SLM DC amplifiers. This can result in up to 30 dB paper recording width with a SLM DC window width of only 20 dB; very useful.

Following the range follower is a voltage amplifier that drives an "inverting input" on the Pen Motor Driver. The strip chart is inked by a pen that mounts in a snap-in container connected in turn to a "slidewire". The slidewire is driven (or moved) back and forth by the voltage supplied to the Pen Motor Driver by the voltage follower. Simply put, the pen is on a wire and the wire is moved through a network of pulleys and wheels back and forth across the chart paper by a motor; and the motor gets its instructions *from the input signal* provided by your SLM detector circuit. When your SLM detector sends out a large (relatively speaking) voltage, the Pen Motor Driver reacts by sending the slidewire mounted pen across the paper to the far right (or far left, depending on how you set it up initially). When your SLM has a low detector voltage output the voltage to the Pen Motor Driver is lower also, and the slidewire mounted pen falls back onto the opposite side of the strip chart paper. And all of the while the pen is *drawing* on the strip chart, the chart drive motor is advancing the paper at some speed which you have chosen (i.e. 1 inch per minute, etc.).

So if you have the ability to calibrate the strip chart with your real life SLM levels (*you do*) and if you have a set, constant chart advance speed (*you do*), and you know when you turn the package on, then it becomes a very simple matter to go back at a later time and remove the strip chart from the machine, and calibrate the chart for actual time; thereby knowing that at a specific time the SLM detector level (which is the same as the SLM meter needle indicator) recorded a certain, *specific level of signal.*

It is all very neat.

Chart recorders in industry and scientific applications tend to be thought of as extremely precise instruments. That is, their users think in terms of resolving or reading variations of a small fraction of a volt; often much less change than a microvolt is of considerable concern to them. Accordingly, the SR-255B is for all practical CATV purposes slightly *over engineered.* Which is another way of saying that the stability of the SR-255B, the response speed of the Pen Motor Driver (with the slidewire mounted recording pen), and the timing aspect of the chart drive motor are well ahead of anything that even the



SR-255B pen tracks noiselessly; drops down onto recording paper when machine is switched into active mode, lifts when turned off.

most critical CATV engineer would find fault with. Signal level changes of 1 dB are easy to see on the strip chart. In fact, level changes that amount to 0.1 dB are easy to spot if that is what you are after.

The chart drive motor, for example, is driven by a 50 Hz *internally generated* clock reference source. This results in operating speed accuracy of 0.5%, which *at 1 inch per minute* (or 60 inches per hour) relates to a *potential maximum timing error* of about 1/3 inch of strip chart, or 20 seconds error in real time. A one inch per minute rate is pretty fast for most CATV applications, excepting perhaps for off-air headend work, and in actual use on the CATV plant you would typically utilize the 0.05 inches per minute (3 inches per hour) or 0.1 inches per minute (6 inches per hour) front panel switch-selected chart drive speed. At 6 inches per hour the 0.5% maximum error amounts to about the width of the pen line on the strip chart paper in real time error; *not significant for CATV purposes.*

One of our minor objections to the older EU-20B chart recorder was that it took an outboard (self fashioned) adapter to make the 20 dB log scale on the SLM track correctly with the fixed 20 dB *paper range* of the EU-20B. This of course is totally cured with the SR-255B with the voltage divider network that expands the range scale by up to 10X. Another problem with the EU-20B in recording off-air signal levels occurs when the signal level rises dramatically and the voltage to the chart recorder drives the recording pen to full scale and "pegs it there". In that condition, the servo drive motor *on the EU-20B* tube type unit sits there and groans and snorts and makes ugly noises, operating as it is above and *beyond* the scale range. We never *lost* a chart drive motor with the EU-20B, but apparently others did because in the new SR-255B Heath has installed a feedback circuit that limits the motor drive current. The end result is that the feedback circuit prevents motor overheating *should* the pen be driven off-scale by a rapidly climbing off-air kind of signal.

Operating SR-255B

Operating the new(er) SR-255B gave us the same feeling that the Aborigine must have had after he had graduated from his first jeep ride to a ride in a

SR-255B SPECS

Mechanical—

Chart Width ....10"
Chart Speeds ......10, 5, 2, 1, 0.5, 0.2, 0.1, 0.05, 0.02 and 0.01" per minute
Chart Speed Stability .....less than 0.05% error
Pen Lift.......Electric, front panel control & remote automatic (TTL compatible)
Recorder Pen ....(Any) Disposable, nylon tipped
Weight ....20 lbs.
Dimensions ....5.34" high x 17.41" wide x 12.31" deep

Electrical—

Balance Time.............Under 1 second, full scale
DC Input Ranges ....10 mV, 100 mV, 1V, 10V full scale with 10 mV to 100 V 10X range adjustment (*)
Type Input.........Floating, greater than 10^7 ohms input impedance on all but 10V range; 1 megohm 10 volt range
Zero Suppression ....Front panel zero set control to set to any point on chart
Overall Error ....Less than 1% full scale, 0.5% typical
Non-Linearity ....Less than 0.5% full scale
Temperature Drift ....Less than 0.005%/ degree C
Line Freq Rejection ....20 dB normal mode, filter out; 40 dB normal mode filter in
Remote Connector ....Functions available include chart control, pen lift, servo mute, chart signal out, chart signal in (all TTL compatible), control common, signal input, null signal, and signal input/pen null common
Operating Voltage .....105/130 VAC or 210-260 VAC
Power Consumption ....30 watts
Price (assembled/calibrated) $365.00

Manufacturer—

Heath/Schlumberger Inc.
Benton Harbor, Michigan 49022
(616/983-3961)

*—Most SLM/FSM DC (detected) outputs will function with SR-255B in 1V range.

first class motor car.

The EU-20B opened up whole new areas of CATV technology to us back in 1969; and as reported in May *CATJ*, the instrument has given us many years of faithful service. By making permanent records available, it took us out of the hurriedly jotted scratch pad notes that we later had to decipher, and put us into the neat, clean, real time recording business.

HOW LONG?

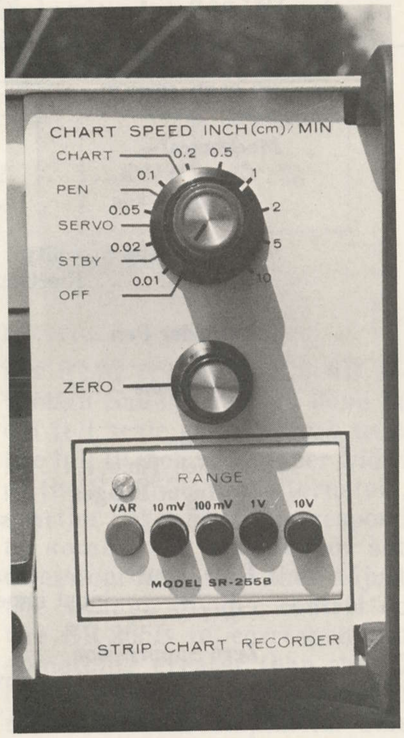
With the chart speeds available, the SR-255B will provide continuous recording on the standard Heath 445-17 strip chart paper (120 foot per roll) as follows:

Inches Per Minute	Total Record Time
10 "	2.4 Hrs
5 "	5.0 Hrs
1 "	24.0 Hrs
0.5 "	48.0 Hrs
0.2 "	120.0 Hrs
0.1 "	240.0 Hrs
0.05"	480.0 Hrs
0.02"	1200.0 Hrs
0.01"	2400.0 Hrs (*)

* — 100 days continuous.

Heath 445-17 chart paper is priced from $4.75 per roll in 1-9 quantities to $3.50 each roll for 97-199 rolls.

But the SR-255B is a whole different world of operating convenience and ease; and the amazing thing is that it is priced within a few dollars of what we paid in 1969 for the EU-20B! For one thing, the SR-255B does not make any *noise*. Any one who has spent three days cooped up in a trailer with the EU-20B can tell you that the constant scratching / crunching / grunting and groaning *does* get to you after awhile. With the EU-20B when you wanted to *advance* the chart paper ahead, to make notes on the chart or to clear the machine of a particular segment of strip chart, you had to hand crank the paper drive roll. We never complained, but we fouled up our share of paper in the process. The SR-255B has a motor advance for the paper; simply push a button and the paper spews out at 10 inches per minute. That's nice.



All operating controls are on front panel; top selector is chart speed (outside ring) and mode selection (inside knob).

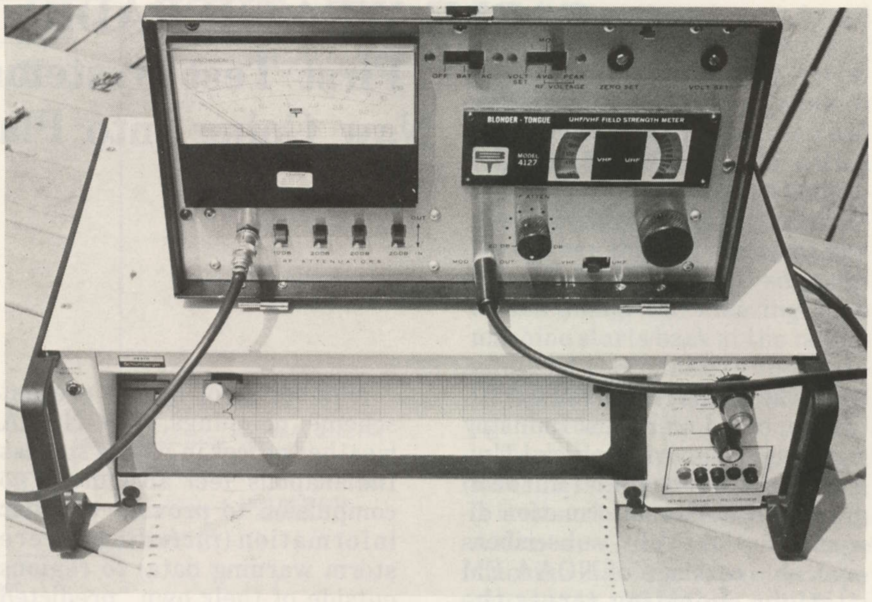
To advance the paper on the EU-20B, you had to first shut off the machine chart motor, *then* shut off the servo drive for the pen (two switches), and *then* mechanically lift the pen out of its holder and off of the strip chart paper to avoid leaving "chicken tracks" on the strip chart paper as you manually advanced the chart.

