# PROCEEDINGS

## 28TH ANNUAL BROADCAST ENGINEERING CONFERENCE

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NATIONAL ASSOCIATION OF BROADCASTERS
HOUSTON, TEXAS • MARCH 17-20, 1974

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**LeRoy Bellwood**
Director of Engineering
KGTV Television
San Diego, Calif.

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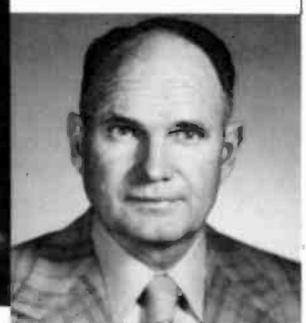
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**Vincent T. Wasilewski**

President
*National Association of Broadcasters*

# Welcoming Remarks

It is always a pleasure to meet with you and I want to welcome you to Houston and NAB's Engineering Conference. Looking over the agenda, I see that you have some interesting and informative sessions ahead of you.

During the past year there have been significant changes in the FCC's regulations that have resulted in relaxed procedures for engineers. And, I know you welcome them.

NAB and FCC task forces have spent many hours working on re-regulation. The results are heartening.

One of the problems solved, and I know this one bothered you for many years, was the FCC requirement that the transmitter be visible from the control console.

Now that the Commission has authorized you to install extension meters you can do away with your mirrors and patch those holes in the wall.

I realize that through the years you had to come up with various methods of complying with FCC regulations on transmitter visibility while trying ones, those years have had some humorous stories.

One that I recall is about the engineer who became so frustrated with trying to meet Commission standards that he cut a hole in the floor so he could just glance down and see the transmitter on the floor below.

He thought he had the FCC taken care of on that one until one day an inspector showed up. The inspector agreed that he was complying with regulations as to visibility, but then he slapped the hapless engineer with a citation for not having guard rails around the hole.

Now someone who would have thought of installing guard rails is George Bartlett. He always seems to be one step ahead of the Commission.

As you know, George does an outstanding job in organizing these conferences, and I want to congratulate him for the fine work he has done with this one.

You'll be hearing some excellent speakers and George tells me you'll also be hearing some excellent papers. I can't tell . . . that's why we keep George around.

Seriously, you do have a good conference to look forward to and I'm sure you'll leave Houston with a little more knowledge about your very important profession.

**Engineer of the Year. . . .**

**James B. Epperson**
*Vice President for Engineering*
*Scripps-Howard Broadcasting Co.*
*Cleveland, O.*

**Recipient of. . .**

# 1974 Engineering Achievement Award

NAB's 1974 Engineering Award was presented to Mr. Epperson (right) by George W. Bartlett, NAB vice president for engineering, at the luncheon on Tuesday, March 19.

## Presentation by Mr. Bartlett:

Ladies, gentlemen, honored guests and friends.

Each year about this time we pause for a few fleeting moments to pay our respects to an individual who, in the eyes of his fellow peers, has made a significant contribution to the art of broadcasting. Needless to say, selection of such an individual is not an easy task and comes only after much discussion and soul-searching.

Today, we honor a man who not only has gained this respect, but who at a very early age dedicated his life to our field of common endeavor kindling a flame which has shown brightly so that others may follow.

Joseph B. Epperson was born in Charleston, Tennessee, where at the tender age of 18 joined the staff of station WNOX while attending the University of Tennessee. Incidently, WNOX operated but one hour per day, later expanding its air time to include an additional 2 hours, Tuesday, Thursday, and Saturday. Evidently, Joe had hitched his wagon to the proper star, for as the station grew so did he, and in seven short years was named Chief Engineer. It was but a few years later that Scripps-Howard bought the station and Joe was named Chief Engineer for three radio facilities in Knoxville, Memphis and Cincinnati.

During World War II, Mr. Epperson served as a member of Dr. Bill Everitt's Pentagon-based research group which provided engineering assistance to the Chief Signal Officer on matters pertaining to radar and communications. . . .

Following his war-time duties he served a brief tour with RCA. But he quickly returned to the Scripps-Howard Broadcasting Company and resumed his duties as Chief Engineer.

With the expansion of Scripps-Howard into television Joe's first assignment was the construction of WEWS, the first commercial television station in Ohio and the ninth in the United States. Next followed WCOP-TV in Cincinnait, and in rapid succession WPTV, West Palm Beach, Florida, WMC-TV, Memphis, Tennessee, and KTEW television in Tulsa, Oklahoma.

In 1956 Joe was named Vice President for Engineering, a post he presently holds.

He is a prolific writer, having co-authored "Radar Electronic Fundamentals" and "Radar Systems Engineering". He also has written numerous articles and is the inventor of the TV Coverage Calculator—a device for determining television coverage.

Mr. Epperson is a registered professional engineer in both Ohio and Washington, D.C., and is a fellow of the Institute of Electrical and Electronics Engineers. He is an active participant of the Society of Motion Picture and Television Engineers; the Association of Federal Communications Consulting Engineers; the Broadcast Pioneers Club and the National Broadcasters Club. He's a past member of the NAB Engineering Advisory and Conference Committees; a member of the Board of Directors of the Association of Maximum Service Telecasters, and a member of technical committee and other groups just too numerous to mention.

A licensed amateur radio operator for nearly 50 years, Joe presently resides in suburban Cleveland, Ohio, with his lovely wife Bennie Elizabeth. Somehow he finds time for a hobby—photography and travel, with his favoriate spot being Florence . . . Italy, that is.

Broadcasting Magazine in its March 11th issue called him "The Last of a Vanishing Breed". I call him "Friend".

There is little need for me to continue to review his background or recite his many accomplishments. It's all in the record.

So, without further ado. . . .

In recognition of his distinguished professional career. . . .

For his many contributions to our nation's knowledge in the field of communication technology. . . .

For his untiring efforts to foster advances in the art of broadcasting. . . .

And for his pioneering spirit which has so richly enhanced the forward progress of broadcast engineering. . . .

It is my pleasure, on behalf of the National Association of Broadcasters, its membership and staff, to bestow upon our good friend . . . Joseph B. Epperson . . . the 1974 NAB Engineering Achievement Award.

## Mr. Epperson's acceptance:

Thank you George. I am deeply grateful to the NAB Awards Committee for naming me as the recipient of the 1974 Engineering Award. I appreciate the high honor being accorded to me today, but I stand here with a great deal of humility. I sincerely believe there are other engineers among us who had a higher priority.

I recall interviewing an applicant for a television operator's job back in 1947 when WEWS began operation. "You are Chief Engineer", he said. I replied that I was. "That's good", he said "for the higher up you get, the less you have to know." Twenty seven years later I can appreciate the validity of his remarks. I would never assign myself to repair a cartridge tape machine, nor a CBS Vidifont Unit.

I would like, here, to pay tribute to the NAB Engineering Department. Under the direction of its very able Engineering Vice President, George Bartlett, this organization has been dedicated to the maintenance of one of the World's finest broadcasting systems. Its Engineering Advisory Committee, made up of outstanding network and station engineers, acts as a liaison to the NAB, the industry, the FCC and other government agencies.

It is through their studies and recommendations that we have such things as transmitter remote control, magnetic recording and reproducing standards, updating of FCC Rules and many, many other things. What would we have done through the years without the NAB Engineering Handbook for reference?

Each year, another committee, the Engineering Conference Committee, plans and executes the annual Engineering Conference such as this one here in Houston. This year the Conference Committee is under the Chairmanship of Le Roy Bellwood.

I wonder how many of you remember the first NAB Engineering Conference? It all began in Atlantic City, N.J., just 27 years ago.

The first Conference was held in conjunction with the annual NAB Convention as is the custom today. The NAB Engineering Director at that time, as some of you may recall, was Royal V. Howard. His assistant was Neal McNaughton. Orrin W. Towner was Chairman of the first NAB Conference Committee.

These men established a pattern for the annual Conference agenda which has endured through the years. Each year, questionnaires are sent out to all broadcast engineers, consultants and others who have a technical interest in the convention. The questionnaire seeks guidance as to topics for technical papers which would be most helpful to broadcast engineers. The final conference agenda is made to conform as closely as possible with the opinions expressed in the replies.

An example: The FCC Roundtable discussion, a feature of the first conference, has been repeated year after year.

I have been fortunate to have been asked to serve on several NAB Engineering Committees by George Bartlett and, before him, by Prose Walker, former NAB Engineering Director. I have been equally fortunate to have had a chance to serve with other groups such as MST, IEEE, IRE and AIEE.

I am indebted to my company, Scripps-Howard Broadcasting, and in particular Jack R. Howard, president, and Mort C. Watters, executive vice president, for the expenditure of time and money required for these projects. I thank the engineering directors at our various stations for their help and cooperation throughout the years.

And so, in accepting this award, I thank all of you for the compliment you have paid to me and through me to my Scripps-Howard associates and to all broadcast engineers. Thank you.

Luncheon Address (Monday, March 18, 1974)

**Lt. Cdr. Robert L. Crippen, USN**

*NASA Astronaut*
*Johnson Space Center*
*Houston, Tex.*

# Skylab..and Space Shuttles

On behalf of the National Aeronautics and Space Administration, better known as NASA, the Johnson Space Center here in Houston, and the Astronaut Office, it's indeed a pleasure for me to be here at this luncheon today. And as a native of Houston, or at least the Houston area, I'd also like to welcome you to our city.

Before I go any further, I see I've been touted as a speaker for this luncheon, and today they sent you a pilot, not a politician. I understand that's on tomorrow's agenda.

At any rate, I don't give speeches, but like most Texans, I like to talk, and I usually try to talk about something I know a little bit about. Today that's going to be Skylab. It's a project that I've been associated with for a number of years now.

Back in 1969 I was working on something called the manned orbiting laboratory, which had nothing to do with NASA. It was a Department of Defense program. I was hopefully going to fly on that, but, unfortunately, it was terminated, and in September of '69, I was transferred to the Astronaut Office here in Houston. Since that time I have been working on the Skylab program, and, at least from my viewpoint, it was rather fortunate. I've had a chance to take a program from its inception when we were identifying requirements on pieces of paper, trying to imagine what it was goint to be, all the way through its later development and testing, and managed to participate in it. In the process I was locked up in a chamber for 56 days. But finally we took Skylab down to the Cape and went through all the final testing before we put it in orbit. But subsequent to that I participated as a Cap Com, or a Capsule Communicator, here in Houston during the mission. And that's as close, I think, I can associate myself to broadcasters. I at least learned, playing Cap Com, that I was not qualified to be a news broadcaster. That was unfortunately one of the duties of Cap Coms, to keep the guys updated with what was happening and trying to read some of the complicated news items that come up. I realized what at least the news broadcasters have to go through.

So, you can see I have been with Skylab a long time. We've recently, terminated the operational portion of that program and today I'd like to familiarize you with what Skylab was and what we accomplished during the mission.

If we could dim the lights a little bit, we will show some slides over here on my right.

This is an artist's conception of what Skylab was supposed to look like. We started back in the late '60s trying to develop a vehicle that would take advantage of some of the Apollo hardware that had been developed so that we could put up at least an initial type of space laboratory in earth orbit. What we did was take advantage of the third stage, or the top portion, of a Saturn V vehicle that we used to go to the moon with. Instead of using it with fuel and oxygen, like you normally use to propel you to the moon, we did not fill it up with fuel. Instead we built living quarters and installed experiments in this particular area. And then we put a couple of adaptive stages on up front. We also added something called the Apollo telescope mount. The name of the venture was originally Apollo Applications Program, and because I guess maybe that didn't have as good a PIO sound, we ended up changing the name to Skylab. At the time some of us tried to change the name of the Apollo telescope mount to Skyscope, but we didn't sell that either.

The weird looking things on the vehicle that makes it look like a helicopter or a windmill are solar arrays. They're just photoelectric cells that when the sun shines on them generates electricity, however, we have batteries tucked around that stores electricity so when we're on the night side of the earth, we've still got electrical power. This other protrusion is another set of solar arrays, both of them just alike, and they kind of appear to be wings.

We were supposed to take the command and service module, which we used to go to the moon with, and go up and dock on three missions, the first to be 28 days, and then two subsequent missions that were supposed to be 56 days apiece.

The next slide, depicts some development work to see what we could actually manufacture in space—some crystal growth experiments, some metal—composite metal forms, and some welding. The solar astronomy was primarily associated with the Apollo telescope mount. We were also going to evaluate how man could participate in earth resources, and then we were going to actually find out what long-term weightless effects had on man and how well he could perform in orbit.

That was our initial objective. It all was supposed to come off as planned. You work hard and you plan a lot to make sure that everything works properly. We had anticipated that we would run into some problems during Skylab, but we didn't realize that when we had a perfect flight that it was only going to last for one minute, and everything after that was to be a problem.

We launched the Saturn V vehicle which was unmanned to carry the Skylab vehicle into earth orbit. We were going to carry it up 235 nautical miles and put it in an orbit that was inclined to the earth's equator about 51 degrees, which was more inclination than we'd flown any previous, at least manned, satellites. That allowed us to go up to the northern reaches of the United States.

About one minute into the flight, something we called a meteoroid shield, which is a thin sheet of black painted metal that goes completely around the vehicle and is intended to absorb some of the impact that might be encountered in earth orbit from meteorites, tore away. It is supposed to deploy and extend off the skin of the vehicle about two inches.

One minute into the flight the shield tore off, and in doing so it managed to tear off the wing, which was folded back. When the shield tore off, the wing deployed and it was in an area of maximum dynamic pressure which meant the wind was blowing pretty hard on it—and it fell off. Also when it got into orbit, the other wing, the one located along the side, did not fully deploy, and we didn't know exactly what the situation was.

We were somewhat concerned at that time because we thought after all the work and effort we had put into it, that we'd lost Skylab. Originally, Pete Conrad, Joe Kerwin, and Paul Witz were supposed to have launched the next day to go up and renedezvous with the vehicle, but seeing the problem that we had, we elected to try to understand it a little bit better before they went up to see if we could alleviate the situation any. We worked pretty hard trying to figure out what was wrong with the vehicle. We suspected that one solar array which hadn't deployed was being blocked by some metal.

We also had another problem because the paint on the meteoroid shield was no longer there. The vehicle was getting too hot for guys to live in, so we ended up designing an arrangement called a parasol, which was to be deployed out a little hole that was originally to be used for putting out scientific experiments. We were going to deploy the parasol and have it unfold and work as a big sunshade.

Anyway, the guys did go up there. They couldn't pull out the wing initially, so they put out the parasol, which worked—not exactly as we'd planned, but it worked. Then later we managed to cut away a piece of metal that was holding down the wing and it extended. Thereafter, the Skylab mission ended up being much more successful than originally anticipated.

I've got a film here that was put together by the second Skylab crew, Al Bean, Owen Garriott and Jack Lousma, and it's sort of their version of a home movie. I borrowed it from Owen before coming out here today and I think I can give you a little better idea of what life was like inside the vehicle at the time.

The initial shot is of a Saturn V vehicle, and it was the Skylab launch, and you're going to see the thing go into the clouds.

If you've never had a chance to get down to the Cape to see one of these things lift off, you've really missed something. There's the Saturn V again, it goes into the clouds. Actually, it went into the clouds just about a minute, and that's about where we ran into the initial problem.

This is an actual shot of the first rendezvous and docking. There's the parasol coming out.

This is an EVA shot of when Joe Kerwin and Pete Conrad went outside, with a long pole with a pair of cutters on the end of it. The pole was about 25 feet long and they managed to cut the metal strap that was holding down the wing and get it to deploy. It was actually pretty dramatic when they did because both of them ended up flying up into the air quite a bit.

This is the shot of Al Bean's crew when they first went up and rendezvoused. There's the parasol that we were talking about, and you can see what's going to happen here when they were doing a fly-around. That bouncing is being caused by the jets from the command module, which we're in right here, impinging on the parasol, and we thought we'd really boo-booed it when this started happening because we came pretty close to knocking off the parasol.

To give you an idea what life was like inside, the capsule was called a wardroom table where you could actually go down and prepare food. This was a tremendous step forward from anything that we'd done in the Apollo, Mercury or Gemini flights. We had little food tables that sit on the side. We had frozen food on board such as ice cream, and small steaks to eat. He's rehydrating a drink. It works sort of like an accordion. The water is inserted in and you shake it to mix it up. They had a cold water and a hot water faucet and we could actually measure how much water we were putting in. Every picture of Skylab shows Jack Lousma eating. Jack is one of our big boys in the astronaut program, and this is Al Bean sitting over here.

Zero-G, is actually not as bad as a lot of people forecast. Parts do float away and then you have to grab them, but we used little metallic knives and forks so at least you have to catch your steak, stay alert.

As part of the medical experiments, we weighed ourselves in space. Since you don't really have a gravity vector helping you out, what we did was use the principle of a mass oscillating at a different frequency on the end of a spring or a pendulum. This was actually designed by one of the guys in the Astronaut Office, Bill Thornton, before he joined the office.

This is one of the medical experiments, called M1-71. You pedal a bicycle-like device, while breathing into a tube, which analyzes how much oxygen you're using, and as a result of that they can tell how efficient your body is. We also use this device for exercising. We found that exercise is very, very important to how well you withstand the effects of being weightless for long periods of time.

This is a shot of Paul Witz, who was on the first Skylab mission, in something called a lower-body negative pressure device. Which sucks all the blood down to your big toe or someplace. Meanwhile the instruments on your body are actually giving you an EKG and transmitting this to the ground so that they can find out what effect this kind of a stress was on your body.

This was a little thing that was designed to make you sick. Because of the problems with so-called motion sickness in orbit, this thing is used on the ground quite a bit to induce motion sickness. I'll guaranty you will be sick. We did take blood samples on Skylab. The first time we'd ever done anything like that.

Owen Garriott, who is a solar physicist, studied the sun and conducted the Apollo telescope mount experiments. We have eight experiments that look at the sun in various wavelengths which we can't see here on earth due to the atmosphere absorbing them.

This is a slow motion shot in extreme ultraviolet of the sun as it rotates, once every 28 days. You'll notice the dark portions there. This is something we didn't realize until Skylab was flown. There are holes in what we call the corona, the outer portion around the sun. Prior to flying Skylab, we presupposed that most of the energy from the sun to the earth was probably induced by small flares, but since we've flown this, we've discovered that probably most of the energy is coming through these holes or gaps in the corona. Now that we know what to look for, we can pick up these holes with devices here on earth that can determine what the magnetic field of the sun is, and that's all that really is, is a big hole in the magnetic field.

This is another shot showing a corona graph of the area around the sun. This is a device that covers up the sun so that you can see what the light is around it. Notice the big area that's coming off the sun. The mass of this thing is many, many more times than the mass of the earth. We couldn't get shots like this except when we had an eclipse here on earth, and because an eclipse is very, very brief and only at specific periods of time, we didn't have an opportunity to look at the sun over prolonged periods, and we did here. You can see this mass moving away, and that's a big eruption, and we saw about three of these things during the Skylab flight of about this same magnitude. But I guess we really had not, up until this time, realized they were so frequent or what there form was.

I didn't realize it before, but this corona actually extends out around the earth's orbit, so we technically live within the sun, in a portion of it called the outer corona. It definitely affects lots of things here on the earth, like our weather and like our communications.

Al Bean and Jack Lousma doing earth resource studies. We had one telescope where one guy looked out and another where a guy sequenced switches and took photographs of the earth, and just as we looked at the sun in different wavelengths, we looked at the earth in different wavelengths. This is a shot taken in infrared where you can differentiate healthy vegetation from sick vegetation by the colors on the infrared photography.

On the last flight we conducted a gravitational experiment with a spider. This experiment was proposed by a high school girl, and she wanted to see what the effect on the animal would be in spinning its web. Apparently they studied this particular type of spider a great deal on the earth and they know a lot about it. So by transferring the spider into space we thought we'd get any differences. We noticed that when she was first turned loose, her web went every which way and didn't make any sense, but after she'd been in space about a week, she began to build a very symmetrical web. Unfortunately, she didn't have any flies to catch.

The minnows that we took up, just continued to swim in an outside loop. They couldn't figure out what was up or down, and they would swim around and around. They never really did stabilize. If you put them against a lighted surface, they'd tend to stabilize a little bit. But we also took some eggs from these particular minnows, and when they hatched these little guys didn't have any problem at all. They swam to where they wanted to go, never seemed unstable. So I guess there's some hope for being able to adapt, at least as far as some of the lower animal forms are concerned.

I mentioned earlier that exercise proved to be an important point. We found that the condition of the guys which stayed in orbit 28 days— showed some deterioration in their, capability to move around here on earth and their muscles didn't work very well. We increased the amount of exercise and the men on the 59 day flight came back in better condition.

Jerry Carry, Ed Gibson and Bill Pogue, who ended up spending 84 days in earth orbit, came back in better condition than any of the previous flights. We had extended their exercise some, but we have learned that the body tends to adapt.

The docs were wanting them to take a medication called scopedecks which was supposed to keep them from getting motion sickness. We argued about that and debated about it for a long time. I was telling Al what the wave heights were going to be. I said, "It's not bad at all, three-foot waves out there." And then I got a new weather report. I said, "They're five-foot waves out there." And I finally ended up telling him they were eight-foot waves, by then he started asking where the scopedeck was because he was convinced he definitely needed them.

There's no doubt about it, that was probably one of the rougher landings and pickups that we've experienced. Perhaps Apollo 12, might have been just about as rough, but it was certainly a rough splashdown.

To give you an idea of what we found out from the main areas of experiments that we wanted to do —I mentioned the metals processing thing. As to crystals used by all of the electronic communication industry, we know in trying to grow them here on earth, we could only get up on the area of two to three centimeters long before you get imperfections that are primarily due to being in a gravity field all the time. On board Skylab we managed to grow them up to 25 centimeters.

We've also found out some very interesting things from being able to produce composite metals of a form that nobody's ever seen before because we can't reproduce them here on earth.

From the solar studies, I mentioned the sun's corona, and the fact that these holes are where most of the energy is coming from, and our ability to predict their effect on the earth's atmosphere, so far as communications and weather is concerned, much more so than we'd ever had any capability of doing previously.

From a medical standpoint, we've learned that we can live in space for a very long time. We saw no negative effects at all from the 84-day mission, and it does tell us that there are some adaptive effects that need 28 days to fully occur. Now we don't understand all of those, but we know that they're there and we've managed to measure them fairly accurately by taking these different steps, so it actually says the longer you stay in space, probably the better condition you're in.

As to earth resources we have learned that we can participate very actively in studying the earth from orbit. We can also do some of that very well unmanned. And what we'd like to try to do to understand a little bit better is how man can marry into this, and we hope from some of the data that we've gained from Skylab that we can do that.

An interesting thing we have learned from some of the Skylab data is that right now there is evidence that there is probably a copper deposit in Nevada that has the potential of producing more ore.

And to give you a little idea of what you can do with just a 35-millimeter camera and a guy in orbit, I'd like to show you a couple of slides here of the Houston area. I brought this one along because it's where you're at today. Perhaps one of the most dramatic things is the Falkland Current which runs between South America and Africa and is probably one of the newest fishing areas that we have learned about. We have discovered things about the Falkland and its color that we have also found off New Zealand, so perhaps by some of the vis-op stuff we're going to be able to get an idea of what some new fishing grounds can be found around the earth.

That just gives you a brief synopsis of what Skylab was like. Next year, as was mentioned, we're going to be doing something called the Apollo-Soyuz Test Project, which is a joint docking mission with the Soviets. We're going to use our command and service module, their Soyuz vehicle, and we're building a little docking adapter, that we're going to put up. It has our docking device on one end and their docking device on the other. We will be doing joint dockings with them and also transferring back and forth between vehicles. We're also taking advantage of this particular flight to perform some more earth resources experiments and several other Zero-G experiments inside the spacecraft.

In the near future we're going to build a device called the Shuttle which is currently in the design phase. The idea is to have an earth orbital transport that is reusable. This airplane-like device would be launched using two solid rockets which, when you got up to a certain altitude, would drop back into the ocean on parachutes where you could go out and tow them back in. There is also a large fuel tank that is expendable that would be jetisoned into the ocean, and then the Shuttle itself would be recoverable. With this we hope to bring the cost of putting a satellite in orbit down to $100 a pound instead of the present $1000 a pound.

We plan on flying the Shuttle into orbit in 1979.

Very briefly, that is what we've been doing lately including a few brief glimpses of what we plan to be doing in the future with at least the manned portion of the space program.

I'm usually guilty of talking too long and it's getting late in the day, so in summation I would like to again hope that you have a very fine convention here in Houston and I would like to extend an invitation to any of you to come out and visit the Johnson Space Center, which is just about a half-hour's drive south of town.

Thank you very much.

**Luncheon Address (Tuesday, March 19, 1974)**

**Dr. Leonard Reiffel**
Chairman of the Board
Interand Corp.
Chicago, Ill.

# The Future of General Audio-Visual Technology

While television, along with the cinema, is certainly the most potent audiovisual (A/V) technology, it is not the only one. Here we will explore A/V in general and, in particular, the *convergence* of techniques that may be anticipated in the future.

The frame of reference for these comments is approximately 1986, with some of the predictions likely to be reduced to practice before then.

Whatever audiovisual developments transpire between now and about 1986, it seems certain that they will occur in the context of a general electronics and communications technology making continuous and rapid strides in miniaturization and speed. By 1986, the electron will, in many devices and systems, be replaced by the photon as integrated optical circuitry operating at extraordinary speed and packing densities takes over from present-day semiconductor-based concepts.

We will now proceed through a general audiovisual system discussing probable developments in each subsystem in turn. The sub-systems we shall consider are as follows:

1) Sensors/Raw Data Recorders
2) Data Formatting
3) Transmission
4) Storage and Retrieval
5) Automatic Correlation/Interpretation/Abstraction and Sorting
6) Display
7) Other Man/Systems Interfaces

## Sensors and Raw Data Recorders

There will continue to be both complementarity and competition between electro-optical and photochemical sensing (and recording) technology. Films will become faster and self-developing in all formats both still and motion. Films will interface with electro-optical intensifiers, color translators, etc. and will use not only silver-based chemistries but also photochromic and other sophisticated techniques. Electron beam recording will be used in conjunction with very fine grain films or with continuous phase holographic recording media (e.g., plastics) for sensing images and storing them at extreme density.

While films, perhaps supplemented by electro-optical processing prior to impingement of the image on the film, will become more powerful, there will be parallel development in purely electro-optical systems such as television. By 1986 television cameras, perhaps full color capable, will be available in the size and price ranges currently occupied by standard 35mm film cameras. Resolution will equal or exceed normal television requirements and the main bulk of a video camera system will be in the lens and case (and storage medium if permanent records or semi-permanent records are required). A very wide range of spectral characteristics will be available in such cameras as will low light level performance limited by quantum noise in the incident optical beam.

## Data Formatting

Large scale integrated circuit technology and CCD or related techniques will permit image scanning, scan conversion, and enhancement of visual data recorded in any medium. Given a firm requirement, a complete scan converter that would allow electronic still framing, live transmission and fast sequences of frames could probably be constructed in a volume of approximately fifty cubic inches with a weight of five pounds or less and a power requirement of the order of one watt.

Data formatting for electronic transmission will be done in single chips similar to those that will be used in the very small TV cameras mentioned in the previous section. Data formatting from photochemical systems to electronic systems could use some form of LSI mosaic and, again, given sufficient resources, industry could make such a facsimile scanner available at low cost and within the reference time frame in a volume comparable to that of an ordinary library book. The output of such a scanner could be in any desired format from very slow scan to normal video, depending on the nature of the transmission to be used.

## Transmission

In another decade it is possible that relatively high capacity, high sensitivity satellite relays will be available in many parts of the world. Whether the relay satellites are reached via laser or more conventional electromagnetic links, such a development will have a profound effect on the networking schemes that might be used in transmission of audiovisual information. Once such technology becomes available, transmission costs become essentially insensitive to distance meaning that data manipulation could be handled, in part, at distant centralized locations. Only relatively simple terminal equipment might thus be necessary to "plug in" to very sophisticated audiovisual systems. Obviously solid state laser links and millimeter wave apparatus will have developed further and will probably be in use for point-to-point communications.

Fiber optical cables will almost surely replace even such simple transmission links as telephone twisted pair simply because of material availability, total weight, and bandwidth capability. One can imagine field telephones connected by armored sheath fiber optical links some miles in length and perhaps of the order of two millimeters in diameter. Of course, the bandwidth of such a link would be enormous in comparison with present-day standards. Depending upon rates of development, concepts analogous to "Seek Bus," if available for A/V purposes sometime around 1986 to 1990, could radically change the strategies and the equipment technology to be employed in both management and operations.

In less time-sensitive applications, such as maintenance and training, the availability of wide band distance-independent links could revolutionize industrial maintenance practices by *centralizing expertise*. Various studies have already contemplated physicians using TV to advise distant hospitals conducting unusual or particularly critical operations. What can be done in the operating theater can also be done in the maintenance shop or in the field.

## Storage and Retrieval

During the next ten years, there will be an enormous increase in the density of information that can be stored in either electronic or other media. Holographic storage is in the process of arriving and molecular level storage is on the horizon. Magnetic techniques will compete with optically written and recovered methods and with electron beam techniques for extreme packing density. For field instruments, an electronic equivalent of film will probably be developed in the form of some electronically or electromagnetically active sheet material which can be written into, readout, and erased, more or less like a reusable photographic film.

One can also imagine mosaic type chips working with some of the sensors described earlier to provide a complete electronically readable picture captured in something the size of a sugar cube. Retrieval technology, of course, will have to parallel storage method development. Very high speed scanning and even transmission of libraries of data by some of the techniques described earlier could make centralized libraries of material accessible in the field sometime soon aftr 1986. Continued development of storage and retrieval techniques will go hand in hand with an ever-increasing data manipulation and computation power in LSI form, providing very powerful computer capability in very small packages.

## Automatic Correlation Interpretation/Abstraction and Sorting

Ever-increasing computational power in ever smaller, faster devices will permit automation of many of the functions which must now be done by human beings. This is not meant to suggest that human beings will be taken out of the loop and replaced by computers. Rather, one can see an increasing trend toward using computers to provide audiovisual data in formats ideally suited to human comprehension and interaction. Shape abstraction, color slicing or translation and shape or characteristic correlations in a given field of view are typical examples. The computer could provide automatic "flags" for portions of the image of special interest.

## Display

It is obvious that display technology will play a key role in the A/V concepts of the future. Laser-written photochromic displays of high resolution will probably be perfected in the near future as will many other types of non-raster scanned multi-color techniques. Current efforts in plasma panels and liquid crystal technology, developmental programs in magnetic bubble domains, electrophoretic and electrochemical displays of many types will probably make versatile flat screen displays rather commonplace by 1986.

It should be possible to provide displays ranging in size from wristwatch to full wall as desired. Helmet-mounted or goggle-mounted "see through" displays will probably be practical by 1986 or before. Certainly this will be true for two-dimensional multi-color data. Toward the end of the time frame of interest, it is likely that a limited three-D holographic display capability will be available.

Capturing data from any or all of the displays just discussed will be possible using the storage techniques and sensor devices described earlier.

## Other Man/Systems Interfaces

The display area directly concerns presentation of information to the human eye. There are, however, other audiovisual man/system interfaces. Displays, in addition to serving as data presentation devices, will increasingly serve as operator-actuated system control interfaces in the spirit of current light pen/computer techniques. The display will become a touch or otherwise response element allowing an operator to interact with what may become a distributed audiovisual network of capabilities. Voice recognition and response systems will reach a significant degree of perfection and will be used with both machine and human recipients of audiovisual data.

Culturally-independent and language systems will begin to emerge from a combination of machine processing of information and symbolic representations of systems and data status.

## Concluding Comments

There will, of course, be an enormous industrial effort in all of the areas discussed above. To a certain extent, many of the technological advances we have projected will arrive sooner or later, independently of whether the U.S. government elects to fund some of the requisite R and D. It is obvious, however, that government policy will nevertheless have profound impact on the probability of arrival of a given capability within the time frame we have been considering.

Committee Reports

Panel Discussions

Technical Papers

**Robert W. Flanders**

*Vice President for Engineering*
*McGraw-Hill Broadcasting Company, Inc.*
*Indianapolis, Indiana*

# NAB Engineering Advisory Committee Report

As chairman of the NAB Advisory Committee, I would like to submit the following report on this committee's activities for the year 1973-74.

1. Tower Icing:

For several years, tower icing has been the subject of a considerable amount of time and effort. This year your committee recommended that NAB put financial support behind the effort to find a solution. The NAB Board agreed and funding is available.

Investigation of the icing problem continues although today's most promising solution is being slowed somewhat by the current energy crisis.

2. Special Signals Within The Vertical Blanking Portion of the TV Broadcast Signal, *(RM #2192, FCC Docket #19907):*

The committee reviewed the proposed rule-making and recommended that NAB file a request for an additional time to respond, stating that the papers presented during this NAB Conference should represent substantial additional information which should be given proper consideration before comments are filed with the Commission.

Additionally recommended is that the JCIC Committee on Television Ancillary Signals be requested to evaluate the proposal in light of their current activities.

3. TV Subtitling, *(RM #2108):*

TV Subtitling has been under investigation by various interested parties for some time. The NAB Sub-Committee for Captioning and Subtitling for Impaired Hearing presented an in-depth report and their recommendations in 1972.

The National Bureau of Standards has since filed with the Commission for rule changes which would permit transmission in the vertical interval of the TV broadcast signals of:

a. time
b. precise frequency
c. channel identification
d. subtitling for the hard of hearing

The Public Broadcasting Systems is presently field-testing the NBS subtitling proposal. The Hazeltine Corporation captioning system is to be field-tested this spring.

The NAB Subtitling Committee will be invited to participate and report on these tests.

4. Radio Re-regulation, Part 73:

The Radio Re-Regulation Sub-Committee has filed reports with the Commission on the following:

a. Automatic transmission systems for AM and TV (with a filing on TV automatic transmission systems to follow in the near future).
b. Overall composition of the rules.
c. Power determination of UHF TV transmitters.
d. Auxiliary transmitters.

The Commission has issued its first re-regulation order effective December 15, 1972; its second re-regulation order effective April 4, 1973; and the third order effective August 13, 1973.

5. Revision of Part 74, *(RM #1735):*

The Commission's action, to date, has not satisfied the points introduced in the NAB filing of about three years ago. The Committee recommended that a letter be sent to the Commission requesting further action.

6. Windshield Antennas:

The Committee's recommendation that the manufacturer of the receivers and associated antennas redesign them for more efficient operation. Some improvements have been made and whip antennas are also now optional on many models.

7. Expansion of The Cars Band, *(RM #2208):*

Teleprompter Corporation has filed with the Commission for rulemaking to expand the frequencies available for assignment to the cable television relay service to be expanded to include the entire 12,700 to 13,250 Mhz band of frequencies. This proposal has been referred to the Auxiliary Frequency Utilization Sub-Committee for study and evaluation.

8. Extension Metering, *(FCC Docket #19906):*

The Committee, after considerable review, suggested that NAB file supporting comments in this proceeding, noting that there may be a need for waivers in the so-called "100 ft., one floor removed" criteria.

9. Aural and Visual Coding of Commercials, *(FCC Dockets #18877 and #19314):*

The Committee recommended that these proceedings continue to be followed carefully, looking toward filing appropriate comments at the proper time.

10. Standardization of Sampling Systems, *(FCC Docket #19692):*

Upon recommendation of the Advisory Committee, NAB filed comments in opposition to this docket. The last filing date has passed and final Commission action is yet to come.

11. Electro-Magnetic Radiation:

Electro-magnetic radiation hazard rules, as covered by OSHA, create a difficult situation in erection and maintenance of certain radio and television antennas and towers, especially in multi-structured complexes. A sub-committee has been ordered to:

a. Determine whether the radiation hazard levels as set forth in the OSHA rules are realistic.
b. Investigate the feasibility of developing a radiation measuring instrument.

12. Frequency Usage in Auxiliary Service:

The continued growth in the use of remote pickups, wireless microphones, studio-to-transmitter links, and intercity relays operating in the auxiliary serivce spectrum has grown substantially over the past ten years. It is the Committee's opinion that additional spectrum space may be needed in the near future and that efforts should immediately be undertaken to determine industry's needs looking toward additional spectrum space or restructuring the present spectrum space to accommodate additional facilities.

13. Strobe Lighting for Tall Towers, *(FCC Docket #19931):*

NAB has filed comments with the FAA which reviewed the many problems associated with the use of strobe lights and reiterates that the use of such lights must be optional. The FCC has just issued a proposed rule-making to change Part 17 to permit high intensity lighting and tower painting to correspond with the FAA rules. It should be noted that the new provisions are intended as an alternative to, not a substitute for, the current rules and provisions which continue in effect. Comments to the FCC are due by March 25th.

14. Elimination of Frequency Monitors, *(FCC Docket #19712):*

Effective November 21, 1973, the Commission deleted the requirement that licensees be equipped with the continuously operating type-accepted frequency monitor. Also deleted was the necessity to log the frequency monitor every three hours but added was that the licensee be required to make frequency measurements at intervals not exceeding 31 days.

The NAB petitioned that this time interval be extended to 41 days and the Commission, on November 26th, substituted a 40-day time interval. They also included some additional clarification of their language in their original proposal which had been subject to several misconceptions in the field.

Other subjects under consideration by this committee include, but are not limited to, television sound quality, AM stereo, quadraphonic sound, parts availability, engineering seminars, CATV technical standards, standards for good engineering practices, and the NAB Engineering Handbook. If you have an interest in any special subject or project, please convey your ideas to anyone on this committee or directly to NAB.

This concludes this NAB Engineering Advisory Committee report. I wish to thank the committee members for their efforts. The committee members are as follows:

Charles F. Abel, Manager of Engineering, KFMB, San Diego, Cal.

Ernest L. Adams, Vice President for Engineering, Cox Broadcasting Corp., Atlanta, Ga.

Ralph F. Batt, Vice President & Manager of Engineering, WGN, Chicago, Illinois

Albin R. Hillstrom, Vice President—Engineering, KOOL Radio & Television, Phoenix, Arizona

John R. Kennedy, Vice President—Operations & Engineering, National Broadcasting Corporation, New York, New York

Leslie S. Learned, Consulting Engineering, Mutual Broadcasting System, New York, New York

James D. Parker, Staff Consultant—Telecommunications, Columbia Broadcasting System, New York, New York

R. LaVerne Pointer, Director—Broadcast Engineering, American Broadcasting Company, New York, New York

Benjamin Wolfe, Vice President for Engineering, The Post-Newsweek Stations, Washington, D. C.

**Robert A. O'Connor**

*Director, Transmission Engineering*
*CBS Television Network*
*New York, N.Y.*

Chairman,
*JCIC Ad Hoc Committee on Television Broadcast Ancillary Signals*

# Status Report on the JCIC Ad Hoc Committee on Television Broadcast Ancillary Signals

Some of the special "piggybacked" signals that have been authorized in the past include unobtrusive audio tones for alerting network affiliates to special announcements or for starting station tape or telecine equipment; vertical interval test and reference signals for the surveillance of video quality on the networks, and more recently, on the signals radiated by remotely-controlled television broadcast stations; time-diplexed signals in the picture area intended for electronic identification of programs and commercials; and frequency diplexed signals in the picture area, to provide an emergency backup for the associated audio. Many other types of special signals are currently under consideration, and still others continue to surface. The Ad Hoc Committee on Television Broadcast Ancillary Signals has been charged with conducting an overall study of *all* potential locations, within the television program signal, for such special signals and to recommend a plan for maximizing the utilization of the available space without in any way jeopardizing the quality or integrity of the program signal.

## Location of Signals

The locations for these special signals might be described as "gaps" either in the time domain, or in the frequency domain, within the program signal. An example of time "gaps" would be the horizontal and vertical blanking intervals of the video signal, and brief interruptions, in the order of tens of milliseconds of the audio signal. An example of frequency "gaps" would be the intervals between harmonics of the line scanning frequency of the video signal, where there is very little program information. (This is, of course, the technique that was used to add color to the monochrome signal—with no additional bandwidth). The comparable portion of the audio signal would be the extreme ends of the audio bandpass where relatively little energy exists.

It should be noted that the question of subcarriers on the broadcast aural carrier is *not* included in this Committee's study. There are others in the industry looking into this technique for additional sound channels, but since some additional capacity might remain for some ancillary signals, the ancillary signal committee is maintaining liason with the other groups.

Some examples of how these locations have already been utilized or are proposed to be used follow:

**Figure 1**—This chart is intended to illustrate the potential communication capacity of the horizontal blanking interval and shows the basic details of several techniques for adding the program audio signal within the horizontal blanking interval, for network transmission. Some have suggested the radiation of such signals to a new generation of television receivers but there are no specific plans along these lines at the present time. However, if used for network transmission, the signals would be deleted at the affiliates' studio, with the horizontal blanking interval again made available, perhaps for signals related to the station's local operation. The systems shown are the Bell System's TIDI-Sound using the front porch, the BBC's Sound-In-Syncs using the tip of sync, and the Japanese PCM-burst system using the back porch.

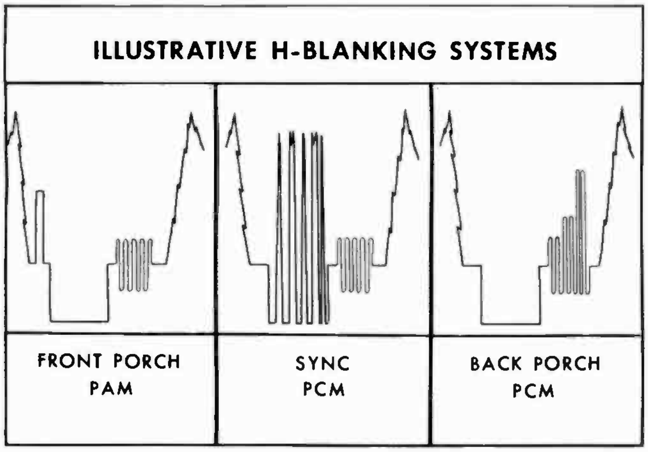



Figure 1

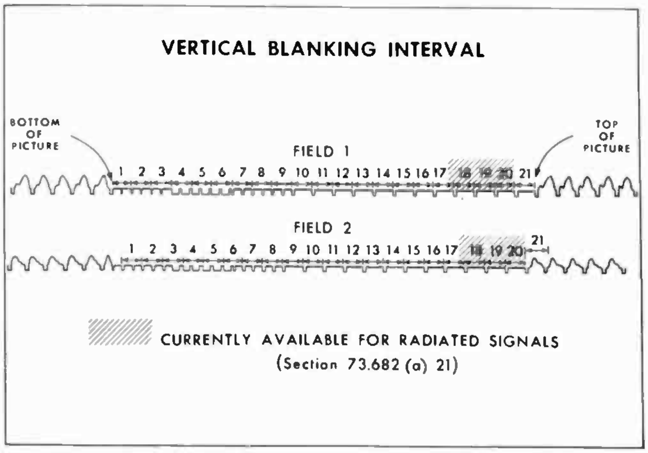



Figure 2

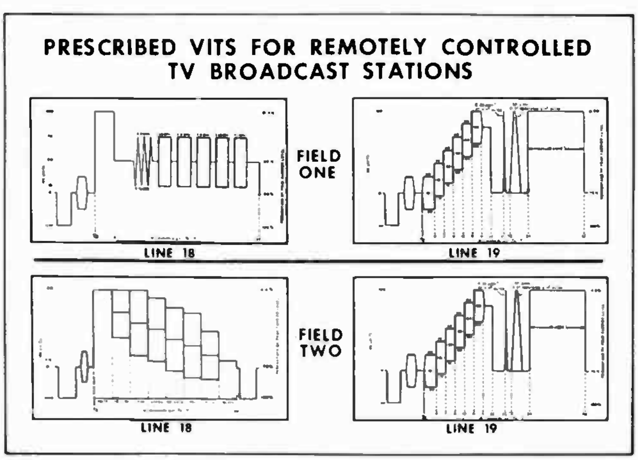



Figure 3

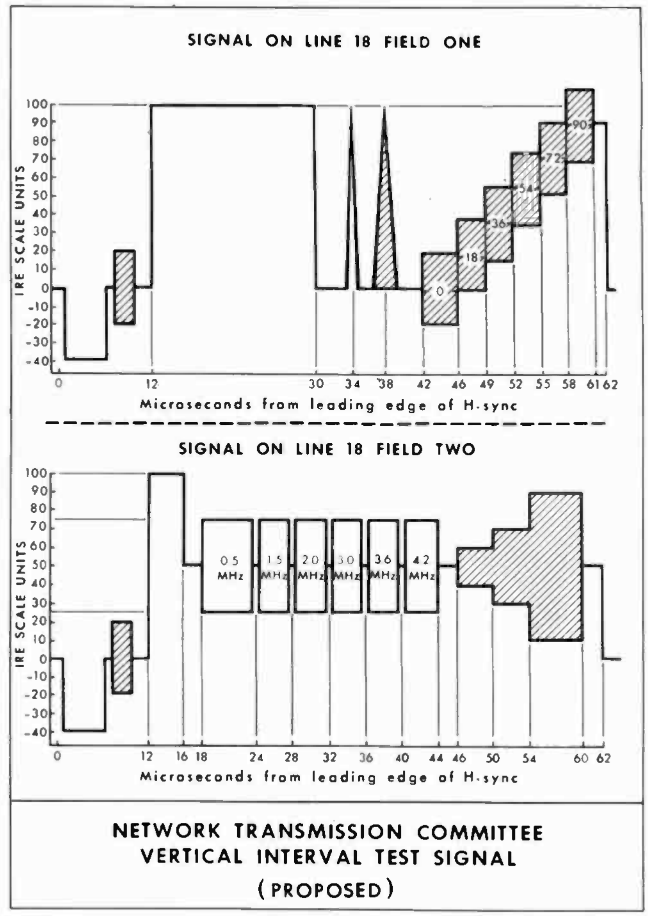



Figure 4

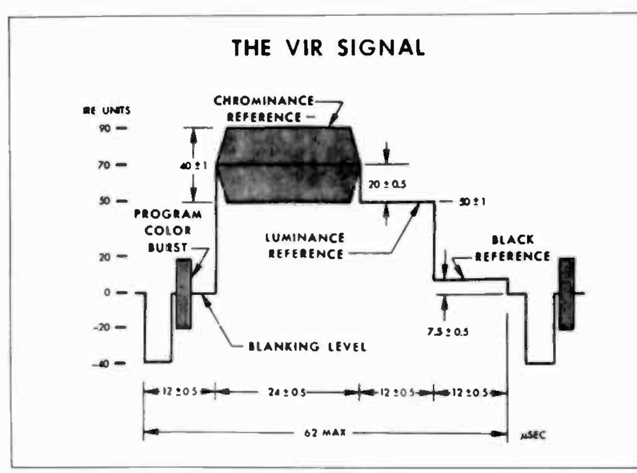



Figure 5

**Figure 2**—shows the vertical blanking interval, with 21 lines of vertical blanking, which has generally become standard within the industry, and the space currently available for radiated signals. Based on a current proposal of the FCC, Docket 19907, this space would be increased in include *all* of line 17, rather than just the last 12 microseconds.

**Figure 3**—shows the vertical interval test (VIT) signal that is prescribed for remotely controlled television broadcast stations.

**Figure 4**—shows the new proposed national and international network transmission VIT signal.

**Figure 5**—shows the vertical interval reference (VIR) signal.

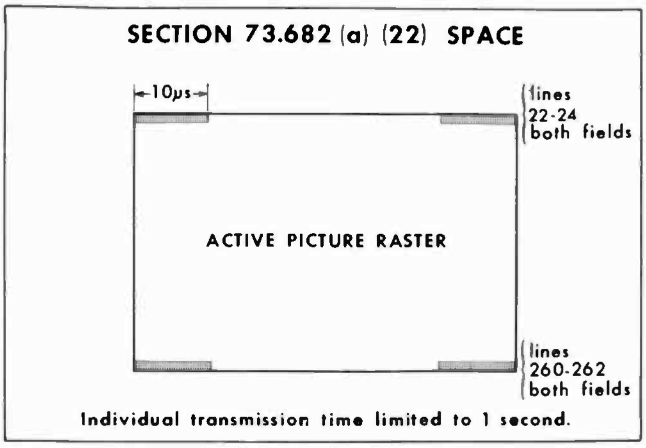



Figure 6

**ILLUSTRATIVE PROGRAM AUDIO SYSTEMS**

| SYSTEM | DETAILS | FUNCTIONS |
|---|---|---|
| A | 3 tones, 2100-3100 Hz, 50msec, -30dB | 1,2 |
| B | 2 tones, about 4900 Hz, 1 sec, -30 dB | 1,2 |
| C | tone in 200 Hz window about 2900 Hz, 3 sec, -40 to-50 dB | 3 |
| D | tone in 90 Hz window, about 150 Hz, 60-120 msec over 4 sec, +10 dB | 3 |
| E | 16-mode "subliminal signalling" | 1,2,3,4 |

1. ALERTING 3. PROGRAM ID
2. CUE 4. PERFORMANCE TESTING

Figure 8

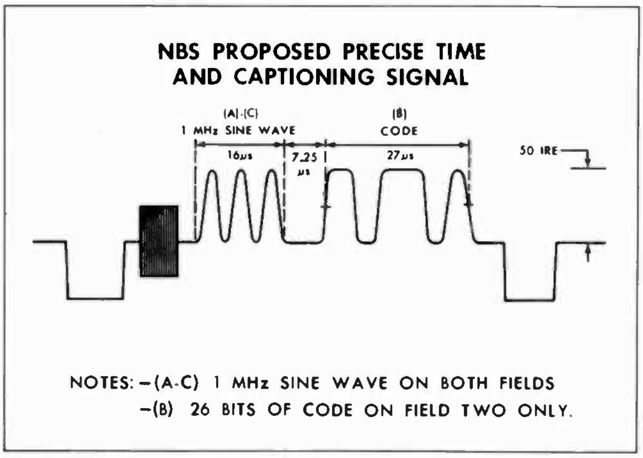



Figure 7

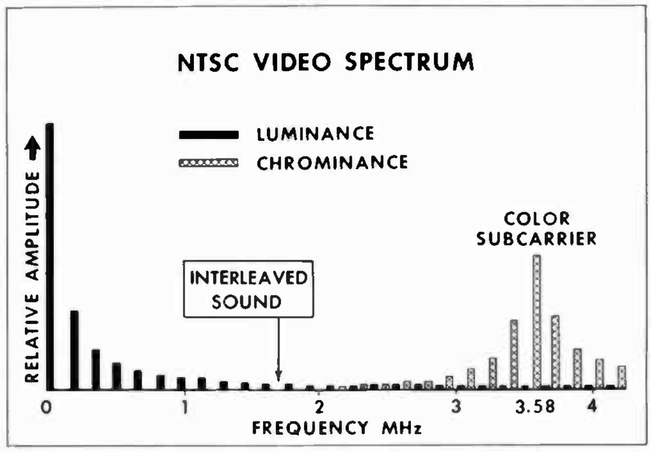



Figure 9

**Figure 6**—shows the data signal proposed by the National Bureau of Standards to provide captioning for the hearing impaired.

**Figure 7**—shows the basic details of some of the systems that are in or have been proposed for the use of tones within the audio program signal.

**Figure 8**—shows the portion of the video program signal that is currently permitted to be used for "coded patterns for the purpose of electronic identification of television programs and spot announcements."

**Figure 9**—illustrates an example of how a frequency "gap" is utilized to provide an emergency network audio, employing a carrier frequency interleaved between the 113th and 114th harmonic of the line frequency.

## Activity to Date

Having studied the subject for approximately one year, in the light of existing and already proposed systems, and looking towards the future, the Committee last Fall submitted to the Federal Communications Commission its "Interim Report No. 1, "15 September 1973." This report outlined the history behind the Committee's formation, stated its views on pending ancillary signal matters, and outlined its plans for the future. Copies of the report are available upon request from Mr. George Bartlett of NAB or myself. Additionally, the report was printed in the December 1973 issue of the Journal of the SMPTE.

## Current Activity

Several subcommittees have been established in order to divide the work load.

*Subcommittee A*—Mr. Carl G. Eilers of the Zenith Radio Corp. is looking into the television receiver aspects of signals inserted in the blanking intervals.

*Subcommittee B*—Mr. John Ball of Public Broadcasting Service is concerned with vertical interval signals, concentrating on a data format that would accomplish a variety of the ancillary signal requirements.

*Subcommittee C*—Mr. Evans Wetmore of Public Broadcasting is studying the associated audio program signal. Mr. Wetmore is also the JCIC representative on the special SMPTE Working Group on Audio Program Identification Signals.

## SOME QUESTIONS ON AUDIO TONES

1. PERCEPTIBILITY OF AUDIO IMPAIRMENTS AS FUNCTION OF TIME AND FREQUENCY "WINDOWS" OF DIFFERENT WIDTHS AND LOCATIONS.
2. PERCEPTIBILITY OF AUDIO IMPAIRMENTS OF TONES OF DIFFERENT LEVELS INSERTED IN WINDOWS.
3. FACTORS AFFECTING AUTOMATIC TONE DETECTION (HENCE RELIABILITY):
   - VELOCITY ERRORS ET, TAPE, FILM.
   - TRANSMISSION DISTORTIONS.
   - DEGRADATION IN DUPLICATION PROCESS.
   - PROPAGATION EFFECTS.

**Figure 10**

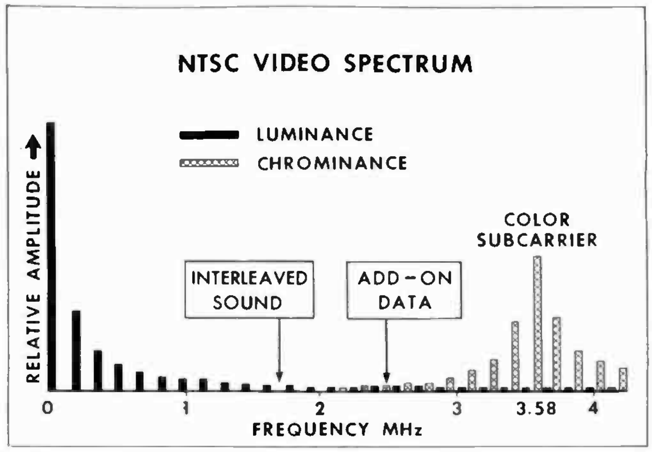



**Figure 11**

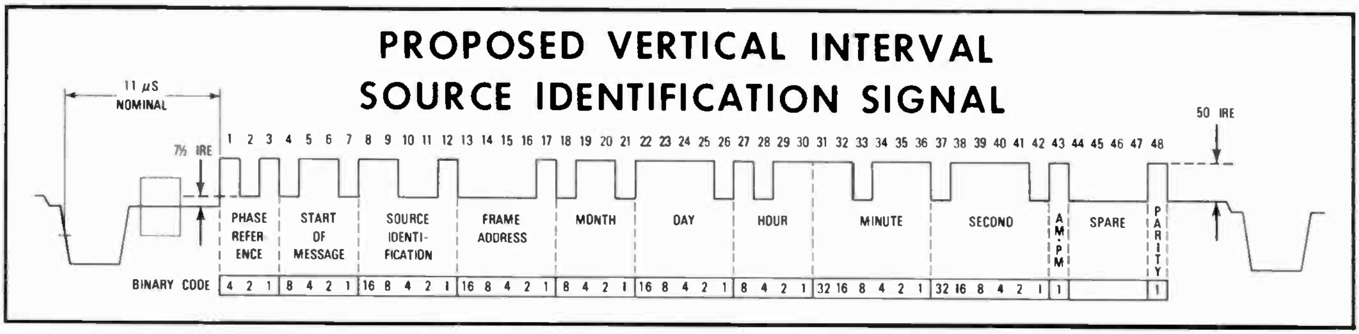



**Figure 12**

*Subcommittee D*—Mr. Robert J. Butler of NBC is looking into the practicality of added signals in the program video signal.

*SMPTE Working Group on Aural Program Identification Systems*—Mr. Roland Zavada of Eastman Kodak is chairman of this SMPTE group, which is concerned with an aural technique specifically for meeting the program identification function.

*Subcarrier Multiplexing Liaison*—Mr. Eilers, who is chairman of a subgroup of the EIA's Broadcast Television System's Committee concerned with additional sub-carriers multiplexed on the aural carrier is keeping the Committee advised of developments in that area.

In terms of specific activity, the Committee is currently concentrating on three specific items:

1) A test program designed to answer many of the questions that have been raised relative to audio tones intended to meet ancillary signal requirements. Figure 10 is a brief summary of some of these questions.
2) A test of the "Television Add-On Data Communication System" developed by Hazeltine Research Inc. Fig. 11 is a repeat of Fig. 9 on to which another interleaved subcarrier has been added at approximately 2.5 MHz. The Hazeltine system uses this subcarrier to provide a data stream that would not be visible in the picture, but with a special decoder could be detected and displayed on the screen as alpha-numeric characters.
3) A test of a proposed vertical interval source identification signal. Fig. 12 shows the basic digital format which would indicate specific network and network location, month, day, hour, minutes and seconds of program origination time.

All of these tests will include transmission over the television networks and will be contingent upon obtaining Special Temporary Authority from the FCC. All affiliated stations who would receive such transmissions will be provided with the pertinent details when they become known.

All of the ancillary signals which have been described herein are *program-related* signals, which the Committee has determined should carry a first priority. It is recognized that many of the techniques under study would be capable of providing a wide variety of new services to the home viewer—not program related, but, of a general broadcast nature—including news bulletins, weather reports, stock market quotations and the like. Much activity in this area is currently underway in Europe, particularly in England where the CEEFAX and ORACLE systems are undergoing field trials. The Committee intends to keep a close watch on this activity, with respect to relevancy to its own goals.

**Daniel R. Wells**

*Director of Engineering*
*Public Broadcasting Service*
*Washington, D.C.*

Chairman,
*JCIC Ad Hoc Committee for*
*Study of Television Sound*

# Status Report of the JCIC Ad Hoc Committee for the Study of Television Sound

The Joint Committee on Intersociety Coordination (JCIC) canvassed its members in the Fall of 1972 asking whether the quality of television sound warranted prompt attention, and, if so, what organization was best constituted to deal with it. The answer was unanimous that there was an opportunity for improvement in television sound and that no one organization could adequately address the problem.

The Joint Committee on Intersociety Coordination, concerns itself with engineering problems in interrelated areas that would benefit from joint action throughout the television broadcasting industry rather than being addressed by any one organization. The study of television sound fell into this category.

The purpose of this Ad Hoc Committee on Television Sound is to examine the entire television system from original production to the sound heard in the home, to identify areas of possible improvement and to assign to appropriate organizations specific questions for resolutions.

There are five organizations which are constituent members of JCIC, namely EIA (Electronics Industry Association), IEEE (Institute of Electrical and Electronic Engineers), NAB (National Association of Broadcasters), NCTA (National Cable Television Association), and SMPTE (Society of Motion Picture and Television Engineers). SMPTE is the administrative organization of this Ad Hoc Committee. The Engineering Vice President, Bill Wintringham, is the administrative officer of the Ad Hoc Committee. In addition to the standing members of JCIC, other organizations were invited to participate in this Ad Hoc Committee on Television Sound, namely, AES (Audio Engineering Society), NTC (Network Transmission Committee) and the PBS Engineering Committee which consists of the Chief Engineers of 14 of the PBS stations. Also participating in an observer status were the Canadian Broadcasting Corporation and the FCC.

With this broad base of representation, the Committee has the capability of looking at the entire television system. The work of the Committee has been divided into six panels.

I. The first panel deals with *Production Process.* The Chairman is Pierce Evans. The production process includes program production and distribution up to the interface with the common carrier. It includes television studios, noise sources within the studios and microphone techniques. It includes control rooms, monitoring within the control rooms, peak reading versus average meters. There is a subcommittee of the Panel under Caroll Adams on film and video tape. It deals with such questions as multiple generation, emulsion position, storage and handling and the fact that equalization for theater is not compatible with the equalization required for television which is also the case with amplitude range. This Panel is also looking into laboratory practices including slippage in printing, sensitometric control and the design of preview rooms.

II. The second panel deals with the *Distribution Process*.

That Panel is chaired by Hank Ahnemann. The distribution process is defined as including the carrier local loops and long lines. This panel has considered questions of signal to noise and crosstalk between the program sound channels and telephony and data circuits. It has looked at bandwidth, distortion, use of compandors, level variations, and is attempting a determination of adequate and suitable testing techniques.

III. The third panel is *Broadcasting*.

Broadcasting is here defined as the studio transmitter link, transmitter, the transmitting antenna, and propagation, in other words the over-the-air process. That Panel is chaired by Dick Burden. Examples of items on their agenda are video to audio crosstalk, incidental phase modulation, compressors and limiters, whether the 25 KHZ deviation is adequate, pre-emphasis curve, relative audio and video carrier levels.

IV. The fourth panel is on *Receiving*.

This includes the home receiver antenna lead in and the television receiver itself. That Panel is chaired by Mike Paladino. They have considered questions of sensitivity, type of detection, AGC, hum, signal-to-noise, intentionally reduced frequency response, the signal power handling capability of the output stage and the loudspeaker, the placement and enclosure of the loudspeaker and intercarrier sound buzz.

V. The fifth panel is *Cable and Master Antenna Systems*.

The Chairman is Blair Benson. That Panel has looked at modulators, converters, multiplexing techniques, and impedance discontinuity at drop points.

VI. The sixth and final panel is *State-of-Art Audio Techniques*.

The Chairman is Tom Keller. That Panel has considered multiple channel sound in television, as would be required for stereo or foreign language broadcasts. They are looking at noise reduction techniques and a possible pilot tone that would allow variable amplitude range according to the environment of viewing the program.

Looking particularly at the first four panels, we have attempted to keep in mind that the quality received in the home could be no better than the quality of the production, distribution, broadcasting and reception. The quality is determined by the weakest link in the chain.

When television began, AT&T chose to utilize the existing telephony carrier system for the transmission of national television distribution, the same system that had been used since the early 1930's for radio station national interconnection. Thus began what we sometimes refer to as the chicken and egg syndrome: the receiver manufacturer said that the common carrier cannot deliver good quality audio, therefore, why should the receiver manufacturer invest in a sound system capable of reproducing good quality audio; on the other hand, the common carrier said that since the receiver cannot reproduce good quality audio why should the carrier make the investment necessary to transmit high quality sound. Both were right.

