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P R O C E E D I N G S

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NATIONAL ASSOCIATION OF BROADCASTERS

Broadcast Engineering Conference

September 15 - 18, 1947
Convention Hall
Atlantic City, New Jersey

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MONDAY MORNING SESSION

September 15, 1947

The Broadcast Engineering Conference of the Twenty-fifth Annual Convention of the National Association of Broadcasters convened at nine-thirty o'clock in Room A of Convention Hall, Atlantic City, New Jersey, Mr. Orrin W. Towner, WHAS, Louisville, Kentucky, Chairman, NAB Engineering Executive Committee, presiding.

MR. ROYAL V. HOWARD [NAB Director of Engineering]: The meeting will come to order, please.

Good morning, ladies and gentlemen. I am sorry that we are late. There has been a little confusion as to the time. The schedule showed that this was to begin at nine-thirty, so we delayed as long as we could.

My name is Howard. Most people think that I am the Director of Engineering for NAB; actually, I am the coordinator of confusion.

We will start this morning session here under the direction of Mr. Orrin Towner, Chairman of the Engineering Executive Committee of the National Association of Broadcasters. Mr. Towner is a well-known engineer throughout the nation, Chief Engineer of WHAS, Louisville. I will now turn the meeting over to Mr. Towner.

CHAIRMAN TOWNER: Thank you, Mr. Howard.

Members and Honored Guests: We are very happy to have you here in this first official NAB Broadcasting Conference, and we are going to move rather rapidly on account of the late hour.

We are very pleased to be able to present as the first paper "Motion Picture Photography of Television Kinescope Images" by Mr. O. B. Hanson, one of our best experts in television. Mr. Hanson is Vice President and Chief Engineer of the National Broadcasting Company. Mr. Hanson! [Applause]

MR. O. B. HANSON [Vice President and Chief Engineer, National Broadcasting Company, New York, New York]: Thank you, Mr. Towner.

Good morning. It seems that Doc Howard was a little optimistic when he expected to fill this auditorium to its capacity with broadcast engineers at 9:00 a.m. on the first day of the Convention.

After about fifteen minutes with this paper, then we will show you some movies of kinescope photography.

Television broadcasting, the greatest mass communication system developed to date by engineering genius, is a technical miracle which fascinates all those who see it, and to the public the witnessing in their own homes of remote events while they occur is an awe-inspiring miracle, the hows and whys of which they never hope to understand.

For a short period of time this fascination of a technical wonder holds the viewer's attention, but sooner or later he will come to accept television in his home as commonplace, as he does radio broadcasting, telephone service, and all other electrical household devices. He will expect it to operate consistently with minimum outages and expense to himself, and his sole interest will be in the entertainment value of the program service which the miracle brings to him. The greatest stage in the world with its technical facilities has no greater value than the show produced upon it, and with television it will always be the show that counts. A television program production, together with the necessary performers and name talent, can be expensive. As was the case in sound broadcasting, it is necessary to distribute such productions over a large number of television stations to include a large television audience to meet costs.

For instantaneous presentation of events while they are happening, intercity networks are vital, but, unlike the early days of sound broadcasting, the facilities for network communication do not exist in the quantity which was available for the building of a network system for sound broadcasting. Some intercity television circuits are available, and the construction of further links are under way or planned, but there will still be a large section of the United States that for several years will not have available intercity connections for television programs.

It is, therefore, important that other means of syndication be utilized. Following the pattern of electrical sound transcriptions, there is an art fully developed which lends itself to that purpose in the form of film transcriptions. Such films for circulation to television broadcasting stations, of course, can be made, using the standard technique of directly filming the scene or production. However, this method is expensive, and syndication would require a large number of stations to defray the cost of such special film productions.

Another method is to directly photograph the television image from a kinescope while a television production is being produced for the air at the key station's studios. Such a method permits the camera and the sound recorder to run continuously while the show is in production, without the usual stop and start and later assembly into a finished film with its waste film, as in the normal motion picture technique. Such films, as photographed from the kinescope, can be developed by rapid processes, and the negative can be retransmitted by television for a repeat show at a later hour. Such films made of outdoor events which occur during the day could be repeated in the evening for those unable to see the original event directly by television. Positive prints of such films could be made for shipment to remote television broadcasting stations to help increase the program service of the particular stations where a network connection either was not available or was economically impractical.

Prior to the war the National Broadcasting Company started to develop experimental apparatus to study the problem of making motion pictures from kinescope images. These early experiments were sufficiently encouraging to provide a stimulus for further development. During the war our experimental work was continued, and equipment was developed for use by the military. Since the war we have continued our work, looking toward commercial application of kinescope motion picture photography. Special amplifiers and special kinescopes have been developed for the express purpose. A 16-mm. experimental motion picture camera has been designed in cooperation with the Eastman Kodak Company, and most encouraging results have been obtained. New camera designs are in manufacture, and we hope for improved performance when such cameras are available.

While the television radio channel set aside for picture transmission is but four megacycles wide, the equipment used in our studios is approximately eight megacycles wide, with the result that the resolution produced on our studio monitors is somewhat higher than that which would be obtained in the home receiver, limited as it is by the radio channel width. Thus, the picture on the special kinescope is of higher quality and more satisfactory for recording on motion picture film than that produced on the home receiver.

Some of our work in this field has been done on 35-mm.

film, but most of the experimental work in this field has been conducted with 16-mm. film in order to reduce the cost of film stock so necessary to keep down the over-all cost of film production. Today films photographed by this method are of adequate quality to permit their being retransmitted through the television system with acceptable results. When this 16-mm. system has proved out its technical and commercial practicability, and when television has more money to spend, it is probable that the system will shift over to 35-mm. in order to further improve the picture and sound fidelity. In the meantime, small-community television stations would find savings in their capital investment by installing only 16-mm. projection equipment, as most cities have stringent fire and building codes governing the facilities required for use of 35-mm. film.

Kinescope photography, regardless of its syndication possibilities, provides documentary and historic record of television events; it is helpful for critical analysis of production techniques, acting, et cetera, and is useful for audition purposes in selling types of programs.

I have with me here some sample films of NBC television shows which you will see in a few minutes. In the meantime, you will be interested in some of our experiences and methods. Some of our early attempts at filming kinescope images were poor, due to the low intensity kinescopes, unsatisfactory spectral response of the phosphors, kinescopes operating on low voltages, and camera drives which were not synchronous with the thirty-frame television system, the latter producing shifting horizontal black or white bars, termed shutter bars, across the picture.

The first pictures that I will show you are pictures that were taken at, I think, eight frames with a standard 16-mm. motion picture camera. When you see them, they are going to be run at twenty-four frames, because we cannot slow that projector down. The motion will be amusing, but you will see the shutter bars. All it indicates is that we were able to at least have sufficient exposure to get a film.

Further, the film available at that time had insufficient sensitivity to give proper exposure synchronous with the television with the kinescope brightness available to us at that time. During the war further equipment was developed to record images for the block and ring television systems used by the military. For military purposes it was not necessary to use a synchronous system, with the result that a slow-moving shutter bar was seen in the projected image field. However, these pictures were adequate for the purposes intended.

The next step was the use of the fifteen-frame-per-second camera driven by a synchronous motor. This method gave an exposure time of just under one-thirtieth of a second with a 170-degree shutter. By careful phasing of the motor so that the opening and closing of the shutter took place during the vertical blanking period, acceptable results were obtained. When projected at sixteen frames per second, no undesirable results due to change of speed were noticeable. This meant that the film recorded two television fields for each motion picture frame, thus permitting more adequate exposure at low kinescope brightness.

There was a question as to whether we should design our system to record at thirty frames per second, to be synchronous with the television system, or to develop a method for recording at the standard rate of twenty-four frames per second. It was felt that it would be best to record at the standard twenty-four frames in order that the films would be usable on standard equipment and the sound would be recorded at the normal rate of thirty-six feet per minute. Therefore, our present system records at twenty-four frames per second from a thirty-frame television system.

I think our British friends have a little easier job there. Their system is a twenty-five-frame system, and they use a standard twenty-four-frame motion picture projector in their system. Of course, in recording they can run a twenty-five frame, and the difference in speed is so negligible that you would hardly know the difference in the sound of the increased motion or speed-up on it and the higher pitch in sound. I think I am right on that.

The camera is driven by a synchronous motor, and the shutter is so designed that it is open for exactly 1/30 of a second in each 1/24 of a second rotation time. It was necessary to decrease the pull-down time of the film in the camera, which is normally of the order of 1/50 of a second, to less than 1/120 of a second. Such a shutter is open for 288 degrees and closed for 72 degrees. This allows for the exposure of two complete television fields. Each subsequent half field corresponding to 1/120 of a second is used for pull-down time. In this manner 48 fields of the television image are photographed, and to produce 24 film frames, 12 remaining fields are used for pull-down during each second, the time of one half field for each pull-down period. The accuracy of timing of the shutter is very important. A flutter or "wow" in the shutter movement will show up as a 12-cycle banding or flicker. In some cases a white band and a dark band will alternate at a 12-cycle rate. Flywheels and other inertia-damping devices are used to remove this effect.

Can we have the lights out to have the first slide, please?

[Slide] This slide shows the segments of exposure and pull-down time on a camera in relation to the field rate of the television image. I think you will find it self-explanatory. You see, the shutter opens and stays open for the duration of two television fields. At that it closes, and the pulling-down period of 1/120 of a second is exactly half the field. That shutter opens again, and you are splitting two split images, if you want to think of it in terms of the image shutting at the top of the frame.

[Slide] This slide shows the experimental setup for recording television images. On the top of the tea wagon, left to right, are the radio amplifier, the enclosure containing the projector tube and the camera with the cover removed. On the lower shelf are a 30-kilovolt radio frequency power supply, production chassis; and on the end right a 300-volt rectifier-scope.

This, of course, is not a finished product; it is just laboratory experimental equipment, and if such equipment was made up for commercial use, it would be in a very pretty box, no doubt.

[Slide] This is the other side of the same tea wagon.

[Slide] This is a close-up of a kinescope with the cover removed. On the tube face is the actual television image of a baseball pickup. It might interest you to know that that picture was taken with two photoflood lamps in order to get normal exposure to the camera, but in spite of that amount of light shining on the face of the kinescope, it did not wash the image out entirely.

Have you any more slides down there?

[Slide] This is just a block diagram which shows how the system is connected into the television system. The shutter and camera are not shown, but they occur as close to the lens as possible in order that the image of the edge of the shutter will be out of focus on the film. It would be desirable to install the shutter between the lenses, but that is a little difficult, not entirely necessary during the experimental period.

Over the period of experimentation a great many films having different spectral sensitivity have been tested and matched to the phosphor spectrum to obtain the optimum actinic efficiency. Without going into the details of the various films and fluorescent materials used in various experiments, it has been found that the most effective screen is made of a blue fluorescent zinc sulphide, together with a blue sensitive film stock. Such a combination is twenty times more actinically effective than the white phosphor screen, P-4, such as used in home-type kinescopes. Thus we have more than enough light for ideal exposure conditions.

The kinescope monitor now in use operates at thirty kilovolts and is capable of a contrast ratio of several hundred times in the areas of large detail. It is the nature of photographic film that as the detail becomes finer between black and white objects, the contrast ratio in this fine detail continues to drop as the detail becomes finer until it reaches unity, which becomes the limit of resolution of the film.

Both television pickup devices and kinescopes exhibit the same type of characteristic. While our kinescope is capable of contrast ratios of several hundreds to one in areas of coarse detail, it is desirable to so adjust the contrast ratio of the kinescope to approximately thirty to one in order to fall well within the latitude of the average film and thus to allow some latitude for normal variation in adjustment of video controls, average brightness of kinescope pictures, and variations in development of films.

While the major portion of the exposure density occurring on the average film is something on the order of 100 to one or 128 to one, depending on the particular film and the method of development, it is very desirable to keep the arid contrast ratio down to thirty to one, something of that order, in order that that rank should slide up or down at exposure. The density curve will still stay in the linear portion, and I think that those of you who are familiar with television systems realize that when you have a field pickup and you are going to vibrate transmitters in the master control rooms, there are a lot of people who can grab hold of the controls. The engineer who tries to make photographs of that must allow himself a little latitude.

Under such circumstances it is possible to record on films resolution down to approximately 500 lines as used on a television test chart, at which point the combination of the film and the television system adds up to unity contrast in the fine black and white detail. This, of course, refers to frame size on 16-mm. film.

If we were using 35-mm. film, the unit contrast limit on average 35-mm. film would probably be somewhere around 1200 lines, but the television system would still be limited to something on the order of 600 lines, and the combination of the two would give a result which might be, we will say, approaching 600 but would be rather more than 500, so it is quite possible that later on, when television has some money to spend, we might go to 35-mm. film.

One type of blue sensitive film which we have used experimentally is a type of safety positive which has much higher resolution cutoff than normal negative stock. It is less expensive than panchromatic film, and while it only has a Weston equivalent rating of .5 for white light, this is sufficient to obtain satisfactory exposure when photographing from the special kinescope having the blue phosphor operated at 30,000 volts. By the way of orientation, Super X has a Weston rating of 50, or 100 times more sensitive.

The range, of course, is much higher than it is in the safety deposit stock. Our objective there was to get very low range.

With the limiting resolution of the film at approximately 500 lines, where the contrast is approaching unity, the scanning lines, being at a resolution fineness higher than this cutoff point, are not visible in the film or in the projected picture. This assumes, of course, that the kinescope monitor is properly interlacing and has proper spot size for the purpose.

In some of these pictures that you will see you will see something in them that you may think is scattering lines, but the earlier pictures do show some lines, and the engineer who made those pictures tells me that there was interference from his high-voltage radio frequency power at some place. At least, that is his story.

It is obviously necessary to record sound, and at present this is done through the use of a standard RCA Photophone, PM 45, sound recorder modified for 16-mm. film. In order to have a marker on both the sound and picture film for later synchronizing during editing and printing of the composite print, a 420-cycle tone is momentarily injected into both the picture and the sound channel. In the interests of economy, of course, it would be possible to record sound in the camera on the original picture negative. However, at the moment our laboratory camera is not so equipped, and for the time being we prefer to use a standard recorder, recording the sound on a separate film, as is normal practice in the motion picture industry. By this method it is possible to process the sound film in such a manner as to produce the best possible sound track.

I hope that we can hear this sound so that that statement will not embarrass me.

I have some samples of various films here, as well as photographic slides and diagrams of the setup, which I shall now show you. The first portion of the film is some of the early attempts, in order that you may orient yourselves to the progress which has been made. The second portion of the film is a series of shots photographed at Radio City of the Louis-Conn fight after reception at Radio City over a wire line having a cutoff at four megacycles. This particular film was photographed using Super X film from a blue phosphor kinescope operating at fifteen kilovolts and does not represent the optimum.

Also, it was made with Auricon cameras, the very first ones that were put out, and is not necessarily a good representation of what an Auricon will do. We have later ones with Auricon pickups.

The resolution cutoff of the film is somewhat lower than that which is now used. The latter portion of the film has been photographed with our present equipment, using the safety positive film. These shots are not presented here for their entertainment value. They were taken at random by our laboratory at such times as suitable signals were available for test films, as part of the general development program.

They also do not represent the ultimate in results, but are shown to you for your technical edification and to report progress in this field of endeavor.

You may be the judge of the quality of these pictures as they appear to you, and if there are any questions that you care to ask following the showing of the film, I should be glad to endeavor to answer them.

May we have the film now, please?

[Film] This is a silent film and is taken with a standard motion picture camera of the setup. It shows you the bars that I was telling about, the stratifiers, because the camera, of course, was running at twenty-four frames. There was no attempt to adjust the shutter time as shown in that slide.

[Commentary] Early attempts at photographing television images were made with nonsynchronous motor-driven cameras operating at approximately eight frames per second. The following sample will show accelerated motion which projects at twenty-four frames per second.

We are now in the National Broadcasting Company's experimental studio.

The Louis-Conn match in 1946 made television history. The television pickup was made with image Auricons. The picture signal was transmitted by telephone cables from the Yankee Stadium to Radio City, where it was photographed at twenty-four frames per second.

[Film] [Commentary] The Giants-Dodgers ball game which follows was picked up at Ebbets Field with image Auricons. The signal was microwaved directly to Empire State. The signal was received at Radio City on a standard television receiver which fed the photographic monitor. The photographic conditions are the same as for the Louis-Conn film.

[Film] [Commentary] The following excerpt is from a live-talent program televised with iconoscope cameras. It was photographed on safety positive film from a blue five-inch projector kinescope operating at thirty kilowatts.

[Film] [Commentary] The following example was photographed under the same conditions as the preceding example, except that the image Auricon cameras are used in the studio.

[Film] [Commentary] The following film is a very recent recording and demonstrates the quality of resolutions that can be obtained.

[Film]

MR. HANSON: I am very sorry that I could not show you these pictures with those windows closed down. We looked at them last night and the contrast really helped them a great deal. You, being engineers, will, I am sure, make allowances for the fact that that screen had an awful lot of light on it. The people sitting off on the side were getting very dim pictures. That is the end of that one. [Applause]

MR. TOWNER: Thank you, Mr. Hanson, for that demonstration of techniques. Unfortunately, our time is running so short that I will beg off any questions on this paper if you will permit that.

Now we plan to go to a different phase of broadcasting.

MR. HANSON: May I just add one word? The engineering development work on this iconoscope photography was done by one of our engineers. Bob Frazier is here. Bob, do you mind standing up? [Applause]

[Mr. Frazier stood to acknowledge the introduction.]

MR. TOWNER: Thank you. We appreciate that word, Mr. Frazier.

Our next paper, "Frequency Modulation Broadcast Station Construction," the next phase of our program, is by Mr. Paul A. de Mars. Mr. de Mars is with the Raymond Wilmotte organization and, with Mr. Wilmotte, heads their construction consulting practice. Mr. de Mars!

MR. PAUL A. de MARS [Consulting Radio Engineer, Washington, D. C.]: Gentlemen and Ladies: When Doc Howard first extended an invitation to address this meeting, the problem seemed a very simple one, especially in view of the fact that I am currently engaged in directing the planning, design, and construction of some ten FM stations. However, reflection convinced me that, actually, it is a very complicated subject, and to attempt to deal with it in all phases in the time allotted here is an impossibility. Consequently, I have chosen to treat the subject by calling attention to some of the outstanding considerations that are involved, broadly speaking, in building broadcasting stations and FM broadcasting stations in particular.

One of the reasons why the subject is difficult is that we are concerned with building broadcasting facilities with powers from 250 watts to tens, and in the case of FM even hundreds, of kilowatts designed to furnish the services that are in the interest of small communities, metropolitan areas, and, in some cases, all regions.

However, no matter what the size of the station, the broadcasting facilities, we are dealing not with the construction of a simple item, but we are dealing with the assembly of components into a system, the object of this system being to transmit programs of information and entertainment into the home.

Except in some of the very smallest facilities, construction of a broadcasting station requires knowledge and skill in many fields, in the field of radio, audio mechanics, acoustics, and architecture.

In the case of stations in which the transmitting facilities run into kilowatts of power, it is essential that the buildings in which the transmitting facilities are housed, or the buildings in which the studio facilities are housed, be very carefully designed and coordinated with the equipment that goes in them. The reason, while plain, is not always understood.