Not so with the SR-255B. Simply move the operational switch (one switch) from "chart" to "standby" and the motor stops, the servo stops and the pen *automatically* lifts up off the strip chart paper. This is more than a convenience, it is a time saver and it sure beats having to clean up a chart when you *forget* to lift the pen out *before* advancing the paper ahead.

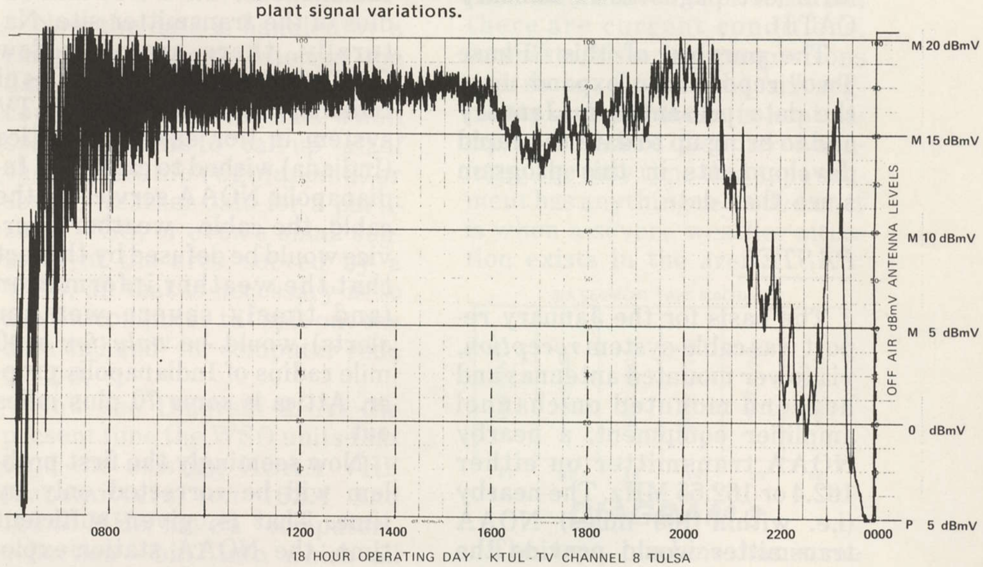
Paper loading with the EU-20B was not all that swift either (although we never complained; we loaded it once while in a helicopter 900' above a projected headend site at Pine Bluff, Arkansas while balancing a TV set on our lap, and wedged between the SLM, a 12 volt portable battery and an inverter!). The SR-255B is again a step forward; pull out two plastic retainers and slide the lower front portion of the machine out of the case. The paper loads quickly and easily, and the chart advance feature lets you seat it into place in just a few seconds time.

Finally, the EU-20B gave us fits when there was some 60 Hz noise present. As we discussed in the May *CATJ*, the manual with the unit told you about this problem and suggested some solutions; we built a 60 Hz filter to solve it ourselves. The SR-255B has a *built-in* 60 Hz filter. Keep in mind that what drives the Pen Motor Driver circuit is DC from your SLM detector; and that any stray AC that gets into the DC signal is sure to give the Pen Motor Drive package some fits. It results in erratic operation, as the motor sensor attempts to follow a 60 Hz voltage that is nothing like the DC signal from your SLM detector. The SR-255B built-in 60 Hz filter has a "corner" frequency of 5 Hz and 20 dB of rejection at 50 Hz (the clock drive frequency for the motor). A switch lets you switch the filter in and out.

The SR-255B has its own internal *reference* sources (i.e. clock for motor drive, etc.); but it also brings out to the rear apron a number of function inputs for remote control applications. We can envision some CATV types wanting to turn the SR-255B on and off from a remote location. The options (not *extra*, just your choice) for remote operation are so many that we will not list them here. Suffice to say that you can do just about anything from a remote location you could do in person, including lifting the pen from the paper for a pre-determined period of time while you remotely switch inputs.



FSM/SLM with detector output plus SR-255B is all system needs to make permanent records of headend and plant signal variations.



The SR-255B has a couple of extra money options also. One is a rack mounting kit ($10.00) and a metric conversion kit ($14.00).

Our only complaint with the unit is that we had to return it to Heath when the tests were completed!

CABLE WEATHERADIO UPDATE
First Test Systems Now Going Into Place

In the January issue of CATJ, we reported on a new industry program to provide official United States Weather (Bureau) Service weather information directly to the CATV subscribers via cable carriage of NOAA FM stations operating across the country on 162.40 and 162.55 MHz (see pages 10-19 January CATJ).

The purpose of this "Phase Two" report is to expand upon the data presented in January and to bring up to date the rapid developments in this program since that date.

PASTEL

The basis for the January report was cable-system *reception*, via tower mounted antennas and headend mounted on-channel amplifier equipment, a nearby NOAA transmitter on either 162.4 or 162.55 MHz. The nearby (i.e. within 100 miles) NOAA transmitter would provide the weather information which the cable company would in turn carry throughout the cable system *on frequency*. Then the cable subscribers would "plug in" to that service through a cable drop, connecting their WeatherAlert receivers to the cable where the processed 162.4 or 162.55 MHz signal was being carried.

There are two *problems* with *this* approach. Number one, there are fewer than 100 such NOAA stations currently operating in the United States and therefore much of the United States is still 'out of range' of NOAA weather service, even *with* an assist from CATV.

Number two, in the present scheme of things, the NOAA weather offices in places such as Indianapolis feel absolutely *no* compulsion to provide weather information (*including* severe storm warning data) to regions outside of their own "predicted coverage areas". In the case of Indianapolis, this is a 40 mile radius of the transmitter site. Naturally, there are very few CATV systems within 40 miles of Indianapolis, so even if a CATV system in (for example) Attica (Indiana) wished to carry the Indianapolis NOAA service on the cable, the cable - weather - service would be defused by the fact that the weather information (and timely severe weather alerts) would be *only for* a 40 mile radius of Indianapolis proper. Attica is some 70 plus miles out.

Now seemingly the first problem will be corrected only by time. That is, given sufficient time, the NOAA station-explosion, like the TV broadcast station explosion of the 50's and 60's, will fill in a *major* portion of the country.

Just as likely is that the reluctance of the Indianapolis NOAA weather station to cover areas outside of a 40 mile radius will also be solved in time. What is missing here is that the Indianapolis station director is responding not to his own *whim*, but to a hard - to - justify NOAA *dictum* that originates in (you guessed it) Washington. To get this absurd "head-in-the-sand" rule changed, CATJ and the people from the WeatherAlert receiver firm are actively meeting with the NOAA people. We happen to believe that as long as it is Indiana (federal) tax money that is putting these NOAA stations in, that residents of Attica should have the same use of the service as residents of Indianapolis, especially when the *cable company* is paying the costs of getting the service into Attica! It costs the government no more money to serve Attica than they now spend, and on a per-home-served basis, the cost comes down everytime a new home gets a receiver and can tune in the broadcasts. If the present talks with NOAA officials fail to get the rule changed, and soon, then CATJ, arm in arm with its publishers (CATA), will put some of the muscle of the cable assoication into the project. Seemingly, a few well placed visits to a few Senate and Representative's offices would get some action in a hurry.

Now let's take another shot at the first problem—not enough stations, now or in the foreseeable future, to cover the country, even with CATV. See Diagram 1. This explains how the present NOAA weather offices operate. Within a state (represented as a square) there are numerous WSO units or Weather Service offices. These offices are interconnected via landline telephone and teletype and data transmission (including facsimile) circuits. The WSO units receive data and they originate data. They receive data from a regional (typically one per state except in very large and very small states) center known as a WSFO or Weather Service Forecast Office. The WSFO is interconnected with its own in-state or in-re-

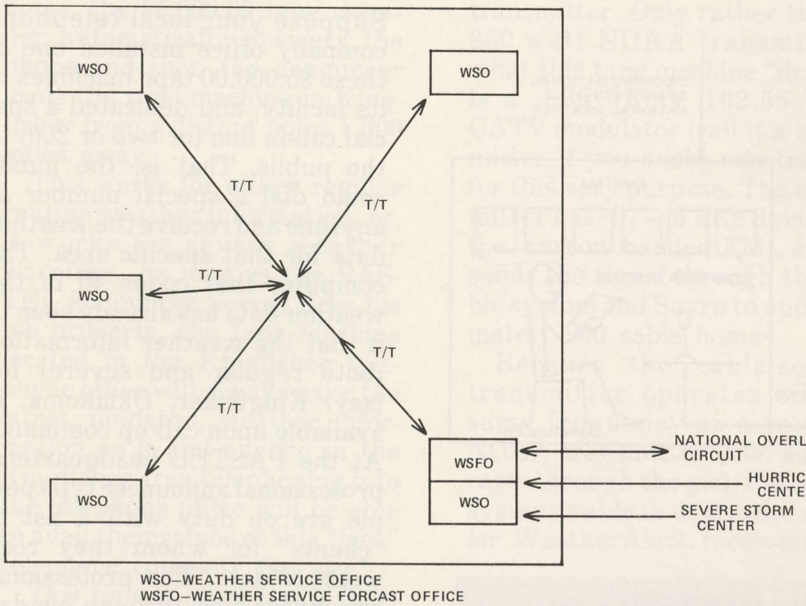


DIAGRAM 1

gion WSO outlets, and it is also inter-connected via a national landline network with all other WSFO units in the country. There is another layer above this, but for this point in time we can stop here.

The WSFO originates things like state wide forecasts, severe storm warnings, and so on. It sends its data on to its own 'wards', the WSO units which report directly to it.

Therefore each state or region has a WSFO that is the *primary source point* for all weather data (routine and emergency) which directly affects that state or region. All data is concentrated at this point.

Now the data is handled by a computer system, wherein the data prepared by the WSFO is computer-coded so that when someone wants to "call up" all of the applicable regular and/or severe weather data for a particular WSO, or even a small *segment* of the area served by a WSO, all that is necessary is to ask the computer to "spit out the data on hand" for computer code XYZ-3.

Now see Diagram 2. At the present time the WSO units that tend the existing NOAA VHF transmitters (on 162.4 and 162.55 MHz) have a "computer - collection - bin" into which all properly coded material designated for broadcast "falls". The material is gathered up and read onto a tape (recorder) at regular intervals. Then the tape recorder, being a marvel of modern electronics, cycles the data read into it so that the listener with a 162.4/55 receiver hears a continuous stream of weather information. When the end of a complete 5-7 minute broadcast segment comes along, the amazing tape machine starts back at the beginning and rebroadcasts the same "program material" again (and again, and again).

