PROCEEDINGS OF THE JTAC VOLUME II

# ALLOCATION STANDARDS FOR VHF TELEVISION AND FM BROADCASTING

REPORT OF THE JOINT TECHNICAL ADVISORY COMMITTEE

(IRE-RMA)

TO THE

FEDERAL COMMUNICATIONS COMMISSION

Docket 9175

December 1948

# ALLOCATION STANDARDS
# FOR VHF TELEVISION AND
# FM BROADCASTING

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# CHAPTER I

## INTRODUCTION

1. Purpose of this Report. This report has been prepared by the Joint Technical Advisory Committee (JTAC) to assist the Federal Communications Commission in its deliberations concerning the allocation of frequencies between 54 and 216 megacycles to commercial television and f-m broadcasting. It is presented in accordance with the request of the Federal Communications Commission contained in a letter from the FCC Chairman to JTAC dated October 28, 1948 (Annex 3 of this report), and is offered as evidence at the Engineering Conferences scheduled for November 30, December 1 and 2, 1948.

2. Narrative of JTAC activity. The Commission and its staff are referred to the Proceedings of the JTAC, Volume 1, "Utilization of Ultra-High Frequencies for Television," Docket 8976, for an account of the formation and purposes of the JTAC. The JTAC membership list is attached as Annex 1 of this report.

On October 1, 1948, the Chairman of JTAC, Mr. Siling, wrote the Chairman of the FCC, Mr. Coy, offering the assistance of the JTAC in the Commission's deliberations on vhf and uhf television. A copy of this letter is attached as Annex 2 of this report. On October 15, the Commission's notice of Further Proposed Rule Making in the Matter of Regulations and Standards for Television and Frequency Modulation Broadcasting Services was released, and the dates for the Engineering Conferences were tentatively announced. Acting in accordance with Mr. Coy's letter dated October 28 (Annex 3), the JTAC circulated a request for information, with a copy of Mr. Coy's letter, to various industry groups, technical committees, and to the trade and technical press. A list of the technical groups which acted for JTAC in this matter is attached as Annex 4.

In anticipation of the FCC's request, the RMA Television System Committee (Mr. F. J. Bingley, Chairman) met on October 25 and appointed a subcommittee to collect information which met November 12. The I.R.E. Television Systems Committee (Mr. D. G. Fink, Chairman) met November 9 and appointed a subcommittee which met November 19. The I.R.E. Wave Propagation Committee (Mr. A. Earl Cullum, Jr., Chairman) met November 18 and appointed a subcommittee to meet with members of the Commission staff. Members of the RMA FM Systems Committee (Mr. George R. Town, Chairman) were circularized by letter and questionnaire. The reports of these groups are printed in full as Annexes to this report. Letters from various other committees and industry groups were received and are reproduced as Annexes.

On November 16, the JTAC held its fourth meeting and invited Messrs. Bingley and Cullum to participate in its discussions regarding allocation standards for vhf television and fm broadcasting. At that meeting a report-writing subcommittee (Mr. Fink, Chairman) was appointed. On November 22, JTAC met in Princeton for its fifth meeting, considered the draft report, and witnessed a demonstration of television carrier synchronization between stations WNBT, New York, and WNBW, Washington. On November 29, at its sixth meeting, the Committee unanimously approved this report, which is hereby submitted in evidence at the Engineering Conferences.

3. <u>Classes of information</u>. In conformity with its previous report on uhf television, JTAC has endeavored to classify the information in this report in three classes of reliability, which are here repeated for convenience:

Class A: Established fact - Data on which there is general agreement among informed specialists.

Class B: Engineering Estimates - Data based on limited experience or theory not fully confirmed.

Class C: Speculation - Conjectures based on more or less arbitrary extrapolation from limited experience.

4. Type of report. This report is an engineering analysis of the available information on propagation and equipment characteristics, to determine the basis for a satisfactory allocation of facilities for vhf television and frequency-modulation broadcasting.

Due to the short time available for the collection and compilation of the information reported, it has not been possible to digest all the data presented. Moreover, the evidence presented, while collected from as many sources as possible in the time available, does not necessarily represent all the data available in the industry. It is understood that additional data will be presented by other organizations to the Commission's staff at the Engineering Conferences.

## CHAPTER II

## GENERAL COMMENT ON THE ISSUES BEFORE THE ENGINEERING CONFERENCES

5. Propagation data and equipment characteristics. Allocation standards for broadcasting are based on two different types of technical knowledge: propagation data and equipment characteristics. The propagation data represent natural phenomena and are not subject to change by technical effort. Equipment characteristics depend on current technology and are subject to improvement as the art progresses. In view of this distinction, and in conformity with the program of the engineering conferences, the JTAC has undertaken to separate its information into these two classes, propagation and equipment, and to examine separately the range of the variable factors in each.

Accordingly separate chapters (Chapters III, IV, and V in this report) are offered on these subjects. Chapter VI shows the manner in which the two types of data are combined to arrive at the final result, that is, an estimate of the grade and duration of service and the extent of the service areas to be expected from given values of frequency, effective radiated power, antenna height, terrain conditions and separation between stations.

6. Non-technical considerations. At the outset JTAC wishes to point out that there are two basic questions which cannot be answered on technical grounds. One is the percentage of the operating hours during which a satisfactory grade of service is necessary in the public interest. Whether 90 per cent service or 99 per cent service (or some other value) is desired must be determined by the Commission. Secondly, the relative importance of (1) the extent of service areas and (2) the number of program choices, must be decided by the Commission. This is an important and vexing question, since the number of

stations available to urban segments of the population can be increased beynond a certain limit only at the expense of restricting the service areas of some or all of the stations involved. Thus, while it is possible to devise an allocation which will maximize the service areas of a given number of stations, and it is equally possible to maximize the number of stations for given service areas, it is not possible to maximize both quantities simulanteously.

A compromise between the number of families served on the one hand, and the number of stations (choices of programs) available on the other, must be established before the allocation can be put into effect.

7. Propagation data. On the assumption that suitable propagation data are available, it is possible to compute the separation in miles between stations required to achieve a given ratio of desired signal to interference, for a given percentage of the time.

Such a process involves a large number of assumptions, the validity of which must be examined with care, as outlined in Chapter III of this report. In particular, the influence of the transmitting antenna height on tropospheric propagation of the signal is a critical question, since the value of

antenna height used in practice may depart widely from the value assumed in the curves cited. If such departures impair the utility of the curves, the effect of such departures must be taken into account in establishing the effective radiated powers and antenna heights permissible or desirable in the allocation plan.

8. Equipment factors. The equipment performance factors relating to allocation standards are (1) the values of field strength required for adequate service in urban and rural areas, (2) the necessary co-channel and adjacent-channel interference protection radios, (3) the power-generating capabilities of transmitters, and (4) the horizontal and vertical directional properties of transmitting and receiving antennas, and (5) synchronization of television station carriers. Subordinate questions, contained within the above headings, include the noise figures of receivers, the required values of signal-to-noise ratio and signal-to-interference ratio required at the loudspeaker or viewing screen, and the losses in transmission lines.

These questions have been referred by JTAC to the RMA Committees on Television Systems and FM Systems. A considerable amount of experience has been amassed as a result of the commercial operation of television and f-m transmitters and the widespread public use of receivers. Accordingly it is believed that the information on present equipment performance is reliable and adequate (in the Class A and Class B categories.) The performance of future designs is in greater question, particularly the power levels which may be achieved in television transmitters. The performance figures of present and future equipment are summarized in Chapters IV and V of this report.

## CHAPTER III

## TROPOSPHERIC PROPAGATION ON VERY-HIGH FREQUENCIES

9. Sources of propagation data. The first engineering conference in this docket, scheduled on or about November 30, 1948, treats the subject of vhf propagation standards, and is intended to collect information on the variations with time of field intensities as functions of frequency, distance, and transmitter antenna height, as well as the effects of diurnal and seasonal variations, simultaneous fading of desired and undesired signals, and terrain effects.

The inquiries conducted by JTAC in technical committees and industrial groups indicate that the only analysis of tropospheric propagation now available in the frequency range in question (54 to 216 megacycles) is that conducted by the Commission's staff and set forth in T.I.D. reports 2.1.3, 2.4.4, 2.4.5, and 4.2.1. These inquiries reveal further that the majority of measurements of field strength under tropospheric propagation conditions, made by commercial and other government organizations, have been communicated to the FCC Staff for use in their analysis. It appears that the industry is in possession of few if any additional digested data.

10. Questions concerning the FCC analysis of propagation data. To assist in this study the JTAC transmitted the following questions to the IRE Wave Propagation Committee:

(a). Do the measurements (recordings of field strengths, etc.) now available to the FCC from various sources constitute a substantial preponderance of the data available from all sources, including government departments and the industry? If not, what other sources are available?

(b). Do the data now available to the FCC constitute an adequate sample on which to base an analysis, with respect to number and distribution of observations, and do they cover a sufficiently wide range of conditions of topography and climate, frequencies and transmitting antenna heights?

(c). Is the analysis performed by the Commission staff on the data valid and free from error?

(d). If the data or the analysis are in question at critical points, what tolerances might be superimposed on the curves, shown as Figs. 21 through 24, T.I.D. Report 2.4.5, to represent the effect of these uncertainties?

(e). If tolerances cannot be specified, what is the overall opinion of the IRE Wave Propagation Committee concerning the utility of the analysis for allocations planning, in comparison with previous formulations of tropospheric propagation effects?

11. Status of IRE Wave Propagation Report. It has proved impossible, because of the short time available, for the IRE Wave Propagation Committee to render a report answering these questions in time for the Engineering Conferences. Accordingly, the questions enumerated in paragraph 10 above remain in the minds of the JTAC members as critical issues not yet resolved. Where the T.I.D. Report 2.4.5 curves are used in this report, therefore, JTAC intends the computations only as illustrative exercises and not as engineering conclusions. It is hoped that a supplementary report on propagation matters will be available within a few weeks.

## CHAPTER IV

## TELEVISION EQUIPMENT CHARACTERISTICS PERTINENT TO ALLOCATION STANDARDS

12. Signal required for satisfactory reception. The Commission's rules governing vhf television specify a signal strength of 500 microvolts per meter* as satisfactory for residential-rural areas and 5000 microvolts per meter as satisfactory for city-business-factory districts.

The RMA Television Systems Subcommittee TS-3 sent a letter to manufacturers of television receivers asking for the values of signal strength required for rural areas (no man-made interference) and metropolitan areas. The replies received indicated values from 100 to 1240 microvolts per meter for rural service. One of these replies (Annex 16, this report) included an extensive calculation of values, based on a receiver noise figure of 12 db, a signal-to-noise ratio at the viewing screen of 30 db, with a typical dipole and transmission line. This calculation shows that the required signal strength increases with the frequency from 310 microvolts per meter at channel 2, to 1240 microvolts per meter at channel 13. The FCC value of 500 microvolts per meter is shown to be satisfactory for the low-band channels 2 through 6, but on the low side for the high-band channels 7 through 13.

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* The customary units for denoting service contours and field intensities, that is, microvolts per meter or millivolts per meter, are used in the report. The I.R.E. Wave Propagation Committee has pointed out to the JTAC that these units are not well suited to allocations problems, particularly for services covering a wide range of frequencies.

These figures apply in the absence of man-made interference. Many rural locations suffer from the effects of automobile ignition interference and diathermy interference. A letter to JTAC (Annex 9) from Mr. K. A. Chittick, Chairman on the RMA-SAE Committee on Vehicular Radio Interference reports the consensus of the committee that a signal strength of 5000 microvolts per meter is required to overcome the normal effects of automobile ignition interference, the rural value of 500 microvolts per meter being too low in the presence of such interference.

The requirement for higher field strengths on the high band channels and in the presence of ignition interference may justify the establishment of a higher value than 500 microvolts per meter. However, the 500 microvolt per meter figure is used in this report as the basis for computing coverage areas, since it represents a median value suitable for the v-h-f band as a whole in the absence of man-made interference.

The field strength required for city districts, reported by RMA Subcommittee TS-3 ranges from 500 to 10,000 microvolts (the latter figure assuming an effective height of the receiving antenna of one meter.) The value of 5000 microvolts per meter, specified by the FCC rules, is used in this report for computing service areas, as representing a median value.

While the values of 500 and 5000 microvolts per meter are used in this report, the general impression given JTAC by the subcommittees reporting is that higher field strengths would be beneficial to the television service. The RMA Television Systems Subcommittee TS-3 recommended that higher transmitter powers be permitted to provide such higher fields, but stated that this change should be carried out by revising the numerical values of field intensity at the contours at which protection is provided, rather than by changing the geographical position of the contours protected.

13. Co-channel Interference protection ratios. RMA Television Systems Subcommittee TS-3 received unanimous agreement in the replies to its questionnaire (Annex 7) that the co-channel interference protection ratio should be 100-to-1 (40 db) in field strength, as is now established in the Commission's rules.

This subcommittee reviewed in detail the previous study of this subject contained in the Report of RTPB Panel 6, Subcommittee on Shared Services, entitled "Interference to Television Service Resulting from Shared Operations by Fixed and Mobile Services", dated December 29, 1947 and previously given in evidence before the Commission in the Hearing on that subject. The subcommittee concluded that the report retains its validity, and is applicable to the computation of interference from other television stations. This is true because the interference from other television stations is caused predominantly by the carrier of the interfering station, which may be substituted for the unmodulated carrier used in the previous study. It should be noted that a television carrier is, in general, continually modulated and that, when modulated, a portion of the radiated power is contained in sidebands of lower amplitude. Consequently the value of interfering carrier field strength employed in computing interference ratios should be that present when the carrier is modulated with sync and picture signals.

14. Effect of carrier synchronization on interference. The JTAC has received information that the co-channel protection ratio of 40 db may be reduced by a substantial amount if the two television picture carriers are rigidly synchronized. Techniques for so synchronizing the carriers have been developed and demonstrated at the RCA Laboratories at Princeton.

Since at least twice as much power, in an amplitude-modulated television wave, resides in the carrier frequency as in all sidebands combined, it

would be expected that beats between the carriers of two stations would produce more visible interference than that produced by the synchronizing, blanking or picture signals. The carrier beat produces horizontal bars, if the beat frequency lies between 60 and 15,750 cps (the field-scanning and line-scanning rates respectively.) The appearance of bars may be avoided if the carrier beat frequency is kept below 60 cps. Flicker due to a carrier beat frequency lower than 60 cps is eliminated if the two carriers are maintained in a fixed phase relationship.

Accordingly if the carrier of the interfering station is locked in phase with that of the desired station, a substantial improvement in the picture should be achieved.

The carriers of stations WNBT, New York and WNBW, Washington, have been synchronized and the results observed at Princeton. A marked improvement in signal-to-interference ratio, estimated as approximately 15 db, has been noted on the viewing screen. If such a method were applied universally to all stations on the same channel in contiguous interference areas, the permissible interfering signal at points intermediate to the stations might be increased by approximately 15 db. This is class C figure.

15. Adjacent channel protection ratios. The adjacent-channel protection ratio (desired-to-undesired signal strength ratio) specified in the Commission's rules is 2 to 1, or 6 db. This value, when studied in 1947 by the Subcommittee on Shared Services, was found by that subcommittee to be somewhat conservative, based on the selectivity characteristics of the receivers measured prior to December 1947. The RMA Television Systems Subcommittee TS-3, re-examining this question, found a wide range of replies to

its questionnaire on this point, ranging from -3 db to 20 db. Most of those responding indicated that for conventional (non-intercarrier receivers), less protection was required on the upper adjacent channel than on the lower adjacent channel, by from 3 to 8 db. One answer, possibly referring to an intercarrier receiver, indicated that high protection (20 db) was required in both adjacent channels, while stating that 0 db would suffice if a receiver, having high adjacent channel selectivity, properly adjusted, were used.

In view of the wide variation in opinion on this point, the JTAC has adopted for the purposes of this report the values of 0 db against the upper adjacent channel and 6 db against the lower adjacent channel. It is believed that these values are suitable for allocations planning, although they require that reasonable care be used in the design of receivers if adjacent-channel interference is to be avoided. The FCC rule specifying 6 db protection is adequate on the lower adjacent channel and more than adequate on the upper adjacent channel. These figures have class B reliability.

16. Power-generating capabilities of transmitters. Time did not permit the RMA Television Transmitter Committee to render a full report on the present and future power-generating capabilities of television transmitters. A letter from the Chairman of this Committee, Mr. P. J. Herbst, on this subject is attached as Annex 10. Direct communications to the JTAC were received, however. One such communication (Annex 11A) indicated that a transmitterpower of 50 kw could be provided on channels 2 through 6, and 15 kw on channels 7 through 13. Another (Annex 11B) quotes a figure of 50 kw up to channel 6, and 25 kw up to channel 13. These are considered class B estimates.

Commercial transmitters currently offered by manufacturers have a maximum peak power rating of 5 kw on any channel.

17. Directional properties of antennas. No report on directive antennas was available at the time of preparing this report. One direct communication (Annex 11) states than an antenna having cardioid directivity could be provided with a radiation null 20 db down from the power radiated in the direction of maximum radiation.

## CHAPTER V

## FM EQUIPMENT CHARACTERISTICS PERTINENT TO ALLOCATION STANDARDS

18. Signal strength required for satisfactory reception. The FCC Rules concerning fm broadcast stations imply that a field strength of 50 microvolts per meter is satisfactory for fm reception, and make provision for protecting this contour in particular circumstances.

To compare this value with the value of field strength actually required by current models of fm receivers, the RMA FM Systems Committee sent a letter and questionnaire (reproduced in Annex 12 of this report) requesting, among other items, the values of quieting sensitivity which apply to current production table and console models, as well as those values expected to be applicable in the forseeable future. The quieting sensitivity, as defined by the IRE Standard "Methods of Testing FM Broadcast Receivers", is that value of input voltage, applied to the antenna terminals of the receiver, which will reduce the noise level at the loudspeaker terminals by 30 db relative to the value in the absence of a carrier. The corresponding value of field strength is this voltage divided by the effective height of the receiving antenna and modified by the loss in the transmission line. Assuming a simple dipole, typical of the antenna used at the fringe of the service area, tuned to the middle frequency of the fm band, and a transmission line with a loss of 2 db, the input terminal voltage must be divided by approximately 0.8 to produce the corresponding field strength.

The average value of quieting sensitivity, typical of current production models, as reported to the RMA Committee is 20 microvolts, corresponding to a field strength of approximately 26 microvolts per meter.

Lower values may apply to receivers to be produced in the foreseeable future.

There is no general agreement in the industry that the field strength corresponding to quieting sensitivity should be used as an allocation standard for satisfactory reception, but in the absence of any other defined standard, the JTAC considers it to be a reasonable value for computing coverage and interference areas. It would appear from these data that the standard of field strength implied in the FCC rules (50 microvolts per meter) is too high.

19. Co-channel interference protection ratio. Fm reception is characterized by the "capture effect", that is, the desired signal remains free from interference until the co-channel interfering signal exceeds a certain threshold level. The ratio of desired to undesired signal at which this threshold occurs is known as the "capture ratio", and has a theoretical lower limit of two times in voltage (6 db). The theoretical value occurs only in the absence of amplitude variations in the detected signal, that is, when ideal limiting action occurs in the receiver. If the limiting action in the receiver is non-ideal, and in particular if the voltages or currents in balance-type frequency detectors are not in balance, the capture ratio is higher than 6 db. An excellent receiver has a value perhaps 1 db above theoretical, and values as high as 10 to 15 db above theoretical may occur in production type receivers. The RMA FM Systems Committee, in the replies to its questionnaire, determined that the range of capture ratios varied from 0 to 13 db above theoretical, with 4 db above (10 db total capture ratio) as a median value. The same value was quoted as applicable to receivers to be produced in the foreseeable future. This is considered to have class B reliability.

Based on the 10 db figure, the desired station will not suffer interference if the undesired signal field strength is weaker than the desired by 10 db or more. Despite the wide variations in capture ratio reported, the JTAC believes that the 10 db figure is a suitable value for computing interference. It requires reasonable care in the design of receivers, however, to assure that co-channel interference will not occur at this level.

20. Ignition interference. Replies to the FM Systems Committee questionnaire revealed that many engineers believe automobile ignition systems are a more potent source of interference than tropospheric propagation, but there is no available information on the levels of ignition interference actually present in typical circumstances. It should be pointed out that ignition interference may be the controlling factor in some circumstances.

21. Adjacent-channel interference protection ratio. The selectivity data on typical receivers reported to the RMA FM Systems Committee indicate that a first adjacent channel selectivity averaging -16 db is typical of current production models and that this value will probably apply to production models in the foreseeable future. The second adjacent channel selectivity averages about-40 db. The JTAC has used these values in computing adjacent channel interference for this service. They are considered to have class B reliability.

22. Power-generating capabilities of transmitters and directive antennas. No report was received from the RMA FM Transmitters Committee on the power generating capabilities of transmitters or on directive antennas. At least two commercial 50-kw transmitter designs are available and in commercial operation, and the 12-kw transmitter of Dr. E. H. Armstrong at Alpine, N. J. has been operating for many years. It would appear, therefore, that a 50 kw

transmitter can be provided in the present state of the art. Whether a higher-power transmitter could be produced, assuming its use might be authorized, is not known.

In the absence of data of the horizontal directivity of available or potentially-available transmitting antennas, it may be assumed that the directivity ratios cited as available for television transmitters would apply easily to the fm case, and in view of the narrower bandwidth requirements of fm, it is quite possible that sharper directivity could be provided for fm transmitter antennas. In any event, if such directivity is to be used as an element of the allocations plan, the directivity figure adopted should be one which can be continually maintained after proof of performance.

The maximum vertical power gain of commercial fm omnidirectional antennas is approximately 12 times.

# CHAPTER VI

## COMPUTATION OF COVERAGE AND INTERFERENCE AREAS

23. Conditions underlying computations. Anticipating a report from the IRE Wave Propagation Committee, certain computations of coverage and interference areas have been undertaken. Since this report has not yet been prepared, computations based on the T.I.D. Report 2.4.5 are offered merely as illustrative examples. The assumptions adopted in these computations are as follows:

1. The tropospheric propagation curves in Figs. 21 through 24, T.I.D. Report 2.4.5 are used without modification. This does not constitute an indorsement of the utility of these curves beyond the bounds of the discussion in Chapter III of this report. (Class C)

2. For television, field strengths of 500 microvolts per meter (residential-rural service) and 5000 microvolts per meter (urban service) are adopted with co-channel interference protection ratios of 40 db (non synchronized carriers) and 25 db (synchronized carriers). (Class B)

3. For fm broadcasting, field strengths of 25 and 50 microvolts per meter, co-channel protection of +10 db and adjacent channel protection ratios of -16 and -40 db for first and second adjacent channels, respectively, are adopted. (Class B)

4. Duration of satisfactory service (protected coverage) in percentage of total operating hours is taken at 99 per cent and 90 per cent.