The small transmitter is normally a complete package which can be crated up, shipped, uncrated, placed in the desired position in the room into which it is going, connected to the power supply, to the antenna, to the audio lines, and it is ready to go; it is a going concern.

When we get into larger powers, the equipment is not so simple. It means that the various components must be engineered into the building construction and that planning, design, and forethought must go into their layout. Otherwise, performance requirements will not be met, or the cost of the project will be excessive.

Possibly the most important consideration in building stations is to realize that integration and coordination of the components are the important factors that will affect sound design and result in attaining desired performance.

We are all more or less familiar with the conditions around AM. After all, we have been building AM stations for a quarter of a century or more, and we are reasonably familiar, therefore, with those factors that enter into the design and building considerations.

All of those, in general, apply to FM, but, in addition, FM is peculiar for the reason that it has been restricted more by FCC rules and standards than AM. In fact, the FCC rules and standards leave only a relatively small amount of freedom to the engineer in designing his facilities. By that I mean that in a large portion of the United States, from the standpoint of population--and it is even getting to be a large portion of the United States geographically--the Commission in its rules and standards of good engineering practice practically specifies the facilities that shall be put in, except as to choice of individual components. I am referring to the 500-foot height, 20-kilowatt effective, radiated power formula.

Were it not for such a restriction, the engineer would have much more opportunity in connection with the choice of site, the amount of power that he would use, the consideration of the area which he was serving, and how to do it with a combination of power, antenna, height, and location.

However, in spite of these limitations established, there are still a lot of technical problems that the engineer must face; for instance, the three factors that affect and determine the coverage of an FM station are the amount of radiated power, the height of the antenna, and the terrain over which the signal is propagated.

Due to the moderate wave lengths involved in FM, it is possible to increase the field intensity tangential to the earth's surface by stacking up a number of radiating elements and attaining in this manner in the antenna so-called power gain. All other considerations being waived for the moment, if we desire twenty kilowatts of radiated power, it is immaterial whether we radiate twenty kilowatts from an antenna which has no power gain, that is, by delivering twenty kilowatts of power to a no-gain antenna, or whether we deliver one kilowatt of power to an antenna which has a gain of twenty.

Actually, some very practical considerations enter when we try to carry this concept very far. In the first place, as we increase the number of elements in an array to increase the field intensities tangentially, we establish certain requirements with respect to the accuracy with which the antennae are designed mechanically, the present situation with which currents and the proper phase of those currents can be maintained in practice.

There are other considerations; for instance, as the dimensions of the antenna get larger and larger, there are attenuation losses from the point at which the transmitter power is fed to the array in the elements themselves.

There has not as yet been enough experience to accurately determine the extent to which antenna gain will under all conditions be the equivalent of transmitter power radiated from a simple antenna. I think that it is up to the engineers to be cautious in this respect. It is my feeling, based on experience, that in many cases in the interest of initial cost and operating economy stations are under construction in which the results are eventually going to be both disappointing and possibly not meet the requirements of the FCC, due to failure to realize the same actual signal intensities by combining low power and high gain as would be obtained with the power radiated from simple antennae.

I do not think there is any question; I think the consensus is that antenna gains of five, six, seven, possibly eight, are practical. It does not mean that all antennae purporting to have that gain are satisfactory but that at least good design will permit utilizing this fortunate characteristic of the shorter wave lengths.

Ever since FM was called to the attention of the art a great deal has been talked, and many demonstrations have been made, of the high-quality characteristics of the system. There is no question about the inherent characteristics of FM making it possible, through reduction of noise, audio band width, freedom from static, to permit the transmission of really high fidelity.

The FCC has, I believe wisely, established very high standards with respect to the over-all audio performance requirements. As a matter of fact, they have established standards that are probably about as high as it is possible to attain under the best circumstances.

While the manufacturers have done an excellent job in designing, manufacturing, and providing components for us, when the large number of audio components are added to the studio to transmit a length into the transmitter itself, only by the most careful coordination and integration of these facilities, only by installation practices that take every advantage of shielding against noise, of matching so that distortions do not occur, is it possible to meet these high standards.

I think that very few of the FM stations built to date will find that their systems will meet the requirements of the FCC. I urge every engineer who is charged with the responsibility of designing an FM system to exercise the best possible sources of information and the utmost care in the planning, design, and layout of his audio system, because while the FCC to date has not insisted upon establishing proof of performance of operation of the over-all system, this is a requirement under the standards, and the day of reckoning is bound to come. It is obviously going to cost much more to have to revamp a system that does not meet the requirements than to install it properly in the first place.

I think probably one of the reasons for not giving too much concern about the audio performance of FM is that right now it is in what I would call the news, weather, and phonograph stage, but FM is rapidly going to outgrow that stage and join the ranks of big broadcasting operations.

Normally, if we were considering the establishment of an FM station purely as an engineering problem in a system of free enterprise, it would be impossible for us to divorce the facts of propagation from consideration because, after all, what we are attempting to do is to set up a facility which will serve an area.

Unfortunately, we are guided--and we have no choice in the matter--by curves published by the FCC and figure our service areas by an arbitrary method established by the FCC. Many of us realize, and new operators in the broadcasting field are quickly coming to the realization, that under many conditions the methods of estimating coverage or service by the FCC's so-called ground-wave curves are grossly in error. Under certain conditions it is found that signals are heard 'way beyond the expected range. In other conditions service is not satisfactory far within what is expected to be a good coverage range.

There are two considerations involved here: one is the abnormal diffraction of the radiated wave due to conditions of the atmosphere, which is responsible for the anomalous long-range conditions and the shadow loss behind hills and mountains which is the principal reason for failure to attain expected coverage.

Because I think that more knowledge of this consideration is important, I am going to put on the screen (and now ask for the first slide) some more detailed information on this matter of propagation.

[Slide] The first slide shows field intensity versus distance for various antenna heights and, by means of the scale on the left, for various antenna powers. I direct your attention first to the dot-dash curves which represent the signal intensity versus distance computed on the basis of a slowed earth and standard atmosphere and, in fact, are taken from the FCC standards and plotted for antenna heights of 500,000 feet.

Two other curves, solid curve and dash curve, represent, respectively, signal intensities that are exceeded 99 per cent of the time and 1 per cent of the time for the antenna height and power conditions indicated.

These figures, percentage of time, were chosen because they sort of come into the picture in this way. Their family is a high-grade service, and the service ought to be good at least 99 per cent of the time. I want you to notice that as we go away from the transmitter the fluctuations that occur above and below, the so-called ground-wave curves, increase with distance, and at a given distance they are less the higher the antenna, so that there is a very important reason for utilizing an antenna which is as high above the level of the surrounding terrain as possible, as far as giving an interference-free service with any considerable distance, because, for example, with the 100-foot antenna, when we get out a distance of more than forty miles, we are getting enormous fluctuations above and below the mean value, and if we are going to consider a 99 per cent service, then this signal intensity is the only one we can rely on for service. On the other hand, this signal intensity here is the signal intensity that is potentially an interfering signal.

I do not want to belabor this matter too much, and time is short, so I will ask for the next slide, please.

[Slide] This is a nomograph which takes into consideration the plan shown on this sketch and estimates the shadow loss in DB below that which would be the result were the hill not there.

The source of this was from some restricted information prepared by the Bell Laboratories during the war and from the measurements which I have made in various bands.

It gives a reasonably good approximation of what we find in practice. I want to call attention to the tremendous losses that can result in hilly or mountainous terrain. For example, we happen to be a community located, say, within five miles beyond the thousand-foot-high ridge. The signals to that community are going to be fourteen, fifteen, DB down, due to the shadow effect of the intervening hills.

When we remember that in most of the northern section of the country and the western seaboard a large portion of our population lives in pretty uneven country, topographically speaking, it means that an awfully large portion of the listeners are going to have to get along with a signal which is many DB below that predicted by the FCC curves.

Since, even under the limitations under which we have designed, built, and located our stations, we do have considerable freedom in the choice of site, one of the most important considerations is to select a site so that the shadow losses to the area we want to serve are at a minimum.

[Slide] Unfortunately, this is not too good a slide, but it attempts to combine the smooth earth propagation curves with the nomograph and come out with a more realistic statement of signals where the effects of terrain are important. This curve in one form has been published in the May issue of FM and is going to be republished in this form in an early issue.

That is all for the slides, and may I have the lights?

I think about all that I can say is to conclude by a very brief summary that construction of broadcast stations, either AM or FM, represents a rather complex undertaking, that they should be treated not as a unit, but as a system's design problem, that we are in a new branch of the art, in which lots of information is current but there is not very much substantiation of a lot of the claims, particularly of antenna performance, and so forth. Therefore, the engineer should look with some skepticism on claims. The safe procedure is to be conservative.

There is no question but what FM is going to revolutionize radio. There have been recognized quite a few implications as a result of the establishment of many, possibly even thousands, of new broadcast facilities in the United States. The effect upon the editorial policy, for example, that is, whether the Government regulatory body should, in view of the possibilities for an almost unlimited number of stations, change its rules and regulations in that respect.

I would just like to wind up on a sort of bizarre note. We hear a lot about the coming atomic age. There have been a lot of serious and semiserious statements made that because of the vital importance of broadcasting in our national life, broadcasting stations, at least a certain number of the large key ones, may have to be put underground in order to prevent a national panic in the event that our present facilities should be totally wiped out. Possibly the large number of FM stations that are technically feasible and that will in all probability be built scattered all over the United States within the next decade may furnish the national service, even in the event of atomic war, that will take the place of the almost impossible problem of putting the old standard facilities under ground. Thank you, gentlemen. [Applause]

CHAIRMAN TOWNER: Thank you, Mr. de Mars. We are sure that there are many questions, probably more than we can handle, for Mr. de Mars, who has had such a wealth of experience in pioneer FM work. For a few minutes we will entertain questions. I am sure that he will be very happy to answer them.

MR. WILEY P. HARRIS [General Manager, WJDX, Jackson, Mississippi]: Has the studio-station length been developed, and is it practical?

MR. de MARS: The use of radio to transmit the program from studio to station is as old as the FM. The Yankee Network, a pioneer installation in Boston with studios in Boston and transmitter in Paxton fifty miles away, used an FM studio-to-station length, and there have been numerous cases since in which studio-to-station lengths have been used. There is no question about the technical and economic feasibility. However, due to the great demands on the frequency spectrum, it has been necessary to set up the assigned frequencies for this service in a region not very highly developed, and the manufacturers have been slow in developing and offering equipment in the band assigned. It is my understanding that equipment is now being developed, and possibly has been developed, and will very soon be shown and made available to broadcasters for studio-to-station lengths.

MR. HARRIS: Is the efficiency in every way comparable to that of the equalized lines, say with your telephone lines equalized to 15,000?

MR. de MARS: There is no question but what the studio-station length can meet all of the requirements as to frequency range and, in most cases, on the basis of the economics involved can attain the standards of signal noise in distortion, where the telephone line facilities cannot.

UNIDENTIFIED [WBDL]: You made a statement that FM will override AM. How, inasmuch as our telephone lines or chain broadcasts are limited to around 5000 cycles and, at least for a chain over a long range, 15,000-cycle response is practically out of the question, do you figure that AM will be overridden by FM, at least for chain broadcasts? I am interested in it, because I would like to know whether, when we go into it this fall, or maybe five years from now--

MR. de MARS: I hope that others have not misconstrued anything I have said to the effect that FM is going to override AM. I think the point of the question is, How, in the face of economics, and so forth, is FM going to hold its own when the cost of distributing it, and so forth, is going to be so much greater than AM? Is that, perhaps, correct?

There are a lot of answers to that, and I would like to leave it this way. There is going to be a demonstration given to you gentlemen here of FM, and it is going to demonstrate to you how programs can be relayed from station to station by FM. I call your attention to the rapid growth and success of the Continental work, which is carrying its programs from station to station by picking up and rebroadcasting those programs from one of the stations of the chain to other stations beyond.

Do not misunderstand. FM is not going to work on a nation-wide basis for stations picking up and rebroadcasting programs, but that procedure is going to be a big factor in it. As the demand for 15,000-cycle facilities increases and grows, the common carriers are going to find ways of supplying that service at costs which the broadcaster can afford, even though at this time they are greater than AM and appear to the FM-ers, who are working in the red, as a sort of impossible limitation to further growth.

MR. O. K. GARLAND [Chief Engineer, WJHL, Johnson City, Tennessee]: There is one question that I am particularly interested in; that is about our transmitter. If you locate a transmitter on a hill or any place else and make measurements or make observations of coverage, say, of 250 watts, then go to 10 kilowatts within the range of the 250-watt transmitter, do you think that these sight measurements will be very powerful in determining the coverage you would receive? What happens to the fluctuation?

MR. de MARS: If measurements are made with 250 watts, and carefully made with all of the precautions that are necessary in these high frequencies, they ought to be an exact indication of the performance that will be obtained with 10 kilowatts. It is not a matter of power so much as it is a matter of distance.

You will recall the first slide that I put on. Beyond a distance of, say, twenty or twenty-five miles with a 500-foot antenna we begin to get fluctuations in signal intensities due to the weather.

Obviously we have either to compare a series of measurements, say at fifty miles, with a 250-watt job and a 10-kilowatt job in order to get agreement, because we might have made the first measurements when we were having super refraction in the atmosphere, and we might have made our check on the higher power when we were having substandard conditions. But that does not change my original statement that measurements at low power do represent what we can expect at high power, but it does not take into consideration the propagational characteristics of this band.

I would say that measurements beyond twenty-five or thirty miles, unless the antenna is among top antennae, would not be of too great value, unless they are made over a period of time.

MR. GARLAND: What would you consider the length of the period of time? Whether it was made in daytime or nighttime or both-- In other words, would the change in temperature in daytime due to cosmic rays, we will say, and so on and so forth, have very much effect on refraction, and so on?

MR. de MARS: The changes in signal intensity due to atmospheric changes go through a daily cycle, which is similar all over the country, and a seasonal cycle. So if we wanted to get measurements that would check, we would really have to go through almost a year. However, the error can be reduced a great deal by choosing the weather and the time of day.

The signals are less affected or disturbed, that is, propagation is nearest the theoretical during the middle of the day. Refraction normally increases and signals rise in the evening, being high during the night, but along during the middle of the day, say from ten in the morning until two or three in the afternoon-- Also, conditions will be disturbed during the passage of air masses, that is, passages of cold winds, warm winds, or any marked changes in the weather. So if we choose to make our measurements under conditions which represent most nearly so-called standard atmosphere or the median conditions, we can eliminate a lot of errors.

A good time is when the air is clear, a moderate breeze is blowing, just a nice day, rather than during the period when a storm is approaching or a storm is receding or there is some meteorological disturbance going on. Under those conditions you are going to get your maximum departure from errors. So in order to limit the amount of time and reduce your errors, make your measurements during the middle of the day during settled weather which represents seasonable weather for that season of the year.

CHAIRMAN TOWNER: I regret that our time is running out here. Perhaps Mr. de Mars will be kind enough to answer some of your questions afterward. I understand that his organization will have a suite over at the Ambassador, and perhaps you will catch him there.

MR. de MARS: We will be very delighted to have you people drop in and discuss your problems with us if you would like to. Thank you. [Applause]

CHAIRMAN TOWNER: Our next paper is "Audio Considerations for Broadcasting Stations, Dealing Principally with Improved Physical and Electrical Operation." We are very fortunate in having Mr. John D. Colvin, Audio Facilities Engineer of the American Broadcasting Company, to bring us this paper. Mr. Colvin. [Applause]

MR. JOHN D. COLVIN [Audio Facilities Engineer, American Broadcasting Company, New York, New York]: I am not moving this microphone to exercise a prerogative of a second-rate artist, but I am trying to achieve the Maxwell effect. Is this about right for a speech, Mr. Nixon? It is about right.

As I talked with Dr. Howard a month or so ago when the subject of this paper came up, I asked Doc what should be considered under the topic of "Audio Considerations." Doc started out very enthusiastically and said, "Well, we ought to include studio design, studio construction, studio switching systems, consider master control room layouts, master control room systems, recording rooms, what modifications we might be doing, then, at ABC to modify the standard communications type of equipment, a whole long list of such things."

Then Doc added, "And you must give it in thirty minutes." [Laughter]

Any one of these subjects, to be properly covered, would take at least an hour and a half or two hours, so I have cut it down quite a bit.

Another thing Doc said was, "Do not read your paper." That rather took the wind out of my sails, but I guess Doc meant it, because yesterday afternoon Doc's secretary took the only copy of the paper I had away from me; he said it was for the press. What the press needs the paper for I do not know, but the only thing I have left is a slip of paper, so, stripped for action, I will proceed with the paper, because I only have twenty-nine minutes and thirty seconds to give the thing in. [Laughter] I will just give you what I intend to cover in this half-hour period.

The suggestions are things that we have been doing at ABC Headquarters in New York. Some might seem simple, but they were done for reasons. The first one covers microphone switching with regard to its connection with the speaker interlocked relays; also, cutting of turntables and two definite methods of operation of turntables showing some of the latest devices we have developed there at ABC; also, the subject of noise depressors will be covered in some detail. If I may have the first slide, we will get going here.

[Slide] Speaking about microphone switching and turntable inputs, this block diagram of a studio that we recently installed at our outlet in Hollywood, KCA, this particular diagram, represents a block diagram of the setup that we used, and it covers pretty well what I want to say about microphone switching and one of the methods of turntable operations.

Let me tell you what this studio is designed for. You know, all the programs that go out of New York and Chicago to Hollywood during the daylight saving period are recorded out in Hollywood and are then played back at various times on the different lanes that go out of Hollywood. So many records had to be played as a result of this that we had to set up two new studios with enough facilities to handle all these records that are played. Thus we have the two turntables and the two microphones. One microphone is for local station-break announcements and the second one for occasional news broadcasts that might originate in this studio.

Since the announcer's mike is turned on and off quite often and somewhat at the will of the announcer, we can see that we allow the announcer to have an on-off push button to turn his mike on and off as required. That is about all you can allow the announcer on the West Coast to do. [Laughter]

These little blocks indicate the on-off push button on the announcer's panel. The operation of these on-off buttons through a relay turns the mike on and also operates the speaker interlocked relay.

One thing that we are concerned about nowadays in equipment design is to eliminate as far as possible any switches or relays in audio circuits. The fewer you have, the less trouble you are going to have from them, especially keys and microphone circuits. It used to be, when we designed studio controls, that almost invariably you would find the microphone switches on top of the fader, and the announcer had to turn the mike switch on. Sometimes he might forget to do it; other times, in the heat of the program, he would accidentally knock this key off. So we tried to leave those switches off as far as possible. The only times when a switch is required is for operation of the speaker interlocked relay, that is, the speaker in the studio. In this case, since the mike was turned on and off by the announcer, we accomplished it by relay operation. As I pointed out, his relay phone is at the microphone. I will show you later on just how this interlocked circuit works out.

The second mike is turned on and off by the control room operator. He simply opens up his fader, and the mike is hot. We still have to turn off the speaker in the studio, so we accomplish this by having the Daven Company put a mike switch on the back of one of their standard faders. As soon as it has been turned on, the switch operates, the speaker relay takes hold, and the speaker goes off. You have no need of any time-delay action in this case between the coming on of the microphone and the going off of the speaker, because the fader is now in operation and you have an attenuation which prevents any acoustic feedback. In the case of the announcer's mike, which comes on and off with the fader hot, some relay operation had to be achieved, so we did not get the feedback between mike and speaker.