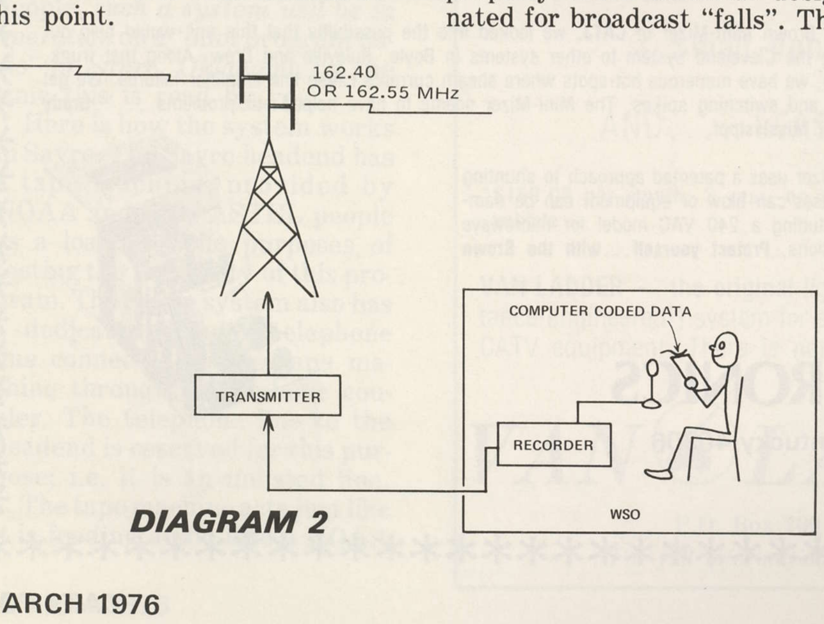


DIAGRAM 2

Now see Diagram 3. The tape machine is about a $5,000.00 box. It is manufactured by an outfit in Atlanta, Georgia. The tape machine has six separate tape segments, each of which is "loaded" with descrete specialized information. For example, there are current conditions, forecasts, historical comparisons and so on. One of the six segments or tape blanks is kept sacred for severe weather warnings. The only time that tape segment has anything recorded on it is when a severe weather situation exists in the area.

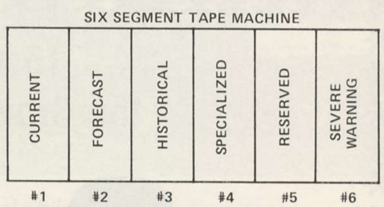


DIAGRAM 3

The tape machine has some logic built into it so that under normal conditions the machine's audio output (i.e. the program material that drives the VHF transmitter) sequences from one tape segment to another, providing sequential data. However, if and when the tape segment reserved for severe weather warnings gets data fed into it from the source, then the logic in the tape deck tells the tape machine to play that data (i.e. recording) *over and over again,* back to back as it were, as long as the emergency situation lasts. In a sense, the severe weather warning program data has *priority* over all other data. The tape segment that is reserved for the severe

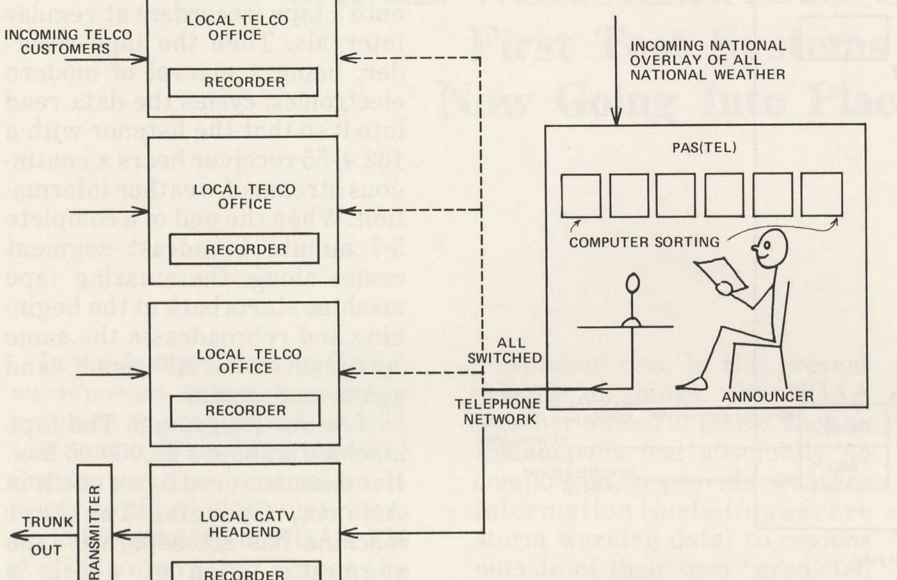


DIAGRAM 4

weather data has a pre-recorded 1050 cycle tone on it, so that when the severe weather tape segment is playing, it *begins with* a nominal 7-10 second blast of 1050 cycle audio tone. *This is the tone*, as described in January, that activates the tone-squelch system *in the receivers.*

Now see Diagram 4. There has been created, largely by a combining of efforts of the nation's telephone systems and NOAA, a nationwide system called PAS (tel) or Public Announcement Service. PAS works this way. Suppose your local telephone company office installed one of these $5,000.00 tape machines in its facility, and dedicated a special call-in line (or two or 200) to the public. That is, the public could dial a special number at anytime and receive the weather data for that specific area. The computer that codes all of the weather data has already seen to it that the weather information (both regular and severe) for (say) Kingfisher, Oklahoma, is available upon call-up command. At the PASTEL headquarters, professional announcer type people are on duty with a list of "clients" for whom they read weather data. The professional announcer goes through his day placing direct dial watts-line-like telephone calls from the PASTEL headquarters to all of the PAS program customers. He does this whenever a change or update is required.

On the opposite end of the line, such as at the telephone company office in Kingfisher, Oklahoma, the $5,000.00 tape recorder automatically answers the phone and then the announcer loads the tape machine in Kingfisher from a distant point 1,000 miles away.

This works for either regular routine weather information, or, it works for severe weather warnings. As long as the PASTEL announcer person does his job properly, the tape machine located in the Kingfisher telephone office will always have the latest, up-dated, weather information on it and anyone in the Kingfisher area telephoning into the telephone office will be able to avail themselves of this "free" telephone company "service".

This type of operation is functioning today. It has been growing for several years.

Notice if you will at the bottom of Diagram 4 that the fourth "receiving location" for the PASTEL calls is *not* a telephone office. *It is a CATV headend.*

If the same $5,000.00 recorder and coupler are placed in the CATV headend, the PASTEL announcer treats the CATV system just as he does a telephone company "customer" for the service. The computer sorts out the data for the cable-town and area, the announcer calls up the CATV headend and reads the weather data to the tape machine, and the cable company now has the data available for distribution.

Through the efforts of CATJ and the WeatherAlert receiver people, *such a system will be in operation* on a "pilot program basis" *in Sayre, Oklahoma* by the time this is read by you.

Here is how the system works in Sayre. The Sayre headend has a tape machine, provided by NOAA and the PASTEL people as a loan, for the purposes of testing the feasibility of this program. The Sayre system also has a dedicated regular telephone line connected to the tape machine through a telephone coupler. The telephone line to the headend is reserved for this purpose; i.e. it is an unlisted line.

The tape machine acts just like it is feeding audio into a NOAA transmitter. Only rather than a 330 watt NOAA transmitter, what this tape machine "drives" is a +55 dBmV 162.55 MHz CATV modulator (call it a transmitter if you wish) constructed for this very purpose. The transmitter has +/— 5 kHz deviation (i.e. narrow banded FM), and it sends the signal through the cable system and Sayre to approximately 900 cable homes.

Because the cable-secure transmitter operates on the same frequency as a regular NOAA transmitter (that broadcasts through the *air*), the Sayre system is able to utilize the *regular* WeatherAlert receivers for its subscribers. There are no special receivers required; the stock receiver does just fine.

In Sayre the CATV subscriber who elects to pay an extra couple of dollars per month (plus a deposit fee on the receiver) has one of the WeatherAlert receivers installed in his home. Twenty-four hours per day, the cable subscriber has weather information; plus he has the severe storm warning data system as well.

Sayre, located in the extreme western portion of Oklahoma, is probably an excellent place to test this system. For one thing, Sayre is outside of the *normal* forecast regions for either Amarillo or Oklahoma City WSO operations. It is also located in a section of Oklahoma (and the nation) where the number of tornados "per square whatever" per year is as high or higher than any other place in the country. People *do care* about severe weather in Sayre, and they have the scars of past years' storms to prove why they should be concerned every spring and early summer.

Finally, because the computer sorts out the weather data by code for specific areas, now Sayre has a full time *quasi*-WSO or WSFO. This is obviously better than having a Indianapolis type NOAA situation where the local NOAA office is reluctant or unable to provide weather data *specifically for* your cable community. In fact, because the computer does the sorting, it is possible that this PASTEL approach to cable-weather *may prove to be a much better approach* than carrying regional NOAA stations via off-air transmission and cabling. Only time will tell.

You might ask about costs. Obviously the $5,000.00 tape machine has got to be paid for by somebody. And understandably, there has to be a charge by someone for the inward bound PASTEL service.

At the present time who will ultimately pay for the $5,000.00 tape machine is not determined. It is *possible* that the PASTEL people who manufacture and own the machines initially *would elect* to rent, lease or sell the unit to the cable system. As this is finally determined, we will advise you here in CATJ. The inward bound telephone calls containing the data provided by PASTEL appears to be in the $100.00 per month ballpark; but even that is subject to some question at this time. We have the assurances of the PASTEL people that the charges will be "reasonable"; and there is the chance that they *may* come *down* as the number of users goes up. The cable company itself will be responsible for supplying the 162.4/55 MHz transmitter (we estimate this will run under $500.00) and the receivers for the customers. That is, of course, where the monthly rental charge for the receivers comes into play. At a receiver cost of between $20.00 and $25.00 each, a monthly receiver plus service rental fee of from $2.00 to $3.00 per month is entirely justified.

Will It Fly?