5. The frequencies considered are 63 and 195 megacycles for television, 98 megacycles for fm broadcasting.

6. Effective radiated powers of 50 kilowatts for television and 20 kilowatts for fm, at an antenna height of 500 feet, are adopted.

24. Procedure - Minimum separation between television stations for 99 and 90 per cent protected time. To find the minimum allowable separation between television stations of the type assumed above, a desired signal of 500 microvolts per meter and an undesired signal of 5 microvolts per meter (40 db down) were taken and converted to 1 kilowatt (71 and 0.7 microvolts per meter respectively). Figures 21-24 of T.I.D. Report 2.4.5 were entered at these values (37 db above and -3 db below 1 microvolt per meter) on the 99 per cent curve for the desired signal and on the 1 per cent curve of the undesired signal. The corresponding distances for the 63 megacycle case are 36 miles for the desired signal and 251 miles for the undesired signal. Hence, at 63 megacycles if the desired signal is to exceed the undesired signal by 40 db during all except one per cent* of the operating hours the stations must be separated at least 36 + 251, or 287 miles.

A similar computation for the 90 per cent protected time case gives a minimum separation of 212 miles at 63 megacycles. At 195 megacycles the 99 per cent minimum separation is 288 miles and the 90 per cent minimum separation is 210 miles. These values exceed by 60 to 138 miles the minimum separation of 150 miles contemplated in the allocation plan for television prior to September 1948.

Similar minimum separations for the 5000 microvolt per meter protected contour are shown in Table I which summarizes the results stated above;

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* An adjustment is needed to account for the uncorrelated nature of the variations in the desired signal relative to those of the undesired signal.

TABLE I - Minimum Separations - 40 db protection

| Contour protected | 90%-63 mc | 99%-63 mc | 90%-195 mc | 99%-195 mc | |
|---|---|---|---|---|---|
| 500 uv/m | 212 | 287 | 210 | 288 | miles |
| 5000 uv/m | 116 | 156 | 133 | 190 | miles |

If these computations are repeated with 25 db protection, as might be feasible if synchronized carriers were employed in all stations, the following Table results:

TABLE II - Minimum Separations - 25 db protection

| Contour protected | 90%-63 mc | 99%-63 mc | 90%-195 mc | 99%-195 mc | |
|---|---|---|---|---|---|
| 500 uv/m | 151 | 199 | 163 | 225 | miles |
| 5000 uv/m | 78 | 94 | 98 | 129 | miles |

Comparison of the values in Tables I and II shows the sppreciable benefit (closer permissible separations) which accrues from carrier synchronization. This benefit would be available provided that the synchronizing techniques now available, or improved techniques, were used by all co-channel stations in contiguous interference areas, and provided further that sudden phase variations in tropospheric propagation or othe deleterious effects, not yet observed, do not make their appearance. A recommendation on the use of carrier synchronization appears in Chapter VII of this report.

25. Reduction of television service areas caused by separations less than minimal. For various reasons it may be impracticable in particular cases to separate stations by the minimum values specified in Tables I and II. The effect of such sub-minimal separation is to reduce the service areas of the stations involved. RMA Television Systems Subcommittee TS-3, using a technique first presented in the RTPB Panel 6 Subcommittee on Shared Services, has shown the service areas to be expected when separations of 150 and 250

miles are adopted, the other factors being those used in computing Table I (40 db protection). Figures 1 through 4, Annex 7 show the results.

At 63 mc, with 150 miles separation, the 99 per cent protected area has a radius of only 20 miles, while the 90 per cent protected area has a radius of 33 miles. When the separation is increased to 250 miles, these radii become 36 miles and 49 miles respectively. Thus, increasing the separation from 150 to 250 miles produces an increase in service area (square miles covered) of 225 per cent (99 per cent service) or 120 per cent (90 per cent service). Similar increases occur at 195 megacycles, as Figs. 3 and 4, Annex 7 show.

A similar study carried out for the synchronized carrier case, with 25 db protection, is shown in Figs. 5 through 8, Annex 7. It will be noted the reduction of service area, assuming 150 mile separation, is much less pronounced than in the non-synchronized case.

26-27. Minimum separations and service areas of fm broadcast stations. On the same basis, the minimum co-channel separation between fm stations can be computed, at 98 mc, with 10 db signal-to-interference ratio and 50 microvolt per meter desired signal. The minimum separation so computed for 99 per cent service is 227 miles. For 90 per cent service the minimum separation is 175 miles. For protection at the 25-microvolt-per-meter contour, the respective separations are 262 miles (99%) and 203 miles (90%).

Curves showing the reduction in service area when the separations fall below these minimal values have been prepared and are shown as Figs. 1 and 2 of Annex 12.

# CHAPTER VII

## CONCLUSIONS

28. Allocation standards. The allocation standards given in the Table III are considered, on the basis of data available to JTAC, to be suitable for vhf allocations to television and fm broadcasting (all data in Class B except the 25 db protection figure for synchronized television which is Class C):

29. Table of standards:

TABLE III - Recommended Allocation Standards

| Service | Signal Strength | Co-channel protection | 1st Adjacent channel protection | 2nd Adjacent channel protection |
|---|---|---|---|---|
| Suburban -Rural TV | 500 uv/m (see note) | 40 db<br>25 db* | 0 db**<br>6 db*** | -- |
| Urban TV | 5000 uv/m | 40 db | 0 db**<br>6 db*** | -- |
| Rural FM | 25 uv/m | 10 db | -16 db | -40 db |
| Urban FM | --- | 10 db | -16 db | -40 db |

* Tentative value when co-channel carriers are phase-synchronized

** Upper adjacent channel

*** Lower adjacent channel

Note: The signal strength for suburban-rural television service on channels 7 through 13 should be somewhat greater than that for channel 2 through 6. A value between 500 and 1000 microvolts is recommended for channels 7 through 13.

30. Separation between television stations: The heart of the allocation problem is the minimum allowable separation between stations. If the data in T. I. D. Report 2.4.5 are taken at face value, it is clear that the separations contemplated in the previous allocation are too small. In that event, greater separations would be indicated. However, if the techniques of synchronization or the appropriate use of directional antennas or both, are available, the previously contemplated separations would be more feasible.

31. Directive antennas. Transmitting antennas having horizontal directivity are considered practicable and should be used in particular instances where they can be shown to afford protection to other stations without unwarranted reduction of the intended service. However, it is suggested that the use of directive antennas be confined to assignments in particular situations warranting their use, and that their use should not be taken as a basis for setting up the basic allocation to television and fm broadcasting stations.

Receiving antennas having horizontal directivity are likewise practicable and may be employed by the public to avoid interference in many situations, particularly in locations collinear with the desired and interfering stations. But in situations where interference may be experienced from more than one direction, and particularly where the desired and interfering stations lie in nearly the same direction, their utility is much reduced. In an event, it is the conviction of JTAC that the allocation should not rely on the possible use by the public of highly directive receiving antennas.

The remarks regarding directive antennas are based on Class A information.

32. Phase-synchronization of television carriers. The benefits of phase-synchronization of television station carriers appear to be so important that they should be considered as a factor in allocations planning, despite the meager experience with the system. In particular it seems to JTAC that it would be unfortunate if an allocations plan were put into effect, in advance of reliable information on phase-synchronized carrier operation, which precluded utilizing the potential benefits of this method.

Experiments indicate that the interfering carrier may be increased by 15 db relative to the desired carrier without incurring additional interference, when the phases of the two carriers are locked in a fixed relationship. This is at present a Class C estimate. There is some theoretical justification, not yet fully developed, for assuming that such an improvement might be expected. If further experience shows that this 15 db increase in interfering signal strength may in fact be tolerated, the advantage gained in allocating stations is very substantial. In the illustrative examples in Chapter VI, it reduces the minimum separation for 90 per cent protected time from over 210 miles to 151 miles at 63 megacycles and to 163 miles at 195 megacycles. In fact, a separation not substantially different from that set up in the allocation prior to September 1948 (150 miles) would become feasible.

The following matters are suggested as requiring further investigation:

1. More precise determination, on experimental and theoretical grounds, of the increase in interfering signal strength permissible when phase-synchronization is employed. (Confirmation or modification of the Class-C 15 db figure here used).

2. Investigation of the effect of percentage modulation on the permissible increase in interfering signal strength. The JTAC notes that a limitation of peak-white modulation to 10 per cent of the peak carried amplitude

is currently being considered by the RMA Television System Committee to avoid improper operation of intercarrier receivers. The additional effect of such a limitation of modulation an interference between synchronized carriers is of interest and should be atudied.

3. The effect of the wave interference pattern between phase-synchronized carriers, particularly in zones where the two carriers are of nearly equal strength, should be studied. It is noted that, in locations collinear with the desired and interfering stations, the phase relatiohship between synchronized carriers changes from positive to negative in a distance of one-quarter wavelength, or about 13 inches at 216 megacycles (channel 13). Motion of the transmitting or receiving antennas by this amount might produce a visible (and possibly annoying) effect. This situation would become much more acute at ultra-high frequencies (one quarter wavelength is about 3 inches at 875 megacycles).

4. The practical or theoretical difficulties (if any) in synchronizing a large number of co-channel stations in contiguous interference areas should be investigated. A demonstration of synchronization among at least three stations, preferably arranged on the apexes of an approximately equilateral triangle, should be undertaken in the earliest opportunity.

5. The provision of communication channels for the synchronizing links should be considered. Ordinary telephone lines appear to be suffcient, but radio links might be required in some circumstances.

6. Other methods of synchronization, possibly using standard frequency transmissions, may offer promise.

The JTAC believes that none of the above listed matters are critical, and that a substantial improvement from the synchronization techniques is in prospect.

33. Effect of transmitter antenna height. It is the opinion of JTAC that the present FCC regulation concerning effective radiated power as a function of antenna height requires careful review. The present rule states that the effective radiated power must vary inversely as the square of the ratio of the actual antenna height to 500 feet. There is practical and theoretical evidence that the signal level propagated to a distance by the troposphere is nearly independent of antenna height. If this is proved generally to be the case, the ratio of the tropospheric interference area to the service area must decrease as the antenna height is increased, the power radiated remaining unchanged. It would then appear that the service to the public would be maximized by the use of the highest feasible antenna height, consistent with cost, regulations of the Civil Aeronautics Authority, and similar factors. The use of a lower than maximum antenna height increases the interference area, when higher power is associated with the lower height, without increasing the service area.

Based on the existing evidence, JTAC surmises that the proper exponent, relating antenna height ratio to the effective radiated power, should lie between the values 0 and 1, (Class C) rather than 2 as presently stipulated in the Commission's rules. The JTAC is not in a position to recommend a definite change in this regulation, but suggests that study of the matter is in order to maximize service areas relative to interference areas.

34. Television Transmitter power. The promised availability of higher power transmitters (Class B) and the generally expressed need for higher field strengths (Class A) prompts the JTAC to recommend that higher power be granted to television stations in the near future. A general increase in

transmitter power, undertaken at once by all stations regardless of location, is not necessary. But a group of stations in the same interference area might be authorized to increase power by the same amount as a group, subject to the allocation standards recommended in Table III in all respects except the numerical values of field strength at the protected contours in the group. While there are evident difficulties in such piecemeal granting of higher power, it appears to be a practical means of initiating an improvement in the public service which must eventually become universal.

## ANNEX LIST

1. List of JTAC Members
2. Letter from Chairman Siling to Chairman Coy, dated October 1, 1948
3. Letter from Chairman Coy to Chairman Siling, dated October 28, 1948
4. List of Committees and Subcommittees acting for JTAC
5. Program of Engineering Conferences (FCC release)
6. Report of IRE Wave Propagation Committee
7. Report of RMA Television System Subcommittee TS-3 on Television Allocation and Protection Against Interference
8. Report by M. W. Baldwin, Jr., "Single Frequency Video Interference Data"
9. Letter from K. A. Chittick on Effect of Automobile Ignition Interference on Television Reception
10. Letter from P. J. Herbst, RMA Television Transmitter Committee
11. Telegram and Letters Regarding Television Transmitter Power and Directional Antennas
12. Report of RMA FM Systems Committee
13. Report on Carrier Synchronization by R. D. Kell
14. Letter from Television Broadcasting Co. (Mr. Leon N. Papernow)
15. Letter from Allen B. DuMont Labs. (Dr. T. T. Goldsmith, Jr.)
16. Letter from RMA Committee on Television Receivers (Mr. I. J. Kaar)
17. Letter from IRE Antennas Committee (L. C. Van Atta)
18. Notice from RMA Television Transmitter Committee (P. J. Herbst)
19. Letter for RMA Receiver Committee (Mr. J. E. Brown)

Mr. Philip F. Siling, Chairman
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Mr. J. V. L. Hogan
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Mr. E. K. Jett
Radio Station WMAR
Sun Papers
Baltimore, Maryland

Mr. Haraden Pratt
272 Chapel Road
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Mr. David B. Smith
Philco Corporation
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Philadelphia, Pennsylvania

Mr. L. G. Cumming, Non-member Secretary
Institute of Radio Engineers
1 East Seventy-ninth Street
New York 21, New York

October 1, 1948

The Honorable Wayne Coy, Chairman
Federal Communications Commission
Washington 25, D. C.

Dear Mr. Coy:

The Joint Technical Advisory Committee wishes to be of the maximum possible benefit to the FCC in obtaining information and data for it which will prove helpful in the decisions which they are required to make.

The first activity of the JTAC was, of course, the preparation of a report in regard to the use of the ultra high frequency spectrum for television, which was given to the Commission during the hearing on that subject September 20. We would like very much to continue to be of assistance in this matter as well as any other pressing problems that you may have in mind and I wish, therefore, that you would feel free to call upon us at any time and we will respond to the best of our ability.

While we are, of course, available for consultation with members of your staff, we feel it would be better on any problem involving a considerable amount of work if the Commission itself would ask us for our opinions, advice or information. We trust that in this way we can save the Commission time by giving it the benefit of all information available through the recognized industrial channels.

With very best personal wishes.

Sincerely,

Philip F. Siling

FEDERAL COMMUNICATIONS COMMISSION
WASHINGTON 25, D. C.

October 28, 1948

Mr. Philip F. Siling, Chairman
The Joint Technical Advisory Committee, IRE-RMA
1 East 79th Street
New York 21, New York

Dear Mr. Siling:

I have your letter of October 1, 1948, offering the continued assistance of the JTAC in providing information which will be helpful to the Commission. I quite agree that the major tasks which JTAC undertakes for the Commission should be in response to requests through the Commission rather than through staff contacts. In this way we can assure that emphasis is placed upon the problems which the Commission considers to be the more important.

While the question of JTAC assistance may appear to have lain dormant since the September 20th hearing, I assure you that such is not the case. Your participation in the current proceedings relative to very-high-frequency and ultra-high-frequency television has been one of the principal topics for discussion in the several Commission and staff meetings which we have held on these subjects since that date. I have deferred answering your letter, however, until our plans for proceeding in the television matters had crystallized and a definite proposal could be made.

The more urgent of the two proceedings is of course the one regarding very-high-frequency, involving as it does a freezing of assignments for an indefinite, but we hope a limited, period. It would appear, therefore, that any activity in regard to the ultra-high-frequency situation which will result in a delay in the very-high-frequency considerations should be postponed until a later date.

Although the time is short and it is appreciated that only a small amount of new information can be developed within its limitations, nevertheless, it should be sufficient for collecting and processing certain pertinent information which has been accumulating since the last major revision of the standards.

I am forwarding herewith a copy of FCC 48-2256, "Notice of Further Proposed Rule Making" in Dockets 8975, 8976, and 9175, outlining the procedure to be followed for VHF television. There is also enclosed a copy of FCC48-1966, the notice of issuance of four reports in preparation for the engineering conferences which are a part of the procedure.

Mr. P. F. Siling October 28, 1948

Ten additional copies of the notices and ten copies of each of the reports are being sent under separate cover for use by JTAC. Copies of the channel studies, referred to in paragraph IVB of FCC 48-2256, will be forwarded when issued.

A reading of the procedure outlined in FCC 48-2256 will indicate that the agenda for the engineering conferences is a rather heavy one, although it is being limited to factors which have an appreciable effect on the station allocation plan. A considerable preparation will be involved, both by the Commission and by the Industry.

While the Commission will be able to make contributions in some degree to a substantial number of the items listed in the agenda, personnel who will be available for this proceeding will devote their time principally to the following:

1. Further study of tropospheric effects, particularly the effect of transmitting antenna heights, Item IVD(1) (a).

2. Further study of terrain effects, IVD(2).

3. TV and FM channel studies, IVB.

4. Preparation of a film showing the effects on the received picture of various signal/noise ratios and desired/undesired ratios of co-channel and adjacent-channel interference, affecting items IVE(3) and (4).

It is not desired to circumscribe the activities of JTAC in its efforts to assist the Commission in this proceeding, but I would recommend that the following matters be given particular attention, the procedure indicated in each case, of course, being merely by way of suggestion.

(1) That JTAC submit the accompanying reports to the proper committees of the IRE and the RMA for comment, recommending that any similar studies which are known or can be prepared by persons on the committees be made available for consideration at the first conference.

(2) That JTAC and the committees of the IRE and the RMA study the agenda announced in FCC 48-2256 critically with a view to (a) detecting any omissions or any items which are believed to be unnecessary to a resolution of the channel allocation problems, (b) determining the items upon which infor-

mation can be furnished by JTAC and its associated committees and (c) assessing the adequacy of the time schedule in permitting the formulation of answers to the various items.

Some of the items on which the JTAC and its committees can be of particular assistance are the following:

IVD(3) Antennas. In addition to transmitting antennas and the practicability of assuming directional operation in the allocation plan, practical receiving antennas and their directional effects should be considered.

IVE(3) Reexamination of co-channel and adjacent-channel ratios, on the basis of test data to be furnished by the manufacturers of various commercial receivers.

IVE(4) Reexamination of contours involving:

a. Noise and interference levels in urban and suburban areas at various frequencies.

b. Noise figures for commercial receivers.

c. Acceptable signal/noise ratios.

d. Typical receiving antennas and transmission lines.

IVE(6) & 7 Present capabilities of power generation for frequencies between 54 and 216 megacycles.

The JTAC may desire to furnish answers to items other than those which I have listed and should, of course, feel perfectly free to do so. Complete or partial answers to some of the items may be found in previous information furnished by JTAC, in which case the reply should so indicate, with appropriate references.

Do not hesitate to call upon the Commission if further details or clarification of our request is desired.

Sincerely yours,

Wayne Coy
Chairman

Enclosures

# ANNEX 4

RMA and IRE Committees Acting for JTAC

in the matter of

VHF Allocation Standards

RMA Television Systems Committee, F. J. Bingley, Chairman
RMA Subcommittee TS-3, Mr. Bingley, Chairman

RMA FM Systems Committee, Mr. George R. Town, Chairman

RMA Television Transmitter Committee, Mr. P. J. Herbst, Chairman

RMA FM Receiver Committee, Mr. J. E. Brown, Vice Chairman

IRE Television Systems Committee, Mr. D. G. Fink, Chairman
Subcommittee, Mr. Fink, Chairman

IRE Wave Propagation Committee, Mr. A. Earl Cullum, Jr., Chairman
Subcommittee, Mr. Cullum, Chairman

ANNEX 5

Received October 18, 1948
FCC 48-2256
27297

FEDERAL COMMUNICATIONS COMMISSION
Washington, D. C.

In the Matter of

| | |
|---|---|
| Amendment of Section 3.606 of the Commission's Rules and Regulations | Docket Nos. 8975 and 8736 |

In the Matter of

| | |
|---|---|
| Amendment of the Commission's Rules, Regulations and Standards concerning the Television and Frequency Modulation Broadcasting Services. | Docket No. 9175 |

## Notice of Further Proposed Rule Making

I. Notice is hereby given of further proposed rule making in the above entitled matter.

II. During the hearing held by the Commission in the above-entitled proceeding (Docket Nos. 8975 and 8736) to consider proposed revisions of the Commission's table of television channel allocations, evidence was presented concerning (A) tropospheric interference to existing and proposed television stations, (B) the use of directional antennas, (C) the use of increased power, and (D) conflicting proposals for closer spacing and wider spacing between television stations than is presently provided for by the Commission. In order to assure that the Commission's national television allocation plan should be based on the soundest engineering foundation, and Industry-Commission Conference was held on September 13 and 14, 1948. The issues for decision at the Conference were:

"1. Whether the Commission should initiate proceedings to revise the television allocation rules and standards prior to final decision in Dockets 8975 and 8736.

2. If the standards are to be revised, what policy should be adopted with respect to applications now pending before the Commission.

3. What procedurs should be adopted in order that the revised standards can be based on the best available engineering information."

III. At the conclusion of said Conference it was announced that the Commission would call an engineering conference to consider questions regarding revisions of the Commission's Rules, Regulations and Standards with respect to the technical phases of television allocations. This

Notice deals with issues "1" and "3" set forth above. On September 30, 1948, the Commission issued its Report and Order herein concerning issue number "2". Further, since the Frequency Modulation Brodcasting Service is directly affected by any action taken with respect to propagation in the VHF band, revisions of the Rules, Regulations and Standards of that service is made a part of this proceeding.

IV. In order to facilitate and expedite the promulgation of rules, regulations and standards herein, the following schedule will be followed:

(A) On or about October 20, 1948, the Commission will make public:

(1) A repOrt containing (a) a summary of available measurements of tropospheric fields, (b) empirical method of treating measurements to formulate field intensity vs distance curves for various frequencies for variation percentages of the time and (c) representative tropospheric field and intensity curves for antenna heights of 500 feet and 30 feet for various frequencies and percentages of time derived by the foregoing method.

(2) A study of the effects on service of the simultaneous fading of both the desired and undesired fields from tropospheric causes.

(3) A report on measurements made at Princeton, Southampton and Laurel on frequencies of 47.1, 106.5 and 700 Mc. radiated from transmitters in New York City.

(4) A study of the effects of terrain upon average signal levels as compared to smooth earth values and upon the variability of signal levels within limited areas.