AT&T decided to do something about this partly because their audio plant is very old and very expensive to maintain. They would like to replace it with a diplexed audio and video system. AT&T chose to work through the Network Transmission Committee which you will recall was one of the organizations represented on the Ad Hoc Committee for the Study of Television Sound. Specifications for a diplexed system were prepared by NTC. They were sent out in November of 1972, and proposals were received. At the present time four systems are now being considered. They are being evaluated by Bell Labs. Three of them employ frequency modulation of a subcarrier above video: one employs pulse code modulation of a subcarrier above video. One of the systems is capable of four channels of 15 KHz audio. The evaluation from Bell Laboratories will be passed on to the Network Transmission Committee, and the decision is expected to be made by early this summer as to which system will be implemented by AT&T.

So, that is one very significant potential step of progress if the distribution system becomes capable of delivering good quality audio. The receiver manufacturers may then be motivated to improve their audio systems.

The scope and terms of reference of the Committee are very broad and cover a large subject. It was necessary to establish priorities as to which problems would be tackled first, and the area which has received the most attention so far is the transmission area. But work is progressing in parallel on all of the other panels.

I think that we see that the Ad Hoc Committee for the Study of Television Sound, in its coordinating role, can deal with the problems that need to be solved by identifying opportunities for engineering improvements and encouraging all segments of the industry to work toward the common goal of upgrading television sound.

**Bernard D. Loughlin**

*Vice President, Research*
*Hazeltine Corporation,*
*Greenlawn, New York*

Chairman,
*EIA Broadcast Television Systems Committee*

# The VIR Signal and its Status

## Very Brief History

The Joint Committee on Intersociety Coordination (JCIC) established an Ad Hoc Color Television Study Committee in 1968 to consider the various possible causes for the significant variations in the color characteristics of pictures observed on home television receivers, and then to allocate to existing industry organizations appropriate questions for further investigation and resolution. Early tests indicate that one of the many possible causes was the effect of video signal variations which are actually within approved FCC specifications. Investigation of these problems was turned over to the Broadcast Television Systems Committee (BTS) of the EIA Engineering Department, since the BTS charge given by EIA includes "examination of the FCC signal specifications and recommendation for desirable changes."

The BTS study soon established the desirability of having an ever-present reference signal during the vertical interval which is associated with a particular program signal and is a proper reference for both the chrominance and luminance of that program signal. Just to quickly illustrate some reasons for this:

The tie of the burst amplitude to the chrominance signal through the various tolerances present in the FCC specifications is inadequate. But, operationally this tie needs to be good since most receivers make use of the burst amplitude as a reference in automatic chrominance controls (ACC) circuits to set the gain of the chrominance channel. NTSC did not consider this problem in setting up the signal specifications. The chrominance to luminance ratio is defined with one tolerance, the luminance to deflection sync ratio is defined through another set of tolerances, and finally, the burst amplitude is defined in relationship to the deflection sync amplitude. The possible buildup of tolerance through this chain is shown in Table 1.

SPECIFICATION OF BURST TO CHROMINANCE AMPLITUDE RANGE

| RELATION | MAX/MIN | dB RANGE |
|---|---|---|
| CHROMINANCE VS LUMINANCE | 1.2/0.8 | 3.5 |
| LUMINANCE VS DEFLECTION SYNC | 3.0/2.09 | 3.2 |
| DEFLECTION SYNC VS BURST | 1.1/0.9 | 1.7 |
| TOTAL AMPLITUDE RANGE | | 8.4 dB |

**Table 1**

Of course, signals actually broadcast may not make full use of this tolerance range on the average, but this sequential set of multiple tolerances to tie the burst to the program chrominance should, if possible, be replaced by a direct tie.

It is standard practice to use "stabilizing amplifiers" throughout a broadcast television system in many places. Once a signal has gone through such a stabilizing amplifier and the sync and color burst have been reconstituted, there is no real check by looking at the signal to confirm that the burst and chrominance do have a proper relationship. Also, the problem of reconstitution of sync and burst can be a severe problem with video tape equipment.

## The VIR Signal and the EIA Bulletin

The above and many other considerations led BTS to devise a Vertical Internal Reference (VIR) signal which, after considerable study and field-testing was made the subject of an EIA Recommended Practice for Use of a Vertical Internal Reference (VIR) Signal. This is EIA Television Systems Bulletin No. 1, issued July, 1972. The VIR signal is shown here in Figure 1. Note that it contains chrominance, luminance and black reference levels and the chrominance reference is superimposed on a luminance pedestal chosen as 70 IRE units to be typical of average skin tone luminances.

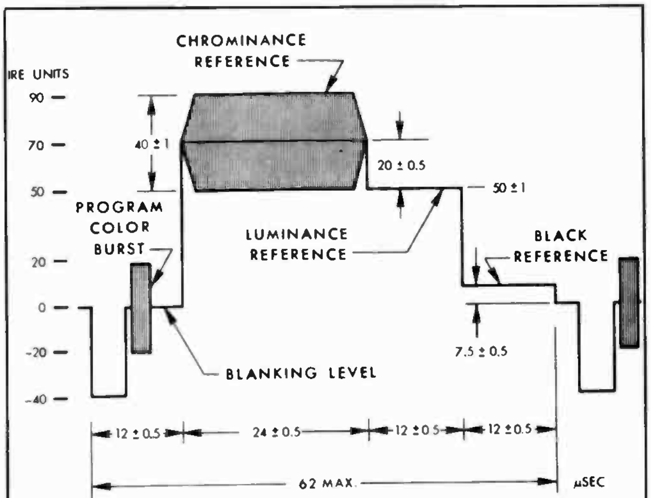



**Figure 1. The VIR Signal**

I should point out that the BTS Committee and its subcommittees contain a good cross section of broadcast network engineers, receiver manufacturers engineers, and color television systems experts, so that this EIA Recommended Practice contains significant industry-wide input and agreement.

To again stress the program-related nature of the *VIR signal, I will repeat here a particular section of* the above bulletin which specifically relates to "certifi-*cation of the VIR signal*"s. .

"The VIR signal is intended to be associated with a particular program. Therefore, the VIR signal should be inserted into the program signal at a point in the video system, where and only where both the correct amplitudes and phase of the composite color signals are established and the artistic judgment is made that color reproduction is as desired. Thus, it is the responsibility of each production organization (local operators, commercial producers, etc.) to make that artistic judgment. Once the VIR signal is inserted in this manner, it represents a certification of, and a reference for, the program signal. After the VIR signal has been inserted into the program signal, it must be treated exactly like the program signal in all equipment through which it passes, so that the VIR signal will always correspond to the program. Then, when adjustments are made to restore a VIR signal to its proper characteristics at any point in the video system, the program will have been reestablished to essentially the same characteristics as when it was initially certified. The VIR signal inserted at the point of certification should remain with the program to its final destination. Exceptions to this practice should be made only at a point of recertification, such as an assembly point of various program segments."

## FCC Notice of Proposed Rule-Making

BTS recognized that after the EIA Recommended Practice for the VIR signal had been issued, a next important step in encouraging and facilitating its usage would be for the FCC to amend its rules to both accord specific status to the VIR signal and to designate and reserve a specific place for its transmission in the vertical interval. As BTS approached this question, it found that its original proposal to use line 20 for the VIR signal was not supported by some broadcasters. After much discussion and reconsideration, BTS decided to request EIA to petition the FCC for reservation of line 19, so as to prevent conflict with other proposed uses of line 20 by broadcasters.

The appropriate divisions of EIA did file a petition with the FCC on May 14, 1973 which seeks amendment of the Commission's Rules to the end that a single line, in both fields, in the vertical blanking interval of the television broadcast signal may be designated for exclusive use in the transmission of a Vertical Interval Reference (VIR) signal. The Commission has followed closely the development of the Vertical Interval Reference (VIR) signal, and shares EIA's belief that its general use by those involved in the production and transmission of color programs will result in greater uniformity in color characteristics, as among programs, in the viewer's receiver. They further agree that an important step in promoting and standardizing VIR signal use is the establishment of a specific vertical interval assignment for its transmission. Also, the Commission has said: "We believe that the public interest requires that we press action toward this end as expeditiously as possible." Accordingly, the Commission has issued Notice of Proposed Rule Making, Docket No. 19907, RM-2192, released December 28, 1973, directed mainly, but not solely, to this subject. The original data for filing of comments was on or before March 1, 1974, but I understand that this has been extended to April 15, 1974 in order to permit further consideration by NAB.

## Comments Regarding Automatic Correction Equipment

The VIR signal can be used with either manually operated color correction equipment or with automatic color correction equipment which compensates for signal deterioration by adjustments which operate on both the VIR and video signals, to reestablish the VIR signal in its original configuration. To be made fully effective, such adjustments should also take into account effects introduced by the transmitter itself, and to accomplish this, radiation of the VIR signal is necessary.

Automatic correction equipment using the VIR signal has been designed and is in effective field use, including use to correct for transmitter distortions. At present, not all usage is precisely in acordance with the certification concept in the EIA Recommended Practice, but I understand that many broadcast networks are moving toward such a certification mode as an aim.

It should be jointed out that the VIR signal is intended to be a true reference and is automatically used as such, at all times when it is present, in automatic correction equipment. Therefore, its presence at other than a proper reference level at any time should be avoided. A possible way that such an improper level might exist (during interim implementation periods) is with certain types of fading circuits when fading between a program segment containing a VIR signal and one not containing a VIR signal. There are a number of solutions for such a problem, and broadcasters should be alerted to protect against possible incorrect levels of the VIR signal during this interim implementation period.

## Summary

The present FCC Rules do not provide direct and/or sufficiently stringent specification of the amplitude and phase relationships between burst, chrominance, luminance and sync to ensure uniformity of color pictures on home receivers.

The present FCC Rules and System practices do not provide a convenient, objective reference through which a program signal, altered by the systems which carry it from the point of program origination to the output of a transmitter, can be correctly reestablished.

A Vertical Interval Reference (VIR) signal has been developed which, if used as described in the VIR Recommended Practice, can provide a convenient objective reference through which a program signal can be correctly reestablished at the output of a transmitter (and at any other point where such is necessary and/or desirable).

The FCC Proposed Rule Making of Docket No. 19907 is a proper step toward encouraging wide usage of the VIR signal which BTS is convinced can be at least one important step toward better quality color television in the American home.

**A Panel Discussion . . .**

*Moderator:*

**James D. Parker**
*Staff Consultant, Telecommunications*
*CBS Television Network*
*New York, N.Y.*

# FCC/Industry Technical Panel

**Mr. Parker:**

The FCC/Industry Panel has been for a number of years one of the highlights of the Engineering Conference. However, for those of you who are attending this session for the first time, let me explain that our objective here is to provide an opportunity for the broadcasting industry to discuss in open forum with responsible members of the FCC matters relating to technical regulation.

The format for this panel discussion departs somewhat from that which is frequently used—namely, there will be no formal presentations by the panel members. We rely entirely upon a simple question-and-answer format. The scope of our discussions is unlimited. Let your questions range all the way from matters of interpretation of the FCC rules to matters of rewriting the rules.

We have on the panel three members of the FCC—Wallace E. Johnson, Chief of the Broadcast Bureau; Harold L. Kassens, the Assistant Chief, Broadcast Bureau; and Neal McNaughton, Chief, Rules and Standards Division, Broadcast Bureau. Representing the industry are Albert H. Chismark, Director of Engineering, Broadcast Division/Meredith Corporation, Syracuse, N.Y.; Richard T. Monroe, Vice President Engineering, Westinghouse Broadcasting Co., Inc., New York, N.Y.; and Daniel H. Smith, Vice President, Director of Engineering, Capital Cities Broadcasting Corp., Philadelphia, Pa.

It is our hope here this afternoon to develop a dialog between the regulators, the FCC representatives, and the regulatees, the industry representative. This dialog depends upon questions from the audience. Our experience has been that both sides will benefit from this discussion. It is helpful for the FCC to know what the problems are for the broadcasting industry in meeting its regulatory requirements, and it is equally helpful for the industry to understand the rationale for those FCC requirements.

There are several microphones in the audience. We would like you to identify yourself with your question, but this is not a requirement if you want your question to be from an unidentified but usually reliable source.

To break the ice, I understand that Dan Smith of Capital Cities has a rather interesting question relative to the operation in the remote broadcasting service, Dan, would you like to break the ice and pose your question, please?

Q—(Mr. Smith) What ever happened to the NAB petition we filed several years ago restructuring Part 74 of the Rules?

**Mr. Kassens:**

The answer is that we're just about done. Certainly within two months, hopefully within a month, we're coming out with new rules on remote pickup. We've done exactly, I think, what Dan has in mind. The general attitude has been "Let's make it as much like land-mobile as we can," which would do away with a lot of the so-called unnecessary requirements on logging. That sort of thing.

We're also trying to rejuggle frequencies. Any of you in the Chicago region know you get your remote pickup frequencies from our regional center and not from Washington. In the Chicago region the shared frequencies are all assigned by computers. What we're going to try to do is set aside certain frequencies for programming and the other frequencies for operational communications and that sort of thing. We are going to make the remote pickup service more like the land-mobile service.

**Mr. Johnson:**

Before we get off Part 74, at the present time our regional center in Chicago is actually assigning frequencies to the users in the Chicago region. One of the things we've been wondering about is how the center is operating as far as remote pickups are concerned. Whether you've had any problems. As far as we know, it's operating very well.

The Commission is considering additional regional centers, so if it goes the way it is planned, we may have regional centers in various parts of the country and many of these assignments will actually be done by this particular concept. Do any of you have a reaction to the Chicago operation?

**Mr. Parker:**

Does anybody have a reaction to the Chicago operation? Even if it's complimentary let's have it.

**Mr. Johnson:**

That's one of our problems. If we don't hear anything, we just hope that it's working right.

**Q—John Clay, WSAZ-TV.** I have a question which, due to its length, I will read.

I'd like to have a discussion of the horizontal blanking width area. It is common practice on both the local stations and network stations to operate their film chain with some optical masking of the edges of video, and usually it's within the neighborhood of about 1½ microseconds. This is true in particular of the RCA TK-23 to create a stable reference black and it's being practiced as a result of an article that was published in 1971 about how to get the best performance out of the TK-27.

A film change setup with electrical blanking width of 11.1 microseconds will actually measure 12½ to 12.6 microseconds of blanking width if you measure it at the 50% video level, or anywhere, for that matter, above setup. And this 12½-12.6 includes the microsecond and a half of optical masking .

As the FCC maximum blanking width is 11.43 microseconds, is this a violation of FCC rules, even though the optical masking does have a standard setup? I talked to RCA and they don't really know what the answer is and said it hadn't been called to their attention before, but I have measured network signals, and I would say that all NBC network chains are sending out about 12½, in that area.

**Mr. Kassens:**

I would say it would be legal if this were a true black reference level, but I'm sure it is because I don't think they really intend it that way.

**Mr. Clay:**

In other words, they say it's total absence of light on the edges of your pictures, And, of course, that's as true a reference black as you can get, and that's why they're doing it, to give a fixed reference black.

Now on the other hand, I don't know what kind of cameras are used on the Dinah Shore Show, but they mask off and on successive days it averages about 14 microseconds video-to-video, measured at 50 or 75%.

The way we've set our blanking is we raise our set-up black level up to 50 or 75%, go thorugh the whole range of video, and measure both rise time and a blanking width, and this is what we arrive at. Then when we mask off, there's no way that we can measure it, actually, in the field and come out with anything in the way of a realistic measure unless you measure it down at the blanking level.

**Mr. Kassens:**

Well, I'm afraid a strict interpretation of the rules would result in a violation. The trouble I have is how you can counter that by measuring the true blanking level. You'd certainly have to do it in non-program time, start it up under your own conditions to show that the actual generated blanking level is proper. I just don't understand why they want to put that black in there except just to help you set up the film chain.

**Mr. Clay:**

Well, when you set it up on a fixed reference black it does hold and gives you a truer reproduction. You do get better operation out of your film chain running in that way.

**Mr. Johnson:**

I think the easy answer is to file a petition for rulemaking.

Q—How come I spent $1,800.00 for a TFT frequency monitor and a month later the Commission deleted the requirement?

**Mr. McNaughton:**

It seems to me you still have a piece of equipment which you can live with, and if I were the engineer, I'd want to live with it.

The whole concept behind getting rid of frequency measurements or relieving the station of the frequency measurements was because of the inherent stability of equipment which we now have today. And not only that, but the inherent high accuracy of even small digital readout meters.

Now what the rule says is that we rely on the licensee to maintain his frequency. We merely suggest as a source of frequency WWV. That's what the Commission uses in its monitoring and that's what you may use in your monitoring. The Commission has no concern if you use a deviation meter, which you're talking about, rather than a frequency monitor, if you consider the accuracy of that meter to be within the rules. That's up to you. We don't care how you measure it. You can measure it with a Hallicrafters $15.00 HT-7, if you wish, because it's got an accuracy that's good maybe for five seconds after you calibrate it. I'm not kidding. That's a fact, if you really know how to use them.

Q—Then why the monthly frequency? The outside frequency checks.

**Mr. McNaughton:**

We don't ask you to make an outside frequency check. You make the check when you feel that you need it. We expect you to make your own check. Now if you want to verify the checking equipment you're using, we don't care whether you do it once a year or not. If you feel that it's stable enough to hold it, fine.

Q—I realize I'm still responsible . . .

**Mr. McNaughton:**

That's right.

**Mr. Kassens:**

Once every 40 days you have to make the required measurement, but what Neal's saying is you're on your own. If you want to use that frequency monitor OK. If you think we pulled the rug on you, you should have heard the manufacturers.

Q—**Richard Nix** from KBLU-TV. We have three essentially identical microwaves in television. Two of them are called intercity relay and one is called STL. How come we can ignore the intercity relays to a large extent but must have a first phone man watching the STL? These are identical microwaves carrying identical signals.

**Mr. Kassens:**

I don't quite understand your question because all you have to have is a licensed operator either at the originating end or at the receiving end for intercities and STLs. It's perfectly all right to have your licensed operator at the receiving end. That's one thing we did in re-regulation.

Q—Speaking of re-regulation, could we ask about the fourth installment of the re-regulation package?

**Mr. Johnson:**

The fourth installment came out about two weeks ago and made some additional changes. We still have a long ways to go in re-regulation, but we're actually hoping that within about a year we'll have completed rewriting the rules and regrouping the rules in a more understandable fashion. We also have some additional technical changes to make. We have some non-technical areas which we are also involved in.

Let me just run through a couple of the things that we still have to do.

As far as the forms are concerned, you may be seeing some new forms coming out. Renewal forms as well as the 301's. The forms that most of you are working with. We still have some work to do on logging rules, and on the operator tests. A lot of you indicated we still have some problems as far as operator tests are concerned. We've had a lot of problems trying to keep the study guides current, as we've been making changes in the technical rules, and we have a new edition coming out from the Printing Office in a couple of weeks. The study guide will finally catch up with our re-regulation rules. As far as operators are concerned, we're also working with Civil Service Commission trying to get the Commission to take over the testing. We'll have many more points where operators can go to take their test.

The program test authorities that we have, the whole problem of trying to prove in AM directional arrays, the procedure you go through in making your proofs, testing and finally requesting program tests is an area that we're working on. The AFCCE has a committee that is going to be working with us on that, reviewing the entire area of making proofs and trying to prove what a directional antenna is actually doing in practice.

That's about it as far as the technical areas are concerned. We're still encouraging everyone to come in with their suggestions as far as additional changes are concerned, and if you have some changes, we'd still like to hear about them.

But, as I said, we are trying to wind this thing up and we're hoping in about a year that we will be quite close to completion except for catching up on some rule-making that will still be outstanding at that time.

Q—In regard to re-regulation, I get a little frustrated because every time you throw us a bone, you throw a couple of hookers in along with it. As an example, on the AM chief operators rules, why is it necessary that the skeleton proofs be graphically analyzed, whereas without the chief operator this is not necessary? Is there any definite practical reason for this?

**Mr. Kassens:**

The skeleton proofs don't have to be analyzed, but the partial, which is now due once every three years, has to be analyzed. The reasoning we gave was that the purpose of a skeleton proof is to get an indication that the directional is still in adjustment. If you're having monitoring point difficulties, the few measurements you make on the radials for a skeleton will indicate in general the nature of the array. However, we felt that once every three years you ought to make the partial proof and analyze it to show that the array is reasonably in adjustment.

We're hoping that the study on directional antennas and how to analyze proofs will come up with a better means of analyzing proofs.

**Q—Al Hillstrom** with KOOL in Phoenix. About 10 months ago we applied for new parameters on a directional pattern and we have received no action to date. The reason given to us is that the FCC does not have the manpower to process these applications. When can we expect to get action on this? Our rubber stamp is wearing out that we use for stating that we are measuring power by the indirect method and that our parameters are out of variance with our license.

**Mr. Johnson:**

Maybe I could tell you a practical problem we're having. You know, there seemed to be a surplus of engineers up until a couple of years ago and we had all sorts of engineers on the register. At the present time there just aren't any engineers available and we have all sorts of vacancies. In fact, in the Bureau right now we have 29 vacancies. They're not all engineers, but we can't beg, borrow or steal any engineers. So maybe some of you will want to come and see us after this session because we do have some good vacancies.

One of our big problems are the number of people that we have working. At the end of last year we had quite a few that actually retired, and we just haven't been able to fill their positions. Come June again, with more graduates, we're hoping that we will be able to pick up some more, but it's strictly a matter of manpower right now.

**Mr. Hillstrom:**

So it still could be a number of months before these applications are processed?

**Mr. Johnson:**

Well, we have other things that have interfered with it. I'm almost afraid to mention this one, but we went into a daylight saving time extension and we had practically all of our engineers working on all sorts of studies which we used in approaching the other countries that we're negotiating with, trying to convince them that we should have a little further relief as far as our agreements are concerned. I think as far as our technical studies are concerned, they're behind us now. We have finished those. The engineers that were diverted to that particular project are back working again.

**Mr. Parker:**

I have a question that was passed to me which I think is of rather broad interest: "When a licensee receives a citation for a technical violation where there is no violation, but merely an incorrect interpretation of the rules by the FCC inspector, what procedures should the licensee follow in responding to the FCC's notice?"

I wonder if perhaps you might explain some of the procedures which are involved which may be helpful, and maybe not pinpointing on the answer, but giving us some idea of the procedures.

**Mr. Johnson:**

As far as the procedure is concerned, when you get a violation, the first step actually is when the engineer goes to your station, then he goes back to his office. If there's a question about interpretation, the first check that can be made is by the engineer in charge. If there is a difference of opinion, the engineer in charge may be able to resolve it at that level.

If you actually do get a citation, then you have to answer that citation. That citation goes back to our field bureau. If they think there's a problem, there's another level at which that problem can be resolved. And if we get into a dispute with the Commission, and there's still a problem, then we in the Broadcast Bureau get involved in the interpretation of any broadcast rules.

So, there are various steps at which your answer can be reviewed, and if it means that we have to make changes and so forth in the rules to make it more understandable, then we will do it as far as the Broadcast Bureau's concerned. But what we would suggest is that if there is a difference of opinion as to what the interpretation is, when you answer the citation, make sure that you get your side on paper to us and to the field bureau so we can review it and determine where the problem actually lies.

Through the re-regulation effort, we're hoping to resolve some of these where there are some actual disputes. Maybe some changes in the words will help as far as the meaning is concerned.

**Mr. McNaughton:**

I just want to add something to what Wally said. When you do get a citation, even though you feel you're not guilty or that there is no violation, you have a given number of days in which to reply to it. Well, please reply because this creates an administrative problem because it's like not paying a fine on time. But really you're not paying a fine. All you're doing is following the procedure. And I asked one of the FOB boys what this could lead to, and his comment was, "Well, under the rules, it could lead to revocation." But they've never gone that far yet.

So, please, do reply. Even if you don't know the answer, tell them you're digging it up.

**Q—**I'm Joe Fitzgerald from WDVL in Vineland, N.J. I had a similar problem. An FCC inspector came in and cited us for not putting down the ratio of base currents and percent deviation from the license values. We were operating at the time of our license renewal with parameters at variance and there was no actual license. We were on a special temporary authority, and we did get cited for not keeping the deviation from the ratio.

I'd like you to comment on that first part. The second parts is: What is the history of the new regulations as far as the antenna monitor is concerned? And will we have to actually dig up the lines, the sample lines and put in styrofoam sample lines?

**Mr. Kassens:**

The answer to your first one, I think, is that's a point that's very unclear. If you have authority to operate with parameters at variance, there doesn't seem to be much need to log ratios, and we will clear that up with the field bureau.

The second one, dealing with sampling lines, is at this stage only a proposal. I don't think you have to worry about it for the time being, until the consulting engineers can all get together and be of one mind—and I'm not so sure that'll ever happen.

That other thing about antenna monitors is that you know the deadline for some of you is June 1 on antenna monitors. People have run into problems getting their hands on them. If you don't have the antenna monitor by June 1 and you're required under your condition to have one, all you have to have is an order on file and posted showing that you have an order for a monitor; it just hasn't been delivered.

**Q—Bill McCarron** from CBS Radio. I've been wondering if, since the daylight 50-watt rule went into effect, if there has been any feedback or comments to the Commission that would indicate any success, or to what degree, of the daytime stations that go on the air with 50 watts. Just how effective are their signals? Do they really feel that it's doing them any good? And also, have any of the clears met with any objectionable interference to their normally protected contours?

**Mr. Johnson:**

I think it all depends on who you talk to. As far as the Commission is concerned, we have a Notice of Inquiry and Proposed Rule Making, and we're hoping that the comments filed in that will give us a better idea as to what the actual interference problems are.

The act that Congress passed states as follows: "Not withstanding any other law or regulation issued under such law, the FCC shall consistent with any existing treaty or other agreement, make adjustments by general rules or by interim action pending such general rules with respect to hours of operation of daytime standard amplitude modulation broadcast stations as may be consistent with the public interest in receiving interference—free service."

And that receiving interference-free service is where we've been having a problem. Our problem has been to try to let the daytimers who are licensed to operate-theoretically, from sunrise to sunset—recoup the hour that they lost in the morning, and yet do that in some fashion that will still preserve an interference-free service to people have been receiving that service from unlimited time stations.

As you know, we went into an interim setup where we authorized 50 watts and we ended up authorizing 50 watts to all those who had PSA's and what we call eligibles. We then went into negotiations with Canada, the Bahamas and Mexico to try to get our agreements changed so that we can at least permit daytimers to operate for an additional hour in the morning. And then we've gone into rulemaking to see what we should do at least for this additional year.

You know that the bill that Congress passed extends this extension of daylight saving time for one year, until the end of April 1975.

It's a problem that's been a real knotty one to us, to try to balance the loss that the daytimers have in that early morning against trying to preserve interference-free service to the unlimited time stations.

**Q—Steve Smith** from KCMO, Kansas City. I'd like to discuss one of the procedures you followed in this re-regulation which has sort of put a hooker in it, and I'd like to explain the position and the facts so you can see my point.

My question is, could we have some preview of your new rules, like you used to do for regular rules, before they become law? I'm sure you have not anticipated the full impact of it because it's really re-regulation in the negative sense. This is the chief operator rules. Our station does not use chief operators. We're still operating with engineers on duty. We had no reason, then, to be penalized or to benefit from the rule unless we wanted to take advantage of it. But under the rules for our chief operator, there were more requirements to change the readings you take, and this resulted in several thousand of dollars to our station in the last year. It cost us hundreds of man-hours and I'd like to describe what it is.

Basically, the rule says that you have to take the remote readings each night during the inspection. That means, in our case, automatic logging readings; it means the base current remote meters. You have to calculate out the current ratio of the base meters themselves, the current ratio on the remote meters, the remote logger, and the standard deviation of all these.

Now maybe it's possible—and I say possible—to interpret the rules other than that way, but that's not the way they're writen for myself, as a chief engineer, to interpret those rules and be prepared to defend myself from one of your inspectors trying to say you have to do that. I think if you read them, you would agree that you do have to make the calculations.

Now to give you an idea of the magnitude of this, in the last year we spent 213 man-hours on overtime at the transmitter making these calculations, and that's because I bought a calculator. Otherwise it would have been round 600 hours. It cost $2,500.00 in overtime. We also wasted 152 man-hours at the studio with that engineer being tied up each night getting the data off the logger, off the metering system, and talking to the guy at the transmitter.

And let's see what it proved. Out of a 28-day period that I analyzed the results, there were 84 of these reading involved, and of all those readings, not one of the base currents exceeded the 5% deviation which is what we were supposed to be checking it for. Prior to this we never even had to calculate base currents at all, period, as far as the ratio. And all of a sudden we not only had to calculate them, we had to check them to the remotes. And yet we are really calibrating the remote system once a week. I mean this says you're really calibrating your remote system daily.

The actual deviations exceed 5% on 10 occasions, and those were always the remote situations because you're compounding error. You've got a 5% deviation allowance in the base current itself, and if you've got a 2% tolerance on the base, between the base and the remote, that means you really only allowed 3% deviation on the base if you're going to keep all your readings within some semblance of 5%.

So it gets pretty complicated and it took awhile to teach everybody how to do it, and thanks to the calculator, it only cost us $2,500.00. But I'd like to address the subject and have someone address not only the possibility of some re-re-regulation, and also suggest the possibility of exposing to the whole industry some of your proposed rule so that people don't stick in these little hookers, as we in the industry refer to them, something that has been talked about for years and all of a sudden it comes back and haunts people who really don't benefit from it.

**Mr. Kassens:**

What you're suggesting gives me problems, not that you shouldn't have an opportunity, but if we get involved in re-regulation in going through the long-drawn-out Commission procedure of Notice of Proposed Rule Making and comments and all that sort of thing, I think it's going to delay us considerably. You still might be reading your meters every hour if we had to go through that procedure. But I think it's certainly incumbent upon you to tell us these things because we don't intentionally do anything wrong.

Now I don't say that everything we ever do in re-regulation is going to make life easier for you. The reason that one happened is because of a new concept that we have, that we think we ought to be able to latch on one guy at the station who's the chief and make sure that he's doing his job, because if he's doing his job, we can assume that the third class and that sort of thing are doing their jobs.

But if you have problems like this, we certainly want to know about them and we'll take a look at them.

**Mr. Smith:**

Is it possible to consider the fact that those stations that aren't taking advantage of the chief operators rule, that still have a chief engineer and an engineering staff, would not have to comply with that portion of the rules?

**Mr. Kassens:**

I think it's easily possible. And I think it would be faster that way than—and have us come out with our sixth order. Our fifth is now in preparation. We could certainly put that in the sixth order.

If you drop me a line. I'd be glad to hear from you. Spell it out, exactly what the problem is, and we'll take it from there.

Just as an example, in our second order we changed the rules on reduced-power operation and remaining silent. It used to be you had to get authority and that sort of thing. We changed it to 10 days. You're on your own up to 10 days. In our fourth order we've changed that to 30 days. We had time to regurgitate and think maybe we shouldn't have made it quite so short, so we extended it to 30 and who knows, a couple of months from now it may be 60 to 90, but keep the letters coming so we know what to do.

**Mr. Parker:**

Another question. Several months ago the FCC issued a Broadcast Bureau telephone directory which listed individuals by phone number and by name and by class of service. I just wondered if you would comment how that's working out, probably to bring to the attention of those who may not know about this service that it is available. Would you want to comment on that?

**Mr. Johnson:**

Well, this was one of the things that came out of our re-regulation study, and it was our attempt to try to make it a little easier for you to contact the proper person at the Commission. With our telephone service, the existing telephone service we have, it's very difficult to try to transfer people around to get to the right spot. And we've had different ideas about how to help you in reaching the right person.

We finally ended up, the only way to do it was to come up with a telephone book indicating subject matter and who to call if you have a problem, depending on what the subject matter is and we've distributed these books to all of the licensees. We have some additional copies down in the booth. We'd like to get some reaction from you as to how it's working. As far as we're concerned it's working very well. We have more people getting to the right person without shifting them around.

It's very difficult when you're talking to somebody on the outside and he tells you that you're the fifth or sixth person he's been transferred to, and you're still not the right person. In at least those numbers of call—that type of call has decreased considerably as far as we're concerned.

We'd like to get some reaction from you as to how it's working. One thing we'd like to know is how many of you are aware of the book. Maybe we failed in even letting you know that it's available. We've distributed one to every station. We'd like to hear something good, if possible.

Q—The book has been very useful, but there are quite a few people with the same phone number . . . which always seems to be busy. Can anything be done?

**Mr. Johnson:**

When there's one line listed, there are actually extensions that work off of that one line. If the first line is busy, it automatically shifts to the second or to the third.

Q—How does the Commission arrive at the amount of forefeiture?

**Mr. Johnson:**

First of all, it depends on the type of forfeiture. It's almost a science now, as far as we're concerned, with the experience we've had.

We take a look at the type of forefeiture, how many times you violated a particular rule, how serious that particular rule is. We also take a look at the finances, as far as the station is concerned, whether or not they're making a profit . . . In other words, we determine the seriousness of the rule, how many times you violated the rule, and then also what kind of financial condition the station is in.

**Q—Bill Honeycutt,** KDFW-TV in Dallas. I have a a question for Mr. Kassens. We've talked a lot about automatic transmitters and re-regulations and so forth. What progress is being made as far as the automatic transmission systems are concerned?

**Mr. Kassens:**

Since Bill and his NAB subcommittee prepared the study and submitted it to the Commission, I think he's entitled to an answer. I had a meeting this morning with an EIA group wherein we discussed this and I think there was a good meeting of minds there. I think TR4.1 knows that we're looking at, and we'll be able to come up with what type of guaranty the Commission needs to make sure the system will work properly.

It's our next big project. Part 74 should be coming through in the very near future and then this is our next project. Hopefully within a matter of months, we'll be coming out with proposed rule-making on AM, FM and TV automatic transmitters.

**Mr. Honeycutt:**

You will include TV also at this time?

**Mr. Kassens:**

Very definitely.

**Mr. Parker:**

Are there any indications as to how the land mobile sharing of UHF broadcast channels 14 and 20 is working out in terms of possible interference to broadcast reception?

**Mr. Johnson:**

As far as we're concerned, we're not getting any complaints in the city where we do have the sharing at the present time. And just within the last two weeks, the Commission did come out with 7 proposed rule—making to permit sharing in three more cities, including Houston. But as far as the location where we presently have sharing, we have not received any complaints.

We don't know exactly whether there are problems and we haven't heard about them, or these happen to be in cities where here is a lot of service and if someone does get interference, maybe they just shift to another channel. But our experience has been so far that if there is a problem, usually we hear from the listeners or we hear from engineers, but on this particular item, we haven't heard anything which would indicate that there is a problem. Maybe some of you who live in these areas where there is sharing at the present time could fill us in on a little bit of your experience.

Q—Jack Benson from Waco, Texas. When the rules were changed and we had to install the new antenna monitor, those of us that are remotely-controlled directional, in order to use third class operators, of course, we have to go to the transmitter within two hours after going directional anyway. If a first class operator throws it directional and makes sure that it's in a proper mode, can we then operate with third class operators from that point on?

**Mr. Kassens:**

Yes, of course you can, but the way you placed the question, I'm not so sure you mean exactly that. Could you go over again? You still have to have the first class man there to make sure everything is working right.

**Mr. Benson:**

Well, I'm saying that he would be at the transmitter at the time that we go directional and he would throw it and he would adjust it if any adjustment was necessary to see that it was OK. After he's done that, could the station then be operated with a third class operator with an approved monitor—antenna monitor?

**Mr. Kassens:**

Sure.

**Mr. Benson:**

You think that would be satisfactory.

**Mr. Kassens:**

Yes.

**Mr. Benson:**

The NAB petitioned the FCC at the time this was made to eliminate the requirement that relays be installed that would assure that the system had gone in its proper mode. This is a rather cumbersome task, especially for older stations, because they have to change the solenoids at the towers, and if they don't have any spare lines out there, they've got to interlock it in some manner with the system so that it will throw itself off the air if it is thrown by a third class man. The NAB asked the FCC to eliminate this requirement, and the FCC denied it on the basis that this third class man would be reluctant to throw it off of the air if it was not in the proper mode.

I have another question which I have talked to Mr. Kassens about, and I'm sure he's getting tired of this. But anyway, we hope to petition the FCC to allow us, since we have a separate facility—namely, a licensed auxiliary transmitter at our studio which a man can put on with the pushing of a button in case the directional system out in the country does not go into its proper mode—could we petition the FCC to allow us to eliminate the installation of those relays that would throw the directional system off the air if we've got this separate facility up at the station—the studio—that a man can put on by throwing a button?

**Mr. Kassens:**

It sounds very reasonable to me. I don't see why not, frankly, because—at least if you have an alternate way. The only reason you have to have anything changed is that if the third class man were to throw it and the relays got hung up and you were out, as you say, we denied the NAB petition on the grounds, that the third class man really wouldn't be able to do anything and he, I don't think, would be about to pull it. But if he has some alternate course of action, sure, it's very reasonable.

Q—Bill Kelley, Metromedia, New York. On the subject of VIR and the Proposed Rule Making. Is VIR going to be a mandatory or optional signal?

**Mr. Kassens:**

It's going to be an optional signal. I haven't read any of the comments in the Notice. I think it's a great thing. I would expect that even if it starts out optional, one day it's going to have to be mandatory because I think there's going to be so much reliance on it. I know the receiver manufacturers are looking forward with great glee to the thought of having that available.

**Mr. Kelley:**

In a closed-loop correction system using VIR, which we've seen demonstrated here and despite the Commission's earlier stand on not type-accepting demods, would this be reconsidered the type acceptance of demods?

**Mr. Kassens:**

I don't quite understand your reasoning. The demand was for remote control purposes, and I recognize what you're saying, but I don't see how the two would tie together.

**Mr. Kelley:**

Well, if you tie the transmitter into a closed-loop correction system using VIR, now you need a demodulator. I would like someone to write the specifications and take some of these demods off the market and let's get one on the market that will work, that we can all trust and that the receiver manufacturers then can design towards.

**Mr. Kassens:**

I agree with you there, that if it's going to be a mandatory system, I think we're going to have to. I don't know that we would go as far as type acceptance. We'd probably do like we did in remote control—determine what the standards of the demod have to be and then not grant any applications unless they have one that does meet those specs. But somehow or other there has to be a recognition that it has certain qualifications.

**Mr. Monroe:**

Referring back to the question of re-regulation, I wondered if the Commission's task force has given any consideration to going back to FCC Standards of Good Practice. Many years ago we had standards that suddenly became rules. Is it possible that in this re-regulation we're going to try to get back to that?

**Mr. Johnson:**

Well, as far as the Standards of Good Practice were concerned, we went from standards to rules because there was no way that we could enforce standards. So standards that were serious enough to really affect the operation of the station we've placed into the rules. Then we can enforce them.

We don't have anything going before us at the present time to try to develop standards again, but I don't think you really want us to put standards into the rules. It sounds almost like you want more regulation, which worries me a little bit. I would think that you, as a professional, would want to have your own standards and operate your stations in accordance with good engineering standards without asking the Commission to come out with our own standards and then try to enforce them.

I don't know if anyone else in the room here has a desire for us the develop standards.

**Mr. Monroe:**

No, I meant put the standards back where they were in the first place.

**Mr. Johnson:**

Well, I doubt whether . . . We would have to identify the technical rules which were previously standards and then try to determine, are these serious enough to try to be enforced? Our whole problem was whether we would enforce the technical standards and then go through this procedure of determining which technical standards were serious enough to warrant enforcement on our part. So it's the enforcement aspect that changed the standards into the rules.

**Mr. Parker:**

Has any action been proposed on the petition to allow the use of wireless microphones on unused VHF channels?

**Mr. McNaughton:**

Well, to make it simple, the answer is yes. I had hoped to have the notice on that petition finished before the convention, but some other things came along and they got caught in the rush. But nevertheless, it is almost completed and, hopefully, it will be out very soon. I'd hate to venture a time, but I'm not talking a matter of months. I'm talking a matter of weeks.

**Q—Steve Burmell,** Laramie, Wyoming. My question is in relation to the FM table of assignments. In the West there are a number of cities and communities which have been assigned FM channels they may never use, and conversly, communities which have no channels assigned but want some. The process is to petition to change the table of allocations so that channels can be moved around to various cities. The result at present is, because of the long waiting period before a decision is made on these petitions, some stations who have received construction permits or are about to receive them can't really go on the air because there's also a corresponding pending rule-making to put them elsewhere. Is there anywhere in the future, or has the Commission considered the need to speed up the process of reallocation of the FM table of assignments where there isn't any significant problem involved in doing so?

**Mr. McNaughton:**

Right now there are something on the order of 280 applications on file for existing FM assigned channels. In addition to that, there are 160 to 170 petitions for additional drop-in channels. Some of them will make it and some of them won't.

In the West, that's fairly easy until you get into Southern California or some of the more populated areas, but east of the Mississippi is becoming extremely difficult. In fact, I think there's some 15 or 16 states where there are no channels left unless they are dropped in or engineered in.

Now if the petition is for a Class A, more or less through informal agreements, among the engineers and the attorneys in Washington, we have been trying to act upon those very rapidly, especially where there's no conflict involved. And perhaps lately you may have seen we've had several notices come out where we've included 8-10-12-14 Class A petitions all in one, none of them conflicting with the other. Now if no opposition comes in on those, we can handle them rather rapidly.

But it's getting to the point now where if a wide-range Class C or Class B is proposed, that ordinarily we have oppositions come in, we'll have counter—proposals, and it gets down to a point where, again—I think in my division, I have money to hire three engnieers, but we can't find them. So consequently we have two engineers working on these things. The engineering evaluation is made. After that is finished, then it's turned over to an attorney to put either on order or the notice in legal form. And right now it's taking anywhere from a year to 14 months for this process to happen, except on those A's which I mentioned.

So, unfortunately, some of the C's are becoming even more complex, especially if they're in the East where it's a little bit like the domino effect. You turn on over and you've turned over about seven or eight existing operations or potential operations.

I don't know if I've answered your question or not, but I've told you my problem.

**Mr. Johnson:**

Maybe I could just add a couple of things here. It's easy for us to say, you know, we'll promise you something, but some of you in the room here were up with us on the Hill. We were before two committees within the last week, the House Committee and the Senate Committe on Appropriations. I think those of you who were there, and reading about it, you know that we promised we're going to do much better in the next year before we get up before the Appropriations. They spent an awful lot of time on our backlogs.

We're actually a little hopeful that by next year we'll be in good position on that. We do have additional manpower which has been authorized. We have a new computer program which we think will have an effect on this. If we can get the additional people and the computer program works the way we hope it will, I think next year we'll either be in much better position than we are now or you'll see three new faces up before you.

**Q—Alton Stawker,** Westinghouse Broadcasting. In the trade publications within the last week or two, apparently the long-standing method of logging frequency deviations has been changed from logging actual deviations as normally read on a frequency monitor to the actual carrier frequency. Now that's not too much of a problem in some cases, but with some of the TV channels, where we're talking about 100 megacycle frequencies, it does present a problem actually logging these things accurately, especially if you are deviating from your carrier by more than a few cycles, where a subtraction has to be effected. What was your reason for making us change?

**Mr. Kassens:**

Well, first, I think I would have to admit we weren't thinking too much about television. We were more concerned about little AM stations and do they really know what's going on when the third class disc jockey writes down a number. The rules require that you log the actual measured frequency, not the deviation from that frequency. If you're off 10 cycles, certainly anybody, including a third class disc jockey, ought to be able to add or subtract 10. It gets a little more complicated, of course, in television. But it's just the way the rule was was written that it required that you log the actual operating frequency so you know whether it's wrong or not.

Q—Art Wilkson. I was just wondering if you had any new reports on the proposed changes or whatever is going to be necessary to get 50 watts on Canadian clears. Also there was some discussion of changing the second and third adjacencies on Class A FM. What progress have we made on that?

**Mr. Johnson:**

As far as the pre-sunrise question is concerned, we've done a lot of work with the Canadians, and I think we're awfully close to an agreement or understanding with them that will permit some type of operation on their clears. At what point in time that will actually become effective, I can't tell you right now. But we have had meetings with them and we've exchanged a lot of information. Earlier, I said we had spent a lot of time as far as our engineers were concerned in coming up with interference studies which would help us in discussions with the Canadians. I think we're quite close to an understanding with them.

**Mr. Kassens:**

On the second and third adjacent channel for FM, right now our laboratory is finishing up a project that started last summer of measuring typical TV receivers to see what we can do about the UHF taboos. When they get that done, presumably by the end of June, their next project is to start measuring FM receivers to see what we can do about FM allocations and if we can change the mileage spacings particularly for second and third channels.

The study should start soon after July. How long it's going to take, I really don't know. I would expect it's another year project.

Q—I would just like to argue a little bit about the frequency measurement. We operate an AM station with disc jockeys, and it's reasonably easy to tell them, "Now look, if that thing gets over 20, you're in trouble." But if he's got to read 1,240,011.1, or something, there's no way. Plus-or-minus 20 he can figure out.

**Mr. Kassens:**

I said earlier that the manufacturers weren"t too happy when we amended the rules on frequency monitors. Maybe they'd like to come up with a device that will calculate it for them.

**Mr. Parker:**

We've time for one more question. I don't want to be accused of being anti-feminist, so I'll take a question from lady here.

Q—Where is the FCC booth?

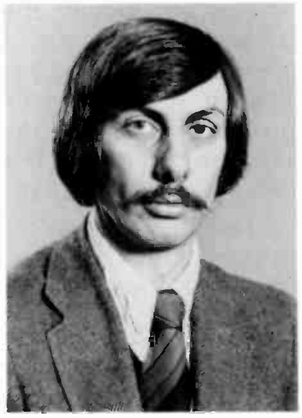
**Mr. Kassens:**

I've got to tell you this story—I was sitting down in the management session and Chairman Wiley walked in and sat down next to me and said, "Harold, where the hell is the FCC booth?" There were some very tight moments, but we had personal escorts to lead him to the booth so he was sure it was there.

It's location number 7, and I couldn't find it myself until a guy from NAB told me, "Go out the front door, the main entrance, go down the side street till you find a hanging tree and you'll find the FCC close by."

**Mr. Parker:**

In concluding, I do want to express my deep thanks to our panel members and I do appreciate the attention of the audience. Thank you very much.



**Ronald Eigenmann**

*Regional Manager*
*Visual Electronics Corp.*
*New York, N.Y.*

# A Corrector for Stereo Phase Shift

*(Co-authored with Ronald S. DeBry of Visual Electronics)*

The Recording and Broadcast Industries in general have recognized the existence of stereo mono-sum signal error problems since the advent of stereo broadcasting. In today's competitive broadcast markets great care is taken in the selection of program materials and speaking personalities. The goal is to project an appealing and pleasant sound to the listening audience.

There is a large percentage of the audience which continues to follow their favorite programs with monaural equipment, and the unpleasant effects of stereo mono-sum error often present the listener with less than pleasant or appealing signal quality. Recognition of the need for means of controlling and correcting the stereo mono-sum error problem prompted the development of this stereo phase shift correction method.

The correction of phase errors caused by reactive elements in descrete stereo channels and lines requires a system of isolating and quantifying phase shift in a manner that will ensure the phase error is not confused with normal amplitude variations, a means of acting on the most offensive elements in a complex signal, a method of referencing channel phase relative to "common-mode" program material and then comparing this information in order to react and adjust the offending phase angle within a few cycles without affecting program amplitude.

We wish to present the results obtained in the development of this Stereo Phase Correction Method with a description of the STE-100 Stereo Phase Enhancer which resulted from the development effort. The STE-100 is now proving itself in actual programming installations.

## Basic System

The stereo phase error correction system was divided into functional circuit elements. The functional elements are shown in the simplified block diagram shown in Figure 1.

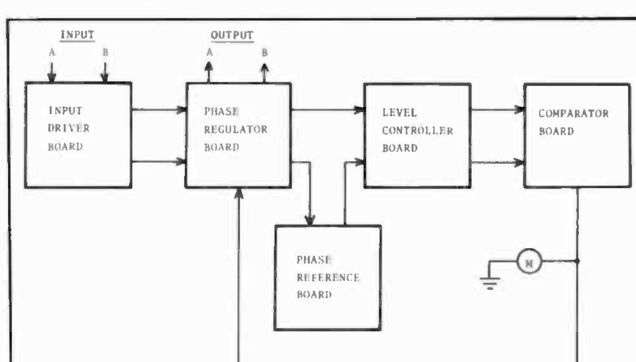



**Figure 1. Functional Elements—Block Diagram**

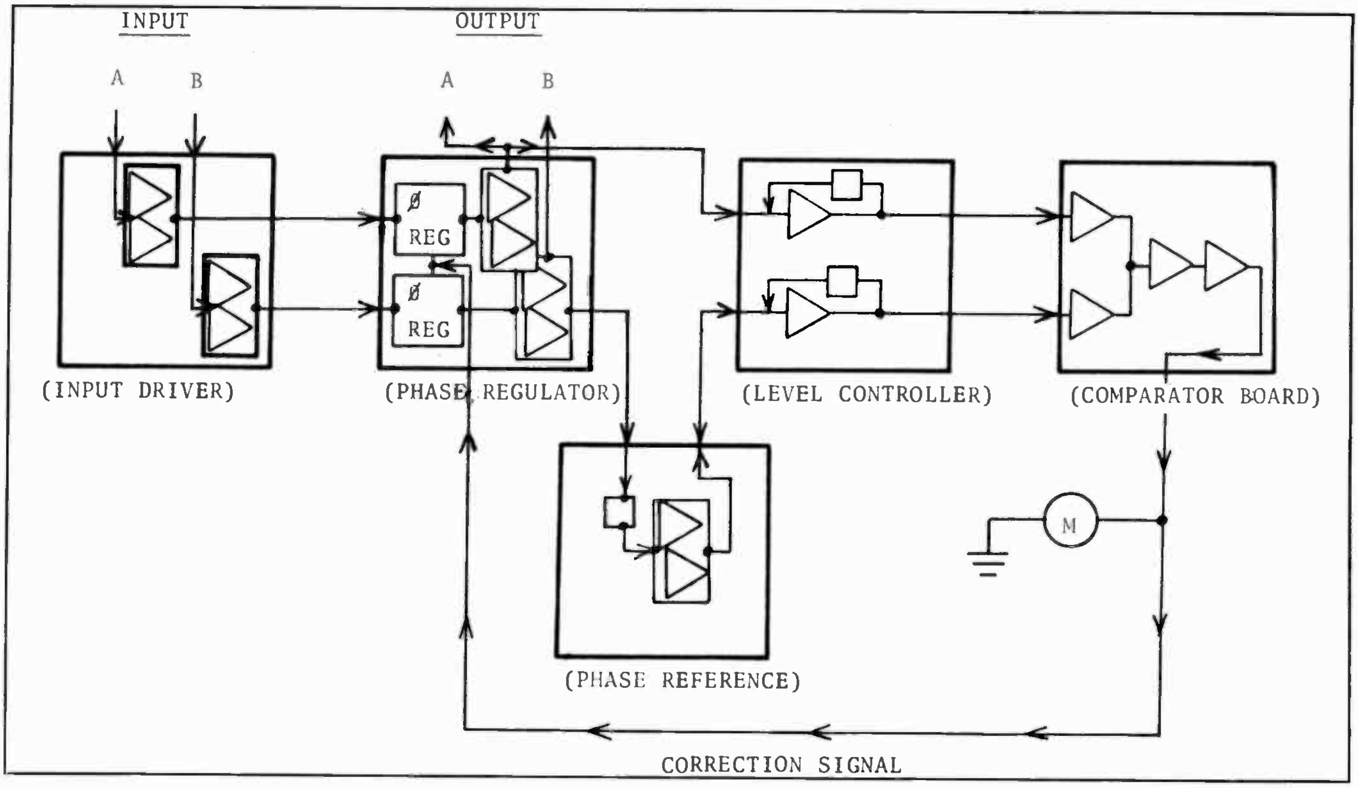



**Figure 2. Signal Flow**

An Input Driver Board is provided for initial conditioning of the stereo input signal. A Phase Regulator Board provides control circuitry, amplified balanced outputs to the signal line and reference and control signal outputs. A Phase Reference Board contains conditioning circuits to establish signal parameters necessary for a reference signal output. A Comparator Board looks for and converts differences between the control and reference signals into a correction signal output which is used to drive the phase correction circuits on the Phase Regulator Board and the front panel phase error indicator.

## Signal Flow

The signal flow is shown in Figure 2.

Left and right signals from the line or stereo source flow through the Input Driver Board and its Amplifiers. Following the amplifiers the signals flow to the Phase Regulator Board where they pass through individual phase regulation circuits. Output from the phase regulation circuits are coupled to balance output amplifiers designed to drive a 600 ohm balanced line. A second set of output terminals couple one descrete signal to the Level Controller Board and the other signal to the Phase Reference Board. The output of the Phase Reference Board drives the second Level Controller Board input. The Level Controller, through AGC action, prepares the two signals for input to the Comparator Board. The output of the Comparator Board is a correction signal which flows back to the Phase Regulator Board where it controls the action on the front panel to indicate the relative magnitude and direction of phase error.

## Circuit Description

Discussion of the circuits will not include the power supply and interconnect cards which are of typical design. Each element of the functional circuitry will be presented individually.

a) *Input Driver*

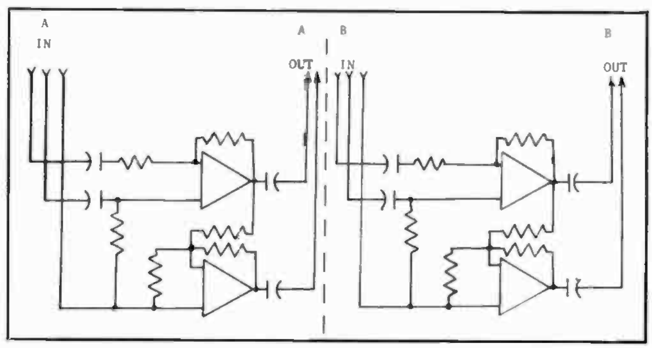



**Figure 3. Input Driver**

Figure 3 depicts the Input Driver.

This circuit element consists of two dual op-amps, one for the left and one for the right stereo signal. The function of this card is to interface either single-ended or balanced inputs with the input impedance of the Phase Regulator Board without placing special restrictions on the signal source driving the system.

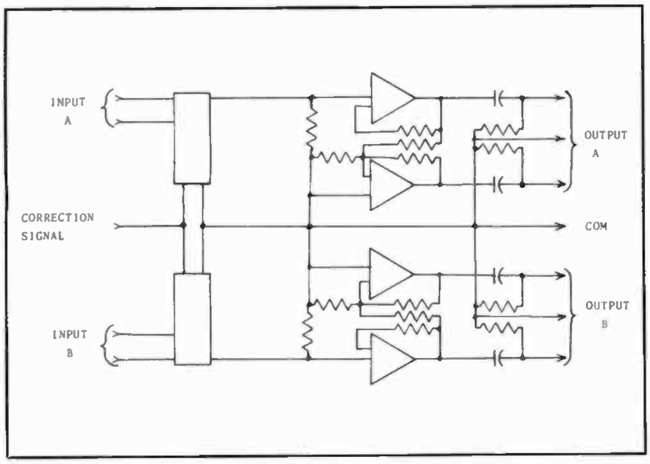



**Figure 4. Phase Regulator Board**

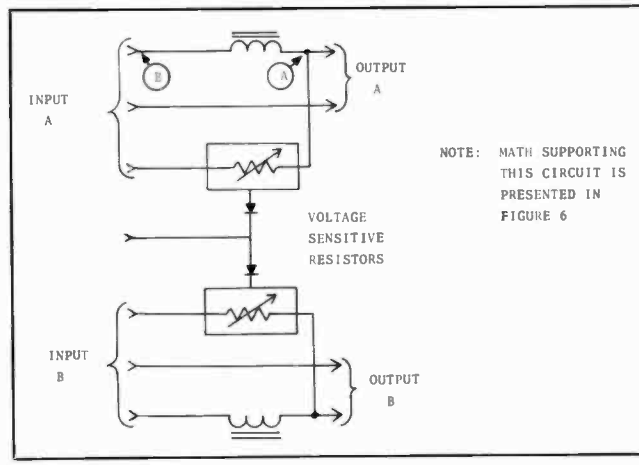



**Figure 5. Phase Regulators**

b) *Phase Regulator*

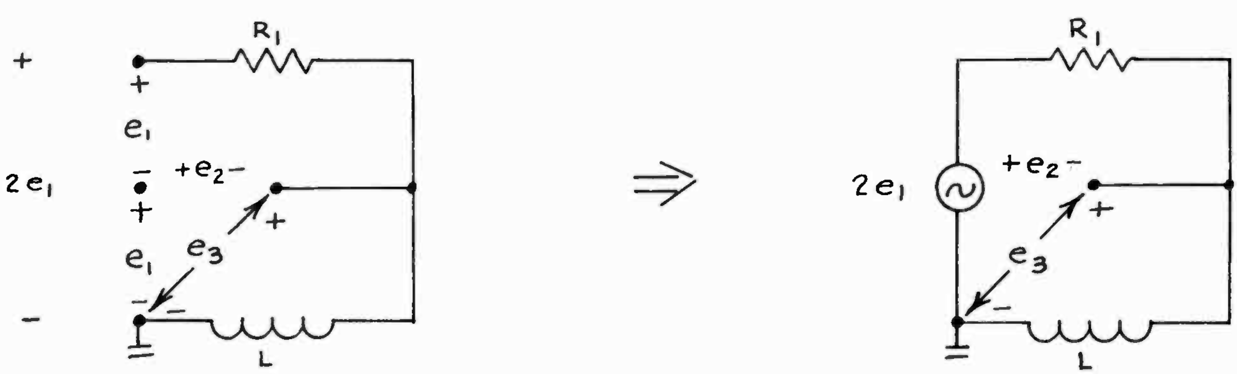
Figure 4 depicts the Phase Regulator Board.

This circuit element is subdivided into two sub-elements. The first sub-element is a pair of phase regulators, one for each channel.

Figure 5 depicts the phase regulators.

Phase regulation is accomplished by bringing each descrete stereo channel in through ballanced inputs for each channel. One leg flows through fixed inductances, L1 (L2) and the other leg through voltage sensitive resistors, R1 (R2). Outputs from the phase regulators are taken be-

$$X_L = j2\pi fL = j\omega L = sL \qquad s = j\omega$$




$$\frac{e_3}{2e_1} = \frac{sL}{R_1 + sL} \quad \therefore \quad e_3 = 2e_1 \frac{sL}{R_1 + sL}$$

$$e_2 = e_1 - e_3 = e_1 - 2e_1\left(\frac{sL}{R_1 + sL}\right)$$

$$\frac{e_2}{e_1} = 1 - 2\left(\frac{sL}{R_1 + sL}\right) = \frac{R_1 + sL}{R_1 + sL} - 2\left(\frac{sL}{R_1 + sL}\right)$$

$$\frac{e_2}{e_1} = \frac{R_1 + sL - 2sL}{R_1 + sL} = \frac{R_1 - sL}{R_1 + sL}$$

For $R_1 \gg sL$ $\quad \angle = 0$

For $R_1 = sL$ $\quad \angle = -90°$

For $sL = R$ $\quad \angle = -180°$

$$\frac{e_2}{e_1} = 1\angle \frac{\arctan \frac{-sL}{R_1}}{\arctan \frac{sL}{R_1}} = 1 \angle 2 \arctan \frac{-sL}{R_1}$$

**Figure 6. Phase Correcting Network—Supporting Math**

tween the junctures of L1-R1 (L2-R2) and signal common.

To illustrate the function of the circuit we can take a reference at the juncture of either phase regulator and any point in the regulator circuit. For our discussion we will take our reference between A and B. If the value of R is infinity, point B is in phase. If the value of R is zero, point 180 degrees is out of phase. Values of R between zero and infinity allow us to cover all phase angles between zero and 180 degrees. Signal amplitude will remain contant for all values of R for any descrete frequency. At any descrete frequency we can shift the phase through a full 180 degrees. With a fixed value of R and a phase shift of 180 degrees at 15 kHz, for example, a reduction in frequency would result in a correspondingly smaller phase angle.

The regulation is a function of reactance, therefore phase errors are brought about of RC networks such as those encountered in telephone line problems or tape recorder head mis-alignment can be corrected.

The math shown on Figure 6 proves that for any value of R the amplitude remains absolutely constant.

The second sub-element consists of a dual op-amp for each descrete channel. The amplifiers are operated in push pull and provide balanced outputs to the line and also supply signal to the Phase Reference and Level Controller Boards.

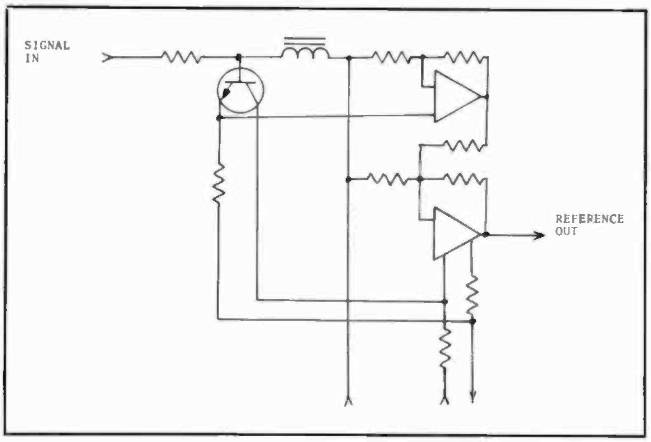



**Figure 7. Phase Reference Board**

c) *Phase Reference Board*
Figure 7 depicts the Phase Reference Board.

This circuit performs a vital function in the phase correction process. In order to have the system work properly, it is necessary to shift one of the descrete stereo channels by 90 degrees. We also want to have pre-emphasis so that high frequencies will have priority as synchronous material for the control function.

The circuit chosen was an inductor driven by a current source, and becomes a differentiating device. When a sine wave is presented to the input, the output is a cosine which is a shift of 90 degrees by definition.

The math supporting this circuit is presented in Figure 8.

The primary point of interest is that this circuit produces an absolute 90 degree phase shift from the lowest frequency to the highest. It also develops a voltage that increases at the rate of 6 db per octave. The significance here is that if you have material of all frequencies in the incoming signal the highest frequencies will have the highest amplitude. The output of this reference signal is then used to drive one input of the Level Controller Board.

d) *Level Controller Board*
Figure 8 depicts the Level Controller Board.