The primary unanswered question at this point is "will cable customers pay extra money for 24 hour per day cable weather; audio only?" We are primarily thought of as a video-medium. Our experiences with audio-only transmissions (i.e. FM broadcasts, etc.) has never been very successful, at least not on a nationwide basis. Many systems have decided that charging extra money for FM-only outlets is a waste of time.

If the weather service is going to prove to be a boon to CATV operators, it will probably be because:

(1) It is an *official* government service;

(2) It is *24 hours per day*, constantly updated and as much as hours ahead of what customers receive on their local radio or television newscasts;

(3) And, the clincher, there is a 24 hour per day ready-on-command *severe weather warning* auxiliary service involved.

But all of this is going to take some marketing ability to sell to the cable customers. The extra 2-3 dollars per month is not unattractive, especially when many systems are finding their present *CATV service rates frozen* in place by reluctant city councils.

The people with the most at stake in this project are probably the WeatherAlert receiver people. With some 4.5 million U.S. cable homes located *within the severe weather belt* in the nation's mid-section, WeatherAlert sees a large potential for receiver sales. Consequently, WeatherAlert is putting together an all-out program to try to make it as attractive as possible for the cable operator to get involved with carrying NOAA broadcasts *or* the PASTEL service. WeatherAlert is developing cable marketing programs, special brochures and phamplets for cable subscribers to help you sell the program, and a number of receiving-stocking plans to help you get started. They recognize that there is more to getting the cable industry interested in their receivers than simply setting up a booth on the corner and offering receivers for sale. Thus the fact that WeatherAlert is willing to take the cable operators by the hand and lead them through the start up phase, where required, is possibly one of the stronger suits going for this whole concept.

Which brings us up to date on the first faltering starts in this project nationwide.

A Strip Amplifier

In the January issue of CATJ we also covered the various techniques practical for taking a 162.4 or 162.55 MHz NOAA signal off-the-air and putting it on the cable. As noted, one of these techniques involves taking an antenna delivered signal (with or without preamplification) and feeding it through an AGC type package to control the level to the cable trunk of the 162.XX MHz transmissions.

We are indebted to CATJ Contributing Editor Steve Richey for the following 'do-it-yourself' strip amplifier project.

The first approach to the National Weather Service narrow band amplifier was to consider constructing an AGC'd amplifier. But the more we considered this, the less we liked it. Our primary goal is to provide design information on a unit that can be (1) duplicated in the field with a minimum amount of parts and test equipment, and, (2) be of a design that could be duplicated commercially in quantities if the need grows to that point.

The following specifications have been adopted:

1) *Gain* .... 70 dB
2) *Output* .... +45 dBmV
3) *Minimum input for 5 dB limiting* .... —15 dBmV
4) *Output change for 50 dB input variation from −15 to +35 dBmV* .... 2 dB

To achieve this set of specs we broke the total unit down into three sub assemblies (Diagram 7). The first is a tuned RF ampli-

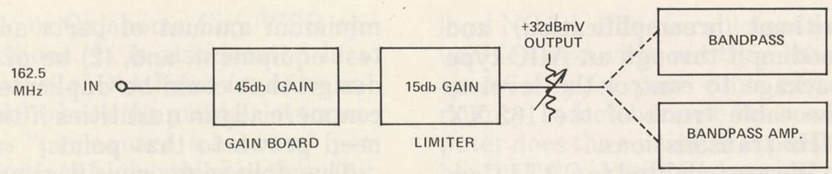


DIAGRAM 7

fier at 162.5 MHz, with 45 dB of gain. The second is a broadband limiter with 15 dB of gain and an output of +32 dBmV (with a built in level control), while the third is an output amplifier to boost the level up to the rated spec output. Alternately, this could be a simple bandpass filter circuit if the +32 dBmV output level is sufficient for your needs.

The RF gain block needs to be fairly *selective* and have a relatively good noise figure, plus about 45 dB of gain. We designed and constructed our own on a small piece of G-10 PC board using three stages of straight forward J-FET amplification, as shown in Diagram 8.

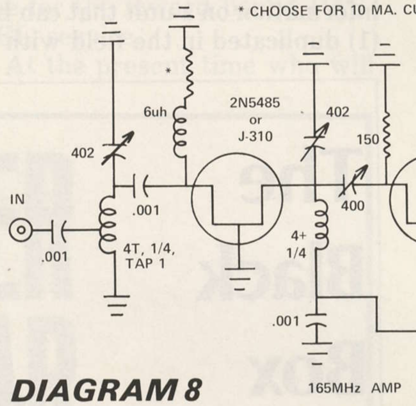


DIAGRAM 8

However, if you have a CADCO or other such single channel high band TV pre-amplifier, you can realign it for this frequency and this service *provided* you can reach the 45 dB gain requirement. You could also use an apartment house amplifier with an input bandpass filter removed from a Jerrold TPR pre-amplifier if that happens to suit what you have on hand laying around the shop.

Our point is this, you *don't have to* build a special pre-amplifier or RF head for this package. You can utilize *sections* of old equipment you already have around the shop *if you utilize your common sense* and follow the general concepts shown in our spec table and Diagram 7 here.

The heart of the limiter portion of the package is an integrated circuit, the RCA CA-3012. The 3012 is primarily used for frequencies up to 10 MHz but (*surprise!*) it will work very well at higher frequencies (such as 162.5 MHz), although with *lower* overall circuit gain. For instance, it is utilized in the sound IF of the Commander II, and a recently introduced heterodyne processor at Richey Development Company utilizes them in the same capacity.

Therefore many systems may have the CA-3012 on hand as a spare part for replacement purposes for the Commander II. If this is a problem, try your RCA parts distributor or obtain a Sylvania number 726 in their ECG series of low cost devices.

The CA-3012 is mounted on a

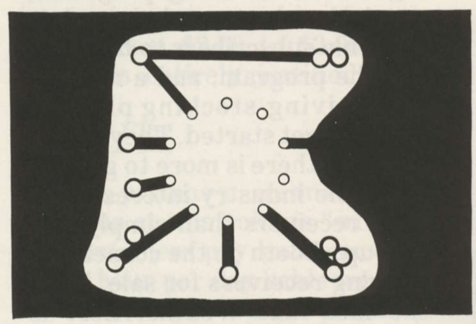


DIAGRAM 9

NOTE: Board as shown 2X actual size.

PC board and we have shown a PC board layout here for the board. The board is simple enough and small enough that you can do it with a resist pen on a small piece of G-10 board in just a couple of minutes time (see Diagram 9).

The rest of the circuit (Diagram 10) in the limiter module is two stages of transistor gain to lower the limiting voltage. The CA-3012 was mounted first on our PC board, then the board was installed in a mini-box and the two stages added. The only caveat is that you *must keep*

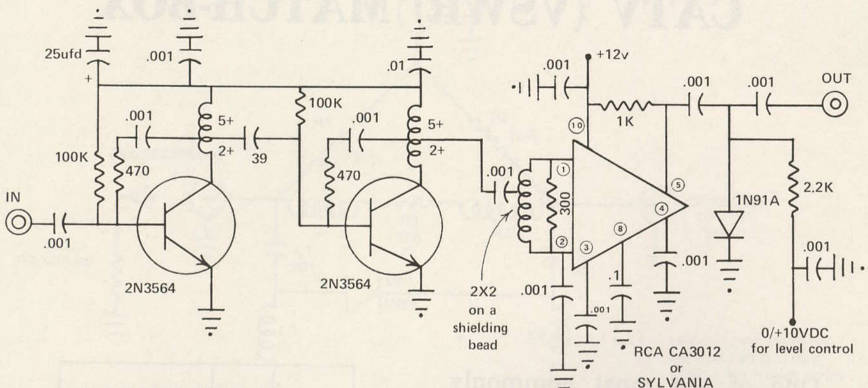


DIAGRAM 10

your *leads short* and this applies in spades to the emitter leads of the two transistor stages.

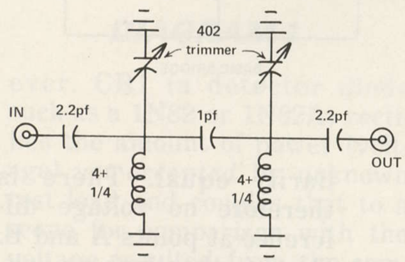


DIAGRAM 11

As for the output level, if +32 dBmV is adequate output for your particular headend mixing application (recall that tests have shown that the cable-carriage signal level for the 162.40/55 MHz signal needs to be *no more than* —8/10 dB relative to the channel 7 *aural* carrier level), you can build the simple filter shown in Diagram 11). If this is not adequate level, you can add the final module, as shown in Diagram 12. This will give an

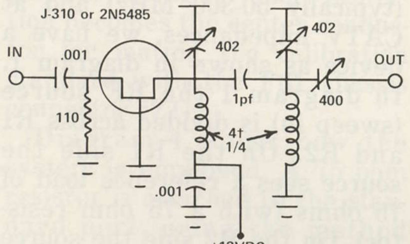


DIAGRAM 12

additional 12-15 dB of gain. And if you need power for the project, 12 volts at 50 mA will handle the whole package. A suitable ho-hum power supply is shown here as Diagram 13.