While we still have this slide here, I want to point out the one method of turntable operation. There are some cases, such as the one that we are talking about here, where the speed of playing of records is not great; in other words, almost all records played through the studio are half-hour shows or fifteen-minute shows. Playing the record for fifteen minutes gives the control operator plenty of time to cue up his next record, and the switch-over very simply starts up the other machine and carries on. He has time, and everything runs very lovely. In other words, it is a turntable setup in which the control room operator runs machines.

To attain a cue, we use Daven's recently announced cue attenuator. That, as you perhaps have found out from reading the ads, will turn the fader off when it has gone back to its opposition, then the input fader goes to what is called cue terminals. That is indicated here by this switch. So the opposition circuit comes down through this circuit through an amplifier into the cue speakers. As a result, there are no switches in the program part of the turntable circuit.

Since delayed broadcasts are being played from here and many of the shows are of half-hour lengths, it is necessary for us to have rapid getaway at times between one or two laps of supposedly half-hour shows. To accomplish this, we put a key over the attenuators for these first two machines, which in this position takes the outward.

[Slide] This is a little sequence style of speaker. These two switches indicate the on-off button on the announcer's panel.

The first thing that happens is that it opens up the output on the amplifier circuit. Contacts then pull up RL-1. The third thing that happens through interlocked contacts to RL-3 is that RL-3 pulls up, and the speaker circuit is again broken at this point, although no signal is now going through it. The output is pushed, RL-2 falls out first, and the amplifier then goes over to this point [indicating], does not get into the speaker.

The next operation sequence is that RL-1 falls out and disconnects the microphone preamplifier; and, lastly, RL-3 then closes, and the speaker circuit is complete. This operation takes place quite rapidly. There are no special relays used, such as slow operating, but the delay is sufficient to prevent speaker feedback. Mike 2, which used the mike switch on the back, simply opens into RL-3. When the fader is open, RL-3 pulls up, and the speaker is open, the sequence not being necessary on the next, because of the attenuation left at that time.

[Slide] This is a picture of the microswitches that Daven had on the standard attenuators. We required two mike switches in this case, one which operated the relay, the second one which operated the indicator light of the studio control panel. We could not get enough contact on our relay, so we had to add another mike switch on the back to operate this indicating light.

[Slide] This is a view of the control panel used in KCA control. This fader is the one for Mike 1 to turn on and off in the announcer's hands. Mike 2 has the mike switch on the back and, opening up, the fader fills the studio speaker. Here are the three turntable faders, the cue position with the off position of the faders. This is the key for halfway between TT-1 and TT-2. The other gadgets on the panel are normal for KCA's operation. This switches the lights that operate the master control system.

[Slide] This is a view of the studio as completed. The control panel that you just saw-- These two turntables on this side are the ones used primarily for playing delayed broadcasts. The third is used to put on local spots. The very tip of the announcer's control box can be seen at the top.

[Slide] This now gets us into these two methods of turntable operation of which I just spoke. The first one was the one that you saw of the KCA setup where record playing goes on at a slower pace, but we have running conditions where record playing proceeds at a very rapid rate. This was brought home to us very plainly and clearly with the recent starting of the Paul Whiteman Club show out of New York. Since Paul Whiteman has gone in for disc jockey business, it became necessary to provide special machines to handle his type of program. One man in this case runs the turntables. He is kept so busy cuing up records, taking spots out of this one, taking a spot out of another one, running from 86 to 78 to 33, that it takes all his time to keep these machines in operation. Another operator operates the fader that controls Paul Whiteman's microphone.

In order to make it easy for the operator to accomplish all the things he has to accomplish, we made, first, the addition of this escutcheon, on which is mounted the vertical attenuator, mounted horizontally, and the motor switch. To operate the thing the operator first has to cue the record up, so he starts the machine by clipping his thumb on the switch. The machine starts, and he listens for the cue. He stops the record with his hand and turns off the switch with his thumb, backs up the record, and makes the turns necessary by starting the machine to going on the way. To put the machine on the air there are two ways, a running start by switching the AC switch, or he can start it by holding the record, turning on the AC switch with his thumb, and at the proper time letting go of the record. It works very nicely, either right-hand or left-hand.

Another addition to the turntable is this strange-looking thing you see on the RCA turntable. We had heard quite a bit about the General Electric pickup and had tried several without too great results until this tone arm came along. A salesman from the Research Development Company happened in the office one day and said, "I have a tone arm I would like to show you." It is built with a GE cartridge attached to it, and the Gray people have a filter which is designed for operation. We liked the performance of the setup so much that we have more or less adopted the Raytheon and GE cartridge as standard for playing records in ABC.

Some advantages of this tone arm are its extreme light weight (only about a half ounce of pressure is required to properly play the record); it is very free in movement, very well built; its point of tone arm resonance is below fifteen cycles. As yet we have to find a record that will set the arm in oscillation and cause it to skid across the record. Pressure can be adjusted. The purpose of this is to keep the mass as low as possible and keep its resonance point down.

We have found so far, much to our surprise, that after playing about 100 to 150 shellacked records on a GE cartridge we have to take it out and replace it; it is worn out sufficiently to cause distortion of the records. Up to recently we have been changing these pickups at the rate of one a week.

[Slide] This shows a view of how we mounted the vertical attenuator in the horizontal position. The attenuator is made by Tech Laboratories. It is mounted with a couple of bars. This is the formal operating arm of the attenuator with a little extension shaft pulled up through the plate. We did that so as not to have the rise and fall of the attenuator knob on the outside of the machine. It swings along more or less with the movement of the turntable.

This, you can see here, is peculiar with our operation in NBC studios. The turntable feeds into NBC-controlled equipment, through whose equipment we do most of our operating at present. We require either a minus 32 or minus 16. Minus 16 is for microphone fader inputs; minus 32 is an equal fader input, depending upon where the machine is attached. Say we want a sixteen output. This little arm slides across the opening through which this shaft moves. The shaft comes up at this point, hits the bar, and stops, giving you a minus sixteen. This removes the necessity of the operator's having to move it to a predetermined spot and trying to remember where he is. It moves itself until it stops, which aids the speed of operation.

[Slide] You can see the little button that operates the bar that stops the attenuator.

[Slide] This shows some further modifications made to the RCA turntable. We added an amplifier to the set. The level for pickups has to be brought to at least a minus sixteen. This black box is the filter supplied by the Gray research people. This is a standard RCA builder and RCA switch.

[Slide] This is the rear view of one of our amplifying turntables. Again, characteristic of NBC operation, we supply detectors on the back of the machine for taking audio out of the turntables and converting it into their standard receptacles. The receptacle is for the purpose of operating two of these machines at parallels. The same thing applies to the AC. This little connector on the bottom was intended for remote starting of these turntables. It permits the operator at some remote position to start the machine if he so desires. So far, we have not actually used this, but it is there in case the situation arises. So many situations arise so fast that we try to prevent them as much as possible.

[Slide] This is a block diagram of the turntable layout, RCA pickup, GE pickup, fixed together with couple resistors. We have to put this little step-up transformer on to raise the level just a little more for headphone operation.

[Slide] This is a view of the Paul Whiteman Club setup as played from Studio AD in Radio City, New York. The machines are mounted on dollies, because it is necessary to push the machines out of the way for other programs to take place in the studio.

[Slide] This is the rear view of the turntables, showing the interconnecting cords. The bars that you see across here are quite interesting. These bars can be lifted out, somewhat like the handle on a baby carriage, or locked in place. Pulling these two bars up and locking them in place makes it impossible to take the turntable out the studio door. The way we operate NBC studios, we have to guard our machines. It is quite embarrassing to come into a studio two minutes before air time and find your turntable missing. [Laughter]

[Slide] Paul Whiteman made it necessary for us to use cloth noise depressors. He digs up some of the oldest records you ever heard. The noise level sometimes almost exceeds the peak program, which is true oftentimes of new shellacked records you buy at the corner store. So in order to give the listening public the best possible in the way of electric shows, we obtained two noise depressors. The remote control units for these two spots are in little boxes, and they are within convenient operating reach. These machines give the operator, usually, sufficient control to take care of the worst records that come along. It used to be necessary occasionally for the operator to get up and turn the pressure switch to the C position, but now we find that the extremely crashy records can be eliminated. We find that these noise depressors do a very excellent job in removing the noise. You do hear occasionally the gate circuit operating. It amuses me considerably to hear some of our operating people, some of whom I see sitting in the audience at present, where you are playing a noisy record. The noise is gone; there they sit and listen, hearing that gate circuit working. It is sort of silly, I think, because the main object of the noise has been removed. We find that by operating the gates at a lower level the noise of the gate circuit has been reduced.

While on the subject of noise depressors, several of us recently visited RCA's principal laboratories, and Dr. Olson showed us a noise depressor that he has recently developed and built a small model of. It was designed primarily, I believe, for application on home phonographs for removing noise from records. The thing operates so nicely, is so simple in general construction (it uses no vacuum tubes), that we decided to try the thing out. With the doctor's permission we came back to New York and designed a layout which we turned over to Commercial Radio-Sound, who build most of our audio equipment for us. They built up this unit, which we have tried out in the last week or two. It works quite well.

The basis of operation of Olson's depressor is dependent upon the characteristics of noise on a record. It is quite an established fact that the noise level on a record remains quite constant, regardless of the level of the recorded program. It is generally found that recorded program peaks run from thirty to forty DP above average noise levels.

The second thing that this type of noise depressor is based upon is the characteristics of the germanium crystal. Most conventional curves show only the lineal part of the curve, and for most practical purposes it is a straight line. Very little investigation has been made of the curve in the region where it approaches the axis, but if you will examine the curve down at this point, you will find that it begins to become tangent to the line at about one-half of the input.

[Slide] This curve is probably not just exactly at the point. It does not come down and bend that sharply. If we keep our noise input within this reach, no output will come out of the crystals; the noise is left behind.

Fortunately, though the curve does not concentrate down at this point, it begins to bend up, and program levels of eight to ten lying on this bend of the curve have resulted in considerable distortion as it comes out of the crystal.

Here Doc used his ingenuity and created a filter circuit for removing distortion.

[Slide] This represents the characteristic curve of a pair of germanium crystals for a full wave length. These are signals, which I have represented as noise. They are increased very much at this level. To operate the noise in this region, the input program level comes out as well, then, on this level. We get this peculiar shape of curve due to cutoff in this region and a curve of that nature which, again, is not drawn quite correctly. Such a curve produces many of higher-order harmonics but, regardless of the order of the distortion at present, it must be removed.

[Slide] This is a block diagram of the noise depressor that we had up in New York. A filter of zero to one-half AC, starting on the assumption that there is no noise on the surface of the record below one-half AC-- That is not entirely true. This is one case where the Scott depressor has it over the Olson. Any rumble or noise that might be on the record will be eliminated by Scott's where, on this, it goes on through.

The band-passings were added, duplicate band-passings with each crystal circuit. On a program up to one and a half to three rings pass through this filter, go through the crystal rectifier, and only the harmonic comes out because of the inability of this section of the filter to affect a size higher than 3 AC.

Mention was made on this setup, as indicated, of distortions that are less than 1 per cent, and we hope to get that down further after we have the thing tuned up a bit more. The boy who was working on this went off and got married a week or so ago, and we have to wait until he gets back to adjust it.

These input controls are adjusted until the optimum noise input for best rejection is obtained, then the output controls balance up what comes out of each section of the filter, so you get the best noise rejection for each band and balanced output.

For over-all control, output faders are used, operating at a tangent; one goes up where the other goes up. If you have a record where the noise output goes down the drain through the noise depressor, it remains constant. The setup as shown there has a loss.

For best operation we find that the input level runs between zero and ten DT, that is, in order to get the proper signal.

[Slide] This shows a view of the noise depressor. We have three switches which cut the crystal in and out, substituting in its place a resistor. The object of this is to prove to people that the crystals actually do cut the noise out. They will say, "That is some funny filter action you have there," so we actually flip the crystal out, put the resistor in its place, and the noise comes out.

[Slide] This is a top view of the chassis, using UTC adjustable reactors for simplicity in tuning this particular one up. Once its consonants are all established, we will probably use preset conductors. The radio crystals are mounted on these tubes.

That concludes the slides. There are several applications that I would like to mention that have been suggested for the use of noise depressors in addition to removing noise from records. One is the case of applause mikes in studio audiences. It is oftentimes necessary that the applause mike be turned off while no applause is going on; otherwise, the coughing and rustling around of the people in the audience would be picked up in the circuit.

I cannot think of the other application at the moment, so we will call it quits, because the time is up. Thank you. [Applause]

CHAIRMAN TOWNER: Thank you, Mr. Colvin.

Now we have a very few minutes for a few questions, and I am sure that while Mr. Colvin is here he would be very happy to answer them for you.

MR. CHARLES SINGER [WOR, Milwaukee, Wisconsin]: I want to ask you a question. I presume that that was an ET studio where you had that console of your original prescription.

MR. COLVIN: Yes, that was an ET studio.

MR. SINGER: Where radio stations have investments in small studios, as the art progresses, the manufacturer comes out with a very supersensitive microphone and, as you place these microphones in these small studios, your studios are quite booming. I wonder whether you gave any consideration to the use of dialogue equalizers on your microphone circuits.

MR. COLVIN: We didn't in this particular case; we simply put the mike in there and turned the announcer on.

MR. SINGER: We have tried it in four of our small ET studios.

MR. COLVIN: There are some great advantages to dialogue equalizers, and we have considered the use of them, but as yet we have not gotten around to it.

CHAIRMAN TOWNER: Have you thought of that other application yet that you might add to your speech?

MR. COLVIN: I cannot; my paper is gone.

MR. BOOKWALTER [KON]: This might be a little off the track. How about grounding one side of the lines? You do not run very far with the ground at one side, do you?

MR. COLVIN: That is a very controversial point of discussion, not only among broadcast companies but even our own organization. We argue for ourselves as to whether we should operate unbalanced or balanced. I was brought up primarily in the balanced school. Perhaps I cannot give you greatly valid reasons why, but so far I have gotten into very little trouble by using balanced circuits. Most of the troubles I ever had I got from working with unbalanced circuits. That is not always true, because there are plenty of unbalanced circuits operating very well today.

Incidentally, this console uses unbalanced circuits in it. We have no great trouble as a result, but I prefer to keep balanced.

MR. BOOKWALTER: You mentioned trying to get away from relays. Has anyone tried any of these vacuum-type relays? After all, I want somebody to experiment for me. Has anyone tried it out yet?

MR. COLVIN: We had a little attempt at it when I was in RCA out in Indianapolis, but the general construction of the type of relays that you get is so weak and wobbly that we hesitate to use them. There may have been recent advances in design over the ones we tried out there. I have found that if you take a good, rugged relay, you will probably have no trouble over a long period of time. They are self-cleaning contacts. Unless you are in the region where the moisture runs high, you should not have any trouble.

MR. SINGER: I merely want to substantiate what you said about unbalanced. For those who are interested in going into FM I strongly recommend that you do not go into unbalanced, because if you are up on top of a building four or five hundred feet high, you do not have any ground. You will spend weeks at it, so I recommend that you do not do it.

MR. PHILLIPS: There seems to be a tendency to get away from the use of cotton braid over shields for audio; is that true?

MR. COLVIN: I would not say so. It just depends on what you mean when you say "cotton braid." Insulation primarily over the metallic braid might be cotton or rubber or some of these others. In low-level circuits in microphone levels I believe it is very advisable to run them in with insulation over the shield. It has been done without the insulation over the shield, probably due to the fact that everything remained quite steady and without any vibration, but on low-level circuits I would always advise using the insulated shield.

CHAIRMAN TOWNER: Thank you, Mr. Colvin.

Now we have the very great privilege of hearing from our President, Judge Justin Miller, who will officially greet us. [Applause]

MR. JUSTIN MILLER [President, National Association of Broadcasters]: Mr. Chairman, I am very happy to be with you this morning. I have not been going to most of these clinics, but I felt a particular obligation to the engineers, especially because NAB may seem to have been neglecting you during the last couple of years preceding this one.

I think you will agree with me that we have taken the first strong steps toward the revitalization of our engineering department. We have found you a man, in whom you can have as great confidence as have I, to direct the operation.

Doc Howard's path and mine have crossed in strange ways across the years. Now we are together on the same team. He is a man of fine experience, fine imagination. He knows how to fit the specialty of engineering into the larger picture, integrate it, emphasize it, and make all of us realize its importance in the over-all.

As a matter of fact, I have always been inclined to regard you folks more or less as the gods of the machine. I confess that if there is anything I do not know about in broadcasting, it is engineering.

I am accustomed to speaking of the mystery of professions. We lawyers have a mystery. As you know, some of us like too much to hide behind it. The $64 words of the law are almost as bad as the $64 words of engineering. I have always had a desire, as a lawyer talking to nonlawyers, to help them get away from the mystery and bring it back to a common-sense basis. Doc has very much the same disposition, and he has been giving me a liberal education during the last few months.

I think it is very important that we get rid of the mystery which has enveloped this business, this industry, this profession so much, that we make the broadcasters realize just how important your work is, not only on the democratic level but on the international level. Most of the broadcasters, especially on the management and ownership level, have almost no appreciation of the significance of the engineering problems on the international level.

Of course, you can leave them that way if you want to, but it seems to me that it would be much wiser to needle them into understanding, even for their own good, their own protection.

Certainly it is not necessary to emphasize the importance of this subject at a time like this, when the ITC high frequency conferences are in operation here. One cannot sit in the sessions of those meetings with the distinguished representatives of all the nations of the world and hear their discussions without realizing how significant and how important that international background is. If we are going to play an intelligent and useful part in it, we must know something about it. Some of the legal phases of it the others are prepared to handle. The more difficult phases, perhaps the more important phases, are on the level on which you work.

I am going to talk about the subject to some extent in my address tomorrow, trying to get a greater understanding and appreciation. I hope that both here and at home you will go to work, if you have not already done so, on management and ownership and impress them with the importance of it, so that we can get the kind of backing, the kind of understanding, that we should have in the engineering area.

It is a very great pleasure to welcome you; it is a great pleasure to see some of the representatives of the other countries here. I hope that you are having a good session. I hope that the rest of your meeting will be equally successful.

Although you have been working with Doc for some time, let me present him to you officially as the new representative of NAB and our diplomatic emissary. [Applause]

CHAIRMAN TOWNER: Thank you, Judge Miller.

We will now adjourn this session until two o'clock, when we will resume and pick up the papers that we did not have time for this morning.

[The Conference adjourned at twelve-five o'clock.]

MONDAY AFTERNOON SESSION

The Conference reconvened at two-fifteen o'clock, Mr. Royal V. Howard, Director of Engineering, National Association of Broadcasters, presiding.

CHAIRMAN HOWARD: The meeting will please come to order.

