CHAIRMAN SCHLAFLY: I am going to cut that discussion right there, with a little question mark in the air. We are running so short of time that I do not want to impose on the good nature and patience of our last speaker. Thank you, Clay, and thank you, Dr. Schenkel.

The last speaker on the agenda this morning concerns a very interesting item of test equipment called the spectrum analyzer. This is a most interesting and useful tool. I am anxious to hear more about it. Allen Ross, who will deliver this paper, is President of Nelson Ross Electronics. Nelson Ross Electronics specializes in Plug-In Spectrum Analyzers. Allen Ross is a graduate of City College of New York and of Brooklyn Poly-Tech. He was with Polarad Electronic Corporation before forming NRE. He spent eight years with them and was in charge of advanced development, pioneering the solid state spectrum analyzer. He was the person who first implemented the Plug In Spectrum Analyzer concept. Allen.

MR. ALLEN ROSS (NELSON ROSS ELECTRONICS): I know it is late and we are running behind, so I will try and cut right to the meat of this. The spectrum analyzer is an instrument that is probably unheard of in this particular industry. It is a useful instrument which has been around for a long time, originating with the esoteric military requirements. The state of the art in spectrum analysis has gradually improved to the point where it is possible to build spectrum analyzers which cover very wide frequency bands. There are now a few people making analyzers which permit observation of the entire CATV spectrum -- channels 2 to 13 (including all the FM in between) in one sweep. These analyzers will permit very useful advances in the systems for testing CATV transmission.

Perhaps it might be appropriate for me first to describe what a spectrum analyzer is and how it operates. I don't know how many people can see this blackboard, so I will try and use a minimum of sketches. We will start with a familiar instrument - the field strength meter. If we start by drawing the block diagram of the most basic field strength meter, what we have would be a signal input which drives a mixer, which I shall designate "M", provided with a local oscillator signal, from a black box which I will designate "LO". The resulting difference frequency drives a narrow band filter, ultimately resulting in a meter reading. Signal F plus Delta F comes from the local oscillator producing Delta F at the mixer output, and depending upon the strength of the input, we get a meter reading. Anybody who has manually tuned one of these things back and forth for a few hours from channel 2 to channel 13 can tell you it gets to be a pain in the neck after awhile. You can make a very good and accurate set of readings of the relative levels of all the picture and sound and color carriers in the system, but it is time-consuming. It would be nice if we had some sort of a system for observing the meter readings on all the channels simultaneously, so we didn't have to tune. This is exactly what a spectrum analyzer does for you.

Suppose we were to replace the meter with the vertical deflection system of an oscilloscope. This presents no basic problem. When we tune through a signal, we would see the modulation (as limited by the band pass) as a wave form on the oscilloscope.

Suppose, in addition, instead of tuning the local oscillator mechanically we somehow were able to tune it electrically. The oscilloscope has - driving the horizontal plates - a sweep generator producing a repetitive sawtooth. If we force the oscillator frequency to follow the sawtooth, we get what is called a panoramic display. In other words; as the spot travels from left to right across the face of the CRT, the field strength meter is tuned across the band of interest. I would like to sketch what the resulting display would be.

Let us assume, first, that the wave meter was tuning across one TV channel. You go through the guard band, and then when you come to the picture carrier, you would see a vertical deflection, the amplitude of which would be proportional to the picture carrier level at the input. There are other signals in there, but they consist mostly of the video modulation. These signals, surprisingly enough, contain very little energy and don't appear until you get to the color carrier which then appears as another vertical deflection, and as you continue, finally you will see the sound carrier.

Of course the display of one TV channel is really of no interest. As Ken pointed out earlier, anything that is passing channel 2 to 13 is certainly going to be reasonably flat over any one channel. However, there are spectrum analyzers available which make it possible to observe all 13 channels at once, and this, of course, becomes useful.

What you see is a flat base line with pairs of pulses wherever there is a channel being transmitted in your system. If you are carrying the FM band, you would see the station carriers in addition to each of the picture and sound carriers. You can observe this at a glance. Of course, an imaginary line drawn through the tops of the carriers is the slope of your transmission system.

The advantage of a device like this, of course, is to the speed with which equipment can be serviced. If there is a question on a pole, you can find out in approximately 30 seconds of observing time whether there is a problem. Get into the tap on the amplifier with the input to the spectrum analyzer and you are looking across the band. You see immediately all your carriers (present and absence) and you see the location, if any, of any interfering signals that might be causing problems. If there is a flatness adjustment which has to be made, you can make it while observing the carriers, limited only by the reaction time between your hand and your eye, which means a very fast adjustment. Obvious things, like the absence of signals, of course, are no problem; you find out right away.

