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Lohr Presents NBC Case at Allocation Hearing

Lenox R. Lohr, president of the National Broadcasting Company at today's allocation hearing before the Federal Communications Commission discussed the economic and social aspects of the case as they appear to his company. Arthur Van Dyck, engineer in charge of the RCA License Laboratory, also presented a statement on behalf of NBC in which he supplied facts concerning the performance of receivers in the home today.

Paul M. Segal, counsel, and Raymond M. Wilmotte, engineer, also appeared on behalf of the stations on the 940 kilocycle channel.

During the course of Mr. Lohr's testimony he recommended that the period of broadcast licenses be extended to three years, the maximum permitted under the law. He also suggested that the Commission take no action which would limit the existing capacity of clear channel stations "or preclude the development of a better and more extensive service by them."

Mr. Lohr recommended also that regional station power be increased to 5 kilowatts for both day and night and he further suggested power increases for local stations "whenever the engineering and economic factors warrant the use of such power."

Lenox R. Lohr

Mr. Lohr said:

It is my purpose in appearing before you today to discuss some of the economic and social aspects of the tremendously complex problems with which these proceedings deal. Before doing so I want to make clear that I speak only for the National Broadcasting Company, and the stations which the National Broadcasting Company is licensed to operate. We have not been authorized by any affiliated station to present its case to you nor have we joined with any other station or group of them. Of course, none of them have purported to speak for us.

In its preparation for this Conference the National Broadcasting Company's objective has been to express its opinions in the form of specific recommendations wherever possible. At the conclusion of the Conference, you gentlemen will have before you not only our specific proposals but many others representing widely divergent views. If you adopt some you must reject others. And, in the process, each proposal will be subjected to the test of whether its adoption will serve the public interest, convenience and necessity. Because our suggestions reflect our interpretation of the phrase "public interest, convenience and necessity" I would like to set forth, necessarily in general terms, what we conceive to be the connotation of these words.

First

We believe the term implies that *the dominating influence at this proceeding must be the welfare of the listener.* We place this requirement first, both in position and importance, because the welfare of the listener may be too easily subordinated in some of the differences of opinion existing between stations or groups represented here today, merely because the listener himself is not present and is therefore inarticulate.

Not Altruism

We would not have you believe that the National Broadcasting Company's concern for these listeners is one of pure altruism. We do want to impress upon you that National Broadcasting Company's only business is that of broadcasting; that our planning and thinking are based upon the premise that we will be in it for many years to come; and that, in the long run, he who serves best, profits most, in this business above all others.

There are two methods by which broadcasting may be conducted. One is to compel the listener to subscribe for the service and to discontinue it when he ceases to pay. That is the foreign method.

The American system of broadcasting differs in one marked respect so extraordinary as to be unparalleled in any other business or in any other country—its listeners support it voluntarily through their purchases of radio advertised products. Their good will is the National Broadcasting Company's most valued and vital asset; upon our ability to retain it depends our very existence. Their welfare cannot be an academic matter to us.

Second

We believe that the term "Public Interest" means the welfare of *all* listeners throughout the United States.

It is unnecessary to tell this Commission that, from a narrow business viewpoint, it is easier and usually more profitable to render broadcasting service to those areas where there is heavy concentration of population. Sparsely settled areas are not only more difficult to serve because they require greater power, with larger capital investment, but this service is frequently less profitable. Unfortunately these sparsely settled areas are also the areas where there are fewer theaters, newspapers, schools and other sources of entertainment and information. They are the areas where broadcasting means the most. We believe that these considerations must be accorded weight in deciding how much and what kind of service rural listeners are entitled to receive. And in this connection we ask you to note that the recent amendment to the Communications Act declares it to be the intent of Congress that all the people of the United States be given *fair, efficient, and equitable* broadcasting service. The standard is not merely one of *equal* service.

Difference of Opinion

It is no more than natural that there should be differences of opinion among the various parties represented at this Conference as to what constitutes a fair and equitable distribution of radio service to all the people of the United States. The American System is based upon competition and competition engenders divergent views. Each individual station owner competes with his neighboring stations for audience and for advertising. He competes with others more distantly located for increased power, a better frequency, or some other advantage which will permit *him* to improve *his* service to *his* listeners and thus to increase *his* net profit from operations.

We would not have you believe that National Broadcasting Company is immune to these influences. But we do want to emphasize that for many years we have supplied programs to outlying stations, frequently at a monetary loss, in order that our service might be national in scope. The National Broadcasting Company relies for its support upon *all* listeners throughout the country.

Third

The term "public interest" means high quality programs. The American audience has become accustomed to a broadcasting service which, for eighteen hours a day, day in and day out, supplies programs which could not possibly be originated in any single city. Our talent resources are, literally, those of the entire world. Programs of the character, quality and diversity which we now regard as commonplace could not be broadcast by any single station or for any advertiser using a single station. But tbey can be built for release over a network of stations—and the larger tbe network tbe larger the audience and the better the program can be.

This practice of syndication not only brings a wealth of fine program material to all parts of the United States, but it has made American network programs the finest in the world. Nearly half the stations which you now license to operate receive some sort of network service eitber from a national or sectional network. These stations and their network programs constitute the cornerstone of American broadcasting.

Fourth

The term "public interest" means signals of sufficient intensity to permit satisfactory reception. It is not remarkable that the high quality signal of a few years ago has become the unsatisfactory signal of today. Neither is it mere coincidence that high-quality programs and high-quality reception almost invariably go together. No matter how strong its signal may be no station will retain its audience against present day competition unless it furnishes an attractive program schedule. By the same token, however, unless the station is able to deliver its programs to the loud speaker sufficiently free of interference from other stations, and sufficiently above the noise level of its community, to render an acceptable and enjoyable service its listeners are not receiving the maximum service which it is possible to give them.

Finally

The term "public interest" means an industry operating upon an economic foundation strong enough to carry these current obligations and to provide resources for the laboratory development of tbe radio to tomorrow.

The history of broadcasting is that of an industry existing in a hand to mouth fashion, under six month licenses, against a background of constant change and rapid obsolescence. Some stations favorably located have rendered excellent service and returned substantial profits to their owners over a long period of years. Some, particularly those having limited hours or operating at some other competitive disadvantage hang on from week to week in the hope that a miracle will eventually bring a sufficiently increased income to justify their existence.

In the long run, most of the economic problems facing this industry must be decided by the owners of stations themselves. But it is obvious that to whatever extent undue economic burdens are imposed upon tbe broadcaster by regulations, to that same extent must his capacity to render service suffer. Or, by exercising your regulatory power wisely, you can bring about an ascending spiral wherein the industry, built upon sound economics, supplies better programs through better stations to a better satisfied public and thus become increasingly prosperous itself.

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Service to Listener

So much for our interpretation of the words "public interest, convenience and necessity." Because it is predicated upon service to the listener and is national in scope, and therefore coextensive, geographically, with the Commission's own sphere of jurisdiction, we feel that it is one with wbich the Commission can properly agree.

May I call to your attention the fact that next month the National Broadcasting Company completes ten years of national network operation. All that anybody knows about nation-wide network service bas been gained witbin that single decade. We have obtained a fairly good idea, I think, of what the American listener wants and what he may reasonably expect to get from his loud speaker.