Our first speaker, Mr. G. Porter Houston, Chief Engineer of WCBM at Baltimore, will discuss "Transmitter Maintenance for the Small and Medium-sized Stations." Mr. Houston! [Applause]

MR. G. PORTER HOUSTON [Chief Engineer, WCBM, Baltimore, Maryland]: Of the several approaches to maintenance, there seem to be two that would have special application to small stations. First, I could give the details of "do this" and "do that," including characteristic troubles and remedies. Secondly, I could describe basic maintenance methods, emphasizing those parts that apply particularly to the small station. Since there are now many different types of small stations, and since detailed do's and dont's could, therefore, become quite voluminous, and since most small-station men move on to the larger stations, I propose to describe a basic maintenance philosophy, giving as much detail as possible in the limited time allotted to this paper.

At this point I will define the word "maintenance" in the sense in which it is used in this discussion.

Maintenance is considered any duty, operation, or task that is necessary or aids in keeping the equipment functioning at optimum performance. Maintenance of the station, then, can be divided into three major parts:

(1) Operation, which is maintenance of the station while on the air.

(2) Preventive maintenance, which is work done while the station is off the air.

(3) Trouble-shooting, which is the analysis of an abnormal indication for preventive maintenance or maintenance of the station that is off the air due to breakdown or the necessity of an unusual adjustment.

These three parts are not independent and disassociated; on the contrary, they are closely dependent, one upon the other, for the best and continued functioning of the station. The purpose of this paper is to show the intimate connection between these three and to assign to each the proper value.

Part (1) is operation, on-the-air maintenance. In operation I want to emphasize the importance of proper starting, the importance of keeping a log, and the importance of proper stopping. Assuming that the station has been correctly installed and is in good operating condition, the proper starting procedure, with an accurate observation of the indications while so doing, assures the engineer that his station is in perfect operating condition. This means much more than simply pushing a button, then at some future date haphazardly reading a few meters. The sequence of operations is most important to the correct starting of the station.

Correct starting sequence, with indications, is usually given by the manufacturer, or it should be determined at the time of installation by the engineer. Briefly, a button is pushed or a switch is thrown; a meter, or a few meters, will be read; a relay kicks in; some tubes light; perhaps a transformer hums; all of these things will occur if they are normal indications, and should occur every time the transmitter is started. Later another relay drops in or another switch is thrown and some more meters are read, and so on, until the entire transmitter is in operation.

Indications are principally visual and audible; meter readings, relay clicks, glowing filaments, transformer hums, are all indications of operation. Each transmitter has its own unique combination of these indications. Failure of one of these indications to occur in the predetermined sequence and in the required quantity indicates trouble, and this abnormal indication (nonnormal) always indicates the circuit and, generally, the exact location of the trouble. If all of the switches and buttons and knobs associated and used for starting are operated in the proper sequence and the normal indications after each operation are observed in turn, it follows that the transmitter must be in normal and correct operating condition. I will have more to say about this starting sequence later on.

[Slide] A short time after starting the transmitter it is advisable that a log be made of all meters and all important indications associated with the transmitter and thereafter, once every two hours if possible, to record again all meters and normal indications, repeating up until closing time. If this cannot be done every two hours, at least three times during the operating period this recording of all meters should be made. This is to obtain a record of the cold starting conditions in the transmitter, the warm running conditions, and the conditions that continue to the end of the day.

[Slide] This log, of course, is for maintenance purposes and does not consider transmitter readings required by the FCC every half hour. In some stations all meters are read every half hour, and in these stations a separate FCC log will not have to be kept.

This log will, if the suggested readings are made, show as a minimum the starting conditions, normal hot running conditions, and conditions at the time of closing down. Any appreciable changes in the meter readings or other abnormal indications should be regarded with suspicion, unless it has been determined through experience that some meters do operate within narrow limits due to changes in temperature or changes in line voltage during the day. Deviations from the normal indications show that a change has taken place within the transmitter, that a tube is losing its emission, that a condenser is overheating, et cetera. These abnormal indications, when noted, are subject for immediate investigation and remedy after closing down and then become a part of preventive maintenance.

As distinguished from the short interval changes just discussed are the long interval changes, changes which take place over a considerably longer period of time, such as one month, two months, or six months, or longer. To readily detect these, it is advised that at some period during the day, say at noon, a series of readings of all meters and all indications be made and entered on a log sheet and that every day at the same time a similar series of readings be entered on this log sheet so that by the time the sheet is filled you will have a record of perhaps a complete month's operations on the one sheet. In practice this means merely copying the regular readings at one predetermined time on the same kind of a sheet used for the daily readings so that this one particular sheet contains twenty or thirty readings, one reading for each day. Then, with the whole month's readings before you, it is easy to observe if any reading has changed in the month, and so on for the successive months.

Again, significant changes in readings indicate an aging tube or other impending troubles and, again, provide special subjects for preventive maintenance. These methods of observing short and long interval changes enable the operator to predict impending failures, and prompt correction avoids breakdowns. Thus it can be seen that the conscientious keeping of the log while in operation is the first, and probably most important, step toward preventive maintenance.

In stopping the transmitter, as in starting, the transmitter should be closed down in a predetermined sequence. This need not necessarily be the reverse of starting but should be a sequence that will give the most in number or the most significant indications, indications that the transmitter is still functioning normally. As in starting, abnormal indications should be analyzed and referred to Part (2), Preventive Maintenance, for correction immediately upon shutdown.

Preventive maintenance is work done while off the air. Duties performed in preventive maintenance come in two major groups: (1) those duties demanded by the abnormal indications while in operation, and (2) those duties that are a part of the basic inspection routine. The preventive maintenance duties demanded by abnormal operation should be obvious; therefore, I will pass on to the basic inspection routines.

[Slide] These preventive procedures have been described in detail by Charles A. Singer in his articles on preventive maintenance published in <u>Communications</u> in June, July, August, September, October, and December of 1946, to which I refer you for the complete preventive maintenance procedures. Mr. Alfred E. Towne will discuss in detail preventive maintenance for the medium-sized station.

[Slide] I have time to outline only briefly these procedures and their application to the small station. They are: feel, inspect, tighten, clean, adjust, lubricate, and measure, the first letters making the easily remembered word "fitcalm."

[Slide] Feel generally for heat; heat always indicates losses. Abnormal heat in a condenser shows an overloaded or aging and failing condenser; in transformers, motors, contacts, lugs, terminals, any heat or abnormal heat predicts future failure. Lugs, terminals, and contacts should be cool; condensers, transformers, and motors generally warm, but not too warm, so that you cannot keep your hand on them. This may apply to resistors, but be careful of a burn; some resistors normally run at quite high temperatures.

[Slide] Inspect for cleanliness; inspect insulation; inspect for dirt, rust, corrosion; inspect connections and terminals for tightness and contacts for pitting, et cetera. This is a general visual inspection of the transmitter.

Tighten terminals, switch contacts, mountings, screws, fan blades, couplings, shields.

Clean terminals, clean contacts, blow out the dirt, clean out rust or corrosion, clean where filters are used, clean insulators and high-voltage conductors and insulation associated therewith. Clean brush holders on motors, if any.

Adjust coupling, relays, safety gaps, bias voltages, filament voltages, in fact, any adjustment in which the standards are incorporated in the transmitter.

Lubricate fan motors, dashpots, bearings, contacts, hinges, locks, et cetera.

Measure implies the use of external standards, such as meters, gauges, or other measuring equipment. This operation includes the adjustments of filament voltages where an external meter is required to measure the voltage. Such measurements as frequency runs, noise, distortion, modulation, and frequency measurements are typical of this group.

All of these procedures apply to the small station and should be performed at regular intervals. I would like to call attention to the "feel" procedure, which may be neglected by the small-station operator. Condensers wear out; so do contacts. Lugs and terminals sometimes become loose. A heat test by feeling generally reveals these abnormalities long before they become serious, particularly in the case of condensers carrying radio frequencies. The "feel" test will nearly always reveal an overloaded transformer. These routine inspections should be made as frequently as possible, always as soon following close-down as practicable, and especially for the heat measurement, and in any case not less than once per week. It is my belief from my experience and observations of others that routine preventive maintenance for the small 250-watt station requires approximately three to five hours per week.

A modulation monitor is very handy for making frequency runs on the transmitter where the operator has an audio oscillator available. As a suggestion in making frequency runs, adjust the percentage of modulation to 50 or 60 per cent modulation rather than close to 100 per cent modulation. The modulation monitor also indicates excessive distortion when no other means are available. Apply a tone (sine wave) to the transmitter and adjust to 50, 80, and 95 per cent modulation, checking positive and negative peaks. Excessive peak unbalance indicates excessive distortion or poor rectifier regulation. Experience with a particular transmitter will indicate the amount of unbalance that could be considered normal, but any unbalance greater than 10 per cent should be regarded with suspicion.

In Class B audio modulated transmitters one modulator tube makes the positive peaks and one modulator tube makes the negative peaks. The modulation monitor, therefore, is a quick check on the goodness of each of these two tubes. They should be frequently checked in daily operation; this is a flash-back to operations and the log sheet. Excessive modulation peak unbalance will indicate that one or the other of the modulator tubes is failing, with a consequent increase in distortion. In grid modulated transmitters an unbalance in the positive and negative peaks usually indicates incorrect bias or incorrect excitation adjustments in the modulated stage, generally the final stage, and indicates distortion and a need for adjustments. I suggest that every engineer examine his transmitter in this respect and mark the positive and negative modulator tubes or determine the limits of bias and excitation.

Part 3, Trouble-Shooting and Repair, is analysis or maintenance of the transmitter when it is broken down, maintenance with the idea of returning it to a normal operating condition or restoring service. Without spending time in the history of the development of this method of trouble-shooting, permit me to say that a man need not be a natural-born trouble-shooter; trouble-shooters can be trained.

[Slide] This trouble-shooting is based on a logical analysis of the circuits involved and antiquates trial-and-error methods, the hit-and-miss methods. It is a characteristic of this method that 90 per cent of all trouble-shooting is done in advance of any trouble, leaving only 10 per cent to be done at the time the trouble becomes apparent. At your leisure you may ponder on the timesaving advantages in a critical situation.

This trouble-shooting system is based on the start-stop procedure, and herein lies its direct connection with the start procedure in operation. The starting steps are identical. The indications are identical. The abnormal indications (nonnormal indications) identify immediately the group, component, or unit of the equipment that is defective or in misadjustment. The corrective measure follows immediately.

[Slide] The manufacturer installs various push buttons, switches, and controls used to start operation, control, and eventually stop the equipment. Each switch or control commands or regulates a limited group of components. For example, in a small transmitter the starting switch operates a line relay which turns on all filaments, all bias voltages, and the plate supply to the crystal oscillators. The indications are that a relay clicks, some transformers hum a little, and line-voltage meters, crystal plate voltage meters, crystal current meters indicate, and meter dial lights come on. Cause of failure of a tube filament to light is simple. It is the tube or a very small section of wiring; failure of a group of filaments to light is due to a transformer or fuse; also, failure of a line meter to indicate is due to the failure of a fuse or the AC; failure of a plate-voltage meter to indicate is due to failure of a rectifier or the plate-voltage supply group; or the lack of crystal current is due to the failure of the tube or some small component in the oscillator circuit or of the crystal. Remedies are obvious.

The next switch throws on the plate supply to all tubes, and the rest of the meters come into operation and should indicate normally. Abnormal indication of any meter directs the engineer's attention immediately to that particular circuit which is comprised of only one or three, or perhaps five, components. They are not unlimited. All filament circuits, the crystal oscillator, the bias, and crystal-plate voltage were tested and proven by the normal indications at the time the first switch was thrown; there is no need to repeat that.

Thus it can be seen that an abnormal indication in a properly chosen sequential starting system immediately directs the operator's attention to a very limited group of components or to an individual component. There is no need to go further. Other circuits have been previously tested or have not yet been called into use. The trouble lies only in the group of equipment associated with this step.

[Slide] How do we utilize these facts? [Laughter] We make up a start-stop procedure. Step 1, give the first operation, throw a switch. Associated with that action are a number of normal indications. If they are normal, the set is normal and we proceed. However, in Column 4 we put down the abnormal indication for each normal indication. For a meter reading of 115 volts as normal we would put high voltage, low voltage, no voltage for the abnormals. There are three groups of troubles that could cause these three abnormals. There may be an incorrect setting of the voltage control or incorrect line voltage or a burned out fuse, unthrown switch, or complete lack of voltage. That is all.

For each normal indication there may be one or more abnormal indications associated therewith for a small group of components. Those abnormal indications, then, directly direct your attention to the component that is causing the trouble.

Switch 416 goes on; the line-voltage meter should read 115 volts. You have no volt meter to read. If the meter was low, it would have to be the switch or the fact that the AC was low; it cannot be anything else. If the meter is high, it must be Switch No. 449, which is probably not going around to the right contact; or it may be the fact that the AC is too high, nothing else.

If the panel lights come on and one light is off, the light is the trouble, or the socket, or maybe the bearing. If both lights are off, you analyze it as a single trouble. All of your troubles associated with your start-stop trouble-shooting are single troubles. You analyze your abnormal indications for any single component's failure. You neglect all duplicate failures. For instance, you might say that a plate-coupling condenser would burn out and take the resistor with it. That is not necessary. You would have that analysis. When you fixed that trouble you would still have a nonnormal indication which would direct you immediately to the abnormal.

For each normal indication there are one or more abnormal indications associated, which you analyze for your single troubles.

The total number of steps in starting a transmitter are very limited. You combine with those calibrating steps in this case the line voltage onto the transmitter. If anything went wrong, there is where it would have to be. Then you would adjust your voltage; then you would push your start switch on. Your relay clicks in; your tube filaments come on; your crystal voltages show. These are the only troubles associated with that.

Therefore, you are able to analyze and put on perhaps three or four sheets of paper any trouble that could happen to your transmitter. If you will insist that there is one trouble that I could not cover, I will accept that and say, "Well, put that one trouble down at the bottom of your analysis." That is the only thing that it can cover, but you can cover every trouble in your transmitter by this analysis. If there are two or three that I have missed, OK; I will still accept them. It is short and it is quick, and if you do this analysis ahead of time, if in starting your transmitter the nonnormal indication shows up, you have your abnormal immediately, and here is the trouble. You do not have to call out your circuit diagrams and sit down and pour over them. You have already done that, or maybe it has already been done for you. That saves time.

I suggest that each engineer examine carefully each step in starting his transmitter, note all the visual and audible indications, determine the abnormals and the causes therefor, and the corrective measures. If these are arranged in chart form in columns with the starting steps and perhaps calibrating steps, which generally need not be more than five or ten steps, 90 per cent of all trouble-shooting in the transmitter has been done. In case of trouble, that is, failure in operation where the trouble is not immediately obvious, it is recommended that the engineer close down his transmitter completely and restart, observing all indications. At some step some abnormal should immediately indicate the cause of the failure. To keep the transmitter on and running with trouble in it does not do it any good, and it is not going to help you if you are just standing there guessing.

This is a logical analysis of service and equipment; it is not based on signal tracing through the circuits or on family trees of troubles or on characteristic troubles. It is a circuit analysis. The analysis is based on, first, the fact that the transmitter is always divided into sections by the manufacturer, which enables you to isolate some group of it and test it by the indications that the manufacturer has generally provided. This analysis is built up on the basis of a starting sequence, a stop-start procedure.

Lack of time prevents further detail on precise methods, and so forth, but the fundamental ideas expressed here should stimulate the individual engineer to examine and analyze his equipment now and determine his procedure so that, in the event of trouble, most of the work is already done.

[Slide] A word about indicators and indications. Indications are normally visual and audible, such as meter readings, dial lamps, tube filaments, and relay clicks, and hums. In later stages grid currents may also indicate the presence of radio frequency at that stage and the correct operation of preceding stages, as far as radio frequency is concerned, but manufacturers are prone to neglect the inclusion of radio frequency indicating elements.

A simple, inexpensive, and effective radio frequency indicator is suggested at this point. The single loop of wire connected to a very small flashlight bulb is an effective indicator of radio frequency current. A bulb that operates at one volt at a quarter of an amp only draws a quarter of a watt. You can stick it almost any place in the transmitter without disturbing you, and you have an instant check of radio frequency in that circuit. It can be used in any except the smallest circuit. I submit it for your information.

You could use them within shields and might find it convenient just to leave them in the transmitter. Within shields you can put them behind a hole drilled in the shield.

I have endeavored to show that maintenance can be considered the placing of the transmitter on the air, keeping it operating at peak efficiency while on the air, predicting failures before they occur; that it embraces routine inspection and corrections; and that it involves quick and accurate analysis of trouble to the end that the transmitter may deliver the maximum of service with a minimum of trouble to the engineer.

I would like to summarize very briefly. So many people have been afraid of preventing trouble through maintenance. I have injected a little humor, or attempted to at least, in the talk, but this is a very serious talk, and I am very serious about maintenance. It is neglected too much, I am afraid. It is sometimes considered a necessary evil, but it is not an evil any more than the little chores that we have to do in our daily life, like combing our hair or brushing our teeth. They are chores too, but remember that that transmitter operates all day and far into the night to maintain your job and maybe the jobs of forty others, furnishing entertainment to many thousands of people. If you treat it with just a little respect and give it a little attention occasionally, you will get a lot of service out of it. If you neglect it, some day it will let you down.

Maintenance is not necessarily just a tough, laborious job, something to be neglected or shirked. Maintenance implies a constant awareness of the transmitter at all times, a constant awareness of the transmitter. I would like to impress that upon you.

I did not mean to put on this mammy talk, but I am very much interested in maintenance and am prejudiced, because my transmitter gives me very good service.

In summing up, maintenance is much simpler than it may seem. You have only to prepare your start-stop procedure and analysis. Thereafter, it is merely a matter of keeping the log and doing the maintenance work. The log requires approximately five minutes; filled in every half hour, it will only consume ten minutes of any hour, perhaps three hours' work in an eighteen-hour day. With the maintenance of only three to five hours per week added to the log time, it is a very small amount of time to devote to keeping the station operating efficiently.

Thank you, gentlemen. [Applause]

CHAIRMAN HOWARD: I am exceedingly surprised and was quite unaware of the need for good maintenance. I think we owe a vote of thanks to Charlie Shields for those slides.

The second part of the maintenance panel will bring to the lectern here Mr. Alfred E. Towne of San Francisco. I will not waste any more of his valuable time by giving him further introduction, for, like the other speakers, his complete, should I say, obituary, after years in the broadcasting business, is in the complete schedule that was distributed this morning. Mr. Alfred E. Towne! [Applause]

MR. ALFRED E. TOWNE [Director of Engineering, KSFO, San Francisco, California]: Mr. Chairman, Gentlemen: If Mr. Howard thinks I have been withholding any trade secrets, he is determined to have them revealed at this time.

I shall now continue with the next portion of transmitter maintenance. Station managers call maintenance by one name or another, and they are not always fine names. Engineers call it a necessary evil and, sometimes, a headache. However, maintenance is certainly not a glamorous part of radio broadcasting; nonetheless, its importance cannot be overstressed. It shall be my endeavor to point out some of the procedures of effective transmitter maintenance applicable to the medium power transmitter and to outline actual practices in current use at a typical station.

Greatest reliability of transmitter performance can be attained only when a definite routine system is followed. In my experience, a simple check chart record has proven most beneficial. This consists of the use of printed forms earmarking various pieces of equipment for weekly, monthly, and yearly attention. Columns and spaces are provided for dating and checking at the times of execution.

