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Before the FCC 61-524
FEDERAL COMMUNICATIONS COMMISSION
Washington 25, D. C. 3143

In the Matter of	)	
	)	
Amendment of Part 3 of the Commission's	)	
Rules and Regulations to Permit FM	)	DOCKET NO. 13506
Broadcast Stations to Transmit	)	
Stereophonic Programs on a Multiplex Basis	)	

REPORT AND ORDER

By the Commission:

1. The Commission on March 22, 1955 released a Report and Order in Docket No. 10832 (FCC 55—340) which adopted rules providing for the issuance of Subsidiary Communications Authorizations (SCA's) to FM broadcasters — Section 3.293, et seq. After a few years of operation under these rules, it became evident that multiplex techniques could be employed for additional uses beyond the limited "news, music, time, and weather" format prescribed therein. Accordingly, a Notice of Inquiry was released on July 8, 1958 (Docket No. 12517; FCC 58—636) for the purpose of exploring possible additional uses of FM multiplexing.

2. A preliminary examination of the comments submitted in response to the Notice of Inquiry in Docket No. 12517 demonstrated a widespread interest in the subject of FM stereophonic broadcasting by means of subcarrier multiplex transmission in conjunction with main channel operation. Accordingly, the Commission on March 12, 1959 released a Further Notice of Inquiry (FCC 59—211) which enlarged the scope of the proceedings under Docket No. 12517 to afford interested persons an opportunity to submit data and opinions directed specifically to the matter of FM stereophonic broadcasting.

3. During the pendency of the Notice of Inquiry, the Electronic Industries Association organized the National Stereophonic Radio Committee. (NSRC) for the purpose of developing and recommending national standards for FM stereophonic radio. As a result of its studies, the NSRC submitted for consideration in Docket No. 12517 seven FM stereophonic broadcasting systems. Supplemental comments were submitted by the Radio Corporation of America, H. M. Davison, National Broadcasting Company, Zenith Radio Corporation, Philco Corporation, Multiplex Development Corporation, Crosby Laboratories, Inc., General Electric Company, FM Station WJBR, Audio Engineering Society, J. David Dykstra and others. This material formed the basis for the instant Notice of Proposed Rule Making (FCC 60—498; 25 FR 4257) released May *9*, 1960 wherein the engineering characteristics of the seven systems submitted by the NSRC and an additional system submitted by the Philco Corporation were described and comments requested thereon.

4. The Notice of Proposed Rule Making in this proceeding emphasized that comments expressing preferences unsupported by engineering analyses were not desired, since adequate provision was made for the submission of general comments in Docket No 12517. Nonetheless, more than 2500 such comments were received, most of which resulted from a series of articles in the trade press which reflected adversely on certain of the systems under consideration and concluded by urging readers to write to the Chairman of this agency on behalf of one particular system. Even though these "votes" cannot form the basis of our decision, they are nonetheless indicative of an intense interest in FM stereophonic broadcasting by a segment of the listening public.

5. Comments of an engineering nature were submitted by the Philco Corporation, Radio Corporation of America, Electric and Musical Industries, Ltd., Concert Network, Moseley Associates, Multiplex Development Corporation, Charles River Broadcasting Co. (WCRB), J. D. Dykstra, H. M. Davison, Zenith Corporation, Channel Broadcasting Company, Inc. (KRCW), General Electric Company, Crosby—Teletronics Corporation, H.H. Scott Company, Inc., Pacific FM, Inc. (KPEN) and others. Additionally, six of the eight systems outlined in the Notice of Proposed Rule Making were thoroughly field tested by the NSRC under FCC observation. Our analysis of the comments together with data empirically derived from the field test program form the basis of our decision in this proceeding. In this connection, we wish to express our gratitude to the National Stereophonic Radio Committee and to its members who devoted their time and talents to the end that we might be fully informed in the matters extant in this proceeding.

6. We feel that FM stereophonic transmission is properly an adjunct to existing aural broadcast service, to be permitted on a voluntary basis as part of the FM broadcast service. Moreover, on the basis of the information developed in this proceeding, we affirm at the threshold our conviction that there must be a single set of national standards governing FM stereophonic broadcasting.