This circuit is simply a dual op-amp which is driven by one unaltered stereo channel and the reference signal generated by the Phase Regulator Board. Regulation is provided to maintain a common output signal level for the unaltered and the reference signals. The outputs of this board are single-ended and are coupled to the inputs of the Comparator Board.

e) *Comparator Board*
Figure 9 depicts the Comparator Board.

This circuit is also a vital elements of the correction system. This circuit is set up to respond to dynamic phase shifts from approximately ± 2 or ± 4 degrees and performs the summing and control of the feedback networks and frequency response.

The Comparator itself produces a zero voltage output when the phase difference between the inputs is 90 degrees. When the input signals are in phase it produces a maximum positive voltage, and when the input signals are 180 degrees out of phase it produces a maximum negative voltage. An ambiguity in this circuit does occur when the phase difference is at exactly 180 degrees. At this phase difference the circuit will not sense the error. From a practical point of application, the probability of such error magnitude and of significant duration over the entire band width of the program material is remote.

The correction voltage from this card is fed back to the Phase Regulation Board where it drives the phase regulators. The signal voltage is metered on the front panel to provide a means of monitoring operation of the system.

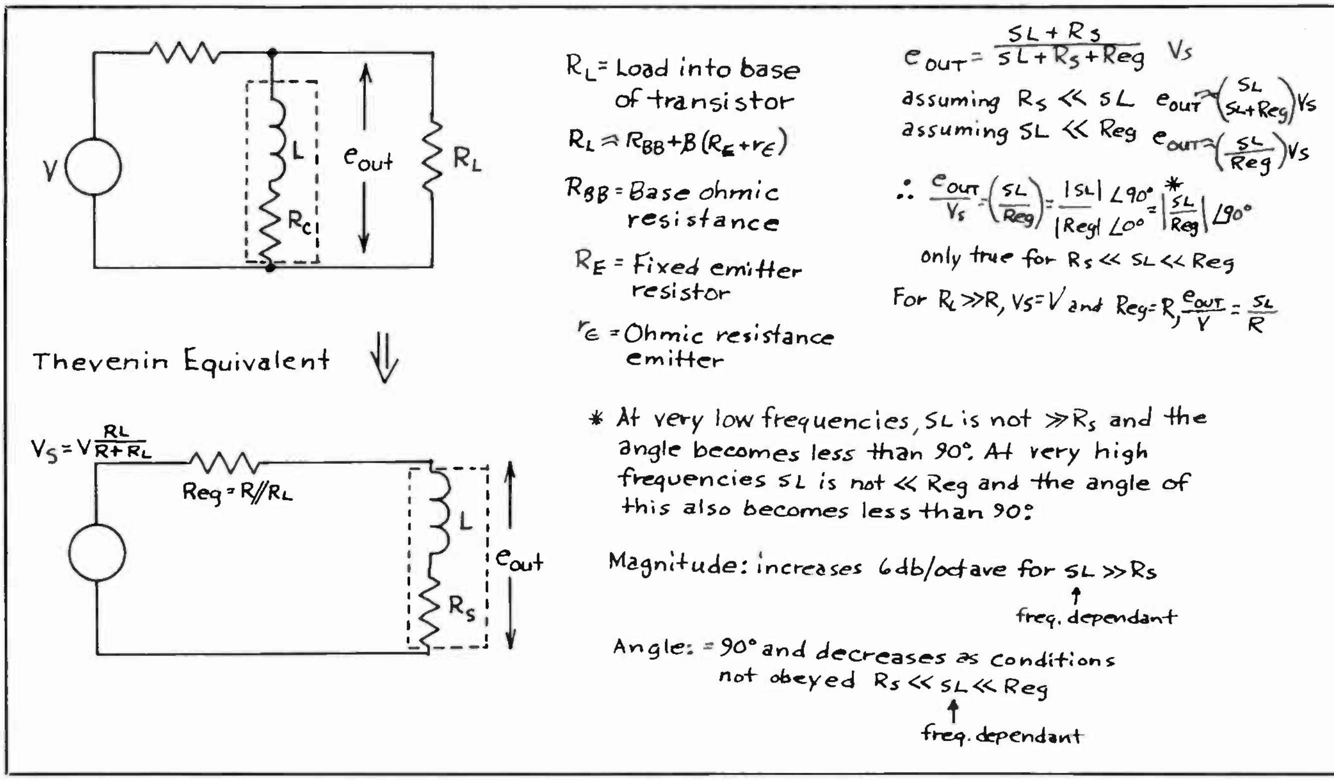



**Figure 8. Phase Reference—Supporting Math**

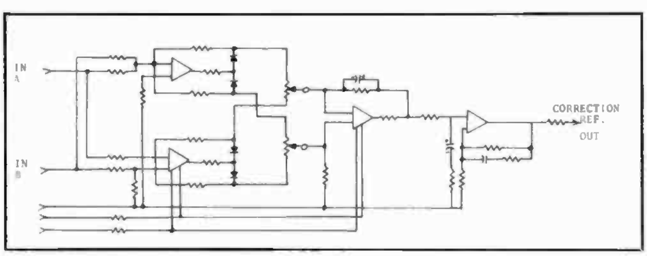



**Figure 9. Comparator Board**

## Summary

To summarize, refer back to the signal flow diagram shown in Fig-2, and we see that we have an input circuit matching standard lines and signal sources to our phase correction system. We have phase regulation for errors ranging from zero to 180 degrees. We have several stages and level limiting, which makes it possible to deal with signal amplitude variations from very low levels up to about +18 dBm. High frequency material takes precidence as common mode synchronous material. The phase correction process reacts to phase but not amplitude variations and the reaction is immediate.

So now we have a phase correction system.

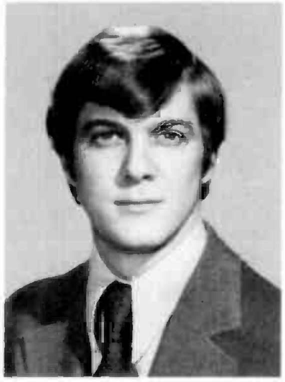
Reason dictates that there is not a cure-all for anything. The system works, but, where can we use it? Even more, where shouldn't we use it? What type of material can we use it on?

Let's establish what types of program material can and can't be used. Essentially the only place this circuit cannot be used is for four channel Matrix type stereo or material which has been generated with special effects derived from phase shift.

Where can it be installed? Generally speaking, this correction system can be installed at any point in a system where it is felt that phase problems exist. If it is desired only to correct a cart machine problem, then it probably should be installed in the line after the cart machine. If you have cart machines on individual pots, then perhaps the best place would be on the output of the remote console. That way any machine that comes on line can be used to key the remote relay on the correction unit to insert it into the line. If the cart machines are all off, the system is out of the line and doesn't affect anything else that going on.

Actual installations have been as individual as the stations using them. Some users place it after all their signal conditioning equipment, just prior to the stereo generator going into the transmitter. Some feel they get phase shift going through their level limiting equipment. Some users wouldn't dream of putting anything after that; they consider it precious.

It is also useful in systems with remote transmitter sites which are fed by telephone lines. The phone lines are subject to various changes in phase shift between the lines and are often severe. In severe cases of this type it is recommended that two correction systems be used; one on the input and one on the output, since the total phase shift resulting from tape recorders and the phone lines could exceed the correction range of the system.



**Kenneth M. Frank**

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# A New Approach to AM Modulation Monitoring Using Digital Displays

AM broadcasters have long been confronted with the problem of determining the precise value of their positive and negative modulation peaks. In recent years the FCC has further complicated the problem by allowing positive modulation up to 125%. Many stations are desirous of operating as close to the 125% modulation limit on positive peaks as possible, while maintaining modulation as close as possible to 100% on negative peaks. They need to know accurately what their modulation peaks are, in order to stay close to the desired modulation parameters.

There has been, except in the earliest days of AM broadcasting, a requirement for an AM station to measure by means of a suitable indicating device both positive and negative peaks of modulation.

Stations licensed by the FCC, must have a type-approved modulation monitor. We are all familiar with these devices. All AM stations use them.

I wonder if anyone can say with assurance that he can accurately know his percentage of modulation by reading the modulation monitor, and with confidence adjust his audio signal and his transmitter to achieve the maximum permissible modulation.

I doubt if anyone can. I have designed type-approved modulation monitors, and I know that, other than with continuous sine wave signals, it is impossible to monitor peak modulation on an analog meter, hence the Commission requirement for a peak flasher tells us when we are overmodulating, and not by how much, and not how close we are to maximum permissible modulation.

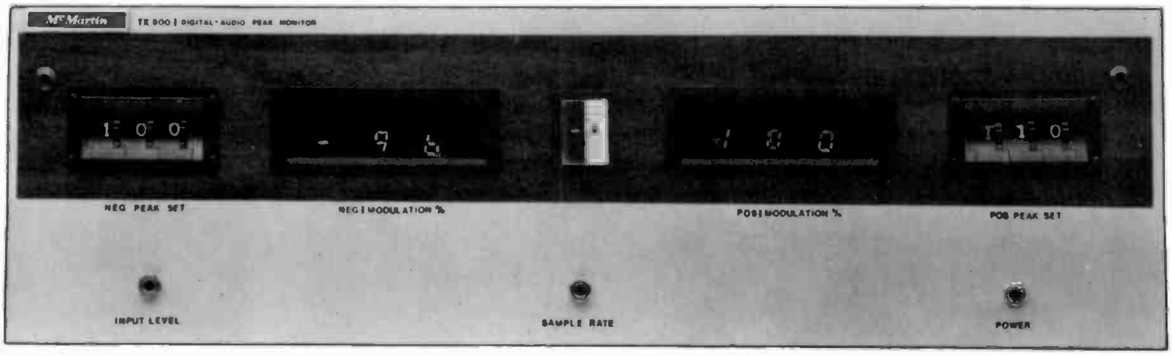
The peak flasher, although an accurate indicator of modulation at a preset "threshold," is not capable of giving a finite answer. It merely shows that a given modulation peak was equal to, or *greater* than the threshold setting.

The modulation meter is by definition semi-peak reading, and the FCC rules relating to rise time, decay time and overshoot make the modulation meter useless for peak indication, of complex program signals. The rise time characteristics of the modulation meter does not allow it to respond to complex amplitude peaks. Calibration of the meter of necessity is accomplished under sine wave conditions, where it responds to the average values of the sine wave. With complex audio and its rich harmonic content calibration is no longer predictable. During normal programming periods, even though the peak flasher may indicate modulation peaks of 100%, or *greater,* the meter typically indicates peaks hovering at 80%.

The peak flasher circuit responds to an analog voltage in excess of a fixed threshold. If for example, a typical peak flasher is set to display 100% peaks and it flashes, the only positive conclusion we can draw is that a peak of at least 100% occurred. We do not know what the precise value is of that peak. It may have been 100%, 101%—or was it 126%?

Modulation meters and peak flashers simply do not give an accurate indication of the *true* modulation peak value.

Another problem encountered in analog modulation monitors is that they do not retain calibration in




**McMartin's TX-800 AM Peak Modulation Indicator**

the presence of carrier shift. The increased use of asymmetrical modulation, inherently increases carrier shift.

Modulation monitors typically employ capacitive coupling of the demodulated audio to the modulation measurement circuits and include no provision to provide a correction voltage to offset the effect of carrier shift.

If a modulation peak occurs which causes a 5% negative carrier shift and the actual positive peak modulation is 100%, it is quite possible for the monitor to indicate a 105% positive peak, and at the same time introduce a similar 5% error in the negative peak reading.

This condition occurs because the recovered audio from the detector centers itself symmetrically around the carrier level which serves as the zero point to the measurement circuits. This is readily observed. Tone modulate your AM transmitter 100% and observe the carrier level meter.

Developments in digital devices and techniques now allow for an instrument that will accurately measure and indicate true values of instantaneous peaks of modulation both positive and negative; correct the carrier-shift problem and permit hard-copy logging and recording of the true peak values.

At McMartin Industries we have devised such a device, our TX-800 AM Digital Peak Modulation Indicator. An AM digital peak modulation indicator

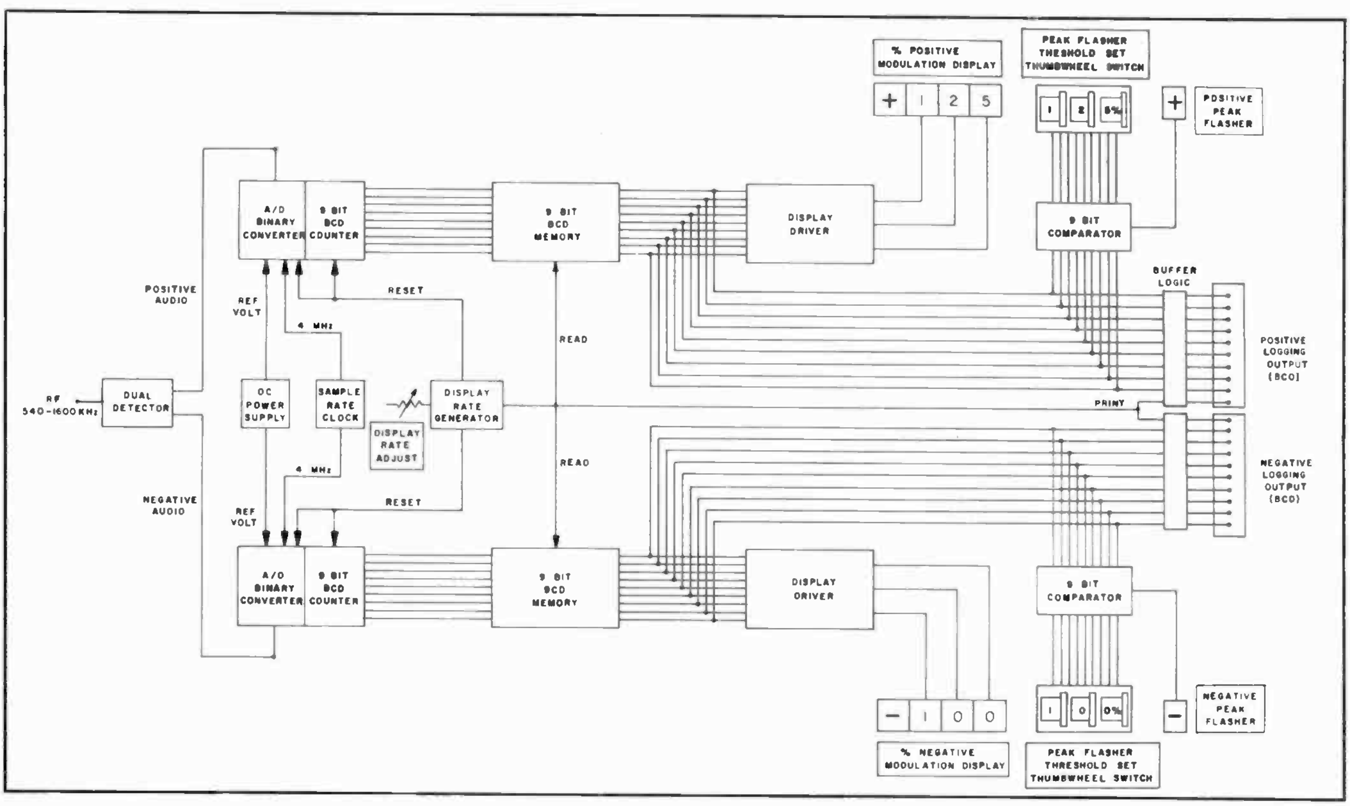



**Figure 1. TX-800—Simplified Block Function**

is by definition a device that will measure and indicate in a real number format modulation peaks by using digital techniques. Since this indicator is for AM it should be capable of indicating peaks of the complex and often asymmetrical audio waveforms that are routinely transmitted by AM stations. Illustration 1 shows the TX-800 and except for the absence of analog meter faces, it looks somewhat like the AM modulation monitor that it is designed to supplement. The front panel shows dual peak flashers and independent displays for positive and negative modulation. No carrier level meter is provided as the conventional type approved monitor that the TX-800 is used with contains this meter. The TX-800 automatically compensates for carrier-shift-induced errors to provide accurate peak indications at all times and under all signal conditions. Figure 1 shows a simplified block diagram of the TX-800.

The amplitude-modulated RF signal to be sampled is applied to the TX-800 input and fed to the Dual Detector block. One detector system recovers the audio from the positive side of the modulation envelope, and a second detector system recovers that from the negative half of the envelope. The dc outputs of each detector system in the TX-800 are positive dc voltages, which track with percentage of modulation.

As can be seen from the block diagram, duplicate systems are employed for positive and negative modulation measurement and indication. Only the positive modulation portion of the TX-800 will be described. The negative portion is identical in operation.

The rectified dc voltage that is at the output of the dual detector is applied to an analog-to-digital (A/D) converter where a binary number corresponding to the instantaneous peak value of the audio voltage is generated.

Since the analog-to-digital conversion utilizes a binary code, but numeric readouts are desired, a binary coded decimal (BCD) counter is also employed in tandum with the A/D converter. This counter provides a BCD coded number for every binary number produced in the A/D converter.

The BCD format has been chosen as it is a compatible format for driving loggers, printers, and other external readout equipment. The A/D converter is clocked at 4 MHz rate. These clock pulses are generated from a crystal oscillator in the Sample Rate Clock.

At this 4 MHz clock rate a complete A/D conversion is accomplished in approximately 30 microseconds which is more than ample time to accurately measure any modulation peak in AM broadcasting.

The BCD number equivalent to the modulation peak value is then read into a 9-bit memory upon command of a READ pulse generated by the Display Rate Generator.

The output of the 9-bit memory is coupled to the Display Drivers which drive the seven segment Light Emitting Diode (LED) readouts which provide the numeric value of the modulation peak.

The A/D converter continuously samples the rectified audio and the BCD counter counts at the 4 MHz clock rate until they receive a RESET pulse from the Display Rate Generator. The RESET pulse immediately follows each READ pulse, and indicates that the display interval is over, and that the A/D conversion process is to be restarted.

The Display Rate Generator produces a READ pulse followed by a RESET pulse on a recurrent basis. The display interval is adjustable over a one-tenth to ten second range. During each display interval the A/D converter will transform each successive higher peak into a binary number until the RESET pulse occurs initiating the start of a new display interval.

The display interval time period is varied by a board mounted switch assembly for coarse adjustment and a front panel vernier control. Changing the display rate has no effect the sampling rate of the A/D converter.

The BCD number that indicates the highest peak of modulation encountered in the sampling process and read into the 9-bit memory is parallel coupled to one set of inputs of a 9-bit comparator. The second set of inputs are programmed by the positioning of the Peak Flasher Thumbwheel switch. If the number produced by the memory is greater than the value programmed by the Thumbwheel switch, the comparator triggers a one-shot multivibrator which energizes the peak flasher driver stage, causing the peak light to flash.

Parallelled memory outputs are fed through buffer logic and brought out to a rear panel connector. This BCD data is the logging output for connection to a digital printer. A PRINT command is also provided at the logging output, allowing connected printers to enter updated information.

Two particular portions of the system warrant more detailed explanation because the accuracy relates directly to their operation. One is the unique three stage detector system, and the second is the A/D (analog-to-digital) conversion process.

First we will examine the three-stage detector system. Figure 2 illustrates the various subsystems com-

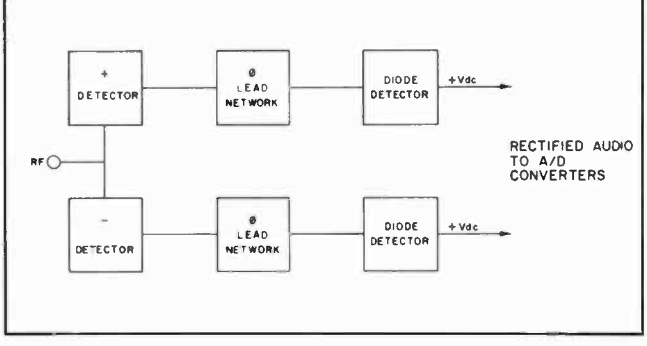



**Figure 2. Dual Detector**

prising the dual detector. Two RF detectors are utilized. One detects positive excursions of the modulated RF signal, the second detects negative excursions of the modulated RF signal. This allows both the positive and negative modulation peaks to both be further processed as positive dc signals.

It is important to note that at the output of each RF detector, a time variant analog signal centered on a dc voltage proportional to the input RF carrier level will appear. This dc voltage is then dc coupled to a phase lead network which is followed by a second diode detector.

The phase lead networks compensate for phase shift induced in the detection process and produce a phase linear signal at the Dual Detector system output. The second diode detector rectifies the detected audio and produces a positive going dc voltage whose peak value we are now going to measure.

Throughout the detection process, the dc nature of the detected audio has been preserved, and any change in carrier level will either add to or subtract from the positive going dc voltage. If positive carrier shift occurs we know that the recovered audio will tend to center itself on a higher voltage level causing the positive modulation peak to appear to be less than its actual value. Since we employ dc coupling the positive increase in carrier level will add to the rectified audio restoring the peak voltage to its true value. In the case of the negative peak the opposite is true, and the decrease in carrier level will subtract from the rectified audio restoring again the peak voltage to its true value. This detection process eliminates modulation measurement errors generally caused by the carrier shift associated with asymmetrical modulation.

The other subsystem of the TX-800 we will discuss in greater detail is the analog-to-digital (A/D) converter. Figure 3 shows a more detailed block diagram

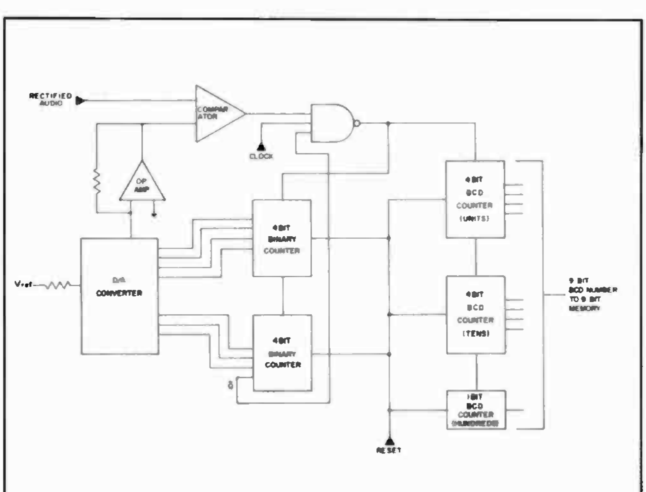



**Figure 3. A/D Converter and BCD Counter**

of the A/D converter and the 9-bit BCD counter utilized in the TX-800.

The A/D converter transforms the analog rectified audio into a digital number.

The converter operates in a "ramp-up" mode. Other conversion processes could be used, but considering the ease of generating a Binary Coded Decimal (BCD) number and the highly transient nature of the analog input voltage which is derived from complex program material, this approach was selected.

Figure 3 shows a 9-bit BCD counter operating in tandem with the binary counter producing a BCD equivalent to each binary number generated.

The 4-bit binary counters, the D/A (digital-to-analog) converter, the Op-Amp (operational amplifier) and the voltage comparator together form the A/D converter.

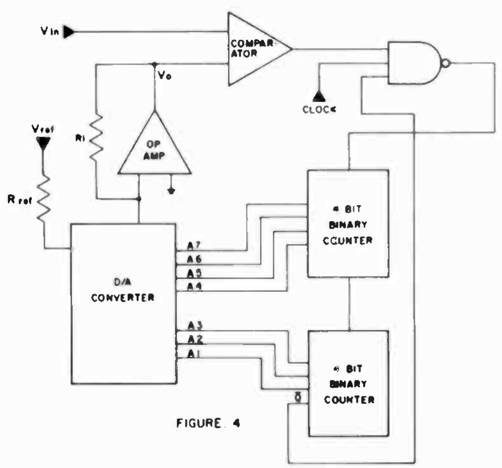
Operation of the converter is such that whenever the rectified audio voltage is greater than that appearing at the Op Amp output the comparator output will be high, therefore allowing the clock pulses to be passed through the NAND gate. The clock pulses initiate the counting process in both the binary and BCD counters. As the counting continues the D/A converter produces a current equal to the binary number present at its inputs. The Op Amp serves as a current-to-voltage converter and presents a dc voltage, equivalent to the binary number contained in the 4-bit counters, to the comparator input. When this voltage reaches the value of the rectified audio signal the comparator output goes low. This stops the binary counters on a number which is equivalent to the rectified audio input voltage. Counting will not restart unless the rectified audio level increases from its previous value. At the end of the selected display interval, the number in the 4-bit counters will be equivalent to the largest value of the rectified audio input signal experienced during the display interval.

In order for the A/D converter to accurately track the rectified audio input signal, the settling time of the A/D converter, the slew rate of the Op Amp, any delays in the comparator, and the clock speed must be taken into consideration.

Since the D/A converter used requires a 7-bit binary code at its input there are 127 possible code combinations. And the binary number for 127 will correspond to 127% modulation. Now if the rectified audio voltage exceeds the voltage level corresponding to 127% modulation the $\bar{Q}$ output of the second 4-bit counter will go low, thereby preventing the clock from advancing the counters any further. This will also stop the tandem 9-bit BCD counter at 127, plus one count, or 128.

Figure 4 illustrates how the A/D converters are calibrated and how accuracy in measurement is assured.

In the equation shown in Figure 4, in order for accuracy to be maintained the values of Vref, and R1 must be selected according to the following criteria. Vref is a well regulated supply voltage, the value of




$$V_o = \frac{V_{ref}}{R_{ref}}(R1)\left[\frac{A1}{2}+\frac{A2}{4}+\frac{A3}{8}+\frac{A4}{16}+\frac{A5}{32}+\frac{A6}{64}+\frac{A7}{128}\right]$$

LET $V_{ref} = 3$ VOLTS

$R_{ref} = 1.5K$ OHMS

ASSUME $\Delta$ $V_{in} = 0.2$ VOLTS FOR EACH 10% CHANGE IN MODULATION,

THEN AT 120% MODULATION $V_{in} = 2.4$ VOLTS

$\therefore$ $V_{in} = V_o = 2.4$ VOLTS

$$2.4 = \frac{V_{ref}}{R_{ref}}(R1)\left[\frac{A1}{2}+\frac{A2}{4}+\frac{A3}{8}+\frac{A4}{16}+\frac{A5}{32}+\frac{A6}{64}+\frac{A7}{128}\right]$$

BINARY EQUIVALENT TO 120 = 1111000

$$\therefore 2.4 = \frac{3}{1.5K}(R1)\left[\frac{1}{2}+\frac{1}{4}+\frac{1}{8}+\frac{1}{16}+0\right]$$

$$2.4 = \frac{3}{1.5K}(R1)\left[0.9375\right]$$

R1 = 1.28K OHMS

**Figure 4. Calibration of A/D Converter**

which is established at 3.0 Vdc.

The optimum reference current of the D/A converter is 2 milliamperes; therefore this dictates the value of Rref shall be 1.5K-ohms, of tolerance of 1% or better. This component must be stable with temperature change.

Assume the detector has been designed so that the rectified audio voltage, Vin, changes 0.2 Vdc for each 10% change in modulation percentage. From this 2.4 Vdc equals 120% modulation. Therefore, to produce a digital number equivalent to Vin, Vo must also equal 2.4 volts.

Since we know the binary equivalent of 120 is equal to 1111000, we can determine a value for R1, which equals 1.28k ohms.

The circuit is now calibrated and Vo will vary from 0 V to 2.54 V as the binary count varies from 0 to 127.

As stated earlier, see Figure 3, the BCD counter will count, in its 9-bit format, the same information which was counted in the binary counter. When the A/D conversion is completed the clock pulses are negated, placing all the counters in a hold mode. Unless the rectified audio voltage, Vin, increases in value, all the counters will reman in that mode when the READ pulse occurs. This places the data in the memory. Refer back to Figure 1.

The data in the memory is now available for the purposes of 1) driving the display driver, the output of which delivers the real decimal number, equivalent to the percentage of modulation to the LED readout display; 2) feeding one set of inputs of the 9-bit comparator which has been programmed by the thumbwheel switch logic to energize the peak flasher when a preset percentage of modulation value has been selected; and 3) remote processing.

The logging outputs are on mulipin connectors, separate connectors are provided for the positive and the negative logging output and a BNC connector is used for RF input.

The TX-800 performance specifications are as follows:

RF Frequency Range:
 540-1600 kHz
RF Input Requirement:
 5 to 10 volts rms
RF Input Impedance:
 50 ohms unbalanced
LED Display:
 ±1% at 100% modulation
Peak Flasher Accuracy:
 ±1% at 100% modulation
Display and Peak Flasher Range:
 0% to 100% Negative Peaks
 0% to 127% Positive Peaks
Logging Outputs:
 Two, One each for positive and Negative 9-bit BCD format. Print commands active high or active low.
Sample Rate Clock:
 MHz.
Display Rate Interval:
 continuously adjustable from less than 0.1 seconds to greater than 10 seconds.
Ambient Temperature:
 0° to 50° Celsuis.

The presentation of modulation percentage information in a numeric form, coupled with the simultaneous presentation of both positive and negative peak information makes the TX-800 the ideal addition to any AM station's monitoring and measuring equipment. The TX-800 allows more accurate indication of peak modulation percentage information than is possible with any currently available FCC type approved modulation monitor.

The TX-800 provides an accuracy of ±1%, at 100% modulation. This substantially exceeds present

FCC requirements and the accuracy available in any currently type approved modulation monitor, including, I might add the McMartin. This accuracy is made possible because once the measurement of the modulation peak is made, the processing of the value is no longer subject to analog means in which errors can be cumulative. The ability to transform complex analog program information into digital form, permits the visual display of the information as well as at the same time providing a means of recording the data externally.

Circuitry similar to that used in the BCD comparator may be used for automatic audio control equipment to provide for pre-modulation adjustment of the audio signal, or for automatic control of the transmitter itself when and if automatic broadcast transmitter operation becomes a reality.

We have described the application of the TX-800 as a digital AM modulation indicator. This is not its only use. Its features are readily adaptable to stereophonic broadcasting and film and tape recording applications.

McMartin Industries has initiated action toward obtaining patents covering the basic TX-800 system.


Mr. Small Mr. Henshell

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# Architectural Considerations In Radio Broadcast Radio Facility Design

Over the past several years I have been directly involved with the construction of several radio stations. For most of these jobs I have had the privilege of working with the same architect and for each of us come a greater understanding of the other's problems and point of view. The intent of this paper is to bring to the broadcaster an understanding of the process of how an architect approaches the design of a radio facility.

To me, the most interesting aspect of the process is the extent to which the major design decisions pivot around people rather than hardware. Gradually, I have found this kind of human engineering thinking affecting my day to day broadcast work with some very positive results. I hope that even for the reader who is not contemplating the construction of a new facility, some of the approaches to making environments fit people instead of the other way around will prove useful.

When the management group (ownership, general manager, program director, and chief engineer) of a radio station faces the problems of building a new facility, a number of common questions seem to arise. Mostly they come from an attempt to extend the kind of thinking used to deal with day to day projects into the kind of thinking needed to deal with capital construction. The following is an example of the kinds of questions that often come up:

Why go to the bother and expense of designing a facility in detail rather than "letting it happen?"
How about the contractor designing it?
Or maybe the station chief engineer?
How closely should the layout be planned around the programming format?
What details are commonly overlooked?
Can the studio environment affect the performance of the air personalities?

These questions provide a flavor for the decision making process that seems to take place when a radio facility is being planned. The rest of this paper will discuss how an architect, working closely with the staff of a station, deals with radio station design.

It may seem a little presumptuous for an Architect to discuss the intricacies of radio station design before a group which knows considerably more about the actual operation. But anyone who has gone through the planning and construction of a station for the first time will agree that, at the very least, it is traumatic and often frustrating. We hope this paper will make your next project a more satisfactory experience.

## Site Selection

Construction programs can consist of a new building, alteration of an existing building for a station or renovation of an existing station for expansion or updating. A successful design must provide an environment in which people can function effectively to produce quality programs. The facility must be economical, flexible and easy to maintain.

The first step in creating such a design is to select a suitable site, either an existing building or land for a new one. The second is to evaluate the items that will affect the final design.

Before the Owner sets out in search for his perfect site, he should establish the location, the optimum rent or capital expenditure, consider the need for future expansion and prepare a list of the kind, number and approximate sizes of the required spaces.

The acoustic environment, as well as the design of the spaces and construction of the partitions, must be considered in the selection of a building site or an existing building. Noise can come from many sources; from outside the building, within the building, or produced by the station and it is less expensive to pick a site that is not noisy than to construct to control it.

Locations in aircraft flight paths or near railroad tracks and drag strips are obviously going to be a problem. Others such as steep hills where trucks labor up in low gear are less apparent. At one station we had to contend with a traffic light at a turnpike exit where heavy trucks with air brakes roared by with tires squealing and gears grind, creating bedlam whenever they came off the pike and hit a red light. It was very costly to provide sufficient sound attenuation to reduce this noise to allowable limits. If the Owner had realized this initially he might have selected a building in a different location.

In existing building common noise sources such as elevator shafts and machine rooms are instantly apparent. Also significant are courtyards or air shafts containing numerous window air conditioning units. Also be aware of the noise potential of storm water drains or steam pipes in pipe shafts, vibration from traffic and stationary machinery. In one station we found that the Owner had planned to locate a studio adjacent to a roof drain. Tapes made during the first heavy rain would have sounded as though they were made under water. We were able to revise this plan, but in another station where we discovered a printing press on the floor above there was nothing to do but isolate the sudio areas by floating the ceilings.

In addition to noise there are other factors to be taken into account when selecting a location. In a multiple story building the elevators must be operable day and night, seven days a week. Since one cannot expect the building to provide air conditioning or heating on this continuous basis you must be sure there is space and power available to install a self-contained mechanical system to serve the studios. Also check if a building can support masonry partitions—they're less constly to construct than lightweight partitions.

If you are going to locate a station on the top floor of a building be certain that the mechanical equipon the roof or the water tower for the sprinkler supply is not directly overhead—otherwise workmen will be entering studios to shut off valves or adjust dampers in the ceiling above.

Also check on potential locations of emergency generators or you may find, too late, that there is no room for them, or that they are not permitted, or that fuel storage tanks are illegal, etc.

A well planned layout must consider circulation; the interrelationship of functions and the clear separation between the sales and its staff support and the

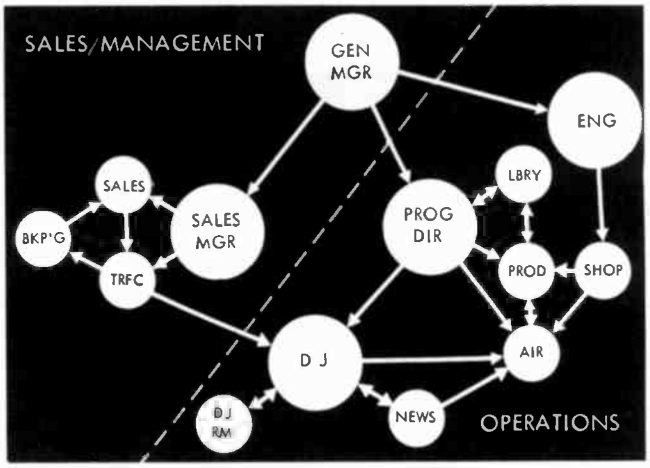



**Figure 1. Functional Relationship Chart**

studio facilities. A simple table of organization does not always reveal the traffic flow as well as a functional relationship chart such as in Figure 1. Your own chart will vary according to the modus operandi of your station and your format. Allow for partition rearrangement should the format change. The studio block will be difficult to alter, therefore, as we will discuss later, it should have flexibility built-in so that changes can be accomplished with the least inconvenience and at minimum cost.

Now that we've reviewed the site selection problems, let's investigate the design features which must be considered. These can be grouped into Architectural, Mechanical and Electrical.

## Architectural Features

A radio station can be compared to a manufacturing facility in which the product is a program. There must be a clear separation between the office operation and the production function, while still maintaining a close interrelationship between them. The management and sales areas are comparatively straightforward and easy to plan; whereas the operations facilities are considerably more difficult. In planning the studio complex space must be properly related to one another, isolated for sound, tuned for proper acoustics and should provide a self contained environment in which D.J.'s can function at top form. Figure 2 is a plan of station WNCN that we designed in 1964. It illustrates some of the points we have just discussed.

The station is on the sixth floor of an existing office building so toilets, elevators and other facilities were provided. Sales and management are grouped around the studio complex and the operations personnel are close by production studios. The studio proportions fall within the proper aspect ratio for good room acoustics and the production portion is effectively isolated from the air studios.

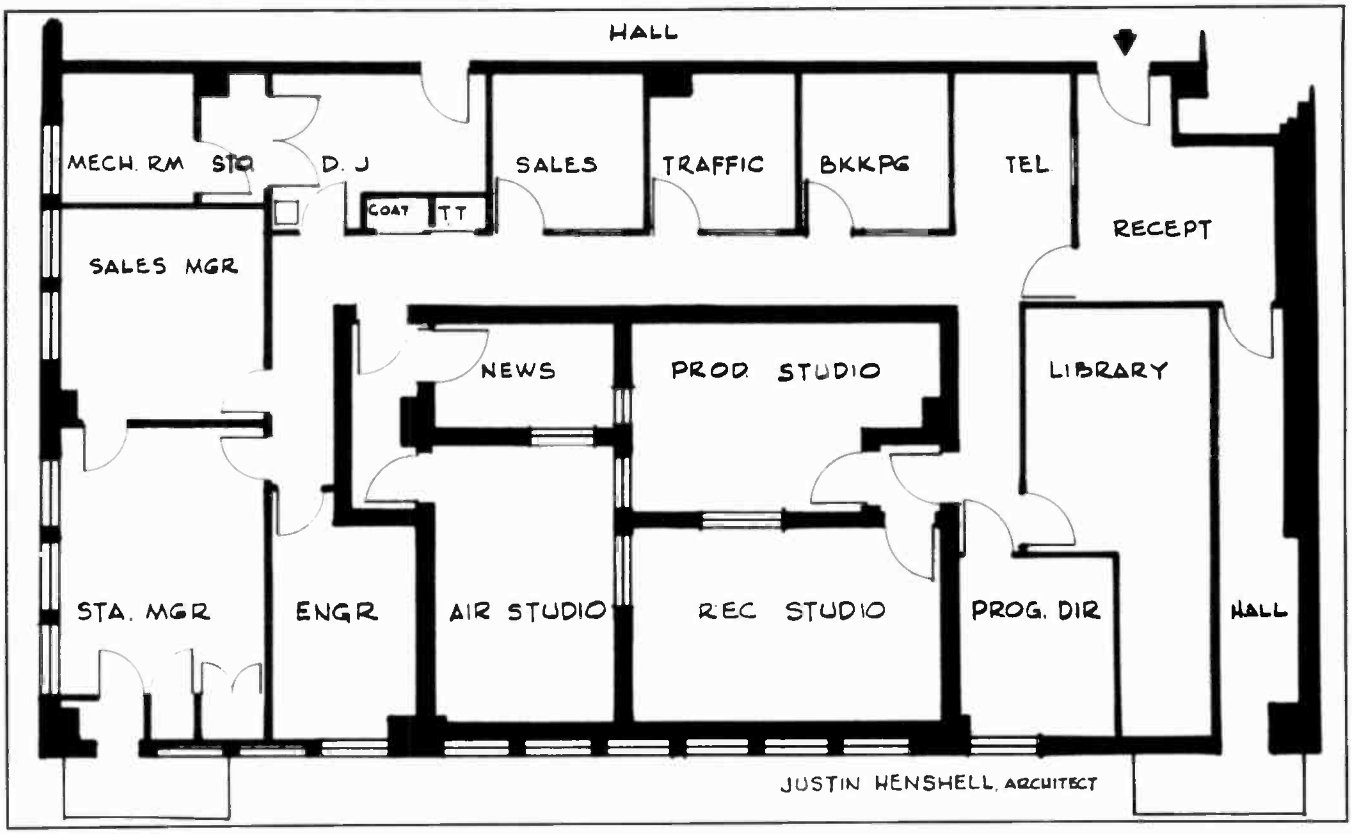



**Figure 2. WNCN Operating Facilities**

I'd like to take a moment here to discuss some of the acoustical attenuation problems of studios. We mentioned before the concern for shutting out external ambient noise. But we must also contend with another situation—the high sound level produced within the studios themselves. D.J.'s and the production staff will often turn up speaker volume to a point where it can not only be heard in adjoining studios, but also in other tenant spaces. This can be a problem. For example, we had to isolate the floor in one station because the studios were over a doctor's office and the sound level produced by the studio speakers could interfere with the practice of medicine below.

Since the most acoustically sensitive space is the Production Studio, we generally concentrate the greatest amount of sound attenuation there. The room is protected by a sound lock and every effort is made to space the doors to the air studios and the production studio as far apart as possible so that the doors to both spaces will not be open at the same time. We usually install sound absorptive material in the corridors leading to studios to create a noticeable drop in sound levels. Psychologically people tend to lower their voices and become aware of the acoustical sanctity of the studios when the entrys are visibly treated with acoustical material.

The air studios must be designed to provide an environment in which the D.J. can operate most effectively for extended periods of time. The design must avoid a claustrophobic atmosphere, provide proper and effective lighting, utilize low maintenance wall finishes, afford visual control of the entrances and, if possible, an outside view.

Interstudio windows serve the dual purpose of extending the apparent area of the space and allowing visual control of one studio from another. If possible, a window to the outside should be provided. Not only does this broaden the visual confines of the studio but it also permits the announcer to tell the listeners that it's snowing even if the weather bulletin says "fair." Soundproofing and bulletproofing these windows is mandatory.

Good lighting is critical. There should be sufficient light to be able to read and write and fixtures should be located or aimed to avoid veiling reflections. Where discs are used light should be aimed to enable accurate cueing if the turntable is not self illuminated. We prefer incandescent light to avoid ballast hum and R.F. interference sometimes present in fluorescent fixtures. These lights are operated by dimmers to allow each D.J. to establish the level of illumination he find best. Lighting is the least expensive and most effective decorating medium we have—and the possibilities are endless if sufficient flexibility is built-in Color filters, local switches, variable positons and the full range of wattages and beam concentratons are available to create the proper ambience and an atmosphere conducive to good working conditions. In addition to the lighting required to operate the board, there should also be at least one fixture for general illumination and one for the maintenance technician to work on the rack.

Studio wall treatment and finishes are probably the most controversial, and perhaps the most expensive, item in the design. Finishes must be acoustically reflective or absorptive to properly tune the room. They must also be easily maintained, resist abrasion and damage and provide a pleasant decor. Acoustic cane fiber and mineral tiles, acoustically absorbent fiberglas and foam glass panels, plastic faced rigid fiberglas board and even draperies are just a few of the materials used, and too often misused. Many of these materials are too soft and are easily damaged, some absorb so much sound that the room is acoustically dead. Perforated panels turn the room into a four walled peg board into which everyone inserts clips and hangs things on the wall. We currently favor panels of perforated vinyl stretched over fiberglas of differing densities which cover three walls above a wainscot. The remaining wall area including the wainscot is covered in the same vinyl but unperforated. This material is easily cleaned, resists abrasion and is available in a wide range of colors and textures. By changing the color on one wall or alternating colored panels the "boxed-in" feeling is reduced and the studio becomes a more pleasant, and less tiring place to work.

Incidentally, a chair rail is highly desirable in both studios and narrow corridors leading to the engineer's shop in order to reduce damage to the walls when turntables, tape decks and similar equipment are moved around.

Before we discuss electrical and mechanical problems, let's just touch on a few other miscellaneous architectural items which should be considered.

Paper from the news wire should empty into a closed fireproof container; If D.J.'s sit down, carpets in studios should be of static resistant nylon construction with dense, looped pile to allow casters to rool easily; Rooms devoted to extensive production of interview shows, commercials etc., should have small closets for storing mikes, pads, ashtrays and similar paraphernalia.

The maintenance engineer's shop should have an adequate bench equipped with a sturdy fireproof wearing surface. Space should be allowed for discrete storage of parts and room to work on portable equipment: A glass covered license cabinet will discourage the removal of station and operator licenses.

Doors to studios and sound locks should be provided with glass for inspection and security. We should also mention other measures to assure safety. If the entrance is visible from the air studio it should be well lit and glazed with bullet resistant glass. Remote entrys should be guarded with television cameras and intercoms. Doors should be controlled by electric strikes actuated by the D.J.

## Mechanical

Heating, ventilating and air-conditioning radio stations pose certain special considerations. Systems for studios generally must be in operation continuously. They must be designed to deliver conditioned air quietly and draft free through ductwork which will stop the passage of sound from one space to another.

A completely self contained mechanical system, independent of the central system, is required to meet these conditions. Such a system usually consists of an air cooled condensing unit or heat pump connected to an air handler which circulates air through supply and return ductwork. Provision should be made for fresh air, humidification and filtration.

Since local climatic conditions, the location and construction of the building, the available fuel, etc., will dictate the type of system most suitable to each job this paper can only discuss the subject in the most general way, covering some points we have found to be common in previous projects.

The most satisfactory method of cooling seems to be a split system in which the air handler is located in the building near the studios and the air cooled condensing units are mounted outside or in a remote window. Because the insulation required for sound attenuation and absorption is usually far in excess of that required for reducing heat loss or solar heat gain the main load will be heat gain from people, lights and equipment. The equipment must also be sized to heat and cool fresh air. Air handlers are rarely shut down for maintenance or repair but heat pumps, evaporative condensers and compressors can be a problem. For this reason, we generally use two of these units to supply a single air handler. Each unit should be capable of providing about ⅔ the total maximum cooling, thus if one is shut down for repairs, the other can condition the spaces without excessive human discomfort. Furthermore, when one machine can handle the load operating savings can be realized.

Electric reheaters installed in the ductwork to each room permit individual temperature control. Clicks and pops from static build-up on discs can be reduced by humidifying those studios where discs are used or stored. Precipitators or bag filters will quickly pay for themselves by reducing the dust in electronic equipment and thus improve reliability. Maintenance can be encouraged by placing the air handlers in an accessible location.

Particular attention should be given to the layout and acoustical treatment of the ductwork to avoid creating speaking tubes or flanking paths for noise transfer from the equipment room or between studios. It is also important to insure a complete seal where ductwork penetrates sound isolating partitions and ceilings in order to preserve the effectiveness of the acoustical design.

## Electric Electronic

The design of the electrical and electronic systems should be a joint effort by the architect and the station engineer. They should review emergency power, design for access to electronic wiring, flexibility of conduit systems, and the proper location of racks, consoles and speakers.

Stations change their formats, air studios become production rooms or go fully automated, equipment must be replaced for more sophisticated elements or something just goes wrong and must be repaired. The harried engineer has to accomplish these changes quickly without interfering with the station operation —that's when the flexibility of an installation will prove itself.

Power, telephone and electronic wiring which will pass in and out of the studio complex and between studios must not reduce the designed sound resistance of the envelope either when initially installed or when alterations are made. Equally important is the need for accessibility for inspection, repair and relocation. To satisfy the first condition we specify looped conduits for cross-overs between adjacent spaces. These are carefully caulked and made discontinuous from the intraspace conduit system. Accessible ceilings and surface mounted raceways with removable covers provide the necessary access. The front of consoles and both sides of racks must also be made accessible.

We mentioned earlier that lighting should be provided for working on the back of the rack. In addition you will need receptacles for tools, soldering irons and similar maintenance equipment. The same receptacle can also serve for vacuum cleaners and portable lighting.

Probably nothing gives us as much trouble as speakers. The selection and location of speakers always seems to get deferred until the end. They're one of the little surprise packages like wall mounted clocks and mike booms that appear out of nowhere and have to be fitted in at the last minute. Wall mounted speakers when run at high sound pressure levels at low frequencies pose a challenge to the attenuation of the best designed walls (and the wall often loses). We prefer to mount speakers on acoustically isolated trapeses, if we know the weight, height, and location in advance. Speakers will also be located outside the studio area and the designer should make some provision for their mounting. We know that there will be one in the reception room but sometimes forget that the D.J. will need one in the toilet room.

Emergency power is a whole subject in itself and can only be discussed briefly here. Most stations prefer to have an emergency generator for the studios as well as at the transmitter. Generators are noisy and require fuel storage, exhausts, batteries and fuel supply lines in locations approved by building owners and meeting local ordinances. The question of generators must be considered early, preferably in the station site selection stage, otherwise, it can become quite costly.

## Conclusion

It should be apparent from the foregoing that the planning and construction of a radio station is very complex and should only be undertaken by experienced designers and planners. Investing in the services of an Architect may prevent costly errors in site selection and space planning and improve the efficiency and environment of the facility. The Architect can assist the Owner in determining his needs, space requirements, circulation and budget. Together with his engineering and acoustical consultants, he will prepare drawings and specifications that set forth the project's requirements in detail so as to avoid ambiguity and eliminate the arguments about the scope of the work and the kind and quality of materials. Precise, coordinated contract documents should result in more accurate bids so that while the total cost may not be lower, the Owner can be more certain of getting his money's worth.

In closing we hope that you have gained a better understanding of the role an architect plays as a member of the station design team. He must be a planner, engineer, lighting consultant, cost estimator, and be capable of meshing the acoustics, electronics and environmental requirements into a unified whole where people can work effectively in pleasant surroundings.

**Homer A. Ray**

*Continental Electronics Manufacturing Co.*
*Dallas, Tex.*

# A Short Broadcast Antenna For Restricted Height Locations

There is a continuing need for the development of small antennas which perform as well as large antennas in current use. This is particularly true at medium and low frequencies where structural height and available sites are fractions of one wavelength.

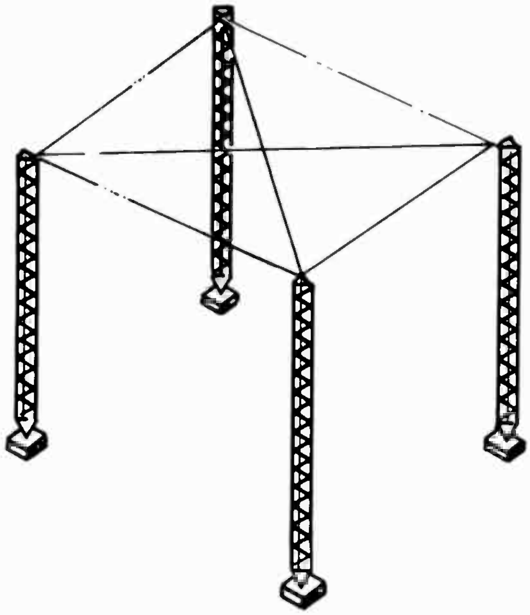
The antenna to be described was developed for very low frequency communications and Loran. It is useful throughout the frequency range where the vertically polarized ground wave is the principle means for radiation.

It has evolved that the maximum bandwidth x efficiency product will be achieved for a given site volume if a current sheet of constant amplitude flows vertically at the site perimeter to the total height of the system. This accounts for the name PARAN or "Perimeter Current Antenna". A useful configuration for broadcast applications is shown in Figure 1.

Where FAA height restrictions prevail it can be used at heights as low as 50 to 100 feet. Low heights tend to restrict the charge or induction fields of low radiators to smaller areas and ground systems may therefore be smaller without excessive losses. It is structurally easier to harden small grounded towers as opposed to tall ones so that survival in hurricane areas can be achieved more readily. Small size allows its use as an on-site emergency antenna in the event of damage to the main radiator.

A pictorial diagram of the components in a monopole tower system as used in broadcasting is shown in Figure 2. In all of the discussion which follows a very short tower is visualized and the impedance is predominantly the capacitance of the tower to ground.

When power is applied to the terminals Z the predominant current flow during each alternation of the cycle is charging and discharging this capacitance C. Its path includes the tower inductance, plus the in-



BROADCAST APPLICATIONS

1. FAA RESTRICTED HEIGHT LOCATIONS
2. SITES WITH LIMITED GROUND AREA
3. HARDENED FOR HURRICANE AREAS
4. ON - SITE EMERGENCY ANTENNA

**Figure 1. The Broadcast Paran Antenna**

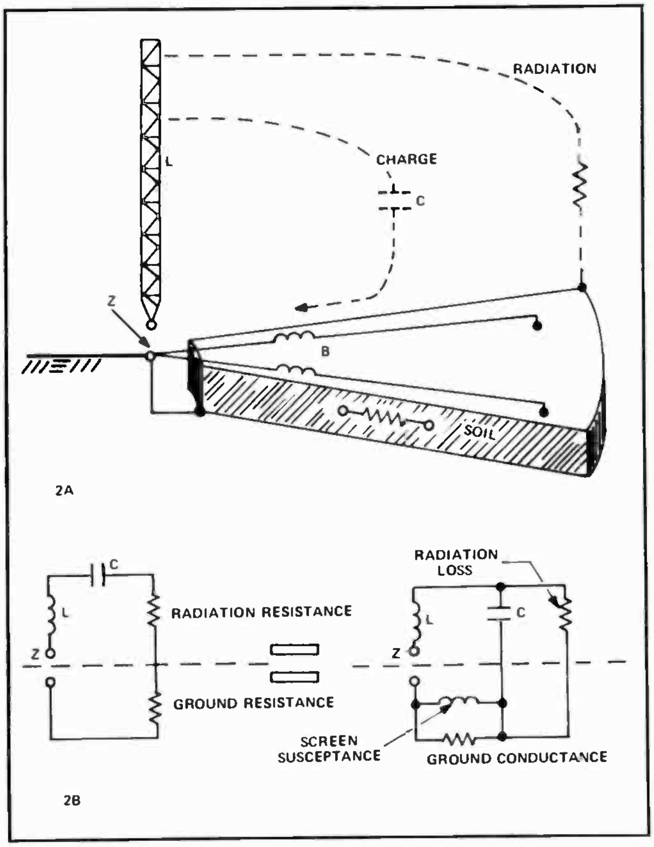



**Figure 2. The Monopole Antenna System**

ductance of the ground screen and the soil resistance in parallel.

In addition to the local charge through C there is energy propagated beyond a radian length from the tower. This energy due to its distance cannot return to the circuit as an in-phase component on each cycle and is therefore lost to the circuit as radiated power. If there were no soil or conductor losses in the antenna circuit the total loss would be due to radiation and the system would be one hundred percent efficient. We must therefore address ourselves to the ratio of the circuit losses versus the radiation loss. The circuit as seen from Terminal Z is the left diagram of Figure 2B.

It is neither economical or practical to reduce the ground resistance to zero. For the moment we will consider it fixed and equal to one ohm which is a familiar value to broadcasters. A tower 20 electrical degrees high will have a one ohm radiation resistance and the efficiency of this system will be

$$\eta = \frac{100\,R_a}{R_a + R_g} = \frac{100}{2} = 50\%$$

If the efficiency of this system is to be improved it must be done by increasing the radiation resistance. Radiation resistance increases as the square of the height and where height is not a limitation is the usual approach. With height limited we have two other options:

1. Current distribution on the tower.
2. Mutual impedance with other towers.

It turns out that each of these options provides a possible four-to-one improvement or a total of sixteen-to-one in the radiation resistance without increasing the tower height.

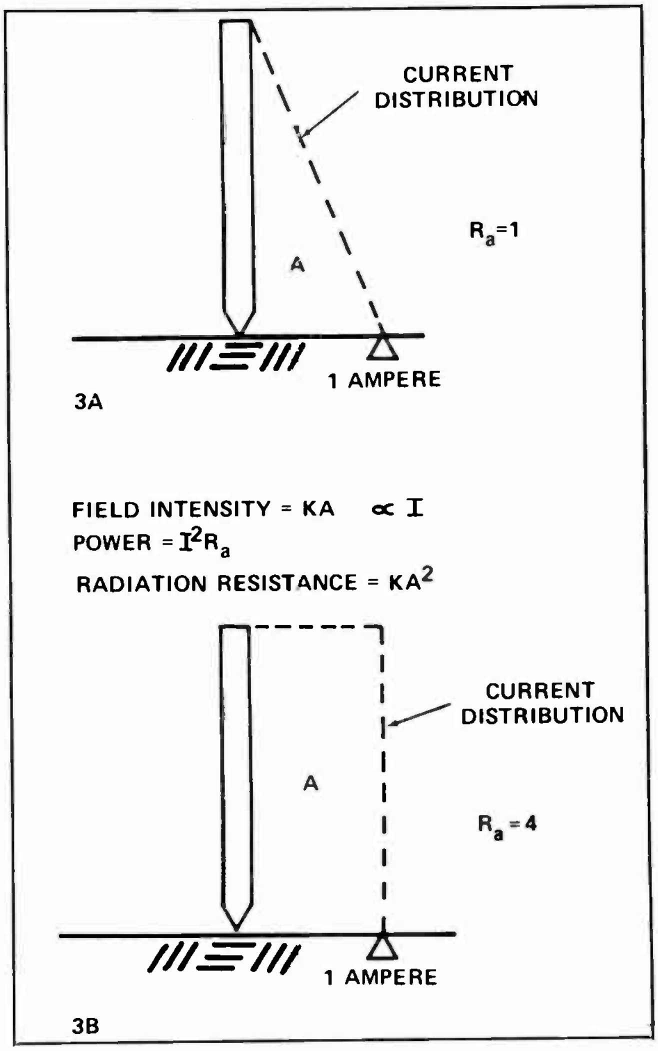



**Figure 3. Current Distribution on Monopoles**

The current distribution on a single short tower conforms to the first few degrees of a sinewave as shown in Figure 3A. For small angles the sine is equal to its argument and the current distribution is a linear function of height. The field intensity from the tower is the integral of the current over the total height which in this case is simply the area of the triangle A. If the tower is 20 degrees high and the base current is one ampere the area A is

$$A = \frac{1 \times 20}{2} = 10 \text{ ampere degrees.}$$

the field intensity is

$$E = KA \quad Mv/m \text{ at } 1 \text{ mile}$$

where $K = 0.65$.

By simple manipulation of ohms low, it follows that the radiation resistance at the base of the tower where one ampere is flowing is

$$R_a = kA^2$$

$$\text{where } k = 1{,}215 \times 10^{-5}$$

If A can be doubled as shown in Figure 3B then the radiation resistance will be quadrupled. This calls for constant current throughout the tower height.

One way to achieve constant current is to put a large top hat on the tower so that it becomes quarter wave resonant as shown in Figure 4A. The current distribution on the vertical tower is a few degrees of sine wave but now near 90 degrees and is almost constant throughout the tower height. The top hat can be shortened without affecting the current distribution by inserting a tuning coil as shown in Figure 4B.

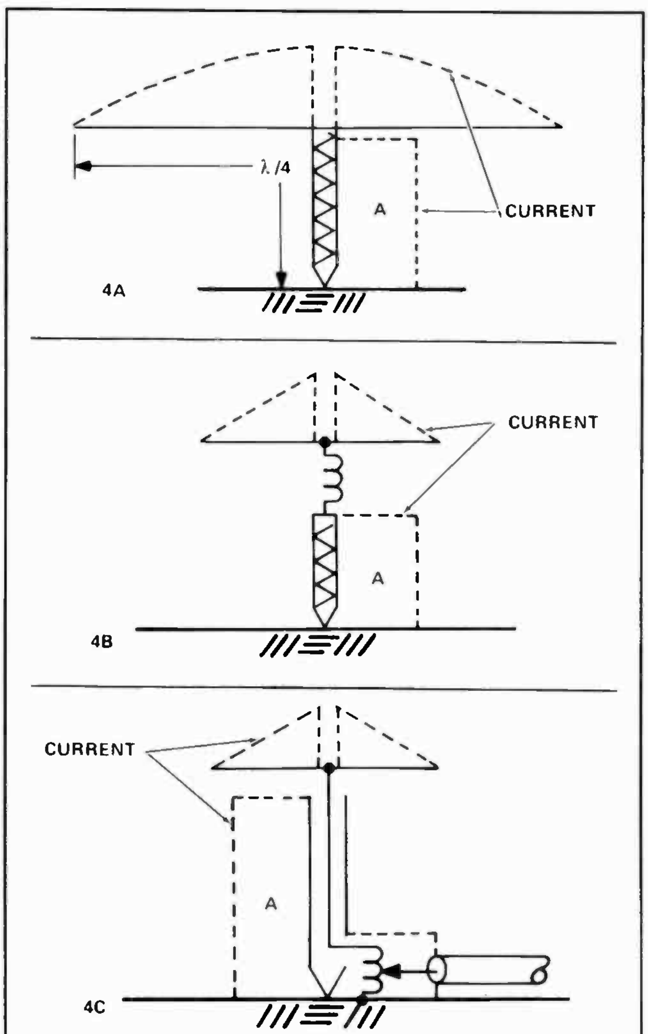



**Fig. 4. Current Distribution on the Paran Antenna**

A coil at the top of the tower is cumbersome and can be placed at the base by using the tower as a coaxial line to effectively connect it at the top as shown in Figure 4C.

An advantage is that a convenient feed point is now provided on the grounded coil. The tower is effectively fed between the top hat and the top of the tower and the current distribution is unchanged. This practical configuration then supplies a four-to-one increase in radiation resistance for the single tower.

Since the top hat must be supported by additional towers it is desirable to use these towers as additional radiators and examine the mutual impedance between them. A circuit for that configuration is shown in Figure 5. Four towers as shown are an economical compromise for broadcasting use. Since there is a common connection between these four elements in the top hat only one needs to be fed by the transmitter. Tuning of this system is simple in that the four inductors are made to contain the same number of turns at all times and the taps are moved until the system is resonant at the frequency of operation.