I would like to have the first slide now. I will try to point out how this has been attained.

[Slide] This is not for reading detail. I merely want to show here how the items can be listed in columns, then other columns provided for dating and checking as to time specification.

These items can be again broken down in greater detail, listing specific equipment by part number for a specific transmitter. The placing of a check mark indicates that a particular item has been thoroughly checked. Any irregularity can be noted at the bottom of the chart. It is important, of course, that personnel charged with maintenance duties be given detailed instructions. Equipment requiring weekly servicing will depend upon the particular transmitter involved. In all cases, however, the periodic frequency of maintenance can be best determined by experience.

Now I would like the next slide; I think we will get greater detail of these items.

[Slide] Commencing with Item 1, may I state that a hasty inspection can prevent possible relay failure. Manual operation will usually reveal any mechanical defects.

Item 2, checking of the condenser protective fuses, is something that applies to some stations in particular where they have been provided for. A simple continuity check placed across the fuse, and usually a protective resistor, will reveal if there has been any condenser failures.

Item 3 is very important, in my estimation, and can be easily checked. Certain artificial means can usually be contrived to create overloads on both AC and DC circuits.

Item 4 requires certain test equipment. I think Mr. Houston dwelled at pretty good length on this particular item, but I think it is very important in revealing long-time tendencies toward any failure of components.

Item 5 refers to a particular switch and may not apply to all stations. However, it can be easily operated by some other automatic device, and it is very important that this be kept in proper operation.

Items 6 and 7, I think, are self-explanatory. They are the normal duties which all station maintenance men are required to do.

Item 8, failure to clean the water coils, is something that will vary with the station also. However, where water coils are composed of sections and assembled by means of clamps and gaskets, it is very important that they be inspected regularly, that all clamping nuts and bolts be checked.

Take the next slide, and we will pick up Item 9.

[Slide] Item 9, running of the stand-by engine, of course, does not apply to normal stations. However, where they have been installed, it is very important that this piece of machinery be checked regularly for normal operation at full load. I would suggest at least ten or fifteen minutes of operation to determine the kind of operation.

The remaining items, 10 to 15, are small items and, I believe, also self-explanatory. However, I believe that in presenting them in form it emphasizes the importance of maintenance and provides an easily followed record for proper emphasis.

Now we shall come to those items requiring monthly attention. I would now like the next slide.

[Slide] Here, again, our reading details are not too clear. I shall pass onto the next slide to get our detail.

[Slide] Item 1, polish and check adjustments of all small relays, and Item 2, polish contacts on all contactors and switches, including tower-light contactor, probably require the greatest attention of all equipment involved in the transmitter. With small relays of the telephone variety, little attention is called for. Once properly adjusted and protected from dust, they have been known to perform satisfactorily for years without adjustment. Other relays require servicing, depending on the current being handled by particular contacts. Inspection will quickly reveal the need for care. Only crocus cloth should be employed on small relay contacts, as the actual plating is rather thin. After contacts are polished, they should always be wiped with a cloth or canvas to remove pumice grains. Large contacts employed on contactors eventually become pitted and burned. Though they will take considerable punishment before failure is threatened, it is no excuse for neglect. These contacts may require the use of a fine-cut file or sandpaper, followed by crow's cloth polishing. If contacts become misshaped, they should be replaced. Where multifinger contacts are used, they should be adjusted so that they make or break simultaneously. The correct spacing when open should be maintained. Large contactors often develop annoying hum. The proper cure for this is grinding of the pole pieces to a smooth fit.

Item 3 here requires the placing of all tubes, except water-cooled, in the transmitter for a short test.

Item 4 may receive different treatment at some stations, but monthly checks are satisfactory for most. Stations using two crystals, that is, a regular and a spare, of course, are afforded a convenient means for checking against the monitor.

Item 5 calls for serious concentration. All connections should be examined for mechanical strength where possible.

Item 6 calls for a good grade of oil and some discretion as to the quantity to use. Over-oiling can also cause failures where dust may accumulate.

Item 9 is another time-consuming process but very important. I suggest that all nuts and screws not be overtightened but merely checked to see if they are tight and secure.

Item 10 will reveal defects, depending on local conditions. Some water-cooling systems become defective from electrolysis; others are quite free from it. Check inspection and maintenance on that item.

The next slide will show Item 11 a little better.

[Slide] All tubes should be checked for corrosion and effects from temperature. Rectifier tubes are especially bad, because the temperature is developed at the base of the tube. Small rectifier tubes, where they are used in the socket at the bottom of the contact, are the greatest offenders.

I think Item 12 is a simple item but something you should check on occasionally. Spark cap balls should be checked for any obstruction and also for spacing.

I think Items 12 through 18 are more or less self-explanatory.

Finally, we must designate certain things for approximate yearly attention. I say "approximate" because tower lights, for example, do not have regular habits. Figure 3 shows a sample of items in this category. I would like briefly to point out the mechanics involved in these. Let me have the next slide now.

[Slide] This is called Figure 3. These items, though they are few in number, nevertheless require serious attention. The repacking of water-pump motor bearings and stuffing boxes requires considerable care, especially where high-speed motors are utilized. The old grease from bearings should be forced out through the relief hole while the motor is running by the application of a grease gun on the fitting, then allowed to operate for a time before the relief plug is replaced.

Replacing distilled water is something that will vary with the installation somewhat, depending on the extent of electrolytic action, but in all installations it should be replaced yearly. The reading of the leakage meter can usually be relied upon to supply this information. It is important that strainers and the storage tank be well cleaned when the system is drained.

Transformer oil in the medium-sized station is not such a problem as far as tests are concerned. I would suggest that tests be made, maybe over a period of a year, to determine the rate of moisture and absorption. However, I think, in general, where only thirty or forty gallons are involved, it is more economic to replace the oil yearly rather than to make regular tests.

Tower lights should be replaced when failure occurs of one lamp or on a regular basis, if that has been established, as at some stations.

It is a good practice to replace all fuses after a year's operation, since they are a small-cost item. Fuses seem to age and have been known to fail when the operating load was not excessive.

As for tools, a few items are worthy of mention. A crow's cloth stick can be very useful and is easily constructed by cementing a strip of the cloth to both sides of a narrow thin paddle. Sandpaper sticks can be made in a similar manner with varying grades of abrasive. A canvas stick should be used for final contact polishing. In congested surroundings a dentist's mirror is of considerable aid. Some form of air blower is essential, though it be only a vacuum cleaner for dust removal. Compressed air blasts should never be used at close range on more delicate parts. Two sizes of camel hair cleaning brushes are always in demand for reaching more inaccessible places where dust accumulates. Care is the byword, however, in order to avoid springing of relay contacts or breaking of wires. Flashlights and test lamps are, of course, required assistants. It goes without saying that all tools should be neatly stored and readily accessible.

I would like to pass on to the subject of lubricants and solvents for a moment. Some thought should be given to the proper use of lubricants and the proper kind. For motors provided with oil cups, special motor oil is recommended. Ball bearings require a special high-speed grease. Switch blades and rotary contacts carrying considerable current perform well when vaseline is employed.

The use of solvents for cleaning purposes requires good judgment. For example, carbon tetrachloride is not recommended where high insulation qualities are involved, as it leaves a film which is conductive. Where greasy or oily surfaces are encountered, carbon tetrachloride may be used, provided a dry soft cloth is used for final wiping. Soap and warm water has been found an effective solvent when parts are accessible, provided they are rendered dry. Tube envelopes and glazed surfaces are typical examples.

The care of large tubes is a very important duty. Tube conditioners are the ultimate to be desired but usually not available to the average station. The next recourse is their periodic use in the transmitter. Spare air-cooled tubes should be rotated periodically, not more than two months. Water-cooled tubes, like some relays, can be handled too much. This is especially true as they age, as parts become brittle. I believe the rotation schedule for water-cooled tubes should be approximately three months. When first placed in the socket, normal filament voltage only should be applied for from thirty to sixty minutes to aid in degassing. Where reduced-plate voltage is available, it should be utilized on first test. When tubes are used for 10,000 hours and more, considerable scale may form on the anode, causing decreased cooling efficiency and increased internal temperatures. It is my opinion that if care is practiced, this scale should be removed by use of some sort of scraper, while the tube is held in an upright position. Large air-cooled tubes of the radiator type require cooling surfaces to be free of dust accumulation for efficient operation. This dictates the use of filtered air intake or frequent blowing out. Rectifier tubes should also be rotated periodically and always stored in an upright position.

I would like now to return to some operating factors. If we may have the next slide, I will say something about further records.

[Slide] This outlines a filing system, more or less. It is a large column of data designating certain items on which records should be kept.

"Carrier and Program Time" sets forth the actual daily, weekly, and monthly time of operation, including the sign-on and sign-off times.

"Failures" record the time the carrier or program is broken and restored, including a brief explanation of the failure.

"Tubes in Service," which will be shown in detail on another slide, is a complete record of all tubes in use. Tubes are listed by type, position, serial number, and hours of service with each month's ending. When a tube failure occurs, the date and hour meter reading is recorded in the corresponding space. Sufficient space is provided to allow for future tube replacements.

"Tube Changes" lists the type of tube, serial number, hours of operation, and remarks as to disposition of the old tube, serial number and hours of life of the replacing tube.

"Spare Tubes" is a monthly accounting of all tubes by types, showing quantity on hand, received, and placed in service.

"Tubes Received" lists the type of tube, serial number, date received and tested, and remarks as to condition.

Under "Miscellaneous Records" should appear items such as (1) oil sample tests and (2) equipment orders and deliveries.

This concise record serves well to relate various operations and present an over-all picture of performance.

As the broadcasting art progresses, maintenance is constantly being made less burdensome. The more or less sealing of equipment units and use of filtered air has contributed much to this cause. Manufacturers have made considerable effort to engineer transmitters for minimum maintenance. The placement of components has received considerable attention. It is hoped that this work can be further perfected. Thank you. [Applause]

CHAIRMAN HOWARD: That type of check chart lubrication, I think, will save a lot of us a lot of headaches all the way through and applies to all sizes of transmitters, not just the 250-kilowatt. It applies to everything, AM and FM.

We are now on the schedule at eleven-fifty, and I do not know whether to let you out for coughing now-- I think we will go on.

We have come now to the third part of this symposium and one that is very important, one that has not been with us always. The AM broadcast structure, that is, as it now is constituted, employs directional antenna arrays through a vast area. This service must be protected and these stations must operate as they were assigned. Therefore, I believe it is most pertinent that we should include in this symposium on maintenance a talk by Mr. Dixie McKey, consulting engineer, of Washington.

Mr. McKey has had vast experience. He built one antenna out in Oklahoma, the Franklin antenna, with an FM antenna on top of that, put two additional short antennas in direct proportion, and I doubt if anyone could find anything more difficult to adjust and make come out right than that. Therefore, Mr. McKey speaks with authority. Mr. McKey!

MR. DIXIE B. McKEY [Consulting Radio Engineer, Washington, D. C.]: Mr. Howard, Ladies and Gentlemen: The great increase in the number of standard band broadcast stations employing complex multi-element arrays presents a new series of maintenance problems for the station engineering personnel. While these problems may be new, they can and should be handled by established scheduled routine tests. The radio engineer, in attempting to plan methods whereby his plant will operate in as orderly a manner as possible, very definitely has the job of applying science to a practical business and, in fulfilling it, shoulders the responsibility of bringing the results of technical achievement and business together.

Prior to the war regular scheduled operating maintenance routines were a well-established practice in a number of our larger broadcast stations. These routines varied considerably from a visual equipment inspection after cleaning to elaborate tests designed to furnish recorded data that would permit the station engineer to anticipate failures and remove questionable equipment. These routines paid dividends in two ways: first, they reduced lost program time due to equipment failure to a minimum; and, secondly, they familiarized the operating personnel with the location and functions of the individual apparatus units, which they would have been unable to acquire during the regular operating period.

Their worth is not debatable, and the long record of uninterrupted program operation of radio broadcast stations using these routine maintenance practices represents a dollar value far in excess of the small maintenance costs.

My constant reference to the cost of a maintenance routine is due to the fact that the suggestions and recommendations that follow will increase the station's yearly operating cost, as such maintenance cannot be handled on a part-time catch-as-catch-can basis but will require intelligent use of both personnel and equipment. You gentlemen individually have the responsibility of operating and maintaining equipment valued at many thousands of dollars. This represents a considerable portion of your station's capital investment, and to this must be added the revenue which will result from the successful technical and business operation of your station. Certainly these values will justify the expenditure of a very small percentage of their total as a form of insurance for both the capital and the revenue. Naturally, even the best maintenance cannot completely eliminate program failure, but it can, however, reduce their number to such an extent that the often-heard "due to circumstances beyond our control" truthfully describes the situation.

With the addition of a multi-element directional antenna the necessity for regular routine maintenance is increased considerably, both for the purpose of providing continuity of program operation and of providing a method for maintaining the operation of the array, within the limits specified by the Federal Communications Commission and established in the original proof of performance test.

Further, it must be realized that in addition to the radio transmitter any directional antenna system is dependent for satisfactory operation on a large number of individual component parts carefully related and adjusted to produce a specified radiation pattern; electrical or mechanical failure of individual units will result in maladjustment of the array.

In many cases complete loss of program time would result until such equipment could be repaired or replaced. Under present existing conditions a large number of standard radio broadcast stations are operating, or have under construction, full-time or night directional antenna arrays that, due to the station's location with respect to other co-channel stations, must of necessity radiate low values of field strength at pertinent angles in the direction of the co-channel stations. An array of this type as originally installed and adjusted will meet the values specified in the construction permit with an allowable tolerance for small day-to-day or seasonal variations, providing the equipment is maintained properly. Failure of individual components in such an array will produce serious trouble by either removing the station from the air, due to the transmitter or transmission line protective circuits, or a shifting in the radiation pattern so as to cause severe objectionable interference to other stations on the channel.

In a number of cases nondirectional operation on a single tower with reduced power is impracticable, if not impossible, due to the difficulty in reducing the transmitter output to a sufficiently low value to produce the required minimum signal toward the co-channel station to prevent any objectional interference. Under these conditions failure of any of the directional antenna array component units means a shutdown and a serious and costly loss of program air time. Consequently, any method or procedure that will reduce such loss to a minimum can be justified on a cost basis.

In preparing suggested maintenance routines for a directional antenna system for use by the average radio station one is immediately faced with an inherent problem. While our speech input and transmitters are fairly well standardized as to type and methods of operation, each and every directional antenna array is a custom-built job designed and constructed to meet certain specified requirements. In view of this fact it is not possible to set up a complete specific maintenance routine that can be directly applied to any and all arrays.

However, it is believed that a general set of maintenance practices based on a typical modern antenna array system can be used by you as a guide for the preparation of similar routines designed to fit your individual antenna array requirements.

We have prepared for our typical example a set of recommended schedules and forms based on a regional station operating with a four-towers-in-line array. As this information is rather specific and detailed, it could not be presented by either blackboard or slides; therefore, we have arranged to turn this information over to Mr. Howard, your Director of Engineering, for distribution through the National Association of Broadcasters upon request.

Before discussing a definite maintenance routine practice it might be well for us to consider briefly some of the maintenance problems which generally have a considerable bearing on the satisfactory operation of a directional antenna array and yet are of such a type that they do not fit into a specified routine. For instance, in the case of many antennas it has been established through considerable experience that in order to maintain the array as adjusted by your consulting radio engineer at the time of the proof of performance tests all the conditions which were present during that period of time must be maintained as closely as possible and, while maintenance routines as later suggested will perform this function as regards the individual apparatus unit, it is these factors which are not readily adaptable to a routine and yet may have a considerable bearing on the successful operation of your system. One of the most important factors in the holding of array adjustments is the maintenance of the ground system, and periodic checks should be made at regular intervals by the supervisor or the chief engineer.

These checks should consist of an examination of the ground screens, radials, and the bonding for a loose or bad connection and corrosion. This is of particular importance in some locations where heavy corrosion due to the particular soil content has caused a considerable shift in the array pattern in a period of six months to a year after installation.

In that particular instance to which I refer there was a station in the Far West in an area with soil with very high alkali content, and in this case practically half the radials disappeared in a period of around six months after installation. It looked like it might be somewhat compared to electrolysis that you find on pipelines.

The area immediately adjacent to the towers should be kept free of high grass and weeds, and where the installation is in rolling terrain the entire ground system area should be planted with a soil-holding type of grass or crop in order to prevent erosion due to heavy rainfall. The latter is particularly important in installations where a fill has been necessary at either the tower locations or within the ground system area.

Another factor which enters into the matter of maintaining proper adjustment of an array is lightning hits, which in many locations are responsible for the largest percentage of lost program time. These hits or surges will cause not only carrier interruption but, in some cases, destruction of the component equipment parts. In the majority of cases multiple vertical radiators make very effective lightning rods and can be expected to receive several direct hits and numerous induced surges during the summer static season. In many other locations this condition is not truly seasonal, as a considerable amount of difficulty has been experienced due to surges that are built up by friction from rain, snow, sand, and wind. Consequently, whenever possible, protective equipment should be utilized to minimize or eliminate potential failures due to these hits or surges. A large number of our modern transmitters contain protective circuits both for the transmitter and the transmission line. However, field experience indicates that it may be necessary to provide additional protective devices and equipment in order to secure maximum protection.

This subject has received considerable treatment by a number of engineers. However, a recent article in Electronic Industries for November 1946 by Mr. H. V. Tollison presents a rather complete summary of a number of methods and circuits which may be employed in the solution of this problem. I would suggest that you study this and other papers on this subject, as it would be difficult, and certainly impracticable, in a discussion of this type to attempt to make any definite recommendations covering such devices that could be used on any and all arrays.

The maintenance tests as outlined have been arranged so that they can be made by regular station personnel, using test and measuring equipment generally found in any modern radio station, with the addition of a field intensity meter and a radio frequency bridge, together with its associated oscillator and detector units. The latter test equipment becomes a necessity for any station operating a complex directional antenna array system under present-day conditions.

This is particularly true at the present time, because we have so many stations that are going on the air with extremely tight pulls, as we might say, where field strengths are down from twenty-five to fifteen million volts, and things of that sort. Unless you do have some means of checking that by a meter, I do not see that it would ever be possible to hold it. That is a question that I know I will probably be asked, so that is why I am just adding it at this time.

The preparation of a station maintenance routine for the directional antenna system should be based on the proof of performance report as prepared and filed by your consulting radio engineer at the time of the original antenna installation. This report is a part of your station's permanent Federal Communications Commission's file and contains a complete description of the array, circuit diagram, circuit components, meter readings, and the field intensity measurement data. The importance of this report cannot be overemphasized, as it provides you with a source of information that is of greatest importance in the day-to-day operation of your station.

Consequently, with this report as the basis for your routine maintenance, the first step in the preparation of such a routine will be to prepare a combined maintenance report book or log.

This report book should be divided into three sections. The first section will consist essentially of a complete description of the individual component parts arranged in four subdivisions consisting of inductance coils, capacitors, resistors, and relays. The listing in each of the subdivisions should carry a description of the unit, its location or function in the circuit, its type number, replacement ordering information, and circuit designation. The listing should also cover the number of turns in use of each inductance coil, the value of each of the capacitors, and the dial settings of the capacitors, if variable.