7. Of the eight stereophonic broadcasting systems contained in the Notice of Proposed Rule Making, Systems 5 and 6 were withdrawn by their proponents. 1/ In order to narrow further the range of choices leading to our ultimate selection of a stereophonic system we turn briefly to the requirements of frequency response and stereo separation as applied to FM stereophonic broadcasting. Respondents disagree as to the desirability of and the need for maintaining suitable frequency response and electrical separation

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1/ See comments of Philco Corporation received July 27, 1960; also report on developmental operation of WGFM received May 23, 1960.

to 15,000 cycles. Each of the proposed systems transmits audio frequencies up to 15,000 cycles as main channel modulation, but Systems 2A and 2B have stereo subcarrier upper limitations at 7,000 and 8,000 cycles respectively. An upper limit of 9,500 cycles has also been suggested. 2/ These two systems are characterized by a cross—feeding technique in the receiver 3/which injects main channel audio components above the stereo subchannel cut—off frequency into the demodulated subcarrier audio. Hence, the systems lack stereo separation above the stereo subcarrier cut—off frequency. There is considerable evidence that frequency response and stereo separation above 8,000 cycles make a significant contribution to stereophonic quality. 4/ 5/ On the basis of this evidence and our analysis of the systems remaining, we find that Systems 1, 4 and 4A provide frequency response and stereo separation markedly superior to Systems 2A and 2B—-up to 15,000 cycles. Since a prime objective is good stereophonic quality, we are not favorably impressed by Systems 2A and 2B. 6/

8. Turning to System 3, we note that it is theoretically superior to all other systems in most respects. We find, however, that in actual operation its capability for producing a subjective stereophonic effect is handicapped by orchestral dynamics in that the separation of left and right microphone signals is not accurately preserved for reproduction at the respective loud speakers. On sustained tones, for example, the output for the stereo receiver becomes monophonic. On the other hand, program material consisting of a number of sound sources produces a very rapid shifting of gain between receiver output channels which is a source of

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2/ The Radio Corporation of America's comments of August 8, 1960 recommended the adoption of a system with a stereophonic subchannel modulation band from 30 to 9,500 cycles. For the reasons indicated elsewhere, we cannot accept this recommendation.

3/ System 2B is intended to provide channel separation without a de-matrix circuit at the receiver, utilizing acoustic cancellation of components of the loudspeaker signals. Optionally, an electrical de-matrix circuit and high frequency cross—over are included. Unless this is done, however, maximum frequency response of the right loudspeaker signal will be limited to 8,000 cycles and its noise output will be approximately 6 db higher than the left speaker.

4/ "Subjective Evaluation of Factors Affecting Two Channel Stereophony" by F. K. Harvey and M. R. Schroeder, presented at the 12th Annual Meeting, Audio Engineering Society, October, 1960.

5/ "Perception of the Stereophonic Effect as a Function of Frequency" by Beaubien and Moore presented at the 11th Annual Meeting, Audio Engineering Society, October, 1959.

6/ Limited frequency response and stereo separation are not the only faults of these systems for, as the field test measurements indicate, Systems 2A and 2B also demonstrate high stereo subchannel noise characteristics and excessive cross-talk.

annoyance to a listener near one loudspeaker. The tape recordings made during the field test program confirm these limitations, which we find to outweigh the virtues of this system. We are keenly aware of the difficulties under which Electric and Musical Industries has labored both as to unfamiliarity with our procedures and to the mileage which separated the "home office" from the sites of the NSRC meetings and field tests. We extend our appreciation to our British friends for their helpfulness in this common endeavor.

9. By the process of elimination there remain for consideration only Systems 1, 4 and 4A. Shortly prior to the issuance of the Notice of Proposed Rule Making, System 4 was modified to the extent that, except for minor parameter differences, Systems 4 and 4A are now theoretically identical and we shall treat them as such. 7/ Accordingly, we proceed with a more detailed examination of System 1 and System 4-4A.

10. For System 1, the main channel modulation, which consists of the addition of the left and right microphone signals (L + R), frequency modulates the main carrier to a maximum deviation of plus or minus 37.5 kilocycles. A subcarrier, which is centered at 50 kilocycles and which is modulated by the difference of the left and right microphone signals (L — R) to a maximum of plus or minus 25 kilocycles, also modulates the main carrier plus or minus 37.5 kilocycles. System 4—4A also provides for modulation of the main carrier by the main channel modulation (L + R) but the maximum deviation of the main carrier by this modulation is 67.5 kilocycles. The subcarrier is at 38 kilocycles but is suppressed and amplitude modulated by the difference signal L — R. The suppressed subcarrier sidebands, which exist in the range 23 to 53 kilocycles, also frequency modulate the main carrier to a maximum of plus or minus 67.5 kilocycles. As previously noted, the record before us demonstrates that both System 1 and System 4-4A are adequate in terms of frequency response and stereo separation up to 15,000 cycles. We believe that these systems as proposed are capable, under properly controlled conditions 8/, of performance superior to that demonstrated thus far, and our Rules, as amended herein, anticipate this improvement.

