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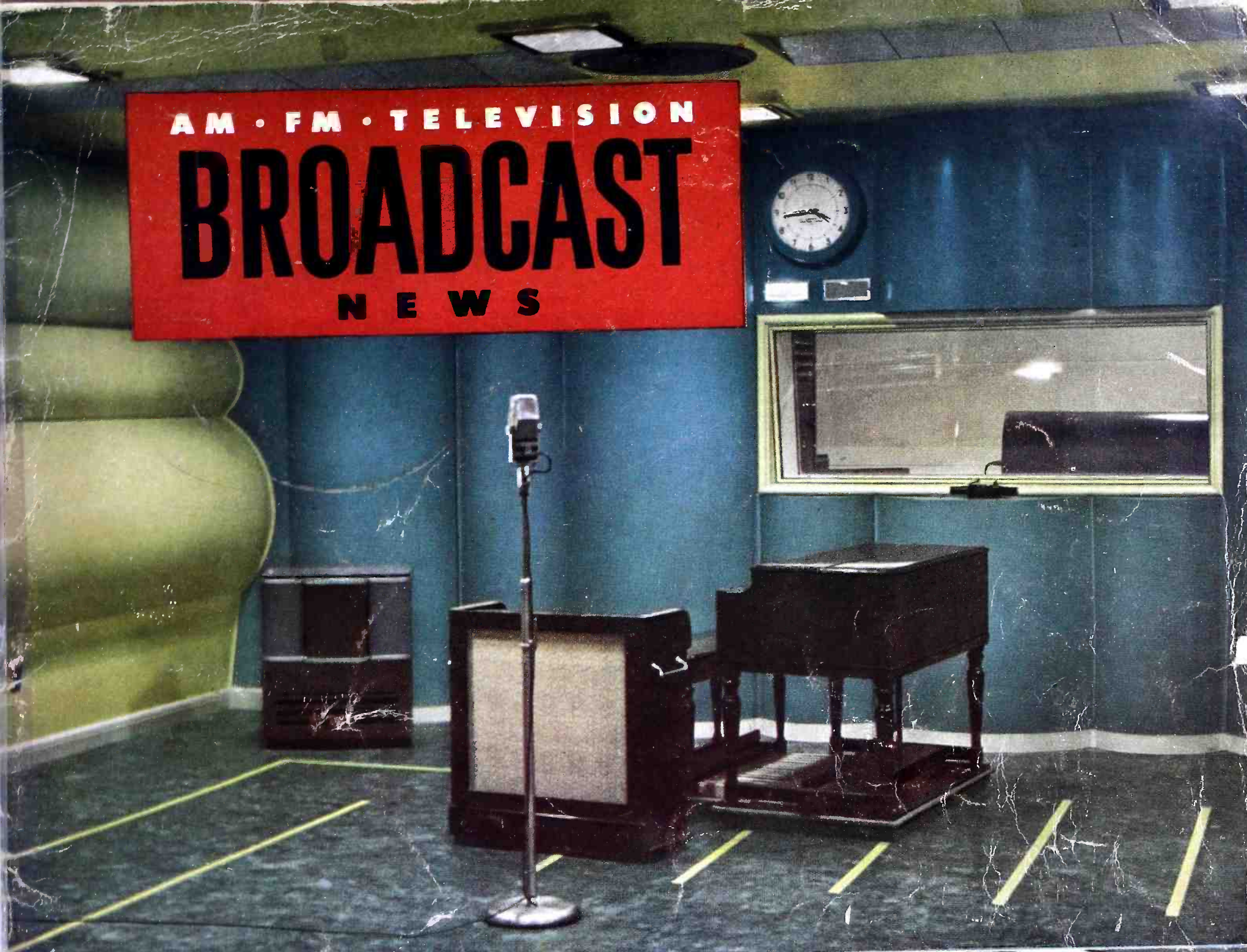
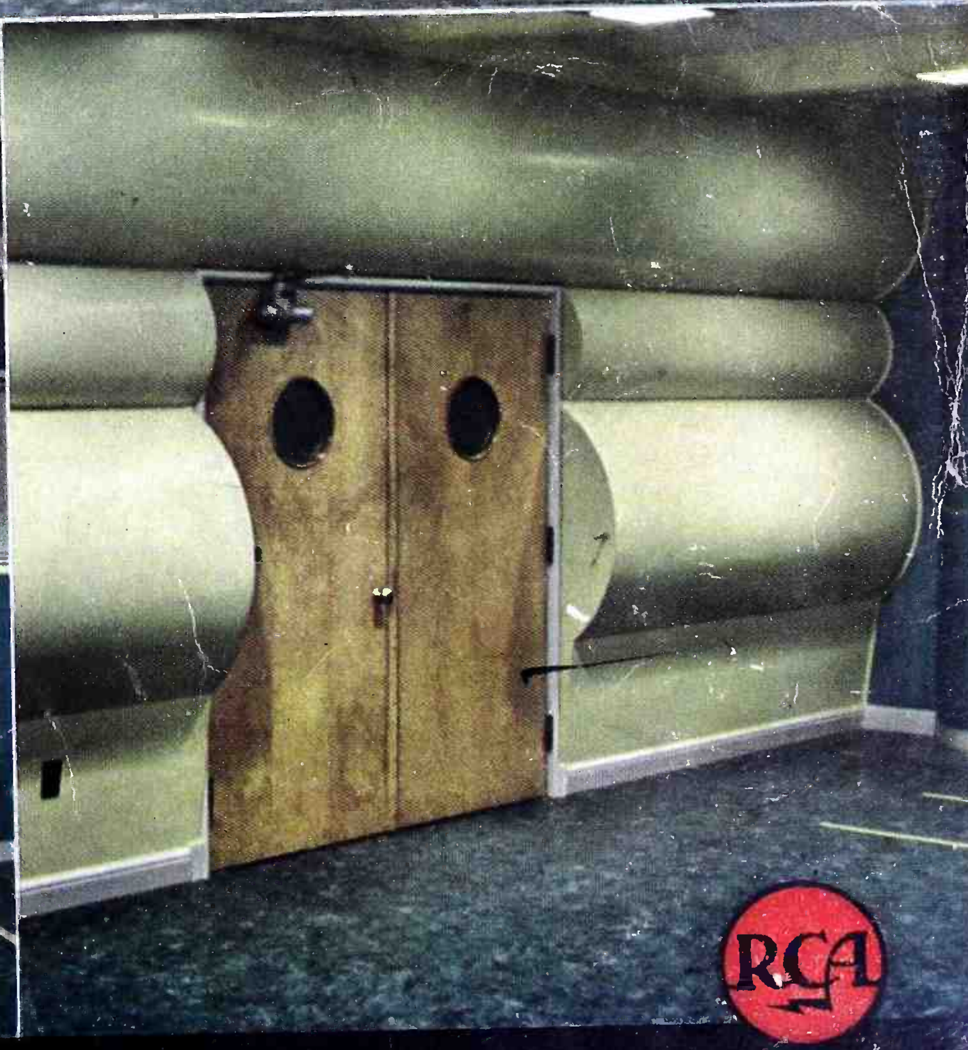
BROADCAST NEWS





RCA

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Broadcast News

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. . .

Published by the

RADIO CORPORATION OF AMERICA

RCA VICTOR DIVISION..CAMDEN, NEW JERSEY

NUMBER 40 JANUARY, 1945

JOHN P. TAYLOR, Editor JUDY J. ALESI, Ass't Editor

Contents

OUR COVER for this issue is made up of three views of WFAA's Studio C. This is one of five studios in the WFAA-KGKO studio installation which is described in some detail in the article beginning on page 26. While these studios are pictured and described rather completely in the article, we decided to run these color pictures on the cover because the color shows up the polycylindrical diffuser construction so much better than the half tones.

Incidentally, these color pictures were made by Bill Witty of our Dallas office with the able assistance of Olin Brown, WFAA's control room supervisor. Bill and Olin, like a good many other broadcast engineers, are just about as much interested in photography as they are in transmitting equipment.

POLYCYLINDRICAL DIFFUSERS come in for a lot of attention in this issue, which is not a coincidence. Many broadcasters are presently planning new studio installations and FM will be an important consideration. If what is known as "FM quality" is to be obtained, these new studios will need to have more high frequency response than most of those in use today. One way of getting studio characteristics uniform out to 15,000 cycles is by using hard-surfaced walls of such design that reflected sounds are well dispersed. The use of half-round plywood panels—technically called "polycylindrical diffusers"—is the easiest way to do this. So, in hopes of helping studio designers, we have collected in this issue as much information on the subject as was readily available. Incidentally, don't overlook the fact that this type of studio construction, not only has that "new-world-of-tomorrow" look, but is also very practical, for these studio walls can be spray-painted or finished any way you like. And they can be refinished whenever necessary without endangering acoustical properties!

BRIG. GEN. DAVID SARNOFF received the major award at the first annual convention of the Television Broadcasters' Association. The meeting, held at the Hotel Commodore in New York on December 11th and 12th, was attended by more than 1,000 engineers, producers and others interested in television progress. The award to Gen. Sarnoff was presented by Paul Raibourn, chairman of the TBA Awards Committee and television chief of Paramount Pictures. The citation read: "For his initial vision of television as a social force and the steadfastness of his leadership in the face of natural and human obstacles in bringing television to its present state of perfection." Mr. Raibourn added that the Committee wished to refer to Gen. Sarnoff as, "The father of American Television".

Gen. Sarnoff, on leave of absence from his peacetime position as president of Radio Corporation of America, recently returned to the United States after eight months' service as special consultant on communications in the office of the Allied Supreme Command in London and with SHAEF in France.

DR. V. K. ZWORYKIN, Associate Director of RCA Laboratories, was also honored by the Television Broadcasters' Association. The citation which accompanied the medal presented Dr. Zworykin read: "For development of the Iconoscope and the storage principle of picture pickup, resulting in the first practical television pickup equipment." In accepting the award Dr. Zworykin briefly depicted some of the things to which television might look forward. One of these was a "walkie-see-ie", a television pickup and transmitting equipment of size comparable to today's walkie-talkie. He envisioned a television news service of the future in which roving reporters equipped with such sets would flash news scenes back to the television station.

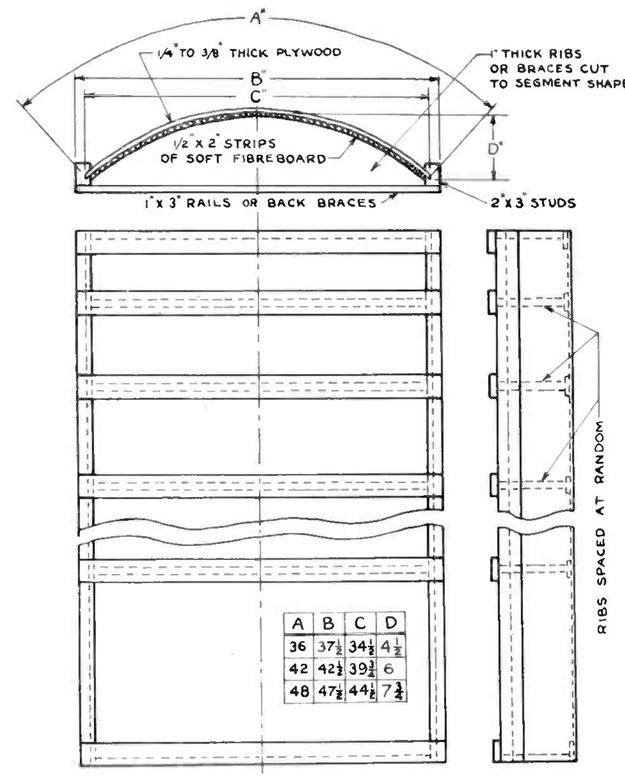
POLYCYLINDRICAL DIFFUSERS IN ROOM ACOUSTIC DESIGN*

by **JOHN E. VOLKMANN**

Acoustic Development Section, Sound Engineering Dept.

Experience in rooms with wood-paneling and sound-diffusing surfaces indicates that the manner in which the reverberant and other aftersounds in a room are distributed has possibly as much to do with the acoustical excellence of a room as the actual time of decay in the room, and from time to time we have heard discussions on the diffusion of sound in rooms not only in regard to fulfilling the assumptions in the Sabine reverberation formula, but in regard to its subjective effect.

Before presenting data on the convexed wood panels or diffusers described in this paper, let us briefly discuss some general observations on the action of sound in rooms and halls known for their acoustic excellence, a fuller discussion of which may be found in the literature.[1] In many of these rooms, as, for example, the Philadelphia Academy of Music, which has several tiers of boxes, and wood paneling throughout the auditorium, the projecting surfaces which are comparable in dimensions to the wave-length of sound tend to disperse the reflections and give a more diffuse distribution of sound. The important point regarding sound diffusion is that it does not lessen the total energy in the room, but rather it increases the number of reflections per unit time and hence lessens the intensity level of the individual reflections. This factor is of practical importance in the placement of microphones in that it lessens the effect of interferences between the direct sound and the first reflections. The small increments of energy and random phases of the diffused sound also produce a smoother decay curve in the enclosure. Since a smooth decay curve[2] presupposes the absence of echoes, rooms with sound diffusers apparently can tolerate a slightly greater reverberation time and thereby effect a better compromise between the optimum conditions for speech and music. This increased re-



A	B	C	D
36	37½	34½	4½
42	42½	39¾	6
48	47½	44½	7¾

FIG. 1. *Convex plywood panel.*

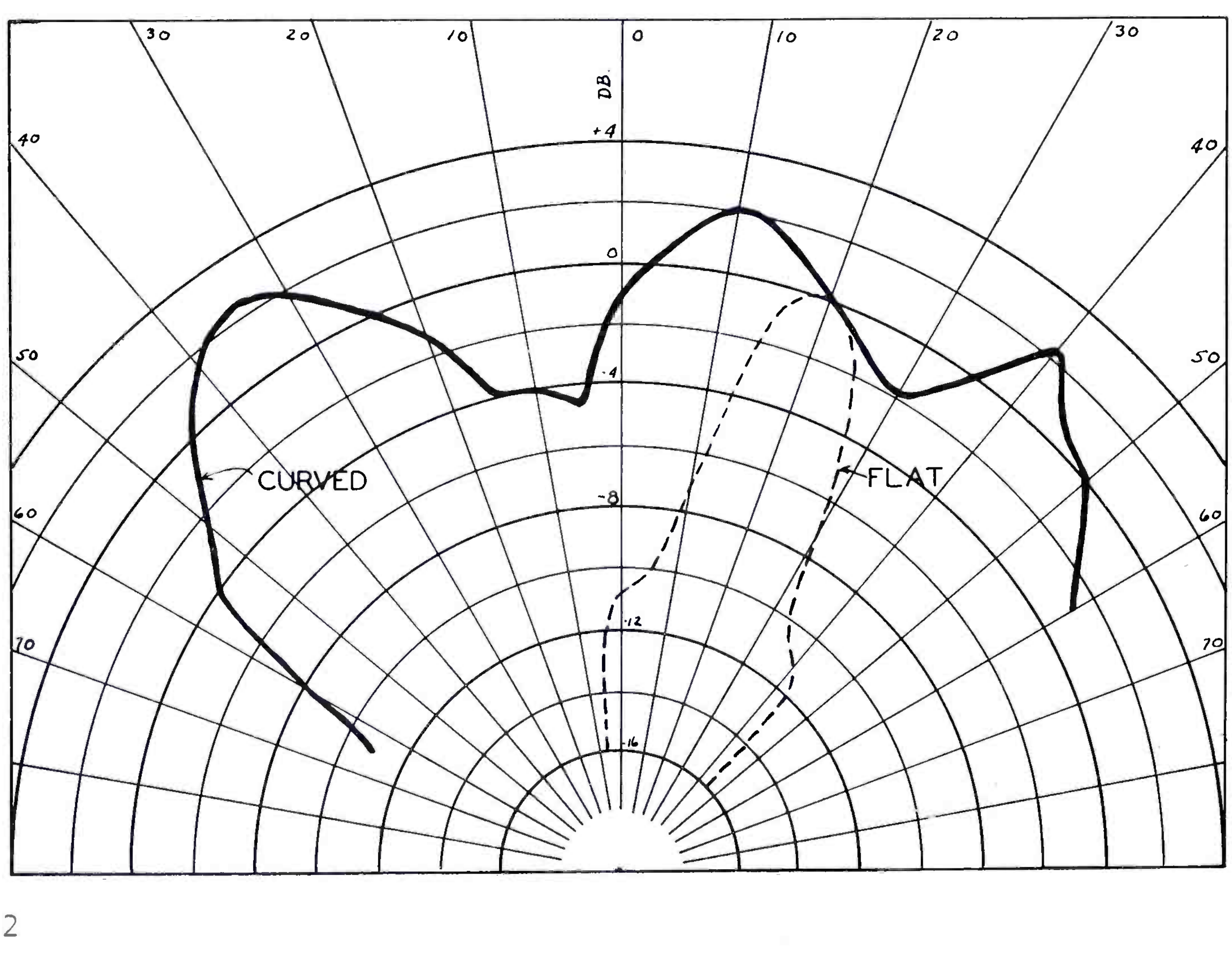


FIG. 2. *Polar distribution characteristics of reflected wave for convex and flat panels.*

verberation time coupled with the effects of panel resonance may account for rooms treated with polycylindrical diffusers sounding somewhat larger than ordinary rooms.

A second factor of importance in the acoustics of the Philadelphia Academy of Music is that the wood paneling also helps to give a diffuse distribution of sound by virtue of the fact that the energy incident on its surface which is not absorbed is reradiated.[3] This reradiated energy does not follow the regular law of equal angle of incidence and reflection, but due to panel vibration acts more like a loudspeaker diaphragm and, therefore, for many frequencies either disperses the incident energy over a wide angle or changes its direction. Similar diffusion also occurs due to reradiation from cavity resonators formed by the boxes and other pockets in the tier balconies. A third important factor in the Academy acoustics is that the radiation from the wood paneling further occurs due to direct "telephonic" transmission from the original sound sources on the stage through the wood flooring and panel mounting structure. Since the panels in the Academy are more or less of different sizes and shapes the panel resonance frequencies are not selective. Two interesting factors to note here are that the panel radiators have a decay time of their own, and that the transmission time in wood is much shorter than in air.

This "diffuse" distribution of energy coming from many random directions and from a great number of small sources of sound in the room has, in addition to giving a more uniform distribution and decay of sound, the important psychological effect created by enveloping the audience with sound which gives a certain feeling of body or depth to the sound. The "feeling" effect of sound is further enhanced in the Academy by the transmission of sound through the wood floor to the seats and from other structures in the room.

Consideration of this diffuse aftersound in rooms known for their good acoustics has led to the following developments: (1) The use of convex curved surfaces, usually cylindrical wood paneling, in the acoustic design of rooms which forms the topic of the present paper. (2) The use of a multiplicity of "room" loudspeakers on sound reproducing systems for creating the feeling of depth or body through the spatial effect of enveloping the audience with sound. Such "room" loudspeakers have been used separately and in combination with "direct" loudspeakers for adding realism to reproduced reverberation.

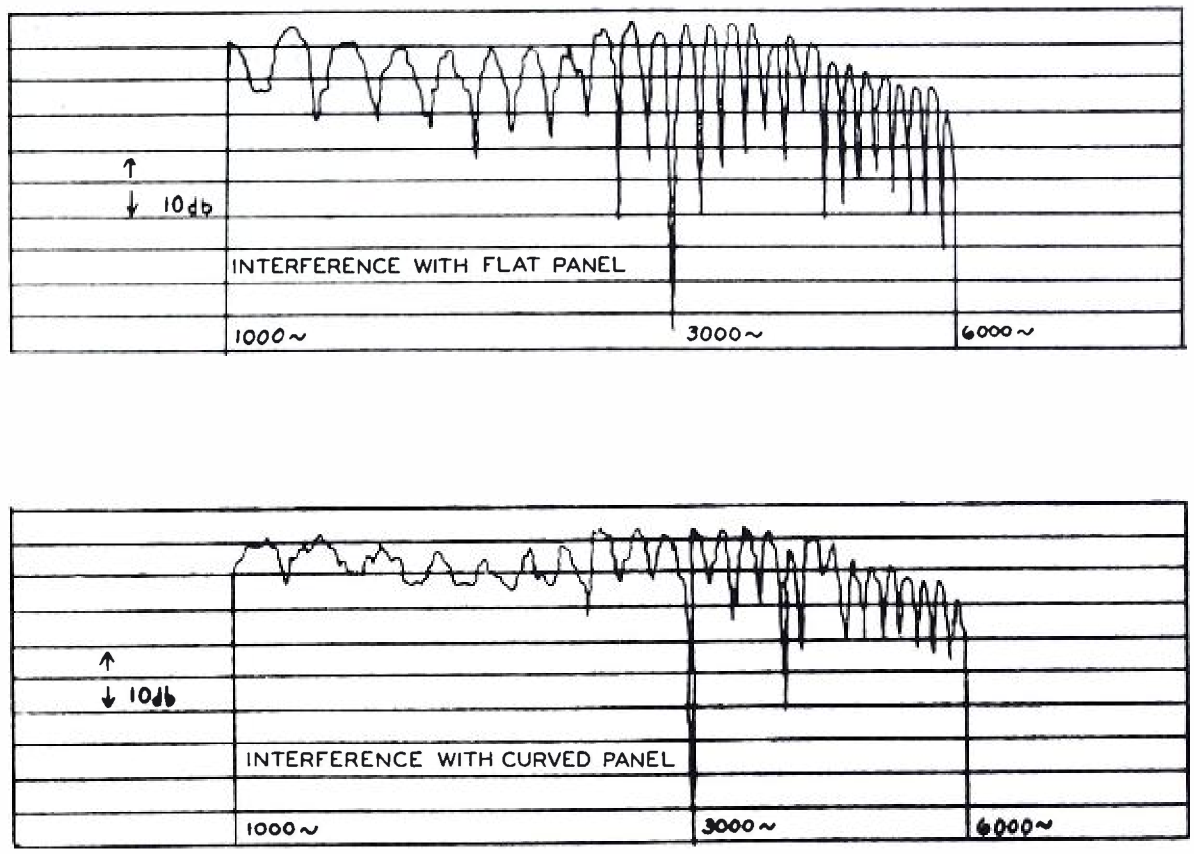


FIG. 3. *Interference between direct and reflected waves for convex and flat panels.*

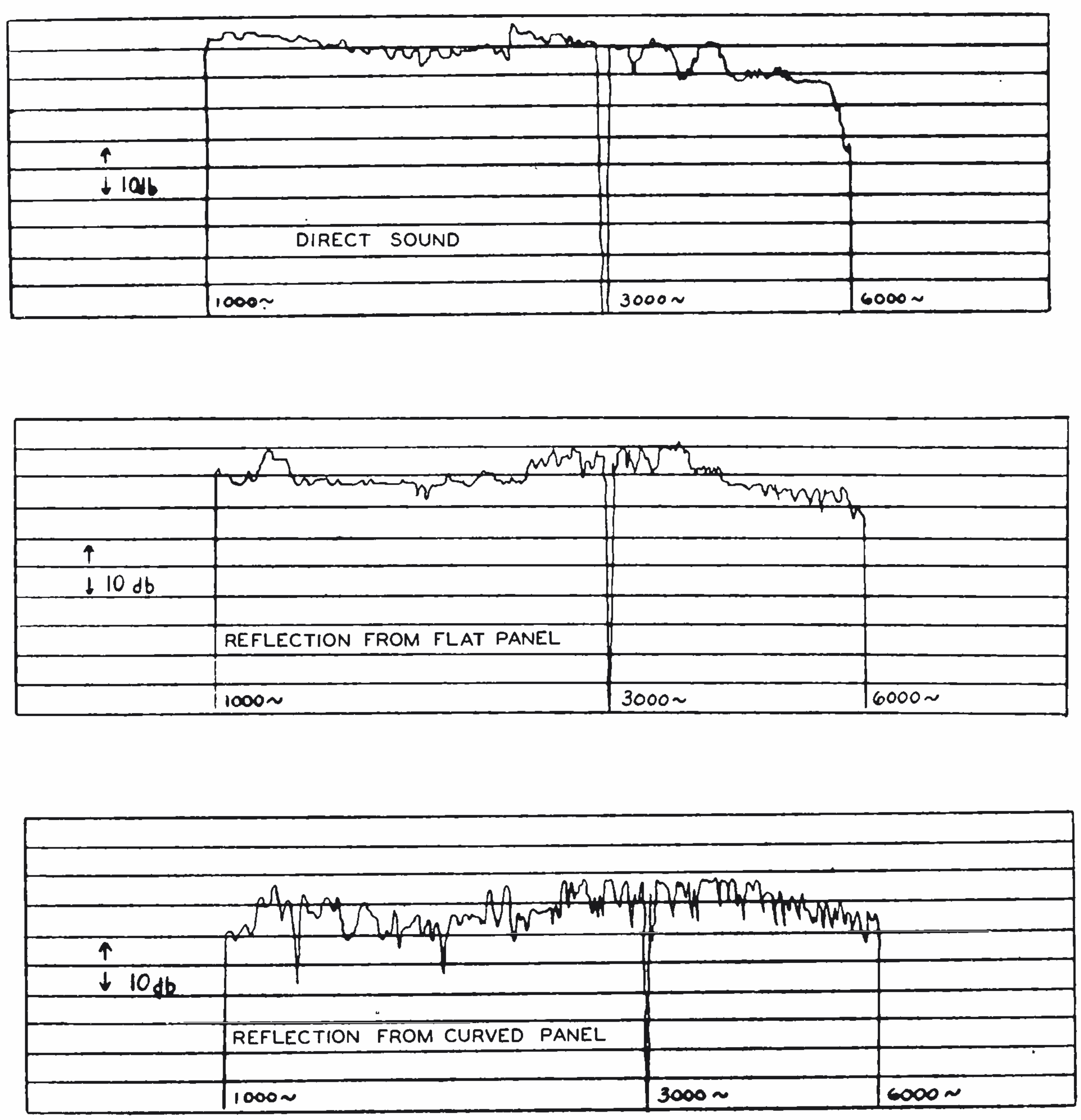


FIG. 4. *Direct and reflected response of panels used in interference measurements.*

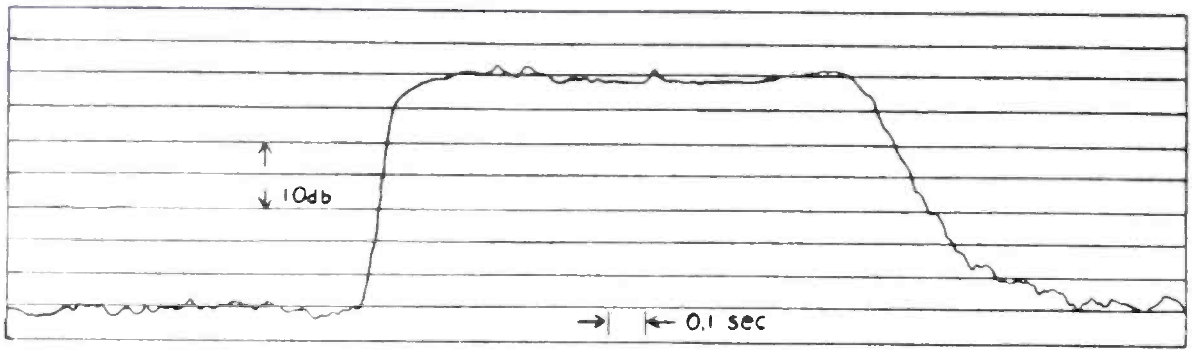


FIG. 5. *Growth and decay curve of vibrating convex panel.*

CONVEX WOOD PANELS

Figure 1 shows a typical curved wood panel consisting of 4′ x 8′ plywood formed over curved segment braces and fitted at the edges with 2″ x 3″ strips which have been routed and held together with 1″ x 3″ back braces. The segment braces which are spaced at random have strips of ½″ Celotex or other soft fiber board placed between them and the paneling to prevent rattles. It is felt that convex cylindrical wood paneling is particularly suited to meet the aforementioned requirements of a good sound diffuser because it disperses sound energy not only by reflection from its curved surface but by radiation due to its resonance action or panel vibration which, as already mentioned, is set up by either direct transmission from the original sources of sound or by partial absorption and reradiation of the aerial sounds impinging on its surface.