(B) On or about November 15, 1948, the Commission will make public:

(1) A TV channel study showing the effects of ground wave and tropospheric interference on representative service areas of stations allocated in accordance with the Commission's Notice herein of May 5, 1948, as amended in the Commission's Supplemental Notice of July 15, 1948.

(2) A TV channel study in a representative area showing the effects of ground wave and tropospheric interference on the service areas of presently operating stations and CP's, but with other allocations spaced so as to protect the 500 u/m contours 90% of the time. (All allocations to be based on 50 kw/500 ft. in the center of the principal city.)

(3) Channel study for FM showing the effects of ground wave and of tropospheric interference for 1% and 10% of the time on representative channels.

(C) On or about November 30, 1948, December 1, 1948 and December 2, 1948, the Commission will hold a series of engineering conferences in Washington, D. C. 1/ All interested persons are invited to attend said conferences, participate fully therein, and to submit written data, views, or arguments with respect thereto. To assist the Commission in the expeditious conduct of said conferences, it is requested that persons who plan to participate therein file (by letter) notice of their intention to do so at least one week prior to the date of commencement of said conferences. Written statements may be filed on or before the dates of the respective conferences.

(D) The first conference to be held on or about November 30, 1948, will be on VHF propagation standards to arrive at standard methods of evaluating the effects upon propagation of the following factors:

(1) Tropospheric effects -

(a) Variation with time in the field intensities to be expected at various distances from the transmitter, as functions of transmitting antenna height and of frequency.

(b) Range of diurnal variations.

(c) Range of seasonal variations.

(d) Effects on service of the simultaneous fading of both the desired and undesired signals.

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1/ The exact date and place of each conference will be announced at a later date.

(2) Terrain effects -

(a) Shadows - relation of the average field intensity in a limited area or limited section of a radial to calculated values as a function of the profile between the area and the transmitter.

(b) Urban field intensities - validity of the FCC standards on Ground Wave Signal Range charts for predicting near-in fields in city areas.

(c) Local terrain effect - variability of field intensities as compared to the average over a limited area or distance.

(d) Receiving antenna height-gain factor- validity of assuming a uniform variation of field intensity with receiving antenna height for relating mobile measurements made at low antenna height to the standard receiving antenna height of 30 feet. Consideration of the alternative method of spot measurements at 30 feet height.

(e) Apparent transmitting antenna height - validity of the 2-10 mile rule for estimating the apparent height of the transmitting antenna.

(f) Validity of the method presently prescribed in the Commission's Standards for equalizing coverage obtained by transmitters of varying antenna heights and power.

(3) Antennas -

(a) Practical limitations on vertical and horizontal directivity of transmitting antennas

(b) Methods for establishing and maintaining the performance of directional antennas.

(c) The engineering basis for utilizing horizontal directivity in allocation problems.

(E) The second conference to be held on or about December 1, 1948 will consider the following items with respect to VHF television broadcasting:

(1) Tropospheric effects:

(a) Specification of grade or grades of service resulting from variations in the intensities of desired and undesired fields.

(b) Discussions of the effects of the specification of various grades of service on particular channel allocation plans.

(c) The development of standard tropospheric curves for various frequencies and antenna heights, calculated in accordance with methods approved at the propagation conference.

(2) Examination of current standards for the prediction of service areas to determine whether any modifications are dictated by the terrain effects considered in the propagation conference.

(3) Reexamination of cochannel and adjacent channel ratios at the receiver terminals in the light of more recent information; and a determination whether a terrain factor should be included in the field intensity ratios.

(4) Reexamination of the contours specified for protection and for recognized service levels at various frequencies.

(5) Reexamination of assumptions as to typical receiving antenna heights for urban and rural areas and of methods of proving station performance by measurement of received fields at such heights.

(6) Examination of theeffects of horizontal increases in power upon protected contours in the channel allocation plans.

(7) Examination of the effects of differential increases in power on the protected contours and on the allocation plans.

(8) Examination of the effects of directional antennas on allocation plans.

(F) The third conference to be held on or about December 2, 1948, will consider the following items with respect to FM broadcasting:

(1) Tropospheric effects:

(a) Specification of grade or grades of service resulting from variations in the intensities of desired and undesired fields.

(b) Study of the areas provided with various grades of service under the present channel assignments and under the tentative allocation plan.

(c) The development of standard tropospheric curves for various antenna heights, calculated in accordance with methods approved at the propagation conference.

(2) Examination of current standards for the prediction of service areas to determine whether any modifications are dictated by the terrain effects considered in the propagation conference.

(3) Reexamination of assumptions as to typical receiving antenna heights for urban and rural areas and of methods of proving station performance by measurement of received fields at such heights.

V. Authority to issue amendments of the Commission's Rules, Regulations and Standards with respect to the matters to be discussed at the conferences listed above is vested in the Commission by Sections 301, 303(b),(c),(d),(f),(h)and(r), and 4 (i) of the Communications Act of 1934, as amended.

VI. In accordance with the provisions of Section 1.764 of the Commission's Rules and Regulations, an original and 14 copies of all written data, views, or arguments filed shall be furnished the Commission.

FEDERAL COMMUNICATIONS COMMISSION

T. J. Slowie
Secretary

Adopted: October 14, 1948
Released: October 15, 1948

ANNEX 7

# Report

# of

# RMA COMMITTEE TS-3

# on

# Television Allocation and Protection Against Interference

Mr. F. J. Bingley, Chairman

Mr. W. E. Bradley | Mr. J. D. Reid

Dr. T. T. Goldsmith, Jr. | Mr. R. E. Shelby

11-24-48

Introduction

The committee was formed at the October 25, 1948 meeting of the Television Systems Committee, for the purpose of considering what principles should be followed in allocation of frequencies in order that television receivers might be protected against interference from distant television stations to the maximum extent possible. Its assignment included the collection of relevant receiver characteristics from the receiver committee of RMA and other pertinent sources, and the examination of the correlative effect of these characteristics on the allocation problem in view of the tropospheric propagation information published recently by FCC.

Television Receiver Questionnaire

A letter questionnaire was circulated to all members of the RMA committee on television receivers, asking for information on the following matters:

1. What is the signal strength which, in your estimation, will give satisfactory receiver performance.

   a. In the absence of man made interference.

   b. In the presence of such interference to the extent it might be encountered in a metropolitan region.

2. What protection ratio (that is, ratio of wanted to unwanted signal) should be provided in the allocation plan against co-channel interference.

3. What protection ratio should be provided in the allocation plan against adjacent channel interference.

   a. With respect to interference from a station in the upper adjacent channel.

   b. With respect to interference from a station in the lower adjacent channel.

4. What other comments do you have regarding allocation principles which you think are desirable.

Many replies were received and the cooperation of Mr. I. J. Kaar (Chairman R-4) and of the members of his committee is gratefully acknowledged.

A tabulation and discussion of the replies received is attached as appendix 1.

With respect to other pertinent data on this matter, the TS-3 Committee examined the report of the subcommittee on Shared Services of the Television Systems Committee. This report was issued December 29, 1947, and contained a subjective analysis of the perceptibility of interference on current television receivers of various manufacture. Figure 1.6 of the above report was considered by TS-3 to be especially pertinent, since it displays the levels of just perceptible interference for interfering signals at various frequencies through the

lower adjacent channel, the desired channel, and the upper adjacent channel. This figure shows that, in general, the present standards of 2/1 (6 db) protection against adjacent channel and 100/1 (40 db) protection against co-channel interference appear to be satisfactory. It also indicates that somewhat less protection is needed against interference from upper adjacent channel than from the lower adjacent channel.

Summarizing the above information, it would appear that present protection ratios are adequate. If any change were to be made, the protection from upper adjacent channel could be reduced, though this committee is not prepared to recommend such a change at this time.

Tropospheric Interference

The committee examined the report of the FCC Bureau of Engineering, Technical Information Division, Report No. T.I.D. 2.4.5.

As an example of the implications to be drawn from this report, the following tabulation was made using Figure 21, to define the various signal contours of a 50 KW 500 ft. station operating at 63 MC.

| Contour Microvolts Meter | Distance to Contour, Miles 99% Signals | 1% Signals |
|---|---|---|
| 5 | | 251 |
| 50 | | 136 |
| 500 | 36 | |
| 5000 | 20 | |

This shows that, to protect the 500 microvolt contour 99% of the time requires a separation of 287 miles between co-channel stations. To protect the 5000 microvolt contour 99% of the time requires a spacing of 156 miles. It should be noted that these separation figures are conservative, since the wanted signal can be greater than 500 microvolts, and the times at which it is greater than 500 microvolts may not coincide with the times when the interfering signal is higher than 50 microvolts.

The committee attempted to adduce corresponding figures for a 12.5 KW station having an antenna 1000 feet high. The information contained within Report T.I.D. 2.4.5 does not apparently contain all the information necessary for this job. It does appear from the report that the fading ratio will be 4 db less with the 1000 foot antenna, but how this is to be apportioned between the 1% curve and the 99% curve is not stated.

However, if we assume that the 6 db increase in signal due to the added height accrues uniformly at all distances to the 99% signal, then the 1% signal is only increased by 6-4=2 db at all distances. This would appear to indicate that the present allocation practise that would require a 6 db decrease in power of the transmitter with a 1000 foot antenna, is an unduly severe restriction since the interference level is only increased 2 db due to the additional height.

The above discussion would indicate a condition consistent with a physical characteristic that the tropospheric field beyond the horizon is dependent mostly upon transmitter power, and very little upon antenna height. Whether this is actually the case should, we feel, be explored through a series of measurements directed towards this point specifically.

If such a condition is, in fact, found to exist, then the committee would recommend that the present allocation practise with respect to reducing assigned power where the antenna height exceeds 500 feet, be modified. This would remove what appears to be a serious inequity in the present allocation plan.

The modification required would be in the direction of assigning power independent of antenna height.

The committee has prepared drawings indicating expected service areas based on 99% and 90% protected time. These drawings are based on several values of co-channel spacing, and upon frequencies of 63 MC and 195 MC respectively. They are similar in character to curves presented in FCC Report T.I.D. 4.3.3, except that the present drawings are prepared directly from figures 21 and 24 of Report T.I.D. 2.4.5, and refer to 63 MC and 195 MC instead of 82 MC as in T.I.D. 4.3.3. These drawings are attached as figures 1,2,3 and 4. Of these figures, figure 1 represents the 63 MC case with 150 mile co-channel spacing; figure 2 shows the effect of increasing the spacing to 250 miles; figure 3 shows the 195 MC case with 150 mile co-channel spacing; and figure 4 shows the effect of increasing the spacing to 250 miles. The scale of these figures is 20 miles to the inch, so that the service area can be determined directly from them. These figures are all based upon a co-channel protection ratio of 40 db.

In order to indicate the effect of reducing the co-channel protection to 25 db, figures 5 through 8 are presented. These figures correspond to figures 1 through 4 respectively, except that the protection has been reduced to 25 db.

All of the figures mentioned above show conservative estimates of the expected service area for the reason previously noted in connection with the tabulation.

It is obvious that in setting up a practical allocation scheme compromises with quality and extent of service are involved. The committee believes that to expect service 99% of the time is probably unnecessarily idealistic. Certainly other broadcast services do not have this near an approach to perfection. Perhaps 90% service may have to be the compromise. In this regard it should be noted that the degree of tolerance of more-than-perceptible interference levels is a subjective problem which has received no study at all so far as this committee is aware. Also, ameliorating local expedients may be useful, such as directional receiving antennas.

## Transmitter Power

The committee notes that, with the present allocation structure based on 50 KW 500 foot stations, many stations having antennas higher than this are operating at reduced powers. In many cases, it has been necessary to reduce the transmitter power output to 50% of the rated transmitter output. We feel that this is unfortunate, since the service provided is degraded to a level lower than

that which the transmitter could provide, were it operated at full output.

It is felt that effective radiated powers must be increased beyond the presently contemplated 50 KW ceiling. If the power increases are made in "horizontal" fashion, the quality of service will be improved over a given area. This will mean that existing ideas of protected contours will have to be revised upwards, but the service areas will remain unaffected. This, the committee feels, is a very desirable object, and urge that its accomplishment be planned and expedited.

## APPENDIX A

| Respondent | Information Supplied: Signal Strength for Satisfactory Receiver Performance (Microvolts/m) (a) No Man-Made Interference | (b) In Typical Metropolitan Region | Co-channel Protection Desired | Adjacent Channel Protection Desired (a) Upper adj | (b) Lower adj |
|---|---|---|---|---|---|
| A | 200-500 | 5000 [1] | 40 db | -3 db | 0 db |
| B | 310-1240 | 5000 [2] | 40 db | 0 db | 6 db |
| C | 300 | 10,000 [3] | 40 db | 6 db (2-1) | 14 db (5-1) |
| D | 250 | 2500 | 40 db | 20 db [4] | 20 db [4] |
| E | 500 [5] | 5000 [5] | 40 db [5] | 6 db [5] | 6 db [5] |
| F | 100 | 1000-5000 | 46 db | NO ANSWER | |
| G | NO OPINION | | | | |
| H | 100 | 1000 | No Ans. [6] | NO ANSWER [7] | |
| I | 100 | 500 | No Ans. [8] | NO ANSWER [8] | |

Notes

1. Ignition Interference an important factor.
2. 90-95% of locations will receive satisfactory service at this level. At a few locations, noise is so high that 50,000 microvolts is insufficient.
3. Microvolts across 300 ohm receiver input.
4. Respondent feels that receivers can be designed to operate with 0 db adjacent channel protection, but that many receivers now in the field do not have good adjacent channel selectivity.
5. Endorses RTPB figures.
6. Co-channel interference is one which is more important from allocations standpoint.
7. Interference from lower adjacent channel more serious than from upper adjacent channel.
8. Present allocation principles where stations are not permitted in adjacent channels in a given service area is a desirable one.

Regarding other comments on allocation matters (item 4) these comments included:

1. Future allocations should be made so as not to require expensive receivers due to severe adjacent channel requirements.

2. Directive antenna recommended at receiver to reduce co-channel interference.

3. Higher power for transmitters recommended. Locate transmitters short distance away from residential areas to reduce crosstalk.

4. Directional transmitting antennas recommended to reduce co-channel interference.

5. If UHF channel assignments are made using present standards, intensive field tests should be used as a basis of allocation.

6. Tropospheric reception of stations 100-300 miles away in the FM band not at all uncommon. More serious effects expected in TV reception.