The second subdivision should furnish complete information concerning all meters used in the operation of the array and should consist of a listing of these units showing the circuit designations, the location and function of the unit, its range, type and serial number, and the current reading for the required output. The required phase monitor reading for normal operation should be listed in this subdivision.

The third subdivision should contain a listing of the monitoring points as designated by the Federal Communications Commission's license and should show the number of the monitoring points, a complete description for reaching these points, the bearing and distance, the specified unattenuated field value at one mile, the obtained unattenuated field value at one mile, together with the actual received field.

The fourth and last subdivision should contain a schematic diagram and, if available, a wiring diagram of the complete antenna array equipment, together with the series of curves from the proof of performance report showing the dividing network or driving point impedance of the array equipment and operating tower impedance if a single tower is used for nondirectional daytime operation. Additional pertinent information that would be of assistance to the maintenance engineer, such as transmission line and capacitor gas pressures, et cetera, should be included. While it may appear that some of this information will be a duplicate of the proof of performance report, it is believed that by rearranging the data in this form and making it part of the maintenance routine, the constant reference to this information by the station engineering personnel will acquaint them with the equipment and its functions far better than a casual reference to the proof of performance report.

The second section of our maintenance report book should contain a complete list and schedules of the daily work to be done and, where necessary, complete instructions covering the methods and equipment to be used. In the case of our typical directional antenna system we have divided the antenna maintenance work into two main classifications. The first classification is designed to cover the daily routine inspection and work that is to be handled by the late-trick station engineer after sign-off. This work has been arranged in such a manner that all parts and circuits will be cleaned and inspected at least once each week. The second classification, already mentioned, has been designed to cover a series of special maintenance routines for checking the array operation at regular specified intervals.

The third section of the maintenance report book contains the weekly station maintenance log. This portion of the routine is of extreme importance, as it will provide the station supervisor or chief engineer with a method for checking the work done, as well as the data necessary to determine the operating conditions of the array and its equipment at all times. The log, as set up for our typical station, is arranged to cover one week's complete maintenance information divided into daily sections.

Each daily section provides space for recording the temperature, weather, array meter readings, phase monitor readings, transmission line pressures, routine maintenance performed, routine tests results, other pertinent data, and the signature of the duty engineer.

The preparation of our typical daily maintenance routines was based on the assumption that the station would use the regular night-shift engineer after program sign-off to handle the daily routine maintenance work as outlined by the schedules, while the second group of special maintenance tests may be made at the specified times by the regular trick engineer and the transmitter supervisor or chief engineer.

To present a more comprehensive picture of how such a system actually will function, let us follow the engineer on his regular Monday night maintenance routines as prescribed by the report.

As outlined in Sections 2 and 3 of our maintenance log or report book, the late-trick engineer first reads and logs a complete set of meter readings just prior to sign-off. Immediately after the equipment is shut down all component equipment within the antenna phasing unit is checked for overheating by carefully feeling all condensers and coils. The transmission line and seals are cleaned and all connections tightened. The antenna phase unit and its component equipment are thoroughly cleaned and all dust removed with a vacuum cleaner and blower. The antenna relay connections are checked and tightened, the relay contacts are cleaned, and the alignment checked under operation. All internal connections are checked and tightened. All inductance coils and condenser adjustment settings are checked and compared with the original settings as tabulated in Section 1 of the maintenance log. The transmission line and condenser gas pressures are read and entered in the log, together with any changes or out-of-the-ordinary activities that have occurred during the tests.

The remainder of the daily routine maintenance work has been arranged for each day in a similar manner, and it is believed that the schedules are sufficiently self-explanatory. Therefore, further discussion is unnecessary. The special maintenance tests have been scheduled for the same day each week and arranged so that the driving point impedance for both directional and nondirectional operation and the field strength at the designated monitor point will be checked bimonthly.

As a quick method for checking the over-all operation condition of the array, we have suggested that bimonthly impedance measurements be made at the input to the antenna phasing unit, as our experience indicates that any variation or shift in the array or maladjustment of the equipment will be reflected in the impedance values measured at this point.

This is done for two reasons, one, to save time, and also it will provide you with practically as good a check as if you had gone out to the tower, once you have thoroughly established that.

You will note that we also use the same point of measurement for checking the nondirectional operation rather than a measurement of the single tower impedance, as measurements at this particular point will also indicate any departure from normal operation of the nondirectional system. The equipment required for these measurements may be either a radio frequency bridge and its associated apparatus or any other type of impedance measuring equipment. The utmost care and accuracy should be used in making these measurements, particularly with reference to the establishment of the operating frequency, as a small variation in frequency will introduce a considerable error in the measured values. The data obtained during the tests and recorded in the log should be compared to the original values shown in the proof of performace report and, if necessary, adjustments should be made to correct any discrepancies.

That is one of the things that you are always hoping will not occur, for the simple reason that you are hoping that the maintenance that you have done of what amounts to cleaning and tightening will prevent that shift in impedance from occurring, and if it has been done properly, it will do that.

As a further method of determining and maintaining the normal operation of the array, we have recommended that field intensity measurements be made at each of the specified monitoring points described in the proof of performance report. These measurements should be made with a standard calibrated field intensity meter, and the location of the points described should be strictly adhered to. In this connection it is suggested that the exact location of the field intensity meter should be suitably marked with a stake to make certain that the measurements are always made at the same point. Further, the time of measurement should be selected to avoid any possible error in the result which might be introduced by sky wave interference from co-channel stations.

Under present-day conditions that becomes rather difficult at times, but it is certainly something that you must recognize. Be very sure that you actually have what amounts to clear air, because if you do not, you are going to get some rather odd-appearing results.

Great care and accuracy should be used in making these measurements, and the calibrated attenuator values should be used in computing the received field. The data should be recorded in the log and compared with the original values.

The recorded data obtained from the daily and special maintenance tests after a period of six months can be plotted to show the actual operating conditions of the array; variations from the normal conditions will undoubtedly appear in the graphs. However, by a careful analysis of the records it will be possible to identify any variations due to seasonal or weather conditions.

In other words, you will establish a variable element which is present in all our arrays over a period of time, and you will know exactly what are those small shifts, once you have set up this record.

This accumulated information properly evaluated should provide the station engineer with a complete and thorough understanding of his directional antenna array operating and maintenance problems.

It is, of course, realized that the suggestions and recommendations we have described are not the total and complete answer to all and every directional antenna. However, I hope that we have demonstrated the need for establishing schedules similar to the program I have outlined in the material presented to Mr. Howard. If we have convinced you of the need for such a program fitted to your individual station requirements, the results will be of mutual benefit to both your station personnel and the industry. I thank you. [Applause]

When Dr. Howard introduced me, if I can just grasp a moment here, he made a remark about the Franklin antenna in Oklahoma. I would like to make it very plain that that antenna I did not design. Mr. Glenn Gillett, sitting down in front here, conceived and designed it all. All I did was make it work.

CHAIRMAN HOWARD: If there are no objections, we will now have a ten-minute recess.

[The Conference recessed for ten minutes.]

CHAIRMAN HOWARD: May I have your attention for a moment? While we are waiting for a moment for everyone to come back, if you would like to look at the circular antenna up here, there is a model of it.

Will you be seated, please? There will be no slides shown in the next session, so if you want to sit up close, it will be perfectly all right.

We are still behind schedule. We will proceed now with the part where we were at two-fifteen. No, I am sorry; this is three o'clock now. I am behind schedule.

The next paper, entitled "Technical Regulation of Radio," will be presented by my very good friend, Mr. George P. Adair, consulting engineer, of Washington. To many of us it is hard to say "consulting engineer of Washington," for we all know of him as the former Chief Engineer of the Federal Communications Commission of Washington. Without further ado I present Mr. Adair. [Applause]

MR. GEORGE P. ADAIR [Radio Engineering Consultant, Washington, D. C.]: Thank you, Mr. Chairman.

Ladies and Gentlemen: I am very grateful for the opportunity of briefly discussing the technical regulation of radio, as it has been my chief occupation for a good many years, and I know that the group here today will have much, if not the principal share, in determining the future technical regulations, not only of broadcasting in its several forms but of the other radio services which play a material part in our lives today, whether we are conscious of it or not. All of us think in terms of broadcasting when radio is mentioned, but there are other services which must be given consideration in making broadcast regulations, several of which are very necessary to the broadcaster.

The term "regulation" is rather odious to the American mind and has undoubtedly been resented from earliest colonial days, in fact, since man was created. It is our natural instinct to think of a regulation as an undesirable and unnecessary restriction to be strenuously opposed by us, but a most beneficial and desirable thing for others, to which they should not only meekly submit, but eagerly seek. Except for an occasional bureaucrat here and there, I think we are all in entire agreement that regulations of any nature should be kept to a minimum, but there are times when poor regulations are better than none.

The needs and benefits of regulation are dependent upon the complexities of the situation. When there is only one, or even a few, the needs and benefits are relatively simple, but some control, even if it is only self-control, is required. If Adam had used a little more self-discipline, he would have been much happier, and we would not be so busy trying to regulate each other today.

When oxcarts were traveling what is now the Lincoln Highway, there was little need for traffic rules, but today, with automobiles meeting and passing each other at high speeds, there certainly would be confusion just before the crash were there no regulations as to which side of the road belonged to each. [Laughter] Just in the same way, there was no need for regulation when there was only one radio station, but as in the case of the oxcart, those days have long since passed.

The necessity of technical regulation of radio arises primarily from the scarcity of spectrum space and the great demand for it, but it goes much further than a mere scarcity. If there were an unlimited number of broadcast channels without regulation, the chaos would be such that none of us would accept a station as a gift. It was out of almost such chaos that the Federal Radio Commission was created. It is only human nature for each of us, when not really thinking, to want to obtain a broadcast station with little or no trouble and to operate it in any way we wish, but we are all for the other fellow's having some real Rubicons in getting his station, and the way we would regulate his operation would really put the most ardent bureaucrat to shame.

When we stop to think, we realize that rules, regulations, standards, guides, or controls must be the same for all in so far as they are applicable. We further realize that these within limits are not only necessary for all to live together, but of actual benefit. When they cease to be necessary or beneficial, they should be abolished or superseded.

As I look at the Commission's technical rules and standards, I cannot see any which are there just to have rules, but all serve a purpose of standardization and guidance; they become restrictions only when someone wants to step out of line and operate in a manner that very probably will be at the expense of some other station.

For example, assuming that I had a station and operated with excess power, I would cause more than my share of interference to some other station or stations, expanding my service and reducing theirs. On the other hand, if I operate carelessly and get off frequency, my service, as well as that of the others, suffers.

At least in daydreams, each station owner would like to have a 100-kilowatt station on 540 kilocycles with no competition, but this is, of course, impossible for several reasons, some of which are obviously technical, but others are of a social, economic, or political nature.

Leaving the technical for the moment, there are many areas which could not support such a station; there are many capable broadcasters in areas that could support it but who could not finance it; there are also many programs that are very important locally or regionally but are of no interest outside that area. Consequently, the use of wide coverage is more than wasted. The political aspects of such a monopoly are obvious.

Realizing the varied types of broadcasters and the need of serving audiences and areas of different sizes with multichoice of programs, as well as the technical limitations, the Commission and its predecessor established several classes of stations within the standard broadcast band.

In providing these classes of service, not only does consideration have to be given to stations operating on the same channel but to those on the adjacent channels. Standards of allocation must be set up which will provide the maximum of service, both with respect to the area served and the number of services to the area. Existing services must be protected from interference which might be caused by new stations, but at the same time the standards cannot be so strict as to prevent the establishment of any new stations or the improvement of existing stations.

In setting up standards there are many factors which must be considered and determined, giving the proper weight to each where conflicting. Some of these are highly variable, for which average or conservative values must be found; others are unknown and must be assumed. Some of the factors which must be considered are:

(1) What ratio between desired and undesired signals is acceptable?

(2) To what percentage of listeners should this value be acceptable?

(3) What is a typical or adequate sampling group to determine this?

(4) What are the noise levels in various areas which

determine the minimum signal strength to be protected?

(5) What are the receiver selectivity characteristics to determine the adjacent channel ratios?

(6) Shall these be determined for the poorest receiver, the best, or the average?

(7) Is this determined from factory measurements of selected receivers or from receivers that have been in use for six months, a year, or how long?

(8) What are the propagation characteristics of the ground wave and of the sky wave?

(9) How do these vary in different areas at different times on different frequencies?

(10) What are the frequencies and powers best suited for the various classes?

(11) If the power of one class is raised horizontally, what are the engineering or economic effects that it has on the others?

(12) Under what conditions should daytime or limited-time stations be permitted?

(13) When does daytime begin and end from the standpoint of radio propagation?

There are hundreds of other questions which must be determined and, in many cases, actually specified in the rules and standards. Some of these are easily answered for a single class or area, but the relation to others and to the picture as a whole is often complex. Sometimes a determination has to be made almost on an "Eenie, meenie, minie, mo" basis.

Under our competitive system and legal processes it is often necessary to establish arbitrary standards and assume ridiculous accuracies. For example, all engineers are fully aware of the inaccuracies of the sky-wave propagation conditions, yet most of us find ourselves in controversies hinging on the third decimal place and reading curves with a magnifying glass that were originally drawn practically blindfolded. [Laughter] This is not nearly as bad as it sounds. The sky-wave curves are the best we have for sky-wave propagation and constitute a yardstick that may have thirty-seven inches or may have thirty-five inches, but it is a standard of comparison that is indispensable until more accurate information is available.

I do not believe there is any doubt that the United States has the best technical regulations of any country, but far be it from us to rest on our laurels. How can we have better regulations? Simply by full cooperation, honesty, a broad outlook, and continual striving for perfection.

Following and accomplishing these precepts is much easier said than done, and it requires the constant efforts of all. Each of us must do his share, accept his responsibilities, and while most of us do not look well in a halo, it may be necessary at times to forget our own specific interests for the good of all. This is really not unselfishness, but far-sightedness.

Promoting a selfish interest sometimes backfires. This is a rapidly changing industry in a rapidly changing world, and blindly clinging to the status quo may hurt the clingers more than anyone else except the public, which is usually the loser when private interests clash.

On the other hand, leaping into changes without knowing where you are going to land can lead to disaster. Many of us connected with the broadcast industry do not realize, or refuse to accept the fact, that broadcasting is no longer confined to the United States. It is true that the United States pioneered broadcasting and was far ahead of many other countries, but this lead is rapidly diminishing, and a failure to realize this is going to be quite a blow. When it hits, it will be nobody's fault but our own, yours and mine.

Decisions must be made without delay and must be right, or the losses of the Third Narba to both the broadcasters and the listeners will make those of the First and Second seem small peanuts. Competition between stations and classes of stations is keen, and rightly so, but this competition must have back of it a spirit of cooperation and united front which is much stronger. Our dirty linen should be washed at home, and soon.

What are our specific responsibilities? What are the responsibilities of the Commission, of the broadcaster, of the engineer? In my opinion, it is the responsibility of the Commission to make informed, farsighted, unbiased decisions promptly. Intelligence and integrity are, of course, prime necessities and go without saying, but beyond these there are important requirements.

There must be adequate staff to keep the backlog to a minimum, and at the same time there must be adequate staff and facilities to look ahead and keep ahead of the requirements of the industry. Enlargement of the laboratory staff and facilities, and more engineers capable of analyzing and applying what is learned in the public interest, are required.

The quality of the present staff and equipment is excellent; what is needed is more of the same. The Commission must, of course, receive information from industry, but a satisfactory condition cannot exist where it is almost entirely dependent on the information so gained, particularly when much of it is a byproduct gained from some other work which, when extrapolated or interpolated for use in making broadcast regulations, may prove very erroneous when the full facts are determined. Not only must the Commission and its staff keep abreast of the technical developments and related matters, but it must keep informed as to the needs of the industry.

It is the responsibility of the broadcaster to assist the Commission in carrying out its duties; to help keep it informed; to supply accurate and full information; to provide means for his engineers to gain knowledge and pass it on to the Commission; to keep informed of the problems of the Commission and of the industry in general; to see that his station is so operated that disciplinary regulations are not required, or so that the Commission's staff can devote its time to productive work instead of policing; to either accept decisions of the Commission in good grace or take an appeal in accordance with the established procedures and not indulge in spreading innuendos and slanderous remarks; to realize that a change in rules beneficial to his class of station may be very disastrous to others and may be only a temporary cure for his own problem; and, above all, to keep the spirit of competition with cooperation in full play.

To the engineer, both in the Commission and in the industry, falls the greatest responsibility of all for establishing and maintaining good technical regulations. Both the Commission and the broadcaster depend upon him for sound technical advice. He is looked to for factual information uncolored by the fact that he is employed by a particular station or class of station. When he does otherwise, his stock as an engineer and a person sinks to a very low value, and his testimony as a technical expert is materially discounted and may even react entirely negatively to what is intended.

Engineers should leave supplying of other than technical information to the others, or make it clear that they are not trying to put a technical cloak on a policy opinion. If a proposal of a station or class of station or service will not stand the daylight of technical analysis to the best of the available information, it should not be promoted by half technical truths disguising the real facts.

Engineers must mix freely, both formally and informally, exchanging information and ideas. There are, of course, certain pieces of information which for patent, or other, reasons are confidential, but in so far as I know no information which has been given to the Engineering Department of the Commission on a confidential basis has been divulged. Yet technical information, even on this basis, is very valuable in that it permits study and planning, providing for speedier and better results when action is required.

As I have mentioned several times before, keeping our regulations up to date is of great importance; in fact, there is little, if any, use for regulations if they are out of date and do not fit the needs. In my opinion, the operator regulations are a prime example of this. Before the war definite advances were made in the method of examination for operators' licenses, but still the basic regulations were conceived long before broadcasting and were designed to regulate the operation of ship stations and not television stations. These were acceptable for the first two or three years of broadcasting, but after that they have been wholly inadequate and inapplicable.

Is the same examination given for a license to operate an airplane as to operate a steam shovel? Is the engineer of a transatlantic liner required to know the block signals used on the Atcheson, Topeka, and Santa Fe? Is a railroad engineer given a license without ever having seen a locomotive? These are, of course, silly but not much sillier than our radio station operator regulations. With the present-day techniques and procedures used in the many different services and classes of stations, there is very little in the examination for a first-class radiotelephone operator's license to determine that he would be a first-class operator of a television station. Why should the FCC issue a license which, in effect, says that he has been examined and has been found qualified to operate and be in full charge of a 100-kilowatt broadcasting station with a fourteen-element directional antenna when he can, and does, get such license without ever having seen a 100-watt station?

The operator-licensing process should be based on the minimum requirements for the class of station or service concerned, with the privilege of qualifying for all stations and services, just as one may obtain a license to operate an automobile, steam shovel, and an airplane, if he is qualified and takes the necessary examinations.

The Commission recently made a start along these lines with respect to low-power broadcasting stations when it issued proposed rules in this regard, but that can be only a start, and before anyone can determine whether this start will be good or bad, the grandfather provisions must be spelled out in detail and at least a preview of the over-all picture shown before one chapter is determined.