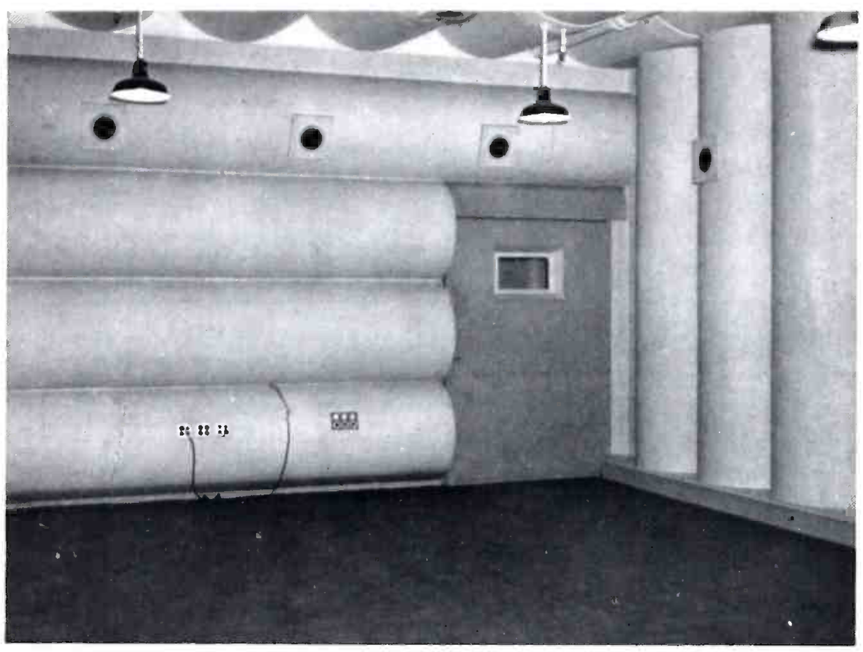


FIG. 6. *Listening studio at RCA showing polycylindrical surfaces with axes mutually perpendicular.*

Dispersion by reflection depends on the size and curvature of the panel and their relation to the wave-length. Dispersion characteristics for a curved and flat panel plotted on polar coordinates are shown in Fig. 2. This shows clearly the diffusing action of convex curved surfaces and was obtained by rotating the panel about its long axis while keeping the source and directional pick-up constant. It should be noted here that the apparent source for convex reflectors is always behind the surface. The value of such surfaces in reducing the interference effect of first reflections as compared to flat surfaces is shown in Fig. 3. Note that the aiding effect at some frequencies and the cancelation at others is less for the convex panel. The relative intensity levels of the direct and reflected waves used in obtaining the interference curves are shown in Fig. 4. The reduction in interference effect is significant when we remember that the total energy content of the reflected wave from either surface remains the same. As mentioned earlier, the reduction of the interference effect of first reflection is important in studio microphone pick-up in allowing greater freedom of placement. For remote surfaces in large

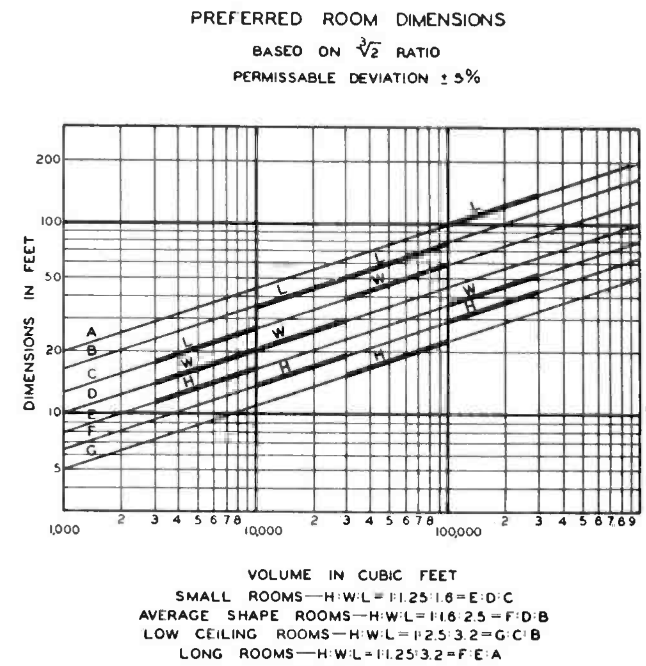


FIG. 8.

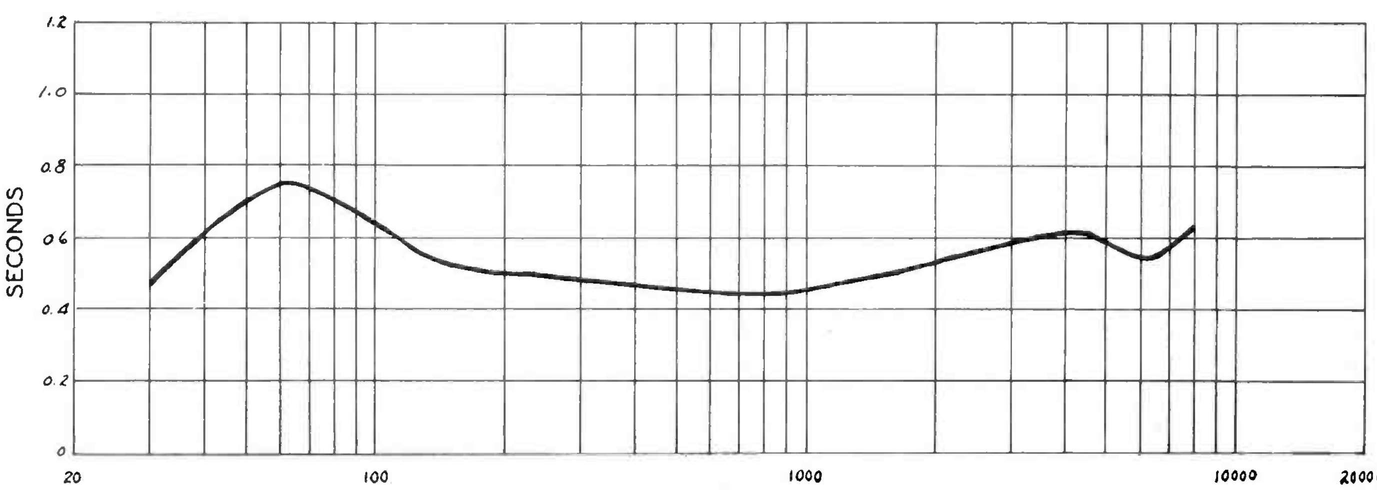


FIG. 7. *Reverberation time of listening studio.*

rooms a similar diffuse reflection may be obtained by means of concave reflectors providing the focus point or the apparent source of sound, which in this case is in front of the reflector, is not within or near the seating area or any other critical area.

Dispersion of sound by means of panel resonance depends on the modes of vibration set up. For areas of motion small compared to the wave-length radiated, the distribution will tend to be non-directional. For vibrations normal to the surface, a convex cylindrical panel would tend to set up a cylindrical wave front as compared to the plane wave front in the case of flat panels. The resonance frequencies and response of a panel depend on a great number of factors such as the damping coefficient of the material, thickness, spacing of braces, method of mounting of the entire panel, etc. It is interesting to note that due to the added stiffness introduced by bending, a smaller panel thickness may be employed for curved panels for the same frequency. The decay time or "resonance time" of a typical panel excited at one of its modes of vibration is shown in Fig. 5. In addition to the dispersion and radiation action, the vibration of the wood paneling aids the aborption efficiency over more rigid materials. Preliminary data indicates a coefficient of approximately 0.18 over a considerable band of frequencies, which checks data given by Bagenal & Wood on flat 3-plywood panels.

FIG. 9. *RCA disk recording studio in South America.*

FIG. 10. *RCA disk recording studio in New York.*

STUDIO WITH POLYCYLINDRICAL WOOD PANELS

Fig. 6 is a photograph of one of the studios in the new RCA Sound Engineering Laboratories at Indianapolis, Indiana, used for listening purposes. In addition to the cylindrical wood diffusers already mentioned, these studios have several other features of interest in room acoustic design.

In order to obtain maximum diffusion in the three orthogonal planes the axes of the polycylindrical surfaces were placed mutually perpendicular to each other. Three different sized panels and curvatures were used further to obtain asymmetry in the pattern of diffused sound. The high degree of diffusion obtained in this type of room is evidenced in the smoothness of the decay curves. The reverberation curve for this studio is shown in Fig. 7, which conforms reasonably well with published optimal times.[4]

Another feature of the studio is he choice of the major dimensions (12.5 ft. x 20 ft. x 32 ft.) which progress in two-third octave steps in order to avoid the "piling up" of room resonances. This is especially important for small rooms where the frequency gap between fundamental and harmonic resonances is oftentimes great, and unless guarded against may lead to a room response with wide hollofs in the audible range. In the present case this consideration was important because the use of large

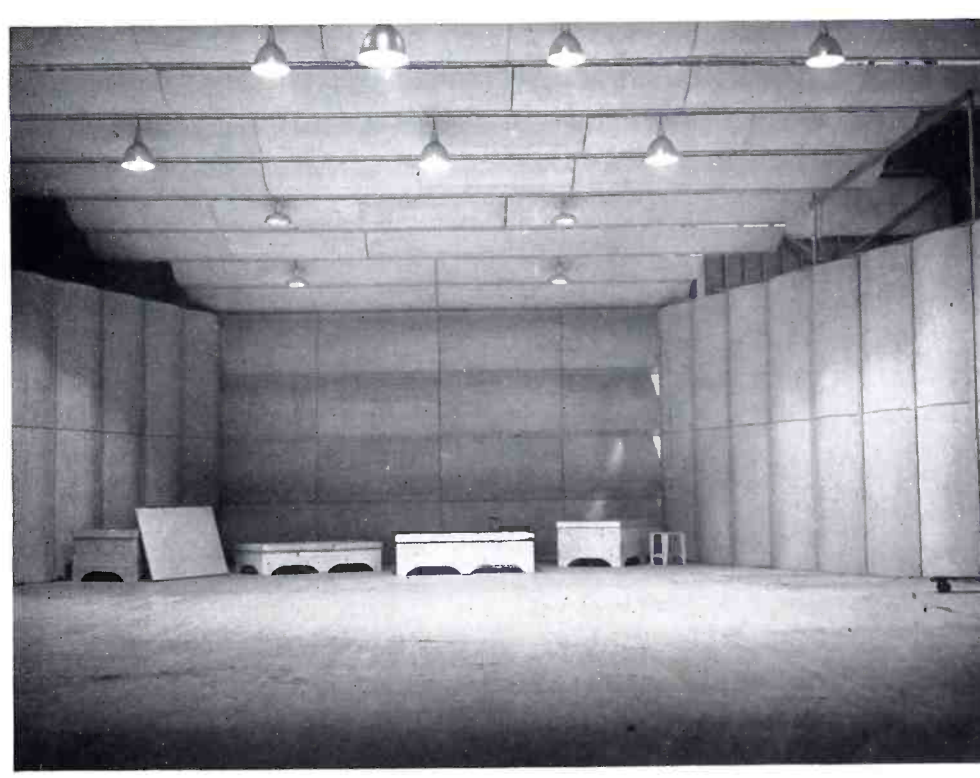


FIG. 11. *Orchestra shell with polycylindrical plywood panels.*
(Courtesy Walt Disney Studios)

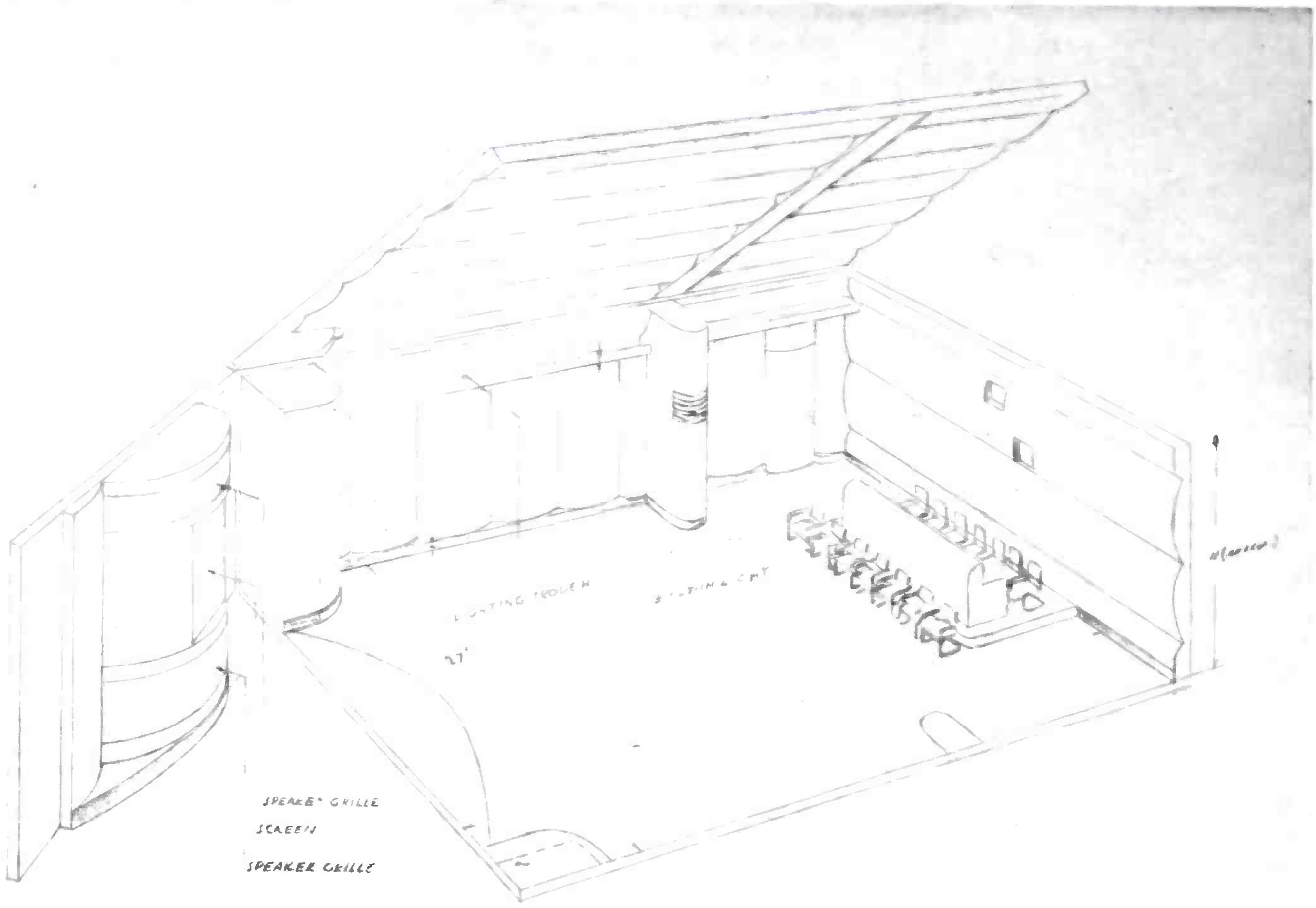


FIG. 12. *Proposed design of a small film recording studio and review room.*

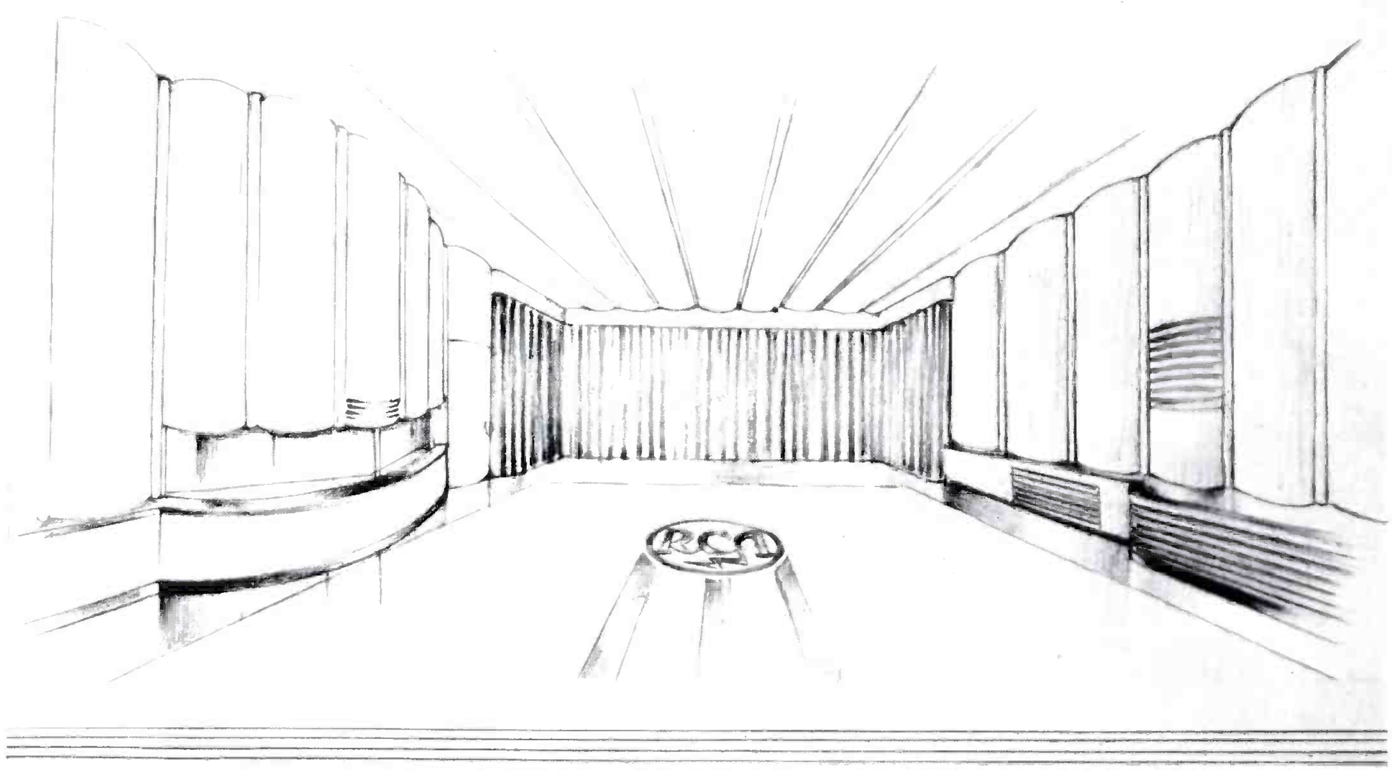


FIG. 13. *Proposed design for RCA film scoring studio.*

convex diffusers effective in the range below approximately 300 c.p.s. was not considered practical. In large rooms consideration should be given to the use of low frequency diffusers as well as for the mid range and high frequencies.

A chart giving preferred dimensions *versus* room size for various types of rooms is shown in Fig. 8. If a room is very small and nearly cubical in shape the direct ratio of the cube root of two would be preferred (see curves $C : D : E$). For average studio sizes the ratio should be near the cube root of four (see curves $B : D : F$). This approximates the frequent practice in the broadcast field of using a ratio of 2 : 3 : 5. If a low ceiling is necessitated then the ratio given by curves $B : C : G$ would be preferred. In all cases the dimensions shown are derived from the ratio of the $\sqrt[3]{2}$. Stating it another way the major dimensions should be separated 1/3 octave with respect to each other, or, other ratios derived from this fundamental ratio by shifting any or all of the dimensions by one or more integral octaves may be used.

OTHER TYPICAL APPLICATIONS OF CONVEX SURFACES

The first application of the general principles outlined in this paper was in the RCA Recording Studio in South America which is shown in Fig. 9. This studio is approximately 38,000 cu. ft. and has a calculated reverberation time of 0.9 sec. It has a wooden floor, 70 percent convex reflectors of 1″ plaster and 30 percent 1″ rockwool. A similar treatment, except that the polycylindrical diffusers were wood and less rockwool was used, is shown in Fig. 10 on the RCA disk recording Studio, New York, New York. This general type of design has also been applied to the WFAA Studios as mentioned in Dr. Boner's paper in collaboration with K. C. Morrical.

An application of polycylindrical design to an orchestra shell which was used last winter for a recording by Leopold Stokowski on the Walt Disney Live Action Stage and which is here reproduced through their courtesy, is shown in Fig. 11. The multiplicity of dispersing surfaces and resonant panels not only minimized the microphone placement problem, but gave a more pleasing reinforcement of sound to the conductor and musicians. The platforms were for elevating and reinforcing the bass instruments in the orchestra.

Functional styling in acoustics is receiving more and more recognition through a growing cooperation between architect and engineer. The styling sketches in Figs. 12 to 14 by Mr. Robert Holley on projects either under way or contemplated, show the adaptability of cylindrical surfaces to functional styling. Fig. 12 is one of several studios now under construction in the east, while Fig. 13 shows the proposed design for the RCA Film Recording Studio in New York. Fig. 14 shows the styling for a theater with side wall panels streamlined. Innumerable combinations of convexly curved surfaces will suggest themselves to the designer.

In conclusion it is gratifying to know that wherever this general type of polycylindrical wood diffusers has been used along with the necessary absorbents for optimum reverberation the results have been more than satisfactory. The author wishes to acknowledge the assistance received from his associates in the collection of data particularly from Dr. K. C. Morrical who carried through the design and tests on the RCA Disk Recording Studio, 24th Street, New York, New York. The author is also indebted to Dr. C. P. Boner for information and discussion in connection with his tests and application of convex panels to broadcast studios.

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* Presented at the Twenty-Sixth Meeting of the Acoustical Society of America in New York, October 24-25, 1941.

[1] F. R. Watson, *Acoustics of Buildings* (John Wiley and Sons, New York, 1930), second edition; H. Bagenal and A. Wood, *Planning for Good Acoustics* (Methuen and Co., 1930); V. O. Knudsen, *Architectural Acoustics* (John Wiley and Sons, New York, 1932); P. E. Sabine, *Acoustics and Architecture* (McGraw-Hill, 1932).

[2] See C. C. Potwin and J. P. Maxfield, "A modern concept of acoustical design," J. Acous. Soc. Am. 11, 48 (1939), for interesting comments on modulation effects in the decay curve due to shifting interference patterns. Also R. L. Hanson, "Liveness of rooms," J. Acous. Soc. Am. 3, 318 (1932).

[3] Hope Bagenal and Alex. Wood, *Planning for Good Acoustics* (Methuen and Co., 1931), p. 10.

[4] Robert M. Morris and George M. Nixon, "NBC studio design," J. Acous. Soc. Am. 11, 48 (1939).

