so as to be able to compensate for anticipated changes in input signal in either direction. Usually, only the gain of the intermediate stages are varied so as to maintain good noise figure and overload characteristics while the input and output stages are at a fixed optimum operating point. The detector is tuned either to a single frequency or is broadband, depending on the type of AGC system used.

In the second system, the entire amplifier is maintained at its optimum operating point as far as noise figure and overload characteristics are concerned. The attenuator ahead of the amplifier is varied to change the overall gain at the amplifier station. The nominal operating point of the attenuator must provide an insertion loss of at least the magnitude of the anticipated downward change in input signal level. The loss of the attenuator is then varied up or down to correct for changes in input level. This arrangement, while allowing optimum operation of each stage of the amplifier, effectively increases the noise figure of the amplifier by the amount of the attenuator's nominal insertion loss. The best solution may be a combination of the two methods. That is, place the attenuator at an intermediate point in the amplifier. This would allow optimum operation of the active elements in the amplifier and, at the same time, provide a good noise figure.

As stated previously, the AGC may be derived from either TV signals or from pilot carrier signals. A single TV signal cannot be used alone to activate the AGC because if that channel went off for any reason, all amplifiers would run wide open.

Excessive gain would be accumulated, and overload would soon occur on the remaining channels. Therefore, if this method is used, a standby oscillator is required which is switched into the system if the primary source goes off.

Another method is to sense the composite signals in the passband of the amplifier and adjust the gain to the composite level. With this method, if a station goes off, the AGC is still operative. No standby oscillator is required since the AGC circuit operates from the remaining carriers.

Still another mtthod utilizes only pilot carriers to drive the AGC circuits. This system is independent of the TV signal levels and has the advantage of providing a fixed standard signal to which the entire system may be referenced.

To summarize, the main advantages of AGC are:

(1) Stabilization of individual channel signals permits adjacent channel operation and maximum utilization of the transmission system.

(2) Proper signal levels may be maintained in the trunk, thereby avoiding problems of noise and cross modulation.

(3) Maintenance problems are reduced by eliminating the necessity to reset levels with changes in temperature.

Thank you. (Applause)

MR. TAYLOR: I think we can take time for one or two questions. Anybody have a question they want to ask Mr. Kuzminsky? One in the back of the room.

UNIDENTIFIED SPEAKER: This might be going back to this envelope delay problem, but I notice on the color set there was another image to the right and I've had this problem on black and white. I don't know what it is. Is it miss match?

MR. KUZMINSKY: Well, sounds like it.

UNIDENTIFIED SPEAKER: Miss match?

MR. KUZMINSKY: Yes.

MR. TAYLOR: Thank you. Thank you very much, Mr. Kuzminsky. (Applause)

Our next speaker is Mr. Robert Cowart, Vice President in Charge of Construction for Viking Company. And, he's going to talk on "System Reliability". I believe the sketches will be circulated while he's talking. Mr. Robert Cowart.

MR. ROBERT COWART: I like in particular that ETA part, so I'll be very brief. I'd like to talk to you this morning briefly on system reliability.

These days we find outselves building more and more systems into areas that already have available to them strong high quality, highly reliable, local off-the-air signals. In order for a system to compete under these conditions, the system must be engineered in such a fashion that it could successfully compete in terms of the same quality, reliability and performance as these off-the-air signals. The preliminary determinants of quality are signal-to-noise ratio, cross modulation and ghosts. You are all familiar with these terms as a result of the industry schools which outline and detail methods of qualitative determination. I am sure that by now you are all familiar with these terms, with their method of determination and know of many ways in which to improve them. A fourth, extremely important, factor is reliability. A subject which has frequently been ignored both in the past and at the present. My purpose today is to acquaint you with the basics of reliability and to point out to you some methods by which present system reliability can be improved.

Many studies have been made in the past both by military and commercial interests in the pursuit of those factors that control and influence reliability. In almost every case explored the most highly reliable system was the simplest system. I am sure you will all agree from your own experience that this is the case. The military answer for increased reliability is redundancy. This means having almost two complete sets of basic equipment, one ready to take over the function of the first, should it fail. The commercial solution to reliability is primarily by increasing the reliability of the components and increasing the size, weight and mass of the device. This is more or less the brute force approach.