While only the surface of technical regulations can be scratched in the time available today, may I urge that each of you take a very personal interest in improving them and continue to increase your cooperation and participation in their determination. No regulation can please everyone, but they can certainly come much closer to it if the Commission is given the benefit of full information. Thank you. [Applause]

CHAIRMAN HOWARD: Thank you very much for that very timely talk, Mr. Adair. I am sure we all appreciate it, and I am sure that the information contained in it will stand up for as long as the present operator license requirements have.

We will now have about a three-minute recess here while we set the stage for the final act.

[The Conference recessed for a few minutes.]

CHAIRMAN HOWARD: On this panel, the FCC-industry round table, my secretary made a mistake when he outlined this thing and put me down originally as mediator, not moderator. [Laughter]

This is a catch-as-catch-can, an Information Please. You are privileged to ask questions, and you are invited to ask questions from the floor of this panel of experts up here. They will try to answer any question (engineering question, of course) that you would like to have answered.

We have Mr. George E. Sterling, Chief Engineer of the Federal Communications Commission. Mr. Sterling. [Applause]

Another good friend of ours, Dr. John A. Willoughby, is Assistant Chief Engineer in Charge of Broadcasting. [Applause]

His alter ego is Mr. James E. Barr, Chief, Standard Broadcast Division. [Applause]

Sitting next to him is Mr. Cyril M. Braum, Chief, FM Broadcast Division. [Applause]

That dual personality and a man with not only television in his hands, but international and special services, Mr. Curtis Plummer! [Applause]

The men on the left you have all heard today; I will not take up the time in introducing them to you. Briefly, Mr. Orrin Towner, Mr. McKey, Mr. Adair, Mr. Hanson, Mr. Houston. [Applause]

This panel has proved to be very interesting in the past. At Ohio State we found many answers to many questions. So we can start out, and will you, when you stand up, please state your name, your radio station or affiliation, and, if possible, if you cannot talk very loudly, we have a microphone right there that you can use.

The first question-- Do I see a hand?

MR. PHILLIPS [WTPT, Kingsport, Tennessee]: I would like to ask one of the members of the Federal Communications panel whether the standards for noise on FM equipment are not a little extreme.

MR. CYRIL M. BRAUM [Chief, FM Broadcast Division, Federal Communications Commission]: Those requirements were worked up during the engineering hearings of 1945 and are similar to the standards that were used in FM before the war, except that the prewar recommendations were not worried about AM noise. But the FM noise is the same as the prewar, and there have been some questions about whether this standard is too stringent. We have not had very many license applications filed since the war, and some of those have met this requirement and some have not. We have said that we will give more time to stations that find that they cannot meet these standards at the time, but we have no plans for changing standards. It is not broken down into the units, except that we recommended that the noise in each of the three units not exceed one-half of the total, that is, the three units are speech equipment, the studio, and the transmitter itself.

UNIDENTIFIED: For Mr. Braum. Along the same line of this FM noise problem I would like to make this comment, that in a system where the transmitter is comparatively low-powered and the audio or speech input equipment can be located rather simply in the transmitter building, or where the studios are very close to the transmitter, the 60-DB noise requirement may be met without too much difficulty, but in many cases the transmitter and studios are located some six, eight, or ten, or maybe fifteen, miles apart. The standard system for feeding such a transmitter as that would be this: pre-amplifiers feeding a program amplifier which, in turn, feeds a line amplifier going into five or six miles of line which, in turn, has a line amplifier in the middle of the line. Coming out of that are another five or six miles of line, and when you get to the transmitter building you are feeding another line amplifier, and possibly a limiter, making a total of five or six amplifiers cascading.

In other words, to meet the 60-DB noise requirement, every one of those amplifiers must be at least a 70-DB amplifier in order to come out over all with 60 DB. As far as I know, there are very few amplifiers being offered by any manufacturer claiming 70 DB.

MR. BRAUM: That is true. It is going to be difficult meeting the standards in cases like that where you have a lot of amplifiers and a studio transmitter circuit which might be raised. But we would like to know more about the troubles of the stations in meeting the standards before considering the change of the standards. The standards were worked up in connection with industry in 1945, and we have not had any requests from them, since that time, for changes.

UNIDENTIFIED: I want to clarify that. I am not suggesting that you change standards, or anything; I just want to make that comment, that it is going to be difficult, and in order to meet the standards in cases of that sort, the amplifiers must be very good, in some cases better than most manufacturers offer on present markets.

MR. GEORGE E. STERLING [Chief Engineer, Federal Communications Commission]: I should like to ask a question, if there are any other members of the station staffs here representing the industry who share the opinion of the gentleman from Kingsport about the standards.

MR. STEVE MAHONEY [WEDO, McKeesport, Pennsylvania]: We had a line equalized at 8000 cycles for broadcasting; they had 8-DB loss along that line. That same line equalized at 3000 cycles was down 43 DB. The noise level amplified that terrifically. I believe our limit was plus 4 DB. By the time we got it out to the end, it was down below, and the noise level was terrifically high.

CHAIRMAN HOWARD: Mr. McKey, do you have something on that?

MR. McKEY: No, I have not.

CHAIRMAN HOWARD: Any further comments on that subject?

Are you all happy with it? No trouble? [Laughter] No trouble at all?

MR. BOOKWALTER: [KOIN [Portland, Oregon]: I think that the low level exists right at the pre-amplifier; isn't that usually the case? As far as the number of amplifiers is concerned, I do not believe that is the problem. It is the first start that is down; it is the microphone. As far as the amplifier on the line is concerned, I think it can be maintained once it is taken out of the pre-amplifiers.

CHAIRMAN HOWARD: Any trouble on any relay circuits?

MR. McKEY: Mr. Howard, to return for a moment to the question that you asked Mr. Braum before, I think also that there is a general impression among the majority of people as to when they would be required to make these tests to meet these requirements they have just been talking about. I think it is very doubtful at the moment/that there is any test equipment that will actually make these measurements. I certainly know of none, and if anyone does, I would like to hear about it, because I do not believe there is available at the moment from any manufacturer apparatus that will make those measurements, that will go down that low and measure those noise levels you have just been talking about. Can you give us any information on that?

MR. BRAUM: We just released something that said in effect that we did not propose to consider changes then, but we would consider requests in connection with license applications. Where the noise and other audio performance characteristics did not meet the standards, we have a few license applications on file that had been filed before that release. I can give the number of them if you wish, Public Notice dated June 17, No. 9338. I have copies with me.

CHAIRMAN HOWARD: Did everyone get that number? Does that answer your question, Mr. McKey?

MR. McKEY: Mr. Braum, have you any information at this time to disclose regarding FM relay channels for remote pickup use?

MR. BRAUM: It is DAR 940 and 952, and we have authorized a number of interim equipments until 940 equipment is available here. In many cases FM centers are used with the number so that the equipment is good to begin with, and it is not difficult to use until the 940 equipment is available.

CHAIRMAN HOWARD: How long will they be allowed to use the television channels?

MR. BRAUM: That is a question that I cannot answer, except that we do not issue licenses for these, but it is a purely temporary authorization on a ninety-day renewal basis until the 940 equipment is available.

CHAIRMAN HOWARD: Any further questions? How is the noise on those channels?

MR. BRAUM: We do not know enough about the present installations to say.

CHAIRMAN HOWARD: Are there any further questions on this from the floor?

MR. WEILAND [WINC, Hollywood, Florida, and WFTC, Kinston, North Carolina]: We are just filing for FM, but as an AM operator I am wondering why the Commission does not allow studio maintenance for AM stations. We have had trouble with telephone lines all these years. You cannot get any frequency response over 6000 at the best, and we would like to get the best audio possible for AM stations. You get an inquiry from the Commission, and you find out you cannot use the studio length for AM.

MR. STERLING: On the 960 channel, if you look at the allocation that is labeled "broadcast," we would entertain applications for such.

MR. JAMES E. BARR [Chief, Standard Broadcast Division, Federal Communications Commission]: I think that in general much the same sort of requirement for studio transmitters do apply to standard broadcasts as would apply to FM. I have had very few, in fact, I know of no requests for studio transmitters in connection with broadcasting, but we are certainly willing to entertain requests for such facilities on the same general requirement basis as by FM. Whether this clause in 952 specifically says that they are applicable for AM stations or not I am not sure. Generally, up until now the standard broadcasts have had one or two organizations for emergency studio length transmitters. None of them, of course, have band lengths.

CHAIRMAN HOWARD: Mr. Carl, didn't you do some work on some relay equipment in the 952 type of band?

MR. CARL: We have not done any work on that. We have ordered two transmitter lines from Bendix. I believe one of them has been completed now and will be available for inspection in a week or so, including the transmitter and receiver. That length of transmitter received works on 950 megacycles. I am trying to get the rest of the information so I can make out the application forms for FCC. It is between the terminal tower and seven hills.

CHAIRMAN HOWARD: When would that be open for inspection?

MR. CARL: I would suggest that you contact Arthur Omberg in charge of research down at Bendix in Baltimore. It is fifteen or twenty watts, I believe; I am not sure.

MR. ADAIR: Will that stay in the channel of those bands?

MR. CARL: That is what he is striving for; we have to do that.

MR. ADAIR: They think they have licked that problem, do they?

MR. CARL: The transmitter looks very good. He does not have the receiver completely finished. He hopes to have it ready in another week or so, and I think he will make it available for industry inspection.

MR. ADAIR: There is quite a bit of trouble in keeping your frequency stability and your noise down.

MR. CARL: It will be crystal controlled. You are talking about the transmitter or the receiver?

MR. ADAIR: The whole system.

MR. CARL: I cannot say too much about it. I have a lot of faith in Arthur, what he can do.

MR. ADAIR: Mr. Braum, do you know whether any manufacturer has submitted specifications which would stay within your channel system there and meet your noise requirements?

MR. BRAUM: No, we have heard of several being developed. We have some that did, but I am not sure that they meet all the standards that we have proposed.

CHAIRMAN HOWARD: Any further questions on that subject?

MR. BEN AKERMAN [Chief Engineer, WGST, Atlanta, Georgia]: I have a question that is somewhat tied in with this, not exactly as it is, but it deals with relay broadcasts. On a number---well, not a number, but several times we have been to the Commission with requests about the use of relay broadcasts on special programs that involve an undue expense as to lines. My experience has been that the telephone company will undertake to put lines to the moon if you are to pay enough money for it. I would like to know something about what the Commission's feeling is with regard to how far a broadcaster can go with the use of his relay broadcast equipment in places where it is obviously impossible to get lines, even though the equipment is in a car and you roll up and broadcast and move away.

MR. BRAUM: The rules were amended a year ago, and the present pickup rules do not contain any restriction limiting the use of remote radio equipment to places where wire lines are not available.

MR. AKERMAN: There is one additional question I would like to ask. Does it take a special act of Congress for a broadcaster to get on mailing lists for these releases? I have requested the Commission's mailing department by letter, and we only get about 20 per cent of the releases at our station.

MR. STERLING: The Commission was forced to cut its public releases. They have been reduced to the barest minimum. All of the orders of the Commission and all of the information going to the public is published in the Federal Register. They will not give us an appropriation which will permit our engaging in the wholesale distribution of information that we used to have. We had to cut it down, and everybody I know is suffering from it. You will have to depend on your trade papers and the Federal Register. I am not sure that we are going to keep up to date on what the Commission is doing, because we do not have the facilities which will permit the widest dissemination of information along the lines which we formerly disseminated it on. We do not see any hope of improving that situation in this fiscal year. I imagine that it will be tighter as the next year rolls around. I am sorry, but it is something beyond our control.

CHAIRMAN HOWARD: May I add to that? All special bulletins affecting broadcasting we try to publish in the NAB reports, and we have been doing that since the middle of the year. It is the intention of NAB to publish, probably as soon as it has been compiled by a group from Washington, the official rules and regulations, complete, sometime the first of the year. It will take four men about five months, and I am sure that you gentlemen can go back and say that nowhere do you find official rules covered so completely. That will be out sometime in the spring, I hope.

MR. AKERMAN: I have one more question that I would like to ask in connection with this proposition. It is of little aid or, rather, it is of some aid, but I wonder if the Commission has given any thought to the fact that there is almost as much necessity for the circuit for communication purposes in some places as there is for a program circuit. We have gotten a proposition from the telephone company that involves about as much as a 50-kilowatt transmitter to put in the facilities. If you do not have communications both ways between the studio and transmitter, you are at some loss. My understanding is that up until the present any such arrangement is a special temporary authorization, and I wonder if there has been any thought about some assignment for the use of that, or multiplexing the regular broadcast channels.

MR. BRAUM: The same revision I was telling about, the Part 4 issued a year ago, contains a provision for remote pickup equipment to be used for communication service when an ST transmitter is used, so there is a rule providing for it at this time. The frequency is not set for it as a rule, and the exact phrases have not been adopted yet. However, it will probably be in the 25-megacycle class. In connection with this request for ST use with AM stations, there may have been some misunderstanding. There are some cases where high frequencies have been used in connection with boosters for AM stations, and that is where the Commission has an open policy. In connection with the use of ST, as such, for AM stations, the rules specify, as I recall, that they are to be used only with FM and international broadcast stations. I believe the reason there is that there are not enough channels to make ST circuits available for all AM stations, since AM stations are normally not located at inaccessible places and since the performance requirements are less stringent.

CHAIRMAN HOWARD: I have here four questions submitted by the delegates from the USSR. Question No. 1, Does the FCC consider it necessary to require the compulsory use of modulation limiters? I wonder, Jim, if you might answer this.

MR. BARR: Is that with reference to the FM or standard?

CHAIRMAN HOWARD: I presume it is standard.

MR. BRAUM: The standards say in connection with FM that where limiting amplifiers are used, care should be used in connection with the use of circuits, but we have no rule prohibiting the use of amplifiers. There is no requirement.

CHAIRMAN HOWARD: The second question is, What are the prospects of the use of model code powerful tubes, that is, for any high-power AM international or any AM?

MR. CURTIS B. PLUMMER [Chief, Television Broadcast Division]: We do not use demountable tubes in this country yet. There are two reasons. In our AM medium-wave broadcasting we have a power limit of fifty kilowatts. I understand that in the Soviet you are considering medium-wave and long-wave transmitters of several hundred kilowatts, so are problems are different there.

Now we move over to the short-wave field. Our transmitters are 200 kilowatts. These tubes used in the 200-kilowatt transmitters are not demountable tubes; they are of 134, which is made by the Federal Company, which is an affiliate of the International Telephone and Telegraph. I believe these tubes dissipate about 150 kilowatts.

CHAIRMAN HOWARD: The third question, which I believe Mr. Plummer also will answer, is-- Mr. McKey wishes to add to the answers given by Mr. Plummer.

MR. McKEY: In addition to the tubes that Mr. Plummer has described there is also a tube manufactured sometime ago by the Western Electric Company. It was originally developed in the anticipation that some day we might have 500-kilowatt stations in the United States. This tube was actually used in broadcasting in one of the Mexican stations. A total of eight of them were used, with a total output power of around 800 kilowatts. Those are the only tubes that I know of that are used in addition to the ones Mr. Plummer has already described.

CHAIRMAN HOWARD: We now come back to the third question, What types of transmitting antennas are recommended by the FCC for use in high-frequency broadcasting? Do you mean international short wave?

MR. PLUMMER: At the present moment the bulk of our antennas in the high-frequency short-wave broadcasting are of the broadside type. As you know, we built our plan up during the war from approximately twelve transmitters to thirty-nine transmitters. Due to the shortage of materials, we were unable to obtain the necessary steel and other material to put up a large number of the broadside type antennas that we believe are the best antennas. However, there are at least three plans for several of the broadside type of antennas that are very similar to the British antenna, and we have some that are two elements high and four elements wide.

Of course, the reason we concentrated on broadsides was because of materials and the ability to erect them quickly.

CHAIRMAN HOWARD: The fourth question we have is, What frequency is preferable for FM broadcasting in big cities? [Laughter]

MR. BRAUM: The Commission conducted an allocation hearing in 1944 and 1945 to study this matter, and the band assigned to FM is eighty-eight to 108 megacycles, and all frequencies in that band are multiplex in their performance characteristics. The old band of forty-two to fifty megacycles is no longer assigned to FM.

CHAIRMAN HOWARD: I imagine that some of you have a lot of questions you would like to ask now. We seem to have covered a pretty good field here so far. How about standard bands?

MR. JOHNSON: This is not a question; I am just throwing it. If they care to comment on it, OK; if not, we will drop it. I wonder if the Commission would care to make any statements regarding what they consider minimum spacing for regional stations, and also any comments they might like to make on maximum nighttime limitations. [Laughter]

MR. BARR: We have no requirements whatsoever with respect to separation of regional stations in terms of miles. We have the sky-wave propagation curves and standards with which Mr. Johnson is as familiar as I am. [Laughter] That is the only criteria we have for determining separation at nighttime as long as there is no ground-wave interference. We have been somewhat concerned about the fact that all the channels are becoming so crowded, so hard to work stations in. The applications come in a little closer, a little closer, and a little closer. We have several on file now. I think we have granted them for five-kilowatt stations. We have some applications on file proposing five-kilowatt operation down to 90. When you apply the propagation curve and the method for determining limitations to the antenna, you usually come up with negligible and no interference. The propagation curves used-- Originally those standards were definitely labeled as not pertinent. We have since had some recordings at those distances, and the curves have been revised. They do show signal intensities to be expected for radiation at the critical angle. That is appreciably lower than the original propagation curve.

Some people seem to think that those curves can be relied on just about as much for distances less than 250 miles as they can for distances over 250 miles. Everybody knows that it has been subject to some variations. We do not have any policy with respect to definite separation. We, as I said, are concerned about possible other effects. What was the other part of the question?

MR. JOHNSON: Regarding nighttime limitations.

MR. BARR: Normally, we take the contours that are standardized. The Commission looks at each application on the basis of what they can serve with any given limitation. The tendency seems to be somewhat to grant a station, even though the nighttime limitation is well over the normal contour for that class, provided he does not interfere with any distant station and as long as he can render a fair degree of service to the community in which he has entered.

CHAIRMAN HOWARD: Could I ask a question, please? [Laughter] This question was passed up to me. Are radio antennas good for broadcasting?

MR. BRAUM: The Commission has discouraged the use of antennas at this time, because we feel that it is too early in the development of FM to look into directional antennas. Their performance is somewhat unknown, particularly with respect to protecting other stations. Another difficulty is the establishment of standards and methods to show that a directional antenna for FM will protect another station satisfactorily, so that, all in all, we feel that it is too early to encourage or give much consideration to the use of directional antennas of that type.

CHAIRMAN HOWARD: You mean that the change of time will eliminate all interference?

MR. BRAUM: We have some cases of interference with stations operating on alternate channels, but that is not the point that I was discussing, because I meant stations along the coast, in which case a proposed issue would protect the existing stations. It is not a matter of stations operating in alternate channels or on channels that are--

CHAIRMAN HOWARD: How about high-powered directional? Are you in favor of that?

MR. BRAUM: Yes, the Commission favors high power for FM. The only limitation is that the Commission is charged with an equitable distribution of facilities and is trying to work out an allocation in which we limit the power only in areas where the allocation problem is tight. This includes the eastern seaboard and certain areas out toward Chicago, plus some areas in the southeastern part of the country, such as North Carolina.