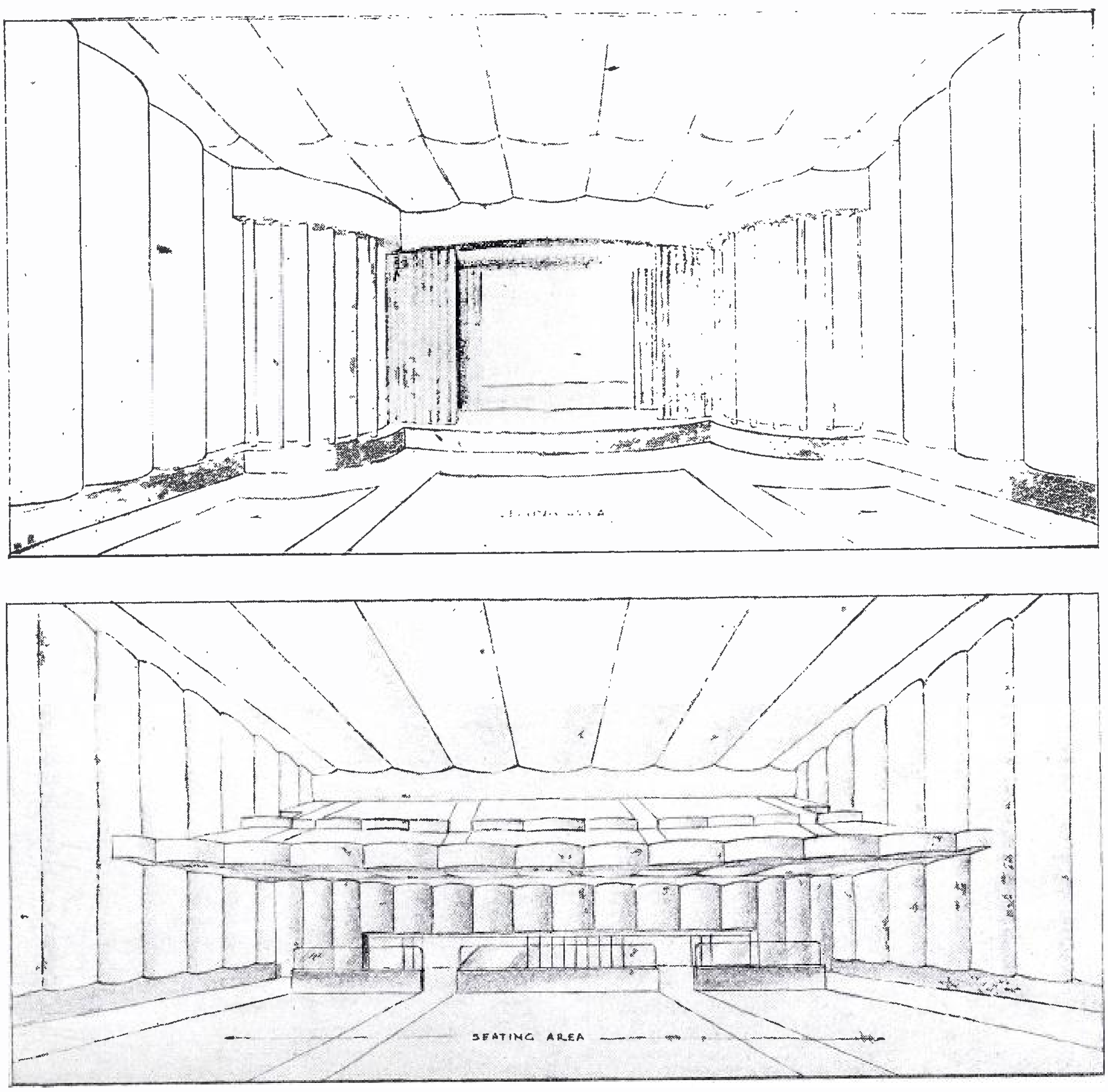

FIG. 14. *Proposed design of a sound movie theater.* Upper, *stage of Cinema Evcanto showing suggested acoustic treatment.* Lower, *view from stage.*

PERFORMANCE OF BROADCAST STUDIOS DESIGNED WITH CONVEX SURFACES OF PLYWOOD*

by C. P. BONER

University of Texas, Austin, Texas

In a number of recent examples of modern acoustical design, use has been made of splayed and shaped surfaces in order to eliminate flutter, to secure "proper" distribution of sound, to aid in control of the absorption of panels, and to accomplish subjective improvements in room performance. Occasional use has been made of cylindrical sections, but results of such designs have not been readily available. The work described in this paper followed initial discussions with Messrs. M. C. Batsel, J. E. Volkmann, and K. C. Morrical of Radio Corporation of America. During these discussions it was, of course, noted that large-scale construction of rooms and extensive measurments should be made in order to determine (a) the objective performance of rooms designed with convex surfaces of plywood and (b) the correlation between objective results and subjective excellence of the rooms.

Fortunately, at the time of these discussions the author was involved in acoustical studies of a proposed Music Building at the University of Texas and of a group of studios for radio stations WFAA and KGKO, of Dallas, Texas. Inasmuch as both projects were in the hands of LaRoche and Dahl, architects, it seemed logical to make the proposed studies of plywood surfaces simultaneously in the two installations. With the enthusiastic approval of University authorities and of the management of WFAA-KGKO, appropriate studies were begun. In the initial studies Dr. Morrical joined the WFAA-KGKO staff, the architects, and the author and contributed considerable data on previous studies of a similar nature. Following completion of the studios and the formal opening of WFAA-KGKO's new plant on June 20, 1941, prolonged experimental studies have been made, and other studios have been similarly constructed. Particular thanks are due the management and staffs of WFAA, KGKO, and KSKY of Dallas and KGBS of Harlingen, Texas, for permission to interfere with studio operation during reverberation measurements and for much active assistance in the tests.

Measurement of reverberation period has followed the customary procedures. A very large number of high speed level recorder records have been taken by Messrs. Charles Rutherford and Franny Seay during these tests. Measurements have been made with single microphone, with five microphones and commutator, and with ten microphones and commutator.

In order to secure maximum diffusion an effort has been made to incorporate plywood cylinders in walls and ceiling, the three groups of cylinders having orthogonal axes. Fig. 1 is a photograph of Studio C at WFAA-KGKO (additional photographs are shown on Pages 29 and 30). In this studio, structural and architectural "difficulties" prevented use of cylinders in the ceiling. In some studios, for further control of reverberation period, absorbing panels have been employed in ceiling and wall areas, and rugs have occasionally been used. Cylinder dimensions have been varied during these studies, as well as the size and location of absorbing panels. Although a limited time has elapsed since the beginning of the work, there is ample ground for drawing certain conclusions, objective and subjective, regarding the rooms constructed to date.

RESULTS

1. The decay in these rooms appears to be more nearly logarithmic than in conventional rooms of the rectangular parallelopiped form.

2. The diffuse state is more closely approximated in these rooms than in conventional rooms. For two rooms of approximately 7000 cubic feet each, one essentially a rectangular paralellopiped and the other the room shown in Fig. 1, the wave pattern at 200 cycles is less marked in the Fig. 1 studio by approximately 30 to 40 db. See Figs. 2 and 3.

3. At wave-lengths approximating the transverse cylinder dimensions (and hence the spacing of the supporting wood studs) the construction affords somewhat increased absorption in relation to that over the remainder of the frequency band. Hence, for extreme flatness of period-frequency characteristic, these dimensions should be made "random." Ordinarily, architectural difficulties will impose a severe limit on such spacing. Curves 5 and 6 show this increased absorption in two studios.

4. If the plywood cylinders are finished with several coats of paint or with shellac and varnish, the absorptivity decreases slowly with increasing frequency, above the frequency of maximum absorption noted in result 3 above. This effect tends to compensate for increasing atmospheric absorption at the higher frequencies. See curves 2 and 10.

5. Painting or varnishing the plywood affects chiefly the band above 10 kilocycles (curve 3 is for an unfinished room). As would be expected, a hard finish reduces the high frequency absorptivity.

6. If an absorbing flat is substituted for one of the cylinders (provided adjacent cylinders have a chord of the same dimensions as the flat surface), the absorptivity of the material in the flat is markedly increased at wave-lengths of the order of magnitude of twice the width of the flat surface.

7. With plywood cylinders as described, rooms of volume comparable to those described in the accompanying curves (excepting perhaps 7 and 9) may be constructed so as to have a reverberation period essentially constant from 40 cycles to 17 kilocycles (curves 2, 5, 6, 10).

8. The Eyring formula applies to this design of room, provided proper coefficients are used for the plywood. Study is being continued on this point and it is hoped that measured values of the coefficients may soon be sufficiently well determined to justify publication. At present it is possible to compute coefficients from existing studios and then to predict the reverberation period of new rooms with fair precision. As would be expected, the coefficient of the plywood is a function of the cylinder dimensions, bracing, material, etc. The coefficient, however, is considerably larger than might be expected from the literature. In some configurations, the plywood may exhibit a coefficient as large as 0.26.

9. Reverberation periods given by Morris and Nixon[1] are essentially optimum for these diffusive designs in broadcast studios. It is interesting to note, however, that our measurements show, in confirmation of the comments of Potwin and Maxfield,[2] that many existing studios have reverberation periods far below the "optimum periods." The measurements also show that some of these dead studios reach the optimum period only in a narrow band from 3 to 7 kilocycles, and that flutter and "brittleness" result (see curve 8). The newer diffusive designs avoid this difficulty.

10. For piano, organ, strings, reeds, and vocal music, a flat characteristic (curve 10) is most acceptable to operators and performers alike. Curve 5 seems also to be acceptable.

11. For brass instruments, a characteristic like curve 7 is more pleasing to the performers, although the flat characteristic seems

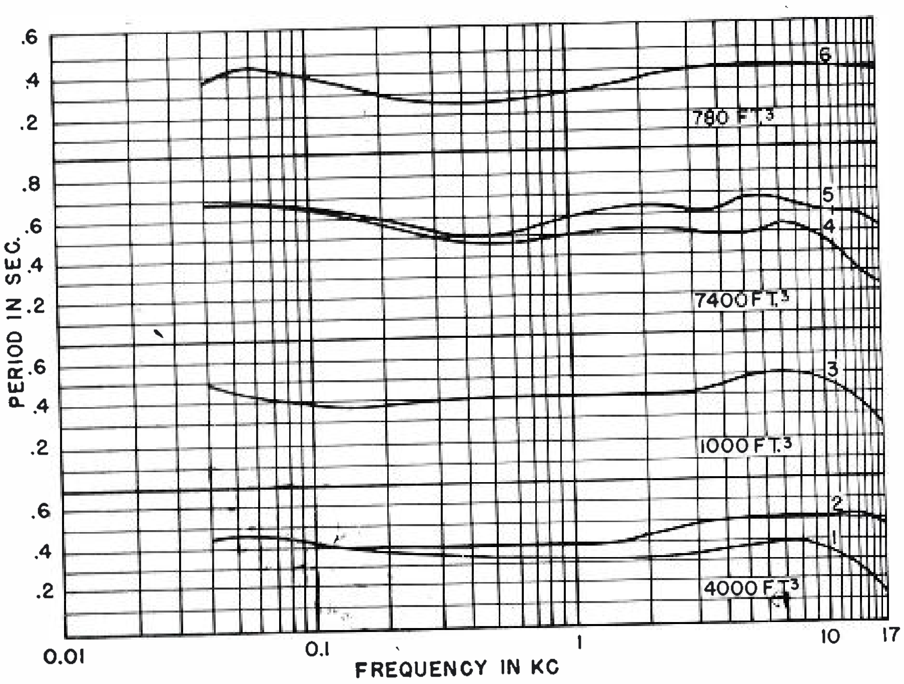

FIG. 2.

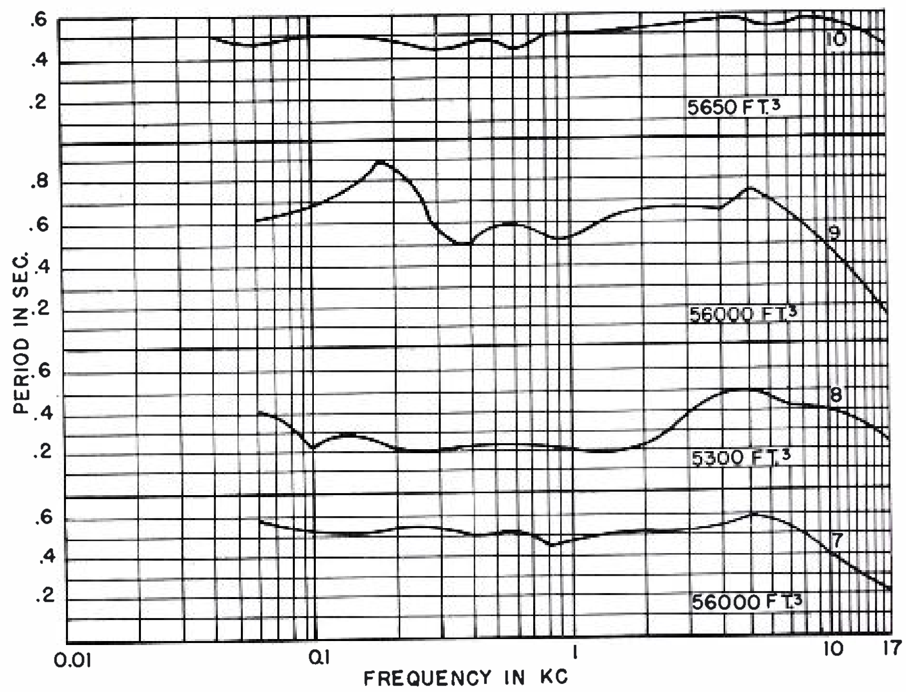

FIG. 3.

to be preferable from the listener's standpoint. In these diffusive rooms, brass players (particularly trumpet and trombone, of course) hear their own high frequency output for the first time and they are sometimes displeased with the result. They are, as it were, submerged in their own diffuse sound field, in the absence of echoes. Unmuted loud brass tone in small rooms tends to annoy other members of the orchestra unless the region above 10kc is rapidly attenuated. In contrast, singers, pianists, and violinists feel a particularly pleasing reenforcement in all these new studios.

12. Bands accustomed to playing in overtreated rooms, outdoors, or in noisy locations where high instrumental output is required are surprised at the ease with which a high level is obtained in these studios. Those who are willing and able to hold their acoustical vigor in check are happy in these rooms; those who do not conform to the surroundings, or whose instruments have considerable high frequency output in a directional beam, may be unhappy. For the latter class, a frequency characteristic flat to 10 kc, at the optimum period, and with a drooping characteristic above 10 kc seems to be the solution.

13. Rugs under microphones aid in reducing floor reflections that are troublesome, although the rug absorption is selectively high above 10 kc. Curve 1 represents a studio with rug (about 3/8" thick); curve 2 is the same studio without the rug. Curves 4 and 5 show similar results for another studio. It is indeed unfortunate that diffusive construction of the floor is so impossible under our present concept of a floor. However, a rug constitutes a very simple way of "regulating" these studios to the desired working conditions after construction.

14. For speech, a rug is particularly desirable. Tests indicate that, if the room has a flat characteristic, the band above 10 kc may annoy a vigorous speaker in the room. Curve 4 shows what is seemingly the optimum condition for speech.

15. Single microphone pick-up for orchestra or chorus in these studios gives the best results. Placement of the single microphone is not particularly critical, provided it is placed well away from the group. The null plane of ribbon microphones, as would be expected, is not well defined in these rooms unless a rug is used.

16. Room dimensions are particularly important. Curves 5 and 10 are for rooms of nearly identical design, except in that room 5 has poor dimension ratios and room 10 has dimensions essentially following the cube root of two rule. Room 10 is preferred by orchestras in most cases. Room 6 is nearly a cube (because of initial structural conditions). The resonant point is easily recognizable.

17. Curves 7 and 9 are for a large studio of more or less conventional design. The loss of high frequencies is apparent, as well as the low reverberation period for this volume of room. Curve 7 is for the case where a fairly heavy drape covers the rear wall of the stage; curve 9 is for the studio without the curtain. The effect of the essentially flat rear wall and its first reflections is noted in a general roughening of the response curve and in a peak near 200 cycles.

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* Presented at the Twenty-Sixth Meeting of the Acoustical Society of America in New York, October 24-25, 1941.

[1] Robert M. Morris and George M. Nixon, "NBC Studio Design," J. Acous. Soc. Am. 8, 81 (1936).

[2] C. C. Potwin and J. P. Maxfield, "A Modern Concept of Acoustical Design," J. Acous. Soc. Am. 11, 48 (1939).

(Left) *Dr. Boner with his reverberation measuring equipment set up in the studios at WFAA—KGKO, Dallas. Acoustical measurements were made at several stages of the construction. In this picture measurements are being made just before application of the floor covering.*

W H L D

NIAGARA FALLS, N. Y.

WHLD in Niagara Falls, New York, was the first broadcast station in this country to employ polycylindrical diffusers for acoustic control. Early in 1940, Earl Hull, an outstanding broadcast engineer for many years and now manager of WHLD, heard from RCA engineers of the successful use of this type of construction in motion picture recording. Without more ado he built the WHLD studio shown in the two views on this page. It was an immediate success and gained such fame that a number of radio engineers made trips to Niagara Falls to inspect it.

The diffusers at WHLD are four-foot wide plywood panels bent over ribs formed to a 22 inch radius (chord 39 inches). On the side walls and ceiling these diffusers alternate with flat panels formed by spraying "Limpet" on unsupported metal lathe (thus giving these panels a certain amount of "diaphragm" effect). The microphone end of the studio is a flat wall of the same type construction, while the opposite end is made up of horizontally placed diffusers. Lights are set flush in the ceiling diffusers.

K A R K

L I T T L E R O C K , A R K .

Another pioneer in the use of polycylindrical diffusers is KARK, Little Rock, Arkansas. The studios shown on this page were constructed in the latter part of 1941 as part of an entire new studio layout which KARK built at that time. The walls of these studios—up to chair rail height—are constructed of lapped joint log siding laid horizontally. Above this height the walls are composed of cylindrical diffusers mounted vertically. The diffuser frames consist of five solid ribs of wood approximately one inch thick cut to the curvature of the surface. One rib is on either end and the other three are irregularly spaced on each diffuser so that no two will have the same resonance. The diffusers were faced with quarter-inch plywood. For the ceiling a smaller size of the lapped joint log siding was used alternately with 12″ x 12″ Acousti-Celetex.

A MODERN MUSIC RECORDING STUDIO

by M. RETTINGER

Hollywood Engineering Department

In planning the remodeling of the local RCA scoring stage, special consideration was given to the preference among musicians and music-lovers for rooms which contain a large amount of wood paneling. This preference can be attributed largely to the ability of such a material to vibrate over a wide range of musical pitch, unlike a panel of plaster or fiber board. The energy employed to set the wood sheet into vibration is partly re-radiated in a manner that does not follow the regular law of equal angle of incidence and reflection. A vibrating surface, because of its size and shape, may therefore emit plane or cylindrical waves, although it is excited by spherical waves. In this sense, the walls of the band shell may also be considered to be an extension of the instruments—an extension which, although loosely coupled to the sources of sound, nevertheless emphasizes many of the frequency components of music sufficiently to lend pleasant support to the music. It is the sounding board again—a device that magnifies the tonal area of the instrument by creating sustaining *surface* sources in proximity to a relative *point*-source or sources.

It was deemed desirable to install such wood panels in the form of convex splays to secure a greater diffusion of the sound in the room. As is well known, the wavefront of a beam of sound reflected from a convex surface is considerably longer than that from an equally large flat surface, provided that the wavelength of the incident sound is small compared to the dimensions of the reflecting surface. Fig. 1 shows this relationship graphically, and it is seen that the wavefront reflected from the convex splay is, for the condition illustrated, considerably longer than the sum of the two reflected from the flat panels. The figure shows also the construction of the wavefronts, analogously to the optical case, the center of the reflected wavefront coming from the curved surface being one-half the radius of the convex splay (assuming the source is at some distance from the surface).

The fact that the wavefront from a convex reflector is longer tends also to reduce the interference effect between direct and reflected sound. This is illustrated in Fig. 2. Since the energy of a propagating wavefront varies inversely with the square of its length, the reduction of the interference effect is appreciable, a factor that may assume considerable importance in the recording of slow-moving music.

A convex splay is also excellent insurance against echoes in a room, particularly when it is intended to keep this surface reflective. For this reason, convex surfaces are helpful in providing a smoother decay of the sound, as well as one that is more nearly logarithmic with time, since the reverberation persists longer in the direction in which echoes occur in a room.

One may therefore summarize the advantages of properly designed convex wood panels in a confined space as follows:

(1) More uniform distribution of the sound pressure, due to the longer wavefront of the reflected sound, particularly pertinent for the high frequencies.

(2) Creation of surface sources of sound, also helpful in increasing the diffusion of the sound in the room, and being of special importance for the low frequencies.

(3) Provision of a wall or ceiling section that is more absorptive for the low than the high frequencies. The fact that work is being done on the panel in moving it, and that sound is radiated from the back as well as front, describes the device also as a relatively efficient low-frequency absorbent.

(4) Reduction of interference effect between direct and reflected sound.

(5) Production of a relatively smooth sound-decay curve.

(6) Erection of reflective surfaces which will minimize echo.

The use of vibrating wood panels in a room has, in the past, sometimes given rise to a cautious consideration of the resonance qualities of such a construction. The uninitiated believe that a

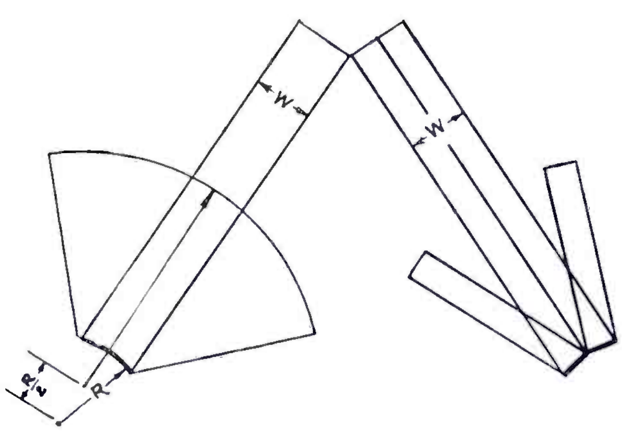

FIG. 1. Illustrating length of reflected wavefront from convex splay and flat panels.

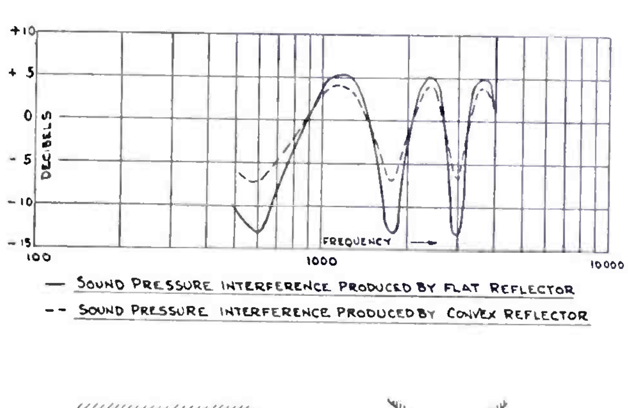

FIG. 2. Sound pressure interference effect produced by a flat and convex reflector.

pronounced tone-bias is produced by such a vibrating panel. Indeed, one is frequently asked, "What is the resonance frequency of this or that splay?"

To avoid such a cautious regard of wood membranes as used in this room, it may be well to enumerate their resonance qualities thus:

(1) A wood splay of the type employed has many resonance frequencies. Fig. 3 shows the response characteristic of a splay at two points on it, randomly chosen, and approximately 5 feet

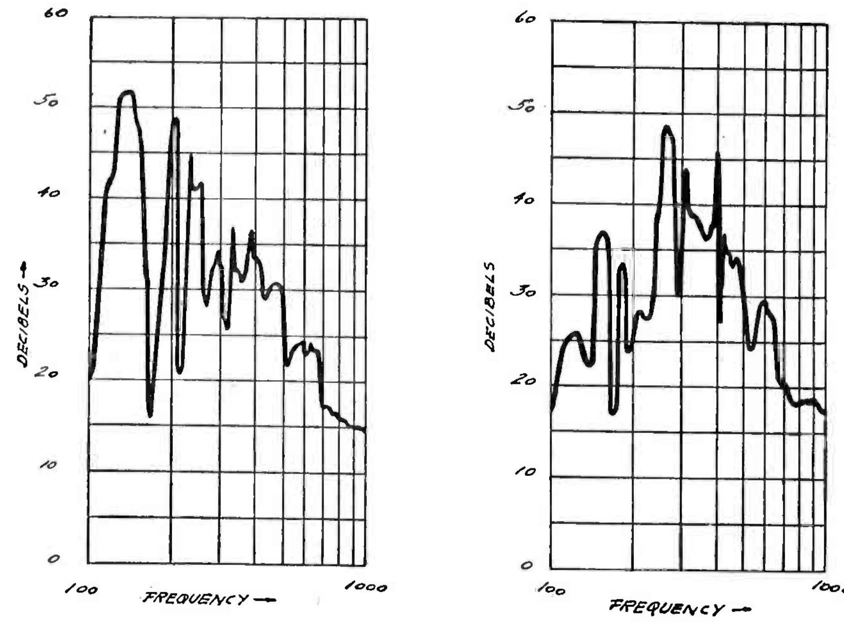

FIG. 3. Response characteristic of a splay at two different points on splay.

apart. The curves were obtained by fastening a crystal pick-up to the two points and then exciting the splay into vibration by generating in the room a sound of a continuously varying warbled tone.

(2) The resonance frequencies are not harmonically related.

(3) The amplitude distribution is made up of the various modes of vibration.

(4) Nodes are not sharply defined, owing to the presence of more than one mode.

The only pronounced resonance to which a splay of this type is subject is that produced by the air-chamber back of it. The natural, low-frequency modes of vibration of this chamber, if it had been kept reflective, would have been transmitted into the stage in an objectionable measure. In the case where the chamber had been kept highly reflective, a "hang-over" effect or prolonged reverberation would have resulted at certain low frequencies, none of which was desired to have a reverberation time markedly longer than those of the middle or high registers, a point that will be discussed in greater detail later. Hence the space back of the splays was kept absorbent and care was taken not to permit the acoustic material to come into contact with the panel itself; which, to note, consisted of two quarter-inch sheets of plywood. Application of fiberboard or other sound-

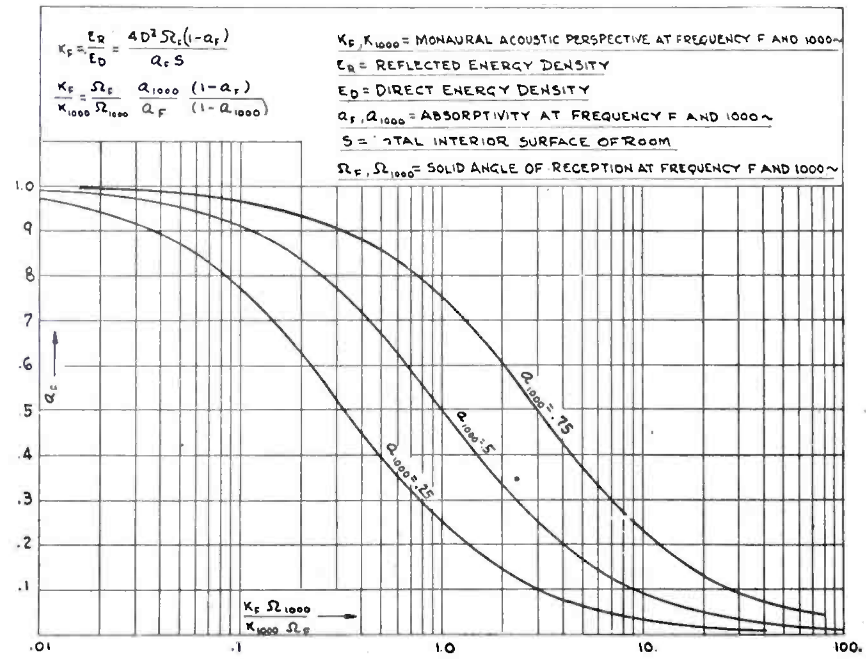

FIG. 4. Relation of monaural acoustic perspective and absorptivity.

absorbent to the wood surface would have exerted a damping effect upon the natural modes of vibration of the wood membranes, which was not considered necessary or desirable for the purpose.