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7/ Examination of the field test data reveals, in some instances, marked differences. These we attribute to variables in receiver design and measuring techniques.

8/ The Comments of the General Electric Company dated October 28, 1960 indicate the importance of maintaining equal transfer characteristics in the L + R channel and the L — R channel with respect to stereo separation. The curves supplied show, for example, that a gain difference of only 1 db between the L + R and L — R channels will result in a stereo separation of 25 db. Additionally, a phase shift difference between the L + R and L — R channels of only 3 degrees will, by itself, result in a stereo separation of 30 db. A combination of these factors would, of course, produce a greater degradation in performance.

11. In the field test program, System 4A exhibited low values of distortion 9/(well below 2%) under all test conditions for frequencies below 7,500 cycles. System 1 produced low distortion for frequencies below 7,500 cycles, except when the transmitted left and right signals are equal and of opposite polarity (L = — R). Then the distortion reached higher values pointing up a transmitter and receiver design problem which is more critical in System 1 than in any other system. Under this condition of L = — R, the instantaneous frequency of the subcarrier varies from 25 kilocycles to 75 kilocycles when the subcarrier is being modulated fully. Hence, the sub—carrier portion of the receiver must contain a filter which will accept all frequencies from 25 to 75 kilocycles with as nearly "flat" response as possible, but must attenuate all frequencies below approximately 25 kilocycles. While it is theoretically possible to design and manufacture a satisfactory subcarrier separation filter for System 1 receivers, there is no evidence that this has been done or that it could be done at moderate cost.

12. The field test program provided for the measurement of harmonic distortion and required the insertion of a 15 kilocycle low—pass filter in the receiver output. In view of the presence of this filter it was not possible to measure harmonic distortion at frequencies above 7,500 cycles. System 4 was measured for "distortion" up to 15,000 cycles, and the distortion analyzer indicated the presence of undesired signal components in the receiver output of this system. The numerical values are not necessarily accurate, because of limitations of the test instruments used and it is reasonable to expect that similar results would have been obtained had the other systems been so tested, In analyzing the measurements to determine the "distortion" characteristics of System 4—4A, we note that measurements at the transmitter failed to exhibit correspondingly high "distortion" figures. While to some degree the inaccuracies may be attributed to measuring techniques and the limitations of test instruments used, there does exist a degree of distortion which originates in the receiver and which is caused by non-linearity in the detector circuits and by certain phase shift characteristics of the receiver intermediate frequency (IF) stages near the extremity of the IF pass-band. On the basis of certain liberal assumptions,

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9/ The term "distortion" as used here includes harmonic distortion, cross—talk and intermodulation products due to system non—linearity either in transmission or reception.

the degree of distortion of AM subcarrier systems (such as System 4—4A) has been calculated. 10/ Re—alignment or modification of existing receivers for a broader, less "peaked" frequency response of IF stages is a remedy although this would reduce selectivity, sensitivity and signal-to—noise performance of the receiver. Our analysis of the problem leads us to the conclusion that the expense involved in overcoming the receiver distortion present in System 4—4A will not be nearly so great as the expense involved in overcoming the receiver distortion problem of System 1. 11/ It is reasonable to assume that this cost differential would be reflected in the pricing of stereophonic receivers.

13. With respect to the question of monophonic distortion, i.e. the distortion that would appear at the output of a monophonic receiver while a station is engaged in stereophonic broadcasting, we find that both System 1 and System 4—4A produce very low distortion values and, accordingly, the monophonic listener would not be affected thereby.

14. The relative absence of noise in the output of receivers is of great importance in any broadcast transmission system. Signal-to—noise ratio, which is the term commonly used to describe this quality, is ordinarily expressed in decibels and is based upon the ratio, at the output of the receiver, of the power of the desired audio to the total noise power in the frequency band under consideration. The total noise is principally composed of (1) ambient noise or "static" radio fields, (2) thermal agitation noise in the resistance that the antenna system presents to the input terminals of the receiver and (3) noise generated within the receiver as a result of thermal agitation effects.

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10/ See Zenith Radio Corporation comments dated October 28, 1960 in Docket No. 13506 and comments of the Radio Corporation of America dated March 14, 1960 in Docket No. 12517.

11/ We also note the comments of the General Electric Company dated October 28, 1960 to the effect that adoption of System 4A would permit the transmitter distortion specifications presently contained in our rules to be extended to stereophonic broadcasting without change.