In CATV, neither of these two standard approaches is really available to us because of the unusual demands we make of the device. In transistorized equipment we sacrifice virtually everything for the sake of a lower noise figure or increased output capability. We are pushing the upper limits of the State of the Art. We can't use redundancy because of cost. We can't use higher reliable components because high reliable, high performance transistors are not available yet. We must achieve our reliability in the method in which we construct our systems, and in the method in which we utilize the manufacture's product.

Most manufacturers today design equipment that is inherently reliable. In many, many cases that we have examined, we find that this inherent reliability of the device is lost in its application.

Reliability in electronics systems is generally considered to mean the length of time between events that render the system incapable of performing its designed function. In industry, exhaustive and extremely expensive studies are made to determine and assign quantitative values for the time between failure. This period is often referred to as mean time between failure or MTBF. In CATV these numbers are not available but the principle guiding the establishment of these numbers is available and it is with this principle that we will concern this discussion.

If all of the components of an electronics system are considered to be functionally in series and if the failure of any components in this series chain results in a system failure then the overall system reliability can be expressed by a very simple formula. This formula states that the overall system reliability, designated by the symbol "R", is equal to the reliability of each of the series components raised to the power of the number of those components that are in series.

$$R = r^n$$

Where r = mean reliability (probability function) of each component.
n = number of components in series.

This expression demonstrates something that you know intuitively to be true. In other words, the longer your trunk line in a system the greater the probability of failure of a component of the trunk. Conversely, the shorter the line the less chance of failure. The formula also allows us to show mathematically that given two different amplifiers if twice as many amplifiers are used in a system of Type "A" as are Type "B" and Type "B" has half the reliability of Type "A" then the overall reliability of the system is exactly the same because there are twice as many pieces used but the reliability of each piece is twice as great. You intuitively know that the statement is correct.

The formula also shows that the high reliability system would have few parts and each part in itself should have the highest possible reliability. Towards accomplishing this end we customarily, in large systems, use extremely low loss trunk cable such as 3/4" aluminum and the highest possible db spacing between amplifiers because in our trunk system the highest reliability component is the cable; secondly, would undoubtedly be the connector; thirdly, the accessory items, splitters, directional couplers, etc.; and lastly with least reliability is the amplifier itself. Our major significant contribution to reliability of that trunk segment would be to decrease, by whatever means we could the cable loss, utilize wide amplifier spacing, etc., the number of amplifiers functionally in series. In our efforts to increase the reliability of that trunk segment we would attempt to reduce the total number of objects with lesser reliability than the cable to a minimum. This would mean we would reduce the number of splices, if possible, by care in our construction; we would reduce the number of splitters, directional couplers, equalizers and other objects inserted in the lines and try and make as much of the line as we could, sheer cable: Because, of course, the cable is the most highly reliable item of our components.

The same reasoning establishes a guide line in the design of equipment and has prompted most major manufacturers to abandon the practice of using splitters to generate inputs to associated distribution equipment and to instead build into the trunk amplifier chassis a fixed directional coupler to provide the input to distribution. When this is done we eliminate a jumper and several connectors that we used to use in the past to accomplish this. The same reasoning demands that in transistorized equipment the equipment should be mounted without equipment enclosures. That means not with the use of an equipment cabinet. When an equipment cabinet is used the signal must pass through a bulkhead connector, a mating connector internally in the cabinet, a jumper, and finally through another connector on the end of the jumper and into the amplifier chassis. The same thing is true on the output of the amplifier. When this is done there are five additional elements functionally in series with the signal between the two ends of the trunk cable. Although connectors have inherently high reliability, by removing the eight connector assemblies from the line and replacing them with two direct entry connectors, we have thus improved the reliability of each amplifier station four times. You intuitively know that the reliability of this configuration is far less than the direct entry type connector permanently mounted to the amplifier chassis.