Revision made 11/24/48

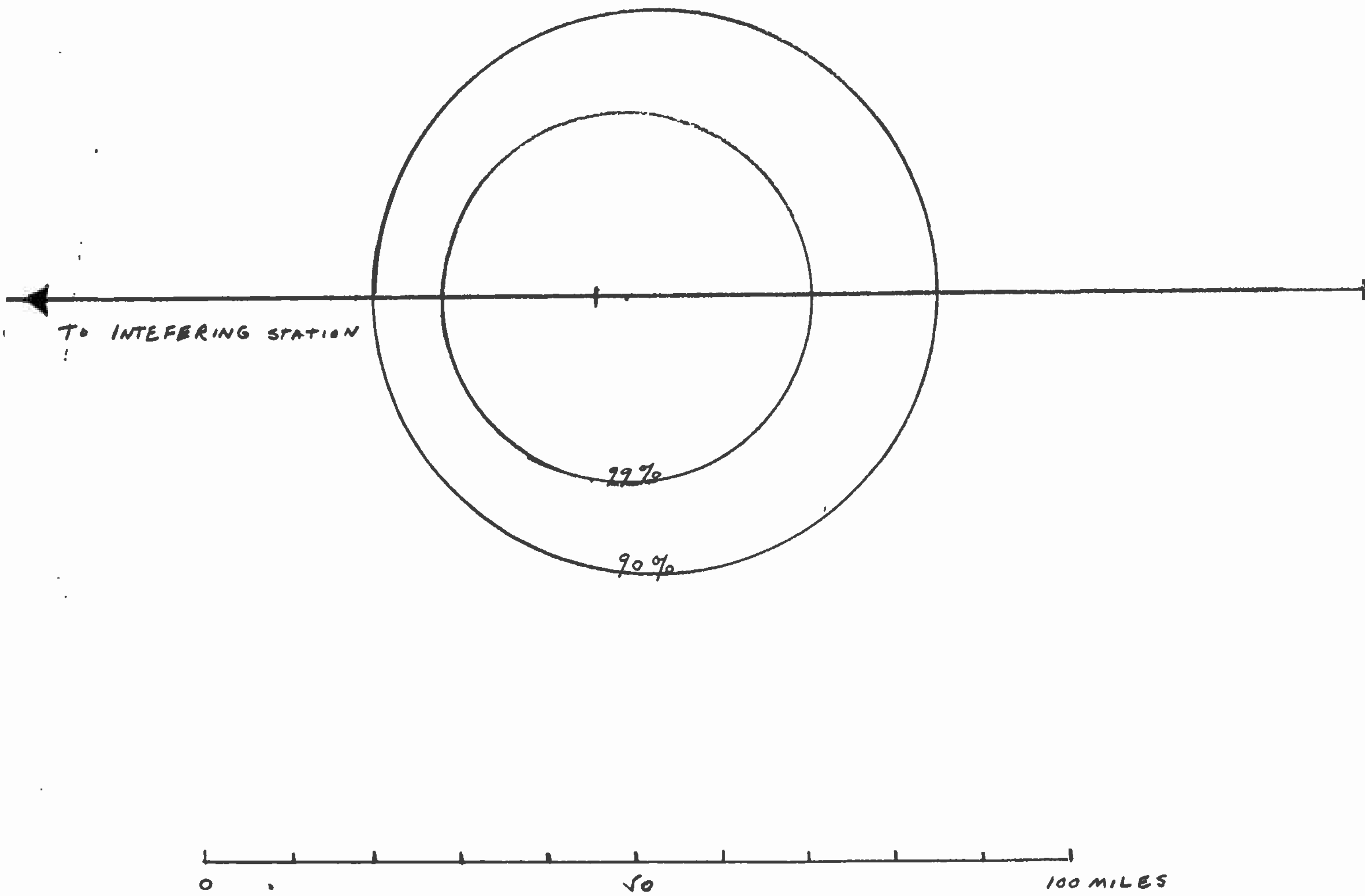



FIG 1
150 MILES
63 Mc.
CO-CHAN.
40DB
TD 549

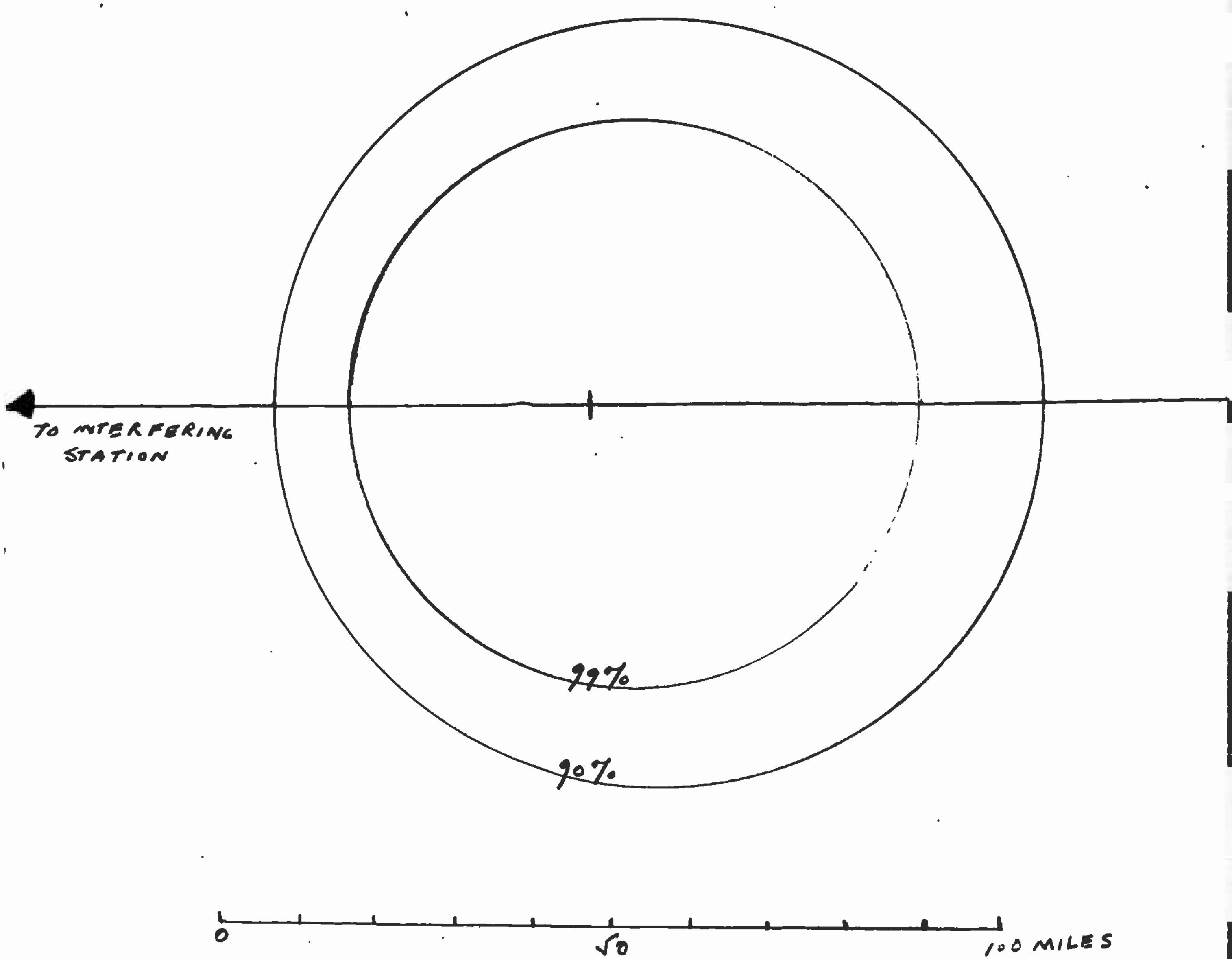



FIG 2
250 MILES
63 MC.
CO-CHAN
40 DB
TD 550

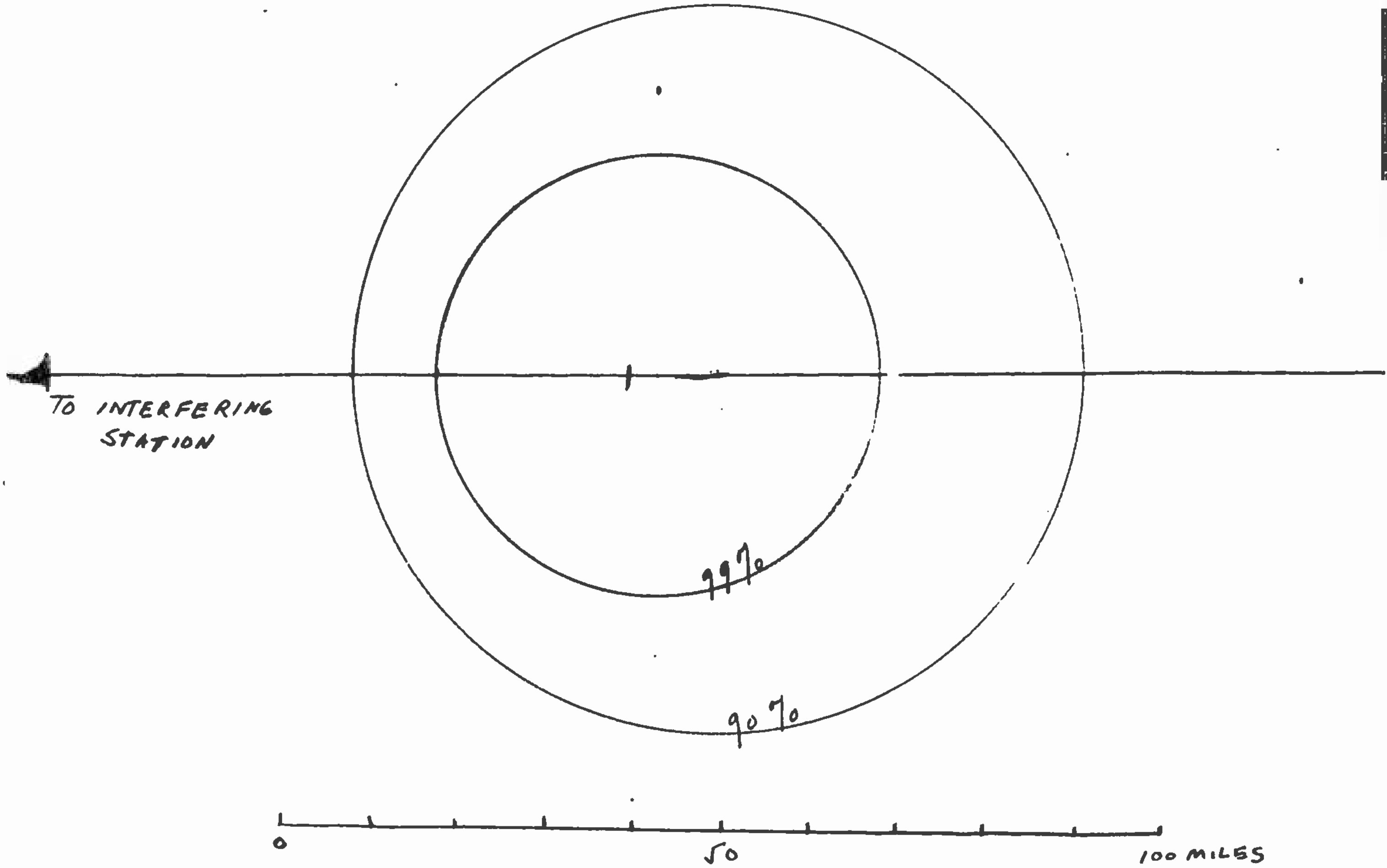



FIG 3

150 MILES
195 Mc.
CO-CHAN
40 DB

TD 551

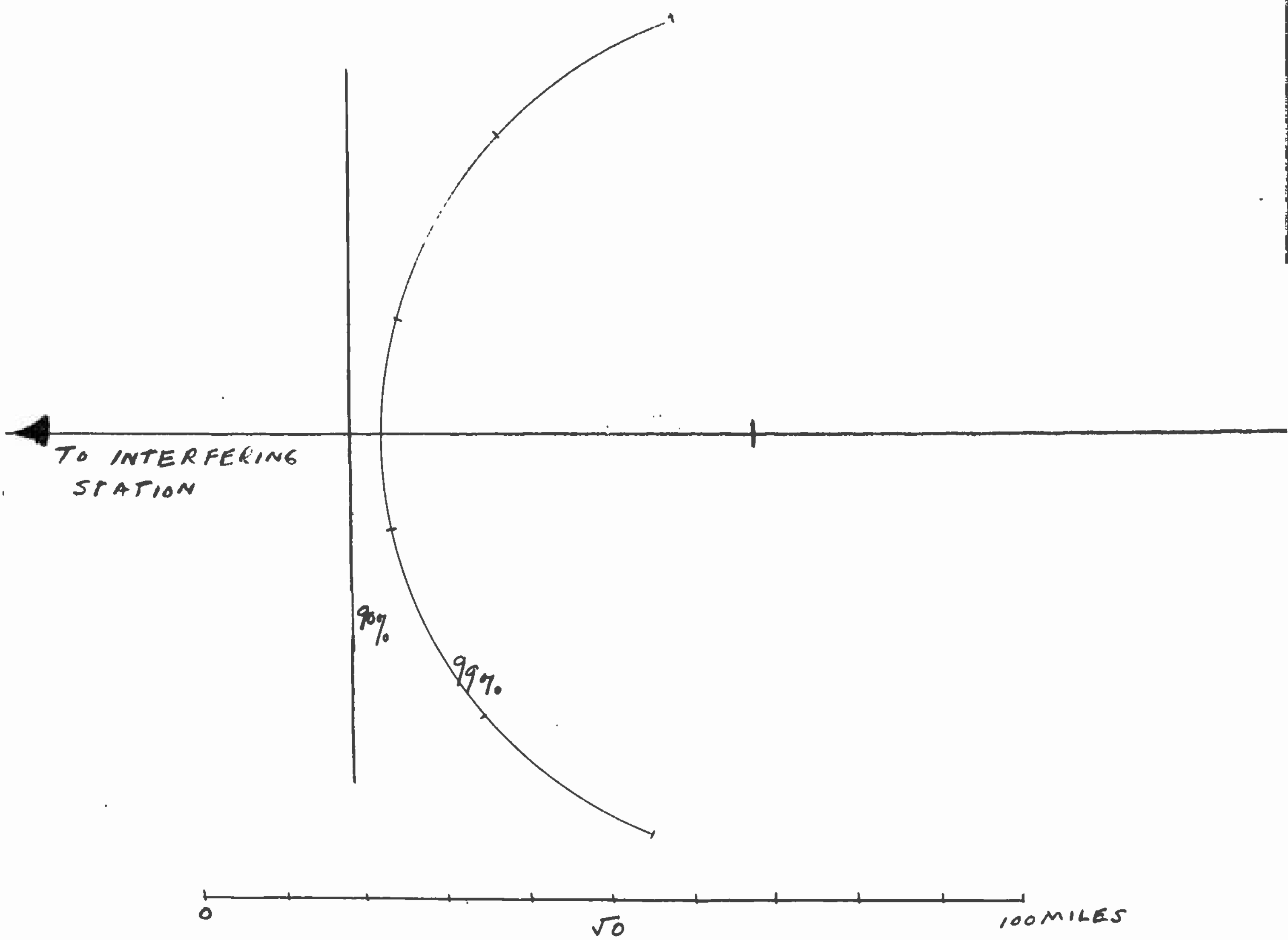



FIG 4
250 MILES
195 Mc
CO-CHAN
40 DB
TD 552

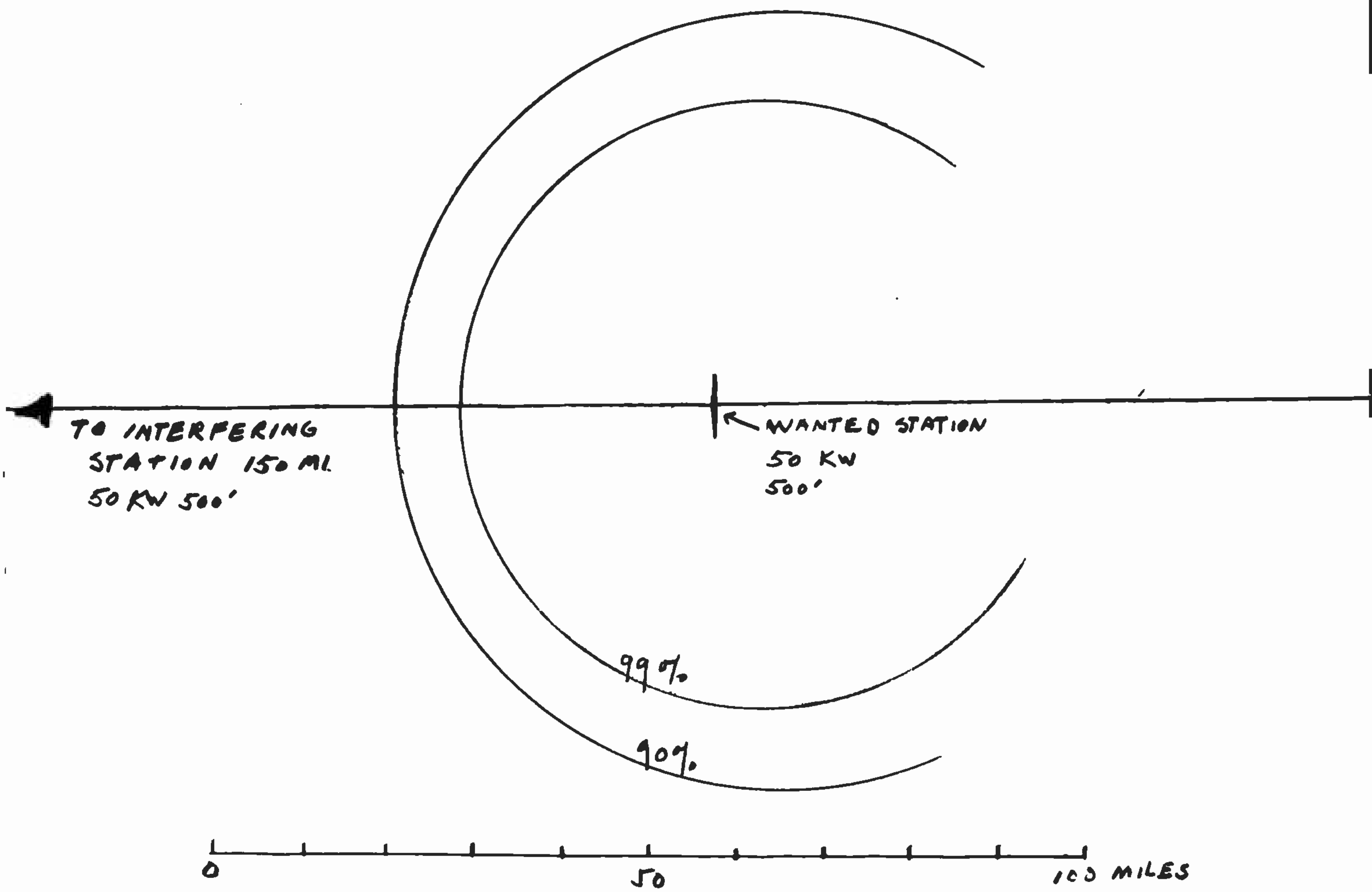



FIG 5
150 MILES
63 Mc.
CO-CHAN
25 DB

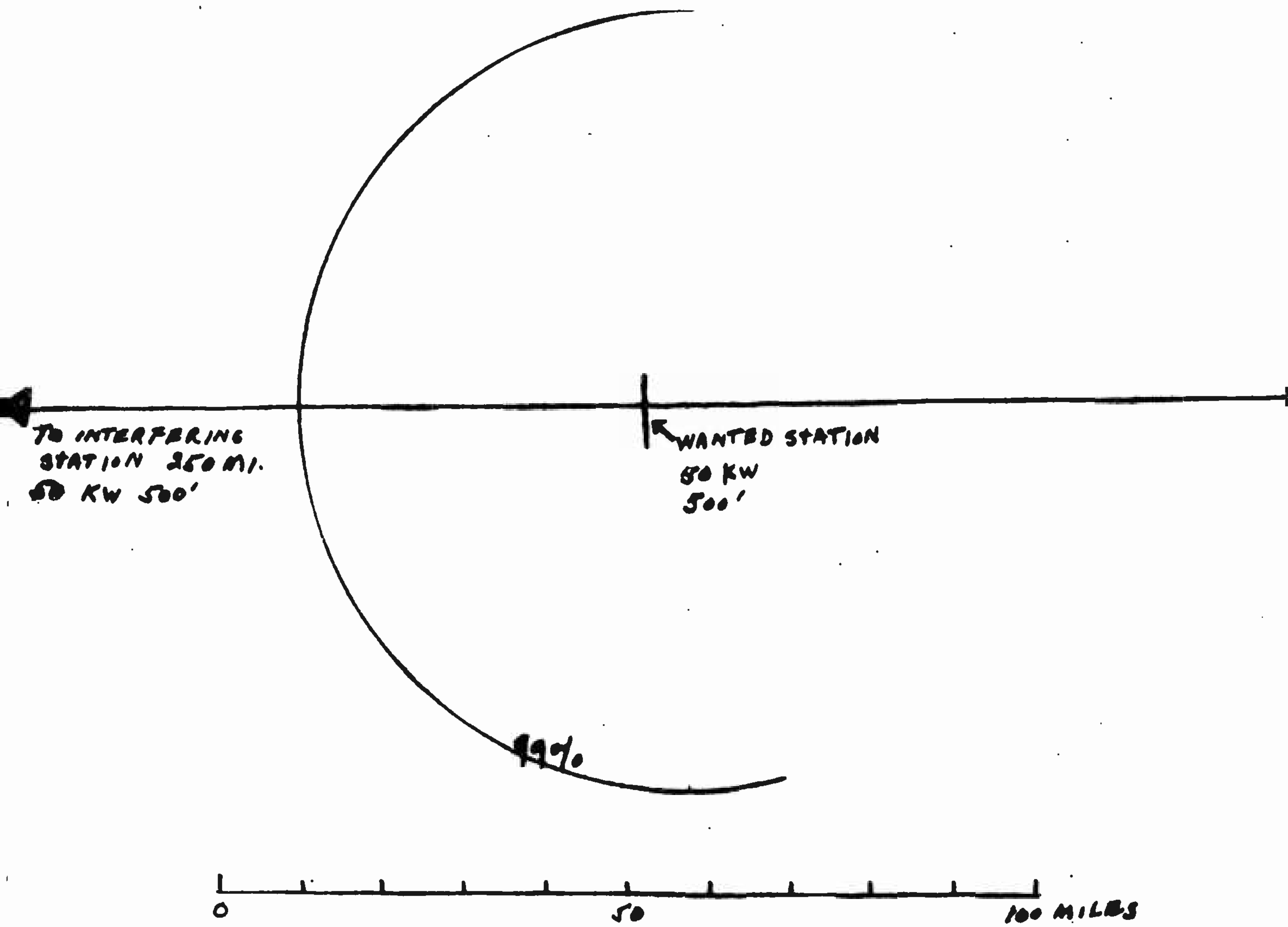



FIG 6
250 MILES
63 Mc.
CO-CHAN
25 DB

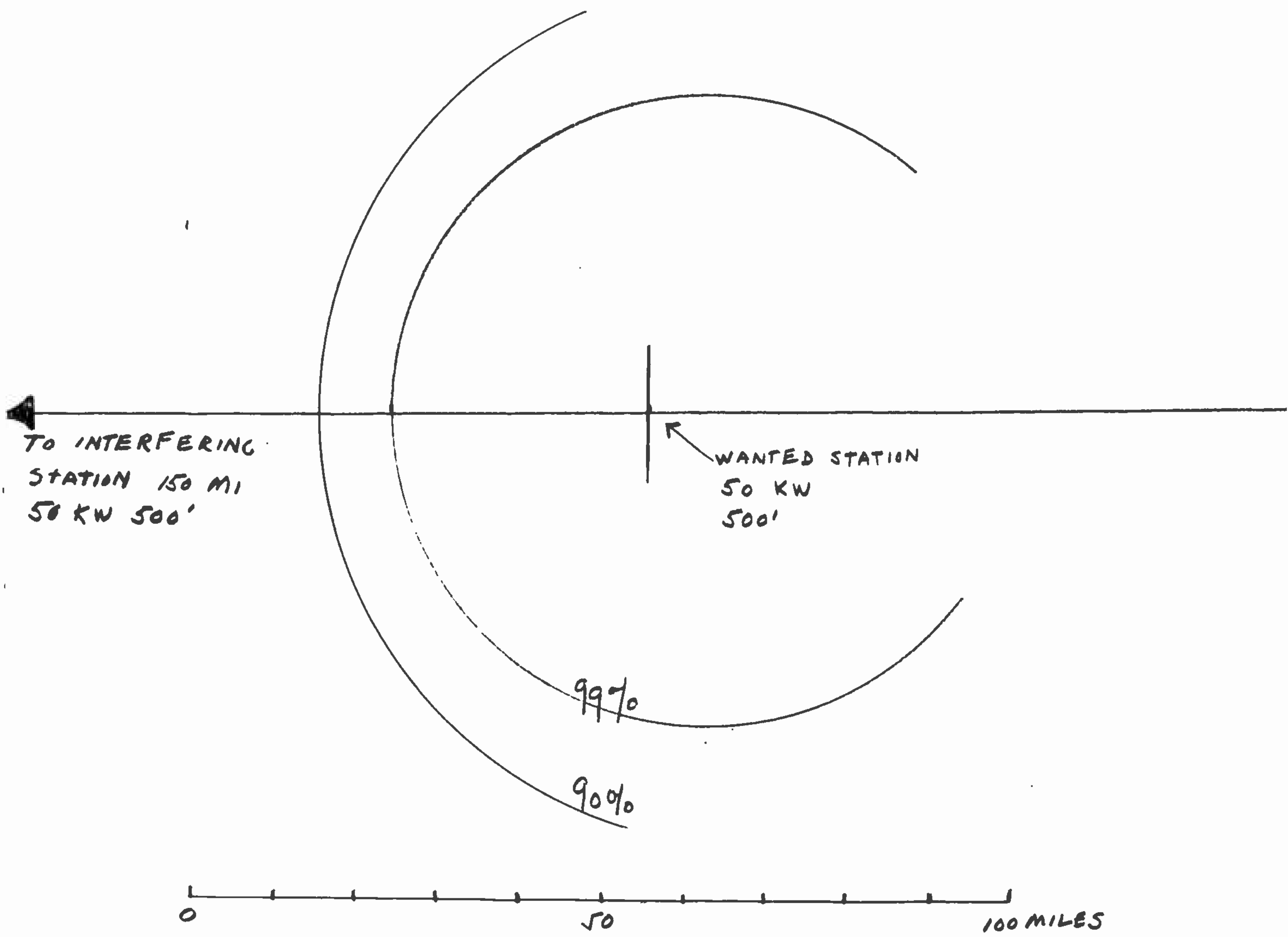



FIG 7
150 MILES
195 Mc
CO-CHAN
25 DB

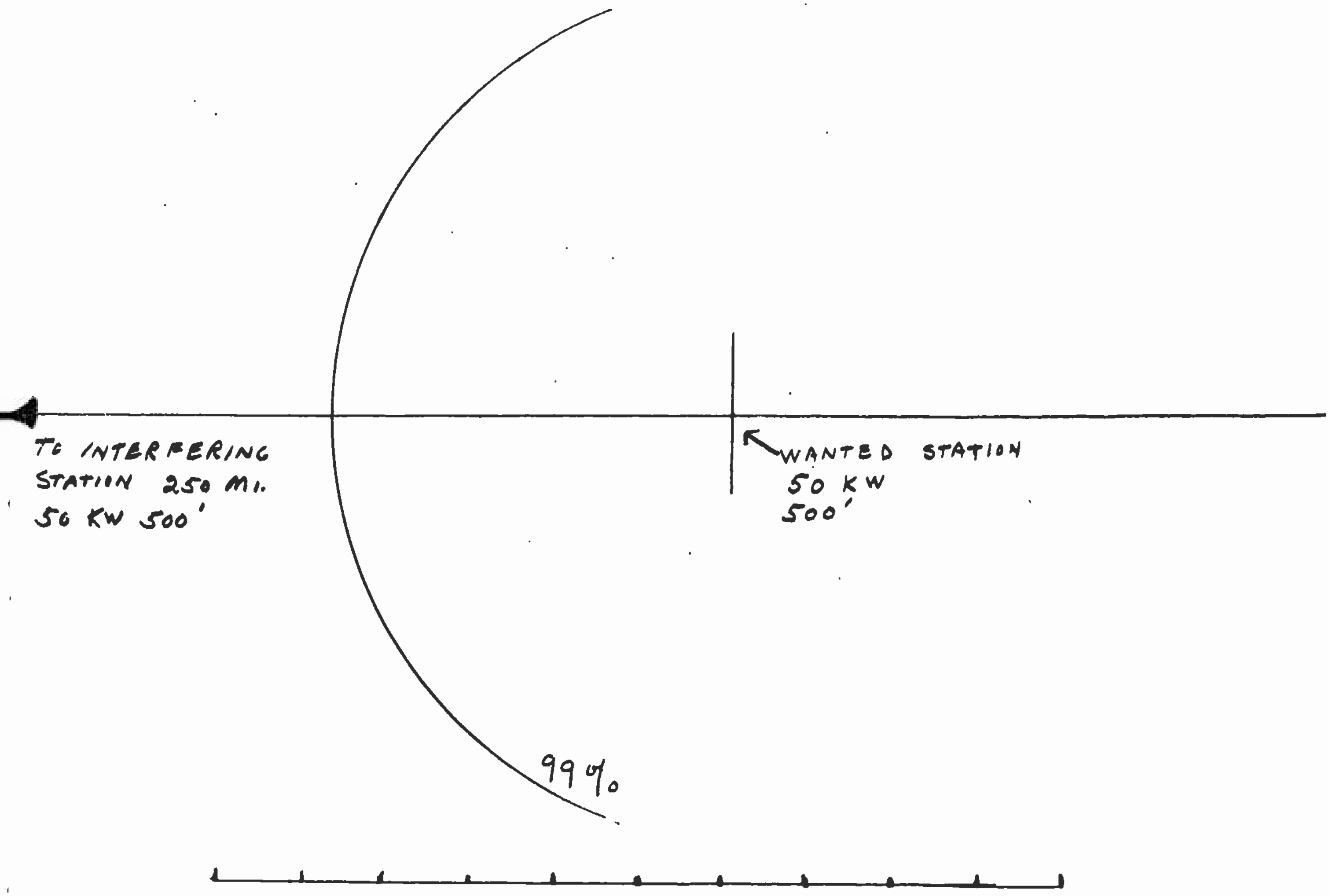



FIG 8
250 MILES
195 MC.
CO-CHAN
25 DB

## SINGLE FREQUENCY VIDEO INTERFERENCE DATA

This is an abstract of a report[1] on visual interference due to sinusoidal video signals on the grid of a television picture tube. The work was done at Bell Telephone Laboratories in 1938. The results are not restricted to the particular television system used at the time - they apply as well to the current standard system. The amount of interference considered here is what we call a near-threshold value; that is, a just-certainly-visible value that must be a little larger than the usual threshold based on the statistics of uncertain judgments. The picture interfered with is the simplest possible one, and the one most susceptible to interference, namely a flat field of uniform and constant brightness.