15. In comparing FM stereophonic systems, it is customary to use as the standard of comparison the signal-to—noise ratio obtained with monophonic transmission and reception for a given amount of transmitted power and other specified conditions, including height of antenna, transmission path and receiver sensitivity. When stereophonic transmission is substituted under the same set of conditions, the main carrier output and subcarrier output at the receiver will have reduced signal-to—noise ratios. The amount of reduction depends upon a number of transmission parameters, including the subcarrier frequency, the frequency swing of the main and subcarriers and the deviation of the main carrier caused by the subcarrier or subcarriers. The calculated loss of signal—to-noise ratio, compared to monophonic transmission and reception for each System is:

	System 1	System 4—4A
Monophonic receiver output	6 db	less than 1 db
Subcarrier output	15 db	23 db
Left signal output	13 db	20 db
Right signal output	13 db	20 db

16. It will be observed that System 1 has the greater loss in signal to noise ratio for monophonic reception and the lesser loss for stereo; conversely, System 4—4A has a smaller loss for monophonic reception and a greater loss for stereo. Both the monophonic and stereo losses for System 4—4A would be greater if SCA subcarrier frequencies were also used. 12/

17. The table below affords some comparison between Systems 1 and 4-4A for expected service range for a given level of signal—to-noise performance. It is based upon the figures in Paragraph 15, supra, the measured performance of two FM tuners (used in the field test program) which differ widely in price, and the curves in Section 3.333 of the Commission Rules.

	System 1		System 4—4A	
	Tuner No. 1	Tuner No. 2	Tuner No. 1	Tuner No. 2
Distance in miles:				
MM *	90	46	90	46
SM **	81	37	88	44
SS ***	71	30	61	23
Coverage in square miles:				
MM	25400	6650	25400	6650
SM	20650	4300	24400	6100
SS	15850	2830	11700	1660

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12/ This further loss may be controlled by limiting the amount of main carrier modulation permitted by SCA subcarriers.

	System 1		System 4-4A	
	Tuner No. 1	Tuner No. 2	Tuner No. 1	Tuner No. 2
Coverage in square miles lost (from MM):				
SM	4750	2350	1000	550
SS	9550	3820	13700	4990

* MM: Monophonic transmission and monophonic reception
** SM: Stereophonic transmission and monophonic reception
*** SS: Stereophonic transmission and stereophonic reception

Assumptions:
Effective radiated power 20 kilowatts; transmitting antenna 500 feet in height; receiving antenna: half—wave dipole, 30 feet in height; service areas not subject to co—channel or adjacent channel interference; frequency: 97 megacycles; signal—to-noise ratio 60 db at output of FM tuner.

18. The most distinct advantage for System 1 would occur under conditions in which stereo listeners would be unable to use outside antennas or otherwise unable to receive anything but low voltages at the receiver antenna input terminals. Under these circumstances, more listeners would receive a usable stereo signal under System 1 than under System 4—4A. With respect to signal—to—noise performance for main channel monophonic reception, listeners in fringe areas or otherwise under low signal conditions would fare better with System 4—4A than under System 1.

19. In anticipation of the noted impairment of main channel coverage associated with System 1, comments were requested in the Notice of Proposed Rule Making on "the need for or desirability of increases in transmitter power output to offset reductions in main channel modulation". After examining the comments we do not consider power increase to be a satisfactory solution. Many FM stations are now operating with a maximum transmitter power output and a requirement to increase transmitter power during hours of stereophonic programming would require the installation of a new transmitter. A more serious consequence, however, is the definite probability that raising transmitter power would increase co—channel and adjacent channel interference during periods of subchannel activity.

20. On May 9, 1960 we released a Report and Order in Docket No. 12517 (FCC 60-497) which modified our Rules to extend the uses to which SCA multi—plex subchannels may be put. Permissible uses must now fall within one or both of the following categories:

(1) Transmission of programs which are of a broadcast nature, but which are of interest primarily to limited segments of the public wishing to subscribe thereto. Illustrative services include: background music; storecasting; detailed weather forecasting; special time signals; and other material of a broadcast nature expressly designed and intended for business, professional, educational, religious, trade, labor, agricultural or other groups engaged in any lawful activity.

(2) Transmission of signals which are directly related to the operation of FM broadcast stations; for example: relaying of broadcast material to other FM and standard broadcast stations; remote cueing and order circuits; remote control telemetering functions associated with authorized STL operation, and similar uses.