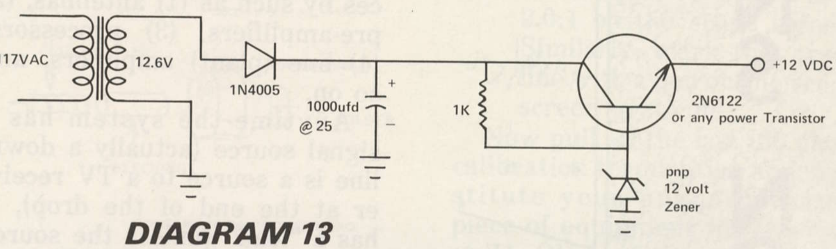
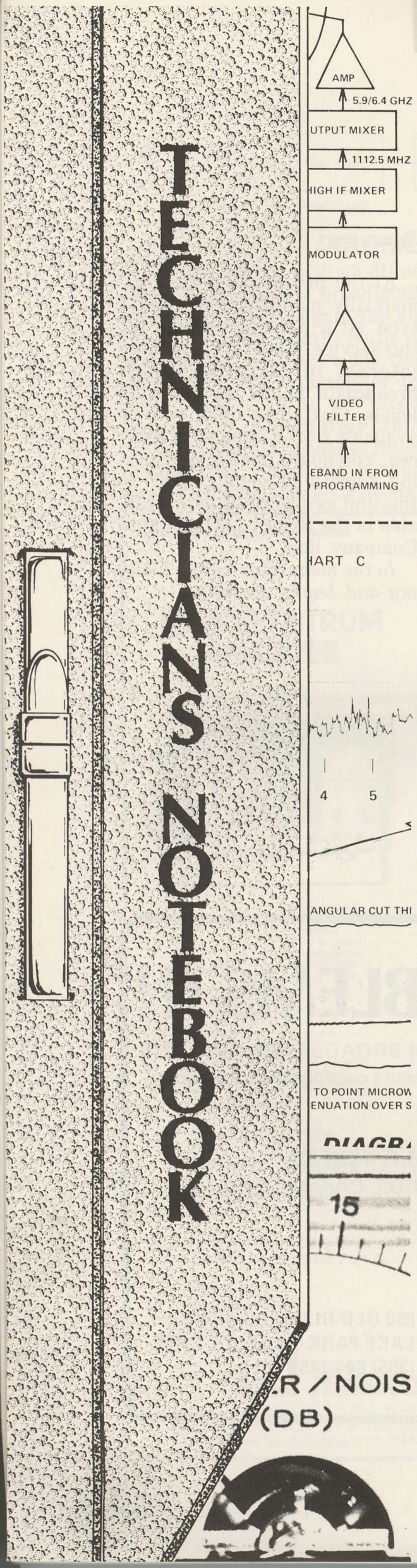


DIAGRAM 13

Summary

At the present time no commercially manufactured AGC'd type strip amplifier exists for this service. It is likely that if the interest in carrying NOAA broadcasts builds to expected levels, that some units will be available from a number of sources. You might even end up seeing something very similar to this unit as described here available in the Richey Development Company line!

In the meantime, happy building and happy alerting.



CATV (VSWR) MATCH-BOX

One of the most commonly referenced CATV equipment specs is "match", or, as covered in the November CATJ, the ability of the source of the RF signal to "see" a purely *resistive* termination.

When there is a *perfect* match, *all* of the source RF power is accepted by the device connected to it. This would include any and all sources by such as (1) antennas, (2) pre-amplifiers, (3) processors, (4) line (plant) amplifiers, and so on.

Anytime the system has a signal source (actually a downline is a source to a TV receiver at the end of the drop), it has a "load" (unless the source is unterminated).

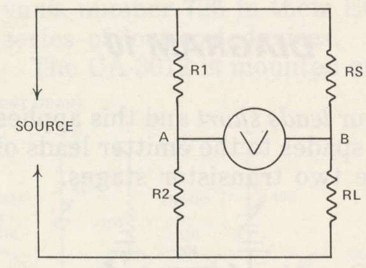
The amount of source power accepted by the load (any load) is the computation that produces match. This is variously referred to as the "match," the "VSWR" and so on (see November *CATJ*, pages 44 to 45).

A CATV system with a sweep source and an oscilloscope has the basic equipment required to determine exact match very accurately; with the addition of a *"CATV Match-Box"* to be described here.

The concept behind the basic VSWR bridge is as follows:

(a) The most simple resistance bridge consists of two voltage dividers in parallel across a voltage source;

(b) As shown in the diagram here, when the voltage drop across R1 equals the drop across RS, the drops across R2 and RL are similarly equal. There is therefore no voltage difference at points A and B.



BASIC BRIDGE

(c) There is therefore no voltage difference at points A and B in the circuit and a voltmeter connected between A and B would read zero.

(d) Thus the bridge is said to be "in balance."

(e) On the other hand, if the drops across R1 and RS are *not* equal, there will be a voltage differential at points A and B, and the voltmeter across these two points will read the voltage difference.

When this circuit is translated to something meeting the requirements of measuring VSWR at CATV frequencies (typically 50-300 MHz) and at CATV impedances, we have a device as shown in diagram 1. In diagram 1 the RF source (sweep in) is divided across R1 and R2. On the R1 side the source sees a reference load of 75 ohms (with a 75 ohm resistor). On the R2 side the source voltage (sweep) sees the unknown test load, such as the input port on an amplifier, a connector, an antenna or what-

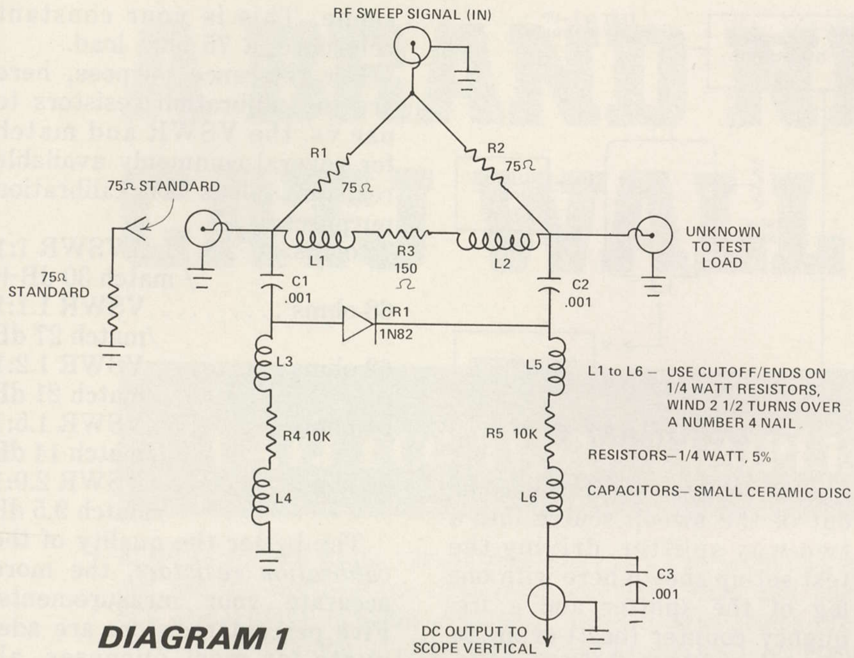


DIAGRAM 1

ever. CR1 (a detector diode such as a 1N82 or 1N82A) rectifies the amount of power (voltage) *not accepted* by unknown test load and couples that to a scope for comparison with the voltage resulted from the comparison with the known standard.

The "CATV Match-Box" is constructed in a small container, such as the Pomona Electronics Number 2417 diecast aluminum housing. Diagram 1 shows the schematic layout for the Match-Box; diagram 3 shows the parts placement within the container. Diagram 2 shows the simple method of constructing your own "calibration" mis-match loads. By using either a 62 or 91 ohm resistor, mounted in an F59 fitting as shown so that one lead is soldered to the ferrule shell and the opposite end inserted into a piece of tubing for short-protection becomes the center conductor for mating the calibration standard with the F61 chassis connector (Z1).

Diagram 4 shows how the system is employed. A 75 ohm resistor is attached to the standard port, using the method shown in diagram 2.

(A) Place a calibration load of 75 ohms at Z1. The scope deflection is adjusted by varying the vertical sensitivity so that the display line is just across the *bottom* of the screen;

(B) Replace the calibration load on Z1 (75 ohms was the first calibration) with a *second* calibration load of 51 ohms. This will produce a display line on the scope equal to a VSWR of 1.5:1. Take a grease pen or felt tip pen and mark that reference point on the scope screen graticule. *Leave the scope controls alone* after initially adjusting for a display at the bottom of the screen with the original 75 ohm reference calibration load at Z1.

(C) Replace the 51 ohm load with a 36 ohm load. This will produce a VSWR trace equal to a VSWR of 2.0:1 on the scope screen. Similarly, mark that trace line with a pen on the scope screen graticule.

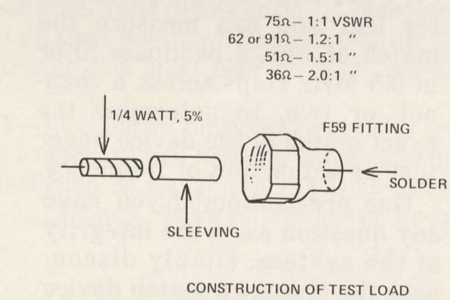


DIAGRAM 2

Now pull off the last (36 ohm) calibration termination and substitute your unknown-match piece of equipment for the load at Z1. Observe the point on the scope where the display line reads. Readings further "up screen" indicate higher VSWR's and poorer match. By calibra-

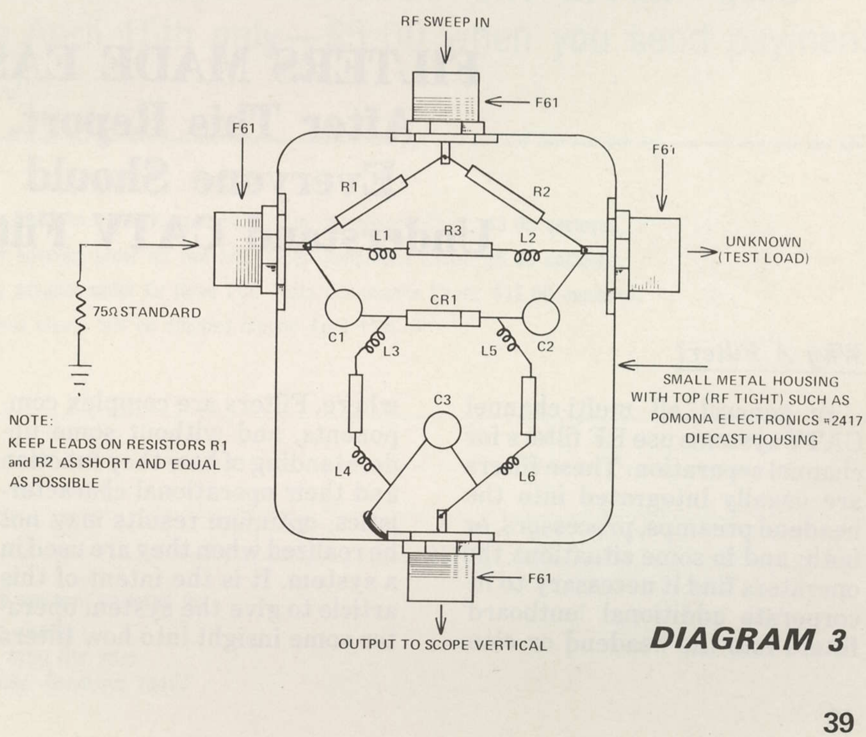


DIAGRAM 3

ting the scope screen display with the horizontal graticule marks, you should be able to read match (VSWR) within 0.1 accuracy areas.