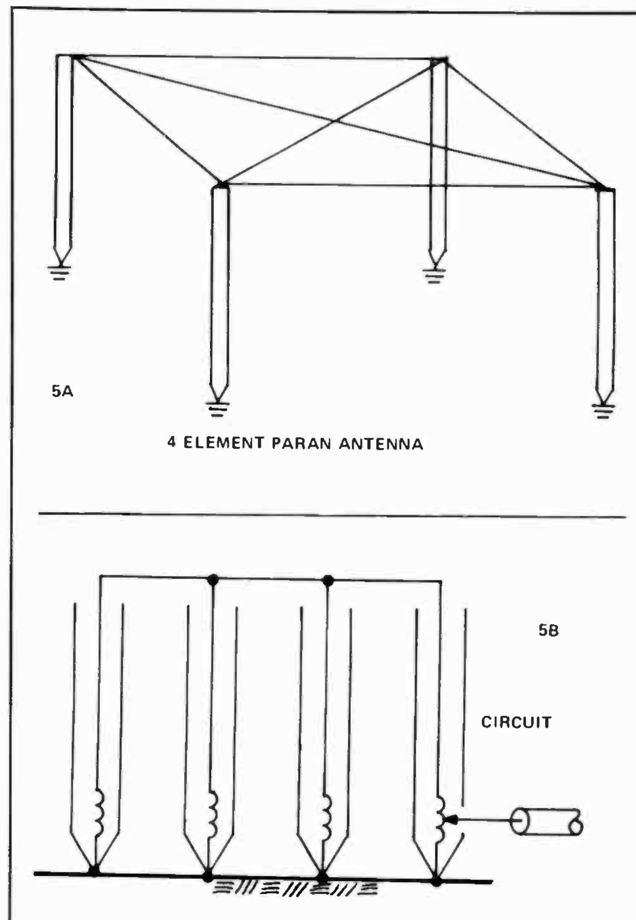



**Figure 5. Circuit of Paran Antenna**

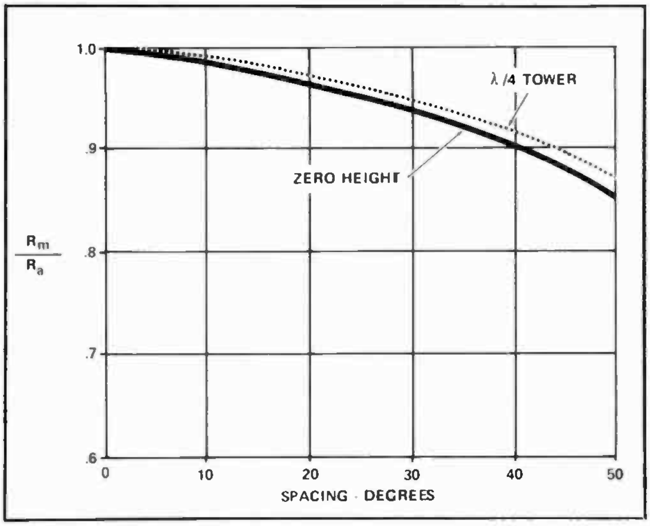



**Figure 6. Mutual Resistance Close Spaced Monopoles**

Experience shows that the currents in the four towers will be matched to within ten percent without any additional adjustment. The match is not critical to operation or efficiency. The ratio of the mutual resistance to the antenna's radiation resistance is shown in Figure 6. A typical spacing is one tower height or form 10 to 20 electrical degrees. Here it can

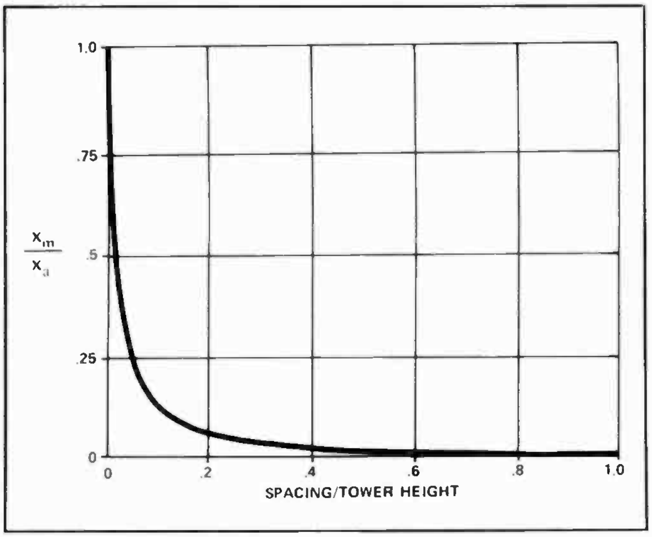



**Figure 7. Mutual Reactance Close Spaced Monopoles**

be seen that the mutual resistance is within 95% of of radiation resistance of each element.

The mutual reactance as shown in Figure 7 where the spacing between towers is one tower height is insignificant. This mutual reactance is not to be confused with the mutual reactance component from Figure 6. Figure 6 is a vector which rotates in proportion to spacing and in fact will be a pure reactance at 140 degrees electrical spacing. Figure 7 is a close-in component which falls rapidly with spacing. We will return to it later when discussing bandwidth.

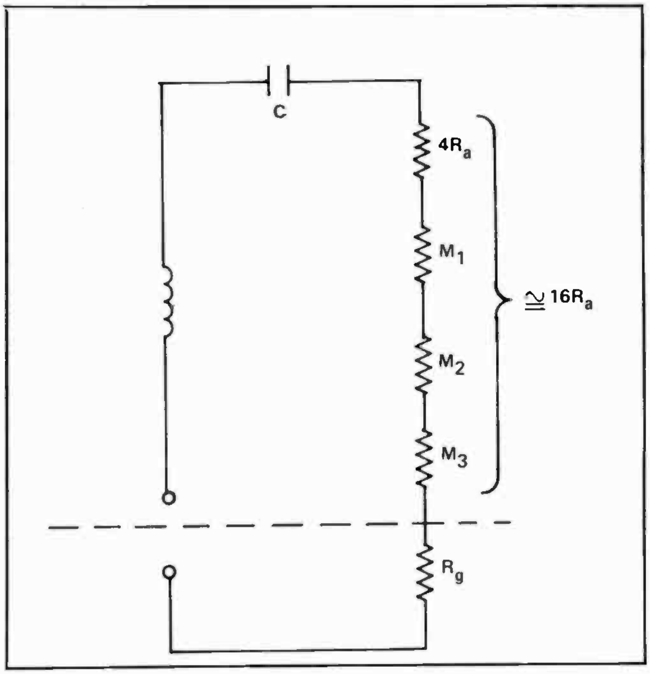



**Figure 8. Circuit Diagram of One Paran Element**

The resulting radiation resistance of each tower when operating with unity phase and amplitude is shown in Figure 8. We have the self radiation resistance of a constant current element which is four times that for a linear current element plus three coupled mutual resistances which are almost equal to the radiation resistance, and their sum approaches sixteen times the radiation resistance for a single tower. To the extent that the ground current to each tower overlap, there will be a mutual ground resistance component which must be added to $R_g$. With one tower height spacing this overlap of ground currents is minor.

The efficiency of our first example which was 50% with one ohm ground resistance and one ohm radiated resistance now approaches

$$\eta \cong \frac{100 \times R_a}{R_a + R_g} = \frac{100 \times 16}{17} = 94\%$$

This example represents a 50 foot antenna at one megahertz or a 100 foot antenna at 500 kilohertz.

The size of the ground system to achieve one ohm or less of ground loss with these antennas is shown in Figure 9. There are many ways to configure the ground system but it is shown with 120 radials and their length is in terms of tower height. With that many radials in a small area the loss resistance within the confines of the radials themselves is very low and the loss is mostly due to the soil beyond the end of the ground system.

With a conductivity of ten millimhos a length equal to one tower height will produce one ohm and with a conductivity to two millimhos the length required will be closer to two tower heights. The radia-

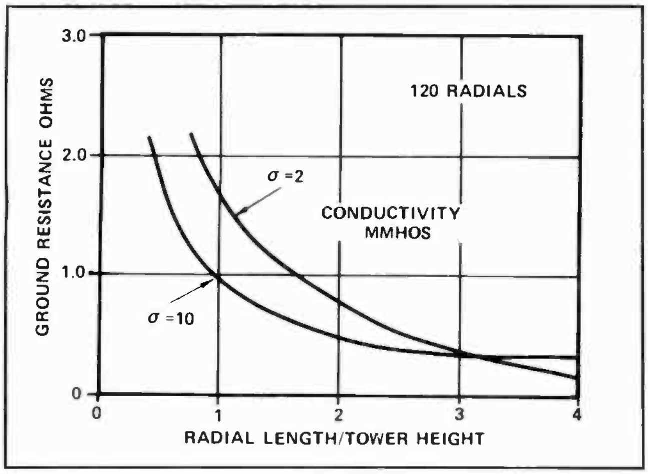



**Figure 9. Paran Ground System Requirements**

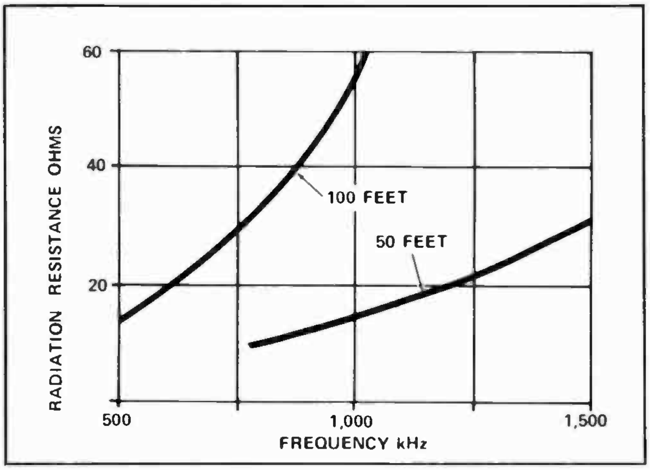



**Figure 10. Paran Element Radiation Resistance**

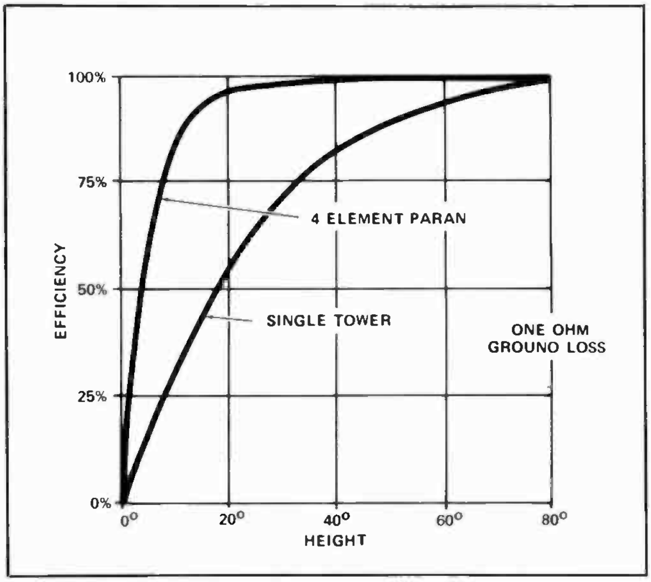



**Figure 11. Comparison of Radiating Efficiency**

tion resistance developed in the PARAN elements for broadcasting is shown in Figure 10. The resulting efficiency with one ohm of ground loss is shown in Figure 11. Here a comparison is made with the efficiency of a single tower under the same conditions. It shows the very large improvement obtained at low heights. It also shows that there is little to be gained where the height of both antennas approaches one quarter wavelength.

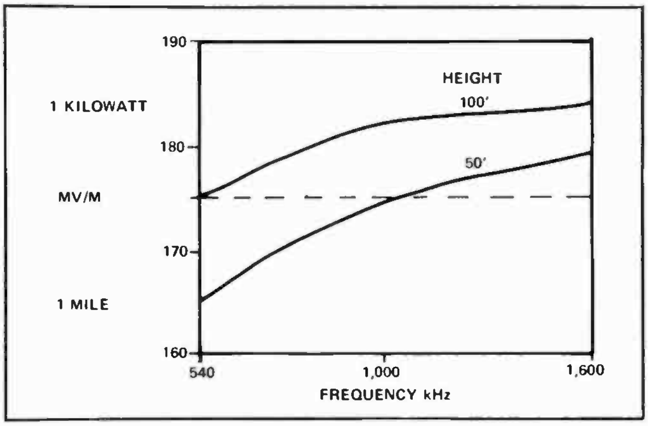



**Figure 12. Paran Field Intensity**

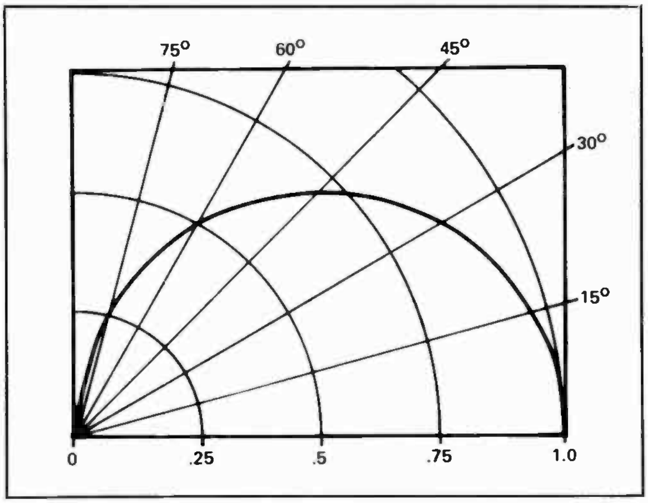



**Figure 13. Vertical Radiation Pattern**

The radiation intensity for fifty and one hundred foot PARANs using one ohm ground loss is shown in Figure 12. with a perfect ground system the radiation for one kilowatt will approach 186.3 mV/m at one mile for all frequencies at short heights.

The vertical radiation pattern for short or zero heights PARAN's is shown in Figure 13. It is the same as that for a short monopole, since it is contained within a one radian cube. For the same reason the horizontal plane pattern is non-directional within plus or minus 0.1 dB.

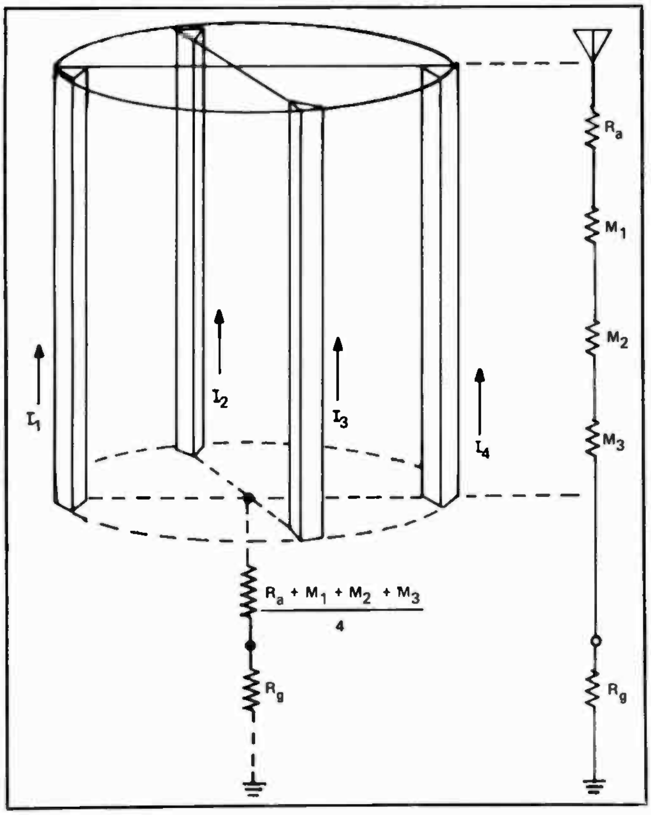



**Figure 14. Convolution mm into a Thick Monopole**

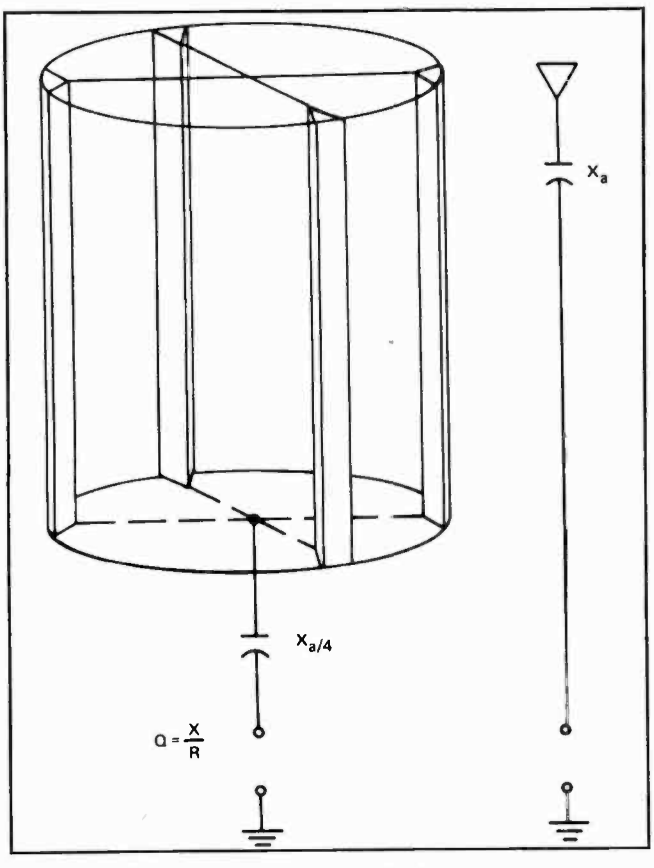



**Figure 15. Bandwidth of Thick Antennas**

The bandwidth also approaches a sixteen-to-one improvement and this can be seen by considering the four elements as current filaments on the surface of a thick cylinder as shown in Figure 14. If the four towers were lifted from ground and fed from a point at the geometrical center the radiation resistance here would be exactly that for a single tower of the same height and no improvement in efficiency would result. The four circuits in parallel have one fourth the radiation of each of the elements. This is a basic concept upon which the mutual impedance between antennas is developed.

The same principle applies to the reactance of the system as shown in Figure 15. The four reactances in parallel produce one fourth the reactance of the elements, however, the mutual reactances are absent for the reason shown in Figure 7. Here we have a four to one decrease in reactance and with a four to one increase in resistance due to current distribution the Q of the cuircuit has been reduced almost sixteen-to-one. This explains a fundamental reason behind the bandwidth improvement of thick radiators.

The power capability of the PARAN system is primarily due to its voltage limitation at the lowest frequency of operation. Using 15 ohms as the practical radiation resistance and—300 ohms reactance at 500 kilohertz the current for 50,000 watts is (12,500W per element)

$$I = \sqrt{\frac{12,500}{15}} = 29 \text{ Amperes}$$

$$E = 29 \times 300 = 8,700 \text{ Volts (carrier)}$$

$$E \text{ (Modulated Peak)} = 8.700 \times 2 \times 1.41 = 25 \text{ kV}$$

The values over the frequency range of interest are shown in Figure 16.

One of the first questions that has been asked is about the use of the PARAN in directional antenna systems.

The complex problem of sky wave radiation must be worked out as a unique problem in each application. This is a task for broadcasters and/or their engineering consultants. Directional systems with PARAN elements are quite feasible if attention is paid to all of the problems involved.

The sky wave radiation from the top hat alone on the PARAN antenna has been calculated for its lowest frequency of operation and is shown in Figure 17 for one kilowatt of power. The maximum radiation value is 1.2 mV/m at one mile and this can be added to Figure 13 where the field is 186.3 mV/m at one mile on the ground. It represents about one half of one percent increase in radiation at a vertical angle of 50 degrees from a phase center on the ground at the geometric center of the PARAN set.

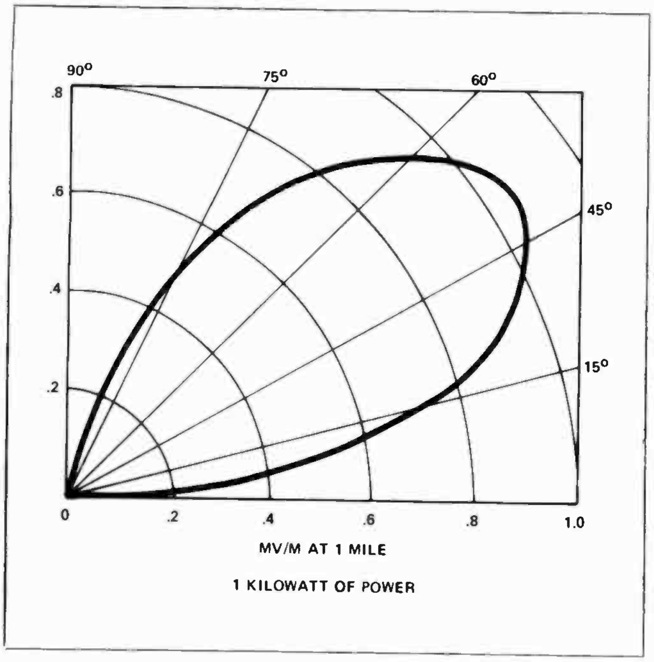



Figure 16. Paran Antenna Voltage 50kW—100% Modulation

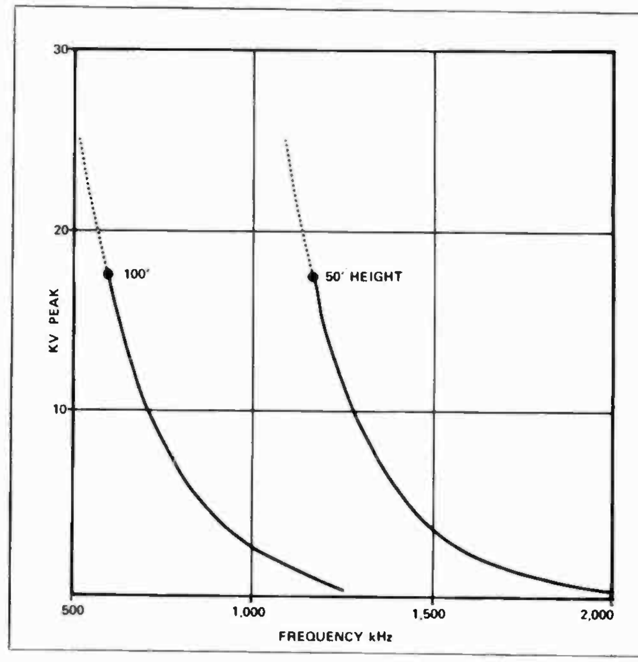



Figure 17. Sum of Radiation Components from the Paran Top Hat

When used as one element in a directional array the vector sum of the top hat components from all of the top hats will take on the pattern of the directional array. The resultant will continue to be a small component increase in the same order of magnitude. The parameters are easily programmed and can be included in computer solutions to directional systems.

In large spaced arrays where the mutual impedance between sets of PARAN's representing tower locations is almost equal for all elements of the set, then four element PARAN's as shown here should be quite feasible depending upon the protection problem. Keep in mind that two tower PARAN's may be used for a potential eight-to-one improvement in efficiency. With normal two tower directional arrays the two element PARAN can be oriented at right angles to the tower line ensuring symmetry of mutual impedances and closer spacings may be used. We offer these as tools for the ingenuity of broadcast engineers.

Monitoring the amplitude and phase from a set of PARAN's can be done at the geometric center of a set, or if the application warrants sampling loops on all towers with a phase meter reading the vector sum of a set.

A number of PARAN 501 kilowatt antennas are in broadcast use overseas. They have also been sold to the United States Government for other purposes.

The basic principles of antenna theory can be used to properly engineer the total system for conformance with the FCC Rules and Regulations as they apply to broadcasting in the Untied States.

Two basic 4 element models are offered which are 50 and 100 feet high. The system can be extended to even lower heights with the use of more elements if the need arises.

**C. Brian Cox**

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# Enhancing AM Signal Coverage Through Improved Modulation Techniques

This paper will describe the various testing procedures that have brought about a new breed of AM transmitters, transmitters that have been designed to enhance the AM signal through improved modulation techniques.

To prove this difference in transmitters performance, we have compared the Gates model MW-5, 5 kw AM transmitter, using the patented PDM modular, with *older* high-level plate modulated transmitters. Before we get into the various tests performed, let's review briefly the signal processing which has changed greatly over the past ten years and which affects the performance of transmitters.

First, we had the old tube type limiter with a one msec, thumping, attack time, which held the modulation levels fairly low.

Soon, the Solid State Limiter with an attack time of one usec, a compression ratio of better than 30 db, and without thumping, came into being.

This limiter picked up 2 db in a transmitter that had good positive peak capability. At this time and point, it was noticed that the transmitter would not continuously hold the negative peaks at 95% and the positive peaks at 120%. The answer then was to add a *clipper* to the output of the limiter to chop off any overshoot, thereby, holding the output at 95% and 120% positive.

However, the transmitter was modifying the input wave and causing overmodulation and distortion. If audio is clipped by 2 db, the loudness should also increase about 2 db, assuming a fast limiter of 30 db compression before the clipper. However, when this clipped audio is fed into the transmitter, the peaks must be reduced and only 1 db of loudness is attained.

What in the transmitter is causing us not to get the desired results without distortion?

With heavy processing, the modulator currents are now changing the loading on the high voltage power supply by two to one. Any *bounce* of the power supply, modulation components, or feedback is significantly affecting the transmitter output.

The first solution was to use separate power supplies, one on the modulator and one for the RF. This nearly eliminated carrier shift and increased the positive peak capability to nearly 170%. But, this still didn't solve all the problems. After carefully evaluating all of the above facts, we have designed the new PDM transmitters to handle highly processed waves.

Let's now discuss the design criteria for the PDM transmitters.

*First*—Our design should consider phase shift. Poor audio phase linearity can modify the input wave and cause overmodulation. Because AM is basically a narrow band system when connected to an antenna, the *high* frequency and *low* frequency phase shift must be considered separately:

(a) *Low frequency phase shift.* The cure to low frequency phase shift is to build a DC coupled transmitter whose gain, phase and linearity were perfect to DC. The PDM (Pulse Duration Modulator) is the answer. After all, PDM is nothing but a highly efficient regulator in series with the power supply and the PA tube. It is DC coupled and has basically "*0*" phase shift. Consequently, low frequen-

cy response, gain and linearity problems are solved.
(b) *High frequency phase shift.* Even though a transmitter has "0" phase shift at the high end, the problem can return when the broadcaster connects this transmitter to the antenna. The best answer is a compromise. We chose to taper the feedback and gain, to match the high frequency phase shift of the transmitter and match what could be expected in the user's antenna.

*Second*—Design criteria—*bounce.* Between the power supply, the modulation system, and feedback, the usual transmitter can have up to 20% bounce. This will not show up as carrier shift because the bounce is both positive and negative.

One cure is throw out the madulation transformer and modulation reactor. *But, be careful. The modulation reactor is also a filter inductor.* We may take it out of the modulation circuit but just put it back as a filter inductor in the high voltage supply.

Then our problem is back—*unless*— we go to a 12 phase power supply. The conventional star or 6 phase supply is normally used, however, it is difficult to get adequate filtering without using a choke or humbucking which is also *unacceptable.* Hum in a 12 phase power supply is over 40 db down under balanced line conditions with *no filter.* By adding a filter capacitor, a very tight power supply with adequate filtering can be attained.

The final touch is to add DC feedback around the entire transmitter and nearly eliminate carrier shift and bounce in a PDM transmitter. We use this system in both the MW-50 and MW-5 transmitters.

We have now designed a new transmitter to cure the problems discussed earlier in this paper. You say—prove it! Okay, let's go to it.

Let's take an old transmitter which has been known to be loud and clean and compare it with the MW-5 PDM transmitter.

*First*—We ran a proof on both transmitters and the response, distortion, and carrier shift were about the same. The MW-5 has slightly lower distortion, a little better response, and "0" carrier shift, but the differences are so small, it could be the test equipment. This proves one of two things. Either the new transmitter is no better or the old tests are not adequate.

I'm sure the new transmitter is better so let's run some less standard tests before we perform the real test—that of the *program material itself.* The first group of tests will be using tone bursts of different frequencies. First, a 20 Hz tone burst using four on and four off pulses is used in an attempt to excite the transmitter similar to a music beat. Maybe this will shake out some problems not seen in a standard proof.

Figure 1 shows the old transmitter. The bright line shows the input and of course, the other scope input is the modulated carrier itself. It can be seen that the

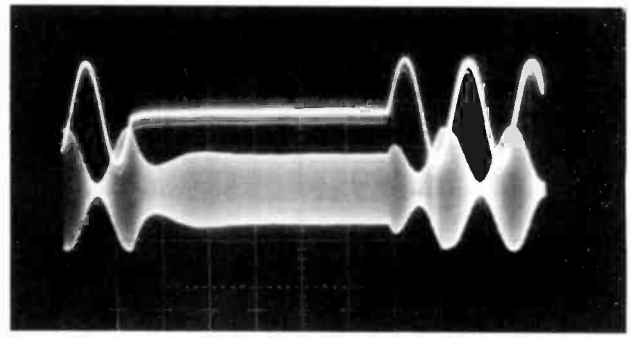


**Figure 1**

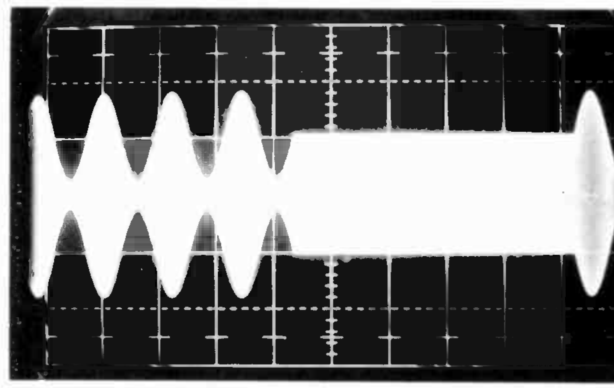


**Figure 2**

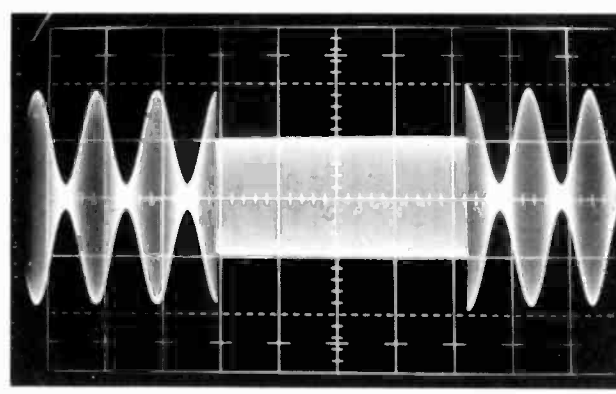


**Figure 3**

transmitter has a hard time getting started and after it does, the audio stops, the transmitter does not. *This is bounce!*

If full modulation were applied immediately after the tone burst, the transmitter would have over-modulated in the negative direction and then as the carrier bounced positive, it would have overmodulated in the positive direction.

Figure 2 shows the MW-5 under the same condition. *A perfect reproduction. No modulation problems and no bounce.*

Figure 3 again shows the MW-5, but this time the tone was stopped at high level of modulation to see if any other resonance or overshoot could be seen. *None is noted.*

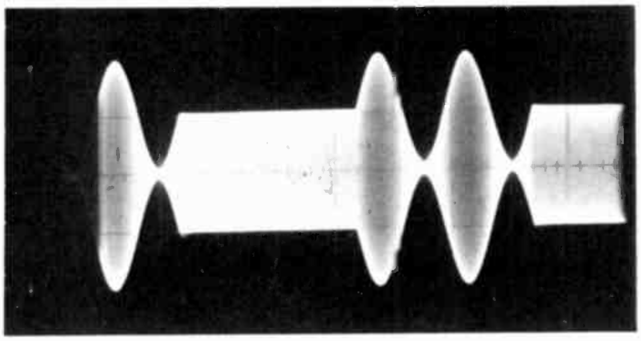


Figure 4

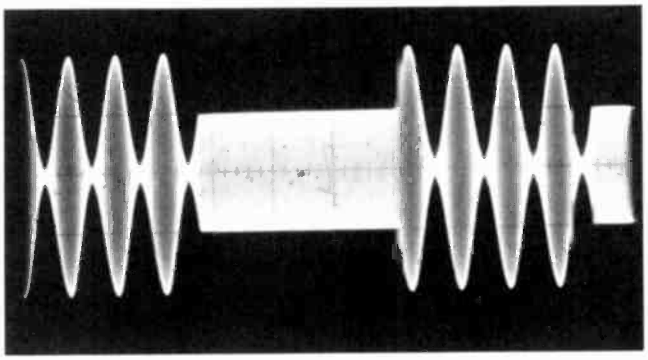


Figure 5

Figure 4 shows the MW-5 with a 50 Hz tone burst with two on and two off cycles. Again a perfect reproduction.

And last, figure 5 shows the MW-5 with a 1000 Hz tone burst with a perfect reproduction.

So far, we have proved that the music beat may be exciting the bounce of a transmitter not designed for heavy modulation. What happens when the clipper is added? How might the two transmitters perform now? Let's compare them using square waves.

First, let's look at the old transmitter, using a 100 Hz square wave (figure 6). The output is very tilted, which could lose all the power the broadcaster expected to gain by using clipping.

If our new design is any better, it should perform better than this at a lower frequency. Let's move the frequency down to 30 Hz or about two octaves below the tests for the old transmitter and see how the new performs.

Figure 7 shows very little tilt or overshoot two octaves below that test performed on the old transmitter.

At 50 Hz, figure 8, even better yet.

Let's go back to the old transmitter using a 1000 Hz square wave. Figure 9 shows a good reproduction. I'm sure this would be very acceptable during clipping.

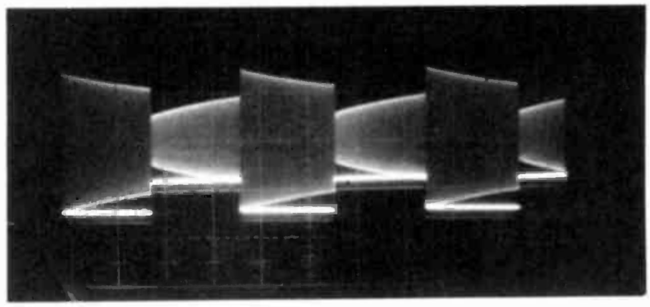


Figure 6

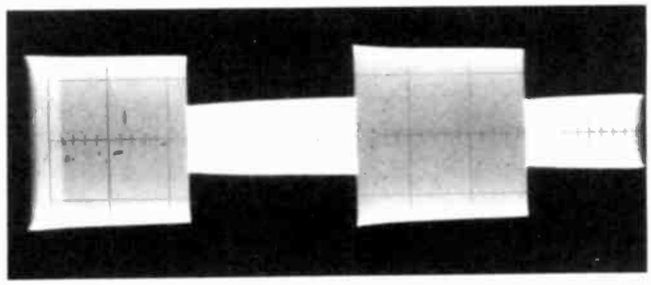


Figure 7

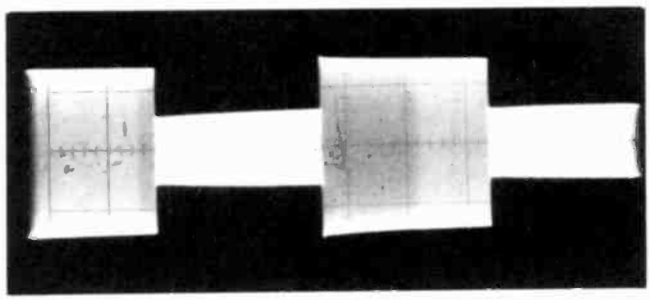


Figure 8

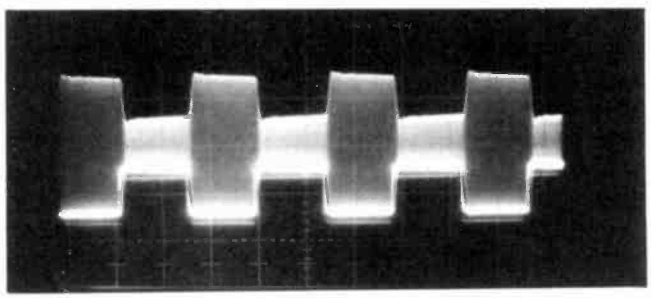


Figure 9

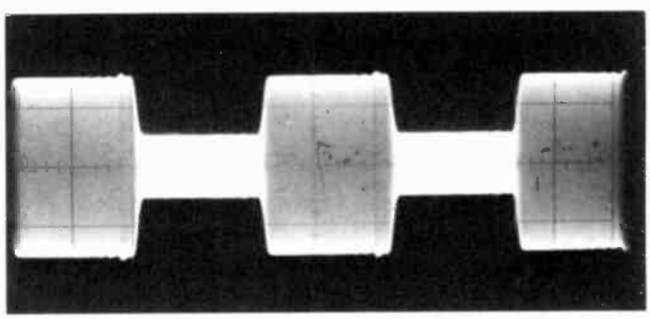


Figure 10

Figure 10 shows the MW-5 using the same test. The wave is even sharper and flatter than the old transmitter. *Most important,* very little ringing or overshoot can be seen. In trying to stretch the high end response, overshoot can show up destroying all that was gained in the low end.

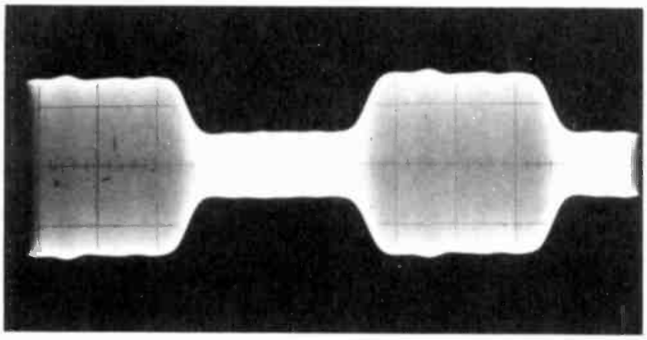


**Figure 11**

Figure 11 shows a 3000 Hz square wave through the MW-5. Very little ringing or overshoot, but the effects of a limited bandwidth system can be seen.

Let's further test the new transmitter and see how it does at high modulation level. Square wave testing, when done, is normally at 50% modulation. The broadcaster uses the transmitter at 100% modulation so let's go to a pulsed and clipped sine wave and see if any problems show up.

We will use a dual trace scope so we can monitor the input and output at the same time. A good scope capable of measuring DC and having a chopper must be used for meaningful information. An AC coupled scope at 30 Hz is useless.

*First,* a 30 Hz clipped sine wave using one pulse on and one pulse off. Figure 12 shows the input (the white or bright line on the top side of the envelope) is tilted at the negative peak due to a problem in the negative side of the clipper. I left the problem to see if the transmitter would follow the tilt on the negative and squared wave on the positive. As you can see, the transmitter hardly modified in input.

Figure 13 shows a 500 Hz clipped and pulsed sine wave going through the MW-5. Looks perfect to me.

Figure 14 shows a 300 Hz clipped and pulsed sine wave. Although the wave was slightly modified, due to the limited bandwidth of AM, it did not overmodulate or cause any problem.

And last, figure 15 shows a 500 Hz test as before. A little more of the limited AM bandwidth problem is showing but still *no overmodulation*.

Our last special test is to prove the transmitter is capable of high positive peaks and little or no distortion. The best proof, at least as far as I'm concerned, is a ramp test. The ramp is asymmetrical and will not

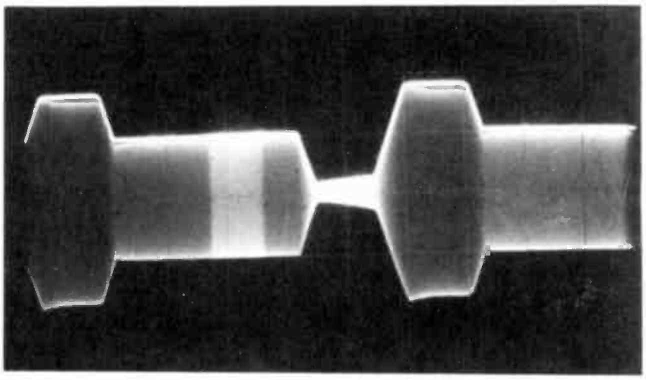


**Figure 12**

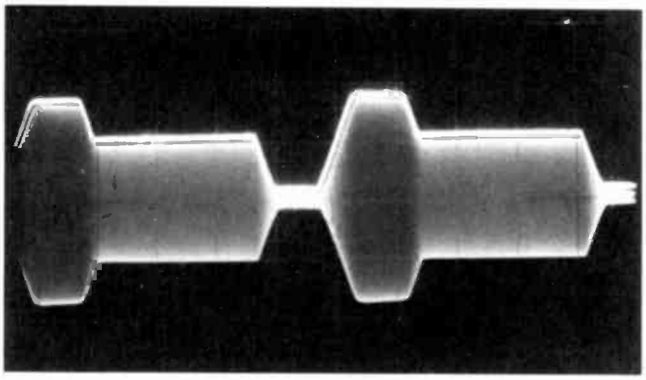


**Figure 13**

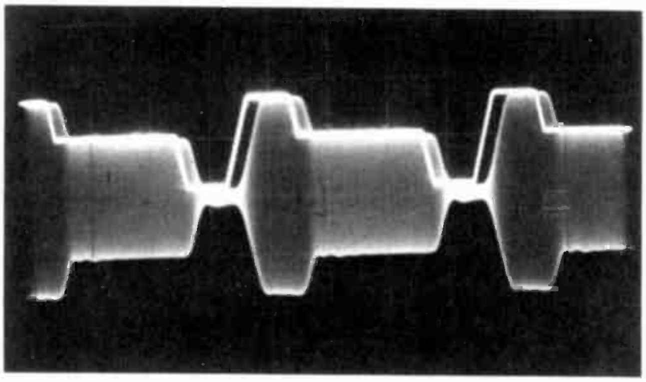


**Figure 14**

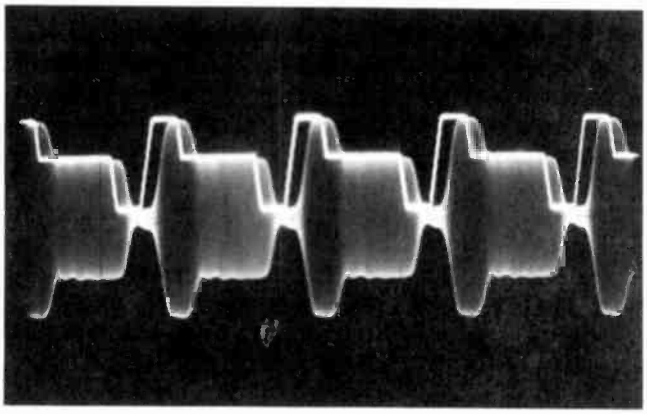


**Figure 15**

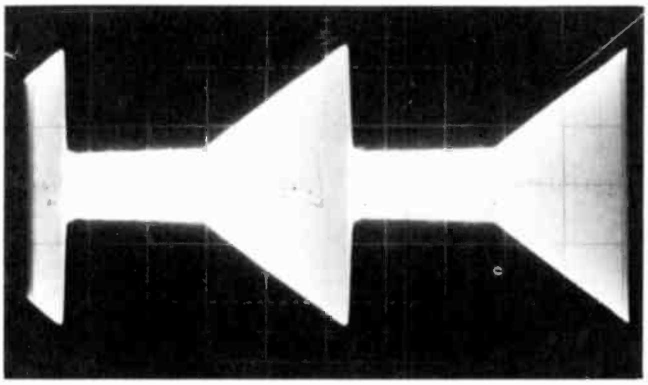


Figure 16

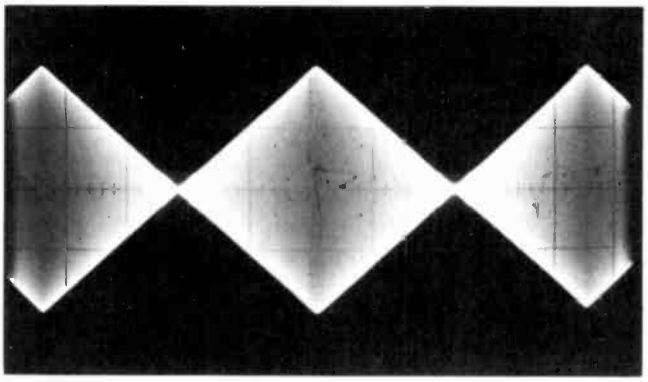


Figure 17

cause overmodulation on the negative peak while looking at the positive peak performance.

Figure 16 shows the MW-5 modulating to about 135% (dotted line on scope is +100% modulation) on the positive peak and about 50% on the negative peak. This ramp has many frequencies in it. The repetition rate is 500 Hz but the rise time of the ramp has frequencies less than 500 Hz, the fast down time is much greater than 500 Hz and the lower flat part is nearly DC. A good overall test.

Finally a saw tooth test, figure 17, to check the linearity down to 100% negative and up to 100% positive. Again near perfect reproduction.

If the explanations given and the tests shown prove anything, the new MW-5 should be able to operate on program audio must better than the old one. Let's face it, transmitters are *not* programmed with square waves, pulsed since waves, or saw tooth waves, they are programmed with a *complex wave* which cannot be simulated. So, let's use the complex wave.

Again, let's set the scope up so it can look at the auido input to the transmitter and the carrier output at the same time. Again, a dual trace DC coupled scope is used. The transmitter is treated like a black box. One trace on the scope is connected to the input audio wire going *to* the transmitter and the other is connected to the RF going *out* of the transmitter.

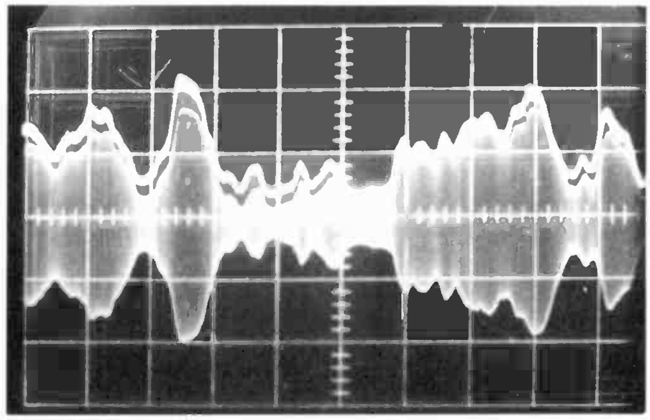


Figure 18

First, the old transmitter. Figure 18 shows the output not following the input (bright line) by a large amount. The transmitter is bouncing but otherwise following the audio. Figure 19, the old transmitter, shows much the same. The modulation level is held down because of the bounce. The positive peaks are undermodulated and the negative peaks are overmodulating with respect to the input.

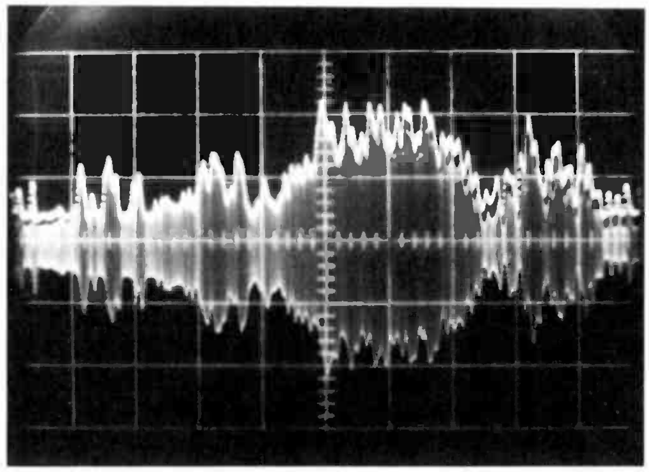


Figure 19

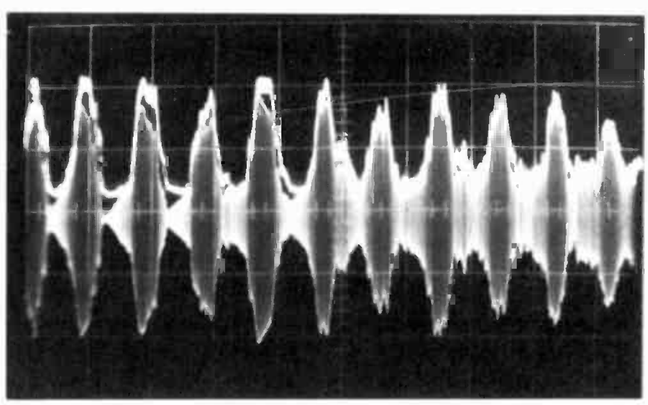


Figure 20

Figure 20 shows the old transmitter after a clipper is added. The input is held to about 80% modulation but the output of the transmitter has overmodulated due to bounce, tilt and overshoot. Holding the input level to average peaks of only 80% is causing overmodulation. 2 db is being lost.

Now, let's look a tour new transmitter, the MW-5 and see how it does under the same conditions.

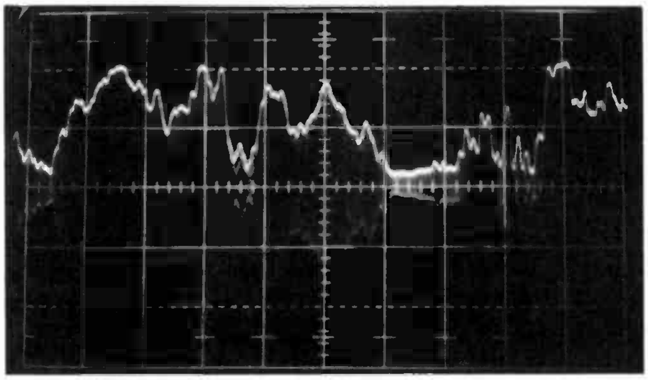


Figure 21

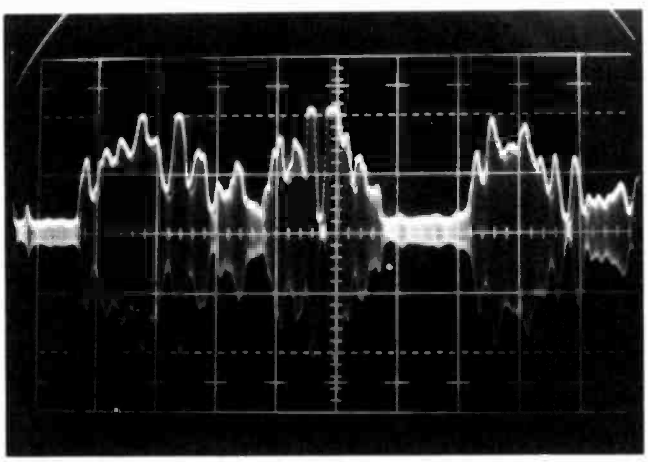


Figure 22

Figure 21 shows a little clipping being used and the input and output following almost exactly. Figure 22

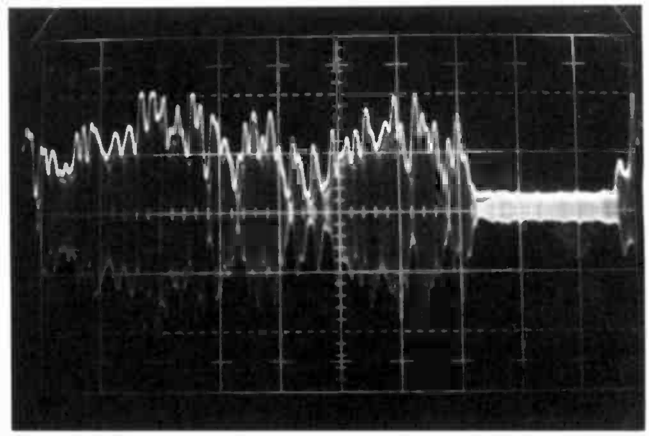


Figure 23

shows the MW-5 with more clipping on the input audio but the transmitter still holding nearly perfect.

Finally, I turned up the clipper until I didn't care to listen to it and *caught this picture.* (Figure 23). Here's some *really violent* clipping and the transmitter nearly made it. It overshot only slightly on this long clip. Notice, no bounce even after this really hard hit.

In summary, what the the features of a properly designed transmitter that will handle *square waves, pulsed waves, saw tooth waves,* and *complex waves:*

1. Low distortion
2. Excellent frequency response
3. High positive peak capability
4. Low or no carrier shift
5. Excellent transient response
6. Increased reliability
7. A cleaner and louder signal

Transmitters and audio processing have advanced rapidly in recent years. Equipment that has the characteristics I have discussed, will give significantly improved listener coverage, and a dominating sound for your area.

**Frank Zeman**

*President,*
*Minneapolis Magnetics, Inc.*
*Minneapolis, Minn.*

# Maintenance Considerations—Magnetic Tape Heads

The use of magnetic tape as the preferred medium for audio work in broadcasting is continually increasing. Today, many stations are approaching total automation of program material. . . an innovation made possible by some highly creative ideas which have been coupled with standard approaches. But all of it based around magnetic tape.

Despite this tremendous dependence on tape, there is a great deal of misinformation, confusion and downright fear on the part of many technicians when it comes to the rather small, touchy component which makes it all possible . . . the magnetic tape head. Stalwart types who wouldn't bat an eyelash about digging into the innards of a bewildering array of highly complex and sophisticated gear will start twitching and dive into the nearest storm cellar before getting involved in any way with the heads on their tape equipment.

Why should this be so? How did it come about, and what can be done to correct it? A little history might be of help in understanding how it happened.

When professional tape recording equipment first appeared on the market (and for a good many years thereafter), the head assembly was assigned a mystique which it has held ever since. Heads were strictly a no-no insofar as poking and probing were concerned.

They usually were housed in a formidable protective enclosure, shielded as much from wandering fingers as from stray hum fields. A careful check of the operating and service manual supplied with the equipment would furnish practically no information about the heads themselves. Other than indicating the single screw or nut to turn for azimuthing the head gap, the manuals were almost useless.

The mere thought of the owner trying to replace his own heads was severely frowned upon and this added to the mystery of just what went on inside that head housing. As time marched on, each manufacturer of professional tape equipment tended to make it more and more imperative that head replacement was strictly a job for the factory and should not be attempted in the field. Fortunately for all of us, this trend has been sharply reversed in recent years. While it is still different to get precise information about the heads used in a given machine, the situation is improving and shows promise of continuing in that direction.

Just to complicate matters further, those of us who are in the business of producing magnetic tape heads for use on professional equipment haven't exactly bared our souls either. I am hard put to think of a single head manufacturer who has ever disclosed any of the processes he uses to get his product together. It's true that many things are proprietary and closely held "trade secrets," but it is no excuse for our failure to outline the basic procedures used.

Making magnetic tape heads is an art, not a science, and this should be kept in mind.

Another thing which we believe has helped to perpetuate this shroud of secrecy is the fact that a well-made, professional tape head will give excellent performance over an extended period of time. So little trouble is encountered with such heads (until they near the end of their useful life), they are almost always the very last thing to be looked at in attempting to correct performance problems.

I have personally seen recording and reproducing amplifiers checked to a fare-thee-well in a frantic search for a defective part when the whole difficulty centered around a worn-out tape head. In a way, this is a left-handed compliment to the tape head business, but it doesn't do much to relieve the frustration of spending many hours looking at everything *except* the tape head!

Before we get into maintenance considerations, let's spend a few moments getting acquainted with the item we propose to lavish this maintenance on. To us, a magnetic tape head intended for use in professional audio work must meet certain basic requirements which by definition put it in the professional class.

First, it must be designed to perform in accordance with the specifications of the equipment it is intended for.

Second, it must be built to deliver that performance over a very lengthy span of time without frequent re-alignment of the electronics.

Third, it must not drastically change characteristics during its useful life and

Last, it must do all these things and still be competitive in cost.

That is quite an order!

Now let's take a look at what a tape head is made of. Figure 1 shows a group of loose laminations ready

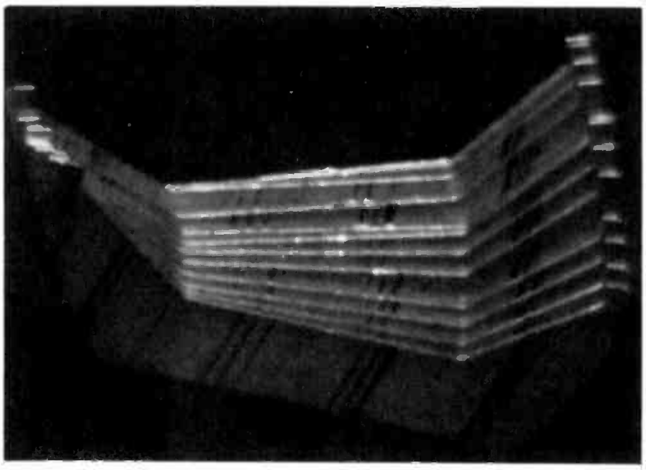


**Figure 1. Loose Laminations for a Tape Head**

for use in making up a stack or core. These lams are produced by high precision stamping dies. Various thicknesses are used. These are .006".

The metal is a high permeability alloy called HyMu 80 or HyMu 800. After stamping, each lamination is given a high temperature anneal and is then slowly and gradually cooled. This process gives the material its permeability. Before annealing, the metal is quite tough . . . comparable to stainless steel. After annealing, it is very soft and quite strain sensitive. Mis-handling damages the permeability so the laminations must be handled with great care.

For this discussion, permeability may be defined as that property which enables a material to become highly magnetized when in the presence of a magnetic field, but to lost its magnetism when the field is removed. Were this not the case, it would be impossible to make a high quality recording, because the head (if it remained magnetized after the field were removed) would start erasing the recording just made in much the same way a bar magnet would.

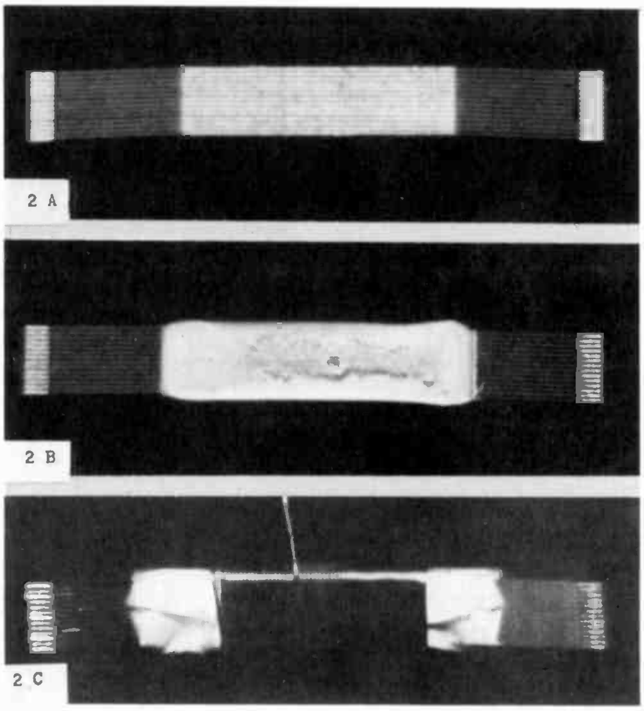



**Figure 2. A Finished Stack, Insulated and Wound with Coil**

Figure 2A is a finished half stack or core. Each lamination is clearly recognizable and the entire surface of each lam is coated with an oxide which serves as an insulator between it and all the other lams in the stack. This is done to keep eddy currents at a low level.

Figure 2B shows a finished half stack with insulation around it. The coil will be wound directly on the insulation, as shown in Figure 2C.

Figure 3A is a half section which contains the precision core holder and two half stacks with the coils. A mating half section will be used to complete the head. Figure 3B shows the same half section after the entire top surface has been lapped to very close tolerances.

Figure 4 shows the same lapped half section after polishing. The shields which go above, between and below the two channels of the head are now installed and the mating half section assembled to it.

Figure 5 shows an assembled head with the gap material protruding at the center. Right now it's an ugly little thing, but grinding, lapping and polishing will turn it into a thing of beauty. The head is now potted to completely encapsulate the interior and ready it for finishing.

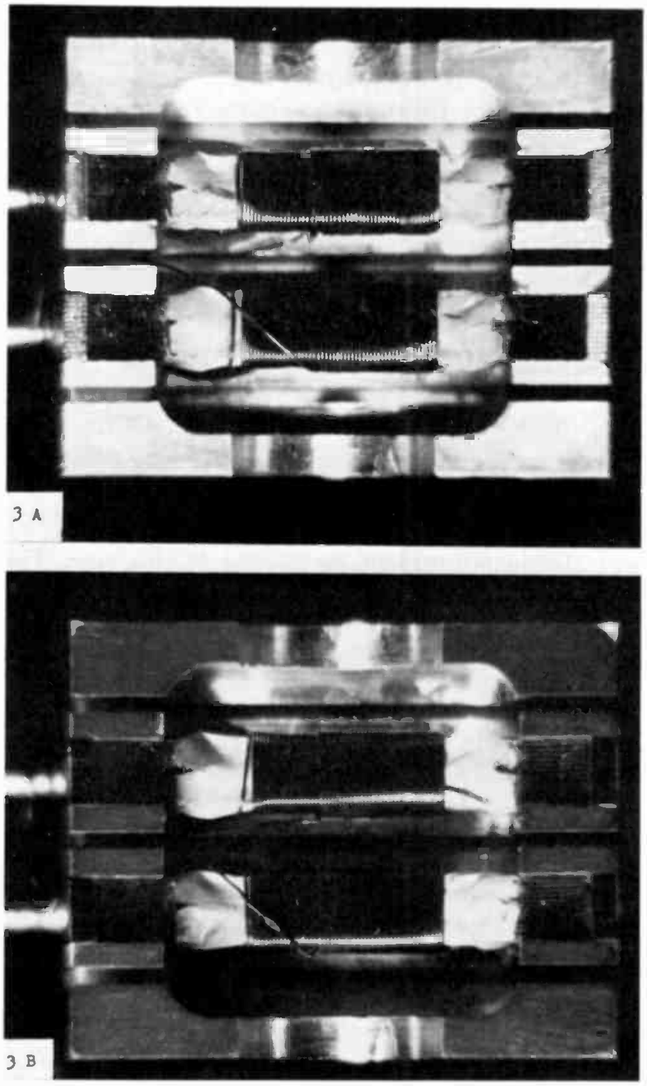



Figure 3. Two Mating Halves with Coils

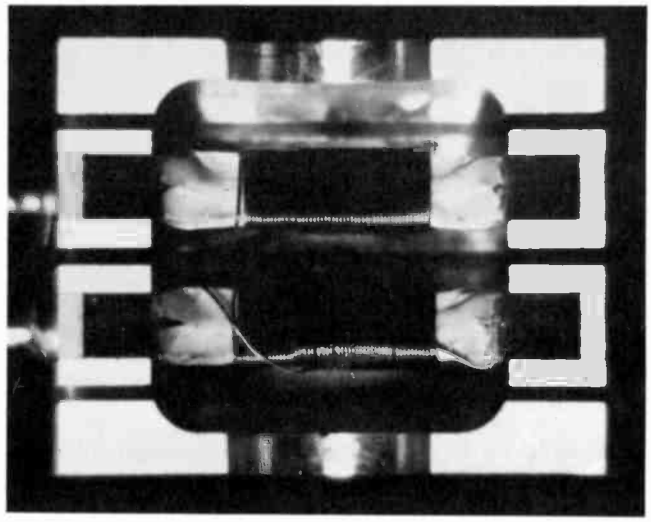


Figure 4. The Half Section After Polishing

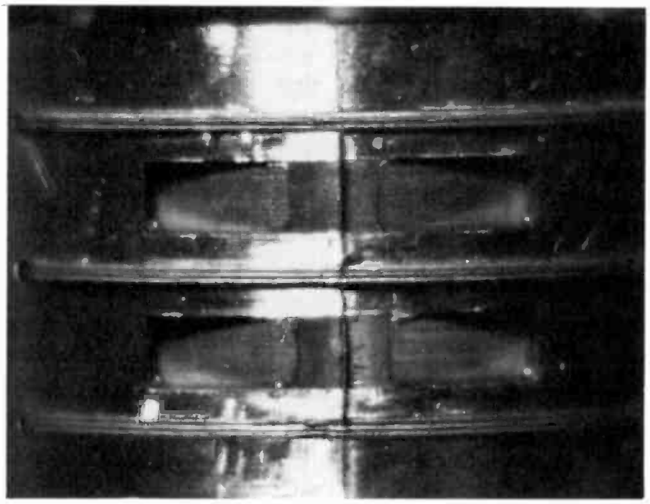


Figure 5. A Head Assembled for Finishing

From this point on, everything had better be strictly "go" because no corrections or changes are possible. Should any injury or defect show up now, the whole head must be scrapped.