21. As of January 31, 1961, more than 250 stations held SCA multiplex authorizations. It is estimated that over 200 stations are actually providing background music and other services on authorized subcarrier frequencies. Because its wide band characteristics make it mutually exclusive with SCA multiplex operation, adoption of System 1 would require each of these stations to choose between SCA operation and stereophonic programming. Some stations, unsupported by companion AM or TV operations, would find it difficult if not financially impossible to forego subscription revenues. Other stations utilizing SCA subcarrier frequencies for relaying broadcast material to other FM and standard broadcast stations and for various telemetering functions would also be foreclosed from engaging in stereophonic broadcasting with System 1. While an exact assessment of the future of SCA operations is impossible, the extended uses recently sanctioned under Docket No. 12517 have focused increased interest on the potentialities of SCA operation and it is possible that the next few years will find the majority of FM broadcast stations engaging in such operation.

22. The necessity, inherent in the adoption of System 1, of choosing between stereophonic broadcasting and SCA operation is of no decisional significance insofar as the major markets are concerned, for in larger cities where numerous FM assignments have been made only a small proportion of FM licensees presently engage in SCA operation. However, our records indicate that of the approximately 250 stations holding SCA's, 81 have been granted to stations in cities which have only one FM station. Here, the necessity of choice assumes greater importance, for a decision by station management to continue with SCA operation would deprive the community of local stereophonic broadcast service for an indeterminate period of time. We also recognize that stations now operating with SCA's have already installed the basic multiplex equipment for stereophonic broadcasting, which equipment could be

used for simultaneous SCA/stereophonic operation only if a narrow band system of stereophonic transmission (such as System 4—4A) is adopted.

23. Another factor to be weighed with respect to SCA operations is that a stereophonic receiver designed for System 4—4A would be incapable of receiving SCA transmissions because the latter are FM emissions, whereas the subcarrier detector in the System 4—4A stereo receiver is designed for the reception of AM multiplex signals.

24. Inasmuch as System 1 rules out the use of additional subchannels, the problem of cross—talk between the stereophonic subchannel and other channels need not be considered in relation to that system. However, this question must be considered with respect to System 4—4A. We are not vitally concerned with cross—talk from the main channel, or stereophonic subchannel into SCA subchannels, for the latter do not carry programming which is intended for the general public. We do find from the record before us, however, that for System 4—4A the cross—talk into SCA channels is not sufficient to destroy the usefulness of SCA services. With respect to crosstalk from SCA subchannels into the main channel and stereophonic subchannel, the field test program did not yield values for System 4—4A which are completely acceptable. In this connection, adoption of System 4—4A would require that we carry forward the protection values already applicable to SCA operation—Section 3.319(e) of the Rules.

25. With the exception of System 2B, the systems described in the Notice of Proposed Rule Making would all transmit the sum of the Left and Right microphone signals (L + R) as the signal heard by the main channel monophonic listener. It appears that, for the monophonic listener, this is preferable to the alternatives of single Left (L) or Right (R) microphone signals or the two Left minus Right (2L — R) combination advocated in System 2B. It is recognized that, because of acoustical effects, some stereophonic recordings fail to provide good monophonic presentation upon straight addition of the L and R channels. This same problem has been encountered by the recording industry in the preparation of monophonic records from stereophonic recordings. 13/ In all probability, most of the stereophonic programming by the broadcasting industry will be from available stereophonic tapes and discs. Hence, FM stations engaging in stereophonic broadcasting will be expected to exercise appropriate discretion in the selection of program material.

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13/ See comment of NSRC dated October 24, 1960, Docket No. 13506.

26. We call attention to existing arrangements among standard, FM and TV broadcast stations whereby Left and Right signals are separately transmitted in order to achieve stereophonic effects. While recognizing that many stations engaging in this type of operation have screened the records and tapes used in stereophonic transmission in order to assure some semblance of aural balance, we feel that dual station stereophonic programming violates good engineering practice insofar as the monophonic listener is concerned. Accordingly, we contemplate the discontinuance of dual station stereophonic programming at such time as equipment to conduct FM stereophonic broadcasting under the Rules herein adopted becomes generally available.

27. In Paragraph 7 of the Notice of Proposed Rule Making comments were requested, among other things, on: (1) the need for or desirability of suitable frequency and modulation monitors for use with the respective systems and the technical specification for such monitors; (2) the approximate cost and practicability of transmitter modifications; and (3) the cost and relative simplicity of stereophonic receivers or adaptations of existing receivers for the respective systems.