Ten years ago there were 5,200,000 receiving sets in use in the United States. By the end of this year there will be approximately 30,000,000. In proportion to population Europe has about one-fourth as many. America's six-fold increase in ten years is attributable, in a large measure, to the excellence of American network programs. At the same time there could hardly be a more persuasive indication that the policies and the fundamental engineering principles for the allocation of broadcasting stations, adopted in 1928, were sound.

Not only has the American radio audience continued to increase every year through prosperity and depression but every single year this audience has given the American system of broadcasting tbe finest possible endorsement—a constant and continued willingness to patronize broadcast advertisers. From time to time the size and satisfaction of our radio audience under the American system is explained away. We are told that the intellectual level of these listeners is not very bigb and that tbey lack powers of discrimination and critical analysis. We urge you not to rely too heavily upon any such explanations. In working out your problems you can still tie to one fact above all others—tbat it is not yet possible to fool all the people all tbe time.

Development of Industry

In the development of the broadcasting industry, National Broadcasting Company's interest has always been a dual one. On the one hand it operates stations some of which are clear channel stations, others regional and one a part-time station. On the otber hand our networks include not only our own stations but a much larger number of stations, independently owned and operated, which are associated with us. Eacb, we believe, is rendering a public service of a high order within its own sphere.

We have given serious consideration to tbe possibility of improving service througb a general reallocation of all station assignments such as took place in 1928. In many ways the prospect is more intriguing to us as a network than it can be to any single station. If it were possible to rearrange tbe power and frequency of all stations so as to bring about a network in which the service areas of the individual stations would fit together like the pieces of a jig-saw puzzle most of our present problems would be answered. Notwithstanding the fascination of this prospect, in the end we have been compelled to return to the point from which we started out—that tbere are some 680 stations and not more than 100 channels for their operation. You may divide and subdivide, shuffle and reshuffle these stations and channels in an infinite variety of combinations. In the process you may improve some stations but inevitably what vou give to one must be taken away from someone else. We perceive no substantial benefit to the public as a whole or to the industry which could be accomplished by any such reallocation.

We do not mean to imply that the present system is so perfect that there is no room for progress or that we do not anticipate many adjustments in the future. We do say that it should not be changed unless the public will profit substantially thereby and that a heavy burden of proof rests upon tbose who advocate changes in the fundamental structure.

Increased Power

We consider that the most important single issue before all stations today is that of increased power. Since its earliest days power has been the outstanding controversial issue of the industry —there bas been more misinformation available upon it than upon all other subjects combined. Your records of past conferences are filled with the fears of false prophets who deplored increases in power but who failed to stay the progress of the radio art.

There are two valid objections to increased power. One is an engineering objection—that of actual physical interference. Our engineers have already given you our views as to what should be considered serious objectionable interference.

The otber is economic. In most instances increased power will necessitate substantial expenditures for new equipment. We believe that it would be unwise and unduly disturbing to the industry for you to require large expenditures for this purpose by any class of stations at this time. And in using the word "require" we mean to include not only affirmative mandatory regulations but also any action which would permanently penalize the station owner who fails or is unable to install higher power upon short notice.

Satisfactory Evidence

Your present practice is to require that each applicant who comes before you seeking increased power shall present evidence satisfactory to you that he bas adequate financial ability to incur the increased operating expenses involved, including depreciation, without jeopardizing his economic ability to render service. We see no reason to change this requirement. What shall be considered adequate financial responsibility must be a question to be determined upon the facts in each case and therefore, the only standard we can suggest is that of reasonableness. We do think that the prospect of increased profit subsequently is not a complete justification for the grant. Considerable weight should be attached to the applicant's ability to prove that he has been able heretofore to do something more than merely to balance his books.

There are no valid social objections to higher power. You bave been told that if you authorize bigher power on some stations it will enable tbem to deliver satisfactory signals in areas not now served by them and that, because tbeir program service is superior, these higber powered stations will attract listeners who must now be content with something less. This has not been the experience of the industry. On the contrary, it has been our experience, and that of the receiving set manufacturers, tbat wben broadcasting service improves in any community the interest of that community in all broadcasting increases proportionately. Moreover, higher power will not come over night. It will come gradually and will be assimilated over a period long enougb to give each station an opportunity to readjust its metbods of operation and to find its proper place in tbe economic and social structure. In any event, it is no answer to protect a station thus affected by depriving the listening public of a superior service. The solution is to improve the service of the smaller station. To that end within the past few years the National Broadcasting Company and otbers have undertaken to supply recorded programs of high quality at relatively low cost.

Now as to our specific recommendations:

First—We earnestly recommend in the interest of economic stability for tbe industry that in your new regulations you lengthen the license period for all broadcasting stations to tbe three year maximum permissible under the law.

Second—With respect to the continuance of clear channels your record will disclose that upon the forty frequencies designated as clear channels in 1928 fifty stations were licensed to operate, each as a dominant clear channel station. In order to bring about this result the Radio Commission required twenty stations to share time upon ten channels. On the whole the past eight years have demonstrated that part time operation of this sort is not successful eitber from the listeners' standpoint or for the station operator. In some instances the stations bave worked out their own salvation by joint use of a single transmitter, synchronization, directive antennas, or some other means. A number of the stations still operating part time on clear channels have asked that they be permitted to submit a plan to the Commission whicb will give each of these stations full time operation and they propose that a hearing be held upon such plan. We believe such a hearing should be held and an earnest effort made to find a solution to the problem.

There remain out of the original forty clear channels some twenty-five or thirty upon wbich progressive forward looking stations are being operated today. Their value as a means of service to rural listeners has been reaffirmed by the recent Clear Channel Survey. We recommend that your Commission take no action which will either limit the existing service capacity of stations of this type or preclude the development of a better and more extensive service by them.

Third—With respect to the power of clear channel stations we recommend tbat your regulations be revised to remove any limitation of maximum power to be used by the dominant station upon these channels. Having adopted regulations of this sort we recommend tbat each individual application be considered and acted upon with due regard for tbe interference problems and the economic justifications which each case presents. Following this reasoning my Company has concluded that at one station, WJZ, 500 kw power would be desirable when measured by the standards referred to previously.

Fourtb—With respect to power on shared channels we recommend increases in power for regional stations to 5 kw, day and nigbt, and we recommend increases in power for local stations whenever tbe engineering and economic factors warrant tbe use of sucb power.

Fifth—Witb respect to differentiation in the maximum power permitted in the daytime and at night we see no objection if the benefit to be derived from the greater power justifies the expense of maintaining the added equipment.

I want to add just a few more words upon the possible future use of frequencies in the band above 30,000 kc for aural broadcasting and for television.