The next step is to decide the contour to be used on the head face. Which shall it be, cylindrical or hyperbolic? Both have their merits and disadvantages.

A hyperbolic contour is a decided advantage in situations where tape contact with the gap is a problem due to low back tension in the tape. The big disadvantage is that the contact *area* is quite small and wear of the head is greatly accelerated by concentration of the tape over a relatively small area of the head face.

Since most professional tape recorders use a considerable amount of back tension to hold the tape firmly against the heads, we use a cylindrical contour on all our heads intended for use with these machines. This greatly reduces the rate of wear. By also leaving .025" depth of metal at the gap, long life is assured.

The classic and humbling example in the cylindrical vs. hyperbolic controversy is the erase head stack used on the old Magnecord PT-6. This machine has an erase head stack approximately $\frac{3}{4}$" wide and the tape travels over the entire cylindrical face of this stack. In 17 years, I have never seen *one* that was worn out! We have relapped a tremendous number of these heads and are still waiting to see the first useless one show up! This is remarkable when you also consider that the design of the PT-6 was such that the tape was ALWAYS on the erase head, even in fast forward and rewind!

Figure 6 shows three completely finished 2-track stereo heads, ready for testing and installation in a recorder. Because of the highly polished surfaces, it is almost impossible to photograph these heads without "hot spots" due to reflection. None of the photographs were retouched to remove this.

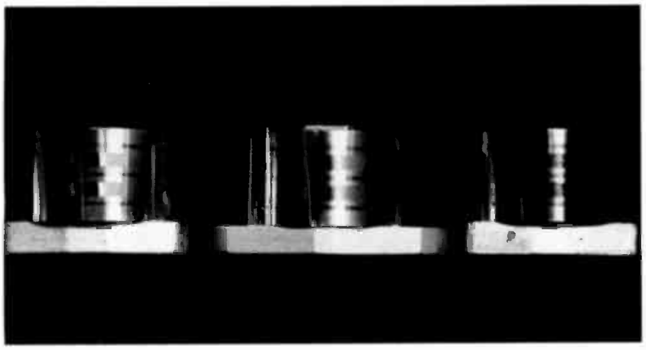


**Figure 6. Three Tape Heads Ready to be Installed**

So now we have this finished component available to us for installation. A lot of work has gone into it because the quality of signal you send out is utterly dependent on it. If you don't get it here, you don't get it.

The head face is particularly vulnerable to scratches, nicks or gouges which will really foul up performance. We suggest that before installing *any* tape head, you cover the entire head face with a strip of heavy, adhesive-backed plastic tape to protect it during installation handling. With this single exception, a tape head is a fairly husky device. Once the head is installed, the tape should be removed and the head face cleaned prior to making any adjustments.

Installation of new heads on nearly all professional tape equipment involves four mechanical adjustments which must be made correctly to assure optimum performance and long service. This is the primary maintenance consideration.

After these adjustments are made, the electronics are checked out and aligned in accordance with the instructions in the owners manual. Nearly all manuals are quite explicit about electronic alignment and the information given should be followed without deviation if you expect the recorder to meet its specifications. Keep in mind that there is no so-called "standard" for electronic alignment of a tape recorder . . . not even between two different models from the same manufacturer. So the golden rule here is: CHECK THE MANUAL! And that means the manual for the specific model involved!

Before any final adjustments are made on a new head, it should be visually squared up in its mounting after installation to minimize the degree of adjustment required.

The four mechanical adjustments required by new heads are: Height, Zenith, Contact and Azimuth.

Since tape travel from the supply to takeup reels is controlled to close tolerances, it is obvious that these four adjustments are made to align the tape head to the tape. The guides and other tape path controls should never be adjusted so they conform to the head position. The tape path represents the standard. If you alter it in any way, you no longer have a valid reference.

All the line drawings which follow utilize a 2-track stereo head for illustration. Figure 7 shows the cor-

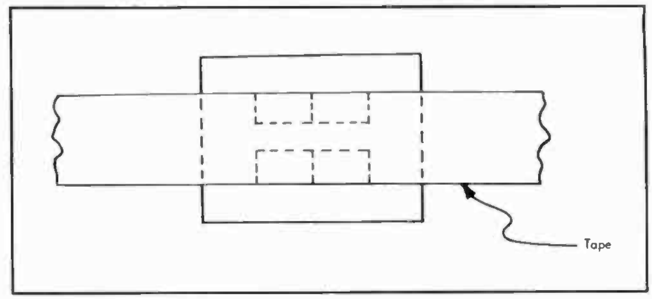



**Figure 7. Correct Height Adjustment (Front View)**

rect Height adjustment for a head of this type. The head should be adjusted so the top edge of the stack in Channel 1 and the bottom edge of the stack in Channel 2 are even with the edges of the tape. This is usually accomplished by two small Allen head set screws which are located at the center line of the head mounting plate but are sometimes placed to one side of this plate. If these screws are on one side, the opposite side has wells containing two compression springs to supply the pivot action necessary to azimuth the head gap. Regardless of where these two set screws are located, they serve a dual function. Not only do they adjust the head for Height but they also serve to adjust it for Zenith or tilt.

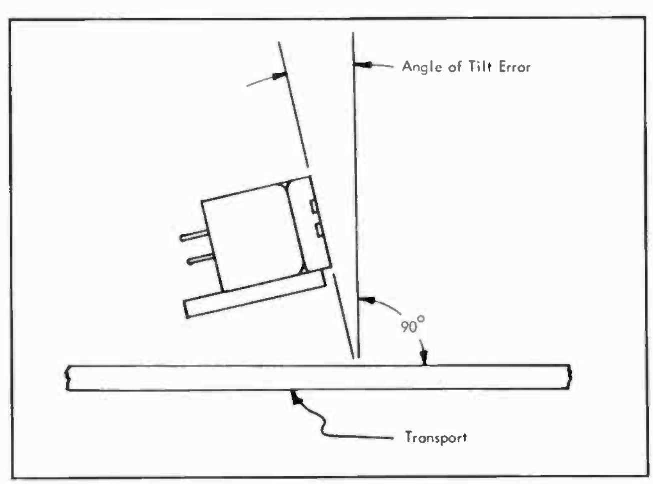



**Figure 8. Misaligned Zenith Adjustment (Side View)**

Figure 8 is an exaggerated view of a head incorrectly aligned for Zenith. The head face should be at a 90° angle to the transport base plate. Any appreciable deviation from this angle will result in marginal tape contact which won't be so noticeable when the head is new but will show up markedly as wear progresses.

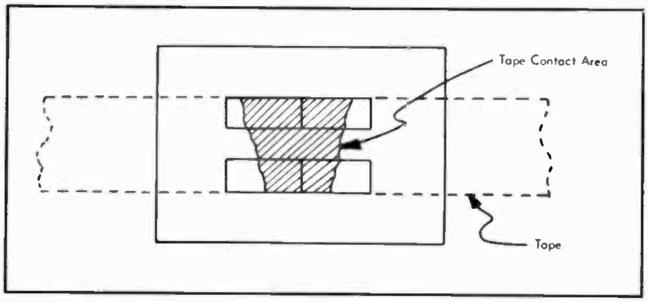



**Figure 9. Keystone Pattern (Front View)**

Figure 9 shows the result of incorrect Zenith alignment. In this case, the head was tilted downward toward the transport base plate at the time it was installed. The keystone wear pattern indicates excessive tape contact at the top of the head and insufficient contact at the bottom. Had this head been tilted away from the base plate, the keystone effect would be reversed.

Keep in mind that any adjustment you make to the head Height is likely to also alter the Zenith and vice-versa. These two adjustments are directly interrelated and must be cross-checked against each other until both are correct.

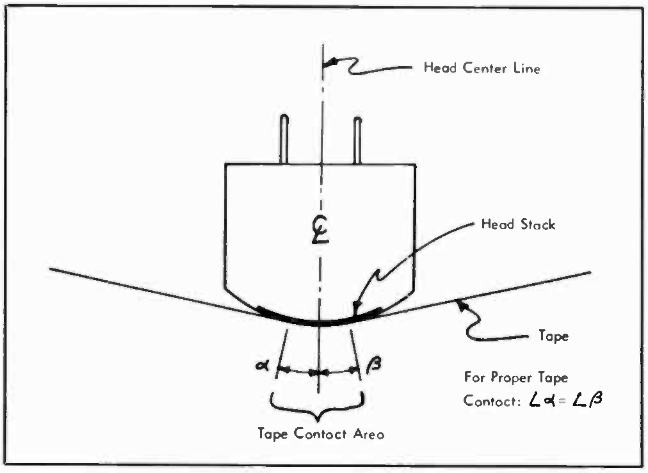



**Figure 10. Proper Tape Contact Adjustment (Top View)**

Figure 10 is a top view of the adjustment for proper contact. As indicated, using the center line of the head as a reference, the formula for correct contact is: Angle Alpha = Angle Beta. To say it another way, the tape should contact the head face an equal amount on either side of the gap.

Figure 11 is a front view of this same adjustment. Contact alignment is accomplished by rotating the head cup or assembly mounting block until the head face is positioned properly.

Thus far we have covered three of the four essential mechanical adjustments which must be made to any new heads installed in most professional tape

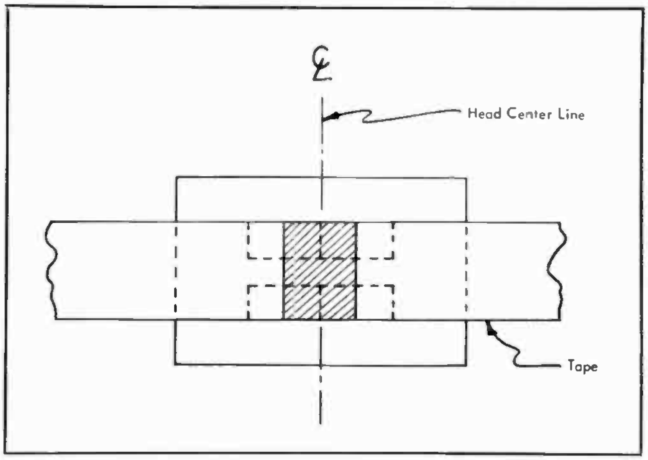



**Figure 11. Proper Tape Contact (Front View)**

equipment. At our plant in Minneapolis, we do a lot of head assembly refurbishing and head installation for our customers, so we have the precision gauges, jigs and fixtures to simplify the work. This is small consolation to anyone who must or prefers to install their own heads. How can you tell when these adjustments are correctly made (within reason) with nothing more to go on than your eyeballs? Here is one technique that works very well:

Use a black marking pen with a soft felt tip to coat the head face from top to bottom and about ¼″ on either side of the gap. Run some tape through the machine in the Play mode. Five or six feet should be enough. Stop the machine and check the head. The tape will have removed the ink from the head face and this clear area can be used to check for Height, Zenith or Contact. The ink can be removed with a cotton tipped applicator and most head cleaners will dissolve it. If yours won't, lighter fluid will. Be sure to clean the head between each adjustment check. The tape you use to wear off the ink shouldn't be a prized master, but it mustn't be worn out or distorted either. The marking pen should be new and the felt tip not contaminated with foreign particles which could scratch the head face.

Figure 12 shows the final mechanical adjustment required by a new head . . . . Azimuth.

The reproduce head gap must be perpendicular to the tape so that all tape equipment conforms to a standard setting, thereby permitting interchangeability of tapes between one recorder and another. Although Azimuth is adjusted mechanically, it must be done while playing a standard alignment tape. At a speed of 7.5 ips, a frequency of at least 12 kHz should be used, with 15 kHz preferred.

As the head is slowly rocked from side to side, the output of the head will increase and will reach its maximum level when the head gap is directly lined up with the recorded high frequency on the alignment tape. This establishes the reproduce head as a standard for setting Azimuth on a record head . . . .

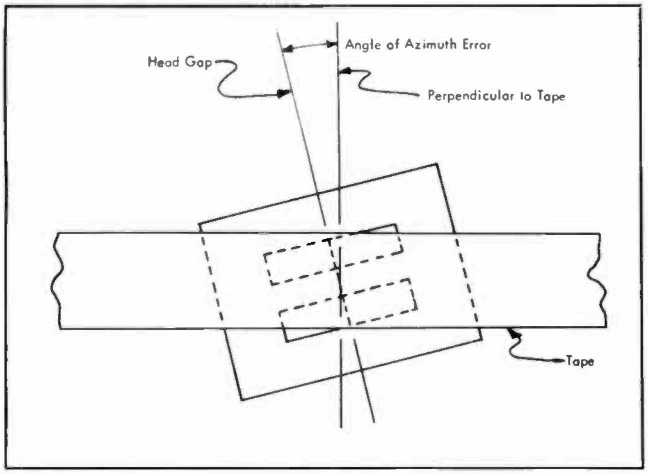



**Figure 12. Improper Azimuth Adjustment (Front View)**

which is done by removing the alignment tape, threading a blank tape on the machine and recording a 15 kHz tone while monitoring it with the reproduce head.

The record head is slowly rocked from side to side while recording this tone until maximum output is obtained from the reproduce head monitoring the recording. At this point, the gaps of both record and reproduce heads are properly Azimuthed. The slight time lag caused by the distance between these heads should be taken into account when azimuthing a Record head.

So now we know something about how a head is made and how it should be adjusted when new heads are installed. What are the symptoms or signs of a head nearing the end of its useful life? What are the major things to look for?

Electrically, as wear progresses on a reproduce head, the inductance of the head drops and the high end begins to fall off. As you begin to peak up the high end response with the equalization adjust, you will note that beyond a certain point, boosting the high end causes a hump in the response further down the line until you get such a hump (usually in the 4 to 6 kHz region. The head must be replaced in order to get smooth response throughout the audio spectrum as specified by the recorder manufacturer.

In the case of a record head, as wear progresses the inductance also drops and the head requires less and less bias current as wear progresses. This in turn affects the audio current required for an operating level recording and also requires readjustment of the recording equalization. If the heads are not replaced at this point, the process just outlined repeats itself with greater frequency until finally the gaps abruptly open and satisfactory performance is impossible.

In addition, there are performance difficulties encountered which are not electrical in nature but show up as electrical malfunctions in the form of dropouts, erratic output (starting first at the high end and working down the audio range as the condition worsens), warbling, and a wide assortment of weird sounds caused by variations in tape contact, and wandering of tape due to wear grooves.

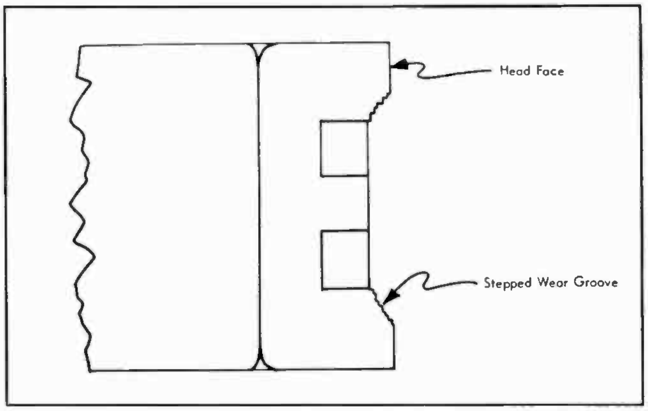



**Figure 13. Wear Groove (Side View)**

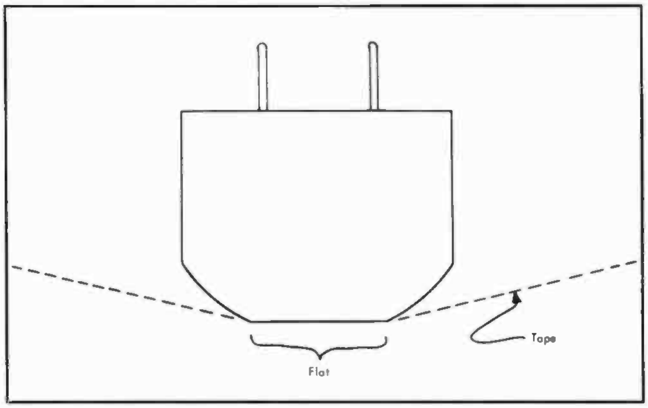



**Figure 14. Wear Flat (Top View)**

Figure 13 shows an exaggerated view of the step effect in a deep wear groove. Originally, the groove was fairly straight as it wore into the head face, but as wear progressed, the edges of the tape (which are not as rigid as the center portion), tend to cup and become rippled. The point at which the edge curls and firm contact begins starts another groove. Tape of varying widths can also cause this condition.

Figure 14 shows the flat that is developed in a head face as wear progresses. This flat exists regardless of whether a wear groove is present or not.

Some head manufacturers have tried to overcome the wear groove problem by undercutting the head face at the top and bottom edges of the stacks to eliminate the possibility of a wear groove. This technique does indeed eliminate the groove but *not* the flat. It has the added requirement of making the height adjustment extremely critical . . . so critical in

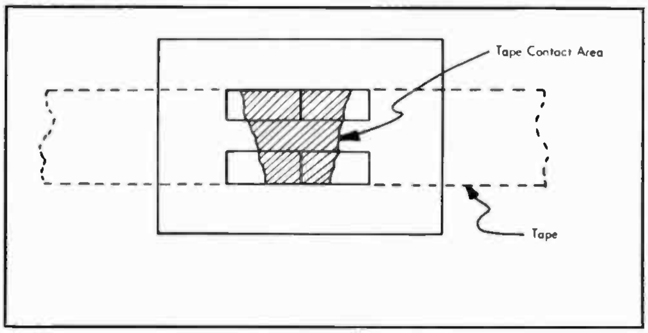



**Figure 15. Keystone Wear Pattern (Front View)**

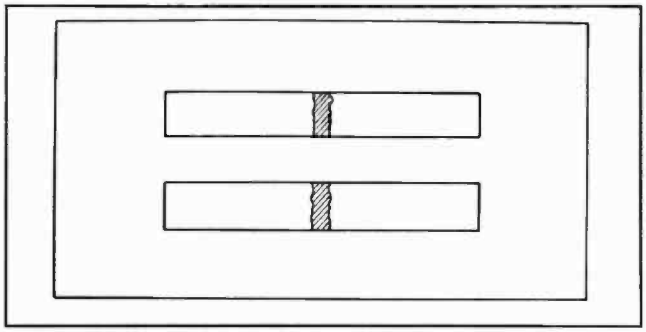


**Figure 16. Open Head Gap (Front View**

fact that an error of only .005" will create a condition where a wear groove will exist in one lamination of the entire head stack and develop into a nice tape slicer as time goes on.

This flat on the head face spreads the tape contact area over a wider and wider space, tending to create poor contact at the gap where everything takes place. The further this flat extends on the head face, the more difficult it will be to ensure good contact with the head gap.

Figure 15 shows the keystone wear pattern caused by improper Zenith adjustment. Once this pattern appears, the head should never be re-adjusted, as erratic contact and output will result.

In most cases where professional heads are involved, such a head can be relapped and polished. It should then be re-installed and the Zenith error corrected.

Figure 16 illustrates a head with a completely open gap. Such a head is fit only for the trash can and while it might be difficult to believe that anyone could use a head until such a condition occurs, we see them frequently.

In summary, the tape head is where the quality of your air signal begins.

It would be difficult to over-emphasize the importance of correct installation as primary maintenance to keep it in good operating condition at all times. Routine maintenance is not difficult. About all a tape head really requires is a regular cleaning, periodic de-magnetization and taking precautions to see it is not subjected to abuse by being hit in the face, scratched with sharp objects or otherwise mis-handled.

Treated with ordinary good care, professional magnetic tape heads will give you years of faithful service. They will also reward you with an air signal that is clean and clear . . . a pleasure to hear!

**Hartwell T. Sweeney**

*Eastman Kodak Co.*
*Rochester, N. Y.*

# Super 8—A Local Recording Medium

Gentlemen, it is a pleasure to have the opportunity to talk to you about the use of super 8 film as a medium for visual communications. Particularly, we appreciate the chance to talk to broadcast television people about what we think super 8 can do and what we feel are its limitations. If you will, we present this to be a progress report as *we* see it.

Eastman Kodak Company has recently introduced equipment and film which, while primarily designed for the business, industrial and educational communicator, may have applications in certain broadcasting situations. These new products provide new opportunities in communications media.

A portable color recorder, the KODAK SUPERMATIC 200 Sound Camera, has a fast, 9 to 21 millimeter zoom lens and a choice of 18-frame or 24-frame filming speeds, allowing recording in low-light situations. In addition, it has the ability to record sound . . . on magnetic prestriped film loaded in a cartridge. Using the KODAK SUPERMATIC 200 Camera, sound can be recorded on the scene just as news and documentary people do now.

The SUPERMATIC 200 Camera accepts the standard fifty-foot cartridge of super 8 film, or the new 50- and 200-foot cartridges, which allows up to 10 minutes of recording from one cartridge, at 24 frames per second.

The camera, with microphone and batteries, weighs about four pounds, making extremely portable. As a relatively inexpensive camera, it is not designed to be the rugged, heavy-duty, professional camera news departments are used to. However, it may provide new options in special applications. The camera and 200-foot cartridge should be available in mid-1974.

The second new product is KODAK EKTACHROME SM Film 7244. Its exposure index of 160 for tungsten or 100 with filter for daylight allows filming by available light. With its magnetic sound stripe, the realism of sound can be added while shooting, or wild sound can be added later after processing and editing. Fifty-foot and 200-foot cartridges will be available with or without magnetic-striped film.

With EKTACHROME SM Film 7244 camera-to-screen time can be less than 15 minutes—because processing time is only $8\frac{1}{2}$ minutes, or a 50-foot roll in $13\frac{1}{2}$ minutes, using the third new product in the family, the SUPERMATIC 8 Processor.

This machine has been designed to process EKTACHROME SM Film 7244 in a normal office environment. It requires no special illumination, no special ventilation, and no special photographic knowledge on the part of the operator. When a cartridge of film is loaded into the film load chamber and the "go" button pushed, the machine first does an instrument check. It checks for proper temperature and solution and replenishment levels. It makes sure the lighttight door is closed and a reel is on the take-up spindle. If any of these checks come up negative, the SUPERMATIC 8 Processor refuses to start . . . sounds an alarm . . . and indicates exactly what's wrong by a light on the control panel. When everything checks out, the machine starts processing and metering replenisher to to the tanks. A red indicator light signals that film is going into the machine. When the machine comes to the end of a roll, it automatically cuts the film and the light goes out. The film is wound on a take-up reel and ready to project.

After the machine has processed five thousand feet of film, a light on the control panel indicates "solution's gone," and when the machine finishes processing that roll, another roll cannot be processed until the chemicals have been changed. Changing chemicals is simple and the person who changes the chemicals needs to know nothing about photography or chemistry, or what chemical goes where. Bottles of premixed chemicals are all shape-coded, so the right bottle fits only in the right slot.

Since the machine meters the chemicals very precisely and replenishes them automatically, there is no need to run sensitometric strips, measure pH, or perform any of the technical operations normally associated with the control of motion picture processing.

While we have been discussing new products, it should be pointed out that the familiar KODAK EKTACHROME EFB Film 7242 will also be made available in the new cartridges and can be processed in the ME-4 process found in many television stations.

Super 8 processed film can be loaded in a cassette of the appropriate size. The cassette is easy to load, takes little storage space, is inexpensive to buy, inexpensive to mail . . . further, super 8 is a standard format, world-wide.

Using a KODAK SUPERMATIC 70 Projector, post recording can be added to the magnetic striped film. Film affixed to the reel is rapidly rewound into the cassette—either automatically at the end or at any time during projection, upon command.

The same cassettes that fit the 70 Sound Projector also fit our newest display option—the KODAK SUPERMATIC Film Videoplayer, VP-1. The videoplayer can be attached easily to the antenna terminals of any standard television receiver . . . or it can be tied into a television station's sync pulse and will generate NTSC video signal that can be broadcast.

The videoplayer is one of the most gentle film-handling devices in use today. The machine threads itself automatically . . . the capstan drive moves the film continuously and, at the end of the presentation the film is automatically rewound into the cassette. The videoplayer has freeze-frame and instant review features. Film can be advanced frame by frame . . . or at 18 frames a second . . . or at 24 frames a second. Because of its versatility, the videoplayer can be used to put film on the air from amateur stringers in your area, or anyone, for that matter, that has filmed an event in super 8. At this time, we know of no other equipment that can offer that possibility.

The networks and some major market stations have for some time been able to incorporate occasional newsworthy amateur 8mm film into their news broadcasts where appropriate. I'm sure most of you have seen the 8mm footage shot from the cabin of a 707 as fire burned off its outboard engine and wingtip—or the 8mm film of the presidential motorcade in Dallas in 1963.

The new products discussed today were developed in response to a widespread need for a convenient, low-cost method of portable color recording. They represent a significant advancement in the ease and economics of local color production, which we feel will extend the reach and impact of visual communications to applications and enterprises which up to now have not been able to afford it.

There are many customers in the television and CATV industries, and in business, industrial, education and government activities who have not been able to justify the higher quality but greater complexity of 16mm production, or who are situated in remote locations, away from film precessing facilities. There are also many who have extensive video facilities but who find remote color recording extremely expensive and inconvenient. It is to respond to these people's needs that these products are designed.

To even the untrained observer, there's a noticeable quality difference between super 8 and 16mm camera original films when viewed over broadcast quality film chains. Many of you probably saw comparisons of 16 and super 8 original footage on our telecine chain when our Videofilm Express visited your locale. Enhancement of the super 8 format provides a significant improvement, but even so for most broadcasters, the graininess and lack of sharpness would present an unfavorable comparison with high quality typical of today's practices.

It is, however, our belief that the super 8 products are so convenient, so easy to use, and their potential effectiveness so high, that they will be used by people who until today never thought of becoming movie makers . . . people whose vocation is not making pictures, but who will find super 8 a marvelously effective communication, persuasion, or selling tool for achieving their own professional objectiveness. We feel that these products make possible even the casual use of sound motion pictures for a whole series of potential new applications, such as instructional aids, field reports, student essays, customized sales presentations, and the like. Some of the applications may offer interesting possibilities for local programming as well as internal station communications.

In summary we believe that with the announcement of these new products, super 8 has truly become a communication tool of great potential value.

Application in broadcast television is still limited but super 8 may offer opportunities in situations such as small market area stations, cablecasters, distant stringer operations and the like to record the events of our day easily and acceptably *and* in color.

Kodak is proud of its association with the television industry and looks forward to continued developments in information accumulation and display technology to assist you.

**Dr. William E. Glenn**

*Director of Research*
*CBS Laboratories Division*
*Stamford, Conn.*

# A New Method for Cyclorama Lighting

*Co-authored with Salvatore J. Bonsignore, CBS Television Network*

The state-of-the-art dictates that almost all the cycloramas in TV and film be lighted by multiple incandescent light sources. Since cycloramas represent very large areas to be lighted the cost involved constitute almost 40% of the total lighting expenditure. This is true for any given lighting task where cycloramas are involved.

## Disadvantages of Present System

The major disadvantages of the present systems are optical and economical.

### *Optical Problems*

The incandescent sources are small and require many instruments to provide overlap and light blend.

The incandescent sources by virtue of their size do not provide a long linear line which would compliment the configuration of the cyclorama and provide more even distribution.

The optics associated with incandescent sources provide that the areas closest to the sources are brightly lighted while the light falls off rapidly as the height of the cyclorama increases. It is also necessary to place sources in close proximity to present black holes.

### *Economic Problems*

The present systems are very costly in terms of power. The average current requirement for a 3′ section of cyclorama 24′ high is 90 amperes at 120 volts.

The power requirement has a direct relationship to the air conditioning cost.

The number of dimmers required is in direct proportion to the amperage or wattage.

Color on the cyclorama is derived by the introduction of colored transparent gelatin filters in front of the light sources. The gelatin absorbs all colors in the visible spectrum not transmitted. This captures great heat in the color media and promotes its failure by cracking and burning. A typical problem is encountered in the blues which sometimes transmit as low as 10% of the energy while retaining and wasting 90% of the light as heat. The preparation, transport and insertion of color media is very costly in terms of material and labor. Some productions require two color changes per show. An additional problem is that the gelatin filters available have fairly wide color band passes. This impairs the ability to mix and combine colors to produce other desired colors.

## Decision to Utilize Fluorescent Light Sources for Cyclorama Lighting

After considering the above disadvantages, the decision was made to develop fluorescent light sources for the following optical and economic reasons:

*Optical*

The fluorescent sources are long and linear and would require fewer instruments.

The long linear physical shape of the tubes would more closely conform to the cyclorama configuration, and provide a more even distribution with less chance of "hot spots" or black holes.

The large soft area of the fluorescent sources would, when properly controlled optically, project very well and provide a more even distribution of light over a larger area.

*Economic Advantages*

The power requirement for an equivalent area of 3′ of cyclorama when using fluorescents is 36 amperes as opposed to 90 amperes for incandescent or a savings of 60%.

The cost for power for air conditioning the studio would be reduced by about 25% over all. Therefore, in new installations, the capital investment for air conditioning would be reduced by approximately the same percentage.

The number of dimmers required for control would be reduced by 60%.

The fluorescent sources have a lumen per watt output of 78 as opposed to 28 for incandescent.

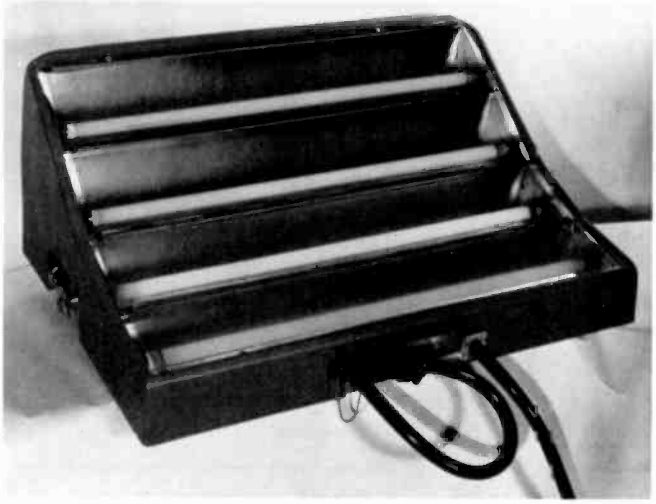
The low temperature of the fluorescent allows employment of permanent color media which is never changed. This eliminates great yearly costs in labor and material.

The permanent colors are an additive system of red, blue and green filtered to the same spectral response as the camera dichroics. This permits mixing of colors to generate any color reproducible by the camera. The band pass of the additive primary colors is narrow enough to permit efficient mixing and new color generation.

The system produces any color temperature white.

The color temperature does not change as the lights are dimmed to low levels.

As stated, the colors in the system are additive primary red, blue and green. This allows us to use a green trim filter with the green tube, a red trim filter with the red tube and a blue trim filter with the blue tube. The transmission of red light through red filter, green light through green filter and blue light through blue filter is naturally very high. Therefore, there is a minimum loss of energy through the filters.



**A fluorescent cyclorama light fixture.**

Most significant of all is the fact that most of the energy used to energize the fluorescent red tube produces red light, most of the energy for the green tube produces green light and most of the energy for the blue tube produces blue light. These colors can be mixed directly with no loss. This is more desirable than a situation in which an incandescent white light must lose 90% of energy in the form of extracted red and green energy to produce blue.

## Description of System

*Color*

The lights use three primary colors which are chosen to match the camera primaries as closely as possible. In this way camera colors with the highest saturation can be produced. This also allows the cyclorama to be used for chroma keying.

It was also desirable to have an equal dimmer setting of red, green and blue produce 3200°K white to match the incandescent fixtures used with it. Since 3200°K white has much red energy than blue, it was necessary to use twice as many red lamps as blue or green. It was found that a standard green and blue phosphor could be used, but a special red phosphor was used since its strong line at 620 nanometers closely matched the peak red sensitivity of the television camera.

It was felt to be desirable to use filters on all colors in order to keep the fluorescent tubes and reflectors clean. These were also used as "trimming" filters to cut out the small amount of undesired color produced primarily by mercury lines. The resulting primaries are shown in Fig. 1.

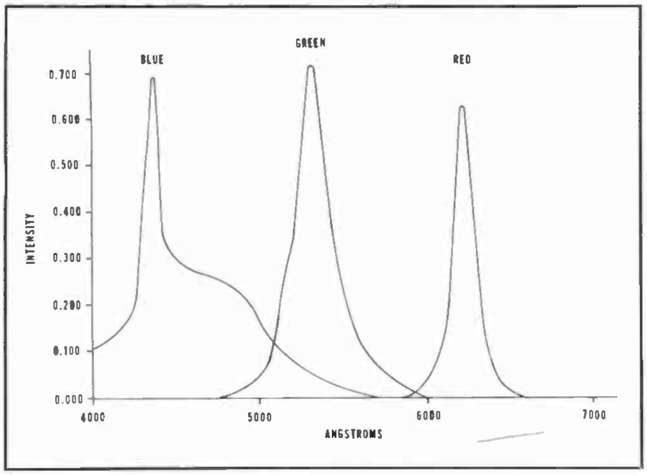



**Figure 1**

**Spectral distribution of the primary colors.**

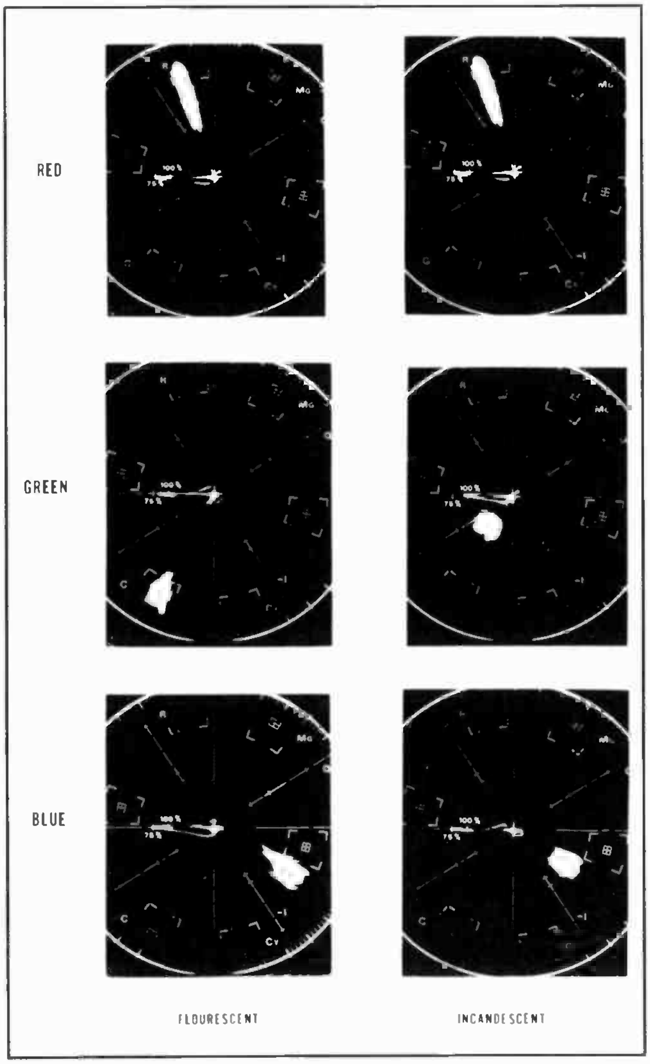



**Figure 2**

**Vector Scope presentation of the primary colors of the fluorescent fixture and the incandescent fixture.**

The primary colors were displayed on a vectorscope using a standard studio color camera. The results are shown in Fig. 2 compared with the primary colors obtained with incandescent cyclorama fixtures with red, green and blue gelatin. It is obvious that the fluorescent combination produces much more saturated primaries and consequently can produce any color that can be seen by the camera.

*Light Distribution*

The fluorescent tubes produce a very uniform horizontal light distribution simply because of the ability to produce a continuous line source of light the width of the cyclorama. In the vertical direction a uniform distribution was obtained by producing a slightly diffused image of the fluorescent light tube ten feet from the fixture. This is done by using reflectors whose cross section is an elipse with one focus at the tube and the other focus ten feet away. The resulting distribution is shown for one row of fixtures in Fig. 3 and for two rows—one at the top and one at the bottom (the way it is normally used) in Fig. 4. The uniformity that was achieved is far better than using standard incandescent fixtures.

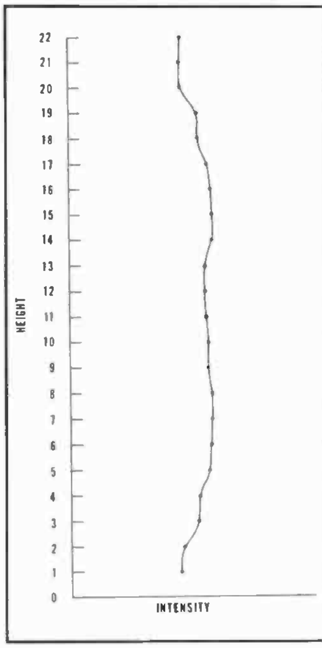



**Figure 3.**

**Intensity distribution with one row of lights.**

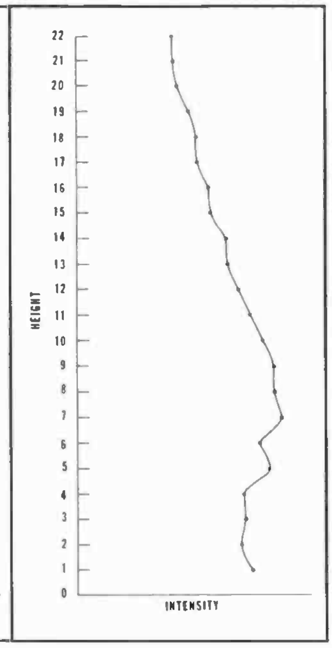



**Figure 4.**

**Intensity distribution with two rows of lights.**

*Other Features*

It was necessary to develop a special dimmer and ballast to obtain smooth reproducible dimming over a wide range of brightness. This was done successfully by Steven Skirpan of Skirpan Electronics. It was also found to be necessary to provide a small cool area thermally attached to a heat sink to stabilize the vapor pressure of the mercury so that the light output would be independent of lamp temperature.

Physically the fixtures were made as shown in the photograph in Fig. 5. The reflectors and housing were vacuum formed in a tough plastic similar to that used in luggage. A carrying handle was provided and the housings were made to "nest" face to face for safe shipping.

Multiconductor power cables and plugs were provided so that fixtures could be connected to each other in a "string."

## Operation of System

*Suspension*

Two parallel rows of instruments are suspended on pipe at the top of the cyclorama. The leading edge of the row closest to the cyclorama is approximately 1′ from the cyc. The second parallel row is butted as close to the first row as possible and suspend low enough in relation to the inside row to allow all the light energy to be projected onto the cyc with no cut off. Both rows follow the configuration of the cyclorama. The curves are lighted by 3′ instruments which are short enough to conform to the curves and to provide smooth even illumination with adequate overlap. In the case of a low cyclorama of 15′ or less, the top would require only one row of instruments.

One row of instruments is used on the floor at the foot of the cyc. The leading edge of this row is approximately 1′ from the cyclorama. This, in combination with the suspended rows, gives a smooth even distribution.

*Focus of Units*

The specially designed reflectors provide that the red, blue and green light from the individual color circuits blend together to produce 3200°K white light six inches from the plane created by the bottom plate of the instrument when the instrument is 1′ from the cyclorama. This provides for smooth white light or colored light distribution over all the cyclorama with no color striation visible at the top or bottom.

The top inside row is aimed at the bottom of the cyclorama. The outside or down stage top row is aimed slightly below the center of the cyclorama and the bottom or floor row is aimed at the top of the cyclorama. This provides the smoothest distribution possible under production conditions. Production needs dictate the proximity of the lighting units to the cyclorama.

*Control of Lighting Instruments*

The instruments are interconnected by plugging multiconductor cable from unit to unit. This multiconductor cable contains eleven wires. One hot and neutral for each of the four color tubes, a pair for the filament circuits and one common ground. Each color tube is a 1500 milliampere high output tube and is driven at twice rated current or 3 amperes. The number of tubes that can be connected together in one color circuit is limited only by the dimmer capacity and the carrying capacity of the interconnecting wire.

The dimmers are assigned to individual colors for control and flexibility in color mixing and determining light level. They are connected to lighting instruments by multiconductor cable similar to cable described above. The multiconductor cable decreases the number of cables run and, consequently, decreases labor cost greatly.

The dimmers can be patched to existing control console or to a small portable console which is assigned to control cyclorama lighting exclusively. The whole cyclorama lighting system is extremely portable and does not require extensive installation costs.

*Cycle Rate*

The system can be designed to operate at 50 or 60 cycles. There is no strobing effect at either rate. We have been unable to detect any interference in our video or audio signals.

*Color Mixing*

By altering intensities and mixing different combinations of the red, blue and green additive primaries, we have been able to produce all the colors contained in the video color bars used for camera set up.

*Maintenance*

Reduced handling of the units extends life of instruments.

Permanent color media keeps reflectors clean and operating at full efficiency.

The life of the fluorescent tubes is at least 400% or 2000 hours, when compared to incandescent bulbs.

Fluorescent tubes cost 50% less than the equivalent number of incandescent bulbs needed to light equal area.

*Chroma-Key*

The system has been used very successfully for chroma-key as designed. No additional equipment is necessary to produce smooth keying.

## Economic Analysis for Typical CBS Studio Employing Fluorescent Cyclorama Lighting

**A. *Operational Lighting Cost Evaluation for Existing System vs New System***

1. *Factors to be used in analysis*
   a) Studio with busiest cyc use—Studio 33—Hollywood.
   b) Hours per week use—48 hours.
   c) Number of production weeks per year in Studio (a)—24 weeks.
   d) Number of lamps in Studio (a)—222.
   e) Watts per lamp in Kw—1.5.
   f) Rated lamp life in hours—500.
   g) Cost per lamp average—$7.26.
   h) Stagehand cost per studio lamp change—$72.
   i) Power cost per K.W.H.—$.04.
   j) Weekly stagehand cost to make up and change gelatings—$126.
   k) Weekly gel material cost—$70.72.

2. *Studio operating cost calculated by using above letter identification as follows:*
   a) Study of existing system
      1) Lamp cost per year
         $\frac{(b) \times (c) \times (d) \times (g)}{F} =$ $3,700.
      2) Labor cost to change lamps per year
         $\frac{(b) \times (c) \times (h)}{F} =$ 165.
      3) Power cost per year

| | | |
|---|---|---|
| (b) × (c) = | 1,152 | hours |
| (d) = | × 222 | number of lamps |
| | 255,744 | total hours per year |
| (e) = | × 1.5 | Kw per lamp |
| | 1,278,720 | |
| | 2,557,44 | |
| | 383,616 | total KWH |
| | × 0.4 | cost per KWH |
| | $17,345 | |

      4) Gelatin filter cost per year
         (c) × (k) = 1,700
      5) Labor cost to change gelatin filters
         (c) × (j) = 3,024
      6) 24 week total = $25,934

   b) Study utilizing new system. Each fixture is 3′ long with four lamps, drawing .30kw per lamp. Lamp cost is $5.43 net. Lamp life is estimated at 2,000 hours.
      1) Lamp cost per year
         $\frac{(b) \times (c)}{2{,}000} \times \frac{74' \text{ (Length of cyc)}}{3'} \times 12 \times 5.43 =$ 926
      2) Labor cost to change lamps per year
         $\frac{(b) \times (c) \times h}{2{,}000} =$ 150.
      3) Power cost per year

| | | |
|---|---|---|
| | 75′ | cyc length |
| | × 1.2 | kw per ft. |
| | 150 | |
| | 75 | |
| | 90.0 | KWH per hour |
| (b) × (c) | 1,152 | hours per year |
| | × 90 | KWH per hour |
| | 103,680 | KWH per year |
| | × .04 | cost per KWH |
| | = | $ 4,148. |

No gel or gelatin changing cost
      4) Total per 24 week 5,224.
      5) Savings per 24 week period 20,710.

**B. *Cost of System for 75′ Cyclorama***

1. *System Components*

| | | |
|---|---|---|
| a) 75 lighting units @ $450 ea. | = | 33,750. |
| b) 12-12K dimmers @ $500 ea. | = | 6,000. |
| c) 1200′ cable @ $1.50 per ft. | = | 1,800. |
| d) patch and control | = | 5,000. |
| Total | | 46,550. |

**C. *Yearly Savings of System***

1. Based on 24 week employment as indicated in Section IV 2 (a) and 2 (b) above—savings equal 20,710.
   a) *write off period—2.2 years.*
2. Based on 48 week employment savings equal 41,420.
   a) *write off period—1.1 years.*

## Conclusion

The optical, financial and energy conserving considerations make the utilization of the fluorescent cyclorama very desirable.

The employment of sources other than incandescent opens a whole new field in television lighting. We must learn to what degree the interrupted spectra and various cycle rates can be adapted to television use. The sizeable advantages afforded by the new very high lumen per watt outputs and the much longer operating life of the new sources are factors which cannot be ignored. As the state-of-the-art improves, we can be the beneficiaries of a new technology with unlimited horizons.

**A Panel Discussion. . . .**

*Moderator:*

**Edward H. Herlihy**

*Director of Technical Services*
*Kaiser Broadcasting Co.*
*Boston, Mass.*

# Video Recorders for Broadcast Use

**Mr. Herlihy:**

At the last NAB convention in Washington, we conducted a similar panel, as some of you may remember, and we had quite a turnout. It was really well attended, demonstrating the broadcasters' high interest in videotape advances, especially from a cost and standards point of view.

In the last year, several items of note have occurred that should be mentioned to set the scene for today's discussion.

At Montreaux, Switzerland last spring, which is the European version of the NAB convention, Ampex, RCA, IVC, along with several European manufacturers, addressed themselves to the European broadcasters' request for new tape formats that offered top quality at reduced tape costs. This request also included the necessity, so the Europeans felt, for high-quality audio channels, more than the present single channel that we have in the United States.

Since this time, there has been much speculation and discussion whether these standards and proposals could or should filter into the domestic tape business. What this really boils down to in the U.S. is the acceptance of slower-speed quad, 7½ IPS or something like that, versus segmented-scan helical format running at a slow tape speed.

American broadcasters in the past have not demonstrated a strong desire to save on tape costs. Perhaps this was due to poor performance of the earlier 7½ IPS machines. Only time will tell whether there is a new interest in saving tape costs with improved quality at slower speeds.

With these thoughts in mind, let's turn to the panel, and here's how we're going to handle it this morning. Each member of the panel has got some individual thoughts and they will address you for approximately seven minutes. Then we'll throw it open to discussion and see what happens.

We've elected to proceed in alphabetical order. The gentleman to my left is Mr. Charles Anderson of Ampex Corp., Redwood City, Cal. The other panelists are Mr. Bert Dann of International Vido Corp., Sunnyvale, Cal., and Arch Luther of RCA, Camden, N.J. First, Mr. Anderson.

**Mr. Anderson:**

While, my remarks duplicate some of what Mr. Herlihy said, I do think it's necessary to review what's happened in the past year and a half.

Much does revolve around the 1973 Montreaux Television Symposium where two new television tape formats were introduced formally to the television world. Both were helical, one by Philips-Ferinze and the other by the IVC Corporation. Three other corporations displayed improved versions of recorders conforming to the standard quad format.

Prior to Montreaux, Ampex had presented two papers, one at the winter conference of the SMPTE and the other at the SMPTE spring conference in Chicago. Both papers presented some ideas which Ampex engineers had on the subject of, quote, what if we were to change or modify quadraplex standards? After all, these standards have been around now for 15 years or so.

The ideas were intriguing enough so that a subcommittee was formed within the SMPTE Videotape Recording Committee to provide users and designers a forum for the exchange of ideas. At Montreaux, both RCA and Ampex gave papers which exposed their thinking to European engineers and to the broadcasters, and we were both invited to present our ideas to a meeting in Montreaux of the EBU Committee, G2. All parties, including Ferinze, who had joined the SMPTE group at that time. We then went our separate ways and performed a variety of experiments during the past summer and fall, as each of us saw fit.

By this time, the possibilities had come to be known as quad-2, which in many ways was unfortunate. Although it should be carefully noted that no proposals had been formally made to any standardizing body or even informally to any group at all. In fact, there was a very spirited technical disagreement within the members of the subcommittee over the details, even though there was general agreement that we should look at the following areas: reduction of tape speed, the addition of a second audio channel, possibly the use of a pilot tone to improve timing, stabilization techniques.

Ampex has worked steadily since Montreaux, and our view is now much more mature than it was a year ago. We explained our position in a position paper which we mailed to many of you prior to the NAB, but let me just briefly review it. Just hit the highlights.

As a result of many discussions by members of our own marketing department with you the users, we feel that U.S. user sentiment runs against any change in the quadraplex standards at this time. We did detect a developing need for two audio channels, certainly not an overwhelming need here in the United States, but a developing need. And to satisfy that need in as nearly a compatible fashion as possible, we have demonstrated at this exhibit a compatible two-channel audio system of reasonable quality.

We feel the use of a pilot tone may be useful, but only if the present high-band standards are seriously changed. However, this appears to run contrary to the desires of U.S. broadcasters, so we have decided not to pursue or introduce such an operation on 525 systems. The 625 situation is different and the gains a pilot tone may offer may make a change in deviation standards advantageous in that area. We're continuing development work in this area, and if certain technical problems can be resolved, we may have some suggestions to make at a later time to the 625 areas.

We feel the dual audio system, which we've introduced here, will fill the needs of many of our international customers having multi-language problems. The 7½ IPS operation of quadraplex recorders has been possible for many, many years, and performance at that speed is now very good. I've been surprised by the number of users who told me they don't use it, not for quality reasons or any objections that they have, but because they don't wish to clutter up their operation by having to keep track of two tape speeds. If you haven't looked at 7½ IPS quad operation for some length of time, I invite you to do so down at our booth. We have machines running at 7½ IPS.

Ampex's position on helical is quite clear. We offer, we think, a top quality helical recorder for sale which produces a signal completely suitable for broadcast use. We feel that helical recorders have inherent limitations which restrict their operational flexibility, and for the fullest flexibility we recommend quad over any form of helical recorder, be it full-field or segmented. But if you have an operation or a special need where a helical recorder can do a good job, we'd like to try and sell ours to you.

**Mr. Herlihy:**

We turn now to Bert Dann from IVC.

**Mr. Dann:**

I'm sure you're all aware, at least in a general way, of the characteristics of the format employed in the new segmented helical scan recorder developed by International Video. A logical question would be: Why did we choose this particular format?

After about three years of blood, sweat and tears, we who developed it still need to rearticulate the answers to this question because our format differs so radically from the well-entrenched quadraplex format.

Of course, an overriding consideration in starting any new design is that it be economically attractive to the user. This not only in the context of reduced capital cost, reduced cost of consumables and reduced maintenance costs. The design should also afford the user all worthwhile additional features and facilities that can reduce his incidental costs and the amount of peripheral equipment he must employ. Examples of such facilities are the provision of an additional full-quality audio channel. Another one is a provision of a separate channel dedicated to the SMPTE or EBU address-code system.

Some of the goals mentioned here could be attained in any of a variety of possible new formats, or even, as has been widely discussed, by modification of an existing one. I can't resist interjecting here that apparently it's not only been widely discussed, but somewhat heatedly discussed.

So, we're back to the original question. Why did we choose this particular format? The answer, very simply, is that we've tried to build a state-of-the-art machine, and to us this means the use of hot-pressed ferrite heads. They have outstanding frequency response characteristics, and properly applied, extremely long life. Proper application, in our view, immediately implies the use of a helical format which not only eliminates impacting of the heads against the tape, but also leads to gentler tape handling, and hence better tape longevity. Incidentally, it sidesteps all of the female guide problems associated with transverse scan formats.

We wanted a format in which no mechanical adjustments of any kind, other than the automatic adjustment of tape tension, would be necessary to retain excellent interchange. We've achieved this. The ferrite heads wear so slowly that no adjustment is needed over the useful life of the head drum, which we warrant to be in excess of 1500 hours.

Another advantage of the slow wearing characteristic of the ferrite head is that reoptimization of record levels is a very infrequent requirement. Similarly, adjustments to the playback system, most of which are in any case automatic, are required largely to take out small interchange factors. Gap depths change very slowly.

All right, why segmented helical? Why not one field per head pass, which does admittedly have some advantages? Because, as critics of helical machines have pointed out from time immemorial, long scan lengths lead to tracking and interchange problems. For example, if we attempted to secure 1500 inches per second, our present riding speed, on a one-field-per-pass basis, we would need a track some 25 inches long in the NTSC standard. And that would be almost five times the length of the track we do in fact employ. Our tracks are short enough and the beam strength of our 2-inch-wide tape is great enough that tracking and interchange simply aren't problems.

Now why two heads instead of one head or four heads or some other number? Well, rather obviously, the fewer heads the better, other things being equal, but we are unaware of any one-head format which allows substantially continuous signal reproduction without introducing other limitations, such as the need to synthesize some part of the video signal or a reduction in flexibility in editing operations. So two is the optimum number. It also turns out that two is the number which enables us to use the principle of odd segmentation in NTSC color reproduction such that the effects of minor misadjustments of the head channels are visually integrated in a manner similar to that used in the simple PAL receiver and they're subjectively pretty well unnoticeable. The pictures we are showing I believe speak for themselves.

I could go on at considerable length about the fact that in our machine head resonances are swamped out in both record and playback modes, eliminating several adjustments, that frictional variations with environmental changes are not a factor because we have 100% air flotation of the tape in the scanner area, about our new automatic edit lineup system, and other details which we believe are moderately clever. But time doesn't permit.

But my primary message is not that the machine is the way it is because we're clever. About 18 years have gone by since the first successful production of television pictures from magnetic tape. In those years technology has advanced and requirements have changed. The present system was probably just a gleam in Dr. Brouck's eye in the first of those years, and computer-controlled editing was probably undreamed of.

Wishing to entice the broadcast recorder marketplace and, unconstrained by the well-known limitations of the long-established quadraplex format, we've attempted to devise a format which takes advantage of the state of the art to provide the user with equivalent or better performance, and it is much better than the PAL standard, additional facilities and features and at the same time afford him some genuine economic gains. We believe we've succeeded in this, but only time and acceptance by the broadcast industry will give us the final answer.

**Mr. Herlihy:**

Last on our panel, Arch Luther.

**Mr. Luther:**

When one speaks of broadcast video recording today, he can expect his listeners to think automatically of quadraplex recorders. This is not surprising when you consider that over 95% of the 7000 recorders in use in broadcasting are of the quadraplex type. This strong preference for quadraplex recording has not occurred by accident, but rather, it represents the overwhelming desire of broadcasters to standardize on one type of system which will allow all recordings and equipments to be interchangeable.

The high performance and excellent interchangeability of quadraplex recorders is taken for granted today, but it is in fact the result of a standardizing effort which began in the early days of quadraplex recording, spearheaded by the SMPTE and strongly supported by the equipment and tape manufacturers. The result is that today we have available a very wide diversity of compatible quadraplex equipments produced by manufacturers around the world.

This strong standardization of quad has been the prime reason for the successful growth and development of braodcast video recording.

Recently you've been hearing a lot of discussion about standards changes or even completely new systems. I would like to discuss these, but first let me talk about some of the problems of making changes to any widely used existing standard.

The introduction of any change into the video recording standards prodnces tremendous problems for the users of the equipment. Those of you who remember the period when quadraplex recorders converted from low band to high band can easily understand that statement. If more than one standard comes into use, everyone using recorders has to begin thinking about what standard does his intended end user have? Who has what kind of equipment? What standard do I want to use in my own operation? What kind of tapes, head wheels and so on?

Therefore, why would anyone want to change? There have been several reasons stated for change, such as, we could lower the cost of equipment or its cost of operation. We might provide better quality of performance. We might provide simpler operation, and so on. Yet, these characteristics are not really related to the choice of format.

Take costs, for example. The cost of running a videotape, operation breaks down into tape costs, head cost, manpower cost, and capital cost. The only element of cost that is directly limited by the recording standard is the tape cost. In choosing a standard, one must make tradeoffs between the performance margin and tape usage. This type of situation was recognized some years ago in quadraplex recorders and an alternate slower tape speed standard, 7½ inches, was introduced. In fact, this standard has not been widely used, largely because the difficulty of handling a second standard was not worth the small saving in cost. I said small saving in cost because tape cost is typically one of the smaller elements in the total for the average broadcaster. The big items of cost are usually manpower and capital costs. These items are clearly not limited by the recording standard, but rather, they depend on the quality of the equipment design.

The same observation can be made about changing standards for the purpose of providing better quality performance or simpler operation. These items too are designed into the equipment.

My point here is that any change to the standards for broadcast video recording, whether it be a change in the quadraplex standard or a change to a completely different standard, such as helical format, must be approached with extreme care, with serious consideration about whether the advantages to be gained by the users in any way equal the difficulties and costs that the user will bear in making the change. The success pattern of video recording in broadcasting today could be completely destroyed by introducing too many changes to our basic recording standards.

Well, how then can broadcast video recording respond to the inevitable advance of technology?

First, if at all possible, we should find ways to apply new technology within the bounds of the existing standards. Over the years, many significant advances have been made without changing the standards. Features such as velocity compensation, chroma amplitude correction, record current optimization have simplified operation and improved performance. We even can see at this convention today a standard quadraplex new machine in the RCA exhibit which provides more capability and more operator-saving automation features per dollar than previously available on any system of equal performance, a direct response to the users' desire to improve cost effectiveness.

It has been our policy at RCA to continually explore the potential of new technology developments to improve the effectiveness or capability of broadcast recording systems. We have not limited these investigations to just items which fall within the standards. It was this kind of effort, for example, which led to our original introduction of 7½ inches operation to the industry in 1962. This has been standardized by the SMPTE and today all high-band quadraplex recorders have 7½-inch-per-second capability.

During the past year we have given considerable publicity to our experimental activities directed to the special needs of the 625-line international markets. This activity has been named in the industry quad-2, and it has been reported on publicly by us for the purpose of obtaining broad industry reaction to the technical possibilities so that we could make a standards proposal that would be optimum for the industry as a whole. Unfortunately, the elements being considered for quad-2 in 625-line systems have sometimes been mistakenly construed to apply also to the 525-line markets. I hope the following will make clear our position at RCA on quadraplex standards for 525-line television systems.

For users who desire economies of tape usage, the industry already has the recording standard of 7½ inch tape speed fully documented by the SMPTE and for the last 10 years. With today's technology in for the last 0 years. With today's technology in heads, tapes and servo systems, that standard provides a very effective performance. We are demonstrating in our exhibit the operation of the TR-70 machine on 7½ inches this year.

During the coming months RCA will be continuing its investigations of standards changes for the objectives of the 625-line international markets, the quad-2 I referred to earlier. It is reasonable to expect that some of this work may result in additional improvements to the 525-line system which should be evaluated for standardization at some future time.

For users who desire a stereo type of audio capability with dual tracks at either tape speed, we agree with the concept of splitting the standard audio track into two. We will be examining the dimensional details and performance characteristics of this modification so that we can participate in standardization of it as an optional feature for quadraplex recorders.

It is my firm belief that the existing quadraplex recording standards are meeting the requirements of broadcasters today and that further improvements within these standards will be developed as the needs of the broadcaster grows in the future.

**Mr. Herlihy:**

Gentlemen, you've heard the opening statements by the three panelists. We'll throw it open to questions. Anybody want to take the plunge? Or are you all confused?

If I don't have a question right away, I think I want to turn to the panel and see, now that we've gone through the thing, see if there are any rebuttals or statements or comments on what we've heard today.

**Mr. Dann:**

I have a couple of questions with regard to 7½-inch-per-second operation. One of my main questions is: We've heard a lot of talk about tape economy in quadraplex through a reduction of tape speed, and this implies, of course, a reduction in track width and guard band. Assuming for the moment, and I note no use of ferrite heads in the machines that we've seen here at the show, what could be said about the head life to be expected? Would it be similar to that of standard quad or perhaps would the warranty have to be reduced? This is really a three-pronged question. If the ferite heads can in fact be used, do you not require to make radical changes to the arc equalization system because of their lack of frequency-dependent losses, particularly if you attempt to go super high band. And thirdly, if metal heads must be used, isn't it essential for you to go to high-energy tape in order to maintain a high signal-to-noise ratio, particularly in the European standard?

**Mr. Luther:**

Taking the head-life part of your question, as you probably know, the narrow-track, quadraplex head-wheels typically use a configuration of a narrowed-down-at-the-gap type of track widths which leads to a head life that is essentially the same as standard quad, so that there is no tradeoff in head life in going to this lower tape speed.

As far as ferrite heads are concerned, at RCA we're not proposing any use of ferrite heads, so we're not proposing the kind of changes that you mentioned that might be needed if you went to ferrite heads.

We're also not proposing at this time the use of high-energy tape. We feel that on standard tape the 7½-inch performance that can be achieved is acceptable for many, many of the broadcasters' uses.

**Mr. Dann:**

May I ask the question with regard to the side-fill gap, which is the way I would describe the kind of head you're talking about. Is the mechanical width actually the same in your 7½ IPS head wheel as it is in the standard quad? Don't you get a secondary-gap effect which could give some difficulty?

**Mr. Luther:**

The mechanical width is the same as the standard head and the type of construction used eliminates any secondary-gap problems.