28. With respect to the necessity for frequency and modulation monitors we find that since stereophonic broadcasting is intended to be received by the general public, it should be conducted only under suitable controls to assure not only the proper operation of the main channel as presently required by our Rules, but of the stereophonic subchannel as well. Accordingly, our Rules will be amended in the near future to require the use of frequency and modulation monitors capable of monitoring the operation of the stereophonic subchannel.

29. As stated in Paragraph 22, supra, stations engaged in SCA operation have already installed the basic multiplex equipment for stereophonic broadcasting. While none of the proponents submitted information specifically related to the cost of transmitter modifications, the General Electric Company indicated that a survey conducted in October of 1960 demonstrated that the cost of suitable stereophonic subcarrier signal generators would be acceptable to the majority of FM broadcasters.

30. With respect to the cost and relative simplicity of stereophonic receivers and adoptations of existing receivers, we have indicated our concern with the cost of a receiver for System 1 providing acceptably low distortion. We are mindful of the fact that a limited number of adapters were built and sold during the relatively short time that System 1 as being tested by various FM broadcast stations under developmental authorizations issued by this agency. It is understood that these adapters were sold for prices ranging from approximately fifty to one hundred dollars, depending on the manufacturer.

31. Since adapters have never been made available to the listening public in connection with the developmental testing of Systems 4-4A, we have no information as to the probable retail cost of such adapters. We do note, however, that the adapter for System 4—4A recommended by the proponent of System 4A would be a relatively small device which could be manufactured for a parts cost of less than eight dollars. However, the cost of the adapter to the ultimate consumer will represent only a fractiona1 part of the cost of conversion to stereophonic reception; the necessity for an additional amplifier and speaker must also be taken into account. And, if the field test results are indicative of the true performance capabilities of present stereo receivers and adapters, we must conclude that receiver development to date has been inadequate for stereo reception of optimum quality, it is therefore to be expected that good stereo receivers will be considerably more costly than monophonic receivers, irrespective of the system adopted.

32. The closing date, as extended, for the submission of original comments in this proceeding was November 8, 1960 with reply comments due November 21, 1960. However, a number of respondents submitted original and rebuttal comments after the dates indicated, a few of which were accompanied by petition for acceptance of late filing. Inasmuch as this material has been of assistance in our deliberations and in view of the non—adjudicatory nature of this proceeding, we take official notice of all comments received through March 1, 1961. The necessity for our acting on petitions for acceptance of late filing in this proceeding has therefore been rendered moot.

33. In our recent Report and Order in Docket No. l3755 (FCC 6l—116, released January 30, 1961) amending the Rules to permit noncommercial educational FM broadcast stations to engage in specified nonbroadcast activities on a multiplex basis, we noted that "to the extent that [such] licensees can demonstrate a need for FM stereophonic broadcasting, such need will be considered by the Commission" in connection with the instant proceeding. In view of the limited response to this issue, we cannot conclude on the existing record that amendment of the Rules governing noncommercial educational FM broadcast stations to provide for stereophonic broadcasting would be warranted at this time. However, in recognition of the comments filed by WGBH Educational Foundation, we intend to institute a separate rule making proceeding in the near future to ascertain whether a requirement for stereophonic broadcasting can be established by educational FM interests.

34. The proponents of Systems 1, 4 and 4A have, as requested in the Notice of Proposed Rule Making, submitted statements which indicate in sub— stance that each is prepared to grant non—exclusive licenses under any one or more of its patent applications and the patents issuing thereon to any responsible party at reasonable royalties for the manufacture, use and sale of the apparatus covered thereby. We find these representations

consistent with the patent policies of the Commission which are designed to obviate any restraint of trade or monopolistic practices in matters coming within its cognizance.

35. In summary, we find that Systems 2A and 2B must be rejected because of inferior frequency response and stereo separation together with excessive cross—talk and high stereo subchannel noise characteristics. System 3, despite impressive theoretical advantages, must be rejected because of its inability to handle orchestral dynamics in a manner that will produce an acceptable subjective stereophonic effect. Systems 5 and 6 were withdrawn by their proponents from further consideration. The adoption of national FM stereophonic broadcast standards therefore reduces to a selection of either System 1 or System 4-4A. With respect to the technical criteria of frequency response and stereophonic separation these two systems compare favorably on a theoretical as well as a practical basis. However, we find that System 4—4A has the clearly decisive advantage of being able to provide stereophonic broadcast service with negligible effect on the monophonic listener and that the correlative disadvantage of System 1 is its detrimental effect on the monophonic listener. 14/ As stated in the Notice of Proposed Rule Making, we feel that ". . . any stereophonic system adopted should be based upon standards capable of rendering as high a quality of service as the art can provide, consistent with economic and other factors involved, without significant degradation of the service now provided under existing FM rules" (emphasis supplied). We find, therefore, that the public interest would best be served by the adoption of System 4-4A. 15/