If the device you are checking match on is a *through-passive device*, such as a bandpass filter or trap, terminate the through port of the device (the *opposite* end from the connection to Z1) with a 75 ohm resistor.

Any device connected to Z1 should be connected in such a way that the connecting cable is almost *non-existent* between Z1 and the device being measured. One of the double-F59 connectors (i.e. one with two F59 connectors back to back with a center conductor floating in an insulating medium) is best. Otherwise the impedance of the connecting cable becomes part of the measurement you are making, and the match you measure with the system may be the match to the connecting cable, and *not* the device on the end of the inter-connecting line.

The sweep source can be broadband (i.e. sweep set in wideband sweep over one or several channels); or, the sweep can be placed in the CW mode and the VSWR of the device being checked plotted as a function of frequency. If you come out of the sweep source into a two-way splitter, driving the test set-up shown here with one leg of the splitter and a frequency counter (best) or an accurately calibrated (for frequency) SLM with the opposite splitter leg, you can measure the match of, one, a bandpass filter in 0.5 MHz steps across a channel, or two, to determine the exact match of the device under test as a function of frequency.

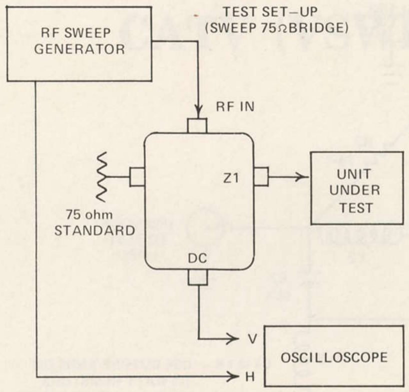


DIAGRAM 4

One pre-caution; if you have any question as to the integrity of the system, simply disconnect the unknown match device at Z1 and replace the calibration standard (a 75 ohm resistor soldered into an F59 fitting) and re-check calibration on your scope. This is your constant reference, a 75 ohm load.

For reference purpose, here are the calibration resistors to use vs. the VSWR and match for several commonly available resistor values for calibration purposes:

75 ohms............VSWR 1:1 / match 30 dB+
68 ohms..........VSWR 1.1:1 /match 27 dB
62 ohms..........VSWR 1.2:1 /match 21 dB
51 ohms..........VSWR 1.5:1 /match 14 dB
36 ohms..........VSWR 2.0:1 /match 9.5 dB

The better the quality of the *calibration resistors*, the more accurate your measurements. Five percent resistors are adequate for most purposes, although closer tolerance resistors (i.e. 1%) will improve measurement accuracy since 5% at 68 ohms is 3.4 ohms, enough to register a measurement error of several dB in the match department.

Editor's Note: The preceding material was developed from basic data and a set of construction plans provided by Hansel Mead of Q-BIT Corporation, Melbourne, Florida.

FILTERS MADE EASY
After This Report, Everyone Should Understand CATV Filters

Why A Filter?

In general all multi-channel CATV systems use RF filters for channel separation. These filters are usually integrated into the headend preamps, processors, or both; and in some situations the operators find it necessary to incorporate additional 'outboard' filters into the headend or elsewhere. Filters are complex components, and without some understanding of how they function and their operational characteristics, optimum results may not be realized when they are used in a system. It is the intent of this article to give the system operator some insight into how filters operate, without having to delve into the very complicated world of actual filter design.

To say that filters are complex is not an exaggeration. There are volumes of very intense books written on filters, and there are electrical engineers who do nothing but design filters for various applications. So a system technician need not be embarrased when he plugs a supposedly ideal filter into his system and gets screwy results! Filters do things to signals which are not always apparent from the amplitude response curve of the system, and filter characteristics are greatly influenced by the input and output impedance interfaces.

Whooops!

There are low pass, bandpass, high pass, bandstop, traps and all pass filters. Of these general filter *classes* the design itself may be constant-K, M derived, butterworth, tschebyscheff, linear phase, elliptical, or constant resistance. Then each design may be sub-classed and described by the number of poles, or poles and zeros, ripple and shape factors, and so on. So choosing the *proper* filter for a particular application is not an easy task. Even deciding *where* a filter should be used is quite a chore, if done correctly. The operator himself is also limited by the particular CATV design filters available and the 75 ohm operating impedance of CATV systems and sub-systems; unless he is particularly clever and has access to a copy of the ARRL Amateur Radio Handbook from whence he may be able to design a few circuits of his own.

Pass/No Pass

It is generally understood that filters pass signals of certain frequencies or certain frequency bands with relatively low filter losses, while at the same time the filter-device is rejecting other bands with high loss. Low pass and bandpass filters *pass* signals above certain (design) frequency bands and reject all out-of-band frequencies. High pass and bandstop filters *reject* signals over certain bands while passing all others.

The parameters mostly of concern to the CATV user is the passband and reject-band characteristics; and, the transfer region where the device transitions from passband to reject band, or vice-versa.

All filters are designed around a characteristic operating *impedance.* For example, if the unit is a 'stand-alone' filter with 75 ohm coaxial cable connectors, then it is designed around a 75 ohm characteristic impedance. On the other hand, interstage filters in i.f. amplifiers (i.e. in a heterodyne signal processor) may be designed around a much *higher* input and output impedance.

If the filter is not a *constant resistance* type (1), it rejects signals by reflecting them back to the driving source. A filter therefore should have a good impedance match in the passband (provided it has a good impedance termination), but will typically display a terrible impedance match for any frequency region outside of the passband area (i.e. within the reject-band region).

Filter Components

Lump element filters use descrete capacitors and inductors; whereas distributed filters, such as are utilized in microwave and UHF regions, are designed around resonant coaxial lines. This discussion will relate only to lump element filters.

Lump element filter design is classically derived from low pass frequency design. As an example, *see diagram 1*; a simple one pole low pass filter. At *frequencies* where the inductive reactance of the inductor is much *less* than the load of the filter (rl), the filter will exhibit low through-loss. The load or impedance seen by the signal source (generator) is RL. As the frequency of the generator *increases*, the inductive reactance also increases. Thus the voltage present at RL will decrease as the frequency increases. Another way of saying this is that as the frequency goes up, the fixed inductor (L) looks more and more lossy to the passage of the through-signal; so the higher the frequency, the higher the loss.

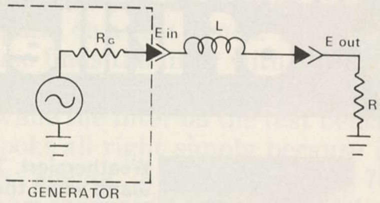


DIAGRAM 1

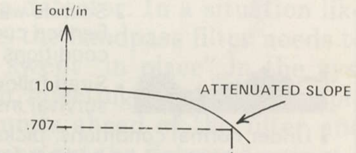


DIAGRAM 1A

It should be apparent at this point that changing RL or RG will effect the point at which the filter cuts off; or, the frequency bandwidth of the pass-portion. The circuit depiction shown in diagram 1 can be translated to a real bandpass filter by series res-

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1) *Most filter designs are not of the constant resistance type* (i.e. reflectionless); *however they need to be mentioned as they are unique. A constant resistance filter displays a relatively good match even in the reject band. This is accomplished by transferring the reflected signals into built-in load resistors which are designed into the filter.*

Editor's Note: *There have been reports that where high-Q bandpass filters are employed, the rejected signals if strong enough will travel back up the downline to the antenna and radiate to the rejected channel's antenna. This shows up as a ghost on the rejected channel because the antenna sees both the direct path and the delayed path via the off-channel antenna/bandpass filter.*

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onating L with a capacitor C1 at some center frequency fo. See diagram 2.

Or, a high pass filter can be constructed by interchanging a capacitor C for inductor L (diagram 3).

Or, a bandstop filter can be designed by parallel resonating the inductor L by a capacitor Cl at frequency fo (see diagram 4).

Now back to the low pass filter shown in diagram 1. The attenuation slope, or the rate at which the filter cuts off depends on the number of elements (L's and C's) used in the low pass structure. This number of elements is usually referred to as "the number of poles." An example of a 1 pole low pass structure, and its slope characteristic of 6 dB per (frequency) octave, see diagram 1.

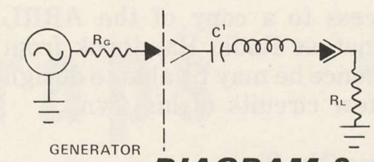


DIAGRAM 2

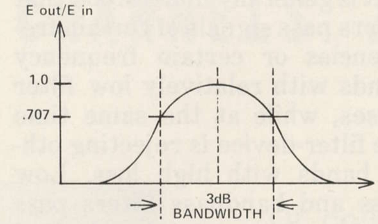


DIAGRAM 2A

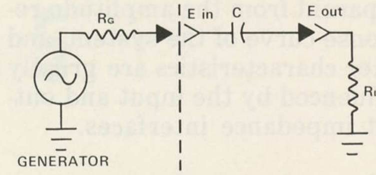


DIAGRAM 3

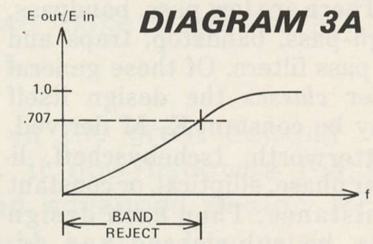


DIAGRAM 3A

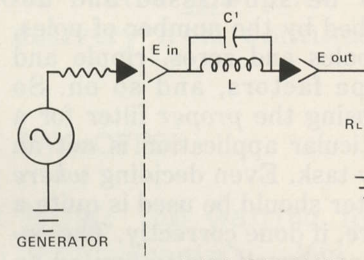


DIAGRAM 4

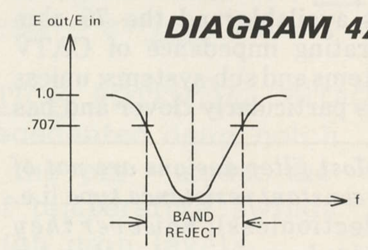


DIAGRAM 4A

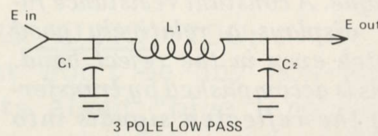


DIAGRAM 5

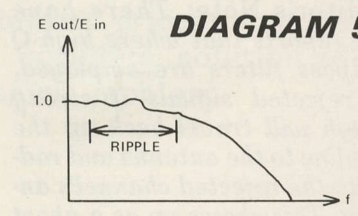


DIAGRAM 5A

Now see diagram 5. This is a 3 pole low pass structure. The attenuation slope is 18 dB per octave (arrived at by 3 x 6 dB per