The use of wood panels was welcome also because with their aid it was possible to achieve a nearly flat reverberation characteristic in the room. As is well known, the absorptivity of most acoustical materials is considerably smaller for the low than for the high frequencies. The only way by which this condition can be reversed is by employing a thin material which by vibration will absorb the low frequencies while acting as a reflector for the highs. In order, however, to avoid a pronounced selective low-frequency absorption it is desirable to vary the size and radii of these convex splays, as was done in this room. This condition was further improved by irregular bracing back of the splays.

A nearly flat reverberation characteristic in this room was considered desirable inasmuch as it was held that the determining factor for a recording studio is not so much the reverberation characteristic as what H. F. Olson terms the recorded reverberation characteristic. It should be said here that the term "recorded reverberation" is believed to be somewhat confusing, and that it

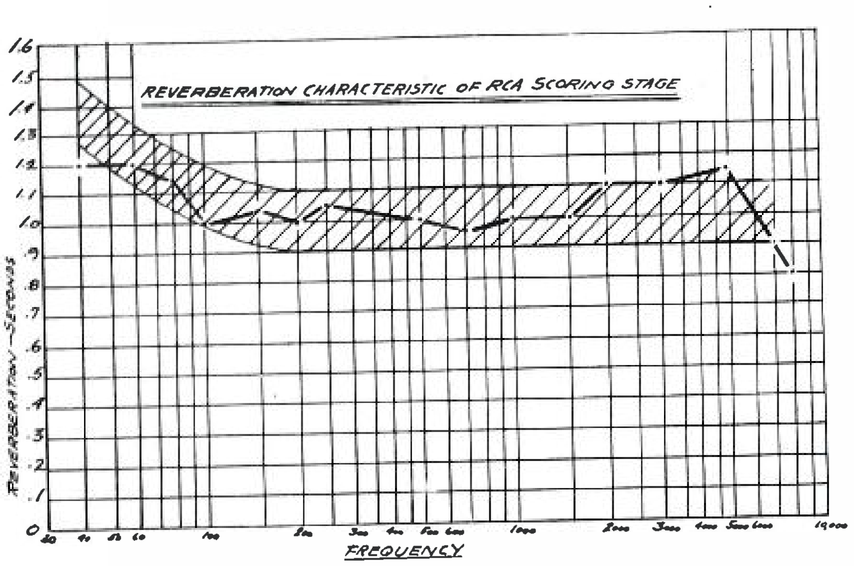

FIG. 5. Reverberation characteristic of RCA scoring stage.

might be better to speak of a monaural acoustic perspective when considering the ratio of reflected to direct sound-energy density. Fig. 4 gives the equation for this ratio, which obviously has no dimensions, but merely states how much more reflected than direct sound exists at any point in the room. It is this ratio that gives to the recorded sound the impression of depth and, indeed, an impression of reverberatoriness, without actually giving a measure of reverberation time in seconds.

The reason for attaching so much importance to the monaural acoustic perspective is that the microphone represents but one ear. As is well known the reverberation in a room appears considerably longer when observed with but one ear than when observed with both ears. The reason for this lies in an unconscious suppression of reflected sound, which appears to the ear as undesirable in the case of speech, since it tends to detract from intelligibility. In the case of music the ear accepts a certain amount of this reflected sound, apparently because it tends to improve the quality of the music. It is for this reason that the reverberation time in music rooms is usually made longer than in speech room. The microphone, however, records the true acoustic conditions at the point of its location, and once the sound is recorded, the ear can during reproduction no longer ignore or discriminate against the reflected sound that was present at the microphone position, since this reflected sound is now part of the direct sound from the loud speaker.

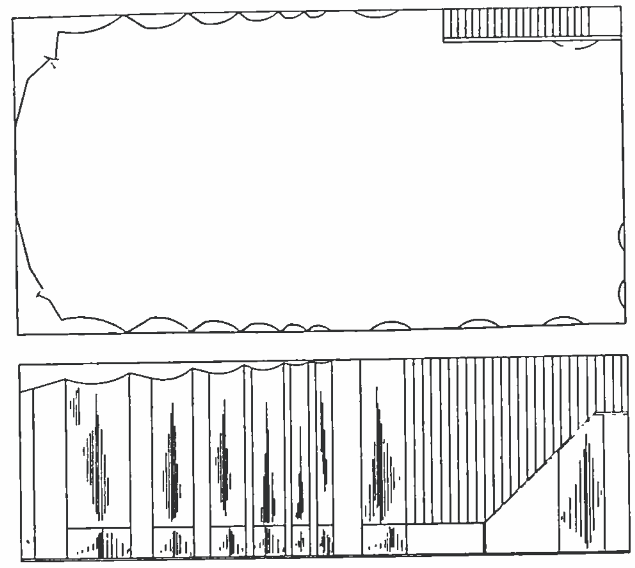

FIG. 6. Plan and elevation of the room.

Now, in order not to obtain excessive ratios of monaural acoustic perspective for the low frequencies, care must be taken to avoid long reverberation times for these frequencies. When the average absorptivity at a given frequency is cut in half, the reverberation time in a room is practically doubled. The monaural acoustic perspective for this case, however, becomes more than twice, and may reach values of three or four times, depending upon the value of the reduced absorptivity. This condition of increased values for the monaural perspective at the low frequencies is further aggravated by the fact that the solid-angle of reception for most microphones is larger for the low frequencies than for the high.

Fig. 5 shows the reverberation characteristic of this stage, which has a volume of 70,000 cu. ft. The measurements were made with a reverberation meter of the rotating commutator type described by H. Olson and F. Massa in their book, "Applied Acoustics."

Fig. 6 shows a plan and elevation view of the room. The color scheme was prepared by the well known industrial designer, Mr. John Vassos, and employs a pastel shade of blue for the splays and a maroon for the trim (door, baseboard, chair-rail, *etc.*).

Several other studios have lately been constructed employing convex splays on the sidewalls with very good results. Among these are the *WFAA* and *KGKO* broadcasting studios in Dallas, Texas, the RCA recording studio in South America, the RCA film

FIG. 7. Rear view of stage.

recording studios in New York, and the Walt Disney scoring stage. The only undesirable feature in these rooms, including this stage, is presented by the comparatively large expanse of the flat floor. However, the use of players' platforms, chairs in the room, and the judicious use of rugs does much to ameliorate this condition.

The floor of this stage is of the elastically floated type. The joists rest on resilient steel chairs grouted in concrete. A sound-absorbent filler is placed between the joists, not only to dampen any resonance effects, but also to assist in reducing the transmission of noise from without.

The monitoring room is paneled with large sheets of wood veneer on the sidewalls except for the wall behind the mixing console which received acoustic treatment of the type employed in the state. This acoustic material was selected on account of its smooth absorption characteristic and because its low-frequency absorption was comparatively high. The windows in the monitoring room are double panes separated by a 4-inch air-space, and the walls between the two sheets of glass carry sound-absorbent treatment.

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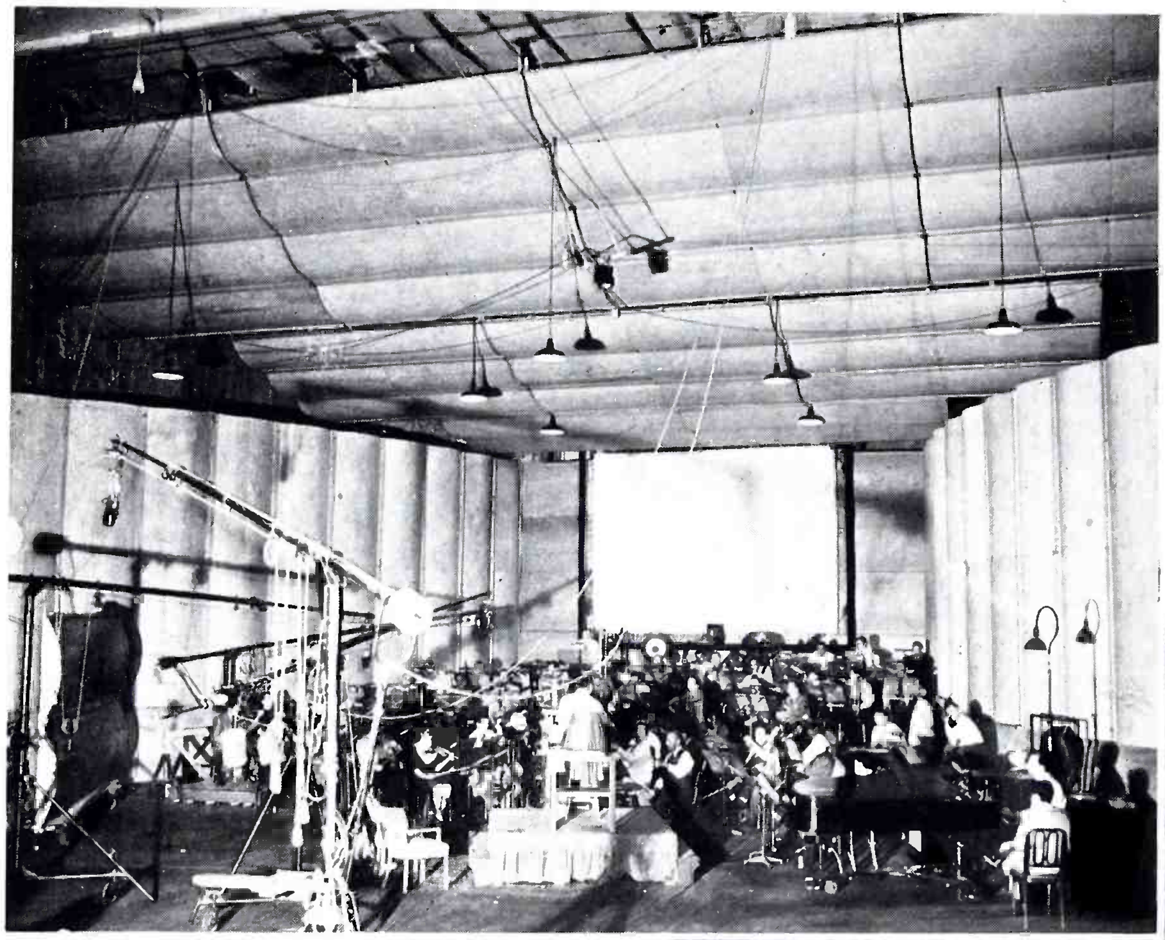
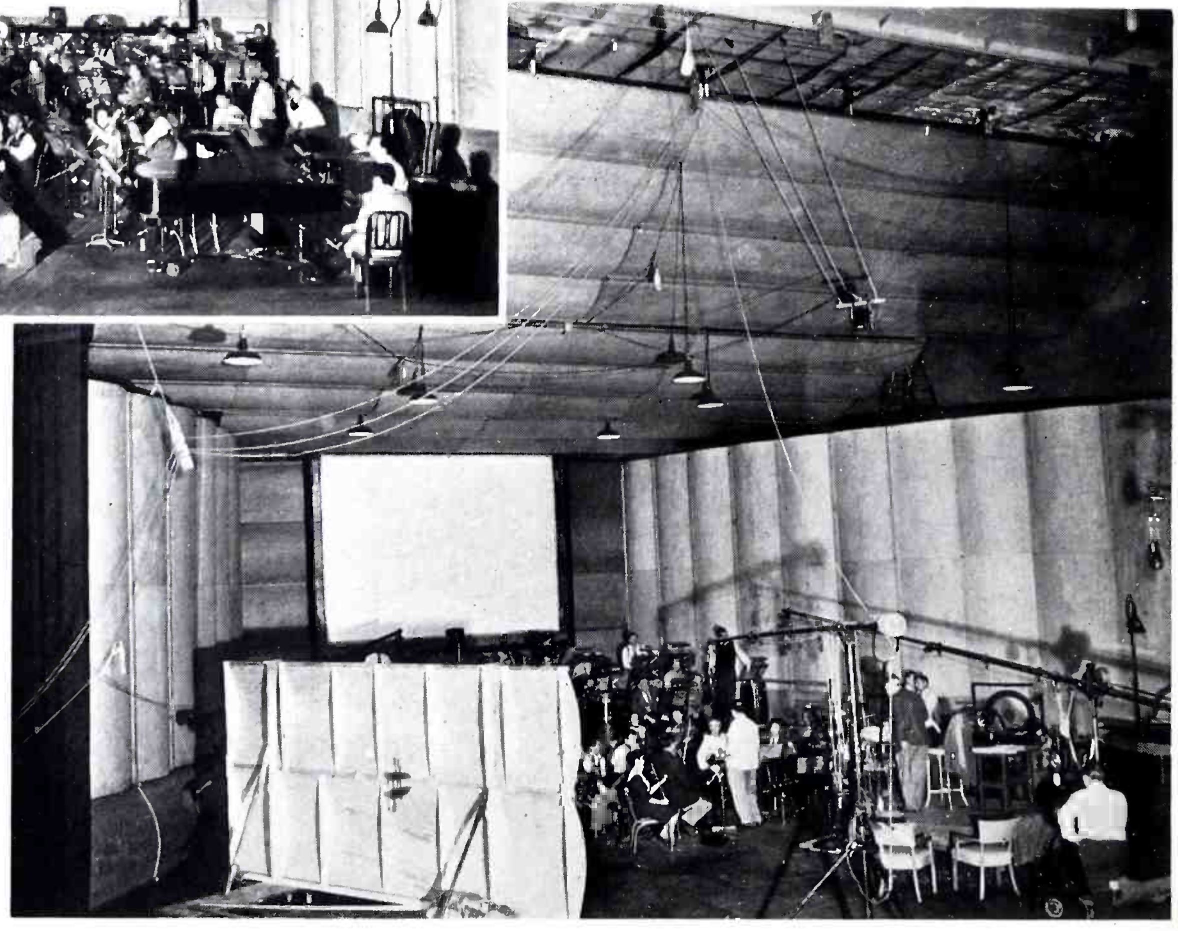


(Left) *Polycylindrical Diffusers on the scoring stage of the Walt Disney Studios, Hollywood, California. Convex splays are made from 3/8" plywood sprung over pre-cut saddles.*



(Right) *Another view of the Walt Disney stage. Note the movable sections in the left foreground.*

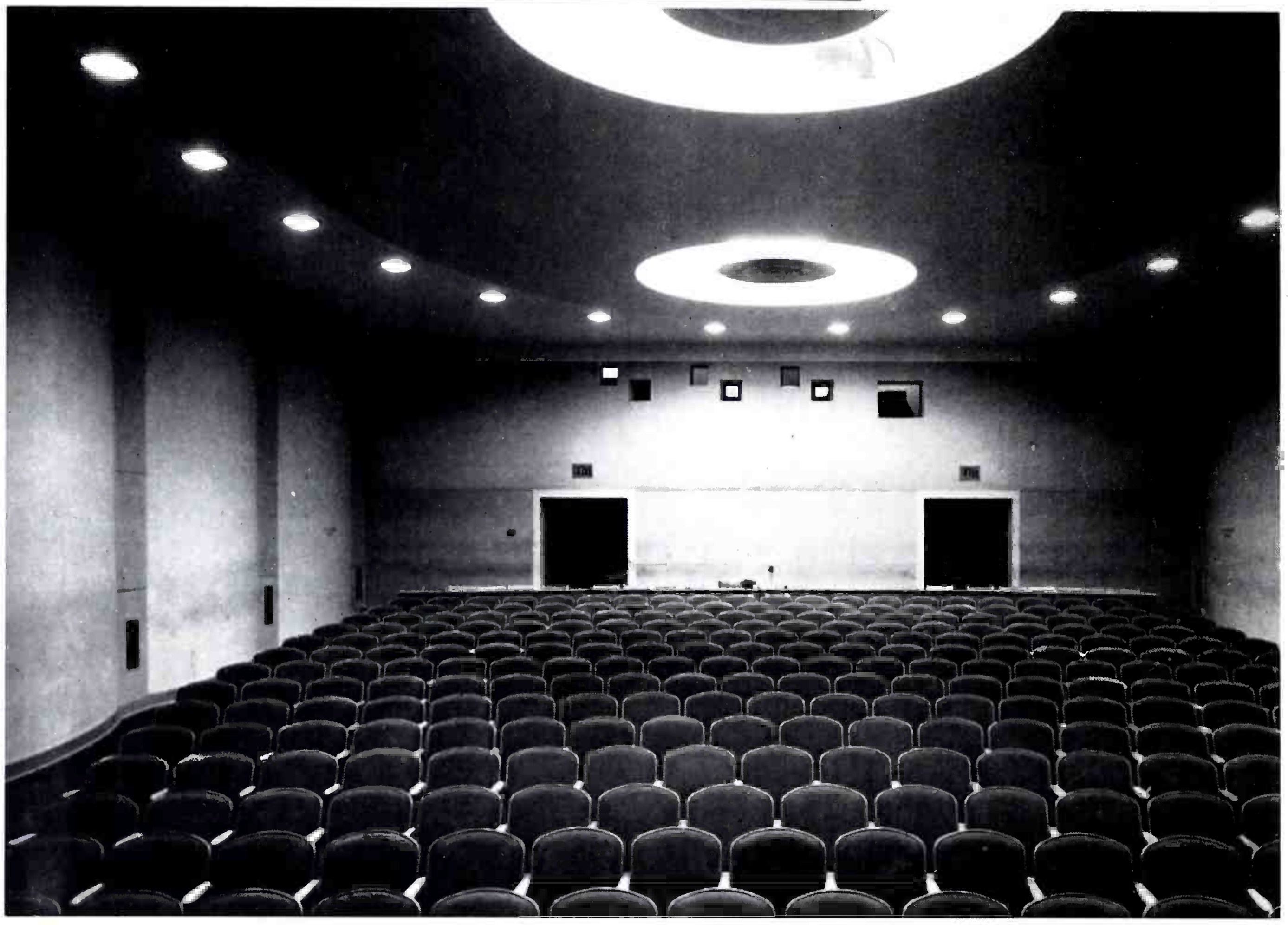
Review Room Photographic Science Lab.

Naval Air Station Anacostia, D. C.

THE REVIEW ROOM, PHOTOGRAPHIC SCIENCE LABORATORY, NAVAL AIR STATION, Anacostia, D. C., shown in the two pictures on this page, is an outstanding example of the use of Polycylindrical Diffusers in acoustic control. This very spacious 50-seat auditorium is 74 feet long, 24 feet wide and 18 feet high. It is used in studying and editing Navy War films. A large desk, at which the official reviewers sit, can be seen at the back of the room. Projection ports for two 16 mm. and two 35 mm. projectors, together with viewing windows are located in the back wall.

The entire surfaces of the side walls, rear wall and ceiling of this auditorium are composed of convex wooden panels of the type described by Volkman (pg. 2). In order to obtain maximum dispersion, the axis of these polycylindrical surfaces are mutually perpendicular in the three planes. The individual panels are quarter rounds with a chord of about three feet. They are finished in natural color so that the grain stands out sharply. The backs of the heavily-cushioned seats are covered with similarly grained panels so that the whole auditorium presents an unusual and pleasing appearance. No acoustic materials of the ordinary type are used anywhere in this auditorium. The carpeted floor and cushioned seats, however, provide a certain amount of absorption.

Auditorium, Army Pictorial Service



Washington, D. C. Pentagon Bldg.

THE PENTAGON BUILDING AUDITORIUM, (Washington, D. C.), shown in the two views on this page is another very interesting example of the use of the dispersive type of acoustical treatment. This 300 seat auditorium is used by the Army Pictorial Service Signal Corps for the showing of War Department films. The acoustical problem presented by this type of auditorium is not too different from that of an auditorium-type broadcast studio of similar dimensions (except that in the latter there is, of course, the additional problem of treating the stage itself). Since no wood could be used in the Pentagon Building, the convex panels in the auditorium shown here are made up of hard plaster mounted on lath. These panels are approximately $\frac{1}{8}$ round sections of about 10 feet chord. Between them (on the side walls) are two foot vertical panels of 1 inch perforated acoustical insulating board. At the rear is a single convex panel of similar dimensions with a flat wall of insulating board from this panel down to the floor. The part of the ceiling near the side walls—and extending out just beyond the recessed lights—is of acoustic plaster while the center part is hard plaster. It should be noted that the large number of cushioned seats present an absorbing medium not always present in broadcast studios. In addition to this auditorium, the Signal Corps has four review rooms in the Pentagon Building which have the same type of treatment.

NBC STUDIOS 6A AND 6B

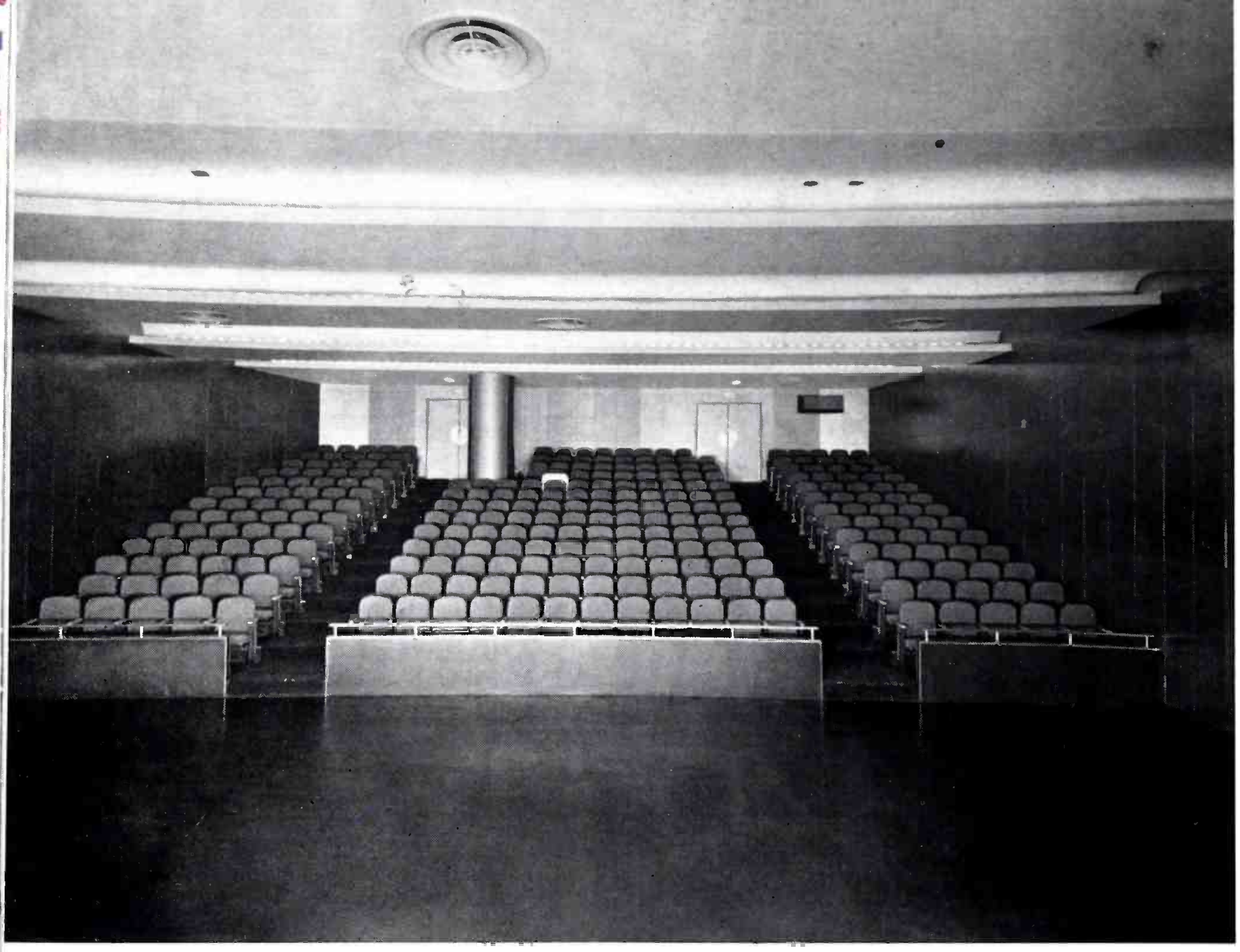
by GEORGE M. NIXON
Engineering Department, National Broadcasting Co.

Two new auditorium-type broadcast studios were placed in operation by the National Broadcasting Company at Radio City, New York, early in November 1941. These studios, designated as Studios 6A and 6B, incorporate the accumulated years of operating experience in the careful planning, constructing, and decorating of studios to coordinate properly all of the various operating requirements of network broadcasting.

The two studios are similar in size and modern architectural design, but distinctively different in decorative treatment to obtain a pleasant contrast in appearance. The overall length of each studio is approximately 100 feet; the width an average of 48 feet; and the ceiling height ranges from 13 to 19½ feet. The stage section is 37 feet deep and 45 feet wide; and its ceiling height is from 13 to 16 feet.

Figures 1 and 2 show the overall appearance of one of the studios—Studio 6A. Figure 1, as viewed from the rear of the elevated and stepped seating section, shows the control booth, to the right of the stage, from which the occupants have an unobstructed view of the stage and of the major portion of the studio seating section. The opening for the clients' observation booth window may be seen in the upper right. From this booth the sponsors of the program may watch and listen to the progress of the program. Figure 2 shows the studio as viewed from the apron of the stage with the seats in the fore part of the studio removed. The opening of the spotlight booth is seen in the upper righthand corner of the picture.