For tbe past several months the National Broadcasting Company has been operating a transmitter at the top of the RCA Building in New York City with power of 100 watts on a frequency of 42,000 kc. Tbe details of these experiments have been made known to you in the reports whicb we have submitted. I want to add to those reports the general comment that for the most part the results of this operation have been highly gratifying. However, our engineers have encountered some difficulties with which we do not have to contend in the present broadcast band. They have found that while ultra high frequency signals are relatively free of natural static, man-made noise, from automobile ignition and diatbermy machines for example, is much more objectionable. We think it very probable that sometime we will be rendering a service of greater fidelity than at present to urban audiences through stations operating in that part of tbe spectrum above 30,000 kc. Before we can do so it will be necessary for all these listeners to purcbase receivers designed for the new service. Obviously, this will not come about over night.

Television

The National Broadcasting Company's views with respect to television are derived from experience which we have gained through operating experimental television stations continuously since 1928. For the past several months we, in cooperation with other RCA Companies, have been operating a new television transmitter from the top of the Empire State Building in New York City as part of a practical field test. We now have in daily use some seventy receivers of standardized design most of which have been placed in homes and are operating under service conditions. We have designed and built tbe first studios for the production of television programs. Not only has there been substantial progress within the past few years in television and facsimile, but that there is likely to be greater progress in the next few years. Here again, however, it will be necessary to re-equip tbe public with entirely new receiving facilities.

High Frequencies

We have discovered notbing in our investigation of ultra high frequencies, either with respect to sound broadcasting or television, wbich would militate against the recommendations which we have made here for stations operating between 550 kc and 1600 kc. We believe that the American audience is going to continue to receive its aural broadcast service upon present frequencies for several and perbaps for many years. Our proposals have been made with a view to giving the best service that it is possible for this audience to receive.

In conclusion may I repeat for the purposes of the record in this proceeding, the announcement which was made when the National Broadcasting Company was organized:

> "Any use of radio transmission which causes the public to feel that the quality of the programs is not the higbest, tbat the use of radio is not the broadest and best use in the public interest, that it is used for political advantage or selfish power, will be detrimental to the public interest in radio, and therefore to the Radio Corporation of America."

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> "If others will engage in this business the Radio Corporation of America will welcome their action wbether it be cooperative or competitive."

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> "The necessity of providing adequate broadcasting is apparent, the problem of finding the best means of doing it is yet experimental. The Radio Corporation of America is making this experiment in the interest of the art and the furtherance of the industry."

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Stumps To Be Pulled

That announcement dates back ten years—to a time wben there was still many stumps to be pulled and many rocks to be blasted in the field of broadcasting. The industry has now reached a point where there is plowed land available for cultivation. And the paramount issue before this Commission is wbether we shall continue the process of clearing new acres.

On this issue the National Broadcasting Company takes tbe same position that it took in 1926—its purpose is still to develop and not to exploit broadcasting. If ten years of experience bave proven anything to us they have proven that the public interest is also the best interest of tbe National Broadcasting Company, its advertisers and its associated stations. If higher power, which is one of tbe problems before us today, means better service to the public tben let tbere be bigher power. If it produces hazards to our present methods of network operation then let us adjust our methods to meet the public interest. The art must be allowed to develop along progressive lines and always in the fullest measure for the best interests of the public. No responsive Government agency can do more than tbis—none dares do less.

Lohr Cross-Examination

At the conclusion of Mr. Lohr's testimony he was given a short cross-examination by T. A. M. Craven, chief engineer of the Commission. Answering questions of the chief engineer, Mr. Lohr stated his experiences up to the time he went with the NBC and indicated that he had only been president of NBC for something less than two years. However, he stated that he thought he was beginning to understand some of the problems of the broadcast industry.

Mr. Craven during the course of the cross-examination several times referred to the possibility of thirty 500 kilowatt stations but Mr. Lohr doubted he said whether there would be that many in the near future. However, he said that in his opinion the effect of the creation of high power stations would be beneficial to the country. Mr. Craven called his attention to the fact that there are now pending before the Commission 14 applications for 500 kilowatt stations and be suggested that there might be more; possibly 20. Mr. Lohr said that undoubtedly each application should be decided on its own merits. The broadcast industry, said Mr. Lohr, can certainly take care of 500 kilowatt stations as well as new developments in the industry.

Answering further questions of Mr. Craven, Mr. Lohr said that the chain renders a national rather than a local service and it should cover as many people in the United States as possible. If thirty high power stations were in existence he said that he was informed by his engineers that the primary coverage would be extended only 25 to 30 miles. In his opinion, said Mr. Lohr, use of 500 kilowatts would be a technical advance and if thirty 500 kilowatt stations were constructed that the NBC would undoubtedly keep substantially its same network.

Interference With Locals

In connection with the effect which 500 kilowatt stations might have on locals Mr. Lohr said that there probably would be a few cases in which the local stations would be affected but he contended that the matter should be looked at from a long range standpoint and the greatest good to the greatest number. He said of course in his opinion there must be local means for local self-expression.

Mr. Lohr admitted that tbere is an international problem in connection with high power stations and in answer to questions by Commissioner Stewart he contended that the Commission would have to decide for itself the number of 500 kilowatt stations which any one person should own or control; that he believed 500 kilowatt stations should not be required to originate their own programs; and that the question of overlapping programs by high power stations must be decided by the Commission.

Arthur Van Dyck

During the caurse of Mr. Van Dyck's testimony today he took up the receivers now in use, a discussion of general considerations of broadcast receivers, and classes of interference. Mr. Van Dyck also discussed at some length the method of measurement and entered into a discussion of various kinds of interference. In summarizing his conclusions Mr. Van Dyck said:

Identifying subjects by the same numbers used in the Commission's Notice of Hearing, the following summarized conclusions are submitted.

6 (a) *Frequency Separation*

From the quantitative conclusions tabulated above it is seen that the most serious interference limit resides in the 10 kc. heterodyne beat condition, and it is the determining 10 kc. factor rather than the 10 kc. cross talk. At lesser separations than 10 kc. this factor becomes increasingly worse and intolerably limiting.

6 (b) *50 Kilocycle separation between stations in same community.*

From data presented it appears that the improved receiver selectivity existing today could be used to advantage in either reducing separation of stations in the same community to 40 kc, or by maintaining the 50 kc. separation and permitting higher field intensities. From the results of the clear channel survey conducted by the Commission, the latter alternative is obviously preferable, since it gives improved service in rural areas without causing objectionable interference close to the transmitter.

6 (c) *Mileage frequency separation tables.*

In spite of the fact that the broadcast system determination of overall performance involves consideration of numerous factors, it is possible to set up tables showing relations between essential factors, which will take satisfactory account of the great majority of allocation problems. There will of course be special cases where general, average condition tables are not suitable, but in the main, and used with discretion, averaged tables can be highly useful.

We therefore believe that suitable tables may be set up if appropriate standards are utilized for their preparation. The standards must include those for wave propagation, including factors of attenuation, transmitter power, antenna efficiency and directivity, and those for receiver performance including selectivity, fidelity, percentage of receivers which may experience interference, and the lower limit of field intensity from desired station necessary to protect.

It is believed that the frequency separation tables now used by the Commission can be reviewed and revised with advantage, in view of the additional and later data submitted herein, which was not available at the time when the present tables were set up.

6 (d) *Permissible disparity in power between stations on adjacent frequencies.*

This is merely one particular case of the general problem of allocation as influenced by frequency separation and relative field intensities. The data which has been given herein, together with propagation data, can be used to determine the performance of stations on adjacent frequencies with any disparity in power, and the permissible disparity determined therefrom for any given case.