**Mr. Dann:**

I could mention in passing that we are also using a side-fill gap approach with our ferrite heads. They're actually wider than the effective gap width. Addressing this question a little further, what about the audio signal-noise ratio in view of the fact that transversely oriented tape is used? I point out in passing again that in our format we use longitudinally oriented tape, and audio is reasonably happy with longitudinally oriented tape and 44 mil track width at 8 inches per second. Now you will have, I think, something on the order of two 26 mil tracks on transversely oriented tape. What kind of signal-noise ratio would you expect to achieve in the audio system?

**Mr. Anderson:**

We have to put this audio thing in perspective. I don't think any of us are happy with the audio performance of VTRs, and I don't think any of us really would like or would get all uptight about 2-db improvement. I think what we'd like is 70 db, not 53, 54, 55. Even 57 might not turn us on too much. But I do think that as long as we're working with a videotape recorder and we're trying to keep the signal in an analog form on that tape and I don't much care whether it's longitudinal or transverse or what have you, I think we're going to be working with performance that none of us would really like for top editing production type of operation. I think in those circumstances we're—unless we're willing to take a major, major change, something as drastic as, say, digitizing it and putting it in the video channel.

I think the way to operate is to get off the videotape recorder and go set mag. This gives you flexibility, all kinds of it. The two channel system that we have come up with we think will satisfy many of the needs of the broadcasters, particularly in Europe, for two audio channels.

**Mr. Herlihy:**

We've got a gentleman in the audience.

**Q:** Considering the splitting of the audio tracks, we now have the problem of two tracks in the same area occupied by one track. The first obvious thing is that we would have to modify our present equipment in order to prevent picking up whatever's on the second track. But prior to that modification, if we were to use, say, a single track—one of the two tracks and play it back on a full-filed head, we would suffer further degradation of audio material. Has this been considered in the planning of the two tracks?

**Mr. Anderson:**

I can't really argue with that statement. That's very, very true. Exactly how these tracks will be used is anyone's guess. From what I can tell, they will be used in many cases to put dialog on one track, put effects and music on the other, and then this dialog track can be stripped off and a different language laid down.

In those cases, a full track head would be playing both tracks very happily. If it's used for stereo, I see no problem. If you're trying to put French on one track and English on the other, yes, then certainly you'll have to put a different head on. And there's just no question when you go to a narrower track you are not going to have the same signal-to-noise ratio. I can't argue with the laws of physics except on Thursday. It's not Thursday.

**Mr. Herlihy:**

Since our last session, I've heard all kinds of formats thrown around. I've heard about quad-2. But I haven't heard mentioned here today what is quad-1A, if it ever existed in fact. I haven't seen it at the convention or heard much about it. I've heard some people talking about it. In fact I heard a gentleman yesterday say, "I think it went away, but I don't know where it went."

**Mr. Luther:**

I guess I have to answer that one because we're the ones that have been saying quad-1A. As I mentioned and Chuck also mentioned, the name quad-2 has been used for both our experimental efforts looking at the possibilities of changing for the 625-line market, and we have used at RCA the name quad-1A for our experimental efforts looking at the 525-line market. And as I said, we felt it necessary to publicize some of these efforts in papers and other ways in order to get industry reaction, and that's what we were doing with quad-1A. We're not making a proposal for a standards change beyond what I already mentioned in my opening statement.

**Q:** I have a couple of questions for all three gentlemen. First, with regard to the quad reduction to 7½ IPS and using narrower tracks, isn't it reasonably true that it's impossible to put a quad tape on a machine and get back a perfect color playback? I'm talking about machines before the AVR-1 category, of which most of them that are out there are, that you have to readjust something in order to play correctly in color, like equalization or a few other things—and if you reduce this to a 7½-inch operation, you are making those characteristics even more critical because you're operating with less of a buffer in terms of all of the performance characteristics of the machine.

Secondly, on the audio part of the quad. I sit at home and look at tapes that are obviously quad tapes in which I hear audio flutter because the edge of the tape has been damaged. If you cut it into further narrower tracks, you have even more tendency towards this on the outside track, and though somewhat less on the inside one, it would still be a problem. What is your opinion with that with regard with normal operations?

**Mr. Anderson:**

In the first place, the only spec that's different on 7½, as far as the video's concerned, is about a 2-db loss of signal-to-noise on the video. There's no reason that any other spec should be any different on 7½.

As far as the audio is concerned, anytime you start narrowing tracks you're going to have more problems when you start upping the packing density. Again, it's not Thursday and I can't really argue with the laws of physics today.

But again, I keep getting this overwhelming response of "Why don't you use 7½? Is it because it's so bad?" And the answer is "No, I just don't want to clutter up my station with it."

Again, I'm trying to be reasonable. I'm not blindly saying that some of the older machines that aren't well kept up are going to look very, very good, but I think that modern machines that have been in production recently, and certainly the machines that we are showing today, they'll do very well at 7½.

**Q:** Are you referring to machines that people are going to have to start buying now to do these things, or are you referring to the ability of older quads, of which, you know, there's a lot of them out there?

**Mr. Anderson:**

We still have 1200s, 2000s, believe it or not, that are still in production in Europe. Our 1200s are in production here. We now have an AVR-1, an AVR-2. We feel that all of these machines will perform well on 7½.

**Q:** Assuming that the user makes whatever changes he needs to achieve that.

**Mr. Anderson:**

Right, plug a head on it.

**Q:** Maybe I'm misunderstanding what you're saying. You're being very cautious about saying whether 7½ IPS with dual audio track would serve as a maximum quality origination machine. I think you're saying it wouldn't. It would serve as a useful playback machine in the studio, and therefore you could accept the slightly degraded characteristics of the spec and the even more degraded characteristics of what happens when you go into day-to-day operation. So you're maintaining that a 15 IPS machine is what someone needs to really produce an original program and edit it down to the third generation and so on, which, you know, is at variance from what the end product at 7½ IPS provides you. So we'd have to operate at a station with two standards, 15 IPS to do all the origination and 7½ IPS to cut tape costs and operate on a playback basis only.

**Mr. Anderson:**

I think that's true. Sure, 15 IPS is always going to be better. If we made 7½ 10 db better, 15 would be 10 db better. If we get better tape and we, say, pick up 7½ IPS operation, we're going to pick it up on 15 as well.

I think the person that is always concerned about getting the very, very best is going to operate at the best standard.

**Q:** I think the problem is that we're comparing apples and oranges all the time. You know, on the one hand we're talking about a machine at 7½ IPS operating at medium levels of performance, and when you get them out into the field it's tougher to make a 7½ IPS machine work well than a 15 no matter what you say. We all know that. And on the other hand we're talking about other machines, that operate at higher levels of performance, either equal to or better than a specific quad. And I'm not talking about the 9000 only. There are other approaches to doing it. And the comparisons, I think, ought to be kept in context, if you do want optimum performance, if you do want the best studio production, if you do want to go down to the third generation, you'd better have good video and good audio to start with at the best that today's technology can do.

**Mr. Dann:**

In my view, we've kind of beat the audio to death, at least insofar as these gentlemen are concerned. I'd like to mention a couple of other things that are of some concern, I believe, in the quadraplex format when you go to a lower speed. One of them would be the accuracy of the edit-erase point.

In a paper last October a certain tape elongation change was proposed which was a beautiful contrast between the mistracking you get in the quad and the mistracking you'd get in some mythical helical machine. I don't remember what the track length was but it turned out that the degree of elongation postulated would also mean that in a quad it would erase by exactly one track off. If it turned out to be an overlap situation, you might get away with it, but a whole of one head pass wouldn't be too happy.

There are a number of subdidiary problems in going to a lower speed. You've got to address yourself to what we call the gap-overlap problem, which is the result of the finite spacing of the audio erase and RP gaps. You've got to obviously take a look at a lot of other things like change of optimization, change of the head-wheel panel and all that in going from one standard to another, from 15 to 7½.

One suspects that there's no switch available which would change the track width, barring the use of two head wheels.

We have in the 9000 a single standard machine. In actuality, to change the machine from PAL to NTSC requires changing only a dozen printed circuit boards.

We'd like to invite you to see a machine operating with 8 megahertz band width in NTSC on a wide resolution color monitor. We think that this is a fairly interesting little added something.

We went super high band primarily to address ourselves to the problem of moray in the PAL standard, and we think that the choices we made were correct because the economics are not that much different in NTSC. In NTSC, of course, the moray is negligible. In PAL it is of the same order as that now being achieved in quadraplex in NTSC.

**Q:** I notice something which is happening here at the NAB show where there are other companies offering modifications to existing quad so as to update their performance, such as constant-tension servo systems that go on the quads, and various other devices —time reading and editing devices.

If you do go towards the 7½ IPS operation, would it be reasonably true to say that a better tension system would improve the performance, and if so, would the major manufacturers offer those kinds of kits as well, or will that be just the domain of other suppliers for older machines?

**Mr. Luther:**

Better tension control would improve the performance of any recorder, and in some of the latest recorders, you do have better tension control than in the older ones. However, we feel that the tension control in most of the existing recorders is of a caliber that 7½-inch operation is practical just the way it is.

**Mr. Anderson:**

Quad is relatively insensitive to tension. It's nice to have it. It improves tape shuttling. Our machine, we think, the AVR-1 has outstanding tape handling, but it isn't necessary for 7½ IPS operation. And almost any product that has been out in the field and has such a long track record as the quadraplex recorder you will find kits. Look at the Volkswagen. You can go into a store and buy more gadgets for Volkswagens. And if IVC is suscessful in bringing the 9000 onto the market, I'm sure that they'll find all sorts of gadgets offered for it. It's inevitable.

**Mr. Herlihy:**

There's one question in my mind, left over from last year that has developed this year. Do the broadcasters really want to save money, cut their tape costs in half? Is that a big problem? There are three hundred of you here today representing an awful lot of broadcasters, and it's your opportunity to say here in the next five or ten minutes whether you really think that's important. I almost feel like having a vote, if anybody's interested, just to see what kind of interest there is in this area. I think everybody'd be kind of interested especially the major users, whether they're interested in going to 7½ IPS or a format along that line.

**Q:** I would say on behalf of the educational and instructional broadcasting segment of the industry that any possible saving in tape consumption would be highly desirable. We have the problem of importing tapes from existing tape libraries around the country. We pay freight on that tape. We have to store it. We have to play it back. We have, therefore, several costs directly bearing on that usage—freight cost, the space to store the tape, environmentally controlled, and the handling of that tape during the day. Now we broadcast educational programs from 8:30 in the morning until 5 o'clock in the evening and we can save considerably in the amount of tape that's passed through the place and the handling of it.

Right now, we are broadcasting at 7½ inches per second where we can. If we can get the playback dubs from the tape libraries at 7½ we do so. It's a great saving to us. Of course, when we do go into production from our studios, we do run into problems if we were to try to edit on our particular machines at 7½ inches. We would realize a saving there, but we normally record at 15, edit our masters, and then dub down to a 7½-inch copy for airing.

On behalf of the educational nonprofit organizations, this saving could be a tremendous help to us.

**Mr. Dann:**

The saving in tape cost is only one of two major economic aspects as far as consumables are concerned. I believe that economies in the head assembly, not only as regards to life, but also as regards to the capital investment required to maintain a spare head assembly, is another factor to be considered when you're thinking of the alternate formats.

Assuming, for the sake of argument, that the wear of a 7½-inch head wheel is susbstantially the same as one operating at 15, with a wider track, there's still a rather favorable comparison between ferrite and metal heads. The number varies, depending on whose warranty certificate you're looking at, I guess, but there's also the factor that the capital investment required to maintain a spare drum, or head wheel, is quite different. Also the handling in shipment of the replaceable element is quite a different proposition.

In our machine we have something which looks vaguely like a one-pound can of pork and beans, and that's what you have to ship around the country. You're all more experienced than I in what you have to do to ship a quad head-wheel assembly around the country.

**Q:** On the economy point of view television is a compromise medium and it always has been. In reducing speed to half-speed, you are reducing quality. A broadcaster cannot afford for the economic saving to let his quality control of his broadcast product go to pieces. Therefore, the broadcaster hasn't gone to 7½ simply for economy because it would be at the expense of his end product.

The second thing is I don't believe that half-speed is a new format. It's a change of standard.

**Mr. Herlihy:**

Gentlemen, we're going to have to wrap it up. I think we probably could go on for another hour or two, as usual. Thank you very much and thank you panel.

**K. Blair Benson**

*Director, Audio-Video Engineering*
*Goldmark Communications Corp.*
*Stamford, Conn.*

Chairman
*JCIC Ad Hoc Color Television Study Committee*

# Progress Report of the JCIC Ad Hoc Color Television Study Committee

Since its formation in 1968, the Ad Hoc Committee has conducted in-depth studies of all segments of the color television broadcasting system in order to pinpoint causes of variability in color reproduction as viewed on the home receiver.

In the interest of initiating some meaningful industry action at the earliest possible date, in the initial stages of the investigations, particular emphasis was placed on some of the more obvious parameters related to signal transmission. This effort resulted in the EIA Broadcast Television Systems (BTS) Committee setting up several working groups to develop, for example, recommendations for tighter signal tolerances and special test signals for transmission control. Progress on one of these BTS activities, the Vertical Interval Reference (VIR) Signal will be covered in another paper on the Convention program.

However, more recently the Ad Hoc Committee's thrust has been toward system colorimetry uniformity in live and film program origination, and in display devices for both home receivers and studio monitors.

## Film Quality

In the case of film characteristics, measurements made four years ago of variations in white and black densities, and of skin color in a wide variety of film program material were repeated to document any trend, for good or bad, which may have occurred in the interim. It was determined there generally is an improvement in the uniformity of color balance from film to film within a given type of program, and the different types are converging on a common balance.

This improvement is most likely due to an industry-wide awareness of the problem, and to the application of SMPTE Recommended Practice RP41-1970, which specifies the 5400 K color balance and ambient for review-room conditions. A divergence in color balance of East and West Coast samples of commercials was noted which requires explanation, however.

On the other hand, an undesirable decrease in print density, especially of 16mm commercials, was noted. Of most concern is the increased prevalence of very thin white densities, which cause problems in television reproduction of these films. From the subject matter it is apparent that some of this white density problem is introduced in the staging and lighting practices currently considered fashionable in commercial production. Solution of this problem may require educational efforts beyond what has been tried to date.

Since the color-balance situation has improved as a result of the efforts made within the SMPTE to identify and solve particular problems, we are optimistic that similar improvement in density characteristics can be achieved, given a similar effort to get at the causes of this problem.

## Telecine Equipment

The survey among broadcasters on telecine equipment and its operation has indicated that there are serious variability problems associated with telecine equipment and practices. The variation in transfer characteristics has been well documented, and a need for specification of a standard or ideal transfer characteristic is clearly indicated. Also, variations in color balance and saturation were found to be wide and frequent; further work is needed to measure and explain these. This work may define more clearly a need to specify aim or ideal telecine colorimetry. In addition, the question of standard operating procedures may need consideration. The contribution of non-standard picture monitors to the telecine variability problem has been pointed out as well. Furthermore, the influence of the problem of excessive shading on telecine variability is noted.

It may seem paradoxical that the committee has uncovered serious variability problems in telecine operation, and yet the results of the questionnaire show that broadcasters feel they have no real problem with telecine equipment and its operation. This comes back to the contention that because the broadcaster tends to attribute all problems with the output of his telecine to the film input only, he may fail to recognize any problems in the telecine operation. We hope the work of our Subcommittee will draw attention to these problems inherent in telecine design and operation.

## Display Equipment Colorimetry

Attempts to develop recommended practices or design standards for telecine and live cameras has been stalled by the need for agreement on specifications of the color picture display system characteristics. Although the FCC Rules and Regulations adopted in 1953 are based upon the NTSC specifications for display chromaticity coordinates, present-day picture tube phosphors differ substantially from these characteristics. However, it is possible by appropriate matrixing in either cameras or display equipment to achieve accurate color reproduction, within the gamut of these phosphor characteristics; and, in fact most receiver design accomplish this in varying degrees by modification of the decoding and matrixing from the circuitry appropriate for NTSC display characteristics.

The following two papers cover in detail how this basic problem affects U. S. television and recommendations for its solution. The first, by Mr. DeMarsh, is a review of the design considerations and the practical effects on color reproduction. The second, by Mr. Davidoff, reports on the progress by a task force of broadcasters in appraising the advantages of the corrective matrix for display phosphor differences from NTSC, and the practicability and means to implement its use in broadcasting operations.

**L. E. DeMarsh**
*Research Associate*
*Eastman Kodak Co.*
*Rochester, N.Y.*

# Optimizing Color Fidelity With Present-Day Phosphors by Matrixing

The objective of current standards efforts in the U. S. television industry is to improve both the uniformity and quality of color television as viewed on the home receiver. Color pictture monitors are used to certify the technical and artistic quality of television images and must be considered in these studies.

The colorimetry of our NTSC color television system is derived entirely from the colorimetry of the display device. Specifically, the camera analysis and the camera matrix for negative lobe correction (if used) and the encoding matrix (the factors used to derive the luminance and color difference components of the coded signal) are based on the assumption that the display device has NTSC primaries. The FCC rules state that the gamma corrected signals from picture generation equipment should be suitable for display on a color picture tube which has the NTSC primaries. While this rule is vague, the obvious way to satisfy the requirement is to evaluate studio output on an NTSC display.

The phosphors used in color television picture tubes have undergone continual change since the NTSC system was specified in 1953. The history of these changes is sketched briefly in Figure 1, where

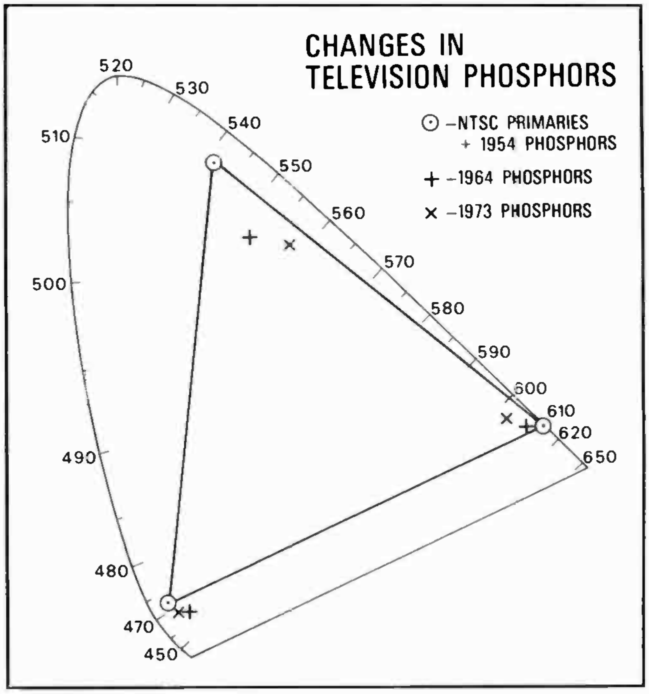



Figure 1

phosphor chromaticities are plotted in the CIE xy chromaticity diagram.

Available phosphors in 1954 were very close to the NTSC primaries, shown as circles in Figure 1. Data for 1964 phosphors are indicated by x symbols, 1973 phosphors by x marks. The phosphors used in some, but not all, monitors have been held constant at a point between the 1964 and 1973 data.

So, our receivers and monitors now have phosphors which do not match the NTSC primaries. This results in the color errors shown in Figure 2.

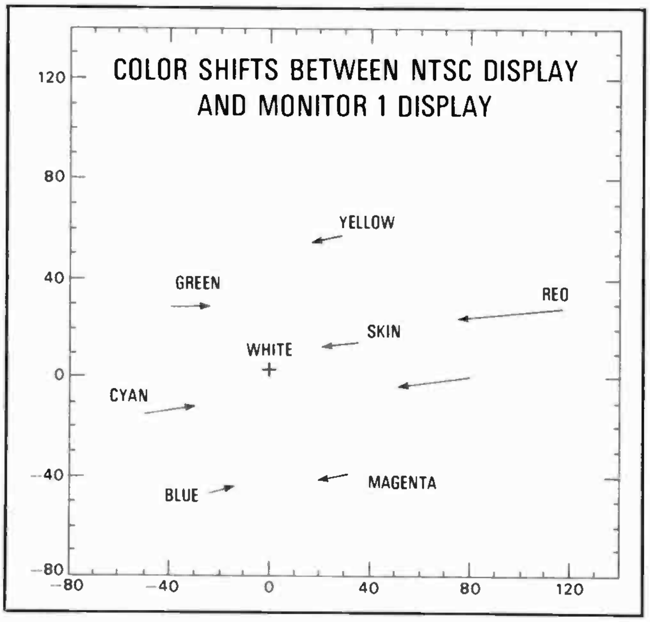



**Figure 2**

This colorimetric diagram shows the color errors which result when a signal suitable for an NTSC display is displayed with modern monitor phosphors. The arrows connect the NTSC reproductions (tails) with the modern phosphor reproductions (heads). The tendency for the arrows to point in toward the white point indicates that the modern phosphor reproduction is desaturated relative to NTSC.

These data can be put into more familiar terms by noting that the error in skin color, a very important color, is greater than 10 degrees in phase and greater than 2 db in chromainance amplitude—errors larger than the errors allowed for the entire system. (In the oral presentation, photographs of an NTSC and modern phosphor display were shown at this point to show the color error in pictures).

Receiver manufacturers have altered the demodulation characteristics of their receivers to compensate for these phosphor differences. Color monitors do not at present have this correction. So, we have an NTSC system but do not use NTSC monitors, and we have a mismatch in colorimetry between monitors and receivers.

Most broadcasters would remark that the pictures we see on control room monitors do not show the gross desaturation indicated by Figure 2. Why?

We suspect that a variety of operating practices have been introduced to compensate for this obvious colorimetric defect in our present system, that current broadcast practices have evolved to produce signals for the current non-NTSC display. Since there is variation in monitor phosphors, and since phosphors are continuing to change, these practices are probably a source of color variability.

The color problems that arise from the changing phosphors have been of concern to broadcasters all over the world. Two approaches have been suggested to adapt television systems to the realities of current phosphors:

1. Change the broadcast standard and base the camera colorimetry an average of on current phosphors, an approach being recommended by the EBU.
2. Retain the NTSC broadcast standard and add electrical correction to the display device to make it approximate an NTSC display.

Although the first approach would lead in theory to a more colorimetrically perfect system, it has several *practical* disadvantages for the U. S. television industry:

1. It would require the addition of camera matrixing to all cameras, a requirement that could obsolete some old equipment which cannot be matrixed.
2. Since phosphors are continuing to change, continual changes in camera characteristics would be required to keep pace with phosphors. Indeed, since standardizing on the current phosphors would limit the transmitted color gamut to that of the current phosphors, we would have to change the standard to take advantage of any future improvements in phosphor technology.
3. Since most color receivers already have electrical correction for their non-NTSC phosphors, this first approach would lead to a reduction in color quality on many home receivers since we would have compensated twice for the changed phosphors.

In the second approach we are putting the correction for the change in the display, the device that is changing. The advantages of this approach are:

1. Older, and non-matrixed cameras can meet the intent of the standard.
2. This alternative will not require future changes in the broadcast standard. Future changes in phosphors can be incorporated into the system with no disruption of broadcast standards.
3. The second approach is compatible with current domestic receivers.

The disadvantages of retaining the NTSC color standard are:

1. It will lead to less perfect colorimetry than the first approach since the correction is applied to nonlinear signals. However, this is a theoretical argument—calculations and practical tests indicate that both approaches lead to highly acceptable color quality.
2. The second approach will require the addition of electrical correction matrixes to all monitors used by broadcasters for critical color evaluation when these monitors utilize non-NTSC phosphors.

After weighing these arguments, the several industry committees involved have recommended that the NTSC colorimetric standards be retained.

It follows from this recommendation that we must incorporate electrical correction in display devices used for critical color evaluation (monitors and receivers) to compensate for the particular phosphors used to make the device approximate an NTSC display. Indeed, with the decision to retain the NTSC standards, to deny the need for a monitor matrix amounts to saying that we would not like NTSC phosphors if we had them.

This correction matrix is inserted in monitors after the normal NTSC demodulator (Figure 3) and made switchable so that it can be switched out to permit monitor adjustment using a normal color bar signal. After monitor adjustment, the matrix is switched on to provide NTSC colorimetry..

The color errors that result when a correction matrix is used with modern phosphors are shown in Figure 4.

Comparing these results with Figure 2 we see that skin color is reproduced with no error and the errors in other colors are considerably reduced. We no longer have the overall desaturations.

At the CCIR final meetings held earlier this month, the subject of colorimetric standards was discussed and the U. S. position was stated in a revision of CCIR report 476 as summarized below:

"The U. S. A. continues to base its transmissions upon the NTSC primaries. However, since color picture tubes do not now contain phosphors whose chromaticities are the same as the NTSC primaries, approximate corrections involving operations on electrical signals are made in receivers in order to achieve satisfactory color reproduction. Furthermore, in order to ensure the uniformity of its transmissions, the U. S. A. recommends that the picture monitors used in studios should also contain circuits which cause the color reproduction to approximate that which would have been obtained if the picture tubes used in the monitors had contained phosphors whose chromaticities matched the NTSC primaries."

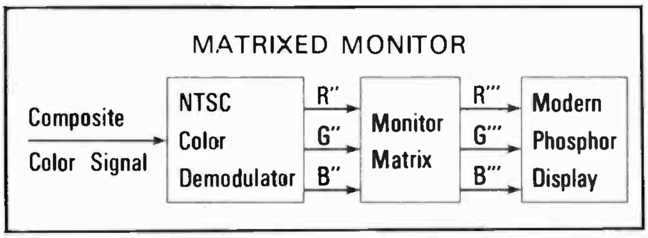



**Figure 3**

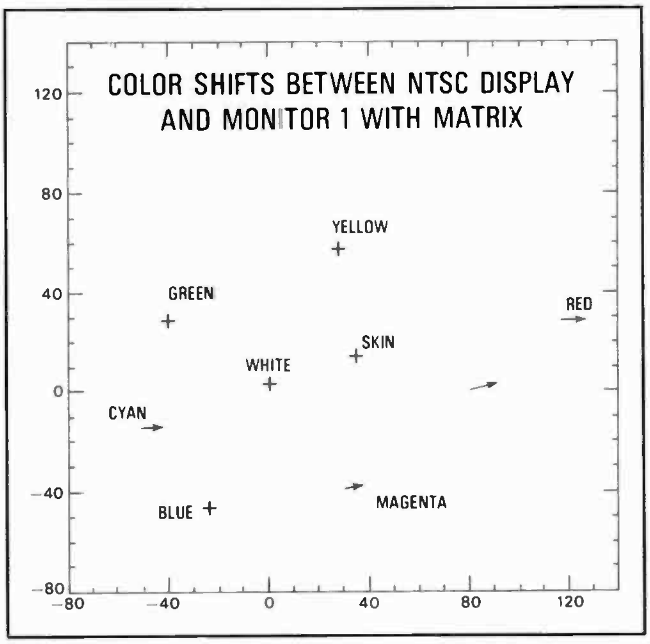



**Figure 4**

To implement this recommendation of the matrixed monitor will require industry cooperation, both to accept the concept and to change existing monitors. The major manufacturers of picture monitors are prepared to supply new monitors with the required matrix and to supply retro-fit kits for current monitors. We realize that the implementation of this recommendation will present some problems and require time.

The implementation of the matrixed monitor should accomplish the following:

1. Make monitors conform to NTSC standards.
2. Match color monitors which have different phosphors.
3. Provide an industry standard display for technical and artistic evaluation of television pictures.
4. Help lead to more uniform color on the home receiver.

**Frank Davidoff**

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*CBS Television Network*
*New York, N.Y.*

# Progress Report of the Broadcasters' Task Force On a Corrective Matrix for Picture Monitors

Mr. Benson and Dr. DeMarsh have discussed the background and the reasons for the decision to recommend that for the U. S. NTSC Television system, a corrective matrix for modern day phosphors should be placed in the display device rather than in the signal generating equipment before transmission.

An important aspect of this recommendation is to have broadcasters use such corrective matrices in the picture monitors used in program generation and production. Three reasons have been advocated by different people at different times for the desirability of having broadcasters use such a matrix. These are:

1. Reduction of variability in color television programs.
2. Improved accuracy of color rendition.
3. Need to conform to a standard for the United States television system.

The considerations that influenced the recommendation discussed above were based principally on theoretical assumptions. Typical real-life broadcast operating procedures were not taken into account.

Several people have questioned how important and meaningful the use of a corrective matrix would be in reducing program variability and improving color accuracy under typical broadcast conditions. It was felt that the value of a corrective matrix would depend greatly on how broadcasters actually operate cameras and generate programs.

Accordingly, the SMPTE Committee on Colorimetry appointed a Broadcasters' Task Force to investigate these questions. The committee is composed of members from ABC, CBS, NBC, NET and Westinghouse. The scope of the committee consists of three areas as follows:

1. Establish broadcasters' typical operating practices with respect to live studio cameras as information for the Colorimetry Subcommittee.
2. Study the technical problems involved in using a monitor with a correction matrix, in conjunction with broadcasters' operating practices.
3. Conduct a field test to investigate the use of a monitor with a correction matrix, under actual broadcast conditions.

With respect to Item 1 above, each of the task force members is investigating how video operators actually adjust live studio cameras in typical production situations. Two of the important procedures about which uncertainty exists are 1) methods of setting camera black level, and 2) whether painting (slight modification of the color balance) is used.

Some members of the parent Colorimetry Subcommittee believe that camera black level should be adjusted with the lens capped and not readjusted when the camera is actually pointed at the scene. However, from the information received to date, almost all broadcasters readjust camera black level to obtain a pleasing picture, depending on the contrast actually existing in the scene. This contrast in typical studio situations may be as low as 20:1.

With respect to the question of painting, some broadcasters say that after initial adjustment for a program, they very rarely touch up a studio camera. Other broadcasters say that they find it necessary to routinely perform slight readjustments so that all the cameras of a studio match each other on most important characteristics of the scene, typically, flesh tones. These adjustments may be required because of different camera angles and viewpoints as well as differences in the cameras themselves.

This investigation of typical broadcast operating practices is proceeding, and a tabulation of these practices will be submitted to the Colorimetry Subcommittee.

With respect to item 2 of the Task Force Scope, some of the problems of using a monitor with a corrective matrix are merely hardware problems such as:

1. The need to have a switch on a matrixed monitor to remove the matrix so that a standard EIA color bar signal may be used to adjust the monitor.
2. The problem of changing the matrix in a monitor, if a color kinescope is replaced by another having different phosphors.

A more fundamental question to be investigated in this part of the Task Force activities is the basic question as to whether different pictures will be generated by broadcasters, if monitors with corrective matrices are used.

At this time, differences of opinion exist with respect to this question. Some broadcasters feel that a camera should be set up on a gray scale and adjusted for the characteristics of the scene by variation of iris and black level only. These broadcasters believe that these adjustments, iris and black level, will not be changed whether or not the color picture monitor has a corrective matrix. Other broadcasters believe that some painting will always be required for matching of cameras and for special production requirements, and a matrixed picture monitor will alter the degree of painting.

No extensive field tests have been performed as yet as intended in part 3 of the Task Force Scope. However, active plans for these tests are under consideration.

One fundamental test which has been suggested is to have a skilled video operator adjust a camera in his normal manner, first using a picture monitor without a matrix and then repeating with a matrix. This would be done under a variety of studio conditions and scenes. The differences in the pictures, if any, would be evaluated in terms of their meaningfulness in broadcast operations and in terms of reduced picture variability and increased color accuracy.

Other plans are to observe actual programs as they are normally produced. We would observe the operator making adjustments, and make quantitative measurements of where camera controls are set and how they conform with actual scene contrasts.

It cannot be too strongly emphasized that all the members of the Broadcasters' Task Force strongly feel that there cannot be a rigid adjustment procedure for studio camera operation. Too much depends on the nature of the scene involved and also on the special wishes and desires of the program producer. However, clearer understanding of the variables and a study of how a monitor with a corrective matrix may benefit and influence program production can only be of help in achieving the ultimate goal of better television service.

**A Panel Discussion**

*Moderator:*

**William B. Honeycutt**

*Director of Engineering*
*KDFW Television*
*Dallas, Tex.*

# Use of Computers in the Total Television Broadcast Facility

During the course of planning for this program the Engineering Conference Committee was very much aware of the fact that the computer is becoming a necessary part of station operations. It was originally felt that we should devote almost a full morning to its various uses, but time does not permit. So we've assembled a panel of people who think will be able to give us a little insight on where we stand, and after that answer any questions you might have.

I'd like to introduce at this time our panel members: James Ziegler, vice president, Data Communications Corporation, Memphis, Tenn.; Howard A. Shephard, manager of broadcast automation systems, Central Dynamics Corp., Northvale, N. J.; Charles H. Magee, manager of engineering, Westinghouse Broadcasting, New York; Ray Johnson, executive vice president and general manager, KMED-TV, Medord, Ore.; Adrian B. Ettlinger, consultant to the Grass Valley Group, Grass Valley, Cal., and George Beattie, director of customer relations for broadcast computer sciences, Kaman Sciences Corp., Colorado Springs, Colo.

We'd like to start the program by having Charley Magee give you a little insight on what has been done in the Westinghouse Group which, while it is a large operation, I think will give you a feeling of what can be done and what is being done at their station.

### Mr. Magee:

When KYW made the decision to relocate its main studio, plans were made to incorporate a master control switching and machine control system using a minicomputer as a real time processor.

This concept was broadened to include the traffic department function of program schedule preparation, that is, information formerly typed onto multilith masters could now be entered into the minicomputer system through CRT terminals. This data base would then be used to print out a program schedule and to supply most of the information necessary to support the master control switching operation, including a program log.

At the same time, the Westinghouse Broadcasting Company EDP group had been developing a sales traffic system to convert sales contracts and other program information into a useful program schedule. Such a system was to provide information on availabilities program schedule and print out hard copy and invoices.

A suitably located data processing center was ultimately designed to service all Group W radio and television stations. Thus two stand-alone systems have evolved, each serving its own purposes, but with overlapping capability. The one system, a minicomputer system, was designed and supplied by Central Dynamics to Group W specifications. Its scope includes master control operations, program schedule printout, but not generation, and a printed program log. The other system, the Group W sales traffic system, has a capability of generating a program schedule from sales and program data inputted through station CRT terminals. This schedule can be transmitted to the station where it is converted to hard copy on a data printer. The results of the execution of this schedule may be fed back into the system using the same CRT terminals that were used to input the original sales and program information.

The desirability of combining the activity of the minicomputer at each television station with the service provided by the larger off-premises host computer became readily obvious. The result of coupling these systems together is a unified system which effectively copes with many of the complex problems of modern broadcast operations.

In the unified system, a Burroughs-3500 data processing system generates program schedules from the data inputted through the station-located CRT terminals. Now, however, in addition to being available in hard-copy form, these schedules are transmitted to the station and stored on magnetic discs under control of the local minicomputer.

After editing, this data is used to print the final form of the schedule and subsequently to directly control the master control program switching operation. Following the broadcast, the certified performance is retransmitted through the minicomputer to the host computer for further processing, including the generation of invoices.

The reasons we had for wanting to automate the master control operation are not unique, but are probably typical among those who have gone down the road before us. The increased complexity of switching operations over the years has made the need to find a better way all the more desirable. Basically, we wanted to minimize operator errors by removing the burden of real-time decision-making during the critical program transition periods. We elected not to use the hard-wired approach because of its inherent restricted performance capability and the relative difficulty in modifying the system to future requirements. Another reason we felt to be important was the elimination of errors due to the mix-ups that occasionally occur in communicating machine assignments between tele-cine or BTR and master control.

It was an objective of the computerized processing and sales program to establish an accurate information base for station operations, give us the ability to make a one-time entry of information that is used repetitively, provide immediately updated availabilities and other data base information, and provide a degree of standarization among stations while still providing for local policy differences.

The general effect of these and other features is to optimize station response to order entries to efficient processing from beginning to end. A benefit of the automation system that was not so obvious at first, but later became quite clear, was the greatly improved communication that has occurred between technical operators and the traffic department personnel. The rigid discipline required in file creation and editing has done much to enhance an understanding of each other's problems and responsibilities, not previously achieved. This is due largely to the fact that file data has controlling effects on master control operations. The result has been typical of what happens whenever team work gets better.

By early 1974 the sales service traffic system was providing the many features of its design to KYW-TV's operation. After a period of independent operation of this system and the technical operations system, the two were joined together via a dedicated data communications channel. For about the last 10 days we have been receiving files for air use. The log feedback portion of the system is currently undergoing final test and evaluation.

We believe the system potential has not been fully developed and are continuing to investigate other tasks that might be done. As an example, we are currently considering a system to further automate the control of our videotape cassette machines. This would feature self-identification of each cassette and subsequent programming for air playback. This would be accomplished by recording the material identification numbers on the cue track.

Our next task is the expansion of the system to other Group W television stations, a project which is expected to be completed in 1974. Thank you.

**Mr. Honeycutt:**

Next we would like to call on Mr. Johnson to tell us about his efforts in this direction.

**Mr. Johnson:**

Thank you. I'm not going to read my prepared script here because largely it would duplicate the preceding speaker's thoughts.

I just want to say that at a meeting similar to this one several years ago, there was a speaker who talked about computers in radio and television stations, and I got very interested in the subject. We have four stations, a television station and three radio stations, and I was aware of the fact that each one of the radio stations had a traffic girl. Television had two-and-a-half girls working on traffic. I was also aware of the fact our managers were always in trouble whenever this particular person, particularly in radio, went on vacation, was ill or for some reason was absent. We did not have adequate backup.

I was also becoming more and more aware of the many pressures that are brought upon management so far as looking towards some kind of a mechanical-electronic method of doing traffic, billing, accounting, payroll, and so on. In June of 1972, I decided to take the first step. However, as most managers will find, there's a great deal of resistance to computers or to any change from the accepted method of doing things and for a while I was quite alone within our organization.

Nevertheless, in June of 1972 I put all of our traffic operation into one room called a Traffic Center. The purpose was to acquaint all of the people in traffic with all of the problems of all of the stations, looking forward to a better way, a more efficient way of handling traffic primarily, but going into the other things such as accounting and bookkeeping and payroll.

I met with a great deal of resistance from the radio managers because each had their own traffic person who was under their control, under their thumb. A sort of "their-own-employee" type of situation. However I prevailed in the end because I sign the checks, and we began to work on a system we call the Milar system of traffic.

I did not know at that time exactly what was going to happen in the minicomputer field, so we looked at a number of mechanical methods of handling these tasks. Then last year, IGM displayed at the convention the BAT-1000, level 1 and level 2, now called the BAT-1000 and the BAT-2000. It seemed to make a lot of sense to us and so we had a private showing after the convention, and in June of 1973 their representatives came to our operation, looked over our traffic, our accounting, our bookkeeping, the whole thing. At that time we made the final decision to go to the BAT-1000 level 2, now called the BAT-2000. IGM, by the way, is now called PSI for Paperwork Services Incorporated.

To terminate my position, I'll simply say that there are two important items, so far as we're concerned. Number one is to hang loose when you're working with the computer because you've got all kinds of problems and if you haven't worked with a computer, you have no idea what those problems are going to be. In the task of hanging loose, I did everything I could to psychologically prepare our people at the station for a change from what they'd known as the normal situation.

The second important thing to do, is to set goals to be broken, not to be met, because at least you know that you're moving somewhere. The stations that I talked to who had some pretty bad experiences with computers had thought in terms of the positive. Thought in terms of goals to be met. Thought in terms of this was going to be as easy to handle as any of the tasks at a radio or television station. And as a result of that, we took the view that this was going to be something entirely different.

I'd say at this point and we just started taking delivery of the equipment and software in October, with everything now on station, so to speak, that we're about 40% home. I'd say we've got about 60% of the way to go to accomplish what I wanted to accomplish and what I intended to accomplish when I signed my name on the dotted line and agreed to put up the money to make it all work at our station.

Now we are a small station and we have much to learn insofar as computers are concerned. I am not sitting here as an expert. When the computer people are in my office and we talk, I feel like a stranger because they speak a language that I don't understand. I'm beginning to sling a few of those terms around myself to entertain my family, but that's about where we are now.

**Mr. Honeycutt:**

Our next panelists is Adrian Ettlinger from the Glass Valley Group, who will describe a little of what they've done in the way of automation hardware.

**Mr. Ettlinger:**

My involvement in this area is, as far as practical experience is concerned, almost entirely from the switching automation function, or what has come to be termed the engineering function, and it goes back pretty much to year one in terms of computer installation at broadcast stations. Back to the very first application of a true computer to switching automation which was done at the CBS-owned station KNXT in Hollywood, in 1960.

Through the years I've looked across at the efforts being made in the sales-traffic automation, which certainly in the last couple of years has mushroomed in terms of the number of installations, but I've tended to have an attitude, of what's taking you guys so long? I think the explanation for it is quite obvious in some of the comments that have been made here so far, communications is the most serious problem, and if we just look at the question "when will the total automation system, that is, the engineering and the sales traffic function in an integrated way, become a reality for the average station, particularly as a practical reality for something that stations in secondary markets will consider?"

As of now, I believe that the Westinghouse installation is really only the second one in the country where this has been attempted. A totally integrated system as of now is something that tends to be attempted only by a large multi-station owner who has the resources to devote to it. But I would just say that I'm quite confident that the totally integrated system is definitely in the future of virtually every station. One reason that I feel this way is that the hardware costs, are continually coming down, and if any station could bring into being a system, a totally integrated system merely for the cost of the hardware, I don't believe they would give it a second thought. Minicomputer, processors and peripherals, the size of mass storage that's needed to do the function are so economical now that it's almost that the entire problem has become the human problem, and the human problem certainly is a big problem, as we all know. It's a problem of communication across the disciplines. That is from the business side to the computer experts, learning each other's language and learning each other's problems. And I feel that's really the only thing that stands in the way of total automation becoming a general reality in the industry. Thank you.

**Mr. Honeycutt:**

Next we'll ask George Beattie, of Broadcast Computer Services to tell us what he knows about this problem.

**Mr. Beattie:**

Mr. Ettlinger has stated, he is most familiar with the technical aspect or the switching side. My personal interest has always been, on the front end.

Kaman Sciences Broadcast Computer Service has been around since 1968 when it designed a system for a station we owned. From the beginning we knew that any system designed to handle traffic, accounting, and the billing systems, would eventually have to be married with the switching side of the total concept. So from the beginning, what we have attempted to do is gather the expertise and the people from the three areas of the broadcasting complex to make sure that we were ready to go when people such as the Grass Valley Group and the other manufacturers were also ready to go.

Broadcast Computer Services began, as I mentioned, with our own station and is a broadcaster-designed organization with depth in three fields, first of all in the management, traffic, accounting, sales; secondly, in the technical aspects, as far as engineering and switch gear; and third, the computer programming area.

As I mentioned, we have attempted to try to build the front end of the system with the knowledge that we must match the back end or interface with whatever hardware system comes up.

Some of you are quite familiar with our system. Others may not be. At the moment we have installations in 31 stations which is everything in the traffic and accounting end of it, from the beginning of the order through the availing of the spots through the projecting of all of the spots, the rotations, the monies and so forth through the actual scheduling of a proposed final log, and then after the fact, an analysis of that log prior to going to the actual switching mechanism.

At this point, what we have planned and what we are currently developing is the bridge between the actual real-time log or log and the actual unit as proposed by the hardware manufacturers. We have also designed a system so that we can interface at whatever level the manufacturer or the buyer, the station owner, needs it, whether that be cards, paper tape, cassette, or direct computer-to-computer.

Four years ago we also found that in our earlier system, which was a large host computer connected to a terminal, a dumb terminal at that time, that there was going to be need in the station for a computer in-house to actually operate the switch gear, or to interface with the switch gear when it came about. So BCS became the pioneer in the minicomputer in-house master computer complex using the speed and availability of the in-house computer with the enormous capacity of the large host computers. So primarily our efforts have been in that direction.

We have three types of systems, one which is a card, one which is the small PDP-8 digital computer, and our latest, which is the PDP-11, which can interface with many of the pieces of equipment on the market today.

As I said, we have built the organization with the knowledge that we can do everything here. Now we must interface with what the industry really needs, and that's a total automated system. At this time we have the people, the expertise in all three areas. We have the knowledge and the equipment, and we look with eager anticipation to the first combining of the entire complex. Thank you.

**Mr. Honeycutt:**

Next, Jim Ziegler from Data Communications Corporation.

**Mr. Ziegler:**

As many of you probably know, Data Communications Corporation provides a service which we call BIAS, Broadcast Industry Automation System. We're currently providing this service to more than 60 television stations in the United States, Canada, and the United Kingdom.

I'd like to talk very briefly about what our system currently provides, what developments we expect within the next 12 to 24 months, and I would like to invite you all to come to the system in operation at our hospitality suite and to continue this discussion, if you so desire, this afternoon.

We currently handle all of the needs of the sales-traffic portion of the television organization. This encompasses order entry, entry of the facility instruction, the media instructions, preparation of schedules, updating logs after broadcast, and preparation and mailing of invoice and statement type of information. We intend to enhance this system. Part of our service is the continual enhancement of the offerings that we provide. Some enhancements in the works for the current system include the preparation of avail submission type of information and the optimization of inventory to provide the best combination of sales for your station, and continued improvement on management reporting.

Two other areas that we are expanding the system into currently and expect to see in operation in the next year or two are offerings for the engineering production department, which will include both inventory control of both commercial film and tape and program film and tape, encompassing allocation and management of the actual storage space, production of instruction or pull sheets for the people who are making up the day's broadcast, and the collection of the information which needs to be provided to automatic switching equipment.

The second area in the engineering and production area would be, of course, the automatic switching equipment operation which we intend to provide primarily in the form of event list and event descriptions to be fed to available switchers from several of the companies that provide this equipment.

The other major area in which we are currently expanding our system is that of a connection between the station computer, which we operate, and the agency's computer. As many of you I'm sure read in the current issue of Broadcasting, we have agreed in principle with Donovan Data Systems to develop a three-way hookup of the computer systems between the agencies, information which they maintain and the station information which we maintain and the record information which we are both currently servicing. This connection would allow us to exchange between the computers order information, product allocation information, facility instructions, and invoice information, all, hopefully, without the need for the tremendous amount of information which is currently being sent through the mails and the attendant delays. We see the biggest problem in the complete tie-up of order entry through actual switching of the television to be that of the tremendous amount of information which needs to be collected and indexed and sorted together to provide the detailed event description which drives the automatic switching equipment. We feel that our approach of collecting the information at its source, namely at the agency passing it through this interconnected computer system to the station and then sorting it together at the time of log preparation in the station, would be—will be the approach which provides the most value to the station for the least amount of detailed work done on premises. Thank you.

**Mr. Honeycutt:**

Next, Howard Shephard of Broadcast Automation Systems.

**Mr. Shepard:**

You have heard the description of the Westinghouse Broadcasting's integrated automation system, which includes the unit developed by Central Dynamics. A detailed technical description of this system would take too much of our time this morning because we want to allow a reasonable amount of time for questions. However, anyone interested in looking into its operation in some detail will be able to do so at our booth here at NAB. The APC-16-200, as used by Westinghouse is quite a large system that may exceed the requirements of the smaller-market television station. Market demand to our company has also indicated that this was true. The main area of demand has also been in the control room automation area. This is in the smaller stations, obviously.

Last year, because of this demand, Central Dynamics embarked upon a development program to produce a new computer-based automation system. The design objectives were as follows: Keep the cost as low as possible, consistent with reliable operation. Use a minicomputer from a manufacturer which has good service backup worldwide. Use flexible timing modes and video-audio transition control to permit the smoothest possible on-air program presentation. Allow a wide range of data input devices to tie the system into a variety of front-end systems. Have sufficient event storage to carry through the most complex break. Be expandable to a full-day's schedule in on-line storage. To permit last minute changes in the form of deletions and insertions with automatic compensation for the scheduled times of the following events.

These design targets have been met and the new 610-100 control room automation system is available. We have a unit here at the show, as well as the larger system.

How does control room automation benefit the station management?

One, by lessening the likelihood of expensive on-air errors which not only affect the station's revenue, but also presents a poor image to the viewer.

Two, station personnel are utilized more effectively and are able to even out their workload as the automation system eliminates the panic breaks.

As a footnote before closing, I'd like to announce a major step forward in station automation which took place only this morning, although it was the result of months of preparation. This was the first successful test of a complete two-way communications between a computer-based broadcast automation system and a video cassette recorder. The test undertaken here before the exhibit opened between the Central Dynamics APC-16-200 and the Ampex ACR-25 proved beyond doubt the feasibility of such an interface.

I'll be happy to answer any further questions about this communication system works during the question period. Thank you very much.

**Mr. Honeycutt:**

All right, now you've heard from each one of these experts in their field. Do we have a question?

**Q:** (Inaudible to the reporter).

**Mr. Beattie:**

Well, as far as I'm concerned, to answer that, I would hate to see an industry that only had one or two to choose from because then you really have no choice.

First of all, I feel that you have to supply us a service that can be used by any market size. You have to be able to supply a service that will handle from the smallest market in radio to the largest market in television, even though the larger television stations do have the capital to produce their own.

I believe that you have to be versatile enough to cover each of these, and I don't really know whether one organization, without any competition, would best benefit the broadcast industry.

**Q:** How many stations are presently using automation systems or computers in their operation?

**Mr. Johnson:**

I really don't know. NAB put out a mailing piece last year to determine how many stations in the United States actually had some kind of automation in it—or, rather, computerization involved. And it was very small. I was surprised.

I think every radio and television station in the United States one day, by virtue of—or, because of several of four pressures, will have some kind of minicomputer. And I think that there's going to be a market of at least 7500 of these computers of various sizes in operation within the not too distant future. I think we're all going to go to it whether we want to or not.

I think the pressures from agencies on those stations that do a reasonable amount of national and regional billing will have an effect. The cost of manpower and girl-power, the pressure of the state of the art of computers in the business, all those things, all those pressures are going to require computers whether we want them or not.

**Mr. Honeycutt:**

I agree 100%. I think we need to clarify as to how many different types of services the industry can support. The marketplace will eventually decide that. What we've tried to show here, is that today there are companies providing both services, both the technical automation and the business automation, and they're talking to each other. Out of this is coming a trend now to the point that these services can be married together and made to operate so that you can fit a system almost to fit any particular needs.

As has been pointed out, Westinghouse, with five or more television stations, can afford to develop their own system. You or I might not be able to. So we're all going to get there one way or the other in order to keep up with the tremendous amount of paperwork and detail that keeps getting worse day by day.

**Mr. Ziegler:**

I just wanted to say that in the area of television business automation, the industry is currently supporting at least two such services, and we see that far less than a fifth of the television stations are currently utilizing these services, so there would appear to be room for a lot more growth in that area.

Q: When you gentlemen speak of totally integrated automation, what are the needs and requirements and the possibility of including program identification . . . that is prerecorded program on film, videotape, and possibly an integration of that type identification into the computer and logging system? Right now there is a requirement for program identification before the FCC. These are presently directed toward off-air monitoring. You're going to have to identify programs to fit within your logging, and I'm just wondering what provisions have been made for this?

**Mr. Magee:**

At the present time, we haven't gone that far down the road in the kind of identification I believe you're talking about. As I said earlier, one of the reasons that we like the software approach is because it affords a flexibility for future incorporation of changes with a relatively minimal effect.

**Mr. Ettlinger:**

I think it can be said that really in the total final system that we see in the future, certainly automatic identification of every program element will be in the picture, and from a technical standpoint, it's completely feasible, that is, there's no real technical problem at all of whether it's sub-audible audio coding or whether it's in video or whatever it is, certainly there are many ways to do it.

It's simply one of these things that will not be standardized until the demand is felt to get enough joint effort around the industry to agree on a standardized approach.

I might just mention, on a worldwide perspective, the Japanese are way ahead of us on this. The mammoth computer system that NHK, the national service of Japan, has in operation in Tokyo does use coding—electronic coding of all their videotape material in a system they've had in operation now for two or three years. That, of course, is a type of system that's hardly relevant to the needs of the independent individual broadcaster in the U.S., but it's an illustration that it's quite feasible to do once you simply decide on an industry-wide basis how to do it.

**Mr. Shephard:**

I think one step forward is indicated by this interface that is currently running with the ACR-25 were actually the electronic identification in the material is mandatory in its actual operation. The idea of it is to eliminate the possibility of a decision on which bins of the carousel to put the tapes so that the tapes or the cassettes can be thrown into any old bin and the system will electronically identify which bins which material is in, and this is in turn transmitted to our computer which scans through and says, "This material is required in this order," and assigns the bin numbers in accordance with the type of contents given to it by the cassette machine. We in turn then return to the cassette machine the order in which to play the cassettes, with standby after an end after cues and so on.

So this electronic identification was mandatory towards that, otherwise you've still got the problem of the manual intervention there. So although it's not as far forward as actually verifying it off-air, it is a step forward in this direction.

Q: Does the cassette have to run to get the identification, or is it external, optically some way, on the cassette? Can you get it before it goes on the air or do you get it on the air?

**Mr. Shephard:**

You get it pre-the requirement for it going on the air, in other words, on command from the automation system that there is sufficient time. The cassette machine will automatically pull cassettes in pairs out of its carousel and electronically identify them in a table. And you might say all this could cause tape wear and head wear and so forth. Well, the tape is pulled up into the vacuum column and the heads aren't engaged. It only has to move a very short distance to read the identification off the cue track, and it puts it back in the carousel again.

**Mr. Ziegler:**

If I may also make a comment. This is one of two possible directions the industry could go in, and I would like to at least mention the other one. The one approach, of course, being that of having identification on all information, but, of course, you have to put that identification on at some point in time and the current state of the industry is that you put that identification on yourself when the film first comes in the door, so you there again still have the manual entry.

The other possible route that could be taken is that as that film comes in the door and you key in its identification, instead of recording the film—or, the identification on the tape or the film, this identification could be stored and the film could be automatically stored in an automated inventory, this never to be touched again by human hands until it's disposed after its useful life is over. This may sound farfetched, but such systems are in fact in existence in the computer industry for computer tape. They will, once the tape is put into the front end of the system, they will store it away, and when it's retrieved by name, the tape will be moved to a playback unit, it will be mounted, threaded, cued, and all of operation is done. After the thing is finished, it is put back into its case and put back into inventory. So this is another possible technology that could be investigated, particularly with the advent of videotape cartridges and film cartridges.

Q: What are the economics of the whole thing? At what level should you be looking at automation? What is it going to cost and what do you really save?

**Mr. Ziegler:**

We have in the area of business—automation, sales traffic automation—we have stations in the number one market down to the 150th market that feel that they have not only saved money, but made money by putting in such a system. The justifications turn out to be different for every station, although we'd be happy to discuss with you the justifications for your station. I'm sure that the representatives of the other services would also have a wide variety of stations that felt that the service was justified economically, even in the smaller markets.

**Mr. Johnson:**

I'd like to comment on that in a little different way. As we visited stations that had computer experience, they had gone into it, almost every one, on the basis that they were going to save money through saving salaries, manpower and girl-power. But as they got into it, they were convinced by the suppliers of them that really wasn't why they went into it. They went into it to get more information faster.

That isn't why we went into. We're reasonably successful without more information faster. The other thing that we found, that the managers, once they had it, really got more information that they really wanted or knew how to handle. It became—their desks became a storage for paper—on top, not in the drawers.

We are continuing to pursue it on the basis that it will actually make us a more efficient operation from a cost point of view.

**Mr. Ziegler:**

Our stations have increased sales. They have decreased receivables, and in some cases they have decreased personnel.

**Mr. Beattie:**

I would like to make one other comment, that if you are going into this with the—as was mentioned by Mr. Johnson—with the idea of lessening your staff immediately, the computerization of the stations that we have in has been justified by decreasing human error and by increasing the ability to control your inventory. That plus the fact that you have your information that much faster.

In so many stations today, even with the existing staffs, you're working 10 to 12-14 hours a day to perform the job and everything is a last-minute job. The people that have been hired in so many of these departments were hired for at least some artistic value, and because of the industry today, there is no time to do it.

So the computer really is there to increase the ability to maximize your product, the inventory, and to at least give the people there help in the routine in the chores where usually the mistakes are made. So by lessening the errors and increasing the inventory control really is what I feel that you'll get down to justifying the costs by.

**Mr. Honeycutt:**

As to how much is it going to cost, our limited knowledge suggests that the price of these units run from about 25 thousand on up, depending upon what you're going to need and what you want it to do. I don't think we can ever go into computerization with the idea that this is a magic wand. It has to be approached from the standpoint that you have a job to do, can you do it more efficiently and eventually more economically? And has been pointed out, can you decrease the number of make-goods; can you prevent operator errors; get your billing out quicker and more accurately; put the program schedule together better; and all of these things?

**Q:** Mr. Ziegler mentioned a very interesting aspect of connection that the others had not mentioned, and that was connection to agencies. Perhaps instructions could be sent directly from an agency terminal to the central processing computer and thence to the station. Obviously an agency might be interested in receiving availabilities information. They sometimes are interested—particularly in a local situation, but I'm sure you're not talking about that—in knowing what time commercials are going to be running on the air. There's some value to sending confirmations directly to agencies. But what other ideas do you have in regard to agencies feeding information directly into a station's data base? Are they going to be using their facilities to overcome some of the traffic problems? Are they going to substitute for traffic entry? Will you please expand on that? Thank you.

**Mr. Ziegler:**

There are basically four areas where information will be interchanged. The first area is orders. We envision the capability for a request for an order to be input at either the agency, the rep, or the station. This request does not affect the station's files or the agency's files at that point. It is merely a pending request for an order. This order can then be reviewed, and will then be reviewed, by the station's sales manager or the person to whom this authority is delegated within the stations. If that order is accepted by the station, then and only then are the sation's files and the agency's files updated.

Similarly, changes can be inputted any of the places, but only when a change is confirmed by the other party, after review, does it affect the files. So there is no ability on the part of any party to get at the other party's information. It's an on line real-time data communications system.

Instead of the information coming through the mail, it would come through the computer system. There is one big advantage to doing it this way in that if, when the agency is allocating the spots it has bought to products, a conflict thereby arises, a product conflict, it's possible in this system for that information to be made available immediately by the system, without the station having to worry about it, to the agency, and therefore the agency can change their product allocation, allocate their products differently in such a way as to not cause the product conflict to arise which would have previously necessitated an order change to settle the situation.

The third area of information interchange with the film, tape, media instructions. This would include the rotation instructions. The rotation instructions would be—and the identification of the media as envisioned—would be input by the agency, therefore eliminating the problems which arise in trying to interpret the varying formats of agency instructions at station level.

The other possibility, down the road somewhat, is that since the agencies or their subcontractors, essentially do in fact make the commercial, it's possible that the description, the detailed even description of this commercial material, which is necessary for input to automatic switching systems, could be input at one time by the agency which creates this commercial and thereafter be used by all stations which are interconnected with this system without necessity for any subsequent re-keyboarding of this type of information.

The fourth area of information interchange would be the invoices—invoice-type information which is currently mailed at the end of the month after transmission, and exception lists, if you will, lists of those things which are not—which were not transmitted as agreed due to technical problems, preemption, whatever, in other words, a list of those things which has to be dealt with before payment can proceed.

So these are the four areas of information interchange. And again, I wish to emphasize that we are not pooling all agency and the station information into a large pool that anyone can get anything they want out of. What we are talking about is replacing the U.S. Postal Service, if you will, with a computer link-up so that the communications between the parties, rather than occurring on a two-or-three-day-delay basis, can occur essentially instantly.

Donovan Data Systems, which is the company that represents the agency information currently has a very large percentage of national TV spots pass through its computer. This is the element that makes this approach practical, the fact that this one connection will provide us with the services of most of the agency information of interest.

**Mr. Beattie:**

I'll must make it brief, but, as with Jim's organization, as with ours, there are remote terminals now hooked up to various reps and so forth that can go into the data base of a station once the station has defined what they're allowed to see or touch, as the case may be. And really what it boils down to is what does the station wish done because as far as the equipment and the ability has existed for some time to be able to go into the data base of a station from a remote organization. I think you're going to find this more and more. By this time next year, I'm sure it'll be quite common, both in the reps and the agencies.

**Mr. Honeycutt:**

Thank you. I think we'll have to conclude our session now and adjourn for the luncheon. So thank you very much for coming.


**Hans Schmid**

*Senior Engineer*
*American Broadcasting Co.*
*New York, N.Y.*


# Audio, the Stepchild of TV Broadcasting

The EIA standard RS-170 (Electrical Performance Standards Monochrome TV Facilities) states that the audio performance is to be in accordance with EIA standard RS-219 (Recommendation for Audio Facilities for Radio Broadcasting). Although this standard and its predecessor EIA TR-105 has been around for the last twenty years, there still is confusion of terminology in the industry, some of which we can hopefully clear up.

The standard on audio facilities defines the input level as −50 dBm and the output level as +18 dBm for single-frequency steady-state signals. This standard operating condition (68 dB gain) is best illustrated by the block diagram and level diagram of an audio console.

The time allotted for the oral presentation of this paper is too short to go through the block diagram in detail; and we will, therefore, concentrate only on the output circuit, the output level and the VU meter.

The standard output level is 18 dBm or 8 VU (more on dBm and VU later). However, an isolation pad must be provided in the output circuit to prevent the impedance variations of the program line (e.g. with frequency) from affecting the VU meter readings. It is good practice that the loss of this isolation pad is 6 dB; and it is, therefore, obvious that the program amplifier must provide 24 dBm output power for 18 dBm power at the console output (Figure 1).