Interference amplitude is expressed, not in terms of alternating grid voltage, but rather in terms of the corresponding alternating brightness pattern that is superposed on the flat field. Our threshold values are values of $\frac{\Delta B}{B}$ expressed in decilums, where:

$\Delta B$ = peak-to-peak brightness change, in foot-lamberts, corresponding to the peak-to-peak voltage of the sinusoidal signal on the grid.

$B_o$ = average brightness, in foot-lamberts, of the entire flat field.

$$\text{Number of decilums} = 20 \cdot \log \frac{\Delta B_o}{B}$$

We prefer not to use decibels in this case, in order to avoid ambiguity. Most people would multiply the log by 20, but there are some who would multiply it by 10 for the reason that luminous flux (brightness) has the dimensions of power. The decilum is defined so that a 1-decibel change in interference voltage produces a 1-decilum change $\Delta$ B.

The brightness patterns considered here are arrays of equally-spaced parallel bars, either horizontal or vertical. The bar interval corresponds to the period of the alternating grid voltage. For m horizontal bars per frame, moving upward at n bars per second, the video frequency is (24m + n) cycles per second. For m vertical bars per frame, moving left at n bars per second, the video frequency is (5,760 m + n) cycles per second. (Under present standards the factors would be 60 and 15,750.)

---

[1] BTL Memorandum No. 38-341-94, July 20, 1938, By T.R.D. Collins.

## Conclusions

In this part, the word "threshold" stands for "near-threshold (just-certainly-visible) value of $\frac{\Delta B}{B}$".

1. Horizontal bars vs. vertical bars: For a given number of bars, the threshold is substantially the same whether the bars are horizontal or vertical.

2. Dependence on brightness: In the range above about 0.3 foot-lambert, the threshold is substantially independent of brightness; it becomes larger as the brightness drops below that value.

3. Dependence on number of bars per frame: The threshold shows a broad minimum at a number of bars between 6 and 30, depending upon viewing conditions. The minimum threshold value is about -40 decilums, or 1 percent. Sample data on ES-784444.

4. Dependence on motion of bar patterns: The threshold is a minimum when the pattern of bars moves over the frame at the rate of 1 or 2 bars per second. When the bar pattern is stationary (video frequency an integral multiple of scanning frequency) the threshold may be raised from the minimum by as much as 10 decilums for a 1-bar pattern, 2 decilums for a 10-bar pattern, and 0 decilums for a 40-bar pattern. When the bar pattern moves at a number of bars per second equal to one-half the number of fields per second, the threshold may be raised from the minimum by as much as 12 decilums. Sample data on ES-784442.

5. Dependence on viewing distance: Too complicated for words. Sample data on ES-784441.

## Numerical Values

1. Scanning system: 240 lines, 24 frames per second, 24 fields per second. Vertical return time less than one line, horizontal return time now known. No blanking. The higher values of brightness showed flicker.

2. Picture tube: Davisson, at 5.0 kilovolts; electrostatic deflection, electrostatic focus, green light.

3. Frame size: 7.2 inches high, 7.6 inches wide.

4. Viewing distance: 3 feet, 6 feet, 12 feet (5, 10 and 20 times the frame height).

5. Number of observers: Usually one, never more than three.

6. Flat-field brightness: 0.04 to 4.0 foot-lamberts, measured by Macbeth Illuminometer.

7. Room light: None.

8. Number of horizontal bars: 1 to 60 per frame.

9. Number of verticalbars: 1 to 140 per frame.

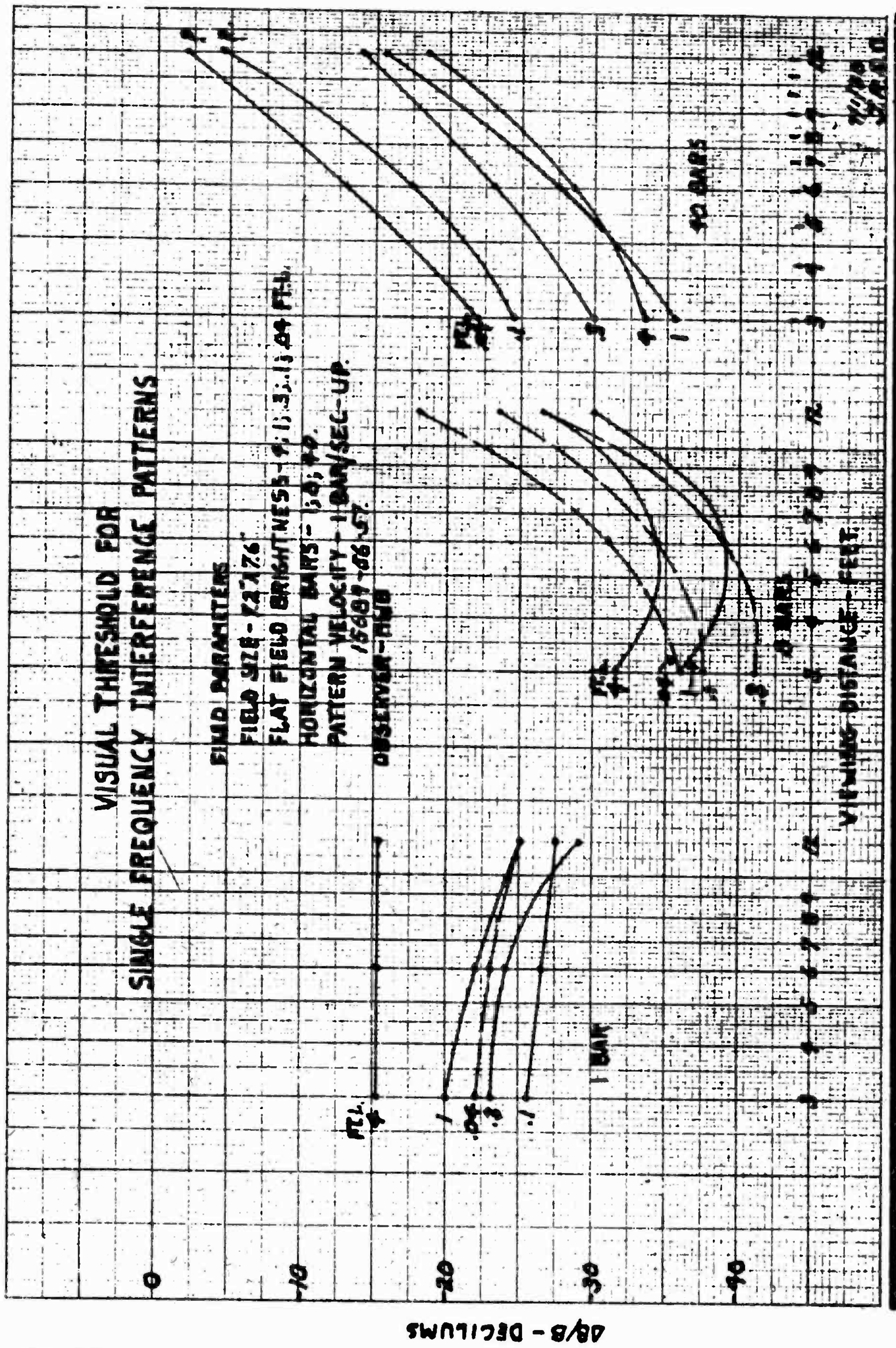
10. Total number of observations: about 350.

MILLARD W. BALDWIN, JR.

November 18, 1948

BELL TELEPHONE LABORATORIES
INCORPORATED

ES 784441

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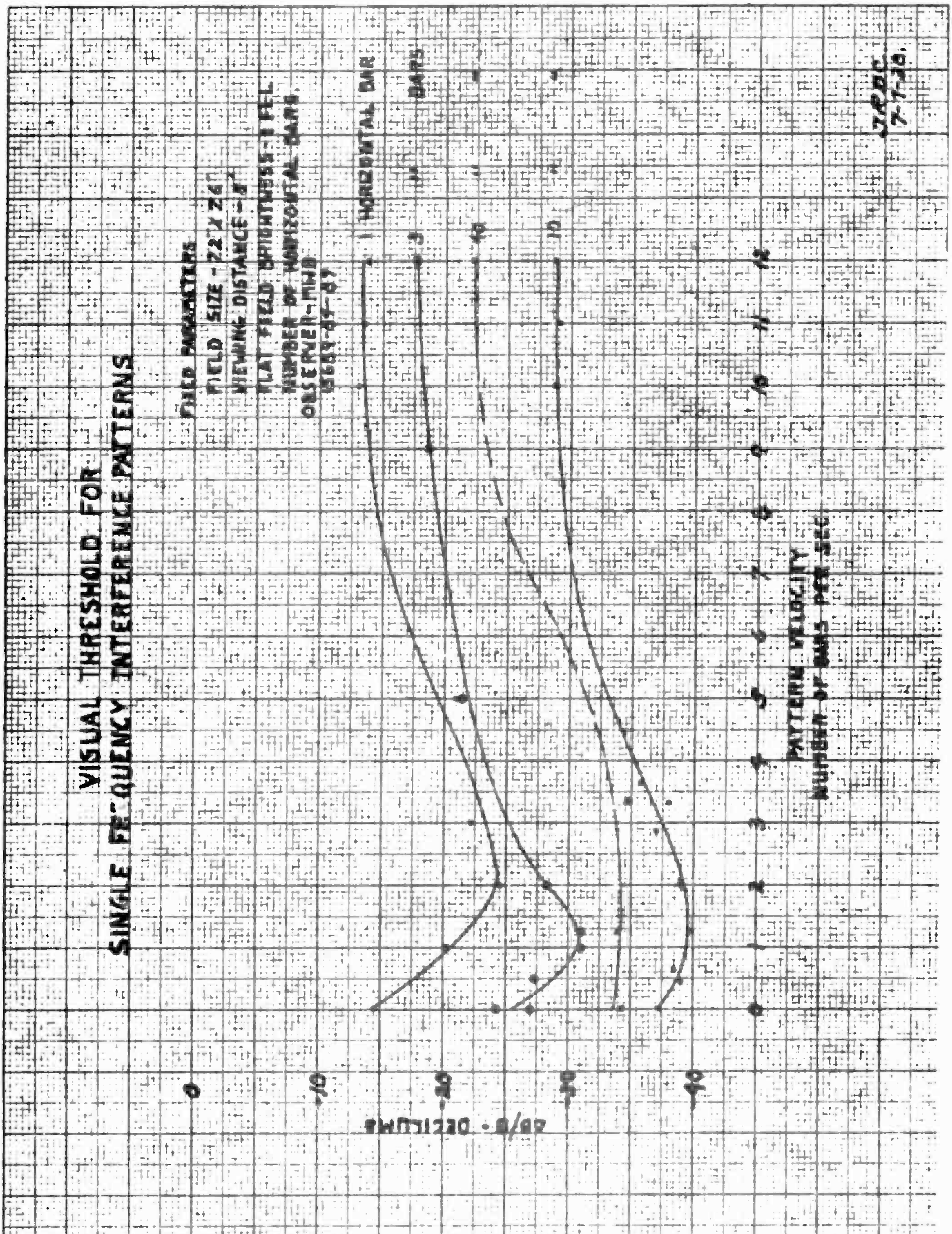
ES 784442.

BELL TELEPHONE LABORATORIES
INCORPORATED




E-342 (4-30)

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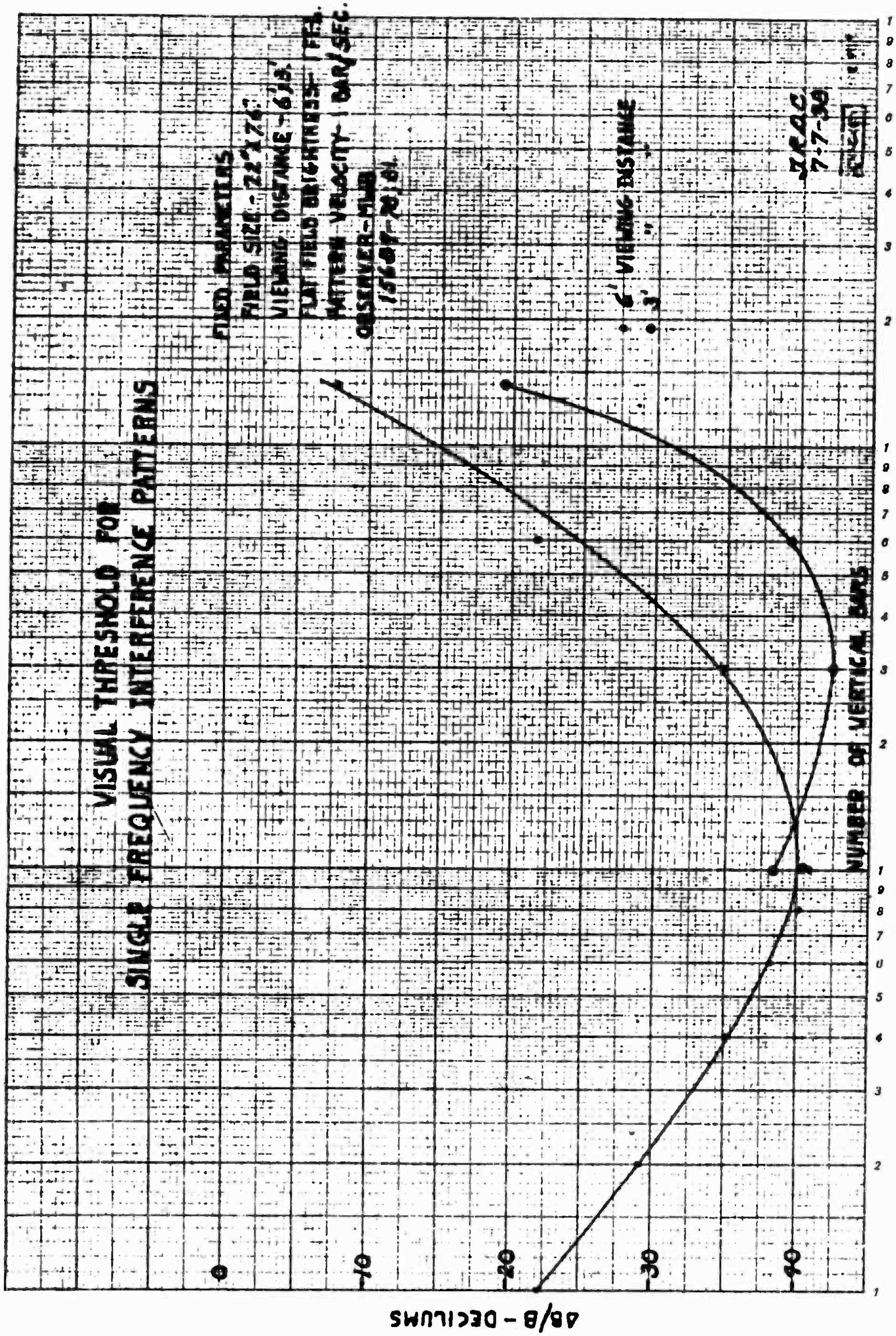
BELL TELEPHONE LABORATORIES
INCORPORATED

ES 784444




E-1938 5-37

PRINTED IN U. S. A.

RADIO CORPORATION OF AMERICA

RCA Victor Division

Camden, New Jersey

November 10, 1948

Mr. Philip F. Siling
1 East 79 Street
New York 21, N.Y.

Chairman, The Joint Technical Advisory Committee, IRE-RMA

Dear Mr. Siling:

You request that each of the Chairmen of RMA Committees provide what information is available to assist in the engineering conference to be held with the FCC on November 30, December 1 & 2. As Chairman of the Vehicle Radio Interference Committee, we have been particularly interested in interference caused by ignition systems in television and FM receivers. The committee which is composed of joint membership of RMA and SAE, has conducted many tests and has set up tentative proposals on the degree of ignition interference which can be tolerated in television and FM receivers, assuming a 500-microvolt contour for television and a 50-microvolt contour for FM. The various automobile companies represented by SAE have done a considerable amount of work towards the reduction of ignition interference, and plan to make a steady improvement towards it further reduction.

Recently, the VRI Committee has canvassed the various television manufacturers relative to the extent of ignition interference caused in modern television receivers and in typical installations. This survey has not yet been completed, but the following is a general summary of the data so far collected. It is believed that this information can be used under Item IVE(4)a., "Noise and Interference Levels in Urban and Suburban areas at Various Frequencies". More detailed information is available if desired.

In general, ignition interference into television receivers is not a problem if the television signal strength is 5000 microvolts per meter or higher. There are few instances where interference is present at these high levels, but most of these cases are due to close proximity to very heavily travelled highways. Ignition interference becomes progressively worse as the television signal frequencies fall below 5000 microvolts. At 1000 microvolts or lower, the ignition interference is a serious problem, both from the stand-

Mr. Philip F. Siling November 10, 1948

point of interference in the picture, and the possible loss of synchronization. One Company has reported that 5.6% of all their television installations are affected by ignition interference to the extent that a service call is necessary.

Very truly yours,

K. A. Chittick
Engineering Division
Home Instrument Department

Chairman, Committee on Vehicle
Radio Interference of RMA

tb

cc: D. D. Israel
L. C. F. Horle
P. J. Kent

ANNEX 10

RADIO CORPORATION OF AMERICA

RCA VICTOR DIVISION

CAMDEN, NEW JERSEY

ENGINEERING PRODUCTS
DEPARTMENT

November 12, 1948

Mr. L. G. Cumming, Secretary
Joint Technical Advisory Committee
1 East 79 Street
New York 21, New York

Dear Mr. Cumming:

In reply to your request for information pertinent to the FCC engineering conference scheduled for November 30, December 1 and December 2, I regret to inform you that the RMA Committee on Television Transmitters, TR 4, will be unable to issue any formal statement prior to the meeting of JTAC on November 15.

It will be appreciated that very little new information has been obtained during the relatively short interval since September 20. However, the Sub-Committee on Program Transmitters, TR 4.1, met on November 10 in New York City and reviewed such data as might be offered for your consideration. It was decided that very little data regarding the status of high power transmitters could be accumulated and considered by the committee membership. It was felt that a similar situation confronted the group in the matter of high gain and directional antennas. The individual members were, therefore, requested to submit such information as they might have directly to you.

On November 4, the membership of the Television Transmitter Committee, and the Sub-Committee on Program Transmitters, and the $Sub_2$-Committee on Television Transmitting Antennas were requested to submit their comments directly to you. I hope that adequate information will be available for your purposes.

Very truly yours,

s/ P. J. HERBST, Chairman
Television Transmitter Committee, TR 4

PJH/mcs

# ANNEX 11A

WESTERN

UNION

November 18, 1948

The following telegram was telephoned to L. Cumming today and relayed over phone to Mr. Fink.

In regard to Wayne Coy letter, paragraph IV Capitol E, sub 6 and 7, with present tubes and circuits we could obtain 50 kw on channels 2 to 6 and 15 kw channels 7 to 13. Item IV D E we can develop cardeoid fig. 8 pattern with a null at 20 db.

H. B. Sancher
General Electric
Syracuse

Annex 11B

WESTINGHOUSE

ELECTRIC CORPORATION

3601 Washington Blvd.
Baltimore 3, Md.
November 17, 1948

Mr. L. G. Cumming
JTAC Institute of Radio Engineers
1 East 79 Street
New York 21, N.Y.

Dear Mr. Cumming:

At the request of Mr. P. J. Herbst, Chairman, TV Transmitter Committee TR-4 and in anticipation of the engineering conference scheduled by the FCC for November 30 through December 2, the following comment is submitted for your interest.

Regarding power capabilities of transmitters in the VHF range 54 to 216 mc, I would like to bring to your attention the Westinghouse FM transmitter which is capable of 50 kw CW power up to 108 mc.

This transmitter uses eight 3X-2500A3 power triodes in a "ring" amplifier. The 3X2500A3 tube will dissipate 2500 watts maximum power and was designed to operate at maximum ratings up to 108 mc. At reduced ratings and with some revision in the tank circuit of this amplifier, we believe that 25 kw CW power is easily obtainable up to 216 mc.

It should be noted that the "ring" amplifier is capable of generating higher powers in the VHF spectrum, and with a power tube similar to the 3X2500A3, but designed for higher frequency, (We believe this tube will soon be available.) this amplifier will be easily capable of 50 kw of CW power from 54 to 216 mc.

Sincerely yours,

Electronics and X-Ray Division
Communication Equipment Eng.

s/ Roger Mathieu, Engineer

al

ANNEX 11C

TELEGRAM

November 24, 1948

Philip F. Siling
4550 Connecticut Avenue

Present Dumont Manufacturing activity is directed toward providing 5 Kw output on channels 2-13 inclusive. With respect to obtaining higher power outputs on the above indicated channels, it should be practical to obtain 10 to 25 Kw on channels 2-6 and 5 to 10 Kw on channels 7-13 with currently available tube and components for higher power is required, multiplex push pull-parallel operation, or some similar arrangements should result in up to 50 Kw on channels 2-6 and 25 Kw on channels 7-13.

G. E. Hamilton, Head RF Development Section
Allen B. Dumont Labs

ANNEX 11D

RCA, Victor Devision, Camden, N. J.

November 26, 1948

Mr. Philip F. Siling,
Chairman JTAC

Dear Mr. Siling:

The following information is submitted in response to your request to various RMA committees for data pertinent to the FCC Engineering Conference to be held November 30, December 1 and December 2. Since the time available to collect information and to submit a formal report by the Television Transmitter Committee (TR 4), was inadequate the membership was requested to submit available information directly to you. It is hoped that you will receive similar data from other members of TR 4.