The walls of Studio 6A and the stage ceiling are of a rich warm copper color. The chairs in this studio are of dark-green fabric upholstery, and the flooring has a rubber covering upon which the carpeting is laid. The walls of Studio 6B and the stage ceiling are of a bright silver color. This studio has a red rubber flooring, with red carpeting, and blue upholstered chairs.



(Left) FIG. 2.

The rear wall is constructed of a series of plaster semi-cylindrical convexly curved surfaces which provide additional diffuse reflection. In Studio 6A the rear wall is of vertical, semi-cylindrical pillars and in Studio 6B these curved surfaces are in horizontal layers. A drapery is provided which may be drawn to cover these surfaces to alter acoustical conditions in the studio, as desired. Two other draperies are in each studio. One, for use as a "draw curtain" in the front of the stage or what would be the proscenium in a theater. The second is about midway along the side walls to reduce the apparent size of the stage when very small performing groups use the studio. The arrangement of the wall and ceiling surfaces may be seen in Figure 3.

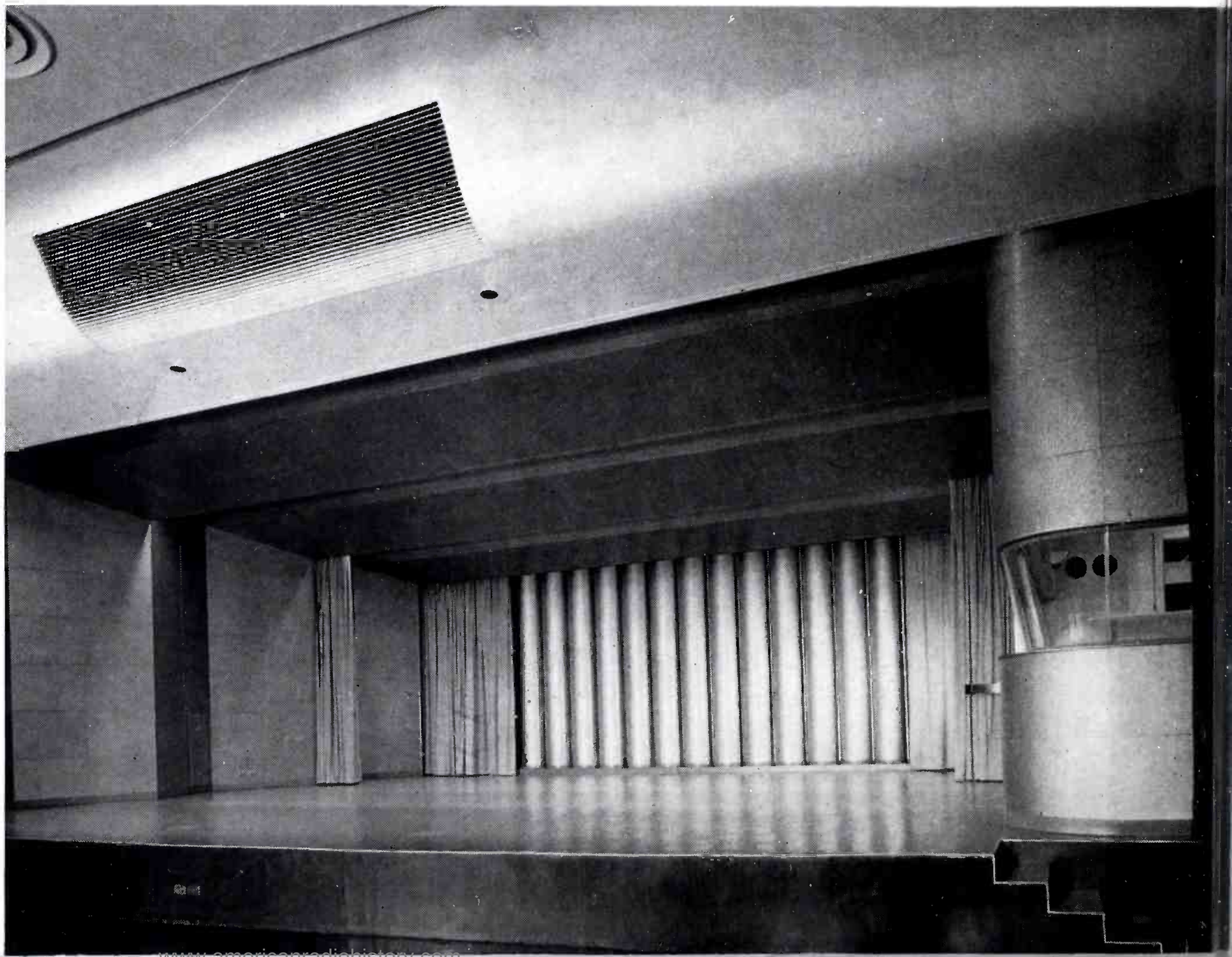
Each studio accommodates an audience of about 450 in comfortably upholstered chairs which are arranged to provide an unobstructed view of the stage. One third of these chairs, 150, are removable and are located on the level floor area immediately in front of the stage. The remainder, 300, are fixed and arranged on a gradually stepped slope so that all seats are "good seats." The seats of the chairs are automatically retractable so that, when unoccupied, the seat slides downward and backward to provide a maximum of space between adjacent rows.

The upholstered chairs, in addition to being comfortable, perform the important function of maintaining substantially the same acoustical conditions with and without an audience present in the studio. Program balance and microphone location may be determined and adjusted carefully during rehearsal, with the assuring knowledge that it will not be disturbed by the influx of the audience. The removable seats in the front of the stage permit use of this area by performing groups or, by the removal of two or three rows of seats and the use of platforms abutting the stage apron, the size of the stage may be augmented to accommodate very large performing groups.

The wall and ceiling surfaces of the stage are arranged to provide sound diffusion so that the reflected sounds are mixed properly and the tonal quality of the performer or performing group is enhanced. The wall on the control booth side is plane, but the opposite wall is deeply "veed" in flat sections of wall, each 4 feet wide, to a depth of 2 feet, from the "crest" to the "trough" of the "vee" so that impinging sounds are reflected dispersely.

The stage ceiling, shown in Figure 4, is in "broken sawtooth" fashion for two reasons, the first to provide a sound diffusing condition, and the second to conceal the border lights and "spots" from the eyes of the audience. This photograph, which is of Studio 6B, also shows the horizontal, semi-cylindrical surfaces on the rear wall of the stage; a closer view of the "veed" side wall and the method of concealing the draperies in "curtain pockets."

The acoustical treatment employed throughout the studio is rock wool 2 inches thick except for the rear portions of the stage ceiling where the rock-wool treatment is 4 inches thick. The acoustical treatment on the walls is covered with perforated asbestos board applied in 2 foot squares. The treatment on the stage ceiling is covered with perforated metal to provide greater absorption at the higher audio frequencies.



(Right) FIG. 3.

(Left) FIG. 4.

The ceiling of the auditorium section is untreated except in relatively small sections near the front of the stage to permit use of this area for broadcasting purposes. The side walls of the auditorium are likewise untreated except near the stage to permit microphone usage in this vicinity. The side walls are "splayed" horizontally in wide flat panels so that very few opposite parallel surfaces exist. The absence of acoustical treatment on the side walls and ceiling of the auditorium section provide beneficial reflections from these surfaces which aid in the transmission of sound from the stage to the listeners.

The rear wall of the auditorium is entirely treated with rock wool 2 inches thick covered with perforated asbestos board; in Studio 6A, the supporting surface is deeply serrated or "veed" and in Studio 6B, horizontally splayed. Impinging sounds are largely absorbed by the rear wall of these studios; the small amount of energy reflected is diffused so that no annoying discrete, delayed reflections or "echoes" from this wall interfere with the enjoyment of listeners in the front seats.

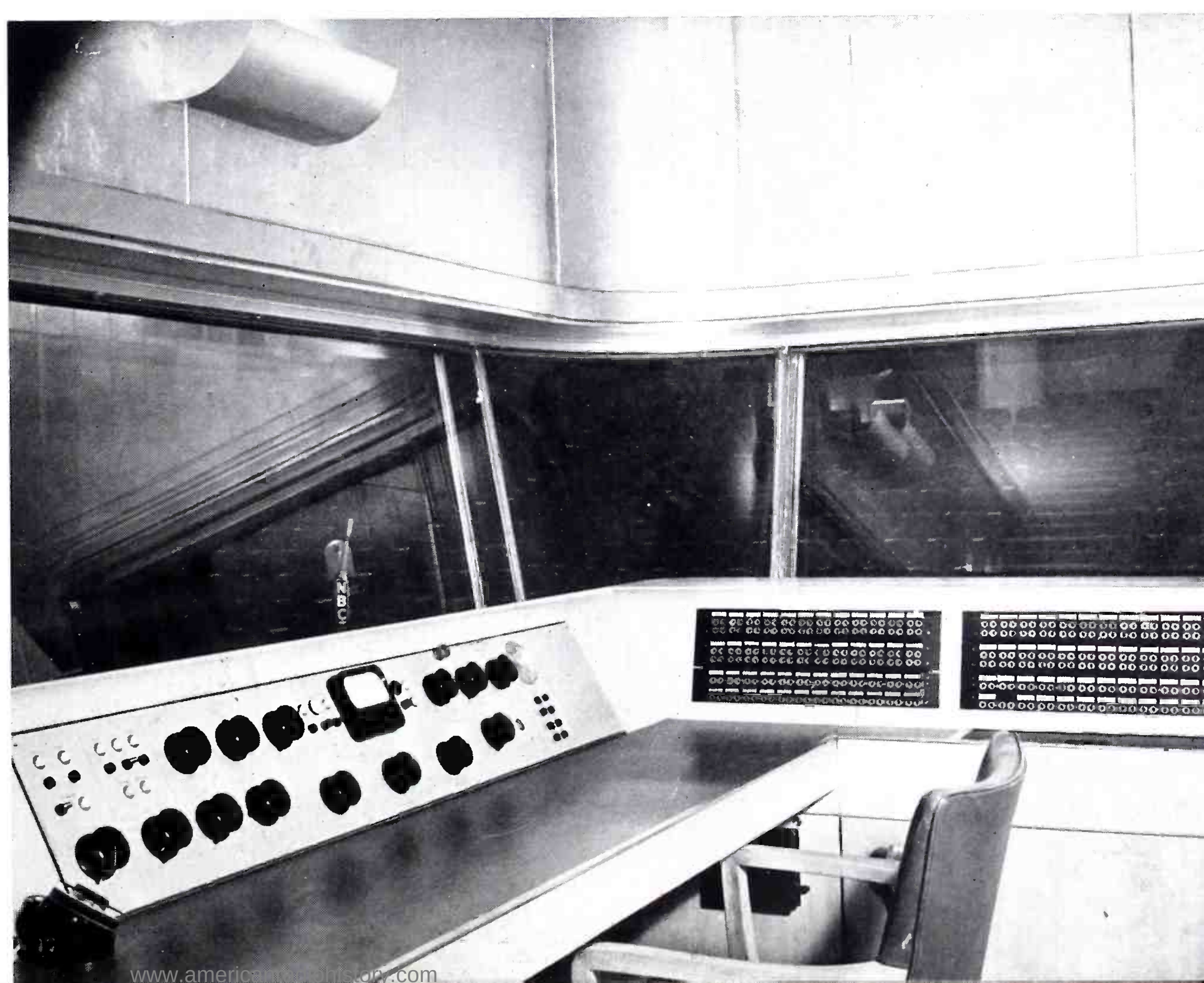
The upholstered seats and broadloom carpeting lined with felt on the aisles also provide a highly absorbent area in this portion of the studio.

Sound isolation is provided by the use of double 6-inch solid-cinder block partitions to avoid sound transmission between the studio and adjacent spaces. The walls, floor, and ceiling of the stage section are supported on metallic springs damped by felt to reduce the transmission of vibration between the studio and the building structure.

The broadcast equipment is "RCA all the way." The controls are mounted on a sloping panel set in a blond mahogany console. (The console is shown in Figure 5.) The amplifying equipment is easily accessible and located in a room just off the control booth.

The sound-reinforcing system for the studio is energized from the broadcast program circuit to permit the visitors to hear those artists who perform close to the microphone and who would be otherwise inaudible to a large portion of the audience. Another important reason for the use of a sound-reinforcing system is that the program is balanced for the microphone and all efforts are directed toward optimum broadcasting results. Consequently, in view of the arrangement of the orchestra, the choral group, sound effects, actors, etc., on the stage, the program as heard directly in the studio from the seating area would differ radically from that heard by the radio listener. The use of a sound-reinforcing system thereby provides the visible audience with the same program balance as heard by the radio listener.

The lighting system is not the least of the important features of these studios. The seating section is pleasantly illuminated by cove lighting in sweeping curves across the width of the studio. The lighting forms an interesting pattern on the ceiling and provides indirect illumination in this portion of the studio. The stage lighting uses border lights with associated circuits arranged so that various color combinations may be obtained to provide an atmosphere in keeping with the program content. Spotlights are provided for individual artists or featured small groups on the program. Individual control of lighting sections together with master and sub-master controls permit flexible operation to obtain desired combinations.



(Right) FIG. 5.

NAVY SETS UP AND GUAM BROAD

By the time this issue of BROADCAST NEWS reaches readers, broadcasts from network reporters in the Central Pacific will be reaching American stations through new broadcasting facilities now being installed by the Navy Department in the Pacific Theatre. These facilities, the first to be installed for this purpose in the Central Pacific, include two studios already in operation, at Pearl Harbor, which will use available RCA transmission circuits, and one studio at Guam where a Navy transmitter has been installed.

The Pearl Harbor installation permits radio correspondents to broadcast the news immediately after it has been received and passed on by the censor at headquarters. The studio has both disc and film recording equipment available and is prepared at all times to censor and edit film recordings as soon as they are received. Two programs can be fed simultaneously over the RCA facilities.

The Guam installation provides for similar operation at the advanced base. Facilities are available to both American and BBC radio correspondents and it is expected that network recording teams will be based there. Planes will be provided to fly back on-the-scene accounts of action to be relayed from the Guam station. This installation also makes possible the immediate broadcast of Marine combat recordings, heretofore flown to the States.

ARRANGEMENTS MADE BY NAVY

Arrangements for these new facilities for news coverage and broadcasting of on-the-scene recordings were made by Rear Admiral A. S. Merrill, U.S.N., Director of Public Relations. Planning was under the direction of Lt. Comdr. J. Harrison Hartley, U.S.N.R., Officer-In-Charge, Radio Section, Navy Public Relations.

(Above left) *When the Navy wanted broadcasting equipment in a hurry it turned to RCA. The necessary equipment was assembled at the Indianapolis plant and is here shown being loaded on trucks for transportation to the airport.*

(Center left) *Three weeks after the equipment assembly was started, a Navy C-54 Transport Plane landed at the Indianapolis airport to pick up the equipment that was ready and waiting.*

(Below left) *Loaded on this special Navy plane the two truckloads of RCA equipment, plus other equipment for this project, were flown directly to Pearl Harbor. Most of this equipment is standard RCA broadcast stock items. A familiar sight in U. S. broadcast stations, before the war, this equipment is now serving all over the world.*

PEARL HARBOR
CASTING FACILITIES

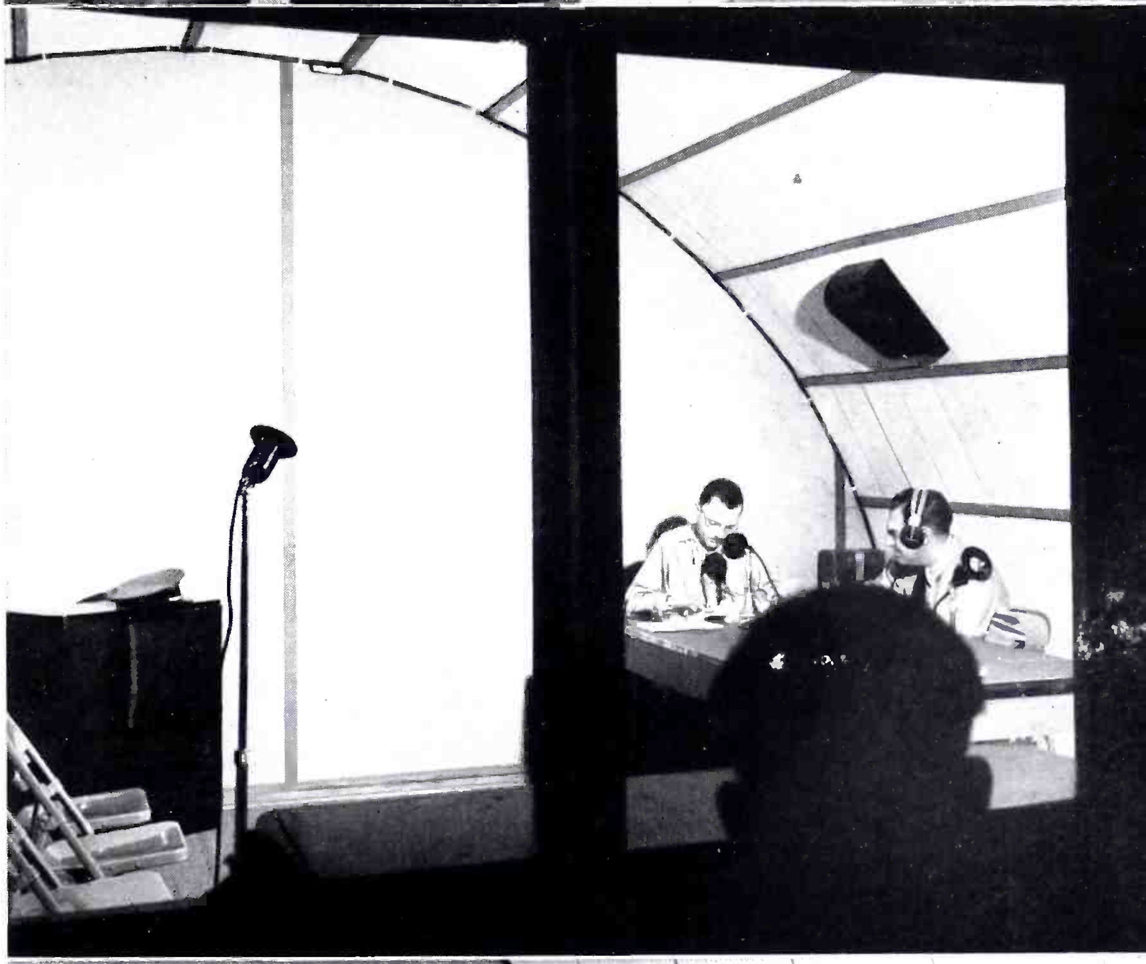
Comdr. Hartley is also supervising the installation and starting of operations. Much of the planning of the equipment layout was done by Lt. Marvin F. Royston, U.S.N.R., who is Engineer-in-Charge. Lt. Royston is on leave from the BLUE network. In charge of the Guam station is Lt. James C. Shattuck, U.S.N.R.. who previously has made a name for himself in covering the Normandy invasion.

In addition to installing these two stations the Navy has agreed to allow live broadcasts to originate from flagships in the center of action, subject to the tactical commander's approval. These broadcasts will be shortwaved by ship's radio to Guam and relayed from there by the equipment now being installed.

STUDIO EQUIPMENT FOR PEARL HARBOR AND GUAM

The main equipment units in the Pearl Harbor and Guam studios are (with the exception of the film recorders) standard RCA broadcast items. Details of the setup were worked out by Lt. Royston and J. D. Colvin of RCA's Application and Development Section. The equipment was assembled—and the various special switching units fabricated—in the RCA plant at Indianapolis. The whole job was completed, packed and ready at the airport for the special Navy plane which was to fly it directly to Pearl Harbor within three weeks after final approval of plans.

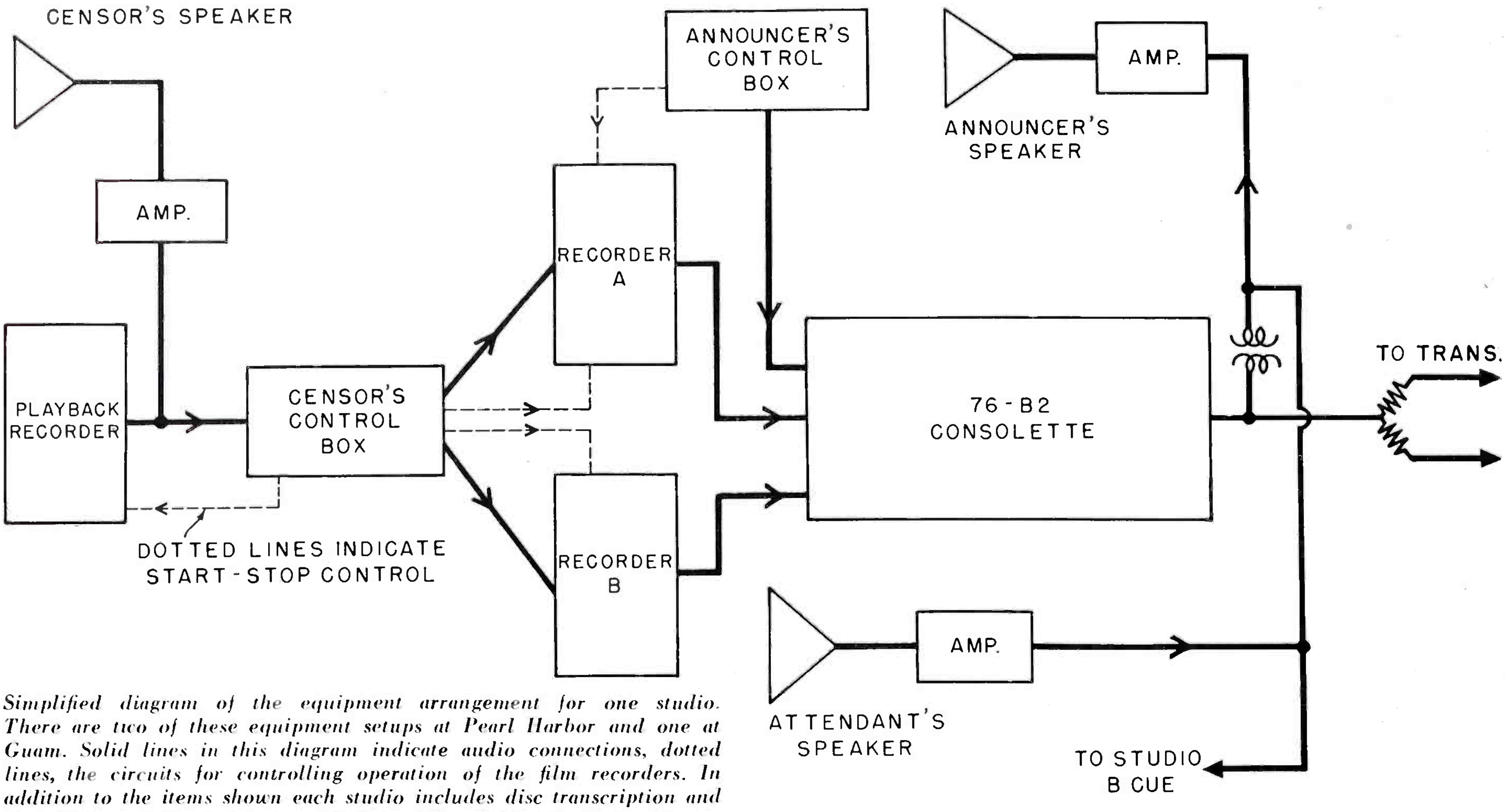
While most of the equipment items are well known to broadcasters, the arrangement of these is of interest because of the emphasis placed on the use of film-recorded on-the-scene accounts. The plan contemplates that network recording teams will make film recordings at the scene of action. These recordings will be flown back to Guam or Pearl Harbor at which points they will be immediately censored (which usually involves re-recording) and put on the air



(Above right) *On arrival at Pearl Harbor the equipment was set up in Quonset huts. Less than 60 days after it was started, the equipment was ready to go on the air. In this picture Lt. Comdr. Hartley is at the typewriter (right) and Lt. Royston is leaning over the table at left.*

(Center right) *View of the interior of the new broadcasting studio at Pearl Harbor with Lt. Comdr. J. Harrison Hartley, U.S.N.R. (right) checking the script as John M. Cooper of NBC goes on the air. Newscasters for all the broadcasting companies and networks accredited to the Pacific Fleet use these facilities.*

(Below right) *Another view of the studio as Webley Edwards (left) of CBS makes a report to his listeners with Lt. James Shattuck, U.S.N.R., checking the script. Connector box in foreground allows extra mics to be plugged in for "interview" type programs.*



Simplified diagram of the equipment arrangement for one studio. There are two of these equipment setups at Pearl Harbor and one at Guam. Solid lines in this diagram indicate audio connections, dotted lines, the circuits for controlling operation of the film recorders. In addition to the items shown each studio includes disc transcription and recording equipment with associated amplifiers and control circuits.

without further delay. The layout of the equipment at both installations has been planned to accomplish this conveniently and expeditiously.

The Speech Input equipment for Pearl Harbor consists of two studio equipments, each having the layout shown in the block diagram above. The arrangement for the Advance Base is identical with the Pearl Harbor setup except that there is only one studio. Since the layout, equipment and operation of these studios is identical, the following description will apply to either of the studios at Pearl Harbor or to the single studio at the Advanced Base.

Basically, each of these studio equipments is composed of three film recorders (one a spare), a switch box for controlling the film recorders and a 76-B2 Consolette. Accessories for controlling circuits are: the Announcers' Panel, a Cue Selector Panel, and a cabinet rack with amplifiers, jacks and filters. A 70-CL Turntable with pickup and recording facilities is also provided for operation from lacquer discs in addition to the normal recording on film.

A film that has been recorded at the scene of action is brought back to the studio. This film must first be censored and re-recorded before it is relayed on to the United States. To accomplish this, the film is played on the machine marked "Playback." The censor's speaker is driven by an amplifier bridged across the output of the "Playback" machine.