36. It should be observed that System 4-4A, like any multiplex transmission system, will increase energy transmission at the edges of the FM channel involved. Accordingly, for optimum stereophonic reception, the bandwidth of stereophonic receivers must be considerably greater than that of monophonic receivers. Stereophonic receivers will thus be inherently more susceptible to adjacent channel interference. Also System 4-4A, in common with other multiplex systems, will not provide an FM stereophonic

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14/ We are also impressed by the apparent lower cost of System 4-4A, its comparative freedom from distortion, and the fact that its use does not ipso facto displace SCA operation.

15/ System 4—4A is a composite of stereophonic transmission standards proposed by the Zenith Radio Corporation and General Electric Company, respectively. The proponents of the other systems were: System 1, Crosby-Teletronics Corporation; System 2A, Calbest Electronics; System 2B, Multiplex Development Corp.; System 3, Electric and Musical Industries, Ltd.; System 5, General Electric Company's alternate proposal; System 6, Philco Corporation.

service area which is co—extensive with the service area available to monophonic listeners. Accordingly, acceptable monophonic reception of a given station will not, per se, insure acceptable stereophonic reception.

37. Upon the effectiveness of the amendments herein ordered, broadcast licensees desiring to undertake stereophonic broadcasting may, without further authority from the Commission, transmit stereophonic programs in accordance with the technical standards and notification procedures herein adopted.

38. Authority for the adoption of this Report and Order and associated rule amendments is contained in Sections 303(b), 303(c), 303(e), 303(g), 303(j), and 303(r) of the Communications Act of 1934, as amended.

39. IT IS ORDERED, This 19th day of April, 1961, that effective June 1, 1961, the Commission's Rules BE AMENDED as set forth in the attached Appendix; and

40. IT IS FURTHER ORDERED, That proceedings under Docket No. 13506 ARE HEREBY TERMINATED.

FEDERAL COMMUNICATIONS COMMISSION

Ben F. Waple
Acting Secretary

Attachment: Appendix

Released: April 20, 1961

NOTE: Rules changes herein will be covered by Transmittal Sheet III—15.

A P P E N D I X

1. New Section 3.297 is added to read as follows:

§3.297 Stereophonic Broadcasting.

FM broadcast stations may, without further authority, transmit stereophonic programs in accordance with the technical standards set forth in §3.322: Provided, however, That the Commission and the Engineer in Charge of the radio district in which the station is located shall be notified within 10 days from the installation of type—accepted stereophonic transmission equipment or any change therein, and: Provided further, that the Commission and the Engineer in Charge shall be notified within 10 days from the commencement of stereophonic operation, scheduled hours of such operation or any change therein.

2. Section 3.310 is amended by adding the following paragraphs:

§3.310 Definitions.

(t) Cross—talk. An undesired signal occurring in one channel caused by an electrical signal in another channel.

(u) FM Stereophonic broadcast. The transmission of a stereophonic program by a single FM broadcast station utilizing the main channel and a stereophonic subchannel.

(v) Left (or right) signal. The electrical output of a microphone or combination of microphones p1aced, so as to convey the intensity, time and location of sounds originating predominately to the 1istener's left (or right) of the center of the performing area.

(w) Left (or right) stereophonic channel. The left (or right) signal as electrically reproduced in reception of FM stereophonic broadcasts.

(x) Main channel. The band of frequencies from 0 to l5,000 cycles which frequency modulate the main carrier.

(y) Pilot subcarrier. A subcarrier serving as a control signal for use in the reception of FM stereophonic broadcasts.

(z) Stereophonic separation. The ratio of the electrical signal caused in the right (or left) stereophonic channel to the electrical signal caused in the left (or right) stereophonic channel by the transmission of only a right (or left) signal.

(aa) Stereophonic subcarrier. A subcarrier having a frequency which is the second harmonic of the pilot subcarrier frequency and which is employed in FM stereophonic broadcasting.

(bb) Stereophonic subchannel. The band of frequencies from 23 to 53 kilocycles containing the stereophonic subcarrier and its associated sidebands.

3. Section 3.319 is amended to read as follows:

§3.319 Subsidiary Communications Multiplex Operations: Engineering Standards.

(a) Frequency modulation of SCA subcarriers shall be used.

(b) The instantaneous frequency of SCA subcarriers shall at all times be within the range 20 to 75 kilocycles: Provided, however, That when the station is engaged in stereophonic broadcasting pursuant to §3.297, the instantaneous frequency of SCA subcarriers shall at all times be within the range 53 to 75 kilocycles.