CHAIRMAN HOWARD: Did you have a question, Mr. McKey?

MR. McKEY: Yes. Mr. Braum, in your answer to the question on directional antennas you considered them only in the case of interference problems. What would be the attitude of the Commission in cases where it might be very desirable to use a directional antenna due to certain terrain characteristics in order to build up, let's say, in the Rocky Mountain area, where you have cities in the valley and practically no population in the hills.

MR. BRAUM: I think there would be much more occasion for directional antenna in a case like that.

CHAIRMAN HOWARD: Would that apply to the DB question?

MR. PLUMMER: In case of television I think that very similar reasons hold. You will probably remember that the industry submitted an allocation plan for television stations based on the use of directional antenna, and we rearranged the plan to eliminate the use of directional antennas. The reason was location. If we were in the position to require you to put in directional in order to get a station into television, you might find that CAA would make it impossible for that town to have a television station. I will give you a specific example.

When we studied the plan submitted by the industry, there were two assignments. One was Trenton and one was Wilmington. If I remember correctly, they required rather restricted locations to use that directional and yet serve the cities. On a check with CAA they wanted two locations to put the transmitter in and put the antenna in. The answer was, "Absolutely no." That is the reason that we did not require them to be used intelligently, but we will entertain an application on the very same basis already mentioned in FM if the case is justified.

MR. ORRIN W. TOWNER [WHAS, Louisville, Kentucky; Chairman, NAB Engineering Executive Committee]: Mr. Plummer, while you are speaking of allocations, where would a station go to determine what television channel would be available if it is not listed on your pre-allocation chart?

MR. PLUMMER: As you probably know, we only did the allocation in television for the first 140 cities or markets, whereas, in FM I believe they have done their allocation down to about cities of 10,000, cities where there are AM stations. We intend to release sometime in the future a similar plan down to cities of about 10,000. We actually have it in rough form at the moment, but the proposed region of Channel 1 has made it, let us say, partially obsolete, and we therefore are not releasing it. I will say this, that there are several methods. One method, of course, is that we make suggestions, and in most cases you can figure it out yourselves. If you really take your cities in your state or area and look around at the wide channels-- For instance, I was looking to somebody recently for channels in Florida, and I believe it is in the plan for only three cities. If you will look at the channels for those three cities, you will find Channels 3, 6, 9, 10, 11, and 12, which are not even assigned to Florida. You can usually figure it out yourself, but if you care to write to us, we will make suggestions wherever we can. I also might say that the answer may be that there are no more available.

MR. HOUSTON: I would like to ask if the Commission would care to comment on the satellite or booster stations. Apparently there are two principal uses: one, the possibility of using the booster to fill in on a very sharp directional in a populated area; and the other, the use of the booster to extend the service of a small station in a community that you would expect you would have a right to serve.

MR. STERLING: Your question is directed at the use of standard broadcasting?

MR. BARR: There is very little comment I can make about it, except to say that the Commission is somewhat concerned with the increased demand for booster or satellite stations in connection with principally extending service of a station to adjacent towns and areas which they did not contemplate serving when they got the original stations. They determined sometime ago that in face of the demand for new stations, unprecedented since the war, this business of boosters raised a number of problems. Among them were such things as that one town has a radio station and a little town twenty miles away, outside their service area, they go over and service too. There is no limit to which a policy like that could be carried, so they decided to withhold action on booster and satellite stations. In special cases, I think, that came up at a time when some engineer conceived an idea of a station to fill a particular need, they were more or less for some experimentation along those lines, and the Commission authorized very few of them in Washington. We have the WBT situation.

Recently in Charlotte, in connection with carrying out the allocation plan for WBT on 1110 kilocycles--it was set up in 1937 and was not carried through until fairly recently for one reason or another, the war primarily, and other reasons before that--the result was that they had to take away nighttime service, and since they have been serviced for a number of years, there was very concerted action to fill that gap. We did not exactly require, but did make a positive suggestion to the station, that they give thought to a booster. That has been put in. We have not had a report on its operation; we are expecting one. We do not know how satisfactory it is going to be. The booster station in that case is located about fifty miles, I believe, from its main transmitter. They do have a number of problems, but it does provide some limited degree of service. I do understand that there are some problems that they did not contemplate.

CHAIRMAN HOWARD: Any questions on that subject? We will consider that question closed, then.

MR. OWEN F. URIDGE [WJR, Detroit, Michigan]: As you know, Windsor is located across the river. There has been some thought of going over there and handling a remote television broadcast. What is the regulation on that procedure that you have to follow in order to broadcast from a foreign country? [Laughter]

MR. PLUMMER: That is a good question at the moment. Unfortunately I am not prepared on that. We have had that situation, though, for a number of years with the remote pickup equipment for the standard FM broadcasts, and I believe that if there is any international arrangement necessary we can arrange to exchange notices with the Canadian Government. At the moment I do not believe the problem has ever been, you might say, thought of or even investigated. Have you any comments, Cy, on the remote pickup equipment situation?

MR. BRAUM: I do not recall any similar situation either, but I think that if you got the approval of the Canadian Government and told the Commission, we could send you a letter authorizing such an operation. I am not sure about that.

MR. STERLING: I would expand on that just a bit, because we have been confronted with the problem with regard to the general mobile service in which you have subscriber automobile equipment in your car when you want to go on a tour. Some arrangements have to be made so that you can talk while you are in Canada and Mexico too, so we are now negotiating with the State Department, having for the purpose some change or new rules which would take care of operations beyond our international borders in those cases. I hope we will have some solution and some release on that in the not too distant future. Of course, it would be applicable to any service.

CHAIRMAN HOWARD: Does that answer your question?

MR. URIDGE: Yes.

MR. HOUSTON: I would like to ask the members if they would care to comment on the operator requirements for the new licenses about which we have been hearing.

MR. STERLING: The operator announcement that we got out surely started an avalanche of protests. I think we perhaps received two chaps who were willing to go along with what we contemplated, but everybody else was opposed to it. I was very much interested today in both Mr. McKey's talk and Mr. Adair's, because they both touched on that subject, which was pretty close to this operator problem. You know, we considered in our public announcement-- We are contemplating the broadcasting engineer-operator. There is surely a justification for such a license. We are preparing to send out into the field a task force of our top-flight engineers to make our own proof of performance tests on directional antennas in addition to making frequency runs and other technical analyses of the performance of stations. I have been reliably informed that some of these consultants in Washington and other places have been unable to make some of these directional arrays, and the owner of the station has been forced to hire somebody else to place it in operation, make it conform in accordance with the authorization.

It is quite obvious that when we have this task force in the field they can make operations that we cannot make for the station owner to fly in with a consultant from Washington to have corrective action taken. We expect action right then and there, and it should be the duty and responsibility of the station licensee to see that corrective action is taken, and he should have a check on his staff of who is capable of making those routine checks, as Mr. McKey pointed out here today, to be sure that the array is performed in accordance with the authorization, if he wants to keep his record clear and free of citations.

I am not sure what action we might have to take. Already one sampling job that we have done showed one array 300 per cent in excess of the authorized field. I think that alone would justify, Mr. Houston, the first classification of the engineering phase. I think too that with the other advancements that have been made in the art there is no cause for question there. I think most of the criticism has been leveled at the operator because of lack of proper information on the third category, the operator class of license. I think everybody gained the impression that that license was going to be this operative permit. It is definitely not so.

A technical examination will be required to obtain a license if we should adopt this plan. It will require knowledge of certain of the characteristics of modulation and oscillators, frequency stability, and all those things that will be a graduative process. You have in the professions various degrees of standings. In the medical profession you have your internship and you have your general practitioner and you have your specialist. In the trades you have your journeymen, you have your masters. We think that this plan has considerable merit, once it is understood.

I think the other thing that is giving the most concern to the license holders in the field, the licensed operators, is what recognition we are going to give them with respect to what they hold. Obviously, any new plan of that sort must have a grandfather clause. We are open for suggestions on it. In the first instance should we, since we are going to have a license which, as we pointed out--Mr. Adair made mention of it--states that a man is qualified to operate a television station-- Obviously, the man who employs him in good faith expects him to be able to operate his station and have sufficient knowledge of the rules and regulations of the Commission and what is required in order to keep that station operating, maintaining it in the best interest of the licensee, so that he can render to the public the service they expect from his station.

I have been toying with the idea of just, (if I may use the expression loosely)-- I have not come to a final decision in my own mind as to how much of this we should recognize. To that extent I would like expressions from the operators, unions, and the fellows who hold the licenses. Should we recognize all who hold first-class licenses; should we give them, upon expiration of their licenses, the next high grade of license, or should we require that they have some service? Or, if we do not, rather than give them the high class of license, should we require them to take an examination in lieu of having the necessary service in order to obtain the next high class of authorization, that is, the engineer class of license?

MR. HOUSTON: Thank you. Would it be in order to ask who was opposed to the new licensing system?

MR. STERLING: As I stated, of the replies that we of the Commission have received from the unions speaking for the licensed operators and individuals speaking for themselves, I would say that 98 per cent of them are opposed. I can only find three or four letters in the whole batch that we have received from people who think that our plan has merit.

MR. HOUSTON: It is hard for an individual to oppose when the license gives him permission to operate on a job that no one else can have.

MR. STERLING: I would not want to debate the labor relations thing at this time, because it is a question where, no doubt, we will either hold a hearing or we will go to-- I think myself that much can be accomplished by informal conferences with the operators at one time and the representatives of industry at the other. I do not think much would be accomplished if they both came in at the same time. [Laughter]

MR. GLENN D. GILLETT [Consulting Engineer, Washington,

D. C.]: I am concerned with Mr. Sterling's comment that he feels that the chief engineers should be competent to make adjustments in the directive antenna, right-on-the-spot-testing. We have found that in about half the cases the worst fault of the directive antenna's performance is the desire of the local engineers to monkey with the dials. All a directive antenna does-- In many cases we have adopted the procedure of actually soldering the adjustments to the coils, because ordinarily the antenna is much more reliable than the engineer. I do not mean than unkindly, but it seems to be a habit of all engineers to wish to see what happens. They monkey with the adjustments.

We feel that where we go in with our engineers and make adjustments, then swear to the fact that the antenna is performing as we have measured, in so far as possible those adjustments should be fixed beyond peradventure of doubt. In most cases the antenna will stay put without difficulty. If you expect to hold an engineer responsible for his group performance, which he has made under oath, you should not, then, allow quick changes by the local engineer, who in a number of cases is thoroughly competent and in a number of cases is not competent, even though he is a very competent maintenance and operating engineer doing an excellent job in the station for which he was hired.

MR. STERLING: Mr. Gillett, two questions come to mind. One, of course, is, What should the Commission expect when its own engineers go out and find an array not meeting the requirements? Secondly, putting it in the interrogative form, Do you think that if we come up with an examination sufficient in scope, those men whom we authorize by this license to do that kind of work can do it adequately?

MR. GILLETT: If the license examination is sufficiently steep, I think that it is true, but I do not think you will find, and I do not know that the industry can properly be expected to support in an operating position, a man with technical ability and require him to adjust these more complex antennas.

MR. STERLING: Then will you answer my first question, please?

MR. GILLETT: I do not see any other out, except that if you do find an antenna that is out, you should put the station on notice, and they should be expected to do something quick. I do not mean today perhaps, but within a few days. Certainly the engineer who is responsible for the design is then under obligation to send a man out there without delay, without excuse, to check thoroughly and find out what has happened.

MR. STERLING: May I direct this question, in view of the wide experience that George Adair has had in this field, both with his knowledge on the industry side, and I know he has had experience before he came to the Commission. I wonder if he would comment on the points I have made with regard to this performance of the direct array and the responsibility of the licensee to the Commission.

MR. ADAIR: It would seem to me that when we get into requiring the engineer-operators to readjust the antennas, they should be able to bring it back to the point where they were, but you also have to have the proper margin of equipment to know when they are right and when they are wrong.

As to Mr. Gillett's comments on soldering the leads, and so on, I think it is possible to do that in some cases, but in others, where it changes from tide and conditions throughout the year may throw them out some, there has to be some adjustment. It may be that the major adjustments can be tied out, only leaving certain adjustments to bring them in.

I believe that we are getting into a more and more complex situation with all these directions, in which it would take quite a bit of cooperation in order to keep them that way.

With respect to that station that was out 300 per cent, it would appear to me that due to poor operation or original adjustments or what--

MR. STERLING: We have not received the final report on that, and I cannot comment on that, but I think one of the outstanding things about it, as I recall the circumstances, was that the engineering staff did not have the equipment or had no one to take the steps to make a determination that it was performing. That is the big responsibility that has been passed over. Too much has been taken for granted.

MR. ADAIR: They did not have the proper monitoring equipment.

MR. STERLING: I am not sure; I have not read the details of the general aspects of the case.

MR. JOHNSON: I think the comments about the monitoring equipment were most pertinent. Possibly it is one of the duties of the Commission to set up standards of monitoring equipment just like you set up accuracies of meters, phase monitors, and so forth; then it is the station's duty to maintain those readings. If their personnel is not technically sufficient to do that, then it is their duty to get in a consulting engineer to do it before the Commission catches them in improper operation, much the same as any other technical violation.

MR. STERLING: I wonder if we could have some comments from Mr. McKey. He gave a very learned discussion on that subject this morning.

MR. McKEY: I think when we started this thing Mr. Gillett was a little confused on the exact question that he raised as to whether the departure from the array pattern was something that had never been pulled in or whether it was something that had taken place a considerable length of time after the adjustment had been made. I quite agree with him in his concern of holding a consulting engineer responsible for a departure of that type, when a considerable period of time has gone by since the original performance was made, and also the fact that a station has no equipment for checking it. If the maintenance is poor, we will get changes of that sort. I think Glenn will agree with me, that if the maintenance is poor-- When I say maintenance, I mean what we might call screw-driver maintenance, that is, the tightening, the cleaning, the things like that.

In some of these low-value fields that we have 300 per cent sounds like a great deal, but in some cases it would not take very much to be that far off. I am of the opinion that that could come from lack of maintenance, as well as mis-adjustment in the original setup. I quite agree with Glenn, and I feel also concerned if, as consulting engineers, we are going to be held responsible for that sort of thing, because we have no way of insuring against it other than, as Glenn suggests, soldering connections. I just do not hold with that, and certainly I would rather keep away from it, but we might be forced to it. Do you agree with that, Glenn? I definitely concur in the monitors.

MR. GILLETT: I can stick my neck out again, because I believe that the engineer who designed the antenna and who adjusted it is also responsible implicitly to his clients to design an antenna that will stay put with reasonable maintenance and supervision, so I am not too willing to step out of the responsibility merely because it has been a year since the group performance was made, if the antenna has not been tampered with. On the other hand, it is true that careless maintenance, lack of maintaining pressure on concentric lines, and such, can throw it out. I think that in these cases where there are deep holes of a few per cent, 10 per cent, 5 per cent, some of them now 1 per cent, of the RMS fields, it is then obligatory on the station to make weekly inspections as to whether they are staying put as predicted and as in group performance. If they are not, then they should be held responsible for either calling in their consultant or notifying the Commission that they themselves are adjusting it to bring it in. But certainly a station has the obligation to keep on enough equipment and personnel able to operate it to know whether the directional is performing as predicted.

I am in favor of having a station held responsible for getting enough equipment to measure the field strength regularly at the monitoring equipment, and if it is out of performance, they should call in a consultant to find out what is happening. I do not think you will find it very successful to have an engineer who is not familiar with that problem try to make the adjustments and pull it back in. On a multi-element antenna the computations are so large that the guesswork becomes infinite if you do not know why it is supposed to work that way.

MR. McKEY: I most certainly concur with you on that, because it merely follows along the line that I covered in my talk today, and I have gone right down the line with you. I think that in some of these arrays that we have today, particularly on some of the channels, conditions are getting so crowded that if we do not keep these things lined up we are going to have chaos. I think that this thing is very, very serious, and something is going to have to be done about it, because we have so many arrays, as you say, with five and ten million volts.

MR. GILLETT: We have, but there have been some designed--

MR. McKEY: And there are some authorized. They are going to be a problem unless proper maintenance is maintained.

MR. GILLETT: My feeling on those that are so very tight is that not only should they have to have measuring equipment, but they should have constant monitoring points with the monitoring field back to the transmitter with recordings on it to show how it stays there. The burden of proof is, then, that the proof of the performance is taken, but it stays right.

MR. STERLING: The number of standard broadcasting stations having direct arrays is probably 50 per cent. I would like to have the Chief of my Broadcast Division, Mr.

Barr, comment on this subject. [Laughter]

MR. BARR: I do not know whether there is anything that I can add to the discussion. It started off, I think, with the operator problem. [Laughter] Mr. Gillett questioned the wisdom of attempting substandards or the operator requirement of placing an engineer-operator in charge of every station with directional antenna and of saying that the engineer-operator ought to have qualifications for making necessary adjustments that are needed. Whether we can go that far at this time in one big swoop and let the operator have an equal status, I will not comment on my feelings in that regard. I think that it is time to look toward raising the standards for operators. Certainly the stations are standard broadcasting stations, and their operation and maintenance require quite a bit more technical knowledge and understanding of problems than we were concerned with some ten years ago.

In line with that advance introduction of new types of modern equipment we are justified, I think, in raising the standards for the operators. I am in agreement with what everybody said, that maintenance of these records is highly important, and I think the answer lies in a number of things, the use of the best equipment for these monitors. We do not have any requirements yet requiring the installation of monitors, the installation of remote reading intensity sets, except in some specific cases where the antenna system, we think, is obviously on the face of it a rather tricky array as proposed and is going to require more than ordinary maintenance, and we do attach stipulations requiring phase monitors and sometimes requiring that a field set be maintained on the premises and that they periodically go out and make checks. I think that all the station licensees would require it if more thought were devoted to setting up requirements, whether or not they are required by the Commission.

The solution, in my opinion, lies in maintaining operation, possibly raising the standards of operators, the use of monitoring equipment and federal strength sets more than has been the practice, and the adoption of some routine maintenance checks such as Mr. McKey has suggested.

CHAIRMAN HOWARD: Thank you very much. It is getting very late; it is after six. Unless there are questions, I think, which could probably be answered yes or no, we shall consider adjourning. [Laughter] Are there any yes-or-no questions in the house?

MR. JOHNSON: Is the Commission now considering the adoption of any standards for phase monitors?

MR. BARR: No, there are no such rules under study.

MR. RIBEN: Are there any regulations of the telephone companies to serve a station on FM telephone service? We had to wait over five months in order to get a fifteen-kilocycle line. Then our telephone company finally called us and since then--this was the middle of last month--they still have not come out to finish up the job which they were supposed to finish up. Isn't it the telephone company's responsibility to maintain that fifteen-kilocycle station?

MR. BARR: That would be a matter between the licensee and the telephone company. I should think the Commission would not enter into it at all.

CHAIRMAN HOWARD: I think we will adjourn now.

[Announcements]

CHAIRMAN HOWARD: I want to thank all of you for your attendance today, and please pardon the delays. In signing off this program I wish to express, on behalf of NAB, our deep appreciation to all of the participants of the Federal Communications Commission and the industry boys. We will see you, possibly, out on the West Coast next Friday. Thank you. [Applause]

[The Conference adjourned at six-five o'clock.]