There are many side aspects of the use of the spectrum analyzer which we are still beginning to find out about. A few people are beginning to use these instruments to service in CATV systems. I was told that in Canada, where they have one of our analyzers (I think it was in London), there was one channel where they had no color, where they couldn't get any color, even though they knew darn well that the picture carrier, the sound carrier, and the color carrier were all present, and they could see it at the headend. This turned out to be a spurious transmission which was 10 or 20 kc away from the color sub-carrier and was being picked up at the headend. Every time it came on it destroyed the phase information in the color carrier and all the color pictures just disappeared and became black and white. They couldn't find this by other means, but when they put a spectrum analyzer on it became immediately obvious. Every time this guy went on the air, you could see a nice big spike rise. The solution was a question of filtering. But once you know what frequency it is at, then you know what to do about it.

We don't really know yet what other things might be done with the instrument, but we do know, for example, that there is some problem in identifying co-channels from other areas. The sligh offset from channel to channel, in the same channel in different areas can be observed on a spectrum analyzer. If you narrow down the bandwidth of the filter so that you are looking at the sound and the picture carrier of one channel, and you were picking up a channel from another area at a lower level, it would be slightly offset, and you could tune your system, rotate your antenna, and make whatever adjustments you find necessary using the spectrum analyzer as a measuring instrument. This is a much more quantative measure than simply judging the windshield wiper effect you see on a CRT of a television receiver, so you can make a much more precise and accurate adjustment. Of course, the obvious uses are the observation of relative levels, picture and sound in each channel and the presence or absence of noise as IM products.

It has also been suggested that the spectrum analyzer be used for preventative maintenance. There are times at night when some channels in an area go off the air, and it is possible to insert a non-modulated carrier in place of the picture carrier. This I understand is a common practice of some places. Also there are occasionally un-modulated pilot tones, or pilot tones with simple modulation which travel down the system. Now, if your system has IM, the synchronization pulses of channels that are on the air, theoretically, should produce IM distortion on the unmodulated pilot carrier. So if you tune to the unmodulated pilot carrier and it looks perfectly clean, you have no IM in your system. Of course, it is never going to look perfectly clean, because no system is perfect. There is going to be some level of IM which appears as synch pulse bumps on the display and they crawl across with the same windshield wiper effect you would get between two stations whose horizontal and vertical frame rates would not synchronize with one another.

If you know, from experience - and you do after a while - what is normal for your system, you can anticipate failures. If, at any particular place in your system, you notice that these levels begin to increase, you can see that you are beginning to have trouble with something in the system between the headend and that point. It gives you a warning. I don't think there is any other device around yet which might give you this kind of a warning - but a spectrum analyzer will.

The plug-in concept was mentioned. That is a vague general word. I think that perhaps I ought to explain what it is. Up until a few years ago, all spectrum analyzers were complete instruments. They were quite expensive because a spectrum analyzer is a combination of many instruments. The local oscillator is a sweeper, which in itself is an expensive instrument. The receiver portion is a receiver and the rest of it is an oscilloscope. You can see, you are really buying three instruments, each of which in its own right, is fairly expensive and elaborate. This, of course, has been one of the reasons why spectrum analyzers, up until recently, have not been in too common use. The plug-in concept helps considerably. There are a great many excellent oscilloscopes on the market which have plug-in vertical amplifiers. The oscilloscope of course is at least half, if not 2/3, of the spectrum analyzer. It provides all the power, it provides the sawtooth for the sweeper, and it provides the CRT display and the amplification. The rest of the analyzer can be built into a package which is identical in shape and size with the conventional vertical amplifier. Plug this in and you have a spectrum analyzer. This is the kind of instrument I am talking about. Plug-ins are currently available for all the standard Tektronix and Hewlett-Packard oscilloscopes.

The oscilloscope is unaffected by the insertion of the plug-in. Pull it out, put your regular amplifier in and you have an oscilloscope again. The advantages are obvious. For example, with the HP140A oscilloscope you can get a time domain reflectometer, a vertical amplifier with reasonable bandwidth and a spectrum analyzer. They all plug in to the same oscilloscope. So there is a considerable saving in money and you have a complete set of equipment capable of making quite sophisticated measurements on your cables.

I have an instrument here. I brought one with me and Hewlett-Packard was kind enough to lend me an oscilloscope. I have since found out that the signal in this area is quite strong. If anybody is interested, I will be delighted to show them this display after the meeting. Thank you.

CHAIRMAN SCHLAFLY: Gentlemen, I thank you for your attention and interest in the papers. I thank the speakers. Thank you very much for your attention.