Regarding the status of high power transmitters operating in the presently allocated commercial channels, RCA has recognized this problem. Engineering effort has been initiated on the development of tubes and cirucits aimed at realizing 50 Kw on channels 2-13.

Regarding high gain and directional antennas, RCA has completed the development work on such equipment and is in the position to supply such radiating systems on order. The realizable power gain of omnidirectional antennas is in the order of 20:1 the directional patterns available are an offset circular pattern, cardioid pattern, and a bi-directional pattern. The ratio of the power radiated in the direction of the maximum and in the direction of the null is in the order of 10:1. The advantages of both the high gain provided by vertical directivity and the directional characteristics in the horizontal plane may be incorporated in one antenna structure.

Respectfully submitted,

P. J. Herbst
Engineering Products Division
Broadcast Engineering Section
Bldg. 53-C-1

C.c: D. F. Schmidt
G. L. Beers
J. B. Coleman
H. E. Gihring
L. J. Wolf
C. D. Kentner
L. G. Cumming (Sec., JTAC)

Annex 12

Report
of the

RMA FM SYSTEMS COMMITTEE

to the

JOINT TECHNICAL ADVISORY COMMITTEE

# Some Factors Affecting the Allocation of FM Broadcasting Stations

November 22, 1948

1. INTRODUCTION

In a letter dated October 29, 1948, the Chairman of the Joint Technical Advisory Committee requested the RMA FM Systems Committee to submit "information, engineering data and comments" which might be of value to JTAC in preparing for an engineering conference which the FCC had called for November 30, December 1 and December 2 for the purpose of discussing matters pertaining to standards and allocations for television and FM broadcasting. The questions at issue were clarified during discussions of the problem between the chairman of the FM Systems Committee and members of JTAC. As a result of these discussions, the chairman wrote members of the FM Systems Committee on November 9, requesting certain data regarding the performance characteristics of FM receivers and the interference which has been experienced in FM broadcasting. A copy of this letter is attached as Appendix A. On November 9, the chairman met with the RMA Committee on FM Receivers and asked that group to cooperate in furnishing desired data. As a result of that meeting, a form was prepared which was sent to all members of the FM Systems Committee and of the Committee on FM Receivers on which the desired data could easily be entered. The form sent to the FM Systems Committee asked for certain data not requested of the other committee. A copy of this form and of the accompanying letter are attached as Appendix B, while a copy of the letter and form sent to the Committee on FM Receivers is found in Appendix C. While these forms were being circulated, the RMA Data Bureau abstracted information from its files regarding the performance of FM broadcast receivers. These data had previously been reported to the Bureau by RMA members. The data obtained by the two RMA committees and from the Data Bureau form the basic material on which Zection 3 of this report is based.

On November 19, the chairman of the FM Systems Committee was asked to make a brief study of FM allocation problems, using the data being collected for this report and propagation data contained in the FCC report entitled Summary of Tropospheric Propagation Measurements and the Development of Empirical VHF Propagation Charts, TID Report 2.4.5. Time has not permitted a thorough analysis of this problem, but calculations have been made of the co-channel interference areas which exist in two specific situations. The results are given in Section 4 of this report.

2. CONCLUSIONS

The following performance characteristics have been found to be representative of these obtained in present day FM broadcast receivers:

Quieting Sensitivity: 20 microvolts

Co-channel Ratio: -10 db

Adjacent Channel Ratio: 16 db

Second Channel Ratio: 40 db

The sensitivity of average current table model FM receivers is 1.5:1 poorer than that of console receivers.

In the relatively near future, FM receivers of appreciably higher sensitivity will be manufactured, although the sensitivity of the average FM receiver may not improve.

Man-made static, especially ignition, forms the most serious type of interference experienced in FM reception.

Built-in antennas are used with most FM receivers in the home.

To protect the 50 microvolt per meter contour of an FM broadcasting station from co-channel interference 99 per cent of the time, the nearest interfering station should be at least 227 miles distant. If protection is to be afforded only 90 per cent of the time, the distance can be decreased to 175 miles.

## 3. DATA REGARDING FM RECEIVERS AND INTERFERENCE TO FM RECEPTION

3.1 DEFINITIONS - In the remainder of this report, certain characteristics of FM receivers are discussed. These include quieting sensitivity, co-channel ratio, adjacent channel ratio and second channel ratio. The first of these is one of the characteristics commonly employed to describe the sensitivity of the receiver in terms of its ability to receive an FM carrier in the presence of internal receiver noise. The other three characteristics describe the ability of the receiver to reject unwanted FM signals. The co-channel ratio gives a measure of the ability of the receiver to discriminate between two signals at the same carrier frequency, while the adjacent channel and second channel ratios combine this discrimination characteristic with the selectivity of the receiver. In all of these measurements, the end result is a ratio of desired to undesired signal or noise output of 30 db.

In making the measurements outlined above, recommendations formulated by the Radio Manufacturers' Association were followed by those reporting data. These recommendations are embodied in RMA Publication DB-2170-A entitled The Measurement of Performance Characteristics of Frequency Modulation Radio Receiver, dated December, 1946. The portions of this publication applying to the present discussion are attached as Appendix D. All measurements were made at a carrier frequency of 100 megacycles.

3.2 RECEIVER SENSITIVITY AND SELECTIVITY. - All data received on the sensitivity and selectivity of FM broadcast receivers are given in Table I. In this Table, the information is tabulated as it was received and all data in a given row came from the same manufacturer and refer to the designated type of receiver. Information from the RMA Data Bureau has been separated from the information received this month from the manufacturers, as it was felt that there might be some significant difference between older and more recent data.

In Tables II, III and IV, data on sensitivity and selectivity of current receivers have been arranged in order of numerical magnitude to facilitate an analysis of the data. Table II relates to information from the RMA Data Bureau, Table III to the more recent data, while all data are combined in Table IV. In cases where a range of values was given in the original information (as for example, a sensitivity of 20 to 50 microvolts), both extreme figures were used in the subsequent analysis as it was felt that these two values must represent actual measurements.

3.2.1 SENSITIVITY.- The following table summarizes the information on sensitivity of current receivers given in detail in Tables I-IV.

| | No. of Observations | Quieting Sensitivity-Microvolts Minimum | Maximum | Median | Average |
|---|---|---|---|---|---|
| Data from RMA Data Bureau | 24 | 5 | 80 | 15 | 23 |
| More Recent Data | 24 | 6 | 50 | 20 | 22 |
| All Data | 48 | 5 | 80 | 19 | 23 |

The median appears to be a more reliable indication of the state of the art than the average since the former is less affected by the exceedingly poor values of sensitivity obtained with receivers of obviously poor design or improper adjustment.

It is concluded that a good value of the quieting sensitivity ofcurrent receivers is 20 microvolts. Many receivers have better sensitivity, but allowance must be made for variation of sensitivity over the frequency band and for slight misalignment of receivers. The value of 20 microvolts therefore appears to be a representative figure.

3.2.2 CO-CHANNEL RATIO.- The following table summarizes the information on the co-channel ratio of current receivers given in detail in Tables I-IV.

| | No. of Observations | Co-channel Ratio-db Minimum | Maximum | Median |
|---|---|---|---|---|
| Data from RMA Data Bureau | 19 | -1 | -19 | -8 |
| More Recent Data | 19 | -6 | -17 | -9 |
| All Data | 38 | -1 | -19 | -9 |

Some of the values reported to the Data Bureau are believed to be in error in that several values of less than 6 db were given. Since the theoretical minimum is of the order of 6 db, these measurements are apparently incorrect. If these four erroneous measurements are disregarded, the following table results:

| | No. of Observations | Co-channel Ratio-db Minimum | Maximum | Median |
|---|---|---|---|---|
| Data from RMA Data Bureau | 15 | -6 | -19 | -10 |
| More Recent Data | 19 | -6 | -17 | -9 |
| All Data | 34 | -6 | -19 | -10 |

It is concluded that a representative value for the co-channel ratio for current receivers is -10 db.

3.2.3 ADJACENT CHANNEL RATIO. - The following table summarizes the information on the adjacent channel ratio of current receivers given in detail in Tables I-IV.

| | No. of Observations | Adjacent Channel Ratio-db Minimum | Maximum | Median |
|---|---|---|---|---|
| Data from RMA Data Bureau | 17 | 4 | 29 | 16 |
| More Recent Data | 18 | 0 | 27 | 15 |
| All Data | 35 | 0 | 29 | 15 |

It is concluded that a representative value for the adjacent channel ratio for current receivers is 16 db.

3.2.4 SECOND CHANNEL RATIO.- The following table summarizes the information on the second channel ratio of current receivers given in detail in Tables I-IV. The obviously incorrect figures of 2 and 5 db have been disregarded.

| | No. of Observations | Second Channel Ratio-db Minimum | Maximum | Median |
|---|---|---|---|---|
| Data from RMA Data Bureau | 14 | 28 | 77 | 45 |
| More Recent Data | 18 | 30 | 50 | 38 |
| All Data | 32 | 28 | 77 | 40 |

It is concluded that a representative value for the second channel ratio for current receivers is 40 db.

3.2.5 COMPARISON OF CONSOLE AND TABLE RECEIVERS.- In Table V, a comparison is made between the characteristics of console and table model receivers. On the average, where comparative data are given by the same manufacturer, the sensitivity of table models appears to be poorer than that of consoles by a ratio of around 1.5:1 while the co-channel, adjacent channel and second channel ratios are not significantly different. If the values of sensitivity of current receivers are separated into columns relating to consoles and to table models, as in Table VI, it is seen that the median and average sensitivity for consoles are 18 and 19 microvolts respectively while the corresponding figures for table models are 21 and 29 microvolts.

3.2.6 COMPARISON OF CURRENT AND FUTURE RECEIVERS.- In Tables VII and VIII, a comparison is made between the characteristics of current receivers and those visualized in the forseeable future. The trend appears to be toward a somewhat better sensitivity, although this trend is by no means universal. It should be noted that the data given in Section 3.2.1 seem to indicate that current receivers have sensitivities somewhat poorer than those manufactured some time ago. There appears to be no significant trend in the co-channel, adjacent channel and second channel ratios.

3.2.7 CONCLUSIONS. - It is concluded that the average current FM broadcast receiver has a quieting sensitivity of around 20 microvolts, a co-channel ratio of around -10 db, an adjacent channel ratio of around 16 db and a second channel ratio of around 40 db. It is concluded further that current consoles have a better sensitivity than table models by a ratio of about 1.5 to 1, while their interference ratio characteristics are not significantly better. The average receiver built in the next few years may or may not have better sensitivity than current receivers. Some will definitely have better sensitivity, while others probably will have poorer sensitivity.

3.3 INTERFERENCE TO FM RECEPTION. - The information on interference is given in Table IX. The general conclusion appears to be that ignition and other man-made static forms the most serious types of interference and that at present , interference from other FM transmitters is not too serious. Distortion due to multipath transmission appears to be of little significance in the overall picture.

3.4 FM RECEIVER ANTENNAS.- In Table X, information is given regarding the type of receiving antenna used in the home for FM broadcast reception. It is apparent that the use of built-in antennas greatly predominates. It should not be concluded, however, that built-in antennas should be assumed in considering allocation problems, since at the limits of the service area, external antennas are doubtless used to a much greater extent than would be concluded from a consideration of Table X alone.

3.5 CALCULATION OF TROPOSPHERIC PROPAGATION. - All replies indicated a lack of first-hand knowledge regarding the validity of the new Norton formula for the field strength due to tropospheric propagation.

## 4. ALLOCATION PROBLEMS

4.1 INTERFERENCE DUE TO TROPOSPHERIC PROPAGATION.- Conclusions regarding the permissible spacing between FM broadcasting stations operating on the same channel, on adjacent channels and on alternate channels can be drawn from the data given in Section 3 and in the FCC TID Report 2.4.5. Figure 23 of that report has been assumed to apply to the case under discussion, since propagation conditions at 100 Mc and 98 Mc differ by negligible amounts.

In preparing the following table, these assumptions were made:

Effective Power of the Transmitter: 20 Kw

Height of Transmitting Antenna: 500 feet

Height of Receiving Antenna: 30 feet

Carrier Frequency: 98 Mc

| Field Strength at Contour- Microvolts per Meter | Reference Level- Microvolts per Meter | Level Relative to Reference Level- db | Distance to Contour - Miles | | | |
|---|---|---|---|---|---|---|
| | | | 99% Signals | 1% Signals | 90% Signals | 10% Signals |
| 50 | 50 | 0 | 52 | | 57 | |
| 16 | 50 | -10 | | 175 | | 118 |
| 315 | 50 | +16 | | 69 | | 54 |
| 5000 | 50 | +40 | | 21 | | 20 |
| 26 | 26 | 0 | 57 | | 64 | |
| 8 | 26 | -10 | | 205 | | 139 |
| 164 | 26 | +16 | | 88 | | 72 |
| 2600 | 26 | +40 | | 29 | | 28 |

The data in this table show that if all points on the 50 microvolt per meter contour of a station are to be protected 99 per cent of the time, the interfering station must be located 52+175 or 227 miles away if it is operating on the same channel, 52+69 or 121 miles away if it is operating on the adjacent channel and 52+21 or 73 miles away if it is operating on the second channel. These conclusions are based on co-channel, adjacent channel and second channel ratios of -10, 16 and 40 db respectively. The corresponding spacings for 90 per cent protection of the 50 microvolt per meter contour are 175 miles, 111 miles and 77 miles.

Figures have been prepared showing the service areas of FM broadcasting stations which will be protected from co-channel interference by a ratio of 10 db for 99 and 90 per cent of the time. These are given

in Figures 1 and 2 which show conditions for station spacings of 150 and 250 miles respectively. These curves are derived from Figure 23 of TID Report 2.4.5 and apply to transmitting and receiving antenna heights of 500 and 30 feet respectively at a carrier frequency of 98 Mc. The interference-free service areas are given by the solid curves and apply regardless of transmitter power as long as the power is the same for the local and the interfering station. In addition to these contours, the contour for 50 microvolts per meter, 99 per cent of the time, is also shown as the dotted curve. This applies only to an effective transmitter power of 20 Kw.

Similar figures could be drawn for other station separations and for adjacent channel and second channel operation.

4.2 REQUIRED FIELD STRENGTH. - It has been concluded in Section 3.2.1 that 20 microvolts is a representative figure for the quieting sensitivity of FM receivers. At 100 Mc, the effective height of a receiving dipole antenna is $3/\pi$ meters. If it is assumed that the average transmission line connecting an external antenna to the receiver is 50 feet long and has a loss of 4db per 100 feet, the required field strength at the antenna to produce 20 microvolts at the input to the receiver is

$$(20 \times \frac{\pi}{3})\ \mu/m + 2\ db$$

or 26 microvolts per meter. This value of field strength has been used in the table in Section 4.1 as well as the value of the field strength at the FCC protected contour, namely 50 microvolts per meter.

It has probably been implied in the above discussion that the quieting sensitivity is the most significant measure of receiver sensitivity. It should be pointed out that this is not the unanimous opinion of the industry. The RMA Committee on FM Receivers recommended the use of quieting sensitivity for the purposes of this survey but did not necessarily recommend that quieting sensitivity be used as a basis for FM allocations. It should be noted that an FM receiver is more susceptible to impulse noise than to receiver internal noise and for this reason, a higher signal input is required than that given by the quieting sensitivity.

5. POSTSCRIPT

The chairman of the FM Systems Committee wishes to acknowledge the wholehearted cooperation of the members of that committee and of the Committee on FM Receivers and especially of Mr. J. E. Brown, chairman of the latter committee, for their prompt action in supplying the data on which this report is based. It should be pointed out that the members of the FM Systems Committee have not had an opportunity to review this report and therefore the conclusions drawn from the data represent the judgment of the chairman, which judgment has not yet been ratified by the Committee. The chairman also wishes to acknowledge

the invaluable aid given by Dr. L. L. Merrill of the Stromberg-Carlson Research Department, without whose cooperative assistance the figures presented in Section 4.1 of this report could not have been prepared in the limited time available.

George R. Town
Chairman
RMA FM Systems Committee

TABLE I

Primary Data on FM Receiver Sensitivity and Selectivity

| Mfg. | Type Receiver | Quieting Sensitivity Microvolts | Selectivity in Terms of Ratio of Signals for 30 db Interference -db | | |
|---|---|---|---|---|---|
| | | | Co-channel | Adjacent Channel | Second Channel |
| | A - Data Collected by RMA Data Bureau | | | | |
| #2 | AC | 6 | | | |
| 3 | AC | 7 | -12 | 21 | Over 40 |
| 4 | AC | 77 | -12 | 7 | 48 |
| 5 | AC | 25 | (-)1 | 3.5 | 5.0 |
| 6 | AC | 11 | -14 | 19 | 36 |
| 7 | AC | 8 | | | |
| 8 | AC | 5 | -8 | 11 | 32 |
| 9 | AC | 80 | | | |
| 10 | AC | 6 | -10 | 26 | 77 |
| 11 | AC | 10 | -8 | 29 | 76 |
| 12 | AC | 50 | -10 | | |
| 13 | AC | | | | |
| 14 | AC | 29 | -14 | 16 | |
| 15 | AC | 40 | -17 | | |
| 16 | AC | 15 | -19 | 15 | 2 |
| 17 | AC | 23 | | | |
| 18 | AC | | | | |
| 19 | AC/DC | 26 | | | |
| 20 | AC | | | | |
| 21 | AC | 8 | -3 | 29 | Over 60 |
| 22 | AC | 15 | -8 | 6 | 32 |
| 23 | AC | 11 | -8 | 4 | 28 |

TABLE I (Cont'd)

Primary Data on FM Receiver Sensitivity and Selectivity

| Mfg. | Type Receiver | Quieting Sensitivity Microvolts | Selectivity in Terms of Ratio of Signals for 30 db Interference -- db | | |
|---|---|---|---|---|---|
| | | | Co-channel | Adjacent Channel | Second Channel |
| 24 | AC/DC | 45 | -1 | 20 | 46 |
| 25 | AC | 32 | -6 | 15 | 45 |
| 26 | AC | 12 | -14 | 28 | 55 |
| 27 | AC | 6 | -6 | -8 | 44 |
| 28 | AC | 8 | -3 | 29 | Over 60 |
| B - Data Collected in November, 1948, by RMA FM Systems Committee and RMA Committee on FM Receivers | | | | | |
| 101 | All Current Models | 7 | -6 | 9 | 47 |
| 102 | Current Consoles | 20 | -9 | 6 | 30 |
| " | Current Tables | 20 | -9 | 6 | 30 |
| " | Future Consoles | ≪20 | -9 | 6 | 30 |
| " | Future Tables | ≪20 | -9 | 6 | 30 |
| 103 | Current Consoles | 20-50 | | | |
| " | Future Consoles | 15 | | | |
| 104 | Current Consoles | 15 | -15 | 15 | 45 |
| " | Current Tables | 50 | -15 | 15 | 30 |
| " | Future Consoles | >15 | -15 | 15 | <45 |
| " | Future Tables | >50 | -15 | 15 | <30 |
| 105 | Current Consoles | 25 | -15 | 20 | 35 |
| " | Current Tables | 50 | -15 | 20 | 35 |
| " | Future Consoles | >25 | -15 | 20 | 35 |
| " | Future Tables | >50 | -15 | 20 | 35 |

TABLE I (Concluded)

Primary Data on FM Receiver Sensitivity and Selectivity

| | | | Selectivity in Terms of Ratio of Signals for 30 db Interference - db | | |
|---|---|---|---|---|---|
| Mfg. | Type Receiver | Quieting Sensitivity Microvolts | Co-channel | Adjacent Channel | Second Channel |
| 106 | Current Consoles | 8-25 | -6 | 19 | 50 |
| " | Current Tables | 20-50 | -6 | 13 | 36 |
| " | Future Consoles | 4-5 | -6 | 19 | 50 |
| " | Future Tables | 20-50 | -6 | 13 | 36 |
| 107 | Current Consoles | 18 | -17 | 27 | 40 |
| " | Current Tables | 22 | -17 | 27 | 40 |
| " | Future Consoles | 13 | -14 | 30 | 40 |
| " | Future Tables | 13 | -14 | 30 | 40 |
| 108 | Current Consoles | 15 | -(>6) | | 40 |
| " | Current Tables | 40 | -(>6) | | 40 |
| " | Future Consoles | 10 | | | 40 |
| " | Future Tables | 30 | | | 40 |
| 109 | Current Consoles | 8 | -9 | 0 | 30 |
| " | Future Consoles | 8 | -9 | 0 | 30 |
| 110 | Current Consoles | 20 | -7 | 5 | 30 |
| " | Current Tables | 20 | -7 | 5 | 30 |
| " | All Future Models | 20 | -7 | 5 | 30 |
| 111 | Current Consoles | 8 | -10 | 20 | >40 |
| " | Current Tables | 8 | -10 | 15 | >40 |
| " | All Future Models | 5 | -12 | 20 | >40 |
| 112 | Current Consoles | 6-14 | -8 | 14-20 | |
| " | Future Consoles | 6-14 | -8 | 14-20 | |

TABLE II

Re-arrangement of Data on Sensitivity and Selectivity.
Data Collected by RMA Data Bureau

| Quieting Sensitivity Microvolts | Selectivity in Terms of Ratio of Signals for 30 db Interference - db | | |
|---|---|---|---|
| | Co-channel | Adjacent Channel | Second Channel |
| 5 | -1 | 3.5 | 2 |
| 6 | -1 | 4 | 5 |
| 6 | -3 | 6 | 28 |
| 6 | -3 | 7 | 32 |
| 7 | -6 | 8 | 32 |
| 8 | -6 | 11 | 36 |
| 8 | -8 | 15 | >40 |
| 8 | -8 | 15 | 44 |
| 10 | -8 | 16 | 45 |
| 11 | -8 | 19 | 46 |
| 11 | -10 | 20 | 48 |
| 12 | -10 | 21 | 55 |
| 15 | -12 | 26 | >60 |
| 15 | -12 | 28 | >60 |
| 23 | -14 | 29 | 76 |
| 25 | -14 | 29 | 77 |
| 26 | -14 | 29 | |
| 29 | -17 | | |
| 32 | -19 | | |
| 40 | | | |
| 45 | | | |
| 50 | | | |
| 77 | | | |