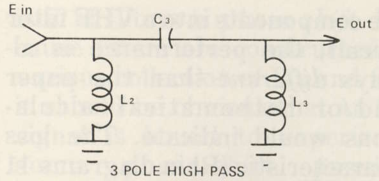
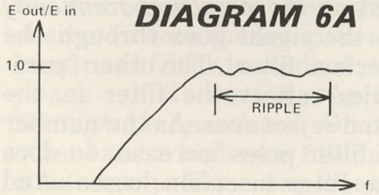


DIAGRAM 6

DIAGRAM 6A



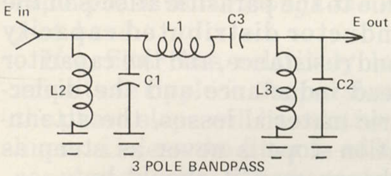


DIAGRAM 7

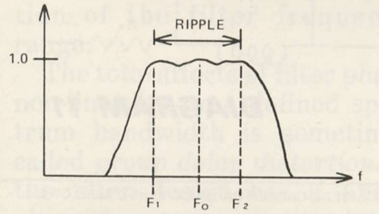


DIAGRAM 7A

pole). Thus each added pole results in an additional 6 dB per octave roll-off (an octave is a 2 to 1 frequency change). The addition of the second, third (etc.) poles causes something known as "ripple" within the pass band portion of the frequency range. This is referred to as "passband ripple."

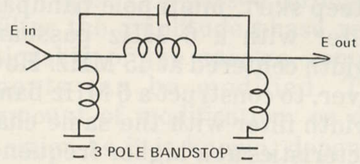
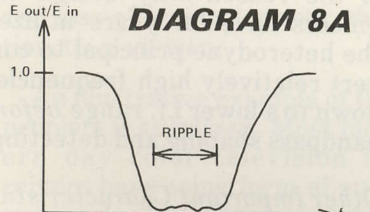


DIAGRAM 8

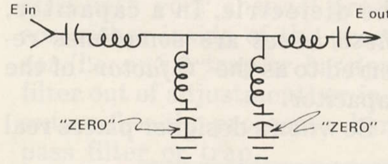
DIAGRAM 8A



Now if a high pass filter is desired, the structure is as shown in diagram 6. And, if you put a high pass filter and a low pass filter *together*, with appropriate selection of low pass cut off and high pass cut off, you have *a bandpass filter*. This is shown in diagram 7. In effect, you retain a relatively narrow *pass band* by rejecting everything below fl with a high pass filter, and everything above f2 with a low pass filter. The combination of the two results in the bandpass filter.

Elliptical Filters

Another design approach, for bandpass characteristics, is the elliptical filter. This filter design has steep attenuation slopes (i.e. good selectivity) with "unusual" rejection features. See diagram 9.



3 POLE/2 ZERO ELLIPTICAL BANDPASS FILTER

DIAGRAM 9

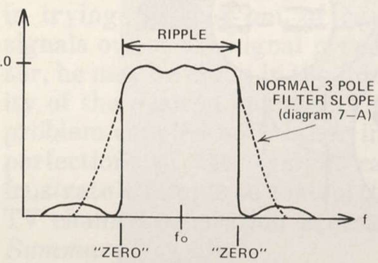


DIAGRAM 9A

The rejection characteristics are represented by the term "zero." A zero-circuit in filter terminology is one where some specific frequency is trapped to ground. In diagram 9 we have a 3 pole elliptical filter with 2 zeroes. This type of filter is sometimes utilized in CATV heterodyne processors with the zeroes set on the frequency of the two adjacent channel carriers (i.e. on lower adjacent aural and upper adjacent video). Note in diagram 9-A that the normal selectivity curve of the elliptical filter is modified (i.e. sharpened) with the zeroes. This pulls the bandpass skirts in *tighter* towards the passband region.

Pole Sensitivity

It is worth noting that as the number of filter-section (i.e. poles) is increased the more sensitive the filter becomes to driving source and load impedances (i.e. match). A single pole filter is relatively tolerant of mismatches at the input and output; but, as the number of poles increases, this tolerance for mismatch goes down.
This intolerance manifests itself as additional ripples within the passband of the filter; ripples which can change the passband characteristics sufficiently that the skirts may be substantially different *in performance* from the *designed performance*. This is why many CATV passband filters seem to function poorly in application, but look good or adequate on a test bench. The field-use finds the filter with either a bad source or load match, or both while the filter on the test bench looks all right simply because it is "seeing" a fairly accurate 75 ohm source in a sweep generator and fairly accurate 75 ohm load in a detector. In a situation like this the bandpass filter needs to be swept "in place" in the system, injecting the sweep a couple of units ahead of the filter and taking out the detected output a couple of units after the filter, where practical. Another approach is to place a 3 or 6 dB pad directly ahead of the input port of the filter and directly after the output port of the filter. This pad-match helps the filter maintain its original design-alignment characteristics. This is practical in *some* situations, but *not in all* situations because you may not be able to "give away" 6/12 dB of signal voltage to the pads. See diagram 10.

Design Restrictions/ Components

Certain restrictions are present with the filter designer,

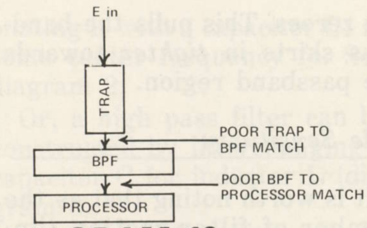


DIAGRAM 10

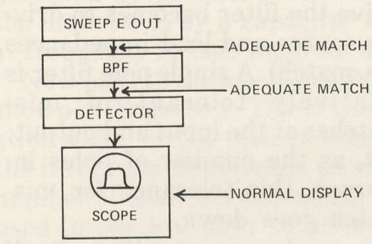


DIAGRAM 10A

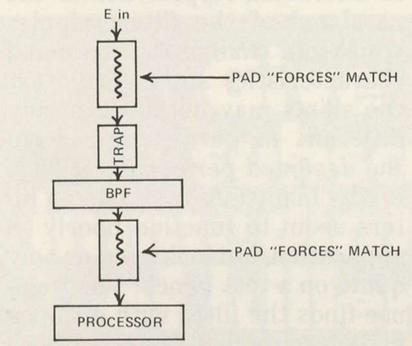


DIAGRAM 10B

when he has to work into his paper design real-life component parts. For example, a narrow band low pass filter translated up to a bandpass filter may require values of L and C which simply cannot be built. There are some transformer tricks which may help out the designer, but overall, inductors and capacitors *are less than ideal* components to work with.

For example, a practical inductor *really* looks like diagram 11. The inductor has more than simple L in it. There is distributed capacity between the windings of the inductor, and there are IR losses (i.e. resistance) in the inductor. Therefore, it is not a pure L; it is a combination of L, C and R.

A practical capacitor looks like diagram 12 in *real life*. The capacitor has inductance in its wire pigtail leads. And it has losses in the dielectric. In a capacitor, *these losses* are sometimes referred to as the *"Q factor"* of the capacitor.

So when a designer places real life components into a VHF filter circuit, the performance is always *different* than the paper and/or mathematical calculations would indicate. The loss characteristic (Rl in diagrams 11 and 12) affect the passband *through losses* (i.e. the signal lost *on the passband frequency* as the signal goes through the 'perfect' filter). The other "parasitics" affect the filter in the band *reject* area. As the number of filter poles increase, so does the filter insertion losses. And due to the parasitic affects of the inductor distributed capacity and resistance, and the capacitor lead inductance and the dielectric material losses, the attenuation slope is never as steep as theory says it should be.

A REAL INDUCTOR HAS L PLUS C AND R

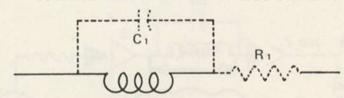


DIAGRAM 11

A REAL CAPACITOR HAS C PLUS 2 SETS OF L

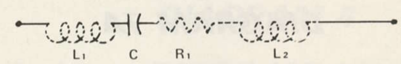


DIAGRAM 12

Up to a physically manageable point, the larger physically you make an inductor, the higher the "Q" or selectivity factor. Thus low pass filters generally come in relatively large boxes.

It is a fairly straight-forward design problem to put together a set of parameters to construct a steep skirt, multi-pole bandpass filter with a 6 MHz passband width centered at 45 MHz. However, to construct a 6 MHz bandwidth filter with the same characteristics at a higher frequency (i.e. channel 13, centered on 213 MHz) is a very difficult task. This is the reason why design engineers have for years utilized the heterodyne principal to convert relatively high frequencies down to a lower i.f. range *before* bandpass shaping and detecting.

Other Important Characteristics

Another important characteristic of filters is *phase shift*. Because filters are constructed of various collection of L's and C's, it should be obvious that an RF signal is bound to experience some phase-shift passing through the filter. The amount of phase shift is dependent upon the number of poles used in the design. In both the low pass and bandpass filter instances, the phase shift varies rapidly *through the passband*. On the other hand, a high pass filter and a bandstop filter experience rapid phase shift *through the reject band*.

If a filter has relatively low amplitude ripple *in the passband* the phase slope will be relatively linear. Unless the filter is of linear phase design, the phase slope becomes non-linear as the filter rolls off into the *band reject* portion of the filter frequency range.

The total affects of filter phase non-linearity on a defined spectrum bandwidth is sometimes called *group delay distortion*. If the filter design has a linear phase slope over a spectra bandwidth it will also have very low delay distortion.

TV Passband Characteristics

Transmission of a North American standards television signal occupies a spectrum of 6 MHz bandwidth. The spectra composition of the television signal is understood by most CATV engineers and technicians. When a TV spectra is passed through a filter the amplitude phase relationship of the spectra components can be modified. The amount of modification, or distortion as it is known, depends upon the filter characteristics. Severe distortion manifests itself as loss of picture crispness and loss of true color reproduction to a viewer.