In an operating system when you examine at the end of the year the maintenance that has been given to the system, you find some rather curious things. You find first of all that many of your system outages were not caused by any inherent failure of the amplifier itself. You find that they were caused by such unrelated things as power failures; by cars breaking off power poles; by trees falling across distribution and trunk cables; by the failure of fuses as a function of temperature; by lightning strikes; and by employee carelessness in leaving amplifiers disconnected, etc. Another important point that gains in significance as we move into the area of transistorized system construction with many, many, amplifiers dependant on a single power supply is that extreme caution should be used in selecting the location for the power supply. I am sure that you have all had an experience where a certain amplifier in your system continually caused you trouble because of failure of secondary voltage delivered by the power company. We have seen amplifiers installed and taking power from power company transformers already seriously over-loaded. Few of you have given any thought to requesting the power company to provide you with your own transformer, which need not be very large, to assure yourself of a non-interrupted source of power.

The cost is very low and the reward in terms of increased reliability is great. These things again point up the fact that in system design, a system should be engineered in such a fashion so that the absolute minimum of active elements of the system are in cascade. Ideally, as we have all discussed many times in the past, a system would be arranged in the manner of a wheel; with the center of the wheel the point of signal origination and of radial lines from the wheel hub to the outlying distribution areas. Although this is obviously impractical in most cases, an attempt to accomplish this type of construction can be made by the adoption and usage of extremely low loss master trunk cables as a backbone of the system. This new configuration will resemble somewhat the skeleton of a fish; with the master trunk cable being the backbone of the skeleton and distribution at right angles to this master trunk but in much, much smaller segments.

Many of you have suggested in the past that you accomplished a form of redundancy by paralleling master trunks perhaps several blocks or half a mile or so apart, but when you examine the situation existing in parallel trunk, you find that you have not accomplished your purpose because the basic law of system reliability catches up with you. Remember, it states that the reliability decreases exponentially in proportion to the number of active elements in cascade. By paralleling master trunk you are in effect doubling the number of elements in cascade. Now it is true that by the redundant parallel trunk method you do restrict the service fault to a smaller area, however, if the two or more trunk segments are exactly the same length, then the system reliability itself, on the basis of our definition of fault, is actually impaired by the same number of trunk lines existing.

In summary, let's recap the major points that we have established. A system gains RELIABILITY by SIMPLICITY. This means that when you make your new layouts, look at them carefully to determine if you have taken the shortest route, if you have arranged your construction to utilize a minimum of connectors and splices, see if your power feeds come from a reliable source and make sure that you are utilizing as fully as possible the reliability delivered to you by the manufacturers.

Thank you. (Applause)

MR. TAYLOR: I would open the floor to questions on any of the subjects we've been answering. Let's take any questions to Bob Cowart first, if you have them, however. Are there any questions on this Systems Reliability that you'd like to ask Bob Cowart? Well, if there are no questions specifically to Bob, they may arise later. I shut off a number of questions earlier, particularly on the subject of envelope delay. Ken Simons.

MR. SIMONS: Again, this isn't a question. I would like to take a few minutes if you don't mind to show you a little scheme that we have used for some years in our lab to measure group delay. You might call it Do-it-yourself-group-delay-measurement. It takes equipment that most of you will have in your service shop or lab and I think there's enough time to sketch it out. The accuracy is not of the highest order but perhaps we'll make up for that in the cheapness of the equipment used.

I should give a credit here. The very fine grease pencil I'm about to use is through the courtesy of VIKING.

Now, the basis of this method of group delay measurement is the constant delay of a long piece of cable. If you have a reel of cable and I'll represent it this way. That's a piece of cable. It's on a reel and you're looking at it in 4th dimension. The delay from here to here is constant, approximately constant as Mr. Rogeness told us. How we can use this constant delay thing to help us in measuring the delay error or the actual group delay of a piece of equipment? Well, we start over here with a sweep frequency generator. There are a good many reputable manufacturers - you can take your choice.

We split two ways with either a 6 db resistive splitter or a 3 db reactive splitter. We have now two outputs, one going here and one here. This one goes up to the