TABLE III

Re-arrangement of Data on Sensitivity and Selectivity Data on Current Receivers Collected in November, 1948, by RMA FM Systems Committee and RMA Committee on FM Receivers

| Quieting Sensitivity Microvolts | Selectivity in Terms of Ratio of Signals for 30 db Interference -db: Co-channel | Adjacent Channel | Second Channel |
|---|---|---|---|
| 6 | -6 | 0 | 30 |
| 7 | -6 | 5 | 30 |
| 8 | -6 | 5 | 30 |
| 8 | -(>6) | 6 | 30 |
| 8 | -(>6) | 6 | 30 |
| 8 | -7 | 9 | 30 |
| 14 | -7 | 13 | 35 |
| 15 | -8 | 14 | 35 |
| 15 | -9 | 15 | 36 |
| 18 | -9 | 15 | 40 |
| 20 | -9 | 15 | 40 |
| 20 | -10 | 19 | 40 |
| 20 | -10 | 20 | 40 |
| 20 | -15 | 20 | >40 |
| 20 | -15 | 20 | >40 |
| 20 | -15 | 20 | 45 |
| 22 | -15 | 27 | 47 |
| 25 | -17 | 27 | 50 |
| 25 | -17 | | |
| 40 | | | |
| 50 | | | |
| 50 | | | |
| 50 | | | |
| 50 | | | |

TABLE IV

Re-arrangement of All Data on Sensitivity and Selectivity on Past and Current Receivers.

| Quieting Sensitivity Microvolts | Selectivity in Terms of Ratio of Signals for 30 db Interference - db | | |
|---|---|---|---|
| | Co-channel | Adjacent Channel | Second Channel |
| 5 | -1 | 0 | 2 |
| 6 | -1 | 3.5 | -5 |
| 6 | -3 | 4 | 28 |
| 6 | -3 | 5 | 30 |
| 6 | -6 | 5 | 30 |
| 7 | -6 | 6 | 30 |
| 7 | -6 | 6 | 30 |
| 8 | -6 | 6 | 30 |
| 8 | -6 | 7 | 32 |
| 8 | -(>6) | 8 | 32 |
| 8 | -(>6) | 9 | 35 |
| 8 | -7 | 11 | 35 |
| 8 | -7 | 13 | 36 |
| 8 | -8 | 14 | 36 |
| 10 | -8 | 15 | 40 |
| 11 | -8 | 15 | 40 |
| 11 | -8 | 15 | 40 |
| 12 | -8 | 15 | 40 |
| 14 | -9 | 15 | >40 |
| 15 | -9 | 16 | >40 |
| 15 | -9 | 19 | >40 |
| 15 | -10 | 19 | 44 |
| 15 | -10 | 20 | 45 |

TABLE IV (Cont'd)

Re-arrangement of All Data on Sensitivity and Selectivity on Past and Current Receivers

| Quieting Sensitivity Microvolts | Selectivity in Terms of Ratio of Signals for 30db Interference - db | | |
|---|---|---|---|
| | Co-channel | Adjacent Channel | Second Channel |
| 18 | -10 | 20 | 45 |
| 20 | -10 | 20 | 46 |
| 20 | -12 | 20 | 47 |
| 20 | -12 | 20 | 48 |
| 20 | -14 | 21 | 50 |
| 20 | -14 | 26 | 55 |
| 20 | -14 | 27 | >60 |
| 22 | -15 | 27 | >60 |
| 23 | -15 | 28 | 76 |
| 25 | -15 | 29 | 77 |
| 25 | -15 | 29 | |
| 25 | -17 | 29 | |
| 26 | -17 | | |
| 29 | -17 | | |
| 32 | -19 | | |
| 40 | | | |
| 40 | | | |
| 45 | | | |
| 50 | | | |
| 50 | | | |
| 50 | | | |
| 50 | | | |
| 50 | | | |
| 77 | | | |
| 80 | | | |

TAPLE V

Comparison of Sensitivity and Selectivity of Current Consoles and Table Model FM Receivers

Data Given in Terms of Performance of Table Models as Compared to Consoles

| Quieting Sensitivity Microvolts | Selectivity in Terms of Ratio of Signals for 30 db Interference - db | | |
|---|---|---|---|
| | Co-channel | Adjacent Channel | Second Channel |
| Same | Same | Same | Same |
| Same | Same | Same | Same |
| Same | Same | Same | Same |
| Same | Same | Same | Same |
| 1.2:1 Poorer | Same | Same | Same |
| 2:1 Poorer | Same | Same | 5 db Poorer |
| 2:1 Poorer | Same | 6 db Poorer | 14 db Poorer |
| 3:1 Poorer | Same | | 15 db Poorer |
| 3:1 Poorer | Same | | |

TABLE VI

Sensitivity of Current Consoles and Table Model
FM Receivers

Quieting Sensitivity - microvolts

| Consoles | Table Models |
|---|---|
| 7 | 7 |
| 8 | 8 |
| 8 | 20 |
| 8 | 20 |
| 15 | 20 |
| 15 | 22 |
| 18 | 40 |
| 20 | 50 |
| 20 | 50 |
| 20 | 50 |
| 25 | |
| 25 | |
| 50 | |

TABLE VII

Sensitivity of Future Receivers Compared
With Sensitivity of Current Receivers

Better by Ratio of Approximately 3:1

Better by Ratio of Approximately 2:1

Better by Ratio of 1.7:1

Better by Ratio of 1.6:1

Better by Ratio of 1.5:1

Better by Ratio of 1.4:1

Better by Ratio of 1.3:1

Much Better

Much Better

Same

Same

Same

Same

Poorer

Poorer

Poorer

Poorer

TAPLE VIII

Selectivity of Future Receivers Compared with
Selectivity of Current Receivers

Co-channel & Adjacent Channel Ratios 3 db Better

Co-channel & Adjacent Channel Ratios 3 db Better

Same

Same

Same

Same

Same

Same

Same

Same

Same

Second Channel Ratio Poorer

Co-Channel Ratio 2 db Poorer

TAPLE IX

Tabulation of Data Regarding Interference

| Mfg. | Most Serious Type of Interference | 2d Most Serious Type of Interference | Seriousness of Tropospheric Propagation | Seriousness of Multipath Transmission |
|---|---|---|---|---|
| 102 | None | | No consequence | No consequence |
| 103 | Man-made static | Co-channel | | Not serious Some trouble due to reflections from aircraft |
| 104 | Ignition | No other | Not now serious | Occasionally severe; statistically small |
| 106 | I-F interference from code stations | Oscillator radiation from other receivers | | Usually minor; Occasionally severe |
| 108 | Ignition and other man-made static | | Common channel more serious than adjacent or 2d channel | Not serious; no complaints from customers |
| 110 | Ignition | Spurious responses | Moderate | Slight |
| 111 | Ignition | | Some difficulty in suburban and rural areas | No customer complaints |
| 112 | Ignition and other man-made static | | | |

TABLE X

Types of Antennas Used in the Home
for FM Reception

| Estimated by Manufacturer | Per Cent External | Per Cent Built-in |
|---|---|---|
| #102 | Unknown | Unknown |
| 104 | 5 | 95 |
| 106 | 5 | 95 |
| 108 | 20 | 80 |
| 111 | 10 | 90 |

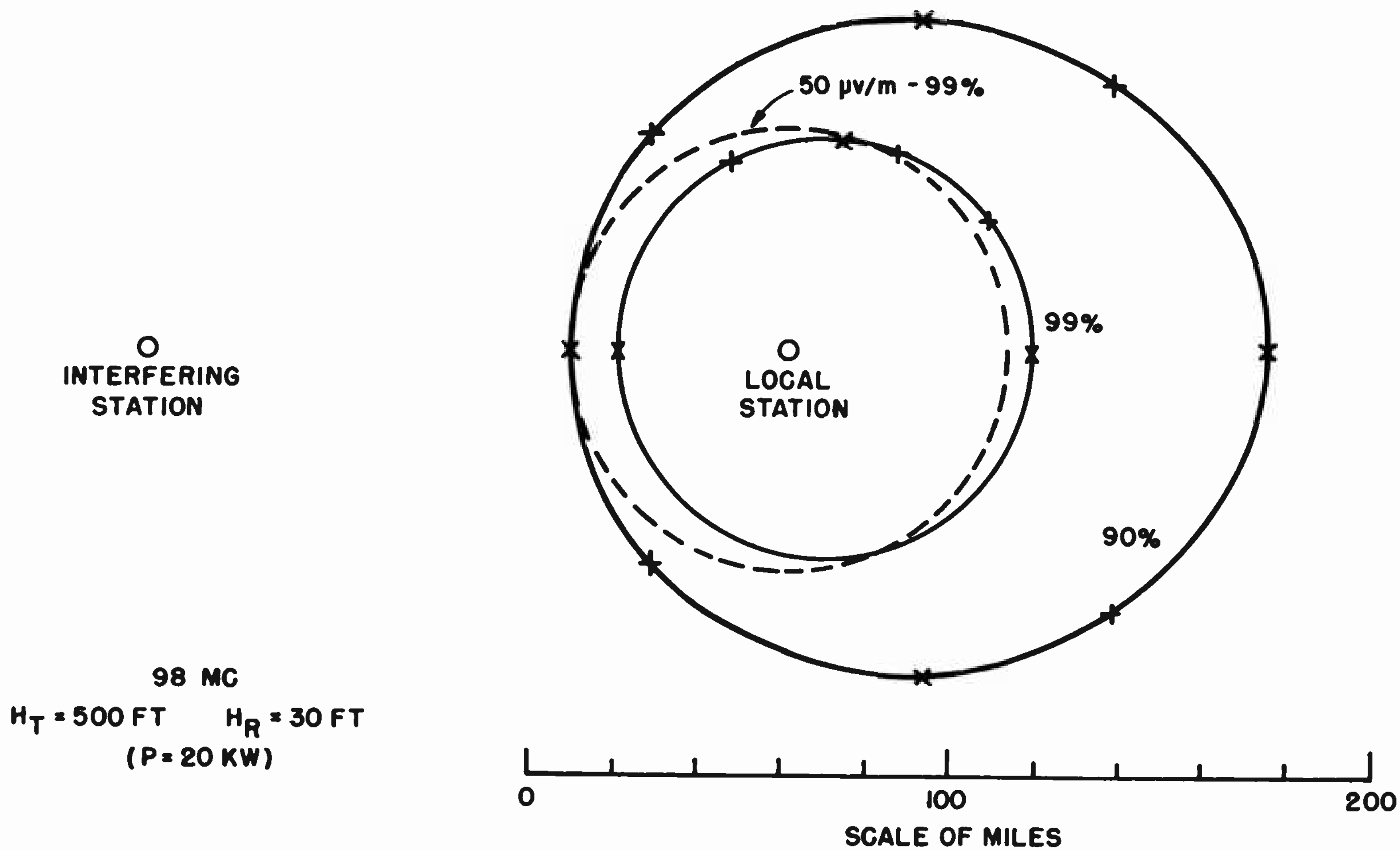



FIGURE I. 150 MILE SEPARATION- CO-CHANNEL INTERFERENCE FOR 10DB RATIO

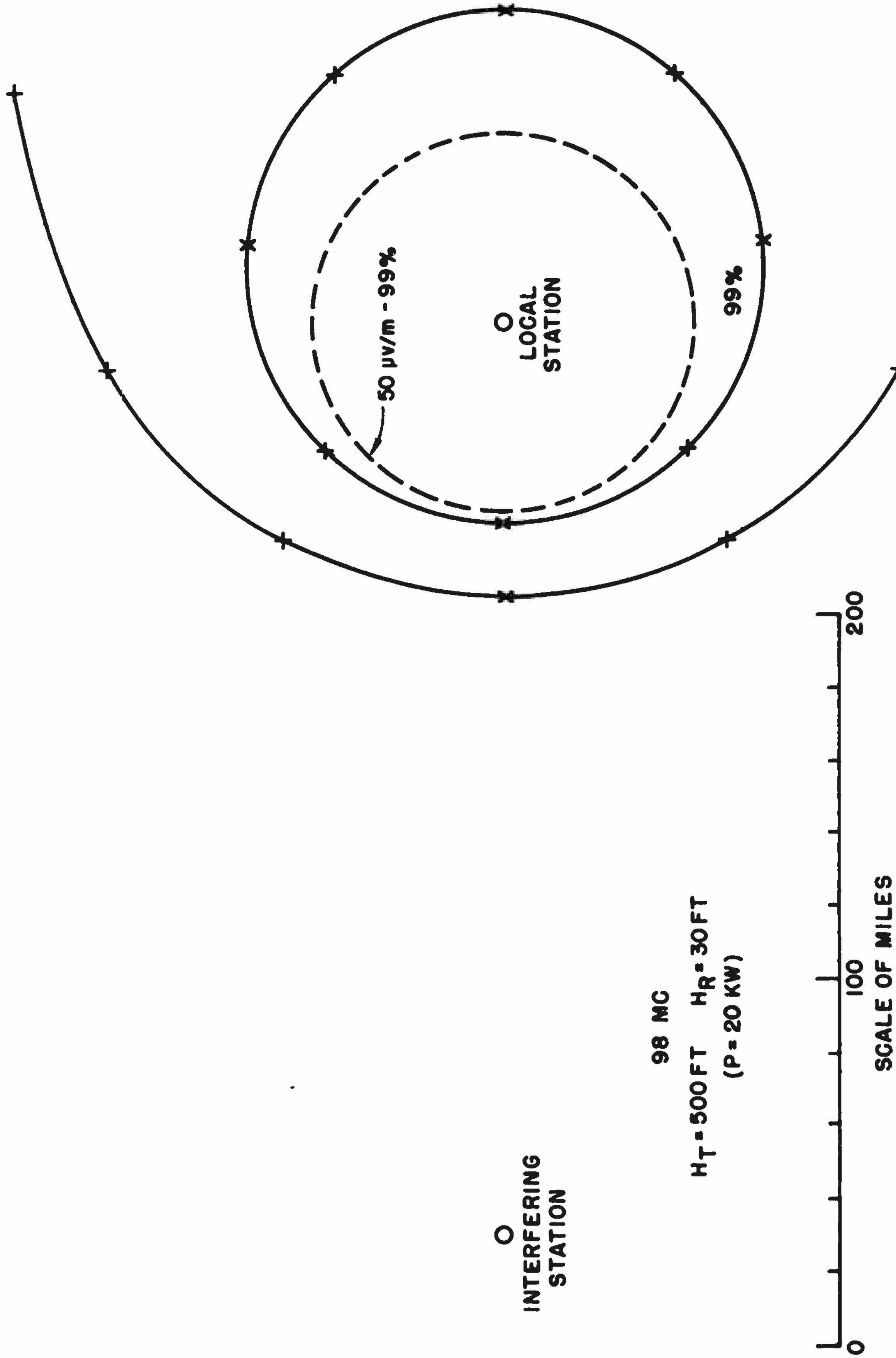



FIGURE 2. 250 MILE SEPARATION- CO-CHANNEL INTERFERENCE FOR 10 DB RATIO

Appendix A

November 9, 1948

To: Members of the RMA FM Systems Committee

For the past two years, the RMA FM Systems Committee has been inactive. Now, the Joint Technical Advisory Committee, which is sponsored by the Radio Manufacturers' Association and the Institute of Radio Engineers, has asked us to give them certain information for presentation to the Federal Communications Commission in hearings to be held on November 30, December 1 and December 2, 1948. These hearings are to be concerned primarily with matters pertaining to the allocation of channels for television broadcasting in the VHF portion of the spectrum. A matter of secondary interest to the FCC, but of definite interest to the FM industry, concerns allocations for FM broadcasting. There is no question regarding any change in general frequency assignments, but the FCC is expected to inquire as to whether its present allocation rules have resulted in providing satisfactory FM broadcasting service, particularly in regard to common-channel and adjacent-channel interference.

JTAC is looking to the FM Systems Committee for answers to the following questions:

1. What is the quieting sensitivity of current FM broadcast receivers - (a) table model receivers; (b) console receivers?
2. What is the quieting sensitivity that can be expected in the forseeable future in FM broadcast receivers - (a) table model receivers; (b) console receivers?
3. What is the capture ratio of desired to undesired signals in current FM broadcast receivers - (a) table model receivers; (b) console receivers?
4. What is the capture ratio that can be expected in the forseeable future in FM broadcast receivers - (a) table model receivers; (b) console receivers?
5. What is the selectivity characteristic of current FM broadcast receivers - (a) table model receivers; (b) console receivers?
6. What is the selectivity characteristic that can be expected in the forseeable future in FM broadcast receivers - (a) table model receivers; (b) console receivers?
7. What type of interference is the limiting factor in determining the service range of FM broadcast stations? More specifically, is common or adjacent channel interference due to tropospheric propagation the limiting factor, or is some other type of interference such as automobile ignition more serious?
8. How serious a factor is distortion due to multi-path transmission?

9. Does the Norton formula for propagation, assuming a sphere of radius 10 times the radius of the earth, give an adequate indication of the signal strength due to tropospheric propagation?

It is realized that complete answers to these questions, and in particular to the last question, cannot be obtained in the limited time before the hearings. Any factual information will, however, be of definite value to JTAC and the FCC. I believe that data can be obtained and presented without the necessity of holding a Committee meeting. I am asking that each member of the Committee send me by November 19 whatever data are available to him. I will tabulate the data and send the results to JTAC for their use. All data will be kept strictly confidential and the source of any information will not be disclosed to JTAC or to anyone else. Each member of the Committee will, of course, receive a copy of the information sent to JTAC.

Since much of the desired information relates to the characteristics of FM receivers, I am sending a copy of this letter to the chairman of the RMA Committee on FM Receivers with a request for the cooperation of that Committee. This does not, however, relieve the FM Systems Committee of its responsibility in this matter.

I believe that with the active cooperation of each member of our Committee, a worthwhile contribution can be made toward the solution of the problems facing the Commission.

Very truly yours,

GRT/jr

George R. Town
Stromberg-Carlson Company
Rochester 3, N. Y.
Chairman, FM Systems Committee

It is suggested that in reporting receiver performance, data be presented on the same basis as that used in filling out the standard RMA data sheet on performance characteristics of FM receivers.

Appendix B

November 11, 1948

To: Members of RMA FM Systems Committee

Subject: Data on FM Receivers for the Joint Technical Advisory Committee

On November 9, I attended a meeting of the RMA Committee on FM Receivers and discussed with them the problems raised in my letter of November 9 addressed to members of the FM Committee. As a result of that meeting and of contacting Mr. L. C. F. Horle, of the RMA Data Bureau, it was decided that in order to permit comparisons to be made on a common basis, both the FM Systems Committee and the FM Receiver Committee would be asked certain specific questions regarding the matters on which data is desired. In comparing the performance characteristics desired by JTAC with the standard RMA Engineering Department form entitled, "Characteristics of FM Broadcasting Receivers," it was decided that the questions which were asked should be put in the same terms as those used in the RMA form; specifically, that capture ratio should be given in terms of the co-channel ratio for 30 db interference and that selectivity should be given in terms of adjacent channel and second channel ratio for 30 db interference. These items are given as 13a, 13b and 13c respectively on the RMA form while quieting sensitivity is given as item 12d.

In order to minimize the amount of work required, a form has been prepared on which you may enter the desired information. Two copies are enclosed, one of which is for your files. Please note that one additional item has been added which was not included in myletter of November 9, namely, an estimate as to the percentage of FM receivers which use outside and built-in antennas. Please fill in the required information and return to me by November 19. Please note that the data sheet does not have to be signed if you prefer not to do so.

Very truly yours,

GRT:jr
Encl

George R. Town, Chairman
RMA FM Systems Committee

Appendix B (Concluded)

RMA FM Systems Committee
Data on FM Broadcasting for Joint Technical Advisory Committee
November, 1948

| Performance Characteristics - All Measurements at 100 Mc.* | Current Receivers | | Anticipated in** Foreseeable Future | |
|---|---|---|---|---|
| | Table | Console | Table | Console |
| 12d Quieting Sensitivity Input - Microvolts | | | | |
| 13a Adjacent Channel Ratio for 30 db Interference - db | | | | |
| 13c Second Channel Ratio for 30 db Interference - db | | | | |

*Measurements made in accordance with RMA Bulletin DB-2170-A entitled The Measurement of Performance Characteristics of Frequency Modulation Radio Receivers, dated December, 1946.

** If you do not care to give numerical values, please indicate whether you believe performance will be better or worse than at present.

What is the most serious type of interference encountered in the receiption of FM broadcasting? ______

The next most serious? ______

How serious is common channel, adjacent channel or second channel interference due to tropospheric propagation? ______

How serious a factor is distortion due to multi-path transmission? ______

______

How valid is thenew Norton formula for field strength due to tropospheric propagation? ______

______

What types of antennas are used in the home with FM receivers? External ______ %; built-in ______ %

Date ______ Name*** ______
Company*** ______

*** This information may be omitted or included

Please return to: George R. Town
Stromberg- Carlson Co.,Rochester, New York

Appendix C

Radio Manufacturers Association
Engineering Department
Receiver Section

November 12, 1948

To Members of the Committee on FM Receivers.

Gentlemen:

As you undoubtedly know, the Federal Communications Commission is conducting hearings on November 30, December 1 and December 2 of 1948 in the matter of certain propagation problems and equipment problems connected with television. The Commission has asked the Joint Technical Advisory Committee for certain information, among other things, on FM receivers.

The request for this information has come to Mr. George R. Town, Chairman of the FM Systems Committee of the Radio Manufacturers Association. Mr. Town has asked me to secure certain data from you. I attach hereto as a matter of information a copy of Mr. Town's letter of November 9, 1948, to Members of the RMA FM Systems Committee.

I attach hereto in duplicate, and this is the matter of immediate concern to you, a questionnaire with the request that you fill it out promptly in duplicate, sending one copy to Mr. Town at the Stromberg-Carlson Company, Rochester 3, New York, and one copy to me. This information will be tabulated promptly by Mr. Town and by me, and sent to Mr. L. G. Cumming of the Joint Technical Advisory Committee.

Since the hearings start November 30, JTAC will need information well before that time and I therefore suggest that you try to have this information in my hands and in Mr. Town's hands not later than November 18. The use of airmail special delivery will be appreciated.

The questionnaire which you are to fill out and which is sent to you herewith in duplicate represents information to be collected strictly in accordance with the methods prescribed by the RMA Data Sheet for FM Receivers, and the numbers appearing on the attached questionnaire such as 12 (d), 13 (a), and so forth, represent directly the corresponding paragraphs on the RMA Data Sheet for FM Receivers. In the matter of sensitivity, only the 100 mc figure is desired.