7 *Blanketing Signal.*

The present Commission definition blanketing signal is believed to be satisfactory in general, except that where it is expressed in terms of area and an average broadcast receiver, it might be expressed more usefully in terms of signal intensity and receiver percentages as used in the data presented herein. In these terms, and imposing the reasonable conditions that the desired signal intensity be five millivolts per meter, and frequency separation be fifty kilocycles, a blanketing signal is one which causes interference in more than 20% of existing receivers, as determined from standard performance curves.

From this fundamental definition it results that for receivers existing in homes today, a blanketing signal is one having field intensity of 1,000 millivolts, or one volt, per meter.

Mr. Van Dyck will be cross-examined at the opening of tomorrow's session.

Paul M. Segal

Mr. Segal on behalf of the stations on the 940 kilocycle channel said that they would offer no specific amendments to the Commission's regulations.

Mr. Segal said:

I want to begin by saying that the 940-kc. stations, whom I represent in this matter, are proposing no specific amendments to your regulations as to any named frequency, nor is it our purpose to discuss individual stations or frequencies. Rather we intend to confine ourselves to general considerations.

Paragraph 120 of the Rules and Regulations establishes a classification of regional frequencies allocated for use by regional stations. It designates the frequencies so classified and prescribes that the operating power of such stations shall not be less than 250 watts nor, during nighttime, greater than 1000 watts.

Among the matters to be considered at the present conference is the question whether or not some change is desirable in this classification so as to permit greater power during nighttime upon some or all of these frequencies.

I assume that anything in the character of an engineering study of this question which has been conducted with care, and which can be presented in detail would be acceptable as helpful to the commission in its labors.

For some years there has been a unique cooperation among the stations assigned for nighttime operation to the 940-kc. frequency, to the extent that they have acted in cooperation in matters affecting tbeir allocation, have exchanged technical information among themselves, and have from time to time appeared before the Commission under common legal representation.

Asked 5 Kw.

Six years ago these stations jointly initiated consideration of 5 kw power for a regional frequency and filed and prosecuted applications requesting authority to use 5 kw nighttime. Those applications were denied by the Federal Radio Commission on August 12, 1932, hy a divided vote, Commissioner Lafount dissenting. In the Commisisoner's dissenting opinion he urged the soundness of the technical considerations for 5 kw power on this frequency.

I think it is fair to say that the principal reason for the denial of the applications was the then-prevailing quota system.

Since that date, and from time to time, the 940-kc. stations have renewed their request and have made cooperative studies of the problem.

Our purpose here today is to present to the Commission the results of those studies.

We do not appear to urge consideration of the merits of any station on 940 kc., or demand any specific regulations for any one or more frequencies.

Our presentation is for the purpose of indicating the general considerations to he horne in mind on the 5 kw question and when examples are given, they are given for illustrative purposes.

We hope that our studies may be of assistance to the Commission in its determination whether or not there are regional frequencies which permit horizontal increases in power, and if there are, then the determination of the standards which may he used in selecting such frequencies from the whole group of regional frequencies.

I wish to offer the testimony of Mr. Raymond M. Wilmotte.

Raymond M. Wilmotte

My name is Raymond M. Wilmotte. I have a First Class Honors Degree (M.A.) from Cambridge University, England.

I have worked on radio propagation prohlems at the National Physical Laboratory in England. This Lahoratory is the British equivalent of the Bureau of Standards. In the course of this work I was connected with the British Post Office in the design of its long distance radio transmission service.

In this country I was in charge of the research work of the Aircraft Radio Corporation, and am now a consultant with offices in New York City.

In 1931 I designed and built the first directional antenna for a hroadcasting station to be approved hy the Commission. I have published some thirty papers in the technical press, dealing with propagation prohlems, allocation and design of equipment.

Introduction

In this discussion, I intend to consider the possihilities and limitations of the service that may he provided hy regional hroadcast stations. Before considering the engineering prohlems involved, the difference in the service required of stations on clear channels, regional channels, and local channels must be reasonahly well agreed upon.

Clear channels are ideally suited to provide service over large areas, areas that may be so large that programs of national interest may and should be broadcast from them. Local stations serve only restricted areas. These areas are so small that these stations are suitahle for service for towns or cities. The purpose of regional stations is to provide a type of service lying somewhere in between these two extremes. There is room in the United States for programs which are of interest over rural as well as urhan areas, and which are not necessarily of national interest. A kind of service is desirahle, therefore, which will serve large local areas comprising hoth urban and rural communities. It is with this service in view that the regional station differs in its purpose from that of the clear channel and local station. In certain cases, the regional station may have a further special reason for existence. In large centers of population, the noise level is high. There it hecomes essential to provide strong signals to overcome this form of interference. It is frequently impossihle to allow local stations sufficient power for this purpose, for they would interfere with other stations on the same frequency, or adjacent frequencies, for which an increase in power may he neither desirahle nor economically possihle. Clear channel and regional stations may provide this service satisfactorily.

In this discussion I am assuming, therefore, that the main purposes of regional stations are:

a. To provide programs of local interest, which should not and cannot he satisfactorily provided hy clear channels.

h. To serve reasonahly large centers of population.

c. To serve as much of the surrounding rural area as possible.

The engineering prohlem is, then, to allocate sufficient, but not too much, power to the stations on regional channels, and space them a sufficient distance apart in order to obtain this desirable service in the best possible manner.

Station Separations

The separation hetween stations limits the possible service area free from interference. Having once settled on the location of the stations on one frequency, there is a certain radius around each station heyond which the ratio of its signal to the interfering signals from the other stations on the same frequency is too small, and the programs from the interfering stations become ohjectionable. Since the interfering signals are on the same frequency, this radius is independent of the type of receiver used. It is also independent of the general power level of the stations; the power of the stations could he increased ten or a hundred times without affecting this radius, provided that the power of all the stations was increased in the same ratio.

What, then, is the advantage of a horizontal increase of power? The advantage is a reduction in the apparent noise level at the receiver; the effect of power lines, of telephone dials, refrigerators, etc., will be less noticeable to the listener when the power is increased. With the present trend of the art toward higher fidelity in hoth receivers and transmitters, the need for overcoming extraneous noise is gradually increasing for two main reasons: first, the trend of receiver design is toward the reception of a hroader audio-frequency band, and consequently toward receiving more of the undesirable noise; and second, the trend toward high quality of transmission is leading the hetter stations to adjust their normal operation to a lower average modulation percentage than was common a few years ago. Still another trend is the increasing use of so-called midget sets. Many of these sets now on the market have very poor sensitivity, and even in quiet surroundings are unable to pick up weak signals satisfactorily. All these factors seem to lead in the same direction, that as the art progresses, more power will be required.