Signal coming from the film in the Playback machine feeds into either or both of the film recorders (A and B). These three machines (Playback A and B) are controlled by the Censor's Control Box. Keys on this box allow the censor to instantly stop either the Playback machine or any of the recorders. Thus he is able to stop the recorders while a word or sentence coming from the Playback machine passes by. In this way the film is censored and re-recorded.

To put the re-recorded film on the air through Studio A equipment, the film is played back from the A machine. Control of the machine is taken from the censor's Control Box by opening the toggle switch over the A operating key and given to the Studio A announcer by patching the A Control Circuit to the A Film Recorder. The Studio A announcer can now run the A machine by throwing the "Annc.-Film" switch on his announce panel to the "Film" position.

To go on the air, the announcer throws the "Annc.-Film" key to the "Annc." position. This kills the studio speaker and, through an interlock on the speaker relay, turns on the microphone relay. The microphone relay connects the announce microphone to the mixer 1 position on the consolette. After the announcement, the A film machine is put on the air (this machine having been previously set up by the attendant) by throwing the "Film-Annc." key to the "Film" position. The key in this position operates the A control relay (in the Cabinet) which starts the film machine. It also closes the A film recorder relay in the cabinet. This relay closes the audio circuit that runs from the output of the A machine, through an isolation transformer, the relay, a 40 db pad and into mixer 4 on the consolette.

If the nature of the material on the film is such that its effectiveness can be increased by a short explanation from the announcer, he may announce over the film by pushing the "Override" button on the Annc. Panel. The operation of this push button performs the same function as throwing the "Film-Annc." key to the "annc." position, but allows the film program to continue. The announcer can continue to monitor the film program while overriding by means of headphones plugged into the Cue Selector Plate. Position 1 on the cue selector switch gives him the program on the air.

A round table type of program can be arranged in the studio by plugging three microphones, in addition to the announcer's microphone, into a Microphone Box at the "Studio Mic" positions. Throwing the Studio Mic's Key to the "on" position connects these three microphones into the circuit and all four in parallel feed into Mixer 1 position on the consolette.

The output from the Consolette feeds into a "dividing" pad. This provides a two line output from the one source with ample isolation between the two lines. Six line jacks are provided for feeding programs to the transmitter or to the commercial radio companies.

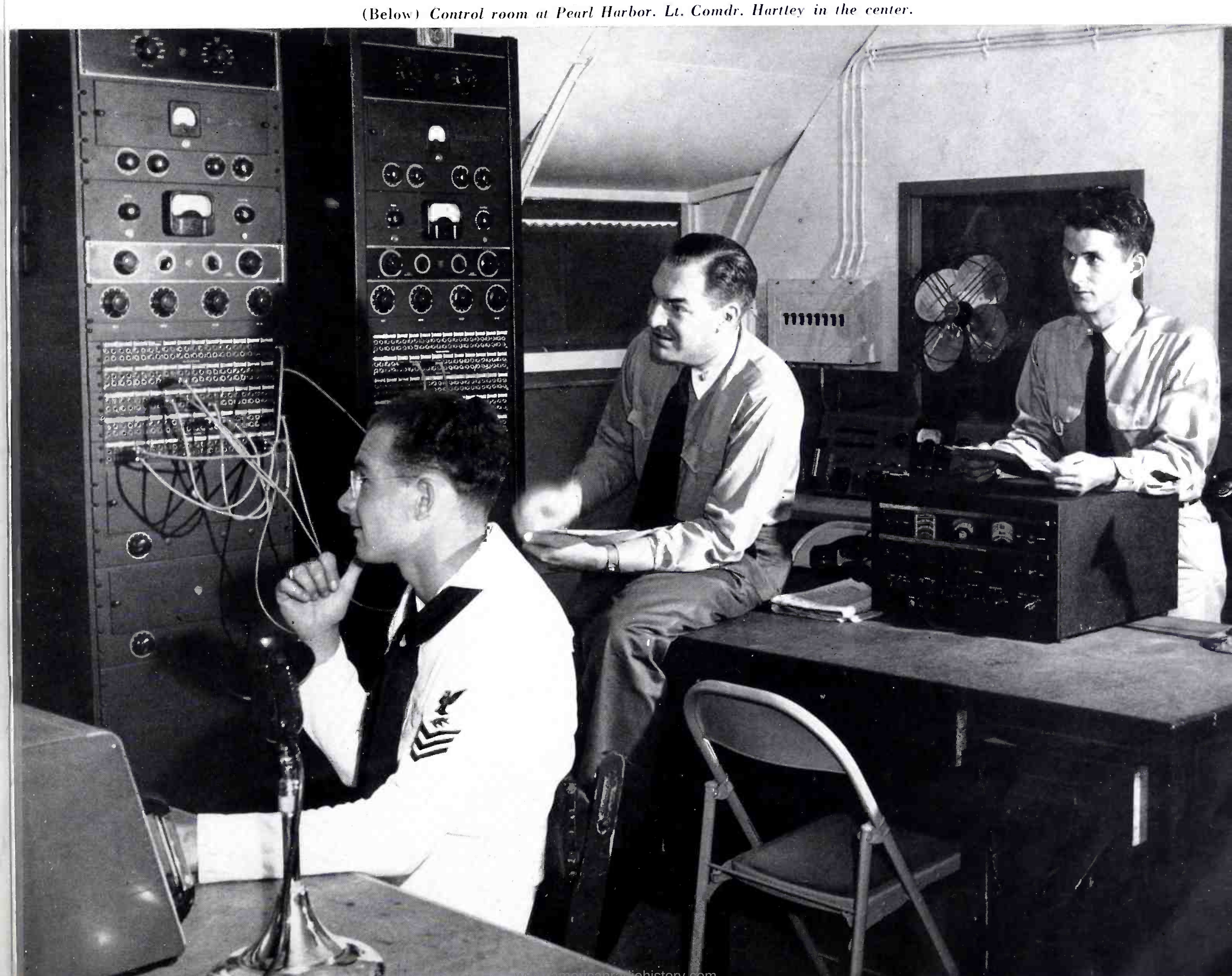
Bridged across the output of the Consolette is a 5000 to 500 ohm transformer. The output of this transformer feeds the number 1 position on the Cue Selector Plate in the studio, thereby providing a means for the announcer to monitor his own program. The output of this transformer also feeds a monitor speaker located at the film machine to allow the attendant to check the film program on the air. Still a third feed is taken from this transformer and is used in the case of a two-studio setup to feed the number 2 position on the Cue Selector Switch. This arrangement provides a means of cueing between the two studios. In addition to the positions on Cue Switch described, two more positions, 3 and 4, are provided and are connected to jacks in the cabinet rack. Thus cue for special setups can be provided for the studio announcer by making the necessary patch at the board.

Operation of the disc recording equipment is secondary in operation to film recorders in that input to the recording amplifiers and the output from the playback amplifiers must be patched to the desired circuits. The recording circuit consists of a pre-amplifier, an equalizer, and a recording amplifier. The output of the recording amplifier feeds into the Record switch mounted on the turntable.

Relays are provided in the turntable and in the rack to allow operation of the turntable by the announcer as is done in the case of the film recorders. The relay in the turntable is normally out of the circuit because of a switch in series with its coil being open. Closing the switch causes the relay to operate with the "Film-Annc." key thrown to the "Film" position. Contacts on this relay are in parallel with the normal OFF-ON motor switch on the turntable. Operation of the relay will start the turntable even though the regular switch is off. The second turntable relay to be operated by the "Film-Annc." key is in the rack and terminates in jacks. The playback circuit can be patched through this relay. Thus, when the announcer throws his key to the "Film" position, the turntable starts and the audio circuit is closed. The set up then operates exactly as though the program were coming from a film machine.

A number of useful devices are furnished in the rack, such as variable pads, isolation transformers, bridging transformers, filters, equalizers, etc. These are all available on jacks. Also, all the normal circuits are supplied with jacks and multiples at all possible points. Thus, by patching, various "trick" setups can be obtained. The intention in laying out this equipment was to make the arrangement just as flexible as possible—so that no matter what the emergency, it could be handled with a minimum of reconnecting.

(Below) *Control room at Pearl Harbor. Lt. Comdr. Hartley in the center.*



WFAA-KGKO STUDIOS

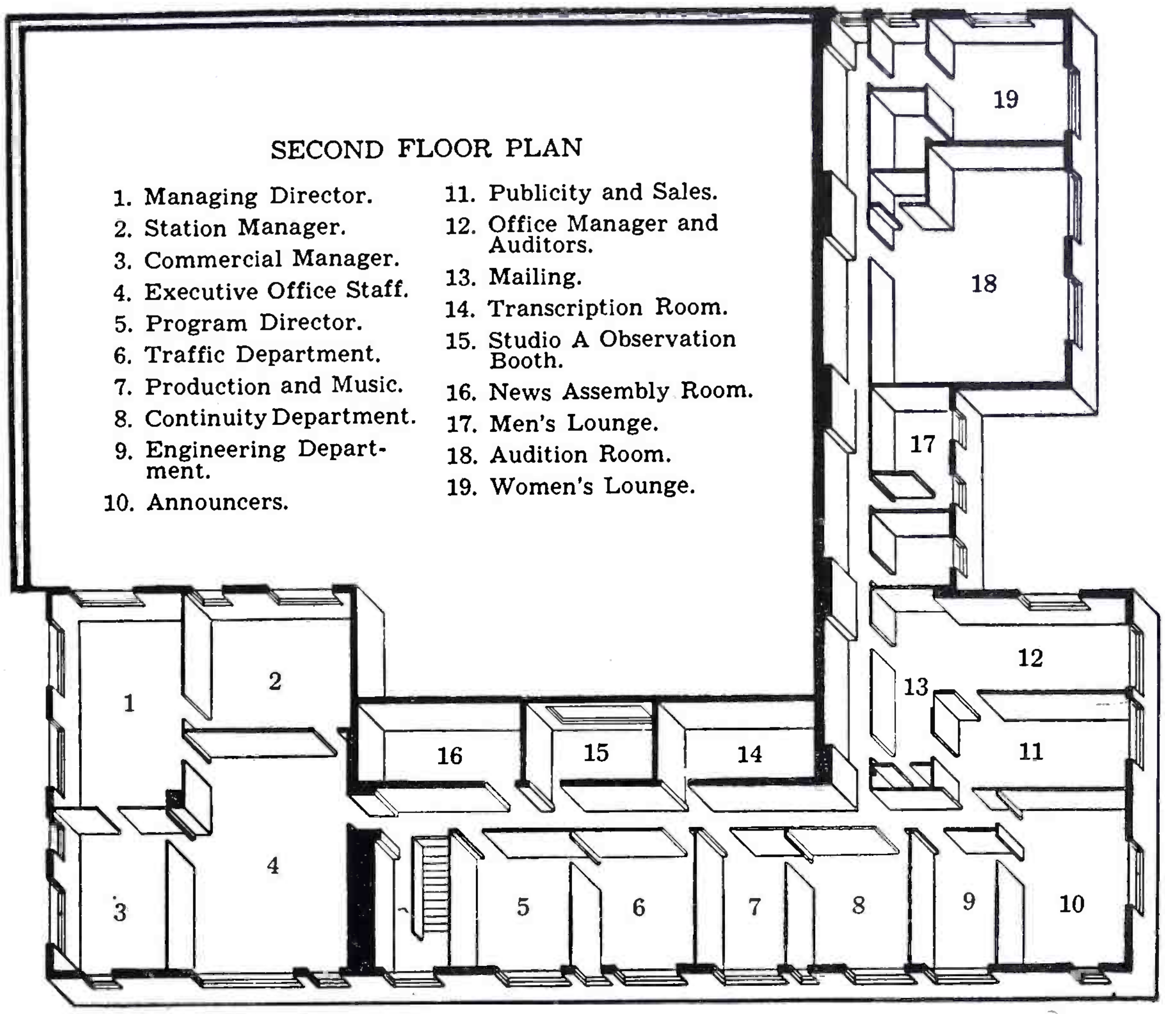
The studios of the Dallas Morning News stations, WFAA and KGKO, are located in a penthouse on top of the Santa Fe Building in downtown Dallas. This penthouse, a two-story structure, some 110 feet square, is almost ideal for its purpose, for while it is centrally located and hence easily accessible, the fact that it is ten stories above the street and completely separated from the rest of the building makes it possible to achieve a high degree of sound isolation. Moreover, since the studios and office occupy the whole penthouse, the arrangement has the advantages of privacy and independence ordinarily obtained only in a separate studio building.

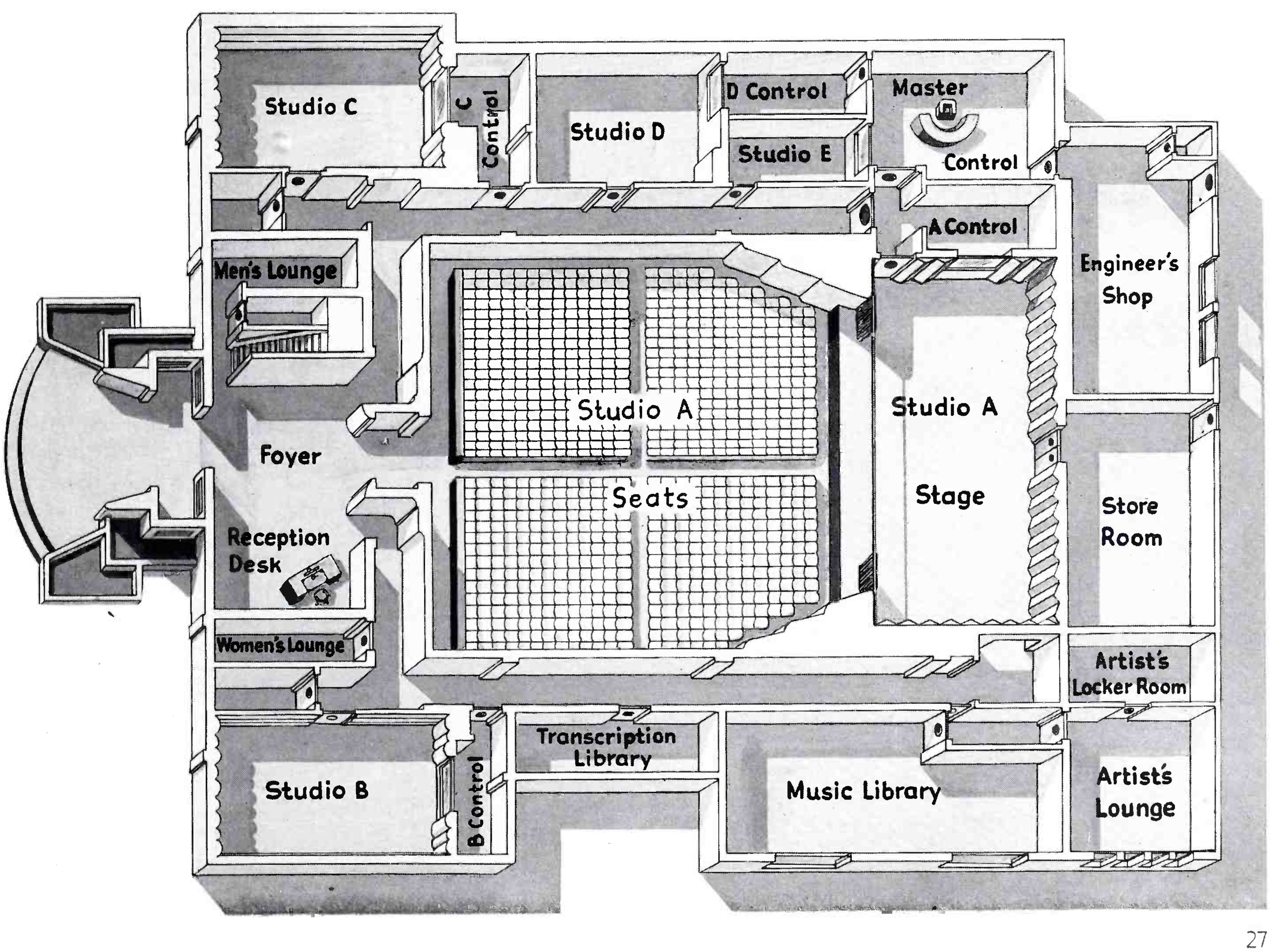
In planning the studio and office layout, Mr. Campbell, the general manager, and Ray Collins, the chief engineer, had to provide for an installation capable of feeding programs to the two stations, WFAA and KGKO. It also had to originate programs not only for these stations, but also for the Texas Quality and Lone Star networks, of handling NBC and BLUE programs, a large number of remotes, special football networks, and a considerable amount of high-quality recording. The switching and control operations involved obviously required an extensive master control system. Similarly, it was apparent that an assortment of studios of rather wide characteristics would be needed. To go with them, a fairly extensive layout of offices and workrooms was indicated. The resulting installation is the largest, newest and best equipped in the South.

In the center of the structure (see the floor plan on the opposite page) is a large auditorium which is two stories in height. Arranged around this auditorium are the smaller studios, the master control room, the music and transcription libraries, several lounges and an engineering shop. On the second floor, along the front and around one side of the building are some twenty offices and lounges (including a clients' booth looking into the observation studio).

The arrangement of entrance-way, studios and offices with relation to each other is particularly interesting because of the efficiency it adds to normal station operations. Visitors to the station enter a large reception room (see above) which is beautifully appointed, the walls being finished in natural wood with the decorations consisting of gilt-painted plates from the Dallas News which are set into the wall behind the reception desk and around the door to the auditorium. This door opens through a large sound-lock directly into the auditorium. Thus, the great majority of visitors to the station (i.e., those who come to see a program in the auditorium studio) enter and leave without interfering in any way with the normal operations of the station. On either side of the auditorium door are entrance-ways to corridors which provide access to the smaller studios, master control, etc. Artists, engineers, and maintenance staff use these corridors. Upstairs, where no programming activity will interfere, are the offices. Thus, each part of the station's activities is channelized with resulting elimination of the confusion found in studio installations where offices, studios and public reception rooms are mixed together.

In addition to the large auditorium (Studio A), there are four other studios. Two of these are medium-sized music studios, the third a small program studio, and the fourth an announce-and-transcription studio. In all of these, a "dispersive-type" acoustic treatment is used—in fact, this was the first large-size installation in which this new method of acoustic control was used throughout. A description and pictures of these unique studios will be found on the following pages.





STUDIO A

Two views of WFAA's auditorium studio are shown on this page. This studio, which is built like a small theatre, has an audience space 49 feet wide by 42 feet deep, and a stage space 46 feet wide and 28 feet deep. Comfortable theatre-type chairs provide for seating an audience of 250 people. This part of the studio is sloped up from the stage so that a good view is obtained from all seats. The relatively large stage space provides for the requirements of audience participation programs and for elaborate presentations of the variety type.

Several types of acoustic treatment are used in this studio. The end and back walls of the stages are saw-tooth splayed with alternate hard and treated surfaces. A heavy brocaded curtain can be drawn across the back wall to provide some variation in stage acoustics. The splayed part of the side walls of the auditorium are hard-surfaced, while the rear, straight parts of these walls are treated. The entire rear wall of the auditorium is covered with brocade splays set horizontally. Behind these is an air-pocket backed by a layer of hair felt.

The ceiling of the stage is also splayed with rows of lights placed in the recesses. These lights are in groups of three, each of the three being of different color. By choosing the groups to be lighted, varying shades of stage lighting can be achieved. Lighting in the auditorium section is provided by lights concealed behind an overhanging false ceiling. Audio equipment on the stage ordinarily includes several 77-C Universal Microphones (one on a boom stand), one or two 44-BX Velocity Microphones and a 64-B Loudspeaker. In addition, PA speakers are mounted in the proscenium. Three entrances to the stage are provided. One, at the right for performers; Another, at the left for engineers; and a third, at the rear for stage props. The control room window opens directly on the stage, the floor of this booth being somewhat elevated so as to provide a better view for the operator and production director.

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STUDIOS B AND C

The two medium sized studios shown on this page originate the biggest share of the WFAA-KGKO local shows. Studio C, (right) is 21 feet wide, 35 feet long and 10 feet high. Studio B, (below) is 21 feet wide, 27 feet long and 10 feet high. These dimensions are such as to provide most conveniently for soloists, quartets, small orchestral groups, and dance bands. Provision of two studios of about the same size and characteristics makes for flexibility in programming and rehearsing.

All four walls of these two studios are entirely hard-surfaced. Acoustic control is obtained by proper use of polycylindrical diffusers as dispersive elements. The arrangement of these elements was worked out by Dr. C. P. Boner, of the University of Texas, who designed these studios for WFAA-KGKO,and who made measurements during construction and after completion to make sure that the expected improvement was obtained. The results have been entirely up to expectations. The studios are more "live," have a greater high frequency response, and the reproduction is altogether more natural sounding than that of studios with other methods of acoustic treatment.

The physical arrangement of the diffusing elements is fairly evident in the two views shown. Horizontal cylindrical elements run the length of each side of these studios, while vertical elements line both ends. The cylinders are made of thin plywood formed over curved ribs, the latter being located at odd intervals to prevent resonance periods in the cylinders themselves. In constructing these cylinders, the procedure was to first nail one sheet of plywood to the ribs, then to glue a second sheet over the first. By this means, a smooth outer surface unblemished by nail holes was obtained. The cylinders were then painted in bright solid colors—yellow and blue in Studio C. purple and mauve in Studio B. The effect is pleasing as well as startling. It is also practical since the painted surfaces are easily refinished. The ceilings of these studios are splayed with approximately 40 per cent of the surface covered with J-M acoustic tile. The floor is covered with linoleum in a matching color. When required, some variation in acoustics can be obtained by the use of rugs to cover a part of the floor area.

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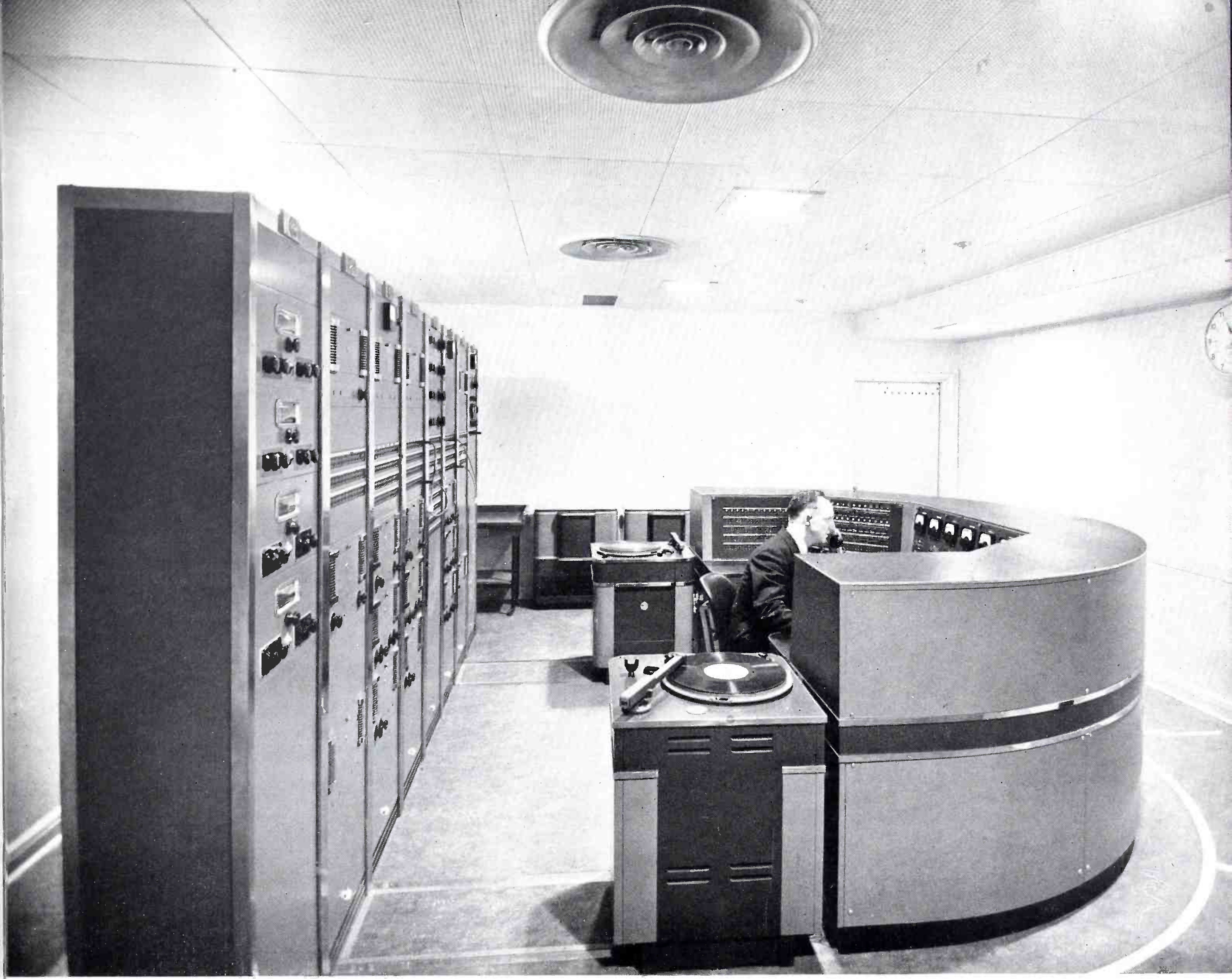
STUDIO D

Studio D (left) is a small studio (10 feet wide by 16 feet long and 9 feet high) which is used for announcing, soloists, and small musical groups of the "intimate" type. In this studio, cylindrical diffusers are used in the ceiling as well as the four walls. The only acoustic material is the center strip of J-M acoustic tile which runs the length of the ceiling and part way down each end. All other surfaces are hard.

The Studio D control room contains a 76-B2 Consolette modified for single-studio use. Inputs on this consolette provide for two microphones, two transcription turntables (located in this control room) and for "normalled-through" inputs from NBC and BLUE lines. During period when there are no local originations, operation of one of the local stations can be entirely handled from this control room.