Very truly yours,

(Signed) J. E. Brown, Chairman
Committee on FM Receivers

APPENDIX C (Cont'd)



| | CURRENT RECEIVERS | | ANTICIPATED* | |
|---|---|---|---|---|
| | Table | Console | Table | Console |
| 12 (d) Quieting sensitivity input | | | | |
| 13 (a) Co-channel Ratio | | | | |
| 13 (b) Adjacent Ratio | | | | |
| 13 (c) 2nd Channel Ratio | | | | |

* If you do not care to give numerical values please indicate whether you think performance will be better or worse.

| | CURRENT RECEIVERS | | ANTICIPATED* | |
|---|---|---|---|---|
| | Table | Console | Table | Console |
| 12 (d) Quieting sensitivity input | | | | |
| 13 (a) Cp-channel Ratio | | | | |
| 13 (b) Adjacent Ratio | | | | |
| 13 (c) 2nd Channel Ratio | | | | |

* If you do not care to give numerical values please indicate whether you think performance will be better or worse.

Appendix D

# The Measurement of Performance Characteristics of Frequency Modulation Receivers

Data Bureau
Radio Manufacturers' Association

DB-2170-A December, 1946

## (B) SENSITIVITY

(d) Quieting-Sensitivity Input.- The quieting-sensitivity test input is the least unmodulated signal input which, when applied to the receiver through the dummy antenna, reduces the internal receiver noise to the point where the test output rises 30 decibels when the standard test modulation is applied to the input signal. It is expressed in microvolts.

## (C) TWO SIGNAL INTERFERENCE

In order to observe completely the interference resulting from the simultaneous reception of two signals, both desired and interfering signals must be present during the test.

The test determines the greatest interference input which may be permitted without the interference modulation output power exceeding minus 30 d. b. of the desired modulation output power, both desired and interfering signals being modulated to the same degree.

For this test, the f-m radio receiver is tuned to 100 Mc. with the first signal generator set at 500 μv at 100 Mc. The receiver volume control is adjusted to give normal test output when the signal is modulated 30 per cent at 400 cycles, after which the modulation is switched off.

An interfering signal input voltage is then applied at the following frequencies to the receiver by the second signal generator in addition to the desired signal carrier which remains unchanged:

| FREQUENCY | USUALLY CALLED |
|---|---|
| 100 Mc. | Co-channel |
| 100 Mc. +200 kc. | Adjacent Channel |
| 100 Mc. -200 kc. | do. |
| 100 Mc. +400 kc. | Second Channel |
| 100 Mc. -400 kc. | do |

Appendix D (Cont'd)

Co-channel matching of the two signal generators shall be assured by zero-beat equalization of the frequencies of the two unmodulated generators, after which modulation can be applied to the interfering signal generator.

The interfering signal is frequently modulated 30 per cent (22.5 kc. deviation) at 400 cycles. The interference test input voltage, which gives interference test output at 400 cycles, is observed and noted in Item 13. Where the interference input is in excess of 0.1 volt, its value need not be determined but may be recorded in Item 13 as "0.1 (+) volts".

TERMINOLOGY

B. INTERFERENCE TEST INPUT

The interference test input is the least interfering signal input voltage of specified carrier frequency, which results in interference test output, as defined below. It is expressed in micro-volts. The nature of the interfering signal and of the interference output are determined by the type of interference under investigation and are specified for the interference test described in other sections of these instructions.

C. NORMAL TEST OUTPUT

a. For receivers capable of delivering at least one watt maximum undistorted output, the normal test output is an audio-frequency power of 0.5 watts delivered to a standard dummy output load.

b. For receivers capable of delivering 0.1 to 1 watt maximum undistorted output, the normal test output is 0.05 watt audio-frequency power delivered to a standard dummy output load. When this value is used it should be so specified in the report, otherwise the 0.5 watt value will be assumed.

D. INTERFERENCE TEST OUTPUT

The interference test output is one-thousandth of the power of the normal test output or 30 decibels less than the normal test output. This output is used only in two-signal interference test.

G. STANDARD TEST MODULATION

The phrase "standard test modulation," in tests on frequency-modulation receivers, refers to a signal that is frequency-modulated at 400 cycles per second with a deviation of 30 per cent of maximum rated system deviation.

# ANNEX 13

## Description of the Carrier Synchronizing System in Operation Between Television Stations WNBT New York and WNBW Washington, D. C.

The equipment used in conducting the synchronizing test between television station WNBT New York and WNBW in Washington consists of two units. The first unit is located in the RCA Laboratories in Princeton, New Jersey, the second is located at WNBT television station transmitter station in New York. The equipment at the Princeton laboratories consists of two narrow band superheterodyne receivers. The voltage from a single local oscillator is applied to the first detectors of both receivers, thus the frequency difference is retained equally. The output of the two intermediate-frequency amplifiers are mixed in a phase discriminator, the output voltage of which is a measure of the phase difference between the two incoming carriers. The output voltage of the discriminator is used to frequency modulate an RC oscillator plus or minus 300 cycles about a mean frequency of 1,000. This frequency modulated 1,000 cycle tone is the control signal which is transmitted over the Class C telephone line. To receive signal from New York a dipole antenna and reflector are used. This arrangement does not receive enough signal from Washington to effect the control circuits. The second antenna used to receive WNBW Washington is also a bridged dipole and reflector combination. It has an excellent front to back ratio, but is not sufficient for our purpose. To further improve the discrimination against the New York signal some signal from the New York antenna is introduced into the transmission line coming from the antenna directed at Washington. This injected signal from New York is adjusted in amplitude and phase so as to further reduce the undesired New York signal on the output terminals of the Washington receiver.

In New York the frequency modulated 1,000 cycle tone is reconverted by a frequency discriminator to a D. C. voltage corresponding to the output of the phase discriminator on the output of the receivers in Princeton. This D. C. voltage is applied to a reactance tube in the transmitter crystal circuit in such a way as to be capable of shifting the crystal frequency plus or minus 300 cycles. This general arrangement is shown in block diagram Figure 1. The operation of the system is as follows: Signals from New York and Washington are compared in the phase discriminator at the output of the two receivers located in Princeton. The information regarding relationship of the two carriers is carried as frequency modulation of the 1,000 cycle tone by telephone line to New York. The frequency shift of this tone is utilized to shift the phase of the New York carrier to maintain a fixed phase relationship between the New York and Washington carriers as observed at Princeton.

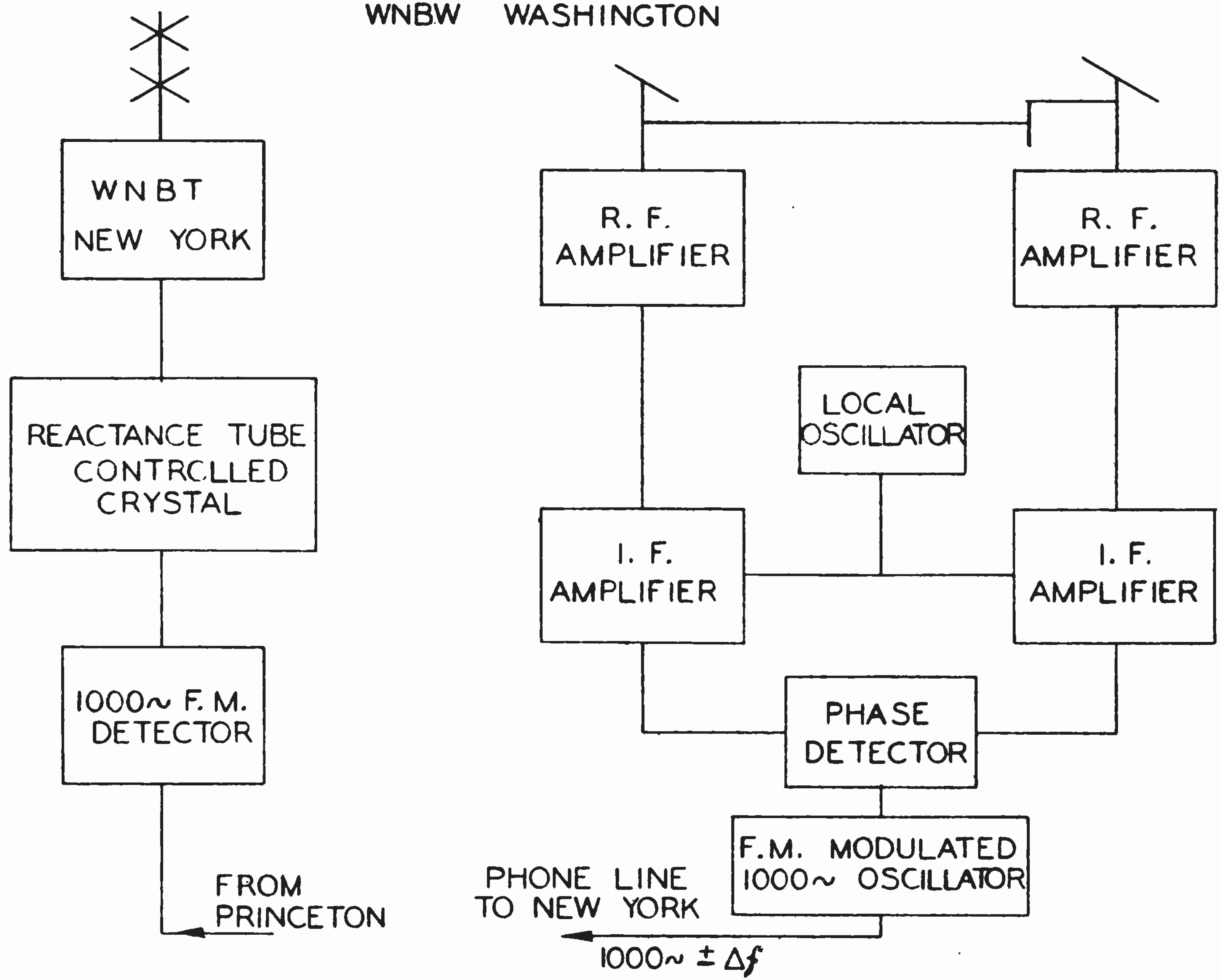
With a synchronizing arrangement of this type it would be possible to add Boston to the synchronous operation by simply establishing a receiving location south of Boston at a point where signal could be received from New York. By this observing station it would be possible to control the Boston transmitter in the same way as New York is controlled with respect to Washington. Schenectady likewise could be synchronized with New York in this same way.

Observations were made in the laboratories using two signal generators modulated with two different television pictures to evaluate the advantage of the

synchronized carrier operation. The tests indicated that if the level of the interfering signal produces barely visible bars in the picture under non-synchronous operation, a five to tenfold increase in the interfering signal level produces the same visible effect when the two carriers are synchronized. This value of improvement is for the most unfavorable phase relationship between the two carrier frequencies. At the most desirable phase position the improvement is about thirty times the voltage. Of course, this phase relationship will change due to many factors and some mean value between optimum phase relationship and the most unfavorable phase relationship is a reasonable value of the improvement to be expected. On this basis it is felt that an improvement corresponding to a reduction in interfering signal by a factor of about ten times in voltage may be reasonably expected.

R. D. Kell

CARRIER SYNCHRONIZING SYSTEM BETWEEN WNBT NEW YORK AND WNBW WASHINGTON



ANNEX 14

T E L E V I S I O N BROADCASTING COMPANY

SAN DIEGO, CALIFORNIA - Post Office Box 577 - La Jolla - California

November 12, 1948

Mr. L. G. Cummings, Sec'y
Joint Technical Advisory Committee
Institute of Radio Engineers
1 East 79th Street
New York 21, N. Y.

Dear Mr. Cummings:

I have gleaned from the trade press that you are compiling propagation data for submission to the Federal Communications Commission in connection with the November 30, December 1 and 2, 1948 hearings pertaining to TV allocations.

I have on hand a collection of field intensity recordings made over a period of several months on transmissions from Los Angeles television stations. The measurements were made in San Diego at a distance of approximately 120 miles. Most of the measurements are for transmissions on the higher channels near 200 megacycles, but there are also others made at 77 megacycles.

If you consider such measurements to be of interest I would be pleased to make the original tapes available to JTAC on a loan basis. They must be returned in the near future as the data will be needed for a later presentation to the Commission in connection with another matter. I must also advise that the data is in a "raw" unanalyzed state consisting of continuous recordings made by an Esterline-Angus tape recorder driven by a Stoddard Field Intensity Meter.

I should also like to request that you mail me one copy of the recent JTAC report prepared for FCC consideration dealing with UHF Television (475-890 mc). This is the report described by Mr. Fink in the current issue of ELECTRONICS. Any other publications dealing with television or related subjects would also be of interest, and if available copies thereof would be appreciated.

Very truly yours,

Leon N. Papernow,
Technical Director

TELEVISION BROADCASTING COMPANY
San Diego, California

LNP:f

DU MONT

Television Studio
515 Madison Avenue, New York, N. Y.

ALLEN B. DU MONT LABORATORIES, INC.

Passaic, New Jersey

November 5, 1948

Mr. L. G. Cumming, Secretary
Joint Technical Advisory Committee
1 East 79th Street
New York 21, New York

Dear Mr. Cumming:

With reference to Mr. Philip Siling's letter of October 29 regarding the November 30, December 1, 2 conference, we have not yet completed any engineering data or information on which we are able to report at the present time.

However, we are making a study of tropospheric transmission data gathered over the Summer months and are endeavoring to have it in such form as to present it properly at the time of the conference. An analysis of field intensity data obtained in the V.H.F. region is also being attempted, so as to determine the possibility of establishing a terrain factor which would be useful.

We regret that our studies are not far enough advanced at the present time to permit a conclusive report. A considerable amount of data remains to be analyzed.

Yours very truly,
ALLEN B. DU MONT LABORATORIES, INC.

Thomas T. Goldsmith, Jr.
Director of Research

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ANNEX 16

Ref: K-171

Committee on Television Receivers (R-4) November 10, 1948

Mr. F. J. Bingley, Chairman
Television Systems Committee
WOR - Mutual Broadcasting Co.
1440 Broadway
New York 18, New York

Dear Mr. Bingley:

This is in reply to your letter of November 8, 1948, concerning the question of the relation between television receiver performance and allocation standards.

The following numbered answers and comments apply to similar numbered questions in your letter:

1.) Signal strength to give satisfactory receiver performance.

a.) In the absence of man-made interference, based on a noise figure of 12DB from ultimate, a receiver input terminal voltage of approximately 550 microvolts across 300 ohms is required to provide a signal 30 DB above the noise level. The signal strength in terms of field intensity requires a conversion involving the effective height of the receiving antenna. If the antenna is a half wave dipole, then its effective height is $H = \lambda / \pi$. Next, assuming the antenna is matched to 300 ohms, the voltage delivered to the transmission line is

$$E = \mathcal{E} H = \frac{\mathcal{E} \lambda}{\pi} \qquad \text{volts (1)}$$

$$\text{or } \mathcal{E} = \frac{\pi E}{\lambda} = \frac{\pi E f}{3 \times 10^8} = 1.05\ Ef \times 10^{-6}\ \text{volts/m.}$$

The following table is computed:

| $f$ | $\mathcal{E}$ | $\mathcal{E}$ if E = 550$\mu$v. |
|---|---|---|
| $54 \times 10^6$ | 0.565E | 310$\mu$v/meter |
| $88 \times 10^6$ | 0.92E | 505$\mu$v/meter |
| $174 \times 10^6$ | 1.82E | 1000$\mu$v/meter |
| $216 \times 10^6$ | 2.26E | 1240$\mu$v/meter |

(f = carrier frequency.)

It would thus appear that no less than the present FCC figure of 500 microvolts per meter should be provided for satisfactory pictures and that even this is only half enough in the high band of 174 MC to 216 MC.

b.) In the presence of man-made interference, in metropolitan regions, the field strength must be increased above the 500 microvolt level. In general, it has been our experience that 5 millivolts is usually sufficient although not always. At a few locations the noise is so high that even 50 millivolts is insufficient. Based on a rough estimate of the number of such situations, however, it is believed that 90% of the locations will receive satisfactory service with a 5 millivolt per meter field strength.

2.)

a.) 100:1 ratio of wanted to unwanted signal should be provided in the allocation plan against co-channel interference. This is 40 DB previously deemed satisfactory for random noise (see item 1 (a) above) the regular pattern formed by carriers beating together is much more annoying than evenly distributed interference of the noise type. The beating carriers cause a "Venetian Blind" pattern on the picture. A 720 cycle carrier frequency difference would cause a pattern haivng 12 "slats".

3.) The protection ratio against interference on adjacent channels is based on the selectivity provided by receivers of practical and economic designs.

a.) With respect to interference in the upper adjacent channel, the ratio of field strengths may be 1:1.

b.) With respect to interference in the lower adjacent channel, the ratio of field strengths should be 2:1 in favor of the desired channel.

4.) Other principles which should be followed in regard to allocations are:

a.) Higher power for the transmitters than at present allowed, but have the transmitters located a short distance away from

residential areas. The reason for this is that receivers tend to overload and exhibit cross-talk difficulties when they are required to receive weaker stations while located "under the tower" of a high power transmitter.

4.)
b.) The use of directional transmitting antennas should be permitted in order to provide more effective coverage and to minimize the nuisance field in the direction of a co-channel station.

I trust that the information contained herein will be of value to you and to TS-3.

Very truly yours,

I. J. Kaar, Chairman
Committee on Television Receivers
RMA ENGINEERING DEPARTMENT

IJK:GHP

LG Cumming
RB Dome
PJ Herbst
LCF Horle
DD Israel
DW Pugsley
WP Short
P Siling

ANNEX 17

NAVY DEPARTMENT
NAVAL RESEARCH LABORATORY
Washington 20, D. C.

November 15, 1948

The Joint Technical Advisory Committee
L. G. Cumming, Secretary
1 East 79 Street
New York 21, New York

Dear Mr. Cumming:

I am not familiar with FCC procedures nor with the form that contributions from the IRE technical committees should take. The following informal comment under IVD(3) of FCC48-2256 will not contribute information but rather indicate a subject for consideration and sources of information.

It is evident that realizable antenna gain and directivity may affect current television VHF allocations as well as later UHF considerations. Helical antennas which are now receiving considerable study, adapt themselves well to these frequencies. As endfire radiators they are easily matched and broad band in performance. They offer the possibility of greater gain and directivity for both transmitting and receiving antennas than are now normally realized. Since the helical antenna radiates a circularly polarized wave, both transmitting and receiving antennas would have to be helical to avoid a 3 db rejection at the receiver. However a helical transmitting antenna would permit the use of either horizontal or vertical linear receiving antennas.

Questions of impedance, pattern, polarization band width for these several characteristics, design criteria and constructional considerations could best be answered by Dr. J. D. Krause of Ohio State University Research Foundation or by Dr. A. E. Marston, Antenna Research Section, Naval Research Laboratory.

Yours very truly,

L. C. Van Atta
Chairman, IRE Antenna Committee

LCV:cet

cc: A. E. Marston

To: Members of TR4

References: FCC Dockets Nos. 8975, 8736 and 9175 11/4/48

In anticipation of the engineering conferences scheduled by the FCC for November 30, December 1 and 2, the engineering groups within RMA and IRE have been requested to submit data, information or comments regarding propagation and allied subjects in the VHF portion of the spectrum, particularly as it affects standards and allocation problems of the television and FM services. This request is made by the JTAC on the advice of the Commission.

The attached letter from Wayne Coy, Chairman of the FCC, to Philip Siling, Chairman of JTAC lists in some detail the points on which information is desired. It is my understanding that matters pertaining to propagation will be referred to the IRE Committee on Propagation and to the sub-committee of the RMA Television Systems Committee, Chairman, F. J. Bingley. Matters related to receiver characteristics such as allowable co-channel and adjacent channel ratios will be referred to the RMA Committee on Television Receivers, Chairman, I. J. Kaar.

The subjects covering fields in which TR4 can contribute are those dealing with transmitting antennas (Mr. Coy's letter, paragraph 2, IVD (3) ) and power capabilities of transmitters (ibid. paragraph 3, IVD (6) and (7) ).

The members of TR4, TR4.1 and TR4.1.1 are requested to review the FCC notice, 48-2256 and to consider the topics to be discussed with particular attention to D (3), E (7) and E (8). Comments on other aspects will be appreciated.

Since Mr. Siling has requested that this information be submitted by November 15, it will not be possible for TR4 to compile a committee report. The individual members are therefore requested to forward such material and comments as may be of interest to:

Mr. L. G. Cumming, Secretary
JTAC
Institute of Radio Engineers
1 East 79 Street
New York 21, N. Y.

Your cooperation is earnestly solicited.

s/ P. J. HERBST, Chairman
Television Transmitter Committee, TR4

copies to:
Members of TR4
Members of TR4.1
Members of TR4.1.1
Philip Siling
D. G. Fink
L. G. Cumming
I. J. Kaar
L. C. F. Horle

ZENITH RADIO CORPORATION

6001 Dickens Avenue Chicago 39, Illinois

November 23, 1948

Mr. L. G. Cumming,
Joint Technical Advisory Committee
c/o Institute of Radio Engineers
1 East 79th Street
New York 21, N. Y.

Dear Mr. Cumming:

At the request of Mr. George Town, Chairman of the FM Systems Committee of the RMA, the FM Receiver Committee, of which I am chairman, has prepared the following analysis of performance characteristics of FM receivers on the basis of questionnaires filled out by committee members. Performance characteristics of currently manufactured receivers are given in the appended tabulation. This is on the basis of replies by nine manufacturers. It indicates the average as well as the best and poorest figures reported under nine classification

| Performance Characteristic | Table Model | | | Console | | |
|---|---|---|---|---|---|---|
| | Average | Highest | Lowest | Average | Highest | Lowest |
| 30 db Quieting Sensitivity | 24 uv | 7 uv | 50 uv | 15 uv | 6 uv | 25 uv |
| Co-Channel Capture Ratio for 30 db S/I | -11 db | -6 db | -17db | -11db | -6db | -17db |
| Adjacent Channel Ratio for 30 db S/I | 14 db | 27 db | 5db | 14db | 27db | 5db |
| Second Channel Ratio for 30 db S/I | 36 db | 47 db | 30db | 37db | 47db | 30db |

We also questioned manufacturers regarding the performance characteristics which might be anticipated in the foreseeable future. The answers to these questions show no definite trend. The averages would be the same as those for current production. Maximum and minimum performance would show a slightly greater spread than that reported above.

We are also enclosing the original answers to our questionnaire in case you feel it desirable to make a further analysis.

Very truly yours,

J. E. Brown, FM Receiver Committee

CC: Messrs. G. Town
L. Horle
J. Rennick