(c) The arithmetic sum of the modulation of the main carrier by SCA subcarriers shall not exceed 30 percent: Provided, however, that when the station is engaged in stereophonic broadcasting pursuant to §3.297, the arithmetic sum of the modulation of the main carrier by the SCA subcarriers shall not exceed 10 percent.

NOTE: Inasmuch as presently approved modulation monitors have been designed to meet requirements for modulation frequencies of from 50 to 15,000 cycles, the use of such monitors for reading the modulation percentages during SCA multiplex operation may not be appropriate since the subcarriers utilized are above 20,000 cycles.

(d) The total modulation of the main carrier, including SCA subcarriers, shall meet the requirements of §3.268.

(e) Frequency modulation of the main carrier caused by the SCA subcarrier operation shall, in the frequency range 50 to 15,000 cycles, be at least 60 db below 100 percent modulation: Provided, however, that when the station is engaged in stereophonic broadcasting pursuant to §3.297, frequency modulation of the main carrier by the SCA subcarrier operation shall, in the frequency range 50 to 53,000 cycles, be at least 60 db below 100 percent modulation.

4. New Section 3.322 is added to read as follows:

§3.322 Stereophonic Transmission Standards.

(a) The modulating signal for the main channel shall consist of the sum of the left and right signals.

(b) A pilot subcarrier at 19,000 cycles plus or minus 2 cycles shall be transmitted that shall frequency modulate the main carrier between the limits of 8 and 10 percent.

(c) The stereophonic subcarrier shall be the second harmonic of the pilot subcarrier and shall cross the time axis with a positive slope simultaneously with each crossing of the time axis by the pilot subcarrier.

(d) Amplitude modulation of the stereophonic subcarrier shall be used.

(e) The stereophonic subcarrier shall be suppressed to a level less than one percent modulation of the main carriers.

(f) The stereophonic subcarrier shall be capable of accepting audio frequencies from 50 to 15,000 cycles.

(g) The modulating signal for the stereophonic subcarrier shall be equal to the difference of the left and right signals.

(h) The pre—emphasis characteristics of the stereophonic subchannel shall be identical with those of the main channel with respect to phase and amplitude at all frequencies.

(i) The sum of the side bands resulting from amplitude modulation of the stereophonic subcarrier shall not cause a peak deviation of the main carrier in excess of 45 percent of total modulation (excluding SCA subcarriers) when only a left (or right) signal exists; simultaneously in the main channel, the deviation when only a left (or right) signal exists shall not exceed 45 percent of total modulation (excluding SCA subcarriers).

(j) Total modulation of the main carrier including pilot subcarrier and SCA subcarriers shall meet the requirements of Section 3.268 with maximum modulation of the main carrier by all SCA subcarriers limited to 10 percent.

(k) At the instant when only a positive left signal is applied, the main channel modulation shall cause an upward deviation of the main carrier frequency; and the stereophonic subcarrier and its sidebands signal shall cross the time axis simultaneously and in the same direction.

(l) The ratio of peak main channel deviation to peak stereophonic subchannel deviation when only a steady state left (or right) signal exists shall be within plus or minus 3.5 percent of unity for all levels of this signal and all frequencies from 50 to 15,000 cycles.

(m) The phase difference between the zero points of the main channel signal and the stereophonic subcarrier sidebands envelope, when only a steady state left (or right) signal exists, shall not exceed plus or minus 3 degrees for audio modulating frequencies from 50 to 15,000 cycles.

N0TE: If the stereophonic separation between left and right stereophonic channels is better than 29.7 decibels at audio modulating frequencies between 50 and 15,000 cycles, it will be assumed that paragraphs (l) and (m) of this section have been complied with.

(n) Cross-talk into the main channel caused by a signal in the stereophonic subchannel shall be attenuated at least 40 decibels below 90 percent modulation.

(o) Cross-talk into the stereophonic subchannel caused by a signal in the main channel shall be attenuated at least 40 decibels below 90 percent modulation.

(p) For required transmitter performance, all of the requirements of Section 3.254 shall apply with the exception that the maximum modulation to be employed is 90 percent (excluding pilot subcarrier) rather than 100 percent.

(q) For electrical performance standards of the transmitter and associated equipment, the requirements of Section 3.317 (a)(2), (3), (4) and (5) shall apply to the main channel and stereophonic subchannel alike, except that where 100 percent modulation is referred to, this figure shall include the pilot subcarrier.