STUDIO E

Studio E is an even smaller studio (8½ feet wide, 10 feet long and 9 feet high) which is used only for announcing and newscasts. The acoustic treatment in this studio consists of several polycylindrical diffuser elements plus a certain amount of surface covered with J-M acoustic tile. The amplifiers and other equipment associated with Studio E are mounted in the racks in the Master Control Room. The microphone switches, faders, and VU meter are located on the right hand panel of the Master Control desk. Thus, operations from this studio can be entirely controlled by the Master Control Operator, or he can, by operation of a lever key, switch actual on-off control of microphones to Announcers Control Unit located in the studio.



WFAA-KGKO STUDIO EQUIPMENT

by J. D. COLVIN

Studio Equipment Engineering Department

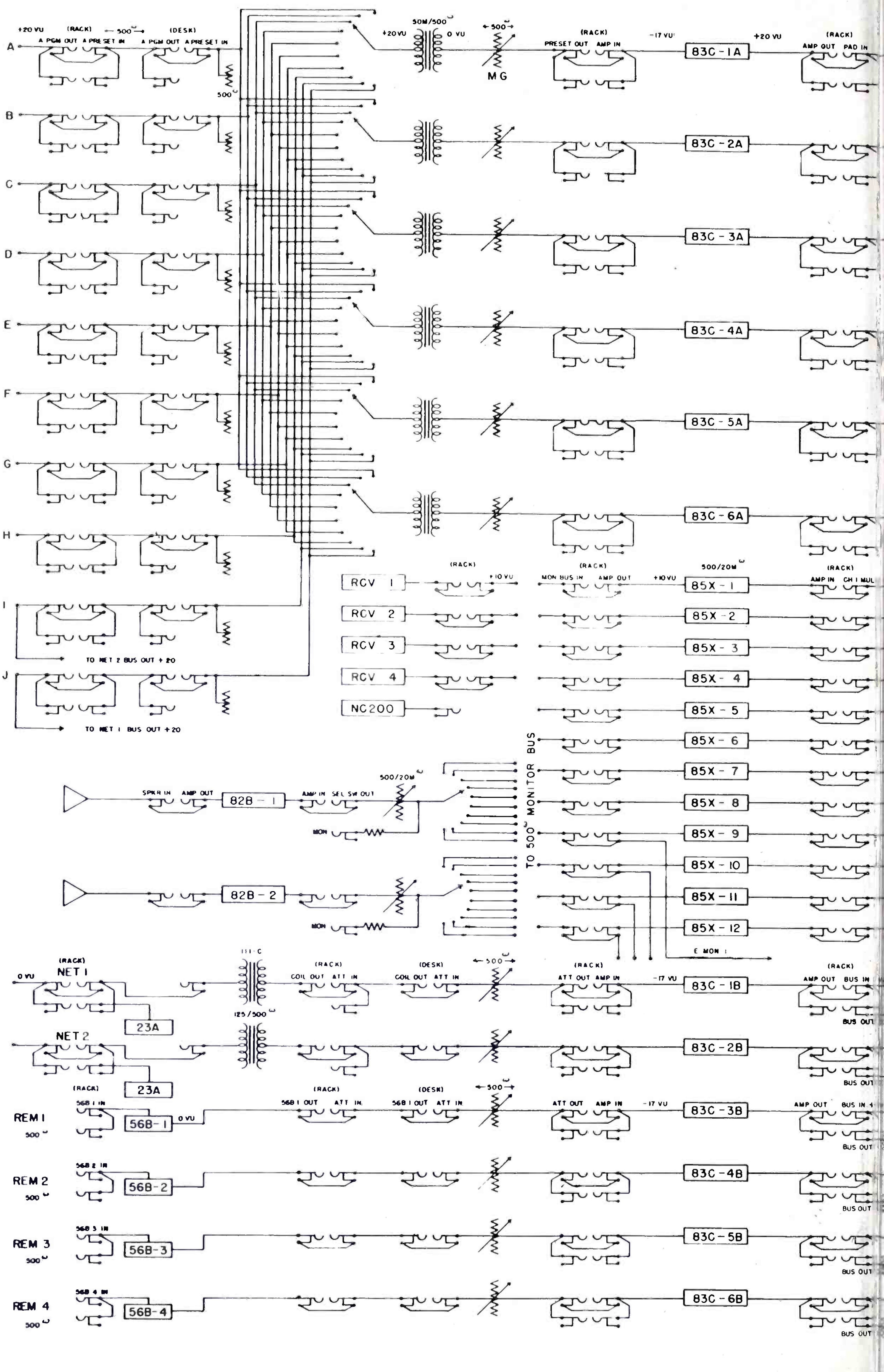
The WFAA-KGKO studios are equipped throughout with RCA studio equipment, of the deluxe custom-built type. The general arrangement of this equipment was worked out by the WFAA technical staff, headed by Ray Collins, chief engineer, working closely with engineers of the RCA Studio Equipment Section.

The WFAA-KGKO studio layout is of the multiple-control-booth type. Four of the five studios described previously are provided with individual control booths. The fifth, which is a news and transcription studio, is controlled from the master control room. As contrasted to the "single-control-room" type of installation, the WFAA-KGKO arrangement provides more flexibility, less interference between rehearsals and programs and, of course, greater convenience in multiple programming.

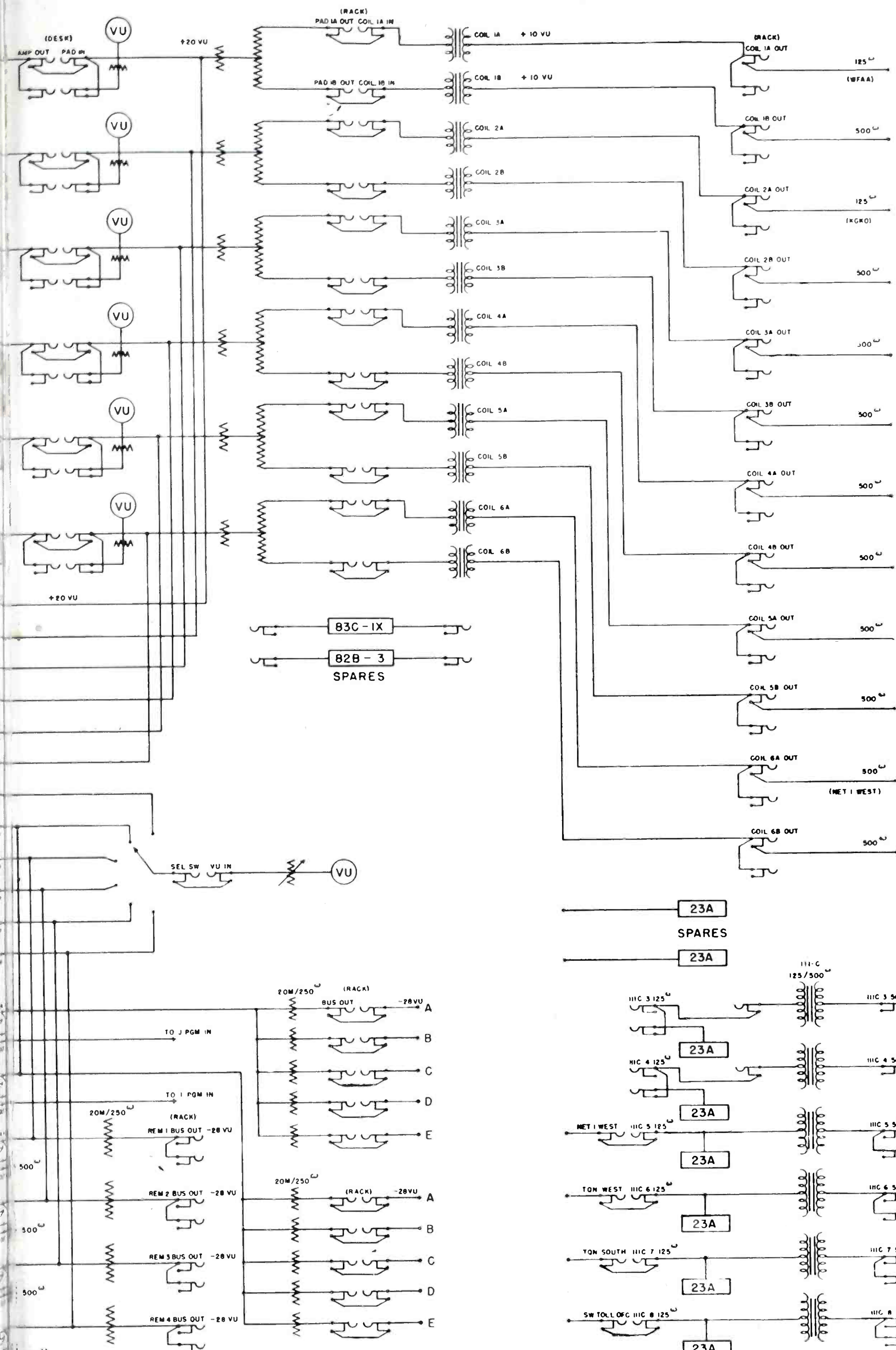
The equipment in Control Booths A, B, and C consists of a specially built control desk and a deluxe type rack housing the amplifier units. In Control Booth D, a modified 76-B Consolette is used. Transcription turntables are also located in this booth.

In the Master Control Room is an RCA deluxe-type control desk especially built to meet the particular requirements of the WFAA-KGKO installation, an assembly of eight equipment racks, two 70-C1 turntables, and two 64-B loudspeakers. The racks contain all of the amplifiers, jack panels, equalizers, line coils, etc., required for normal operation. Several monitoring receivers are also located on these racks as well as an oscillator, a distortion meter, and an attenuator panel. One rack is used for the termination and distribution of the 21 monitor circuits. These circuits are piped through lead-covered cable to all studio control rooms and the various executive offices.

The master control desk and the equipment racks in the WFAA-KGKO Master Control Room are shown in the view above. These equipments, as well as those located in the individual control booths, are described in detail on the following pages.



WFAA-KGKO MAST



R CONTROL ROOM

THE MASTER CONTROL SYSTEM

Ten inputs to six outgoing channels, with each channel divided to feed two lines each—this basically describes the WFAA-KGKO Master Control. A block diagram of the equipment in the Master Control Room is shown on pages 32 and 33. The switching system is a complete relay-operated arrangement that allows preset of the programs coming up the next period. At the switching time, any channel can be turned over to its preset program by throwing a key associated with the channel to "Operate." If a number or all channels are to be switched simultaneously, those channels are preset for such operation by throwing their operate keys to "Master." Then the operation of a master key at switching time throws all channels simultaneously. A view of the Master Control desk is shown on this page and a close-up of the Master Control Panel proper in the center view on the opposite page. Red lights serve to indicate which studios are on the air while green lights are used to show the studios preset. The single light immediately below each channel VI meter indicates to the master operator that the studio switched to that channel has thrown its program key to the line out position. Likewise, each studio control console has a light that indicates that it is preset, and another light showing when the master operator has put it on the air.

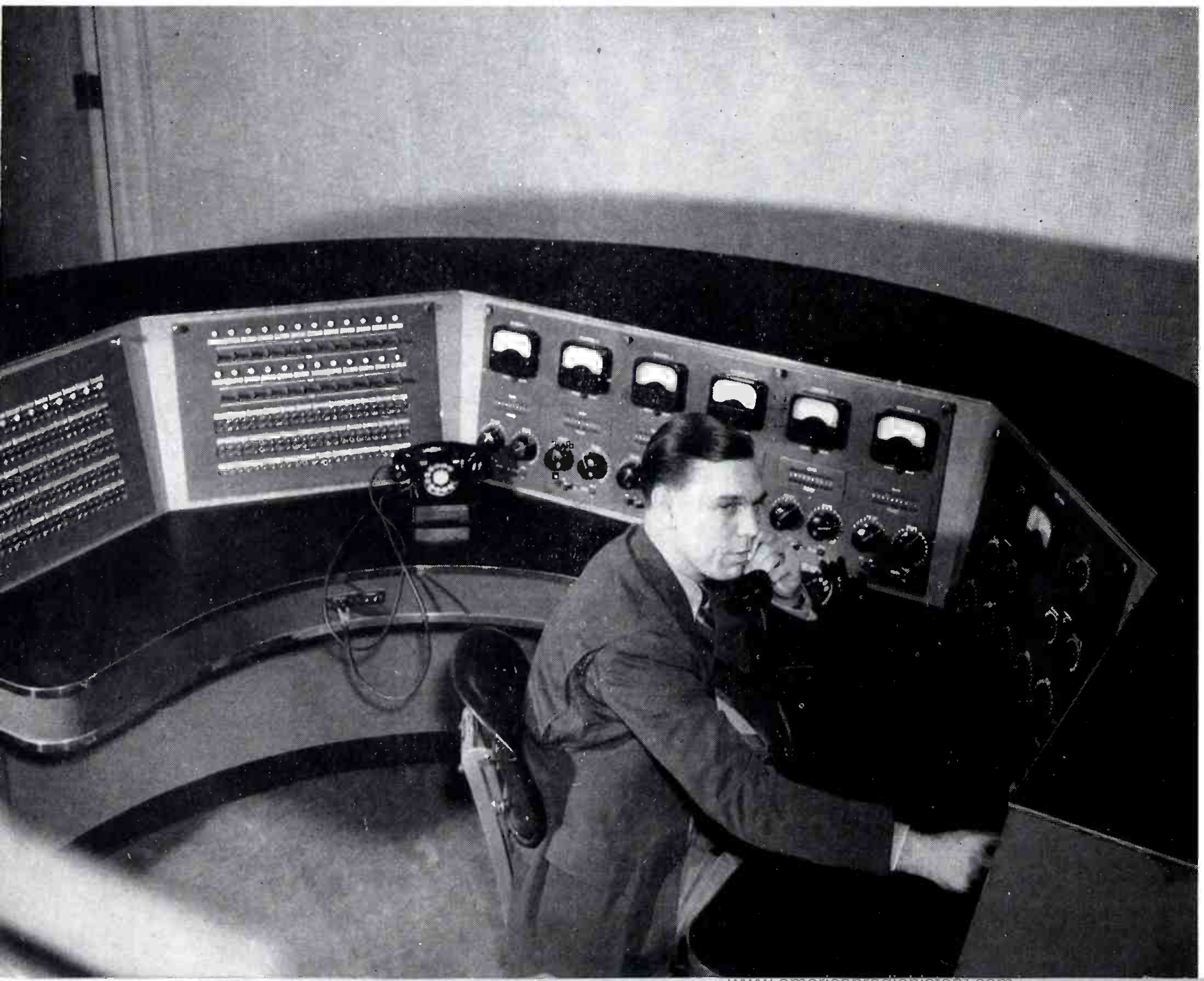
The interlock system allows any one studio to go on any one or all channels simultaneously, but will not permit two studios to go on the same channel at the same time. Master gain controls located next to the preset selector switches are provided to regulate the outgoing level to the lines. The output of each channel divides through a bridge arrangement which permits simultaneous feeding of two lines with the same program. An outstanding feature of this bridge type of pad is that it creates a 60 db isolation between the two lines being fed from the same channel, at the expense of only a 10 db transmission loss.

The top and bottom views on the opposite page show the left and right hand sections of the Master Control Desk. The extreme left hand panel contains jack panels through which pass all program channels at their various stages of entrance throughout the system. At this panel the master operator can, without getting up from the desk, make an emergency patch to circumvent a failure of any part of the system, including patching through an incoming network program directly into the transmitter line in case of a complete power failure. A number of trunks between this panel and the equipment racks permits trick setups to be made that can be handled directly at the master desk. Remote patching is also done at this point.

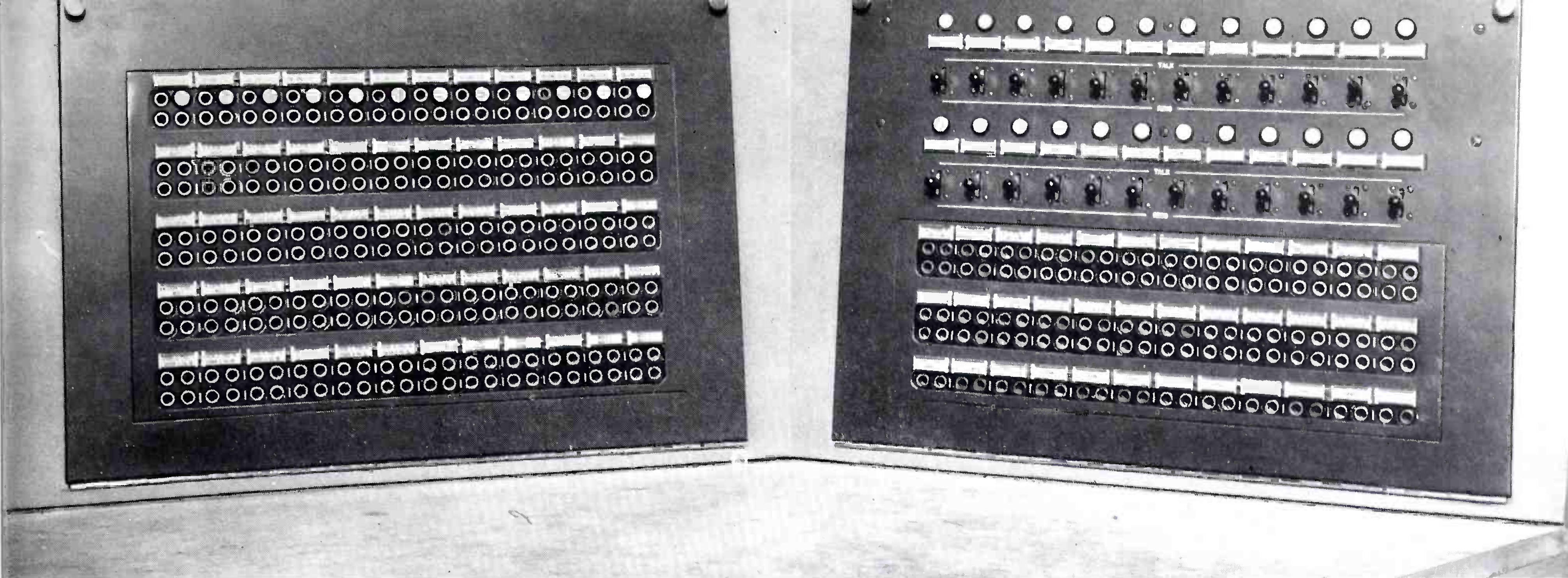
The second panel from the left contains a telephone ring-down panel which provides phone circuits between master control and all studios, transmitters, remotes, local telephone company, A. T. & T. and the local PBX board. Tie keys permit routing phone circuits through the board such as a studio directly to a remote, or the transmitter through to a studio or even a remote through to the local telephone company to tell the wife he won't be home for supper.

On the right hand wing of the desk, (lower view, opposite page) the left hand panel contains the controls for the two master control room monitor selector switches and volume controls and for incoming networks and remotes. The two network circuits are permanently equalized by A. T. & T. in the line rack, and then pass through gain controls on this panel. Net programs of the proper level as governed by master control are then piped to all studios who pick it up with bridging pads. Master control can, if so desired, pick up the network program from the patch panel on the desk and feed it directly into the master switch, thereby eliminating studio control. The four remote circuits are equalized by individual variable equalizers at the equipment racks. Program level is controlled at the desk and then patched either through to a studio or directly into the master switch. By setting up the four remote circuits at the equipment rack, it is possible to handle the normal number of remote programs for the day without further patching.

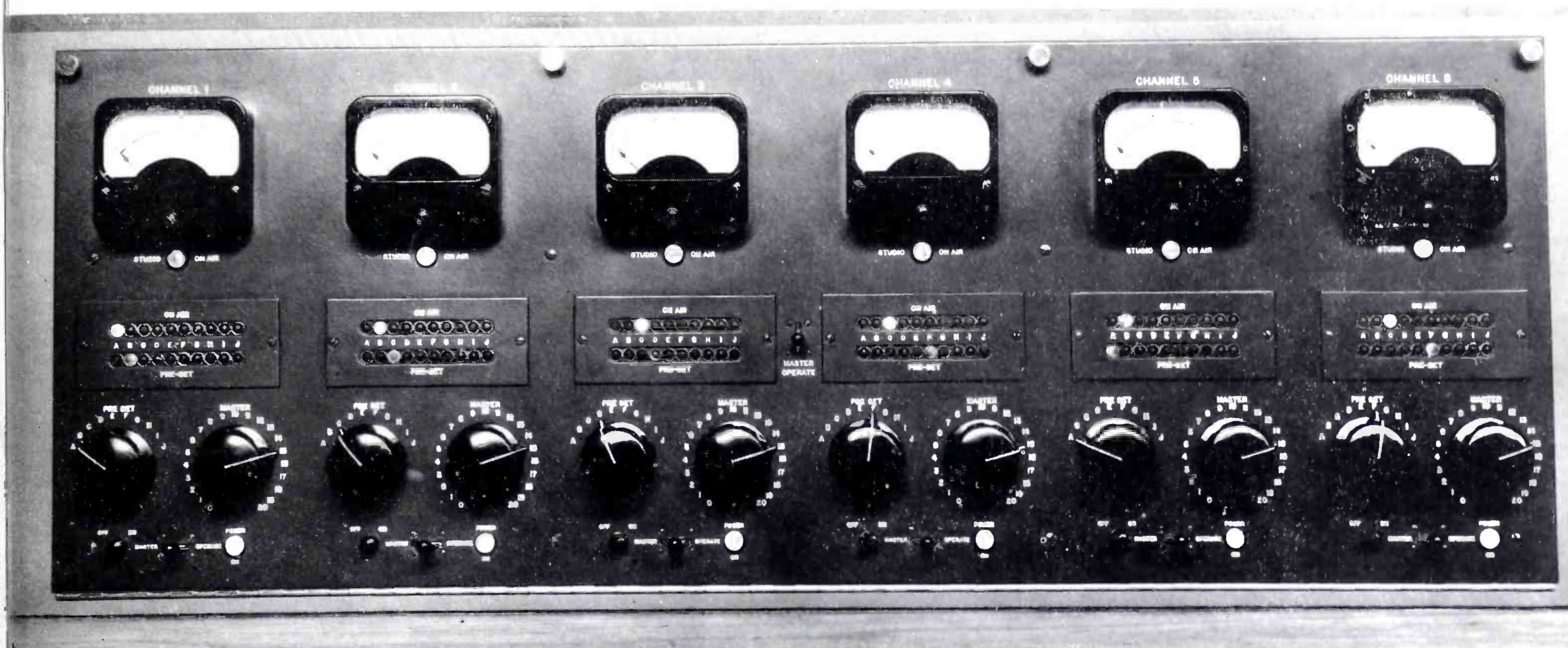
An announce studio is controlled from the extreme right hand panel of the desk. Gain controls are provided on the panel for two microphones and two turntables. On-off relays in these four circuits are so connected that they may be operated by the master operator or their control transferred by means of a lever key to an announcer's console located in the studio. The announcer can, with this feature, turn on or off the announce and news microphones and also the two turntables. A "throat clearing" button is provided on the announcer's console that will kill both microphones regardless of whether master or the announcer has control of the On-Off relays. The two turntable faders can also be used to handle remote or net programs by throwing associated keys to "Adjunct" positions. A spare volume control arranged for bridging or matching input as well as a spare lever key are provided on this announce control panel on the master desk. These two extra features are very useful in making trick setups for special program conditions.