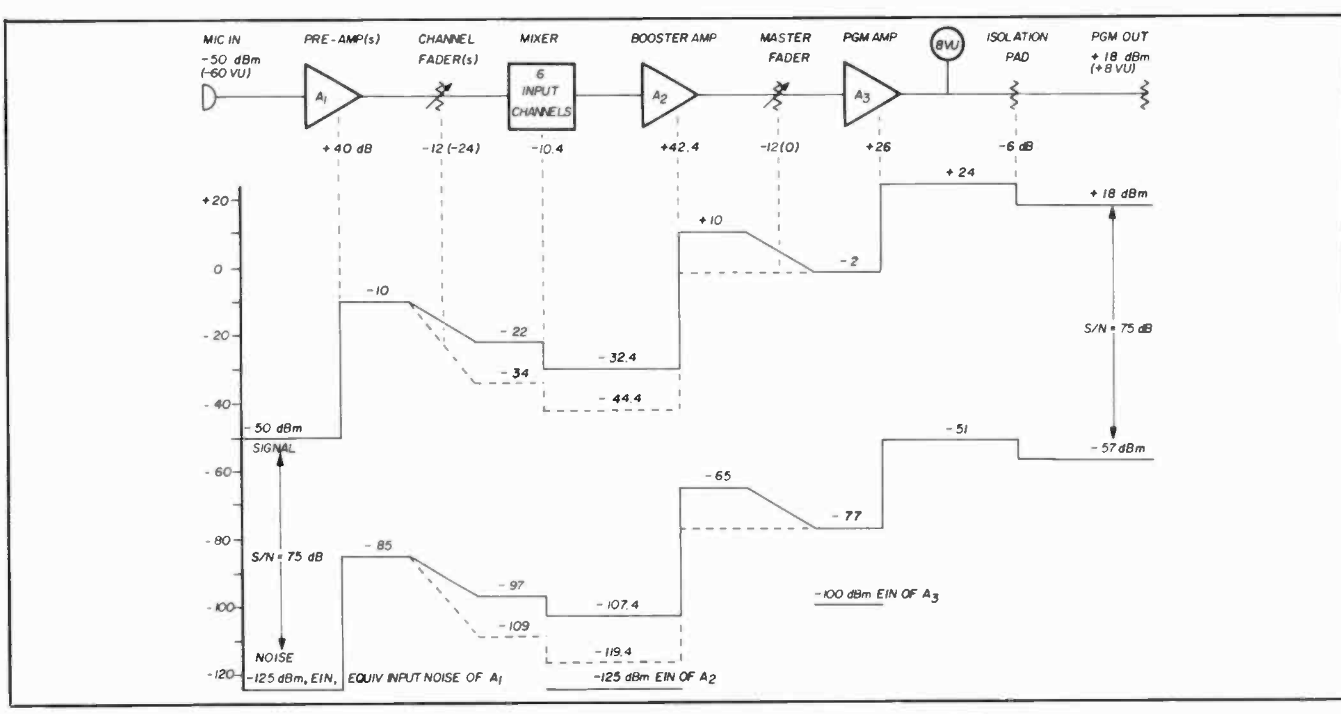


**Figure 1. Block Diagram and Level Diagram of a Typical Audio Console.**

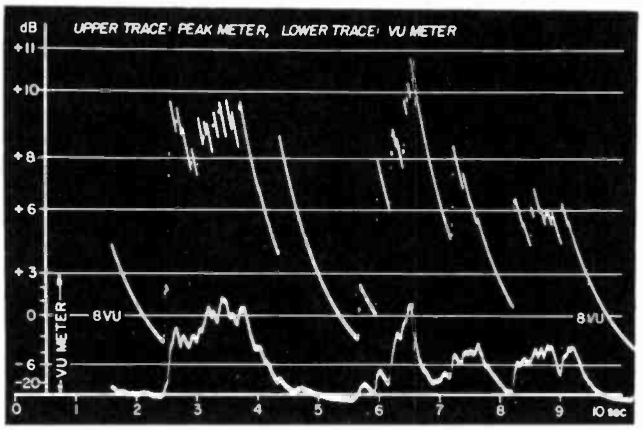


**Figure 2. VU vs. Peak Meter Reading of Program Material.**

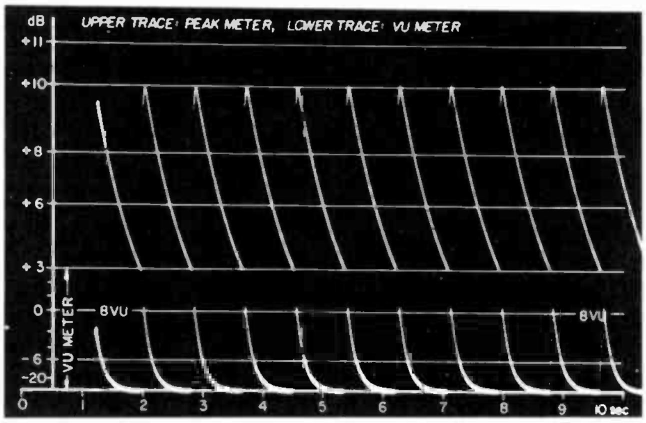


**Figure 3. VU vs. Peak Meter Reading of Program Level Tone Burst.**

And that is not all. Since it is good design practice to allow at least 6 dB of headroom in any amplifier before signal clipping occurs, it is equally obvious that the program amplifier must be capable of providing a maximum output power of 30 dBm.

The VU meter is essentially an averaging type voltmeter that registers program voltage peaks at about 10 dB below their actual amplitude. This VU meter lag of 10 dB is only typical for normal program material and has been adopted by convention despite the fact that occasionally under certain conditions the lag may be somewhat larger or smaller.

Figure 2 illustrates this condition by displaying simultaneously the meter deflections of a VU meter and a peak program meter at identical steady-state sensitivities during a nine second interval of a program with a level of 8 VU. (Actually the display is a dual trace oscillogram, the dynamic responses of the meters having been simulated by their electrical equivalents.) The lower trace is the deflection of the "VU meter" with an 8 VU scale while the upper trace is the deflection of the "peak meter" showing the peaks to reach 9-11 db above 8 VU.

Figure 3 shows the dynamic conditions of the meter deflections when a program level tone burst is used. The program level tone burst is an 8 VU signal which is obtained by gating an 18 dBm steady-state signal ON for 50 ms and OFF for more than 300 ms. And finally we can show that two different tone bursts may well have the same VU level (as they would have in a normal operated console) and yet they are different in loudness as well as peak level; a fact that must be recognized for loudness considerations.

We can now summarize the whole subject with some hard and fast rules:

1. An 18 dBm output level of a console with 6 dB isolation requires a 24 dBm level of the output amplifier, which however must be capable of 30 dBm output power to provide a 6 dB clip-level margin above 24 dBm.
2. "Headroom" is a term used by some to describe the difference (10 dB by definition) between a program VU level and the actual program peak level. Others use the term "headroom" to describe a safety margin (Usually 6 dB in audio amplifiers) between the program peak level and a level at which signal clipping occurs. To avoid confusion the former may be called VU meter lag and the latter clip-level margin.
3. VU and dBm are both measures to express the level of an audio signal. VU is used only for fluctuating program signals and only when read on a VU meter, VU's cannot be read on a dBm meter; dBm is used only for single frequency steady-state signals, dBm's can be read on a VU meter but must be expressed in dBm.
4. For a given point in an audio system, the level expressed in number of VU's is 10 less than when expressed in number of dBm's e.g. a program line level can be stated as 18 dBm or 8 VU or both. If a VU meter is connected to this program line and the line carries an 18 dBm signal, the VU meter is "off-scale".
5. To use the term "program peaks" when referring to VU meter readings will only cause confusion with the true program peaks. To use the term "VU peaks" is redundant since per IEEE standard 151" the VU reading is determined by the greatest deflection occurring in a period of about a minute from program waves, . . ., excluding not more than one or two deflections of unusual amplitude."
6. "O dBm equals 1 mW on 600 ohm" is a phrase used by some but this is improper since 1 mW is 1 mW on any inpedance. The confusion stems from the fact that dBm meters (not being power meters) are actually volt meters that indicate power (in dBm) as a function of a voltage across a given inpedance (usually 600 ohm).

**Malcolm M. Burleson**

*Burleson Associates, Inc.*
*Washington, D.C.*

# TV Remote Control
# Its Present Status and Future Goals

Can an engineering survey be meaningful? We feel the answer is a definite loud YES!

In the Fall of 1973, at the request of several clients, we were asked to survey the current state of television station transmitter remote control. The following questionnaire was sent to 759 stations with 509 returns coming back.

*Survey Question.—*

1. Is your transmitter remote controlled now?
2. If No, do you plan to do so at a later date?
3. If Yes, which make of remote equipment?
4. If Yes, which make of logging equipment, if any?
5. If now remote, please answer the following:
   a. No. of engineers at transmitter before_____; now_____.
   b. No. of man days engineers at transmitter now.
   c. Purpose of man at transmitter now.
   d. No. of days when no engineer at transmitter now.
   e. No. of man days the station saves with remote control.
6. Age of Transmitter_______ Make:_________ Type:_________.
7. If not now remote, when are you planning to make the installation, within _____months _____years?
8. Would you consider using an outside installation service company to do a turnkey (package) job?
9. Was (or is) a labor contract involved in your going remote control?
10. If Yes, how?

*Survey Answers.—*

| | | |
|---|---|---|
| 1. | Number of stations now remote controlled | 116 |
| 2. | Number of stations not remote controlled | 393 |
| 3. | Of 393 not remote—that plan to do later | 192 |
| 4. | Of 393 not remote—that do not plan later (some of these have studio and transmitter at same location so remote not needed). | 178 |
| 5. | Of the 116 remote controlled stations had engineers or an average of 4.2 per station —before being remote control. | 493 |
| 6. | For 116 stations after being remoted there were engineers, or average of 1.5 per station. | 184 |

7. Main purpose stated for man at transmitter, after transmiter remoted, was *maintenance*.
8. Average number of days out of 7 after being remote that no engineer at transmitter during week is 5.6.
9. Total number of man days saved by 116 stations was 2291, or average of 19 mandays per station per week or for a 5 day week per man an average station saving of 3.8 men.
10. Average age of transmitters is *11 years.*

*FCC—Application Status*

| | |
|---|---|
| No. of Commercial VHF and UHF applications filed | 179 |
| No. of Commercial VHF and UHF applications granted | 162 |
| No. of Commercial VHF and UHF applications w/problems | 17 |
| No. of Educational VHF & UHF applications filed | 61 |
| No. of Educational VHF & UHF applications granted | 48 |
| No. of Educational VHF & UHF applications w/problems | 13 |
| Total No. of existing TV Stations all types | 940 |

The main FCC operational concerns related to issuing the operating authority have been, and still are the practical daily inspection problems, demodulator quality problems, control over distances greater than 50 miles. The main problem with applications has been lack of detail on EBS monitoring and audio monitoring, plus inadequate system block diagrams and failsafe provisions.

FCC Monitoring Branch lists as main problem areas:

> EBS Tests, correct test signals, proper maintenance of signal levels, proper logging, proper transmission of test signals. Future field checks will include use of the vector scope and waveform monitor characteristics.

Future FCC goals include greater allowance of automatic transmission techniques as newer equipment and those wishing to use it come forward.

Once the stations executive management decision to "Go Remote" is made, it must remain strong. It is determined to a large extent by the positive attitude and action of the management engineers and the engineering staff. One group owner we contacted had received the following comments:

1. "it won't work"
2. "we'll have to man the transmitter during prime time"
3. "the transmitter employees don't know how to do anything else"
4. "we won't save any manpower because we will need maintenance crews on a minimum of eight hours a day, seven days a week"

Of course management must maintain the quality on air product with good reliability the same as before. The answer is Yes! Here is the quote from one group owner station manager in a large market.

> "Operations have not been hurt in any way. There was no change in the quality of transmission and our excellent record of "time lost" has not changed, and we have reduced the transmitter engineering staff by four".

Engineering and production personnel will accept the remote control operation and benefit, if it is properly presented, installed, operated and maintained.

In depth engineering concerns on "Going Remote" are many, and include:

1. Adequate planning,
2. Personnel considerations.
3. Equipment budget.
4. Basic Equipment
5. Actual installation, plus
6. Trial operation.
7. Regular operation.

As a company that does facility planning and installations we have noted that the greatest problems in "Going Remote" are Adaptation of transmitter control systems to remote control and Metering of the system.

Most newer transmitters use low voltage control systems and have remote control terminals readily available, considerable care must be exercised with older transmitters in modifying the control system for remote operation.

Metering of antenna power is the most serious problem facing the technical installation. Most power measuring equipment, thru line pick-up devices on thermo-couple meters are quite non-linear units. Most remote reading devices are linear devices, requiring a converter or conversion charts.

The required weekly calibration check can be quite a time consuming chore. Selection of a remote control system with a local indicating device can reduce the calibration process. These are most generally found in the newer digital remote control and logging systems.

**T. M. Gluyas**

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# TV Transmitting Systems for Unattended Operation

Ever since Collins Radio Company petitioned the FCC seven years ago to consider licensing automatic FM transmitters, there has been intermittent revival of interest in unattended broadcast transmitters—including not only FM but also Standard Broadcast and TV transmitters.

About a year ago—on Feb. 5, 1973, to be exact—the NAB submitted a report to the FCC supporting the case for unattended transmitters and suggesting rule changes to permit such operation. Later in the year, responding to the NAB report, in talks at regional NAB meetings and at the NAEB convention, the FCC indicated that they are working toward rules covering automatic transmitter systems.

Therefore, it is timely at this convention to consider how an unattended transmitter plant might be implemented and what special considerations are appropriate for the hardware.

## What is an Automatic Transmitter?

For reasons that will appear later in this report we prefer the phrase *transmitting system for unattended operation* to the term *automatic transmitters* which has been used in the past to mean nearly the same thing. However, the term automatic transmitters will be applied, where appropriate, to bridge the gap between earlier publications and the present discussion.

What ist meant by the term *automatic transmitters*? The 1967 Collins Radio Company petition to the FCC stated:

- An automatic transmitter is self-monitoring and self-adjusting of essential operating parameters.

That statement describes an automatic transmitter, but what are the essential operating parameters?

We define essential operating parameters as the parameters required to be logged by the FCC plus parameters that normally would be observed *and corrected* by an operator during the broadcast day. For example:

- Power output—aural and Visual
- Modulation levels:
  - Visual reference white
  - Visual sync-to-picture ratio
  - Aural modulation
- Frequency

These items and others will be discussed in the balance of this report which deals mainly with television transmitters but it will be obvious that many of the concepts apply equally to aural broadcasting.

## Flexible Requirements for Unattended Transmitting Systems

Unattended TV and aural broadcast transmitters have been used in other parts of the world for many years but the system complexities vary widely with local requirements and the economics of the situation. For example, in the thinly populated areas of northern Canda the simplest, least expensive, kind of transmitters are simply turned on and off by a clock or by a video presence detector. There often is no logging, automatic control, standby facility, or anything special to distinguish an unattended transmitter system from an attended one.

On the other hand, in Great Britain, the BBC serving London and other heavily populated areas, has been evolving unattended TV stations with many automatic features including automatic switch-over to alternate subsystems based on automatic assessment of picture quality and output signal comparisons.

These extremes may not be required for typical U.S. broadcast stations but adequate system flexibility should be maintained to satisfy varying needs. Also, a choice of manual local control, remote control, or automatic systems should be accommodated. It follows that it is better to produce a reliable and stable basic transmitter, that can fit into manned situations and into unattended plants, than to proliferate an uneconomic variety of transmitter types including various versions of "automatic" transmitters. That is why we prefer the term "unattended transmitting systems" over "automatic transmitters".

RCA has designed current generation transmitters to be stable and reliable with circuits to permit external control by electrical means of all normal operating adjustments. An ample number of metering circuits, status indicator circuits and mode control circuits are wired to interface terminals in the transmitters. These circuits accommodate manual control, remote control, computer control, or dedicated logic circuits as desired by different broadcasters for custom systems. They can be wired into automatic systems of varying degrees of complexity. These transmitters are available now and suitable for use in unattended transmitting systems.

## Automatic Power Output Control

It is basic that the transmitter power must stay well within FCC limits over long periods of time without manual intervention. We are inclined to believe that this should be accomplished by automatic supervision and control. An overall transmitter system feedback loop qualifies as such a system.

It is possible, but expensive, to design circuits that are so stable that no automatic control is required for *normal* operation. However, it is all too easy to develop an "exception" to normal operation in the form of a weak, or out-of-tolerance component, a poor cable connection, or a temperature sensitive RF connection that can cause a power drift, that would be handled easily in an automatic control system. Therefore, we prefer an automatic control system.

In the case of the visual transmitter it is sufficient to regulate either blanking level power or sync peak power, provided that automatic means are included to maintain the various modulation levels in proper *ratio* to each other at the output of the transmitter. The use of an automatic VIR corrector to do this will be described later. Alternately, each modulation level (i.e. white, blanking, sync.) could be regulated independently.

RCA's current line of VHF-TV transmitters—the "F" line—provide separate automatic power control loops at the blanking level and at sync. level. Either or both control loops can be turned on or off. Both loops are standard in the "FH" transmitters. In the "FL" series, automatic blanking level control is standard and automatic sync level control is optional. The principle of operation of these automatic power circuits are described with reference to Figure 1.

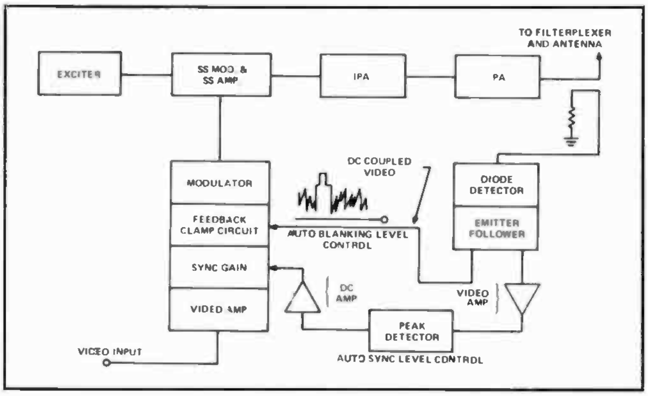



**Figure 1. Block Diagram. Automatic blanking level and automatic sync level controls in RCA "FL" and "FH" transmitters.**

A diode demodulator samples the ouput of the transmitter. The video signal is passed through an emitter follower, preserving the dc information and then through two parallel paths. One path includes the automatic blanking level control circuits and the other the sync level control. The blanking level at the output of the transmitter from the demodulator is sampled during the back porch of horizontal sync. This sample is referenced against a regulated dc potential and the difference, or error signal, is stored between samples and used to adjust the modulator bias. This constitutes an overall feedback clamp circuit, which holds the blanking level steady at the transmitter output.

The second video output from the demodulator is amplified and peak detected to obtain a dc voltage proportional to sync peak power. This is filtered, amplified, compared to a reference voltage and the error signal is then used to control the sync gain circuits between the video amplifier and the modulator. These circuits have dc gain control capability and can either expand or compress the sync. The automatic sync level (ASL) loop gain is approx. 50 dB so that the transmitter peak power output is very closely held to its initial setting.

Until the present time, there has been little incentive to build automatic control circuits for aural power. Aural power stability has been adequate for remote control; however, automatic aural power control will be made available for unattended transmitter systems. All that is required is to close the loop between existing power output monitor and aural power control circuits.

UHF TV transmitters are normally operated close to saturated power for best efficiency. With anode supplies regulated to $\pm 1\%$, visual peak power output stability has been good. However, for automatic transmitters, a blanking level automatic power output control option will be made available.

## Automatic Control of Modulation Levels and Signal Parameters

We have found that a most convenient way to automate modulation levels and signal parameters is to use a Tektronix model 1440 Automatic Video Corrector in a closed loop mode around a transmitter, such as an RCA TT-30FL or TT-50FH. These transmitters have built in automatic power output control. The arrangement is shown in the block diagram, Figure 2.

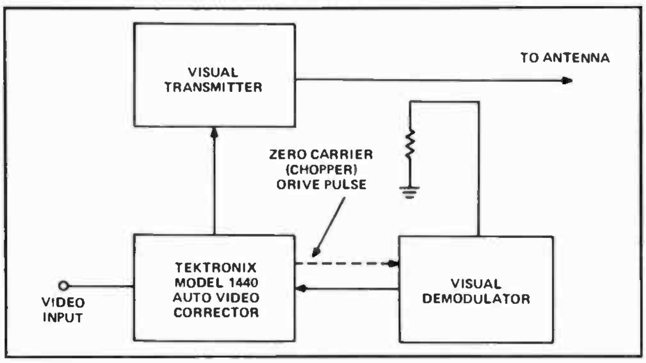



**Figure 2. Automatic modulation control using Tektronix Model 1440 Automatic Video Corrector.**

The automatic video corrector keeps the important signal levels in the correct *ratio* and the built-in transmitter power output control then establishes the proper absolute signal levels. The Tektronix model 1440, used in this way, automatically maintains correctly, at the transmitter output, the following parameters:

- Reference white level
- Blanking level
- Transmitter power output
- Setup
- Sync./Pix ratio
- Burst amplitude
- Burst phase relative to VIR
- Chrominance/Luminance ratio

If the transmitter includes both built in automatic sync level and automatic blanking level controls, then the automatic Sync/Pix ratio circuit of the Tektronix 1440 can be disabled by a simple internal modification.

For the system of Figure 2 to function, it is necessary to insure the presence of a VIR signal and one that is properly related to the picture signal. A Tektronix model 1441 VIR Signal Deleter/Inserter or model 147 or 149 NTSC Signal Generator can be used at Master Control to sense the presence of incoming VIR signal and, if absent, to automatically insert VIR on the signal going to the transmitter. If the VIR signal is locally inserted it will be necessary for an operator to monitor the video signal level to properly maintain white level relative to VIR. The automatic VIR inserter can be programmed to insert VIR, minus the burst, when the incoming signal is in monochrome.

The use of an automatic VIR corrector in a closed loop mode around the transmitter is not the only way to automatically maintain correct modulation levels. As stated earlier, current generation RCA VHF TV transmitters have the capability for automatic control of blanking level and peak power. A closed loop video AGC could be added as illustrated in Figure 3.

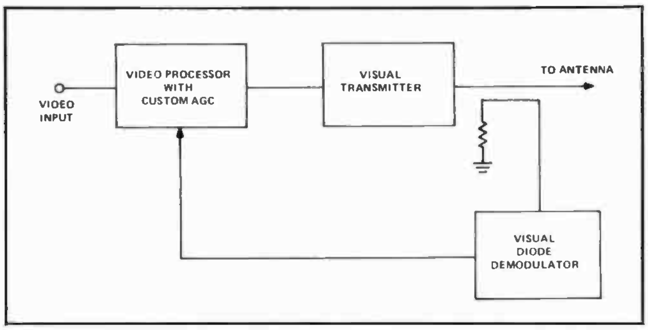



**Figure 3. Alternate concept for maintaining correct modulation depth at output of visual transmitter.**

This would maintain correct depth of modulation. In this case an automatic VIR corrector, or manual means, could be used to provide a good video signal at the transmitter input. Then, the inherent long term stability of modern transmitters in regard to frequency response, envelope delay, differential gain and differential phase makes it unnecessary to provide automatic correction around the transmitter for signal parameters other than power output and modulation levels.

Even if an automatic VIR corrector is provided, closed loop around the transmitter, consideration should be given to an additional VIR corrector on network signals or remotes, or at Master control, or at the transmitter input, to establish a good signal for comparison with the transmitter output. This is illustrated in Figure 4. The capability for comparing the

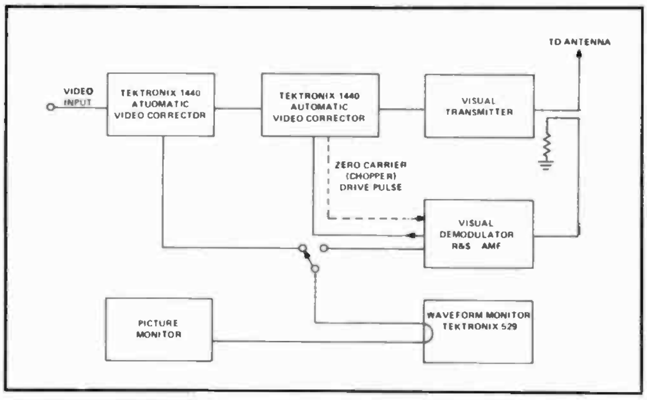



**Figure 4. System for comparing corrected video input and transmitter output signals.**

corrected transmitter input signal to the transmitter output is a useful addition for inspection, trouble-shooting and maintenance. If VIT signals are inserted, they should be inserted between the two VIR correctors to prevent correction of incoming signals from overmodulating the transmitter during VIT interval.

## Parallel Transmitters in Unattended Systems

If an automatic control loop is closed around a pair of parallel transmitters are shown in Figure 5,

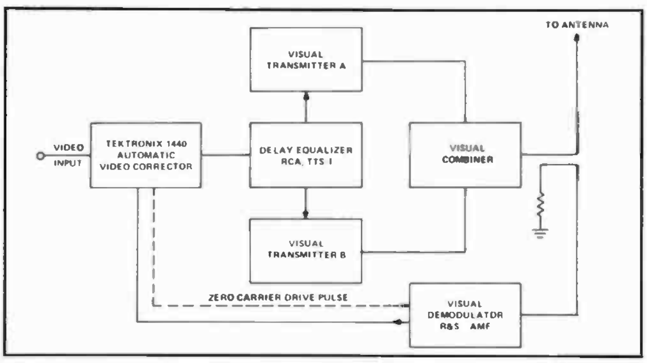



**Figure 5. Automatic modulation control loop around a pair of parallel transmitters.**

then it is possible for the performance of one transmitter to drift relative to the other while the combined output remains stable. In the case of RCA TT-30FL or TT-50 FH transmitters, the blanking level of each of the parallel transmitters is automatically controlled but small differential drift can occur in white level or other signal parameters. The question then is, can the differential drift be troublesome? We have found that it is not.

Only small differential drifts occur in practice over extended periods but much larger differential drifts are tolerable. Depth of modulation (reference white level) and "per cent sync" can be purposely unbalanced by 25% or so, with negligible affect on combined modulation levels, frequency response, differential gain, differential phase, or other important signal parameters.

If individual transmitter automatic blanking level and automatic sync level controls are both available, there is greater tolerance to tube ageing when using both compared to operating on only automatic blanking level control, but either operating method is satisfactory.

## Frequency Control and Monitoring

The FCC rules for attended or remotely controlled stations, require carrier frequencies to be measured and recorded on a monthly basis with intervals between successive readings not to exceed 40 days. Frequency measurements are mandatory but the use of a frequency monitor to serve licensee's purposes is optional. It is presumed that the same rule, or a similar one, will apply to unattended transmitters.

Automatic means to shut a transmitter down based on an off-frequency indication from a frequency monitor seems pointless since it is difficult to design a frequency monitor to be both more accurate and more reliable than the transmitter it is intended to supervise. However, an interesting concept has been proposed for parallel or alternate/main transmitters. It is anticipated that most unattended transmitters will be of one or the other of these types and that the transmitters will include two exciters.

The exciters or transmitters will be automatically switched in the event of failure of the in-use exciter. It has been proposed to expand the logic to switch exciters if the in-use exciter appears to be off-frequency based upon a majority vote among the two exciters and the frequency monitor. For example, if exciter A were on air but the monitor indictated a frequency error, exciter B would be substituted provided that its frequency read correctly. If A and B each produced a similar off—frequency reading, then A would remain on air and a frequency monitor fault would be reported through a status and alarm system. A majority vote system could also be devised using a single transmitter exciter and two frequency monitors.

Either of the subsystems just described could be provided as a custom option but it is doubtful that it will be included in a standard product offering since the probability of off—frequency operation is too low to warrant the design of the additional logic circuits.

## Automatic Start-up and Shut-down

If automatic start-up and shut-down are desired in order to have completely automatic system operation, then the simplest way to accomplish this is with a video presence detector to turn the transmitter on whenever video from Master Control is sensed. Initial program material fed to the transmitter plant at the start of a broadcast day could be a test pattern or station call sign to allow time for the transmitter to cycle on. On the other hand, it might be desirable to let filaments, cooling systems and everything but the high voltage supplies run 24 hours a day. Video presence could then turn on the high voltage.

A refinement to simple video controlled turn-on is an additional subsystem to automatically insert locally generated visual and aural announce and identification signals at the transmitter plant and inhibit turnoff in the event of program loss during times set in the memory of a transmitter control clock.

Other automatic means of transmitter turn-on are clock control or vertical interval command signals. However, these require manual effort to program or initiate a control and have little if any advantage, except possible cost advantage, over manual turn-on using a remote control link or separate order wire.

In fact, remote control manual turn-on and turn-off takes so little effort that providing equipment at the transmitter, for automatic operation of this function, hardly seems worthwhile.

## Automatic Logging

For manually operated stations, the present FCC requirements for operating logs are few and not especially burdensome. For unattended transmitters, the NAB Engineering Sub-Committee on Automatic Transmitters went further and recommended against any specific logging requirement, partly on the grounds that it creates unnecessary paperwork. In the absence of any confining requirements on logging, the system designer will have freedom to decide what should be logged, if anything, and this will vary with the system concept.

We are inclined to think that some stations may want more, not less, information on the heatlh of an unattended system compared to an attended one. Also, a record of parameter trends can be used to anticipate component wearout or the requirement for readjustment. To avoid unnecessary accumulation of paperwork, most parameters might be logged only once per day, or not at all unless the value changed by some percentage from the previously logged value. Our view would be to provide flexible and extensive options for logging and alarm. Fortunately, current generation RCA transmitters provide interface terminals to many monitoring points and some new ones may be added as the optional logging and alarm subsystems evolve.

It has often been suggested that automatic systems should provide an indication or alarm when the key parameters of power output, modulation levels, or frequency have drifted to some fraction—say half—of the permissible tolerance. Perhaps so; but for automatically controlled parameters with substantial control loop gain, the values may not change very much until the control system has approached the end of its range. Logging and possible alarm of the control loop error signals would seem to be more useful than alarming the controlled parameter itself. Interface terminals to control loop error signals are a minor addition that is worth considering for future transmitters.

## Reliability

It is self-evident that a transmitting system for unattended operation must be reliable, but no matter how well designed and manufactured, there is always a chance of a random component failure. Program interruption can be avoided, in spite of such failure, by parallel redundancy or automatic switchover to a standby subsystem. Then, no matter what fails, a replacement automatically will be inserted or an alternate mode selected. It is probably this system characteristic that most distinguishes an automatic transmitter system from a manual one.

Remotely controlled transmitters usually have a degree of remotely switchable subsystems and it is a small step to make such switchover automatic. How far the concept of full automatic backup of all subsystems is carried, is largely a matter of cost and the importance to the market of a possible service interruption. For these reasons, system design should be flexible and sub-system options available.

One example of the many alternate modes possible in modern TV transmitters is found in the RCA "FL" and "FH" lines of parallel transmitters. An option permits parallel operation, switchable to single transmitter mode. The single transmitter power automatically doubles in the alternate mode while maintaining proper modulation levels, thus maintaining a full power normal signal in either mode.

Transmitters selected for unattended operation should be of modern design. Today's transmitters which are largely solid state with ample cooling and overdesigned power supplies, are about as reliable as the state-of-the-art will permit without a major jump in equipment cost to military type of reliability testing and reliability enhancement techniques. Elimination of fuses and manually resettable circuit breakers is important for unattended operation where there is no opportunity to manually reset at overload. The current foldback, regulated power supplies in the RCA TT-50FH, which require no overload protection, are examples of progress in equipment development toward unattended operation.

## Maintenance

For whatever maintenance schedule and periodic performance tests that may be recommended by the manufacturer or evolved, from experience, by the broadcaster, there will be a need for local manual control. How then, can the engineer be assured that the station is left unattended in the automatic mode, with the antenna connected, all necessary switches on, interlock doors closed, etc.?

The author had the pleasure of visiting a high power unattended TV transmitter system in another country during 1971. Above the exit door was a panel with large yellow lights. It was called a "GO HOME" panel. If all lights were on, the maintenance and test engineer could leave with assurance that the plant was in the automatic mode and operational. It was a manual function in an otherwise automatic plant, but it was effective.

## The TV Transmitter "Hands-Off" Operating Experiment

Through the courtesy and cooperation of the Westinghouse Broadcasting Co., a 30 day "hands-off" experiment was performed at KDKA-TV to simulate unattended television transmitter operation. The transmitter system was, in fact, attended by licensed operators as required by the rules, but operators were instructed to keep "hands-off" the controls, except for scheduled maintenance sessions, to demonstrate that the system need not have been attended. Touching any control, except for the on-off control, was "verboten", unless the system performance should approach limits set by the FCC rules. The plan was to carry out all maintenance, performance measurements and adjustments on a regular basis; and to operate the transmitter "hands-off" between these sessions. To begin in a conservative way, maintenance and adjustments were scheduled on a weekly basis with the hope that the interval could be extended in the future after a shakedown and "debugging" period.

The transmitter system configuration for the tests is shown in Figure 6. The parallel transmitter is an

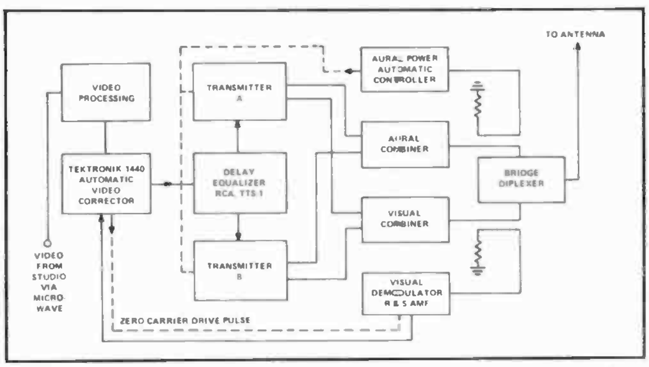



**Figure 6. Block diagram. Transmitter system, "Hands-off" experiment at KDKA.**

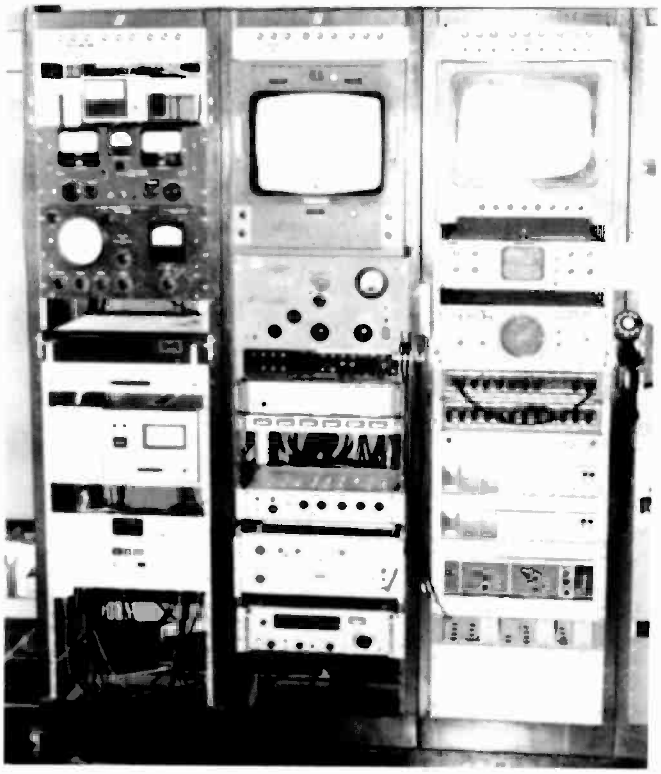
RCA model TT-30FL. The ancillary automatic aural power control device, shown in the diagram, was purposely not operated for the first three weeks of the test in order to evaluate aural stability without automatic control.

A VIR signal was inserted at Studio Master Control by means of a Tektronix model 147 NTSC Signal Generator.

A view of the transmitter room with the TT-30FL transmitter in the righthand background is shown in the first photograph in the opposite column. The second photograph is a closeup of the transmitter center cabinet which contains all the normal operating controls. Notice the strip of masking tape that was placed across the switches of the electrically operated controls as a reminder to the operators not to make adjustments.

**KDKA transmitter. RCA, TT-30FL.**


**TT-30 FL Tuning and operating control panel.**



KDKA auxiliary equipment rack, showing equipment used in "hands-off" experiment.

The third photograph is a view of the auxiliary racks in which were mounted the Tektronix 1440 Automatic Video Corrector, its optional meter panel, and the aural automatic power control equipments. This was in addition to existing equipments such as: RF oscilloscope, TFT frequency and modulation monitor, picture monitors and Tektronix 529 waveformer monitor for comparing transmitter input and output signals, a Rohde & Schwarz AMF demodulator, Tektronix 520 vectoscope, Grass Valley video processing amplifier, RCA TTS–1 envelope dealy equalizer and various test equipment items. The vector scope A + B input was used to display superimposed test signal waveforms supplied by diode demodulators on the outputs of the individual transmitters. This gave a very garphic display of any differences in modulation levels between the two paralleled transmitters.

In addition to the FCC operating log, a special log was maintained with an entry immediately at sign-on, at sign-off and every three hours during the broadcast day. Entries were:

| *Parameter* | *Transmitter A* | *Transmitter B* | *Combined* |
|---|---|---|---|
| Plate Voltage, Aural PA | • | • | |
| Plate Current, Aural PA | • | • | |
| Reflectometer, Aural | • | • | • |
| Reflectometer, Visual | • | • | • |
| Frequency Monitor, Aural | | | • |
| Frequency Monitor, Visual | | | • |
| Sync, IRE Units | • | • | • |
| VIT Reference White | • | • | • |
| VIT Luminance Reference | • | • | • |
| Burst Amplitude | • | • | • |

Also, error correction signals were recorded from a Tektronix 1440 Auxiliary Meter Panel. The meter panel displays six parameter corrections but only three were recorded. It should be noted that these are corrections for total transmission system errors including master control output circuits, microwave, link, transmitter plant auxiliary equipment and transmitter errors.

The error correction signals recorded were: Sync Gain, Burst Gain, and Master Gain

The thirty day test was begun on Feburary 6 and at the date of this writing, Feb. 25, it is approximately two-thirds complete. Already, approximately 2400 meter and oscilloscope data points have been recorded and plotted in the graphs to follow. Presentation at the NAB Engineering Conference on March 20 will include the test results based on all the data and may differ slightly from that which will now be reported. The aural data to date is with the automatic power controller disconnected to check the basic stability of the aural transmitter.

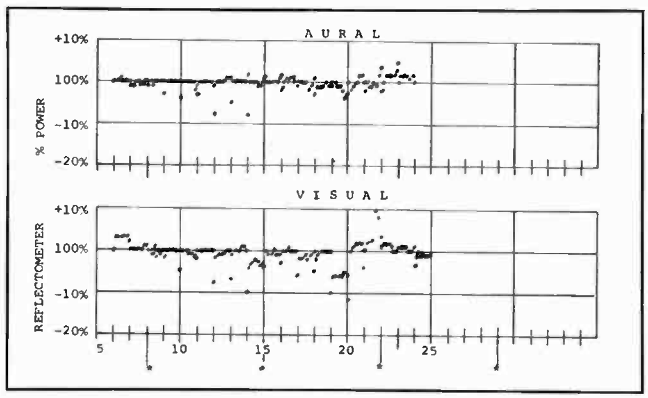



Figure 7. "Hands Off" experiment. Aural and visual power output stability. Combined transmitter.

Figure 7 shows the "hands-off" stability of power output. Approximately 95% of the readings are within FCC power output tolerance by a 2/1 margin. The single low data point on certain days is the initial turn-on reading which climbs to normal in approximately ten minutes. If these are discarded, only the two high readings on Feb. 22 are of consequence.

There was one, perhaps unnecessary, manual adjustment made shortly after turn-on on Feb. 20 because the power ran low on Feb. 19. However, the Feb. 19 low readings were never-the-less within FCC tolerance by almost a 2/1 margin. An attempt will be made to find and correct the cause of these two power output irregularities at the next scheduled maintenance session.

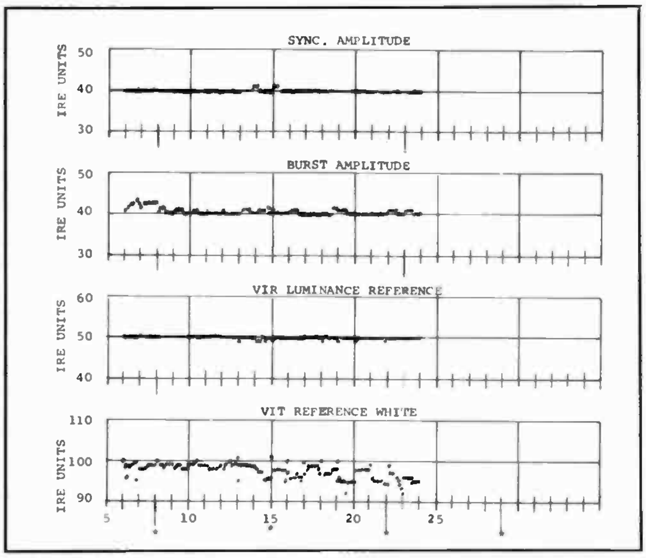



**Figure 8. "Hands Off" experiment. Stability of modulation levels. Combined transmitter.**

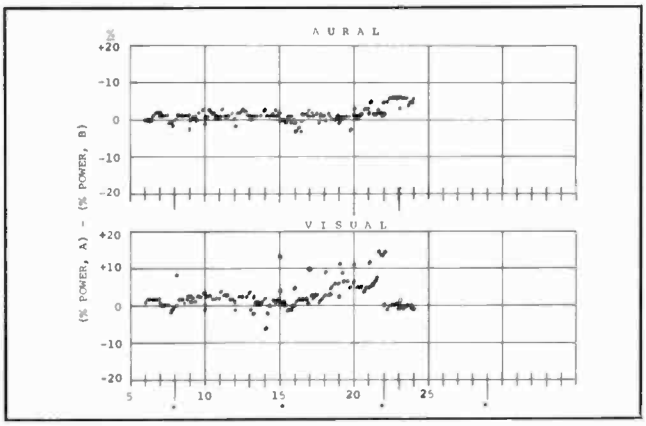



**Figure 9. Differential power output of combined transmitters. Aural power (A-B) and visual power (A-B).**

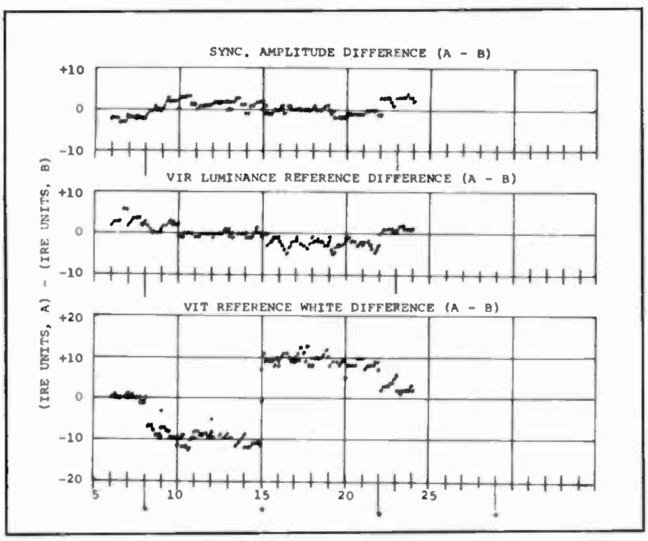



**Figure 10. Differential modulation levels of combined transmitters.**

Figure 8 shows the stability of modulation levels. The stability of all modulation levels was excellent. Sync amplitude remained within 2 IRE units. Actually the number is not significant since the waveform monitor readings are not repeatable among the four different operators to that precision.

Burst amplitude ranged up to four IRE units high during the first week. Then the Automatic VIR corrector was adjusted to reduce the level to be correct as read by the operators. After that, it was stable within the precision of observation. It is a moot question which adjustment is really correct. Eliminating part of one chrominance sideband by the 4.5 MHz low pass filter at the transmitter input, distorts the burst envelope, producing a double lobed peak. The operators tended to read the tips of the burst envelope including the transient.

The VIR luminance reference remained within 2 IRE units! Again, this is beyond the reliable precision of reading the waveform monitor.

The VIT reference white remained within 6 IRE units except for three isolated readings. This is probably closer control than routinely achieved under manual operation.

Figure 9 shows how the power of one of the parallel transmitters drifted with respect to the other. The differential aural drift without automatic control was surprisingly small. The differential visual drift was larger than expected but of no consequence in the output of the parallel transmitter operation. It is partly caused by some sync compression in one of the transmitters. Since the blanking level is regulated, sync compression shows up as differential peak power. Notice the improvement after transmitter adjustment on Feb. 22.

Figure 10 shows the differential drift of modulation levels between the two transmitters. The observed drift was small and the data supports the statement, made earlier in this report, that it is unnecessary to individually control the modulation levels of two transmitters operated in parallel when the parallel combination is automatically controlled. Apparently, the individual VIT reference white levels were not precisely set during the adjustment sessions (*) since they are stable between adjustments but vary from one adjustment period to another.

Figure 11 is the indicated frequency error or, more correctly, the difference between the monitor frequency and the transmitter frequency. All 262 frequency readings except one were within ±50 Hz of the assigned frequency.

Figure 12 shows the signal amplitude corrections automatically introduced by the Tektronix 1440 Video Corrector when keeping the transmitting system within the close limits recorded in the present test. At times, the video gain was automatically increased by amounts up to +1.5 dB, the burst was ex-

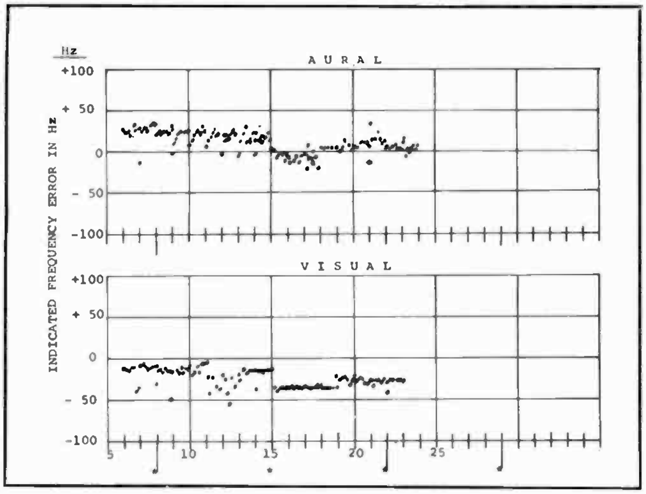



**Figure 11. "Hands Off" experiment. Aural and visual indicated frequency errors.**

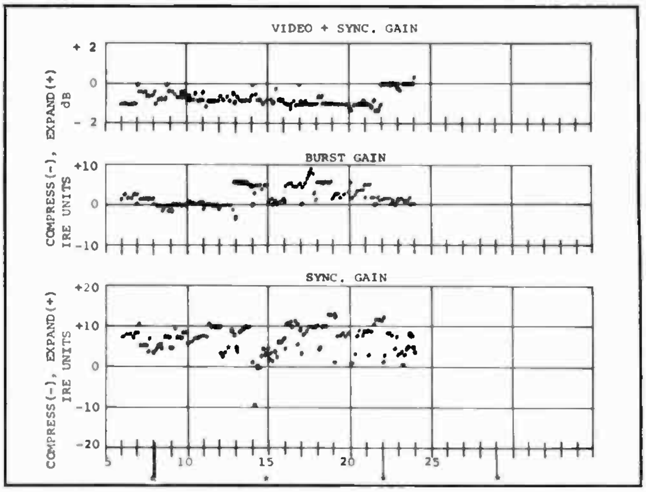



**Figure 12. Tektronix 1440 error correction signal for total system comprised of microwave, auxiliary equipment and TV broadcast transmitter.**

panded up to +1.8 dB and the sync was expanded up to +2.2 dB.

The experiment at KDKA-TV dramatically demonstrates that a modern television transmitter with auxiliary automatic controls can operate in an unattended mode. In fact the experiment indicated that such a system probably will maintain modulation levels to closer tolerances than typically attained in manual operation.

## Conclusion

In conclusion, it can be said that it is a relatively small step to implement an automatic TV transmitter system comprised of:

- Current generation transmitter.
- Off-the-shelf terminal products including video and audio presence detectors.
- Available automatic logging and alarm.
- Closed loop connection between visual demodulator and video processor (e.g. Automatic VIR Corrector) for automatic white level control.
- Custom automatic switching systems tailored to the choice of transmitter and degree of subsystem backup selected by the customer.

We are confident that as soon as automatic transmitting systems are authorized, a practical and reliable system can be delivered. After that, through operating experience and technical progress, future generations of automatic systems will be further simplified and improved toward minimal maintenance attention.


**William T. Howard**

*Senior Engineer, Engineering Development*
*National Broadcasting Co.*
*New York, N.Y.*


# NBC Election Returns

The reporting of Election Returns by NBC News is considered to be one of the most important scheduled news events of the year, especially in the years of Presidential elections. This is substantiated by the fact that in the 1972 election returns, the three television Networks spent approximately 10 million dollars on this one-shot coverage with a listening audience estimated at 120 million viewers in 18 nations on four continents.

The procuring and tabulation of vote count throughout the United States was provided by News Election Service (NES). NES was formed in 1964 by the three television Networks, the Associated Press, and United Press International.

In the 1972 election returns, NES had 100,000 reporters in voting precincts throughout the United States, reporting vote count information by telephone and wire service to six regional centers as shown in Figure 1.

The regional centers tabulated the vote count and, by use of wire services fed this information into NES National Control Center in New York where computers were used to tabulate, sort, and process the information into a special NES format. This information was distributed by wire to the three television Networks and to the two wire services.

## NBC Analysis and Projection

In addition to the vote count information supplied by NES, NBC had reporters deployed throughout the country in special key and tag precincts (Figure 2).

The key precincts were selected on the basis of being typical of the United States as a whole, and projections were based on these precinct samples. The

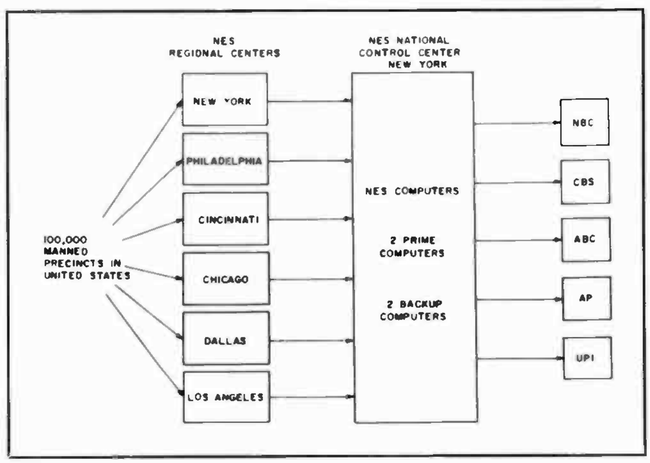



**Figure 1**
**1972 news election service (NES).**

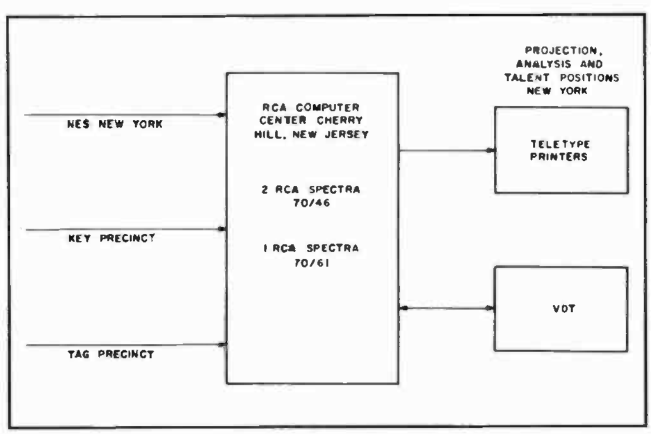



**Figure 2**
**NBC 1972 election analysis and projection coverage.**

special tag precincts provided analysis of the races, selected from the viewpoints of income, race, ethnic composition, religion, and blue collar voters.

This information was fed by telephone and wire service to the RCA Computer Center in Cherry Hill, N.J., where computers were used to process the information and make comparison with vote count from NES. This information was available on call-up by a Video Data Terminal (VDT) from the NBC projection and analysis desk in New York. This made projection and analysis of vote count possible at a very early time.

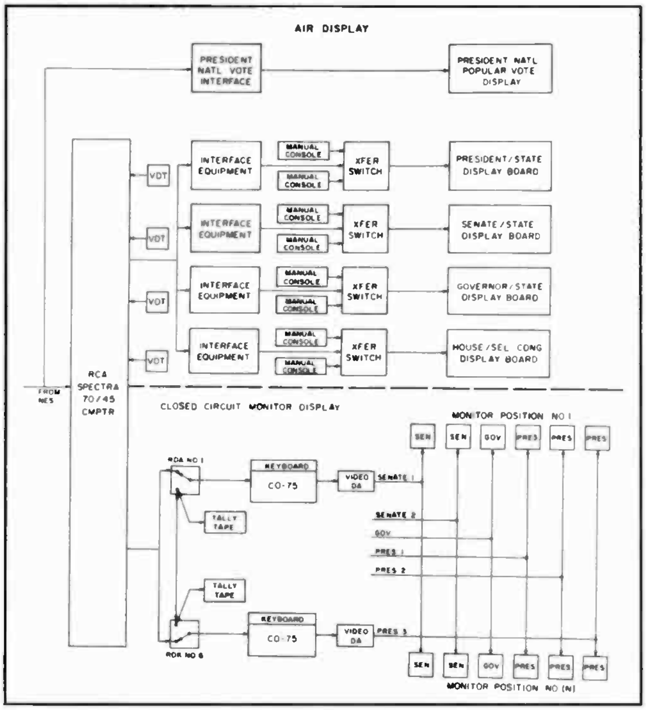



**Figure 3**
**Air and monitor displays.**

## Major System Components

The equipment used by NBC for air and monitor display in the 1972 election returns is illustrated in Figure 3.

For air display there were five computer controlled display boards used: the Presidential National Popular Vote, Presidential by State, Senate by State, Governor by State, and House of Representatives by State.

These air display boards were controlled by interface units that were specified and procured by the NBC Engineering Department. The Presidential national popular vote unit received its feed directly from NEW. The display boards by State got their feeds from the computers controlled by NBC located adjacent to the NBC Studios.

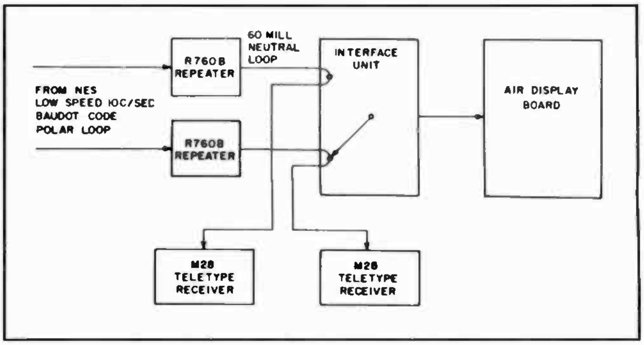



**Figure 4**
**NBC popular presidential vote interface and air display.**

An editorial closed circuit monitor display system was used with approximately 150 monitors distributed throughout the operating area which received their feeds from video character generators controlled by the NBC computers.

The Presidential national popular vote interface equipment, as illustrated in Figure 4, was used in 1968 and 1972 election returns with outstanding success. It accepted a low-speed 10 character/second Baudot code teletype feed directly from NES in a special NES format. The input to the interface equipment was bridging and the lines terminated in a teletype receiver which produced hard copy.

The interface equipment converted the incoming signal from serial to parallel, sorted and stored one complete message according to percentage of precincts reporting, candidate's name with party affiliation, vote count for each candidate, and percentage of vote for each candidate. At the end-of-message, this information was automatically posted on the air display board.

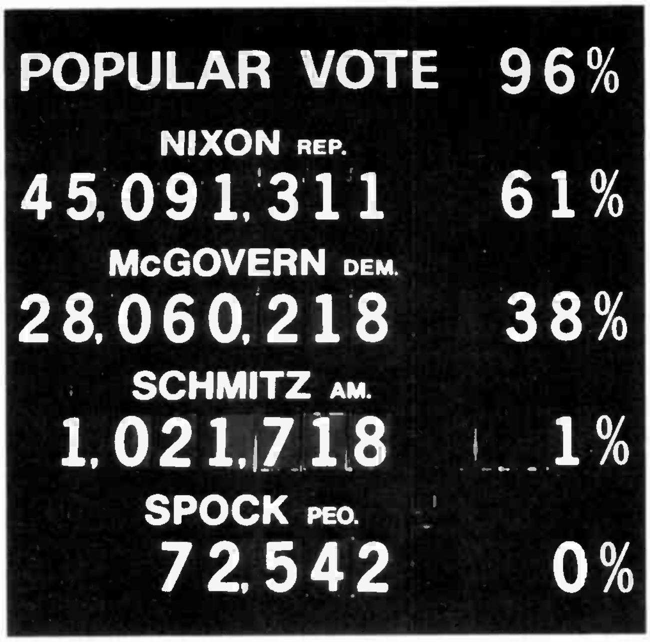
A complete message was transmitted by NES every minute.

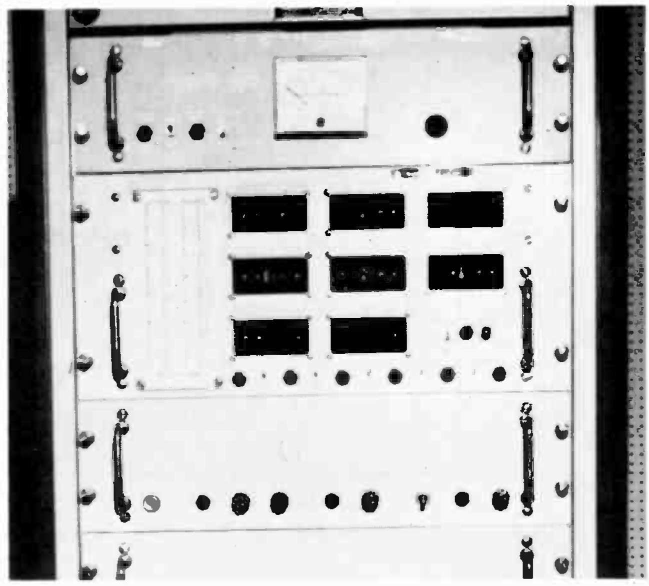
Figure 5 is a sample of the NES format that was accepted by the interface equipment.

```
(PNAT
NATL 82,276 - 47%
NIXON R: 24,085,684 - 62%  IEV 504
MCGOVERN D: 14,093,260 - 37%  IEV 27
SCHMITZ A: 430,071 - 1%  IEV 0
SPOCK P: 16,552 - 0%  IEV 0
                            #0041W)

(PNAT
NATL 82,723 - 48%
NIXON R: 24,165,459 - 62%  IEV 504
MCGOVERN D: 14,141,999 - 37%  IEV 27
SCHMITZ A: 431,352 - 1%  IEV 0
SPOCK P: 16,566 - 0%  IEV 0
                            #0042W)
```

**Figure 5**
**NES election format.**



Interface equipment for presidential tallies.

The air display board used for the Presidential national popular vote for 1972 is shown in the photograph above.

The interface equipment for this popular vote display consisted of necessary logic and storage circuits, output line drive and power supplies. It was all contained in a 77 inch rack, the top of which is shown in the second photograph.

## NBC-Controlled Computers

The computers under NBC's control stored all pertinent information in long term memory, and upon demand, supplied an output of up to four selected races at a time via Video Data Terminals. This information from the computer was in the form of serial teletype signals and was processed by four NBC display devices. The computers also justified the incoming information from NES, introduced a percentage of vote and stored projected winner candidate information for display on call-up.

The input to the NBC-controlled computers, as shown in Figure 6, consisted of eight low speed 10 character/second, 75 baud, Baudot code teletype feeds, and carried vote count information for the President, Senate, and Governor by State.

The three high speed lines were 150 baud, ASCII code and carried vote count information for the House of Representatives by State.

The outputs of the computer consisted of three 2400 baud, ASCII code circuits for the interface equipment by State, and six 1200 baud, ASCII code Circuits for the closed circuit monitor display system.

Display interface equipment for the four display boards by State consisted of four identical units like the one in the following photograph. Each unit was

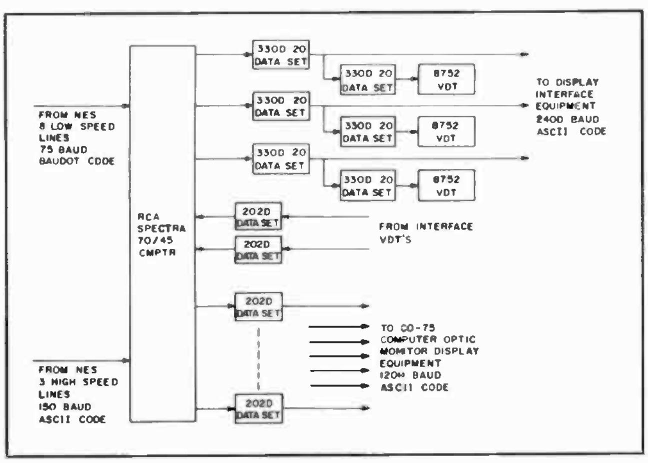
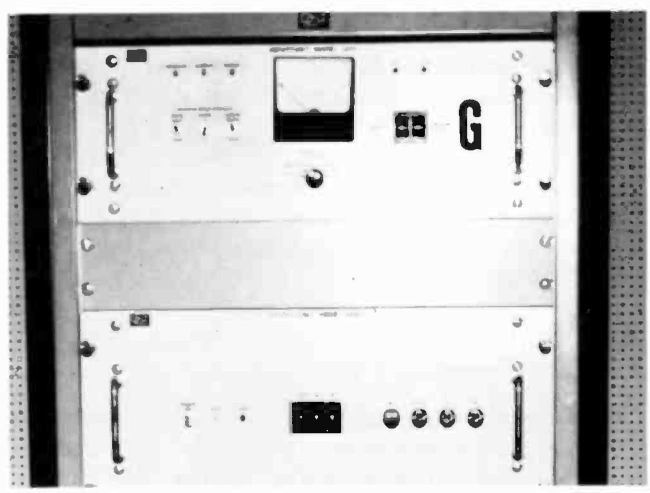



Figure 6
Computer input and output.



Display boards for tabulations by states.