An illustrative example of this problem is as follows. Most modern day color television receivers have some form of automatic color hue (tone) and intensity (color amount) adjustment. As the scene changes, or as the viewer changes the channel, the hues and intensity should remain relatively constant. On the other hand, these changes can only be compensated for *automatically by the receiver* if the apparent phase and color sub-carrier level is relatively constant from channel to channel. If you are in a cable home and you find that one channel (or more) require *hue re-adjustment* as you *switch* channels (i.e. if the color hue has been previously set on one channel, and it holds for hue control as you switch from channel to channel, *all except perhaps one channel*), this is a *sure* sign that someplace between your receiving antenna and the subscriber's set terminals something you have placed in the "line" is distorting the phase of the incoming signal. The odds are very good that "*the something*" is associated with your channel processor, either inside of the processor (i.e. an i.f. trap or bandpass filter out of adjustment) or in an external-to-the-processor bandpass filter or trap.

The CATV system engineer is therefore faced with a dilemma: in trying to filter out of band signals out at the signal processor, he may be doing-in the fidelity of the desired channel. This problem coupled with other imperfections of the system can frustrate attempts to control the TV channel separation process.

Summary

There are certain things a system engineer can do to realize the most performance from the component-units utilizing filters.

1) When *interfacing* components with input and/or output filters, be certain the interface has a good broadband impedance match. Remember, the more complex the filter, the better the match must be.
2) When using a *stand alone* filter, be certain that both the input and output sees a good broadband match.
3) *Never* hook a filter in series with another filter (and this includes a trap in series with another trap) unless you place some sort of normalizing isolation between the two units (i.e. normalize the impedance between the two units with a pad).
4) If only one or two interfering signals need to be attenuated, use a *bandstop* (or trap) filter, as it will display *less* phase distortion away from the reject notch than a bandpass filter.
5) Never utilize any more filters than *absolutely* necessary to accomplish the channel separation process.
6) When you purchase filter units, *burden the vendor* with the responsibility of specifying the amplitude/phase characteristics of the unit, and, the required interface impedance match to accomplish the stated specifications of the unit.

ASSOCIATE MEMBER ROSTER

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frequency (+/— 75 kHz for FM broadcasting, +/— 25 kHz for the aural signal in television broadcasting). The problem with measuring the frequency of the FM signal is that sidebands are generated at integral multiples of the modulating frequency, infinitely on either side of the carrier. How many significant sidebands are actually generated depends on the ratio between the frequency deviation of the carrier and the modulating frequency. This ratio is called the modulation index, and the ratio of the maximum deviation to the highest modulating frequency is known as the deviation ratio.

Inspite of all of this fairly deep engineering terminology, the end result **is as expressed in the article.** I.e., it is very difficult to measure such a complex signal using a frequency counter (a single frequency device) without some form of averging over a relatively long measurement period.

I found this particular article, as well as practically all the technical articles in CATJ, very well done and written in a very readable style. Congratulations on a fine book.''

Northe K. Osbrink
Senior Publications Writer
Avantek, Inc.
Santa Clara, Ca. 95051

Northe—

You caught us at something we do every now and again, and that is start off with a correct **statement of face (i.e.** ''. . . it is very difficult to measure such a complex signal . . . without some form of averaging over a long measurement period . . .''), **which is sort of the** bottom-line **of aural frequency measurements, and then work our way into explaining why it is so.**

Your explanation or description of what actually happens to an FM **(frequency modulated) signal is of course the way it** really **is. But, our experience has taught us that** if we presented it that way **initially, a very large percentage of the industry readers would stop before they got to the bottom line, or would have forgotten the** important point **when it was all done. So we 'fudged' a little** (we admit it) **and made up a simple-to-understand (if not factually correct) explanation of why** 'long term averaging' **is required. We think that for a novice in frequency measurements, our explanation (although not textbook correct) makes the important point ('averaging required')** in a way **that it won't be forgotten soon.**

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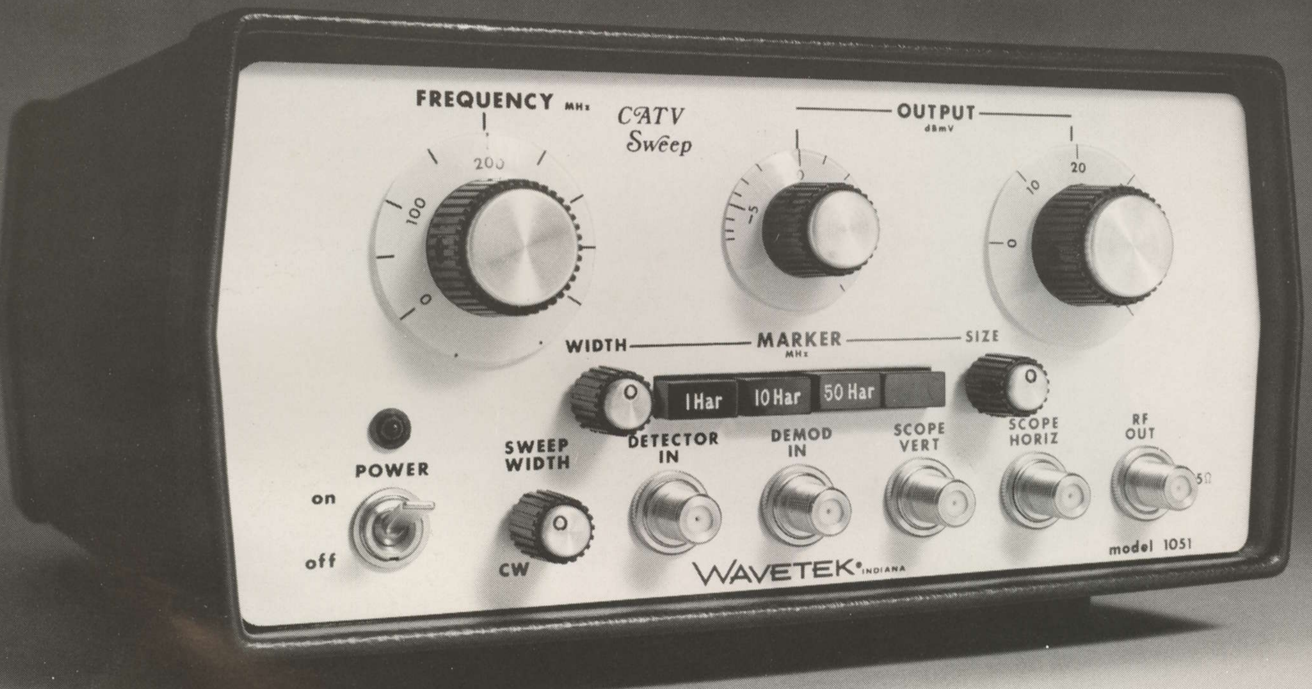

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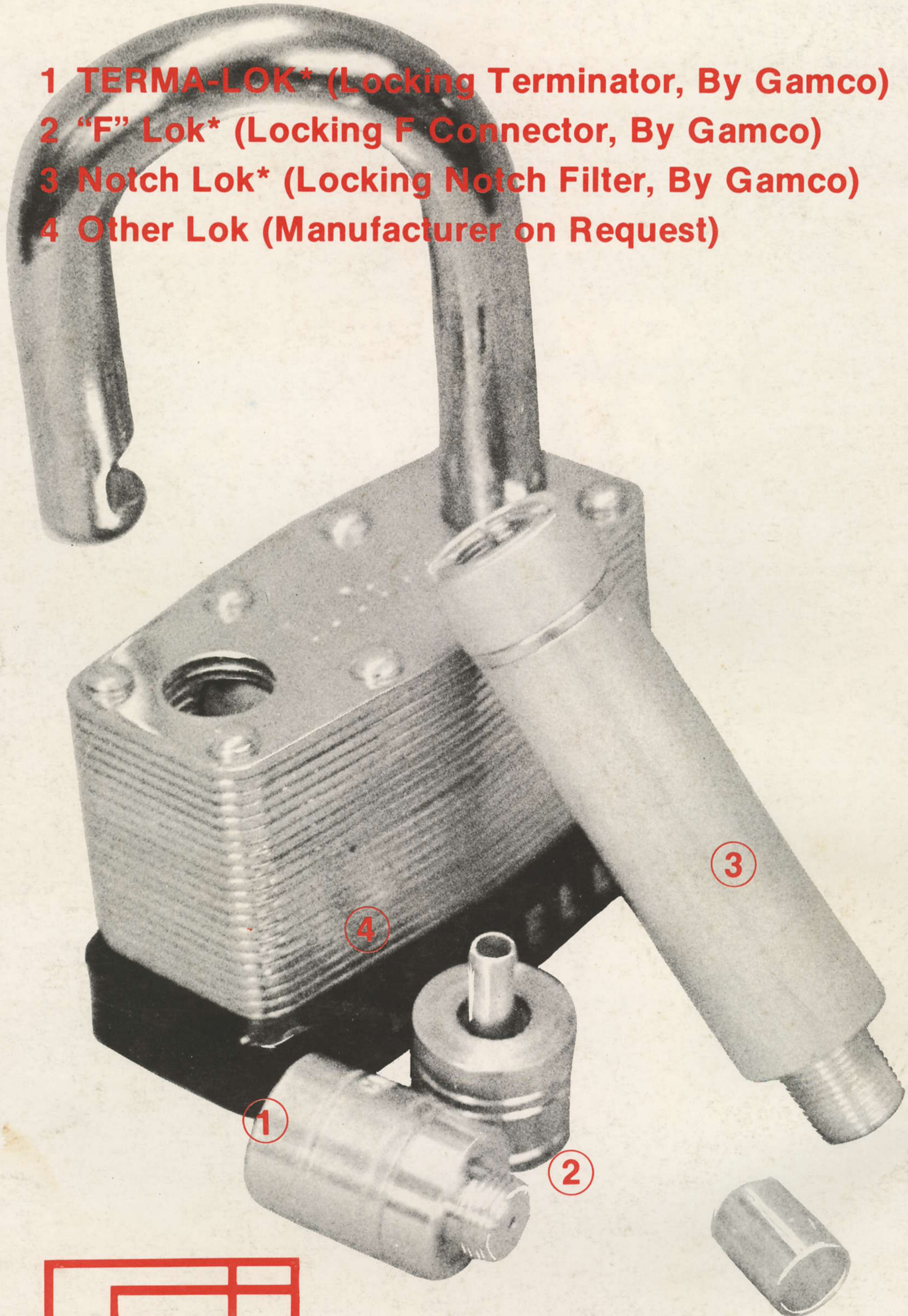

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