Adjacent Channel

The effect on adjacent channels limits the extent hy which the power of all stations on a single frequency may he increased horizontally. If the power is so increased, the interference which these stations will cause to the stations on adjacent channels will he also increased. If it is desired to retain a *status quo* of interfering patterns, the power on the adjacent channels would have to he increased in proportion. This argument may be applied from channel to channel, until finally a situation will he reached in which an increase in power on a single channel would lead to a horizontal increase in the power of all hroadcast stations. The development of a receiver design may he of assistance, however. Modern receivers are much more selective than they used to be some six or seven years ago, and with the gradual elimination of tuned radio frequency sets and the substitution of superheterodynes, the discrimination hetween stations on adjacent channels is gradually improving. Broadcast channels are therefore gradually hecoming more nearly independent of each other.

Fundamental Difference

There is a fundamental difference hetween the engineering problem of the proper allocation of stations on a single frequency, and the allocation of these stations relative to stations on adjacent frequencies. The separation and power required hy stations on a single frequency to provide good service is practically independent of the design of the receiver. The allocation of stations within a single frequency is therefore entirely wtihin the control of the Federal Communications Commission. The separation between stations on adjacent frequencies is only indirectly controlled by the commission. In this case, there are two forces acting toward each other. One is the effort of the commission to adjust the separation of stations in adjacent channels to fit the selectivity of the receivers in use, and the second is the efforts of manufacturers of receivers to design receivers which can satisfactorily meet the interference which the commission thinks proper.

I am therefore going to consider separately the two problems of the interference hy stations on the same channel, and the interference hy stations on adjacent channels. I shall first of all consider the coverage possihle on a single frequency, assuming that there is no need to meet the prohlem of interference with adjacent channels. I will then consider what are the limitations introduced by these adjacent channels. In the first section, when considering the service area limited only by the interference caused by stations on the same frequency,, I shall analyze four cases:

A. A single isolated station.

B. Two stations 2,000 miles apart.

C. A few fairly spaced stations.
D. A few closely spaced stations.

I will then compare these cases (Section E) and consider whether different operation of the stations could improve their service (Section F).

940 Channel

For the fairly spaced stations, I have selected an actual case—the 940-Kc. channel. This channel is convenient as an example because it is near the middle of the broadcast range, and the stations operating on it are reasonably well spaced. For the more closely spaced stations, I have selected an arbitrary situation. The arrangement selected approximates and may be considered typical of a number of regional channels as they exist at the present time.

In making the calculations, I have made much use of the information gathered by the Engineering Division of the commission. The Division is to be congratulated on the material it has recently gathered in the field strength surveys of the clear channel stations. The analysis of the results is already extremely valuable. If the variables, such as time of night, direction of transmission, nature of the ground at the receiver and the transmitter, are segregated, it is possible that the variations shown in the published curve may disappear. We will then have a far more complete and accurate picture of radio transmission within the broadcast band than we have ever had before.

Possible Coverage Without Interference from Adjacent Channels

When there is no interference, the area which can be satisfactorily served depends upon the power of the station and the noise level at the receiver. Exhibit I and Table I show the service area in square miles during the day and the night, at selected power levels.

TABLE I.

Service area of a single station on 1000 kc. with a ground conductivity of 5×10^{-14}

Service area for a minimum signal of

	−20 db.		−6 db.		0 db.		+6 db.		+20 db.	
Power of station	Radius miles	Area sq. miles	Radius miles	Area sq. miles	Radius miles	Area sq. miles	Radius miles	Area sq. miles	Radius miles	Area sq. miles
0.5 kw. regional	55	9,000	29	2,700	21	1,500	15	800	7	150
1 kw. regional	63	13,000	33	3,600	24	1,900	17	1,000	8	200
5 kw. regional	750	1,800,000	49	8,000	35	4,000	27	2,300	13	500
10 kw. regional	850	2,200,000	150	70,000	41	5,000	32	3,500	15	800

I have used decibels instead of millivolts per meter as the unit for signal strength, taking 1 mv/m=O db. In making calculations it is frequently easier to use decibels instead of millivolts per meter. Decibels are proportional to the logarithm of the signal strength measured in millivolts per meter. The convenience for calculations of signal levels lies in the fact that, when they are measured in decibels, in order to find the ratio between two signals, it is only necessary to subtract their value. If one is not accustomed to this unit, it can be very readily transferred back to millivolts per meter after the calculations have been made. I have assumed a frequency of 1,000 Kc., and a conductivity for the ground of 5×10^{-14}. Throughout this discussion, I have used for the strength of the sky ray the average value obtained by the Engineering Division in their recent survey on clear channel stations. The curve used was that corresponding to two hours after sunset. If a later time were taken, the numerical results would be changed, but the general deductions would remain substantially unaltered. In making these calculations, the curve for the sky ray has been assumed to indicate the strength of the signal as definitely as though it were a ground ray. It must not be forgotten, however, in interpreting the results of these calculations that the value of the signal from the sky ray varies up and down over a considerable range from day to day, season to season, and year to year.

The lines in Exhibit I show the service area for signals of –20, –6, 0, 6, and 20 decibels. These figures are equivalent to 0.1, 0.5, 1, 2, and 10 mv/m respectively. There are two charts in Exhibit I. The only difference between them is a difference in scale. The right hand chart shows the service areas down to a signal of –20 db., while in the left hand chart, the minimum signal is –6 db. The scale of one chart is five times that of the other.

Large Change

It will be noticed that there is an extraordinary large change in the area covered by signals greater than –6 db. when the power is increased from 5 to 10 kilowatts. Exhibit II gives the explanation of this effect. This exhibit shows how the signal varies with the distance for a 1-kilowatt regional station. It will be seen that at a distance of about 60 miles, the mean value of the sky ray is equal to the ground ray. Up to 60 miles, then, the ground ray predominates. At further distances, the sky ray does. It happens that the attenuation of the sky with distance is very slight; in fact, the strength of the signal remains practically constant up to about 200 miles. Consequently, as soon as the sky ray becomes strong enough to be used for service, the area covered is enormously increased. The broadcast band of frequencies and the frequencies immediately above and below it are particularly well suited for this sky ray to be used. If it is not used, this excellent property of having an unusually low attenuation at comparatively short distances (100 to 400 miles) is not only lost, but actually causes trouble by interfering in the service area of other stations. It happens that the sky ray 60 miles away from the 5-kilowatt station has an average value of –10 db., corresponding to .33 mv/m, so that a power of 5 kilowatts is just on the verge of having a large potential service area with a signal of –6 db.

Possible Coverage of Two Stations 2,000 Miles Apart

Exhibit III and Table II show the day and night coverage of two equal stations 2,000 miles apart at selected power levels. The horizontal lines are the lines of interference for different modes of operation.

TABLE II.

Interference in the case of two equal stations on the same frequency 2000 miles part.

Ground conductivity = 5×10^{-14} Frequency 1000 kc.

Degree of synchronization		± 50 cycles	± 5 cycles	Synchronism
Ratio desired to undesired signal in db.		26	20	12
Service radius in miles		55	200	700
Service area in square miles		9,000	120,000	1,500,000
Minimum signal free from interference with				
	0.5 kw	−20 db.	....	....
	1 kw.	−17	....	....
	5 kw.	− 9	−11	−19
	10 kw.	− 6	− 8	−16

The interference begins at a distance which is independent of the power, provided the power of the two stations remains the same. The area free from interference may therefore be represented hy a horizontal line of interference, cutting all diagrams, corresponding to different powers on the same level. Such interference lines are shown dotted. The level of the lines depends on the mode of operation of the two stations: the top dotted line, for instance, in Exhibit III is the interference line corresponding to the operation of the two stations within ± 50 cycles. If the stations were operated within ± 5 cycles, the ratio of the desired to undesired signals at the interference line could be reduced from 20:1 to 10:1. The line corresponding to this mode of operation is the second dotted line on the diagram. The third dotted line corresponds to synchronous operation.