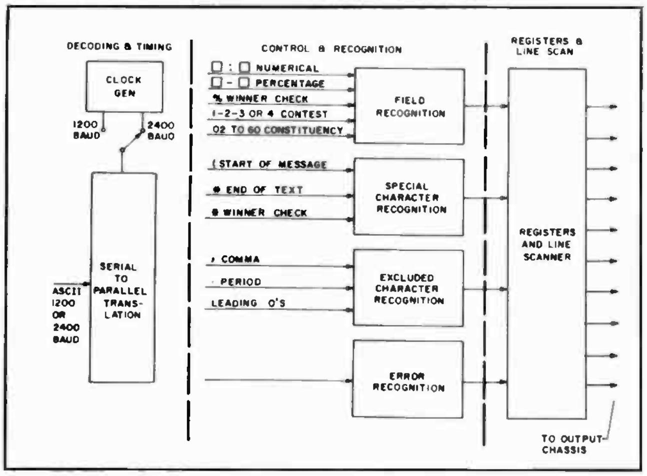



**Figure 7**
**Interface input chasis.**

```
                         < CARRIAGE RETURN

                         ≡ LINE FEEDS

( 1 0 5 < ≡

- 9 9 % < ≡

: 4 , 5 0 2 , 1 3 0 - 5 5 % * * < ≡

: 3 , 4 7 1 , 7 1 2 - 4 3 % < ≡

: 2 2 7 , 8 4 5 - 2 % < ≡

: 5 3 , 1 3 2 < ≡

              #
```

**Figure 8**
**Message format for a four-candidate race.**

housed within one 77-inch rack. It consisted of one input chassis, two output line drive chassis, and the required power supplies.

The normal requirement as used in the 1972 election returns, was for the input chassis to feed only two output line drive units. However, it is capable of feeding up to four output units. This specification allows two interface racks to be placed side-by-side to provide an eight candidate display interface when appropriately interconnected. This would meet special requirements in many of the primary races when there could be up to eight candidates.

A switch on the front panel of the input chassis marked "Message Length" determined the upper limits of the candidate vote lines which would be accepted in any given race.

The input chassis included the logic circuits necessary to perform the following functions: timing, assembling the sequential teletype input signal into characters, recognition of certain characters that are to be excluded, error recognition, and the control of the storage and output section of the interface system. These functions are illustrated in the block diagrams shown in Figure 7.

A clock generator provides timing for 1200 or 2400 baud input signals and a switch on the front panel provides for this selection. The eight level ASCII code input is converted to a two digit octal code; six bit character, one bit parity and one bit control.

Switches on the front panel provide for the selection of either plus or minus 6 volt input and for odd or even parity.

## Message Format

The message format, shown in figure 8, was recognized by the interface equipment for the State-by-State displays and was similar to the NES format. The message format consisted of three basic parts: the transmission code line, the title line, and the candidate vote lines.

The transmission code line began with an open parenthesis "(" which indicated start-of-message. A tally on the front panel marked "message" indicated a valid message being received. The transmission code following the start-of-message character consisted of two fields: a contest field and constituency field. The contest field character consisted of one numerical digit, indicating the nature of the contest involved:

1 for President
2 for Senate
3 for Governor
4 for House

A thumbwheel control on the front marked "Address" was provided for the selection of the proper cotest field.

The constituency field character consisted of two numerical digits indicating geographical location. The numerical digits 10 through 60 were assigned to the 50 states or to Congressional Districts:

02 Alaska
05 California
32 New Mexico
51 Wyoming

These digit characters controlled 60 vane name flaps on the display board.

The transmission code line ended with a carriage return — line feed.

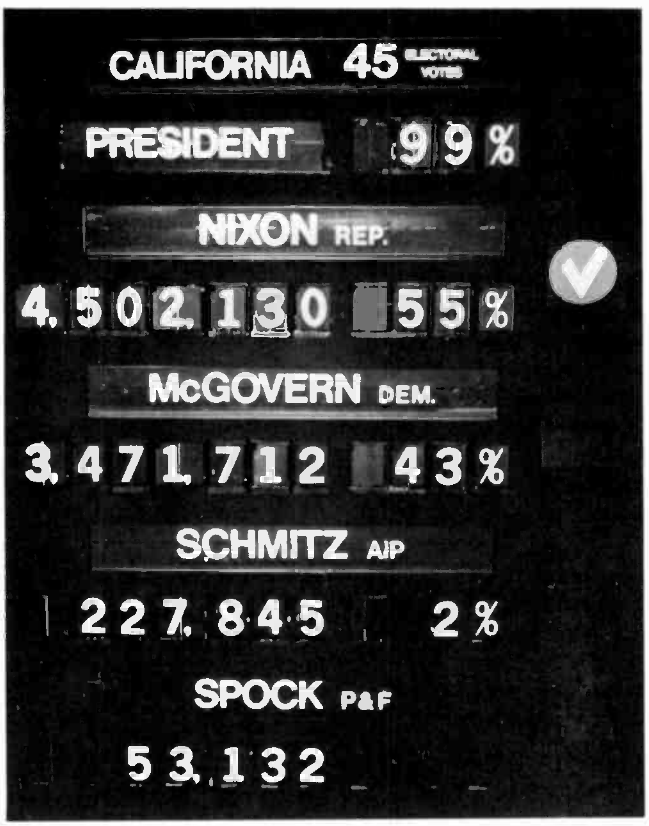
In the title line, the interface equipment recognized only the percent reporting field which indicated the percent of precincts reporting. The character opening this field was a space-dash-space which was followed by three numerical digits to accommodate percentages from zero to one hundred. The title line was terminated by a percent sign "%", carriage return and line feed.

In the 1972 election returns, the candidate vote line on all races was set for a maximum of four lines. Each line consisted of a vote field, a percent field, and a winner check field. A space-colon-space ":" character was used to open the candidate vote field which consisted of up to seven numerical digits with commas where necessary. The interface equipment did not recognize the commas or any leading zeros in the vote field. This field was closed with a space-dash-space "-" character which also served to open the percent field.

The percentage vote field consisted of from zero to three numerical digits and was closed with a percent sign "%" which also served to oven the winner check field.

The Red winner check was entered into the format in the NBC computer via teletype machine near the analysis desk and the character used was a double asterisk "**". On candidate lines where a winner had not been projected, a double space was used. A carriage return and line feed terminated the candidate vote line.

The last candidate vote line terminated with only a line feed which was followed by a number sign "#" indicating end-of-text for the interface equipment, which directed the outputs and storage section to the appropriate line of flap units within one display board simultaneously.




The photograph above shows how the display board appeared to the viewer after all this information had been posted.

## Line Drive and Flap Units

The output line drive chassis shown in Figure 9 contained memory for the storage of one complete message, up to 52 characters, and the output circuitry for driving the flap units on one display board.

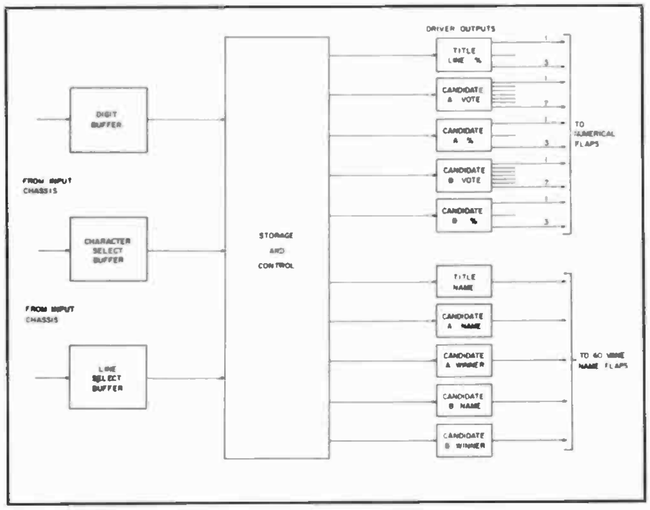



**Figure 9**
**Output line drive chassis.**

The updating is one message-at-a-time in which the flap units on one display board do not start to assume their new positions until the end-of-message signal, at which time all characters move at once.

The signal into the output line drive chassis is in the form of a two digit octal code and contains information for code name, seven vote digits, three percent digits, and a winner check digit. The output section serves to direct the output of the storage sections to the different lines of flap units within one display board.

An output line drive chassis was provided with thumb wheel controls for selection of the proper title and candidate vote lines.

A 12-vane flap unit like the one pictured on the following page was used for numericals and percentage signs. The signaltron flap units required 115 volts AC drive and incorporated a normally closed wafer switch which required three seconds for one revolution.

The unit shown was modified by NBC to include a 24 volt DC relay so that the solid state switches in the output chassis switched 24 volts DC. The 115 volts AC was supplied to the flap units at the display board.

A 60-vane flap unit shown in the next photograph was used for names and winner check signs. The Mischiatti integrated solid state display unit avoided the complex problems inherent in relay controls.

Twelve-vane flap unit used in changing vote totals.


Sixty-vane flap unit for designating names of winning candidates.

Control for these flap units is a special Mischiatti six bit code embossed on the metal surface of a code wheel within the unit. The drive for the flaps is a 115 volt AC motor with this voltage being supplied at each display board.

## Closed Circuit Monitor Display

An editorial closed circuit monitor display system was used. It consisted of 150 monitors distributed throughout the operating area which were used for editorial, analysis, and projection purposes.

The monitors received their feeds from six video character generators which were automatically loaded from the NBC-controlled computers through a remote data adapter (illustrated in Figure 10).

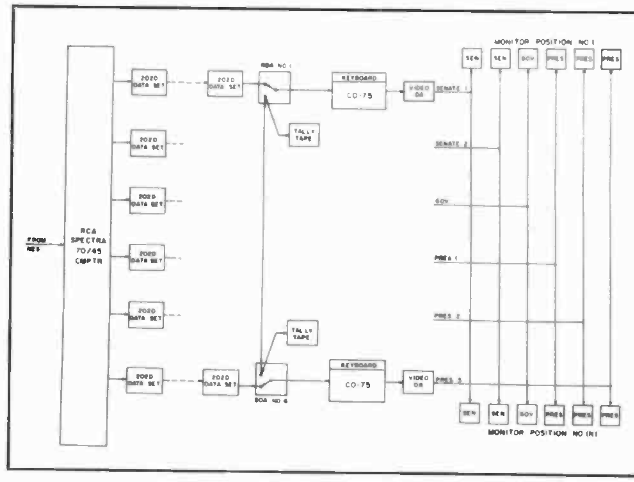


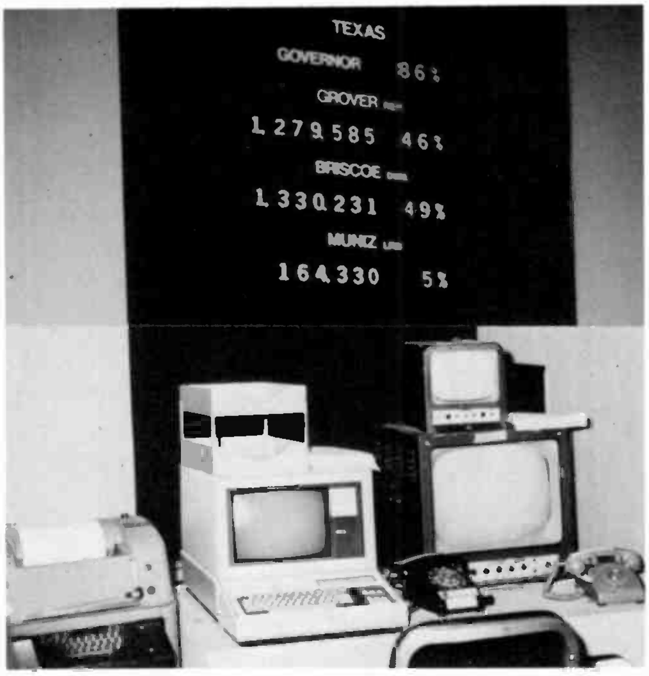

**Figure 10**
**Video monitor display.**

Each character generator consisted of a separate control unit and separate display capable of 3000 characters. Each unit operated from a low speed 110 baud remote date adapter. The video output conformed to EIA standards.

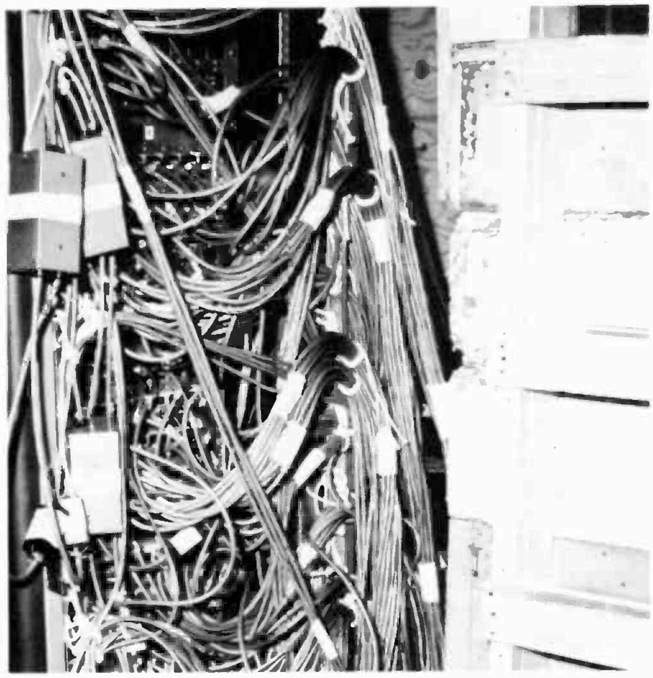
Two tally tape units were used in conjunction with the character generators to provide an emergency service in case of failure of the computer. Six formats were stored in each of the tape units and a series arrangement with an off-line/on-line switch on each display, so that any one unit or all six could be fed by the computer or the tally tape units.

No dynamic data was stored on the tape and in an emergency operation, this data would be entered into the character generators by the manual keyboards as taken directly from the NES lines.


The photograph above shows the display monitor and keyboard of the video character generator used. It has logic circuitry, RDA's and power supplies in the cabinet.




**Data terminal for display board on gubernatorial races.**



**Necessary cabling on back of a transfer switch rack.**

## Data Terminal Operating Position

The photograph above shows the video data terminal position for the Governor's air display board. There were similar positions for President, Senate, and House of Representatives.

Each operating position was adjacent to the air display board. The keyboard and display were located to the right, and a video monitor with a feed from the character generator with the Governor's format was on the left. The air display was directly above.

A special format for each case was provided (TG for Texas governor, for example). As the information was called for, it was displayed on the Video Data Terminal display by depressing the "call-up" key. To load the information into the interface equipment and onto the air display boards, the "call-up" key was depressed a second time.

Each of the four air display units were connected through a relay transfer switch to either the interface equipment for automatic operation, or to two manual control consoles. The transfer relays and receptacles for one candidate vote line were included on one chassis. Each consisted of 12 relays with multiple C contacts for transferring individual circuits.

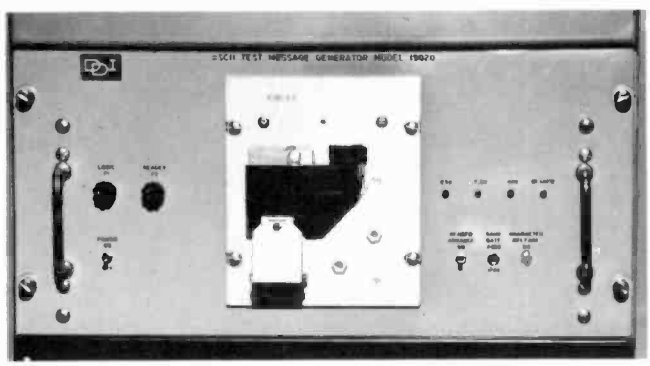
The back of a transfer switch rack with necessary cabling for title line and four candidate vote line displays is shown in the photograph above.

## Test Procedures

A test set was provided for checkout of the interface equipment independent of the computer.

The test set consisted of an ASCII test message generator for 1200 or 2400 baud code, using a tally model 625 tape reader. A test tape could be punched from a standard teletype machine using the same vote format that was provided on the ouput of the computer.

A tape cartridge was also prepared using the NES format so that the entire NBC system, including the computers, could be tested independent of NES.



**Test set for check-out of interface equipment.**

## Conclusions

The performance of the NBC system with automatic updating of the Presidential popular vote and the four races by State was highly satisfactory.

This enabled NBC to update the air display boards within seconds after information was made available from NES and also to project winners at a very early time on all races.

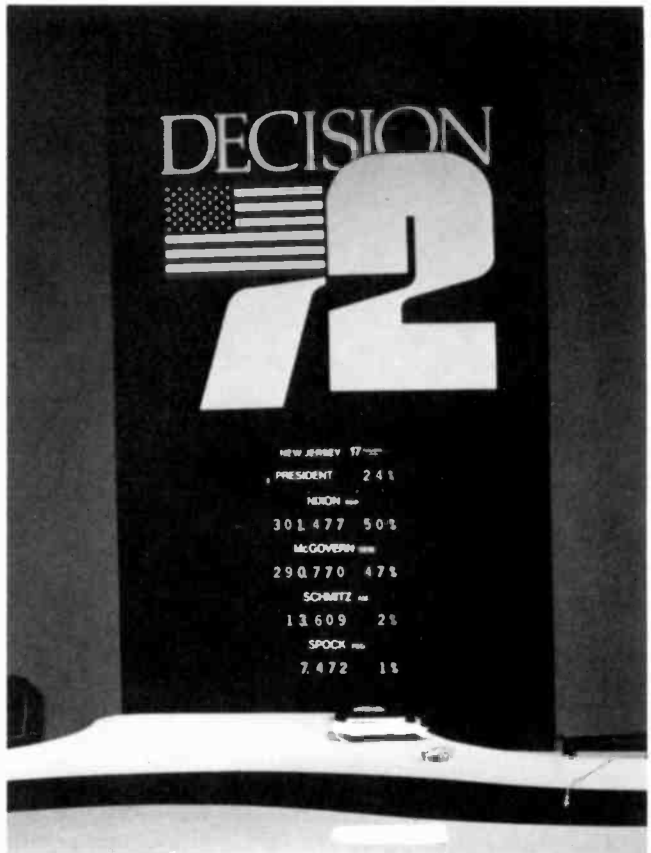
This system also simplified the operation and excluded the use of many manually operated display boards and the large amount of paper work necessary to update these displays manually, as used in past years.

From a production viewpoint, the system offers a tremendous advantage in that up to 60 races can be covered from one camera angle.

The final photograph of the NBC set illustrates how talent can be positioned in front of the display board so that both can be viewed simultaneously from the same camera.

One limitation of the system was the mechanical alphanumerical display units.

NBC will continue its efforts to improve its performance in bringing to its viewers fast and accurate information in reporting election returns.




**How it looked to the viewer.**

**L. S. Golding**

*Manager, Signal Processing Department*
*COMSAT Laboratories*
*Clarksburg, Md.*

# Digital Television Techniques

*This paper is based upon work performed in COMSAT Laboratories under the sponsorship of the Communications Satellite Corporation.*

In the past few years an increasing interest has been shown in the use of digital television techniques. This has resulted from the feasibility of implementing digital television hardware and the potential advantages of digital television signal processing-equipment over current analog television equipment.

Some of these advantages are:

a. Digital encoding of the television and sound program signals permits more complex processing of the signals without introducing perceptible degradation.

b. Problems of distortion, both linear and nonlinear, frequently encountered within studio and transmission equipment can be dealt with more effectively when the signal is in digital form. This leads to much better control of degradation in the video and sound program signals.

c. Regeneration of the digital pulse stream permits much slower buildup of the cumulative degradation which may result from extensive handling of the video and sound program signals.

d. Operating performance very close to design performance, with more stable operation achievable and less adjustment needed, can be realized over the design lifetime of the digital equipment. Also, more automatic test and maintenance procedures are possible.

e. Completely synchronous system operation using high-frequency digital clocks permits accurate control of timing throughout the system.

f. The digitally coded television signal requires wide bandwidths for the baseband signal. This requirement allows more audio and data handling capacity to be obtained within the synchronization (line and field) intervals of the video signal.

g. Narrow RF bandwidth is required for transmission of the digital signals over communications links. This permits efficient utilization of bandwidth and power in the communications links and in turn requires less capacity for the transmission of video and sound program signals over such links.

These advantages have aroused considerable interest throughout the world in the application of digital coding to commercial broadcast services. Currently active programs can be found in many countries in Europe, the United States, Canada, and Japan, leading to the development of new digital equipment for commercial broadcast television service.

With such a large amount of activity, one becomes interested first in the fundamentals of digital coding of the television signal; second, in the application of these fundamentals to the television signal and their use to develop equipment both for studio and transmission purposes; and third, in the impact of this equipment on present commercial broadcast station operations and planning. Some of these points will be considered.

## The Analog-to-Digital Coding Process

To convert the analog television signal or sound program signal into digital form (or a discrete representation of the signal), two operations must be performed. First, the signal must be sampled in time, and second, the continuum of possible amplitudes of the signal must be quantized into a discrete set of values.

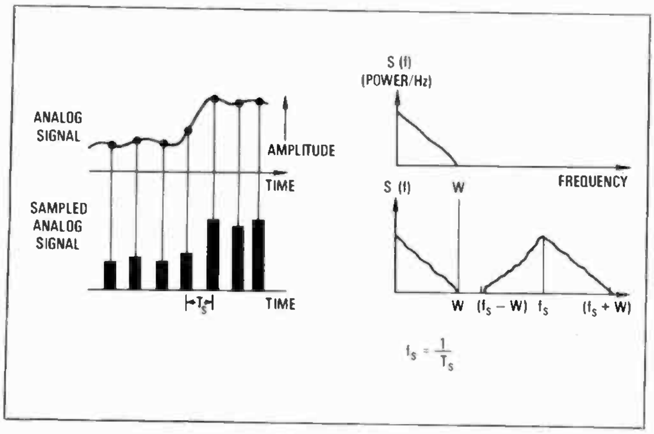



**Figure 1**
**Sampling process.**

Shown in Figure 1 is an example of the sampling process. The original analog signal is converted into a pulse amplitude modulated signal by applying the analog signal to a sample and hold circuit. It is important to note that the spectrum of the sampled signal is related to the spectrum of the original analog signal. That is, the original spectrum is repeated in frequency at multiples of the sampling frequency, with the sampling frequency equal to the inverse of the time duration between successive samples.

A comparison of the spectrum of the original signal with that of the sampled signal indicates that, if the uppermost frequency of the original signal is W, to avoid sampling error, the sampling frequency will have to be equal to at least 2W. This condition has been called the Nyquist Criterion. If the sampling frequency is selected to be less than 2W, the repeated portions of the spectrum will overlap, thereby preventing a recovery of the original analog signal without some distortion or sampling error being encountered.

It is also clear from Figure 1 that the original analog signal can be recovered from the sampled signal by using a low-pass filter with bandwidth W. Thus, one source of noise present in the analog-to-digital conversion process is sampling noise resulting from the use of a sampling frequency which is too low or improper filtering.

It is interesting to note that, if the spectrum of the signal is not continuous from 0 to W in frequency, then according to the Nyquist Criterion, a sampling frequency less than 2W can be used without encountering sampling error. The video signal spectrum typically has concentrations of energy at multiples of the line frequency.

When viewed in detail, the spectrum exhibits regions of nearly zero energy between successive line harmonics. This property can be employed to reduce the sampling rate similar to the manner in which the unique video spectrum is used to insert the chrominance signal within the luminance signal bandwidth. This technique is called spectrum redundancy.

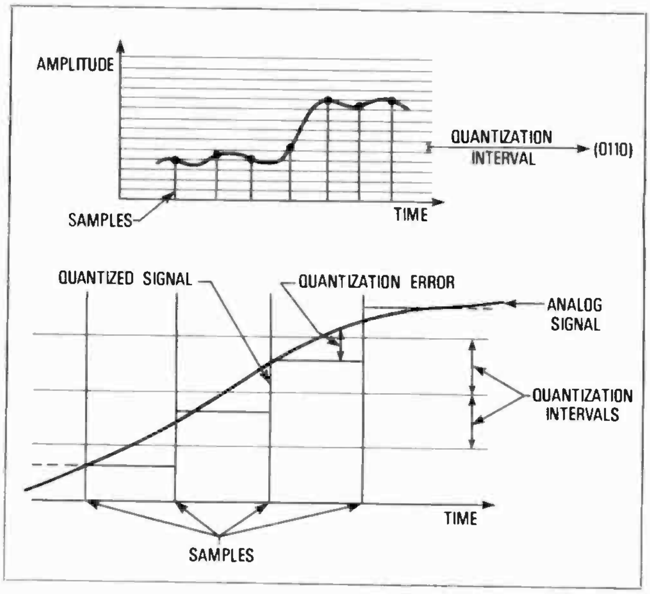



**Figure 2**
**Quantization process.**

The second operation which must be carried out to convert the analog signal into digital form is the quantization operation illustrated in Figure 2.

The total amplitude range of the video signal is divided into a finite set of intervals. For example, if the signal is divided into 256 possible intervals, each interval within the amplitude range can be assigned an 8-bit code word. If a sample of the analog signal falls within one of these intervals, then a single point within the interval, generally the mid-point of the interval, is designated as the representative analog level for that amplitude sample, and the corresponding binary code word is transmitted for that sample.

As shown in Figure 2, this leads to a second source of noise attributed to the conversion process, namely the representation of a continuum of possible amplitudes by a discrete set of representative values (in this example, 256 possible amplitude levels).

One of the differences between analog and digital systems is that the sampling and quantizing noise in the digital system is correlated with the signal, leading to noise characteristics which are quite different from those found in analog systems.

For example, use of too few bits per sample leads to quantization noise which results in artificial contours (or edges) appearing in the picture, a very noticeable effect even though the total noise power may be small. Similarly, sampling error can produce very noticeable moiré patterns, even for small amounts of sampling noise power.

Sampling and quantization noise are noises associated with the analog-to-digital conversion process. Two other primary sources of noise associated with misinterpretation of pulse amplitudes can occur before the analog signal is regenerated: bit errors due to additive thermal noise or pulse distortion, and timing errors due to timing slips and clock jitter.

The above-described analog-to-digital conversion process, generally referred to as pulse code modulation (PCM), requires sampling rates from 10 to 14.2 MHz and from 6 to 8 bits per sample [2],[3], resulting in bit rates from 80 to 100 Mbps. At these rates the sampling and quantization noise are imperceptible.

The first advantage of digital television described earlier can be applied to reduce the required bit rate below the figures cited in the paragraph above. If the correlation that exists between a single frame of a television signal and from frame to frame is exploited, it appears feasible to reduce the bit rate below 50 Mbps.

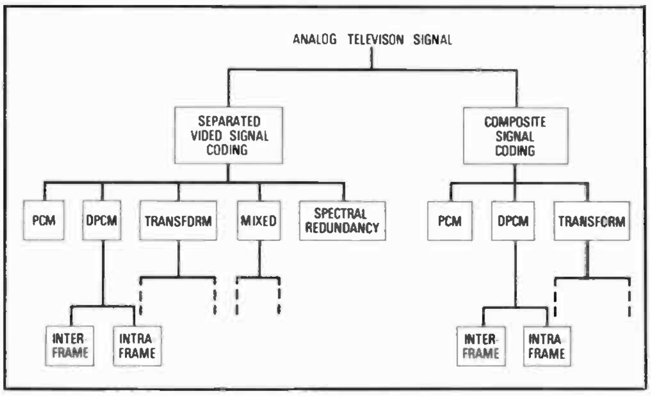



**Figure 3**
**Digital television signal coding techniques.**

Figure 3 shows the major directions of present digital television signal processing development. There are three main alternatives:

a. Direct encoding of the composite color signal versus decoding of the composite signal into Y, I, and Q or Y, R-Y, and B-Y, followed by separate digital encoding of each of these three signals.

b. The use of differential PCM versus transform coding.

c. The use of information within a single frame (intraframe) versus the use of frame-to-frame information (inter-frame).

These techniques will not be discussed in this paper, since it would require a paper of its own.

| Source | Sampling Frequency (MHz) | Bits/ Sample | Type of Coding | Gross Bit Rate (M bps) | Bit-Error Rate |
|---|---|---|---|---|---|
| AT&T | 10.29 | 9 | PCM-Composite | 92.61 | $10^{-6}$ |
| CBS Labs | 14.3 | 6 | PCM-Composite | 85.8 | — |
| COMSAT Labs | Y-6.02<br>I-1.77<br>Q-0.68 | Y-5<br>I-4<br>Q-4 | DPCM-Separate<br>Spectral Redundancy<br>Intra-frame | 33.6 | $10^{-4}$ |
| OKI Electric | 10.7 | 3.5 | Transform-Composite<br>Intra-frame | 37.5 | $10^{-7}$ |

**Table 1**
**Proposed broadcast television digital coding systems.**

Table 1 lists some proposed systems which have already been developed. It is important to note that digital techniques permit the use of complex signal processing of the video signal to achieve more efficient handling of the signal without thereby degrading the signal.

## Applications of Digital Television Techniques

Following is a list of potential applications of digital television techniques:

a. digital television cameras;
b. time base correction—synchronizers;
c. video tape recording;
d. electronic masking and gamma correction;
e. special effects, mixing, and real-time switching;
f. standards conversion;
g. image enhancement;
h. transmission; and
i. automated operation.

Ultimately the television camera will be the point at which analog-to-digital conversion will take place. Placing analog-to-digital converters in the camera would make it possible to separately encode the R, B, and G signals without forming an NTSC signal. This process would permit higher quality and lower bit rates.

The three digitally encoded signals would be time multiplexed together and transmitted around the studio in this fashion. Also, some of the newer solid-state cameras generate a sampled video signal which is more directly compatible with digital encoding of signals.

One of the most important attributes of digital television signals is the ease with which they may be stored for long periods of time and read out very accurately without degrading the signal. Both time base correction of analog video tape recorders and synchronization of two video signals require adjustable delay or storage of the video signals over long periods of time. This has been very difficult to achieve with analog ultrasonic delay lines, but can be readily achieved with integrated circuit digital storage devices.

The ability to store the video signal without degradation has important implications for video tape recording. Whereas tape and timing imperfections cause dropouts, color banding, and other types of degradation, if the pulse stream is recorded in a digital tape recorder, tape and timing problems result in bit errors whose number can be limited. As long as the number of bit errors is kept below the threshold level of perceptibility, the last generation dub will be as good as the first, and continuous degradation of taped material can be avoided. Furthermore, once multiple track recording techniques can be employed with digital recording devices, it may be possible to eliminate the need for rotating recording head tape recorders and the expense and problems which they entail.

Another aspect of digital television techniques is the ability to perform both linear and nonlinear signal processing very accurately. Using a sufficiently large number of bits for the signal and any constants employed in the operations of addition and multiplication makes it possible to carefully control accuracy.

Operations such as electronic masking, gamma correction, and special effects can be performed with a great deal more control and precision than is possible with current analog methods. Standards conversion, which requires frame storage and line and field interpolation, can be performed with much less digital degradation. Such converters have been built in both the United Kingdom and Japan.

The ability to accurately carry out many different types of signal processing permits the use of image enhancement techniques, such as vertical and horizontal aperture correction, time aperture correction, noise removal, geometric distortion correction, and improved chrominance luminance separation.

The effects of transmission distortion can be markedly reduced with digital transmission. Nonlinear effects in the transmission link can be dealt with more effectively in a digital transmission mode without in turn producing degradation in the video signal. Furthermore, if the transmission bit rate can be reduced below 50 Mbps, for many links the bandwidth and power required for the video signal can be reduced below those required by current FM methods.

Also, the large data capacity in the synchronization intervals of the video signal makes it possible to carry several sound program signals and associated video signals without an accompanying increase in bit rate.

One aspect of digital systems not to be overlooked from an operational standpoint is that these systems operate very close to design specifications and require few operational adjustments. Also, monitoring and maintenance can be more automated with diagnostic signals used to locate faulty components, and automatic monitoring used to determine failures. The techniques may eventually lead to lower operational costs; however, they will take some time to develop.

## Operational Impact

As digital technology becomes more commonplace in the broadcast industry, I believe that a number of new trends will develop in operational procedure.

Because digital handling of the signal permits more elaborate signal processing to be performed without degradation, there will be a greater use of electronic handling of the signal in program production and less use of film, both in production and for airing programs.

There also will be a greater use of special effects and mixing of several signals.

A tendency toward automated operation already underway will be accelerated, particularly in the normal operation and maintenance areas.

Exchange of program material recorded in different countries using different standards will be made easier as higher quality and less expensive standards conversion is achieved, encouraging more frequent airing of foreign program material.

Program material may be transmitted and stored more easily using digital technology and satellite distribution, thus providing larger libraries of program material readily available to stations throughout the country.

However, the introduction of digital technology will require a learning period so that technicians can familiarize themselves with this new kind of hardware and learn how to operate and maintain it. Also, the interface of this hardware to the existing television plant will have to be carefully planned to avoid a troublesome transitional period.

The benefits of digital technology to the broadcast industry are great, and if some planning is given to the introduction of this equipment into the industry, I believe that most people will make good use of this new technology.

**Vincent E. Rocco**

*Manager, Relay Systems*
*CBS Television Network*
*New York, N.Y.*

# A New Unattended Multi-Directional Microwave Receiving Antenna System

In the past, television remote broadcasts which originated at different points in a city and its environs, required the use of a manned relay station mounted on a tall building in the city center to which the remote television signal was transmitted by microwave link. The signal was then transmitted to the studio by a video line or by another microwave system.

The first part of the link from the remote pickup site to the relay station presented a number of problems. Difficulties were encountered in securing a transmission of adequate strength and free from distortions. Especially, the presence of other buildings close to the receiving and relay station could cause multipath distortions.

To ensure that an adequate signal would be received from a remote site, surveys were often conducted prior to a live transmission.

The receiving system used for the relay station was often a tripod-mounted parabolic antenna and microwave receiver as shown in Figure 1. This unit required the continuous presence of an operator who had to aim the antenna to obtain the best signal from the remote site.

With the advent of Electronic News Gathering as an important feature of local television news services, many remote feeds were required, often at short notice. It thus became necessary to effect microwave links from many points in a city. These links had to be set up in the shortest possible time, and without the luxury of a site survey.

CBS has developed an unattended multi-directional receiving system which is operational in five cities in the United States, and the problems listed above have been overcome.

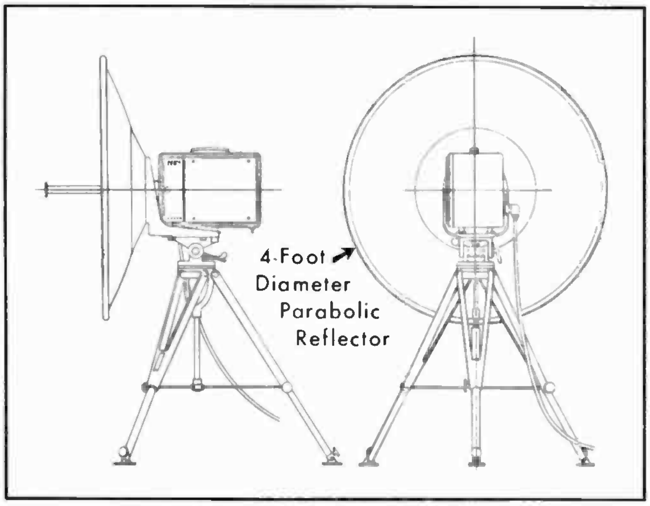



**Figure 1.**
**Portable microwave receiving system.**

## System Design

The requirements for the new receiving antenna system were:

a. The relay station must be unattended and operated by remote controls from the studio.

b. Satisfactory signals must be received from remote sites located at any range up to 50 miles, and in any direction from the relay station.

c. For short range operation, the system must achieve a signal transmission to the relay station even if other buildings lie in or close to the path between the remote pickup and the relay station.

d. The time required to set up a good microwave transmission should be less than ten minutes.

Here's how these requirements were met.

*Antenna Radiation Characteristics.*

It was necessary to devise an antenna receiving system that provided sufficient gain and directivity, while at the same time providing 360° azimuth coverage.

To meet these requirements, a number of antenna designs were considered, ranging from broad beam, low gain designs, to pencil beam high gain systems.

While some low gain systems meet the directivity requirements for reduction of multipath interference, they do not meet the system gain requirements.

High gain directional systems, while meeting both the gain and directivity requirements, require either an excessive number of antennas or a mechanical rotation feature.

The complexities and cost of either of these approaches were considered to be excessive.

It was decided, therefore, to use four receiving antennas, each covering a horizontal quadrant.

Electrical antenna "rotation" is accomplished by switching to the desired horn antenna, an operation which can be performed remotely from the television station studio.

*Antenna Polarization Agility.*

"Circularly polarized antennas are unique in being unable to see their own images in any symmetrical reflecting surface. The reflected wave has its sense reversed and is therefore orthogonal to the polarization of the antenna from which it originated."

This fact may be used to advantage to minimize the disruptive effects of multipath radio propagation.

Circular polarization is used for the transmitting antenna. The receiving antenna is capable of being switched for operation with circular polarization of either sense, linear vertical or linear horizontal polarizations.

In many practical operating situations such as may be found in large cities, reflected signals must also be used to complete the link. Under these conditions, it is necessary to change the polarization of the receiving antennas to match that of the incoming wave.

It should be pointed out that even with circular polarization transmission, one of the linear components of the wave can be lost due to reflections in the radio path. Under these conditions, adequate transmission may still be obtained by selecting one of the linear receiving antenna polarizations. In any case, the polarization and appropriate horn antenna are selected for optimum transmission at a remote control console by a studio operator.

*Unattended Operation.*

Since no mechanical movement of any part of the receiving antenna system is required, and since the selection of the reciving quadrant and polarization is effected remotely, the system requires no attendant.

Further, the absence of motors and servo systems improves the system reliability and lessens the need for routine maintenance.

*Link Setup Procedure.*

The new antenna system permits a marked reduction in the time required to set up an effective link with a remote site. To this end, the studio operator and the field crew cooperate, using a radio communications system.

If the path from the remote site to the relay station is unobstructed, it is required only that the studio operator select the antenna facing the remote site, and the circular or linear polarization to match the polarization of the transmitting antenna or the incoming signal.

When the link path is partially or entirely obstructed, the procedure followed is somewhat more complicated.

Thus, if the field crew reports that they are trying to reflect a signal from a specific building, the studio operator first selects the antenna quadrant facing that building and the counter clockwise circular polarization. This procedure is followed because, for a reflected signal, the sense of the wave polarization is reversed, thus requiring that the circular polarization be in the sense opposite that of the transmitting antenna. When a signal is obtained at the studio by this procedure, the field crew is instructed to pan the transmitting antenna over small horizontal and vertical arcs until the best noise-free signal is received. Finally, a check of all other antenna polarizations is made to ensure that an optimum link has been obtained.

If no acceptable signal is obtained by this method, another building may be tried as a reflector. On rare occasions, when no single reflection path is obvious, the procedure is then one of experiment.

In such cases, the receiving antenna facing the most likely reflecting building is selected, while the transmitting antenna is panned in azimuth until some signal is received. At this point, all polarizations may be tried for optimum results. If necessary, this setup procedure may be repeated, using other buildings as reflecting sources.

With skill and experience, even the latter seemingly complicated procedure can be carried out in a short time. In practice, it has been found that the majority of setups are effected in less than five minutes.

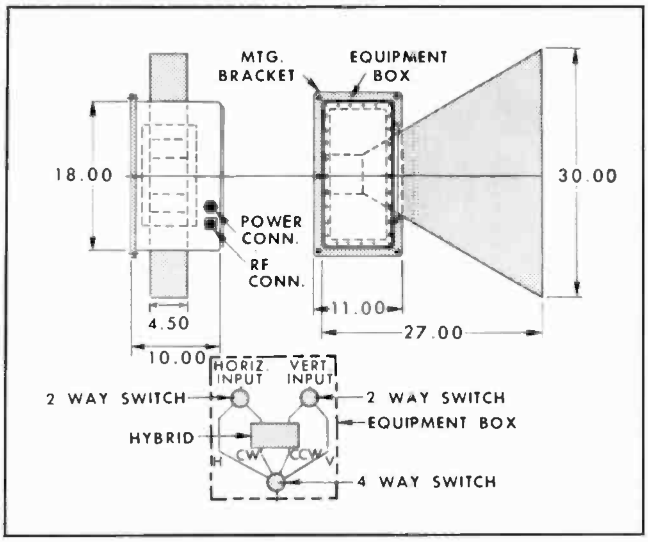



**Figure 2.**
**Detail of horn antenna element and connections for variable polarization.**

## System Description

Figure 2 is a drawing of a single horn antenna. It will be noted that the horn's aperture is asymmetric. It has been made narrow in the horizontal plane in order to obtain the wide azimuth beam of 90°. In turn, the large vertical aperture is necessary for obtaining the relatively high antenna gain.

The box shown in the lower portion of the illustration depicts the RF circuit required to obtain all four antenna polarizations.

A simplified system block diagram is shown in Figure 3.

A polarization selector unit is shown in conjunction with each horn. The four antennas feed into an antenna selector unit. The output of this selector is fed through a broadband filter to an isolator, and thence to a low noise preamplifier.

The preamplifier's output is then passed through another isolator, and a narrow band filter, to a post-amplifier. The output of the post-amplifier is then fed to a microwave receiver.

Selection of all antenna functions is made by means of a tone encoder, located at the television studio.

The four antenna elements may be mounted in a box configuration as shown in the photograph of the installation in use at WBBM-TV in Chicago. If the building on which the antennas are mounted does not permit this arrangement, the antennas may be mounted separately on the sides of the building.

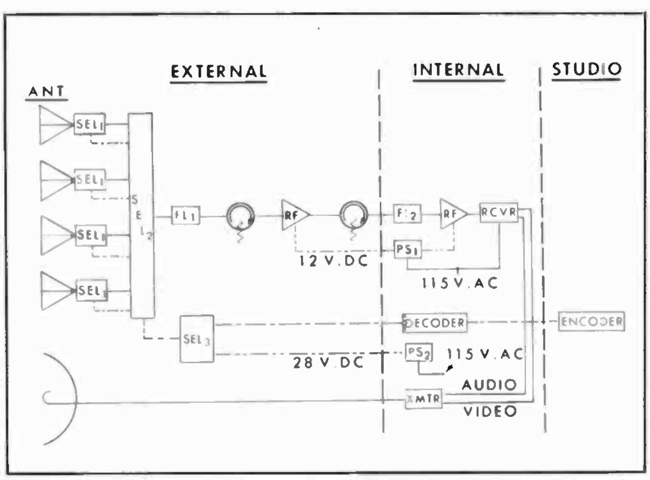
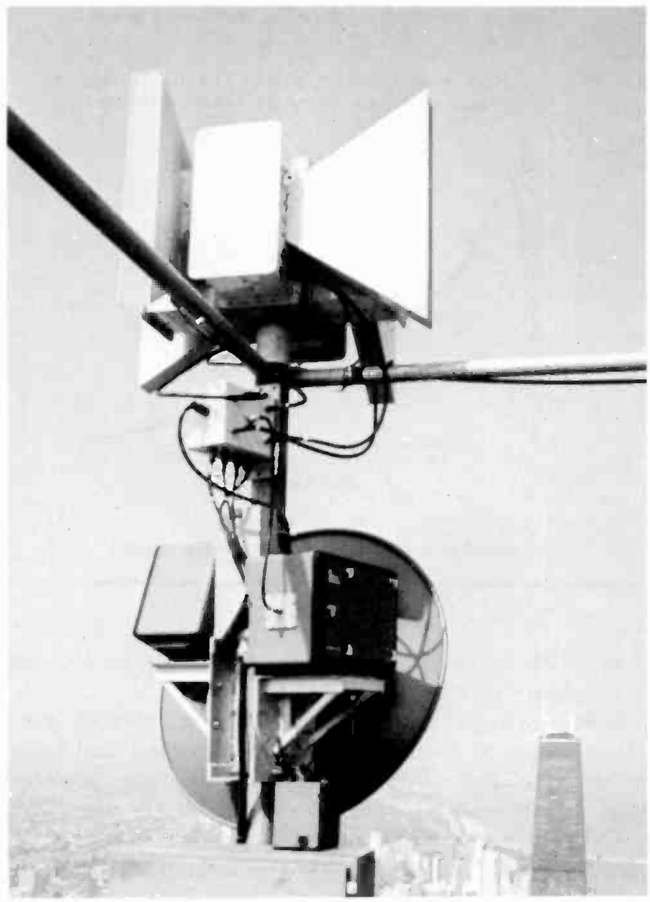



**Figure 3**
**Simplified block diagram.**



**Compact installation arrangement at WGN, Chicago.**

## System Performance

The antenna systems installed thus far have performed well, and good transmission links have been established from many field sites located in all directions from the receiving station.

The completed system has the following characteristics:

a. Each antenna has a gain of 14 dB and a horizontal beam width of 90°, as shown in Figure 4.

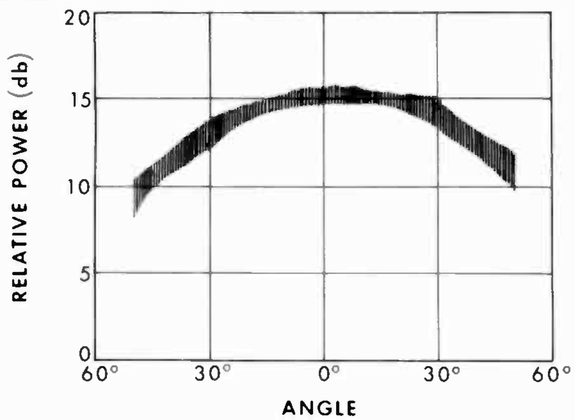


**Figure 4.**
**Antenna radiation pattern for horizontal plane.**

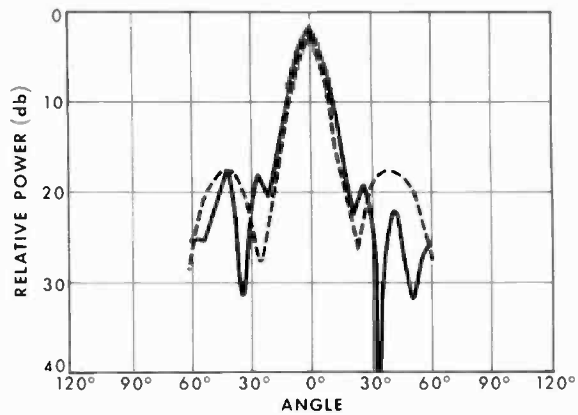


**Figure 5.**
**Measured horizontal and vertical antenna radiation patterns for vertical plane.**

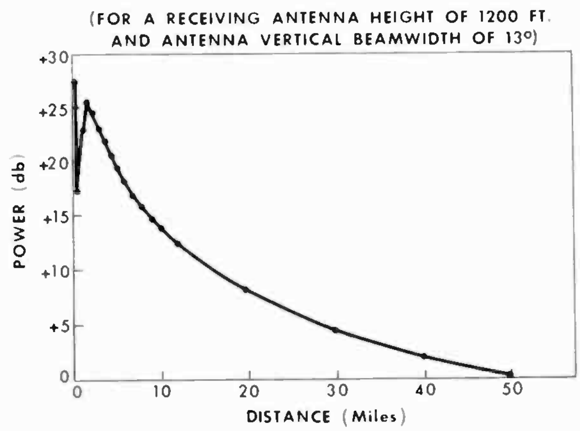


**Figure 6.**
**Signal strength contours over 50-mile range.**

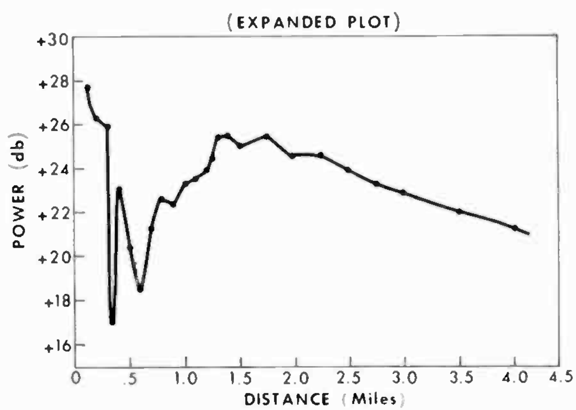


**Figure 7.**
**Signal strength contours at a shorter range.**

b. The nominal vertical beam width is 13°, as shown in Figure 5.

The multi-polarized horns and the ortho-mode generator required to feed them were designed and built by Nurad, Inc. The illustrated radiation patterns were measured by Nurad.

Calculations predict that an effective range of 50 miles can be achieved with the system, with a received signal-to-noise ratio of 54 dB. This has been obtained in practical operation, and the signal strength contour is as shown in Figure 6.

Figure 7 shows the same signal strength contour but for shorter ranges, and demonstrates that the 13° vertical beam width is adequate for even the shortest ranges of transmission.

## Conclusion

The new receiving antenna system has performed well in cities with very tall buildings, and good microwave links have been established in minutes from remote sites using either direct transmission or by means of signals reflected off buildings in the vicinity of the central receiving site.

Economies have been demonstrated by the speed of setup and the elimination of personnel manning the receiving site, and in most cases it is unnecessary to conduct a site survey prior to a broadcast.

The new system is evidently suitable for all auxiliary broadcasts and in particular, meets the needs of a city-based Electronic News Gathering service.

**Aaron Shelton**

*Technical Director*
*Station WSM,*
*Nashville, Tenn.*

# RF Shielding AM/FM/TV Studios

Investigation of the amount of R.F. shielding to be expected inside buildings to be used as a radio and TV broadcasting complex was undertaken in connection with the proposed theatre and TV studios of "Opryland U. S. A."

Measurements at a frequency of 980 kHz in representative buildings employing various forms of construction were tabulated showing the reduction of the R.F. field obtained inside the building.

Various kinds of shielding material were tried on a mock up room placed in a field of 500 mv/m from a 980 kHz radio transmitter. The amount of attenuation that these materials produced was measured and noted.

Effects of radial forms of earth grounds were investigated.

The necessity for use of an enclosed or shell concept for the shielded environment was established. The use of a shell within a shell was indicated where very high attenuation was desired.

**Interior of new Grand Ole Opry House. Careful shielding resulted in better than 50 db attenuation of broadcast signals.**

Selection of a site for a huge musically orientated amusement complex required the consideration of many factors. Chief among these were the available acreage and public access to this acreage.

The site selected for "Opryland U. S. A." was a natural only when the above factors were considered. A natural parklike tract of almost 400 acres was available along the bank of the Cumberland River, only six miles from downtown Nashville. Access to the location from all the Interstate Highways serving Nashville was available by Briley Parkway, a beltline express highway completely encircling Metropolitan Nashville.

Opryland U. S. A. was to be built around the Opry Plaza where a 4200 seat theatre was to house the world famous Grand Ole Opry radio and TV show. A rather large TV production studio was planned to be housed in this same building.

TV engineers associated with our Channel 4 TV station, WSM-TV, were immediately alarmed by this site selection because of the adjacency of a 5Kw radio station on 980 kHz laying down a 500 mv/m signal over the very spot where plumbicon color cameras, vidicon film chains and low level solid state audio consoles must work.

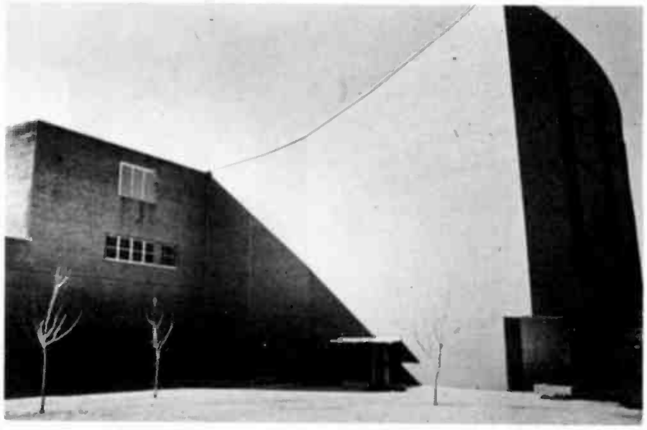
History has shown an R. F. signal of this magnitude to be most objectionable in the operation of these low level signal sources. Unfortunately, the literature has very little information to offer concerning problems of this nature, so an investigation was undertaken to get data that would be useful in our future construction in this site.

## Normal Building Attenuation

It was decided that, since no particular attention had been given the problem, to measure the attenuations produced by various buildings of different types of construction, to see what order of signal attenuation occurred. Pertinent information was obtained on the buildings investigated, including amount of attenuation measured in each case.

*The Vanderbilt University Gymnasium* features a very tight steel framework with exterior walls of concrete block and brick facing. The exterior walls are reinforced with considerable steel supporting columns. No particular effort was apparently made to tie together these steel members except in the interest of mechanical strength.

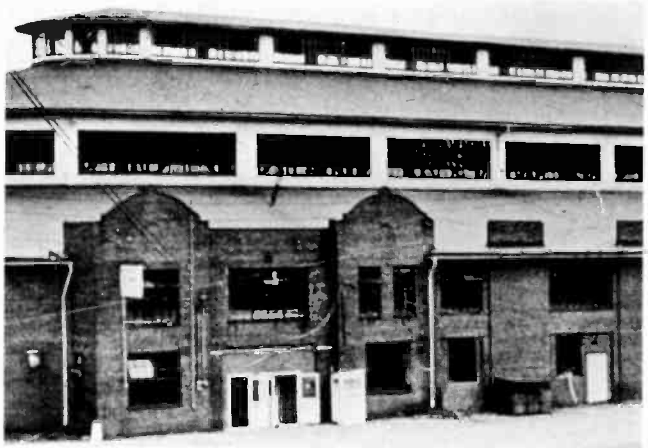
1. Average of approximately 20 measurements taken outside the gym was 20 mv/m.
2. Average of a like number of measurements inside the building in the seating area = 0.435 mv/m – Ratio O/I = 45/1 – 33 db.
3. On the gymnasium floor = 0.172 mv/M – Ratio O/I = 116/1 = 41 db.



**Vanderbilt University Gymnasium.**

*The Tennessee State Fairground Coliseum* has interior steel framework—vertical steel members and roof cross trusses on approximately 25′ centers and walls of masonry construction.

1. Average field outside – 27 mv/m.
2. Average field inside on arena floor = 2.9 mv/m Ratio O/I = 9/1 = 19 db.



**State Fairgrounds Coliseum.**

*Nashville Municipal Auditorium* has an all-metal roof supported by a steel framework of vertical steel girder columns. Its interior and exterior walls are masonry with vertical steel members. Rather large glass windows face street levels.

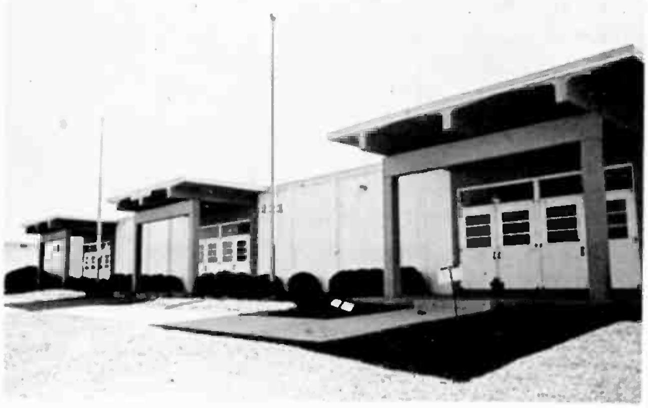
1. Average field outside = 54.4 mv/m.
2. Average inner corridor on the arena level = 1.45 mv/m – Ratio O/I = 37.5/1 – 32 db.
3. Average field along outer boundary of arena floor – 0.332 mv/m – Ratio O/I = 164/ = 44 db.
4. Average field on floor of arena = 0.152 mv/m – Ratio O/I = 358/1 = 51 db.
5. Average field around first balcony level circle = 0.368 mv/m – Ratio O/I = 148/1 = 43 db.
6. Ratio of average outside field to overall average of all inside measurements = 200/1 = 46 db.

**Municipal Auditorium.**

**New Nashville Hospital.**

*Women's Building, Tennessee Fairgrounds.* This one-story building is constructed of pre-stressed concrete with inside walls of concrete block.

1. Average field ouside = 27.4 mv/m.
2. Average field inside – outer corridors = 11.6 mv/m – Ratio O/I = 2.4/1 = 7.6 db.
3. Inside heart of building = 4.7 mv/m – Ratio O/I = 5.8/1 = 16 db.



**Women's Building at Fairgrounds.**

Investigation of a hospital then under construction also was undertaken. This particular building had special interest because its roof construction was the same as proposed for the Opry House theatre.

This roof construction consists of metal decking in the form of corrugated metal sheets covered by mesh-reinforced concrete. The metal sheets, four (4) feet wide and 20 feet long, but together so the edges can be crimped at four (4) foot intervals. At each crimped joint the two sheets are tack welded to form an almost solid metal surface. Reinforcing wire is placed atop the metal roof and the concrete poured. The metal reinforced mesh is the so called 6 x 6 x 6/6—meaning the mesh has six inch square openings and the wires are #6 size in both directions.

To check the attenuation of the R. F. field at 980 KHz, a series of 14 measurements were made encircling the building on the outside approximately 30-50 feet from the walls. These readings gave an average field of 42 MV.

Then 4-5 measurements were made on each floor level. As might be expected, the minimum field on each floor occurred in the approximate center of each floor. These fields measured 0.82, 0.85 and 0.9 MV on the first, second and third floor where the floors above had been poured under the construction methods outlined above. This gave a maximum attenuation of 34 db. On the fourth floor where this roof or floor had not been applied and only the I beams on 3 foot centers were overhead, a field of 16 MV was read. This is only a reduction of 8.3 db.

Measurements made on each floor outward from the center toward the outside walls which consisted only of large I beams spaced about 20 feet on centers, showed increasing fields as was to be expected. These fields came up to an 8.10 MV average at distances of 15-20 feet from outside walls.

From the aforementioned examples, we see that quite a variation in possible R. F. transmission loss occurs in the various types of constructions—from a low attenuation of 7.6 db to a high attenuation of 51 db.

## Practical Shielding for New Construction

In order to collect data that would be useful in setting up specifications for the construction of the Opry Theatre and TV Studio, a mock up building 8′ x 8′ x 16′ was fabricated of 2″ x 4″ studs. This small room was set up on the Opryland site in the exact location for the future theatre and studio.

A series of 13-12 measurements made outside approximately 10′ from the walls established an average field of 500 mv/m in the immediate vicinity.

Around this rectangular room at ground level a 3″ strap of #30 galvanized bonding metal was fastened to the upright studs. This was to serve as a grounding strap for the ground radials and also as a tie strap for all the wall and ceiling panels.

A 2″ mesh poultry wire was then laid on the ground and fastened to this 3″ galvanized strap on 1′ centers. A series of eight radials, two normal to each face of the room and placed at the corners was then constructed. These radials were 8″ wide of #30 galvanized strap and extended out 8 from each wall. Each radial was buried in a trench 1 foot deep and a mixture of salt and excavated dirt was used as back fill.

The field strength meter was then placed on a 4 foot stand in center of the room and the field again checked 500 mv/m.

Various types of shielding were then placed over and around this building and the FSM was read in each case to obtain the amount of attenuation achieved for each type material used.

A covering of #12 copper wires on 20″ centers was first tried. This resulted in a field of 140 mv/m, an 11 db reduction.

A four-inch mesh poultry wire was then placed over the building and tied into the bonding strap. This resulted in a field inside of 60 mv/m or 18.4 db reduction.

A two-inch mesh poultry wire was next tried and this resulted in a field of 7 mv/m or 37 db reduction.

A one-inch mesh gave no significant reduction nor did a 16 mesh aluminum window screening material.

It was therefore apparent that it was not necessary to employ any material with less than a two inch square opening.

Other coverings were undertaken using commonly employed reinforcing steel. A six-inch mesh of #10 steel wires resulted in a field of 50 mv/m—a reduction of 20 db.

It thus became apparent that it would be wise to employ a two-inch mesh of reinforcing metal fabric such as Type 22-1010—a 2″ mesh of #10 steel wires—for all reinforcing steel in walls, roofing and floors.

## Summary

Further investigation of the grounding employed showed that no significant increase occurred when all the radial grounds were removed. This indicated that the most important thing was to establish a complete shell of metallic material around the area to be shielded.

This metallic material could be of mesh construction. With mesh openings of 2″ x 2″, a high degree of shielding would be obtained and even with a mesh opening of 6″ x 6″ a reduction in the order of 20 db was possible.

This metallic material could be incorporated into the construction as reinforcing steel fabric or as support for acoustic material when attached to wall and ceiling. The material could be as heavy as reinforcing steel fabric or as light as chicken wire and still achieve the same order of shielding.

If still greater shielding is required, an inner shell of metallic material using the same 2″ mesh opening could be employed.

At the frequency investigated (980 kHz), any smaller mesh opening does not seem to be justified. At a much higher frequency, a smaller mesh opening might very well be justified. At a very much lower frequency, a considerably larger mesh opening should achieve a high degree of shielding.

From our measurements, an elaborate radial ground system cannot be justified. Measurements made in existing structures, as outlined earlier in the paper, indicate even higher orders of attenuation might be expected when larger rooms are involved.

## Results Obtained

Thus the architects specified this type of reinforcing steel—the type 22-1010—be used in the basement flooring, foundations and walls that rose to support the roof of poured concrete over the corrugated 4′ by 20′ steel sheets.

This reinforcing steel for basement, floors and walls normally comes in 10′ by 20′ sheets. It was specified that these sheets should overlap at least 6″ and that spot weld joints be made where these sheets overlapped every 3′.

The corrugated steel sheets for the roof sections were also specified to be welded every four feet along the butt joints.

The final configuration was to approximate as close as possible to a closed shell of reinforcing steel and corrugated roof sheet steel. This shell was in turn connected to the common ground point—the water main to the building by a #40 copper wire.

During the construction period, WSM engineering personnel made inspections as to the weld joints of this reinforcing steel and roofing steel before any concrete pouring could proceed.

The results obtained in our effort to attenuate the existing R. F. field is shown in the following tabulation of R. F. fields and db reductions obtained in the New Opry House at the various locations noted.

1. MCR—area occupied by VTRs, film chain, tape editing equipment—500 uv/m—60 db.
2. Video control room—camera controls—35 uv/m —83 db.
3. Audio control room—250 uv/m—66 db.
4. Director's room—100 uv/m—74 db.
5. Average of three readings in TV studio—1.8 mv/m = 48.8 db.
6. Average of three readings on theatre stage—0.6 mv/m log—834/1 or 2.9 or 58 db.
7. Audio control room, projection room and lighting director's room all measured better than 60 db down.
8. Midway of balcony field better than 54 db down.

It is very hard to set an upper level of R. F. field in which various TV and audio equipments will operate satisfactorily, but the writer believes that almost any equipment will not be subject to R. F. interference in fields below 25 mv/m.

Using this as a criteria, it is apparent that we have established a very safe level of R. F. over the entire Grand Ole Opry House.