In order to make full use of the available service area free from interference, it is necessary to increase the power so that the signal at the interference line is high enough to be of use. For instance, a one kilowatt station has a signal well helow –20 dh. at the interference line corresponding to operation within ± 5 cycles. Evidently much of the potential service area of this station is not used hecause its power is too low. What power should he used in any particular case will depend on the noise level which it is intended to overcome.

Limits of Service Area

In calculating the limits of service areas due to interference, the limiting ratio of the desired to undesired signals has heen taken as that suggested hy the commission in Tahle 6 and Figure 1, page 20, of its Seventh Annual Report, 1933. In this report, it was suggested that the limiting ratio of desired to undesired signals should decrease with the distance of the interfering station. An important reason for suggesting this decrease with distance was paucity of the experimental results availahle, on which an estimate of the strength of the interfering signal could he hased. With the recent work of the Engineering Division of the commission, it seems no longer necessary to make such an allowance for lack of accurate information. I have not used, therefore, the so-called allocation factor suggested in Figure 2 of the same Annual Report. The value I have used for the limiting ratio of the desired to the undesired signals is the one given by the dotted curve BD in Figure 1 of the Seventh Annual Report.

In making the calculations on the interference hetween stations, I have also assumed that satisfactory reception will he obtained, if objectionahle interference occurs less than 10 per cent of the time. The analysis made hy the Engineering Division of the Commission has proved very useful in estimating the percentage of time during which interference is ohjectionable between two signals. This ratio is different if the interference is caused hy a sky ray on a ground ray, or by a sky ray on another sky ray. In the case of two sky rays, the ratio should he ahout 4 db. (equivalent to 1.6 times) greater than in the case of the interference between a sky ray and a ground ray. The difference is due to the fact that the strength of the ground ray remains constant at any given location, while that of a sky ray is continually varying. I have also assumed in these calculations that the interfering signal was constant over the whole service area. Actually, the signal is generally greater in that part of the service area which is nearest to the interfering station. When the area is very large, an appreciable and sometimes large error may he introduced by this assumption, hut it will not affect the conclusion materially. Some diagrams showing coverage of many hundreds of thousands of square miles, must not he considered as accurate, they merely indicate that the coverage is very large.

Possible Coverage of a Few Fairly Spaced Stations

As an example for the study of the coverage possihle by several stations operating on the same frequency when they are spaced a fair distance apart, a channel in actual operation has been selected. The channel chosen is near the middle of the hroadcast band. It is the regional channel on 940 kc. The stations on this channel are: KOIN, located in Portland, Ore.; WDAY, in Fargo, N. D.; WAVE, in Louisville, Ky.; and WCSH, in Portland, Maine. Their relative location is shown in Exhibit IV. On the present method of operation, with the stations within ± 50 cycles of each other, the service area free from interference of each is shown hy the middle section of Exhibit V, and in Table III.

TABLE III.

Interference in the case of four fairly spaced stations on the same frequency.

Conductivity 5×10^{-14} Frequency 940 kc.

Station	Interfering station	Separation miles	Strength of interfering signal db.	Minimum signal free from interference dh.	Service Radius miles	Service Area Sq. miles
KOIN	WDAY	1,230	—40	—6	33	3,600
WDAY	WAVE	810	—30	+4	19	1,200
WAVE	WDAY	810	—30	+4	19	1,200
WCSH	WAVE	880	—32	+2	24	1,900

Possible Coverage of a Few Closely Spaced Stations

For the purpose of the discussion of the coverage possible with a few closely spaced stations operating on the same frequency, an arbitrary case has heen taken as an example. The selected locations of the stations in this case are shown in Exhibit VI. There are three stations, A, B, and D, having one kilowatt each, and a fourth smaller station, C, with half a kilowatt. On this Exhibit, the location of the stations of 940 kc is also given for purposes of comparison. The minimum spacing on the 940 kc channel is ahout 50 per cent greater than that hetween the one-kilowatt stations in the arhitrary case chosen. This arbitrary case was picked after considering a numher of regional channels in actual operation. While the separation is admittedly small compared with the standards advocated by the Commission, there are in existence a number of channels operating under somewhat similar conditions. The possihle areas free from interference around each station are shown in the right hand section of Exhibit V, and in Tahle IV.

TABLE IV.

Interference in the case of four closely spaced stations on the same frequency.

Conductivity 5×10^{-14} Frequency 1,000 kc.

Station	Power kw.	Interfering station	Separation miles	Signal free from interference dh.	Service Radius miles	Service Area sq. miles
A	1	B	550	10	14	600
		C	450	9		
B	1	C	400	10	14	600
		D	650	8		
C	0.5	B	400	10	12	500
D	1	B	650	8		
		C	480	9	15	800

The half-kilowatt station C has heen located to produce about the same degree of interference with the other stations as they produce on each other. Station C does not, therefore, increase appreciahly the mutual interference between the stations.

Possible Coverage of Several Stations of the Same Frequency

Exhihit V shows the relative service areas possihle in the case of two stations, of four fairly spaced stations, and of four closely spaced stations. The calculations assume that sufficient power is economically possible to make use of the full area free from interference. The reduction in the service area as the separation hetween the stations is decreased is very marked. From 9,000 square miles around each of the two stations in the first case, the service area falls to around 600 square miles around each station in the arhitrary case selected of four closely spaced stations. The total area which may he served without interference in the case of two stations 2,000 miles apart, is 18,000 square miles. The area covered hy all four stations on 940 kc. is 8,000 square miles, and the total area covered hy the four closely spaced stations in the arbitrary case is less than 2,000 square miles. It is surprising how large is the difference hetween these three cases, more especially hetween the 940 kc channel and the arbitrary case selected, since in these two cases the separations hetween the stations are not enormously different.

Coverage of Stations on a Single Channel by Modification of Their Mode of Operation

There are several ways in which stations on a single frequency may cooperate to increase their service areas. One of the simplest ways is to operate more closely in synchronism. In the Seventh Annual Report of the Commission, page 20, the Engineering Division suggested that the ratio of the desired to undesired signals need only be 10:1 when the synchronization was within ± 5 cycles, instead of 20:1 when the synchronization was within ± 50 cycles. When the carriers of the two signals were in perfect synchronism, the ratios could be still further reduced to 4:1. For the present calculations, I have assumed that these ratios are satisfactory, keeping in mind, however, that further experience may lead to changes in these standards.

Besides improved synchronism, there is the possibility of the stations protecting each other by using partially directive antennas. A station like WAVE, for instance, would permit a greater service area to WCSH, if it built a directional antenna to reduce the signal in the direction of WCSH. The interference from WAVE at WCSH would then occur at a greater distance from WCSH than if no directional antenna were used.

In making a comparison of the increase in service area possible by means of improvements in operation, I have taken a typical station from each of the three cases considered previously. These cases are: two stations 2,000 miles apart; four fairly spaced stations on the 940 kc channel; and four closely spaced stations in the arbitrary case.

The combination of improved synchronization and directional antennas allows of many possibilities. It would involve more careful study than I have given to the cases under consideration to find what combination was the most effective and the most economical. As a guide, I have calculated the improvement possible with some of these combinations arbitrarily chosen, on the assumption that these improvements could be installed without raising other difficulties.

Increases in Service Area

These increases in service area possible under different conditions of operation are shown in Exhibit VII and Table V. In the case of the two stations 2,000 miles apart, the change from operation within ± 50 cycles to within ± 5 cycles brings the sky ray into service with a corresponding enormous increase in the possible service area from 9,000 square miles to some 120,000 square miles. Synchronous operation increases this area still further.

TABLE V.

Possible increase in coverage of stations on the same frequency by modification of their mode of operation.

Conductivity 5 x 10^{-14} Frequency 1,000 kc.

A. Two 1 kw. stations 2000 miles apart.

Types of operation	Minimum signal free from interference. db.	Service Radius miles	Service Area sq. miles
± 50 cycles	−17	55	9000
± 5 cycles	−19	200	120,000
Synchronism	−27	....	....

B. Four fairly spaced stations (WCSH)

Type of operation	Minimum signal free from interference. db.	Service Radius miles	Service Area sq. miles
± 50 cycles	+2	24	1900
± 5 cycles	−4	30	2400
Synchronism	−12	44	6000
± 5 cycles with 7 db. directional	−11	42	5500
Synchronism with 7 db. directional	−19	200	120,000

C. Four closely spaced stations (Station D)

Type of operation	Minimum signal free from interference. db.	Service Radius miles	Service Area sq. miles
± 50 cycles	9	15	800
± 5 cycles	3	20	1300
Synchronism	−5	31	3000

In the arbitrary case of the closely spaced stations, improving synchronization still does not allow the sky ray to be of use to provide service. The service area of about 800 square miles available when the synchronization is within ± 50 cycles, is increased to only 3,000 square miles with perfect synchronism. Major improvements by the use of directional antennas are almost impossible, for it would be difficult to build a directional antenna at any one of the stations to protect a second without damaging the service area of the third or fourth. Directional antennas may produce minor improvements that may be worth while, but no great increase in service area can reasonably be expected for all the stations.

Four Stations

In the case of the four fairly spaced stations on 940 kc., I have selected WCSH as typical of this channel. Operation within ± 5 cycles increases the service area of this station from 1900 square miles to 3700 square miles, and synchronous operation increases it still further to 7400 square miles. If a directional antenna is installed at WAVE, so that the interfering signal is reduced by slightly more than one-half, compared with the average signal transmitted in other directions, and the stations are operated within ± 5 cycles, the possible service area will be roughly equal to the service area with synchronous operation but without directional effects. In none of these cases, however, does the sky ray come into service. As a source of service, it is wasted. It can become useful, however, if synchronous operation is combined with the directional effects. The service area would then be enormously increased.

These increases in service area depend, of course, on the stations having sufficient power to make use of gains permitted by improved operation. In the present state of the art, it is difficult to obtain perfect synchronization, but there is no reason to assume that future developments will not permit such operation to be applied economically.

In suggesting directional antennas, I have no intention of advocating them for all cases. Although I was the first to build and have approved by the Commission a directional antenna to protect one broadcast station from another, I think that there are definite limitations in their application, and I would like to take this opportunity to list broadly the cases where, in my opinion, they are useful, and the cases where they may appear as an ideal solution to a particular problem, but may lead eventually to difficulties.

Directional Antennas

The principal objection to the use of directional antennas is that they limit future changes in allocation. For instance, turning to Exhibit VI, if a station were located at P, halfway between WDAY and WAVE, in order to prevent interference with either of these two stations, a directional pattern approximating a figure eight would have to be used, with the zeros in the directions of WDAY and WAVE. Such a station would effectively prevent any appreciable increase in the service areas of WDAY and WAVE by improved operation, such as have been discussed above. Station P would also tend to freeze the allocation of stations of the 940 kc. channel to the present arrangement, for any major changes, however desirable they might seem, would be likely to involve radical changes in the antenna, and such changes might make the location and even the existence of the station undesirable. This station would also prohibit the erection of a new station in the direction of Southwestern New Mexico, except at a great distance, because in that direction the interfering signal from P would be very large. Against these disadvantages would have to be balanced the advantage of the service provided around the Station P. The service area would be very limited, however, because of the strong interference from WDAY and WAVE, and that service, moreover, would be weak in two directions. While a directional antenna would appear ideal for a station at P, it would produce disadvantages which might not be balanced by the special service provided around P.

Generally speaking, it is dangerous to permit the erection of a directional antenna which suppresses the signal in one or more directions fairly completely, because it tends to freeze the allocation of stations on that particular frequency. There are some special cases where a substantial decrease in signal in some particular direction is desirable. For instance, in the case of WFLA in Clearwater, Florida, the antenna substantially prevents transmission into the rest of the United States, and pushes the signal toward the south of Florida. This station serves Florida without causing appreciable interference in the rest of the country. Even in this case, however, it was found desirable to allow a small signal in the direction of suppression in order to serve a town a few miles away from the station in that particular direction.

Where directional antennas are particularly valuable are in such cases as have been discussed above, in which it is possible to increase the coverage of stations spaced a considerable distance apart by giving to each other partial protection from interference.

Another valuable application of directional antennas is to provide a sufficiently loud signal in densely populated areas where the noise level is high, provided, of course, that the service to the rural community is not unduly reduced.

Directional antennas may be used with good effect on channels where stations are so close that improvements in service can hardly be expected through technical developments such as improved synchronization or better allocation. The stations on these channels are inherently limited to provide only local service. There does not seem to be any harm in building additional stations fitted with directional antennas, and locating them in such a way that the service provided to the cities served by the other stations on the same frequency is not materially impaired. It is often comparatively simple to achieve such results because the service area of the stations is so limited.

Generally speaking, we may conclude that a directional antenna is desirable, if it improves service without prohibiting developments either in allocation or in better conditions of operation. It is undesirable in cases where its erection would reduce flexibility of allocation and improvements. On those channels where stations are located close together, much of this flexibility is already lost. There may therefore be comparatively little harm in reducing it still further by introducing directional antennas.

There have been many applications of directional antennas to solve certain problems of individual stations. Their application by stations on the same frequency to improve each other's service areas is not yet common, yet directional antennas could prove to be a valuable weapon to increase these service areas. A limiting factor in the use of directional antennas is the location of the station relative to the town being served. The town should not lie in the direction of minimum signal. In granting a license it may, therefore, be worth while for the Commission to consider carefully the location of the new station relative to the nearest town, and to the other stations, in case it should be found at some later date desirable to give them greater protection because of some new technique or other reason.

Interference With Adjacent Channels

As explained in the introduction, it is more difficult to make any broad generalization on the problem of the interference between stations on adjacent channels than it is between stations on the same channel, because, in the case of the interference of stations on adjacent channels, the selectivity of the receiver is one of the most important factors. There is little available information on the selectivity of receivers in general use.

A single case will be taken as an example of the problem of interference between adjacent channels. I have taken for this example the case already used of the stations operating on 940 kc. This case is comparatively simple because the interference created with adjacent channels is unusually low, and is negligible, to all practical purposes, on all channels more than 10 kc distant. The fact that the case selected as an example is unusually simple does not change the general principle involved.

Interference

The interference produced is depicted in Exhibit VIII and Table VI. The interference caused by the stations on 930 and 950 kc with each other was calculated, giving the maximum possible service area under normal conditions of operation. This area is shown in Exhibit VIII by the closely shaded sections. The interference caused with these stations by the stations on 940 kc was also calculated. This interference also limits the service area of the station. This area is shown in the same exhibit by the lightly shaded sections. It is seen that in no case is the interference by the stations on 940 kc. in the service area of the station on adjacent channels greater than the interference of these stations with each other. Under present conditions of operation, therefore, the stations on 940 kc. do not interfere with any stations on adjacent channels.

(See Exhibit VIII)

TABLE VI.

Interference on adjacent channels to 940 kc.

A. Interference from station on the same frequency.

Station			Nearest station on same frequency			Service	
Call Letters	Power Kw.	Frequency	Call Letters	Separation Miles	Strength of signal free from interference	Radius Miles	Area Sq. Miles
WDBJ	1	930 kc.	WBRC	430	12	12	500
KROW	1	930 kc.	KMA	1140	−4	30	2900
KMA	1	930 kc.	WBRC	660	7	16	900
WBRC	1	930 kc.	WDBJ	430	12	12	500
WRC	0.5	950 kc.	KMBC	900	1	18	1100
KFWB	1	950 kc.	KMBC	1200	−5	31	3000
KMBC	1	950 kc.	WRC	900	−2	27	2300

B. Interference from stations on 940 kc.

Station	Nearest station on 940 kc.	Separation miles	Strength of signal free from interference	Service: Radius miles	Service: Area Sq. miles
WDBJ	WAVE	320	−6	33	3,600
KROW	KOIN	540	−10	40	5,000
KMA	WDAY	420	−7	35	4,000
WBRC	WAVE	340	−6	33	3,600
WRC	WCSH	480	−9	38	4,600
KFWB	KOIN	830	−17	55	9,500
KMBC	WAVE	470	−8	36	4,000

Ideally, the best allocation would be one in which the stations on adjacent channels produced exactly the same degree of interference as the stations on the same channel. From an allocation point of view, therefore, the lightly shaded areas in Exhibit VIII represents a waste. It would be possible, and theoretically beneficial, to increase the power of all the stations on 940 kc uniformly by 6 db (four times) without causing interference to adjacent channels. At this point, the interference caused by WAVE on 940 kc with KMBC on 950 kc would be effectively equal to the interference by the other stations on 950 kc. At the same time, the interference by KOIN on 940 kc with KROW on 930 kc would also be effectively equal to the interference by other stations on 930 kc. Such an increase in power would reduce the lightly shaded areas on all the stations shown in Exhibit VIII, and thus eliminate some of the wasted facilities of allocation. In the case of KMBC and KROW, these wasted areas would be reduced to zero.

If it were possible to use a partial directional effect to protect KROW from KOIN and KMBC from WAVE, to the extent of 4 db (which corresponds to reducing the signals in those particular directions by one-third, relatively to the average signal transmitted in the other directions) it would be possible to permit a horizontal increase of power of all the stations on 940 kc by as much as 10 db (which corresponds to increasing the power 10 times), without interfering with any of the stations on adjacent channels to an extent greater than they already interfere with themselves.

Conclusion

There are many possibilities available with the development of the art which would allow considerable increase in the service areas of certain stations, an increase which in some cases may lead to the use of the sky ray for service. When the sky ray can be used, the possible service area is tremendously increased. The full use of the area free from interference can only be made, if the power is sufficient to produce a reasonable signal strength at the boundary of this area.

When the separation between stations is small, the advantages possible by improved operations are also small. This is clearly shown in Exhibit VII. Reducing separation will therefore tend to limit the possibilities of improvement with the development of the art, and will indirectly tend to retard them. Moreover, when the stations are close together, the service area becomes very small. Only local service can be provided, and practically no rural area can be covered. By far the greatest part of the signal goes to create interference instead of service. The sky ray, with its astonishingly low attenuation at broadcast frequencies, is completely wasted. From a purely engineering point of view, without giving any consideration to the economic problem, such local service would be provided most satisfactorily by broadcasting at such high frequencies that no sky ray returned to the ground to create interference with other stations. If the only economic consideration was the extra cost of the receivers, such a high frequency broadcast service would not seem, off-hand, to be outside the realm of possibility.

If, however, the broadcast band is retained as it exists at present, when there are many stations on a single frequency, their usefulness will be limited to serving densely populated areas where the interfering noise level is high. They should, therefore, produce a sufficient signal in such areas to overcome this noise. On the other hand, there is no use in producing a signal which is unnecessarily high, for the service area is not increased by allowing all the stations a proportional increase in their power.

A happy compromise may be made for the purpose of providing local service to rural areas of a reasonable size, with a number of well spaced stations on the same frequency. In this case, at the limit of their service area, where interference begins to become objectionable, the signal should be well above, but not excessively above, the probable or possible noise level. These stations, by cooperating with each other and protecting each others' service areas (with directional antennas, better synchronization of their frequencies, etc.) may adjust their operations so that the area within which they do not interfere with each other is greatly increased.

Interference Problem

On the problem of interference with adjacent channels, the ideal conditions occur when the interference to the service area of a station by stations on adjacent channels is effectively equal to the interference by the nearest station on the same frequency. To the extent that stations on adjacent channels do not create interference with stations on the same channel, there is a theoretical waste of allocation facilities. On the sole basis of interference, therefore, all stations on one channel could have their power increased or decreased until the interference they cause with one or more of the adjacent channels was effectively equal to the interference caused by other stations. In the example considered of the 940-Kc. channel (see Exhibit VIII), it is possible, with partial directional effects, to increase the power horizontally ten times, without causing more interference on adjacent channels than exists already. We have also seen that this power could be effectively used by these stations and their service areas considerably increased with suitable operation and cooperation among themselves.

It seems a pity that regional stations do not make more use of the low attenuation of the sky ray at broadcast frequencies, for, if this ray could be used, the service area of the stations would be enormously increased and real local service provided to rural areas.

In final conclusion, I would like to urge the commission that, in granting licenses, it give careful consideration to the location of stations, not only relative to other stations, but relative to the nearest town, so that better synchronization, directional effects, etc., may be used when wanted to the best possible advantage. Our present knowledge and future developments (to the extent that we can forecast them) should be allowed full opportunity and as much latitude as possible so that our total knowledge may be useable to provide the best service possible.

I make a special plea that future engineering developments and the progress of broadcasting be not endangered by freezing the space available on the basis of our present knowledge and technical skill. There should be room, much room for evolution.