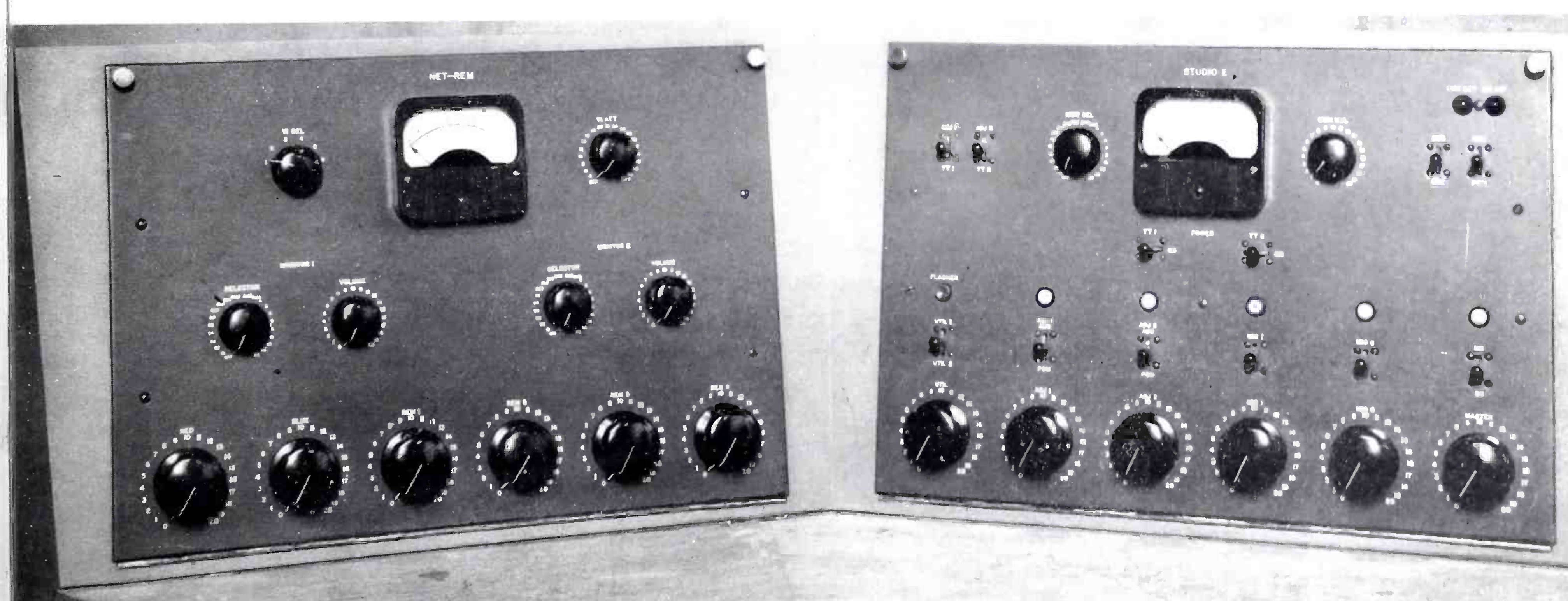
(Left) *Paul Barnes, WFAA Plant Supervisor, at the master control desk.*



(Above) *Jack panels and telephone ring-down panels on left side of desk.*



(Above) *"Pre-set" switching of six outgoing channels is provided by center panel.*

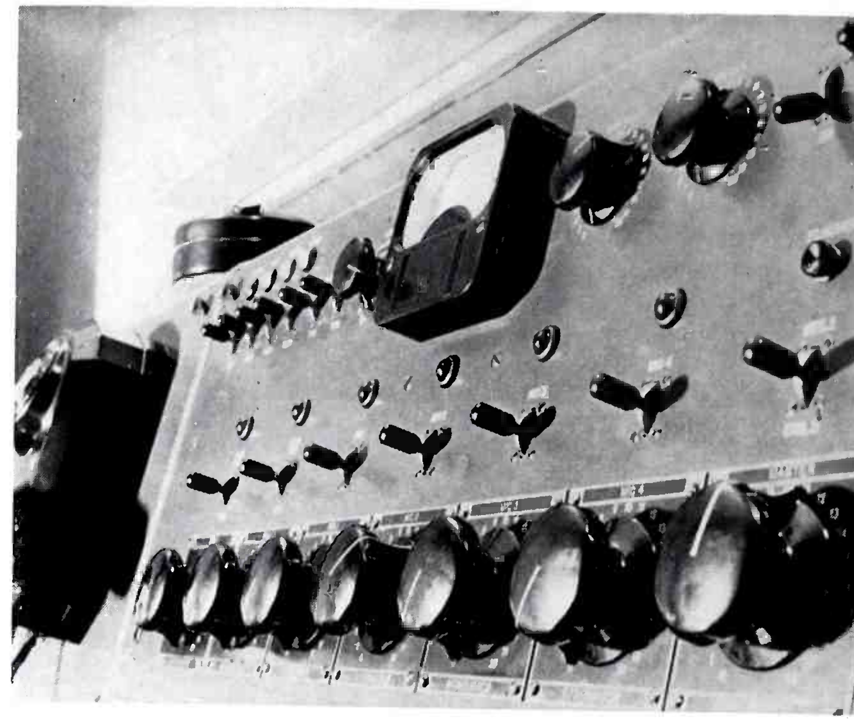


(Above) *NET-REM and Studio E control panels on right side of desk.*

INDIVIDUAL CONTROL BOOTH EQUIPMENTS

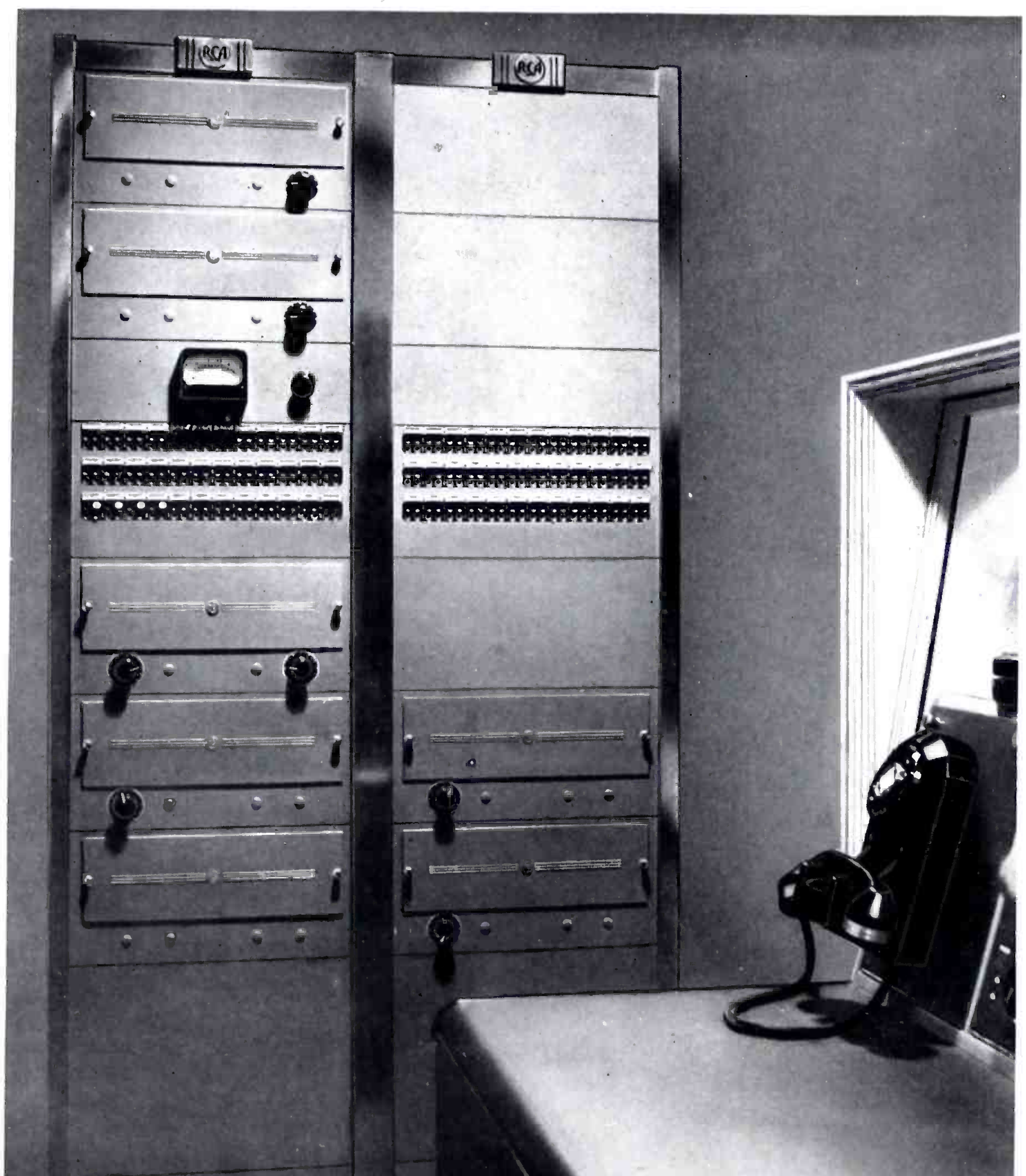
Five of the ten inputs to the WFAA-KGKO master switching system are normally fed from the five active studios. The remaining five provide for network and remote programs, emergency situations and for future expansion. Of the five studios, three are equipped with custom built control consoles and equipment racks of the type shown on this page; one is controlled by an RCA 76-B2 Consolette; and the fifth is the announce studio previously described.

The block diagram on the opposite page shows the circuit layout of the three custom built studio control units. Studio A differs from Studios B and C only in that controls are provided for sound reinforcing in the Studio A auditorium, and an extra rack is required to contain the speaker amplifiers. Otherwise, each console contains inputs for four microphones and two turntables. These turntable inputs may be used to receive network inputs by throwing a key after the preamplifier. Remotes are also handled through these same controls by picking up a trunk from master and patching it into the key. The interlock circuits are so arranged that it is possible to talk-back and feed cue into the studio when the line key is neither in the "On Air" or "Audition" positions. Cue can be fed into the studio when the line key is in either the "On Air" or "Audition" position provided no microphones are turned on. The studio speakers remain on while the line key is in the "On Air" position if program is being handled through the turntable positions and provided no microphones are turned on. The arrangement of the relays is such that it is impossible to get feed back under any condition between the microphones and the studio speakers.

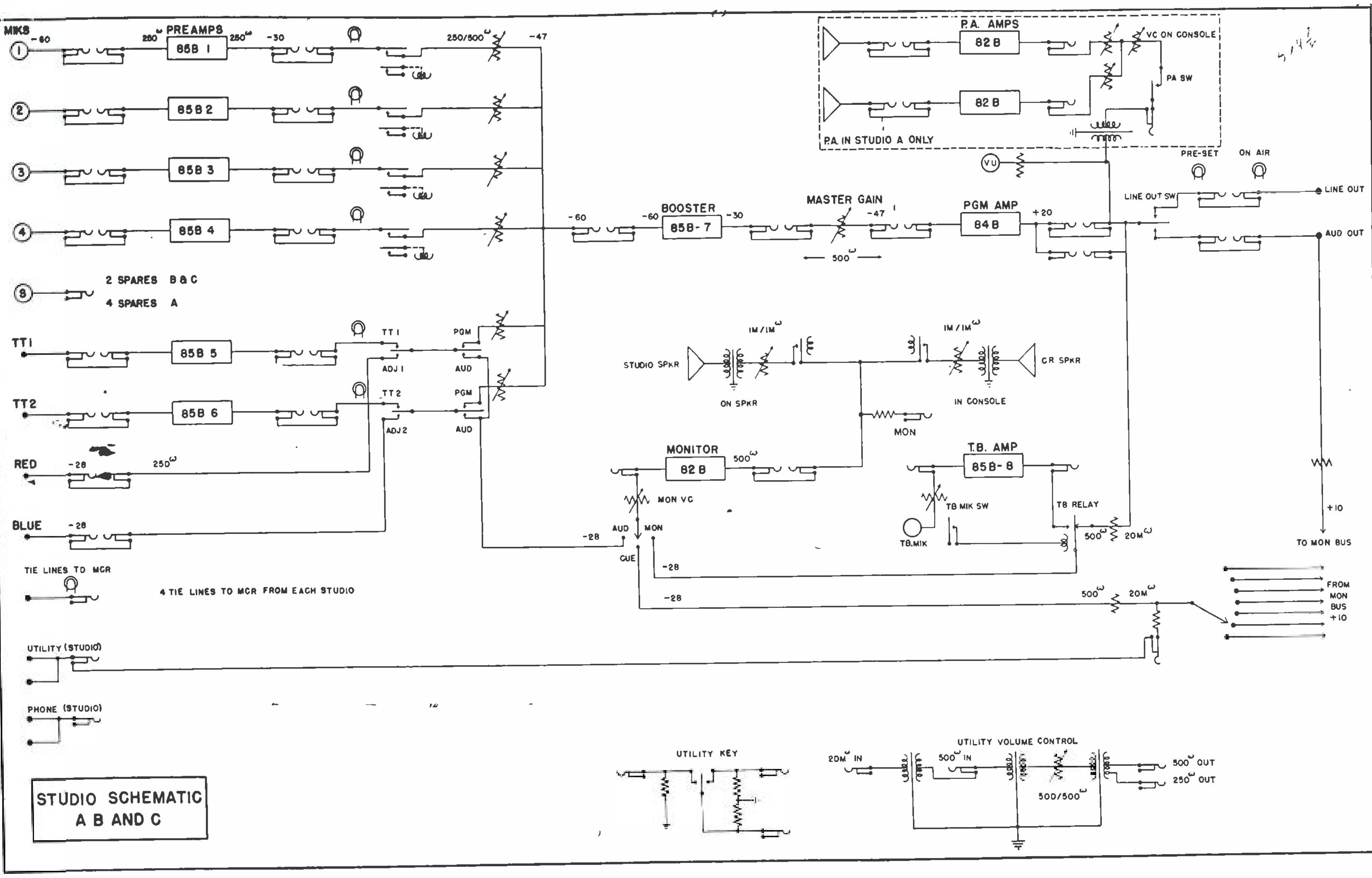


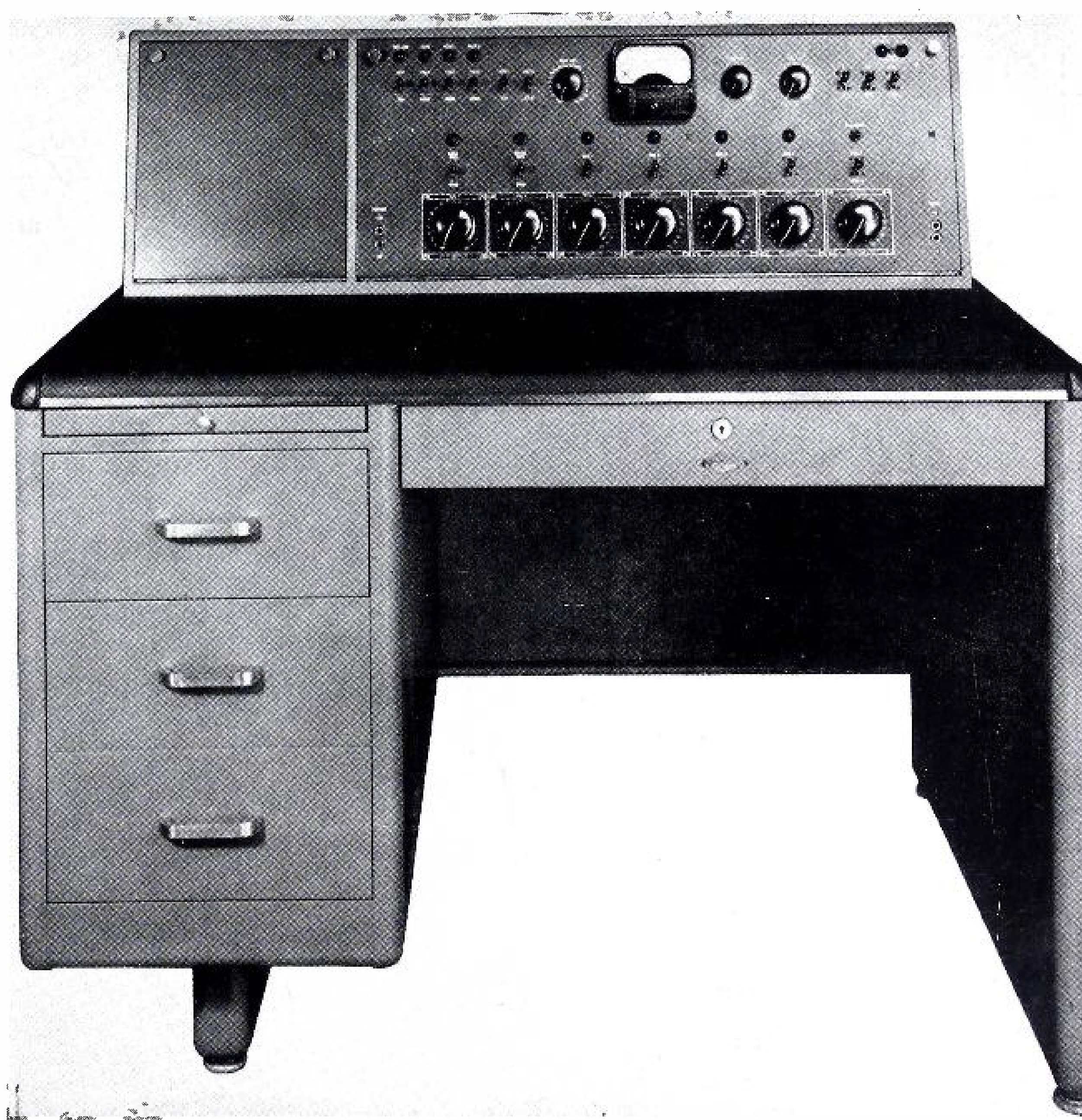
(Above) *Closeup of controls on the studio control consoles used in Studios A, B, and C control booths. Six mixers plus a master control are provided.*

Three ringdown circuits are provided on the consoles; one to master control and the remaining two for patching through to remotes. A utility volume control with bridging or matching input and a utility key are provided for arranging special program setups. Another useful feature is the "Flasher" button. This button is located on the panel near the line out key, and when operated, flashes a bright light in the studio as a warning that the studio is going on the air. In some instances, it has been found necessary to use a photoflood lamp in the announce studio to call the announcer's attention to the fact that he is about to go on the air.



(Left) *Equipment racks in Studio A control booth. A corner of the control console is visible at the lower right.*





(Right) *Custom-built control console used in WFAA-KGKO studio control booths. Racks which house associated amplifiers and switching equipment are shown in photo on opposite page. Schematic diagram of equipment contained in each studio setup is shown above. A converted 76-B2 Console is used in Studio D control booth.*

SELECTING A SITE FOR AN FM STATION

Factors to consider in choosing an FM site; The various types of sites; Advantages and disadvantages

by JOHN P. TAYLOR
Engineering Products Department

Once the area which an FM station is to serve has been established the next step in planning the station—and it is, perhaps, the most important step of all—is to select a site. Because of the very marked effect which antenna height has on FM station coverage, the search for a suitable station site usually boils down to a hunt for a good elevation on which to place the antenna proper. The words "good elevation" are used advisedly for, despite the importance of height, the site selected must also have certain other qualifications.

I. FACTORS GOVERNING CHOICE OF AN FM SITE

The factors which govern the location of FM stations are several, and their relative importance will vary widely with local conditions. Some of these factors have to do with competition, prestige, population distribution and other local conditions about which it is obviously impossible to generalize. The technical requirements, on the other hand, are fairly universal and can be set down in well-defined terms. For this reason, as well as because of their importance, they form a logical starting point.

Technical Requirements

The technical requirements governing the location of an FM transmitter are basically as follows:

(a) The location should be centrally located with respect to the area to be served (unless a directional antenna is to be used).

(b) The location must be as high as possible—always higher than surrounding buildings or elevations.

(c) The location must meet practical requirements as to accessibility, space, service facilities, etc. (These requirements are listed not in order of importance, since in fact, all are equally important, but rather in the order of logical consideration.)

Importance of Central Location

The search for a site can be immediately narrowed down by noting that the site should—very preferably—be near the center of the area to be served. The boundaries of this service area are

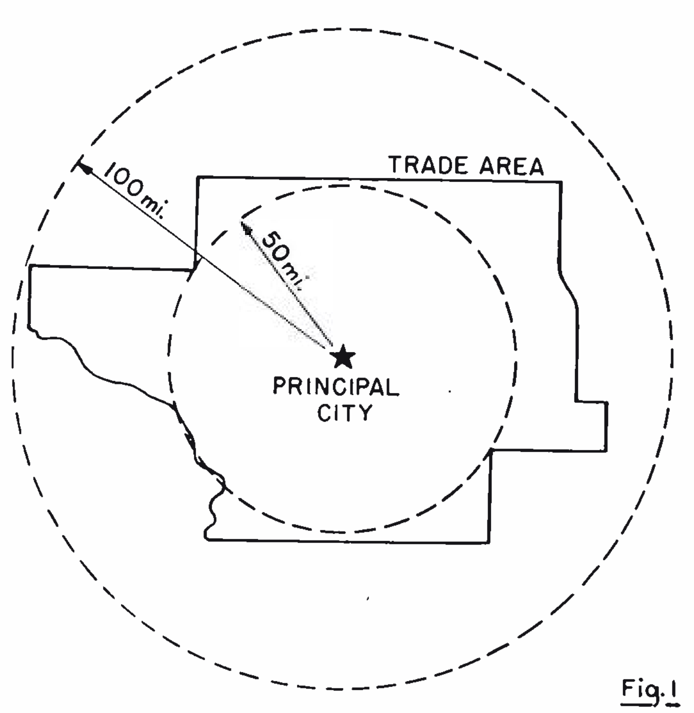


FIG. 1. *When the "principal city" is centrally located with respect to the "trade area," a site within or near the city will provide the most uniform coverage.*

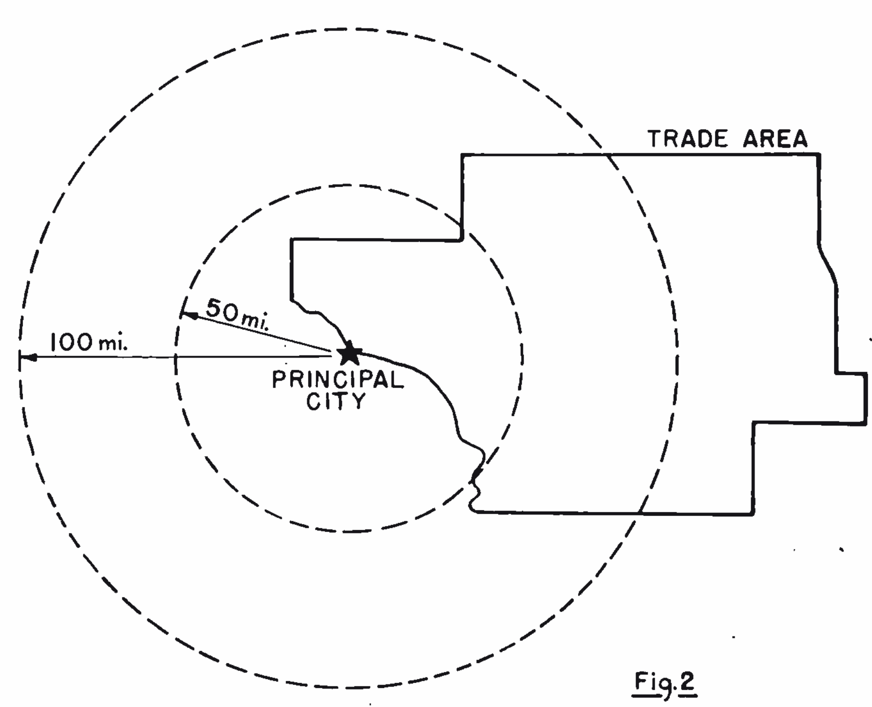


FIG. 2. *When the "principal city" is near one edge of the "trade area," a site in or near the city will not (with the standard "non-directive" antennas) provide the required type of coverage.*

determined within narrow limits by rules laid down by the FCC. Moreover, these rules stipulate that the coverage of the station (defined as the area receiving a signal of 50 microvolts per meter or better) must coincide at least approximately with this service area. Thus, if we assume that the antenna and terrain are such that approximately uniform transmission occurs in all directions, then the site must obviously be near the center of the area. This is illustrated in Fig. 1.

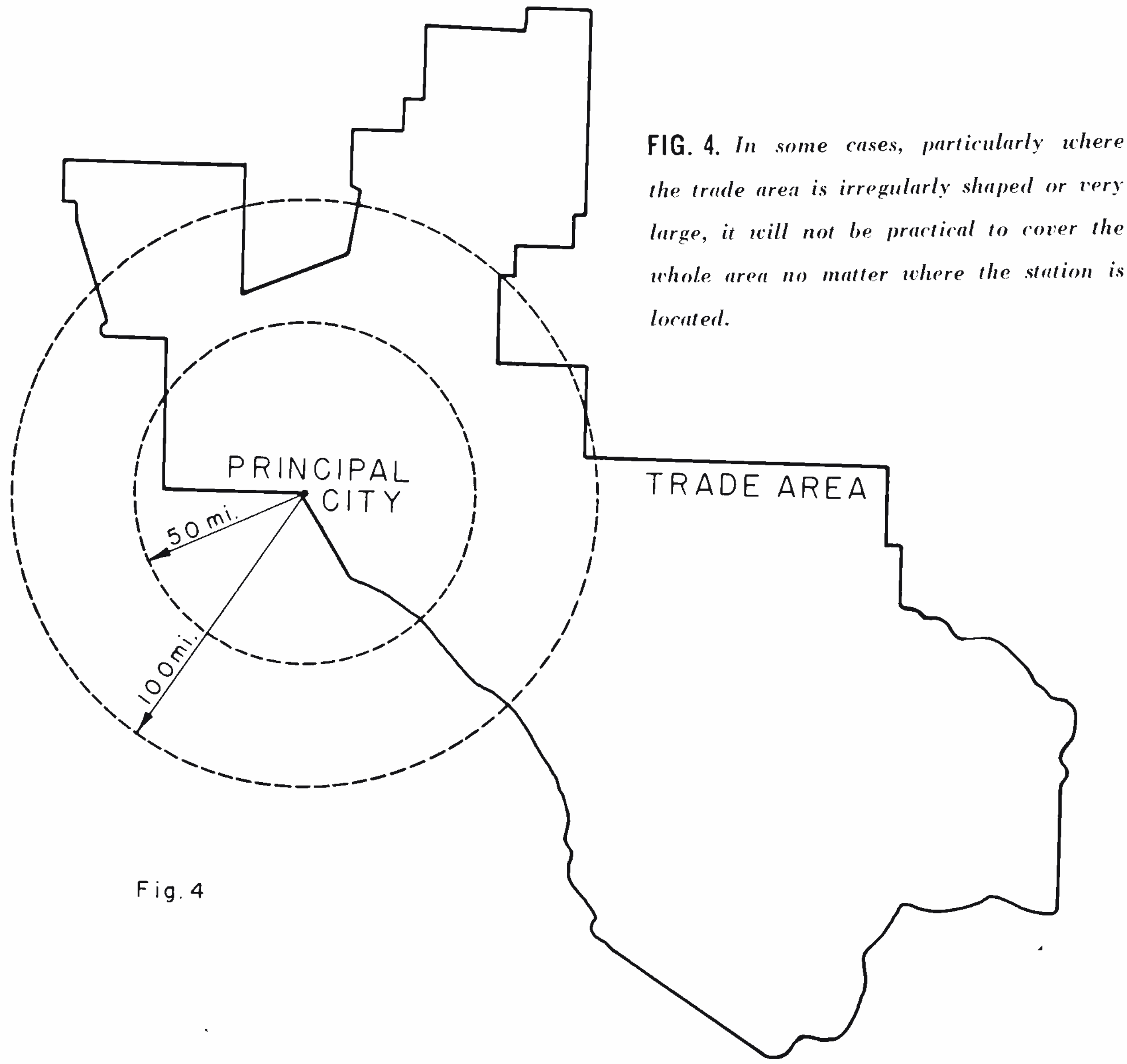


FIG. 4. *In some cases, particularly where the trade area is irregularly shaped or very large, it will not be practical to cover the whole area no matter where the station is located.*

The difficulty of finding a central location will vary with the type of station as well as the nature of the local terrain. Since "basic trade areas" are, by definition, retail shopping areas surrounding principal cities, it will often be found that such areas lie more or less symmetrically around the principal city. Thus, if a suitable site in the city is available, such a location will automatically answer the requirement of concentricity for a station of the basic trade area type.

In many cases, however, the principal city will—because of irregularities of terrain or the proximity or distance of other principal cities—lie to one side of or in one end of the basic trade area, as shown in Fig. 2. Again, because of availability or non-availability of suitable elevations, it may be necessary to locate the transmitter to one side of the area, regardless of symmetry. The question then arises as to how to satisfy the requirement that coverage coincide with service area.

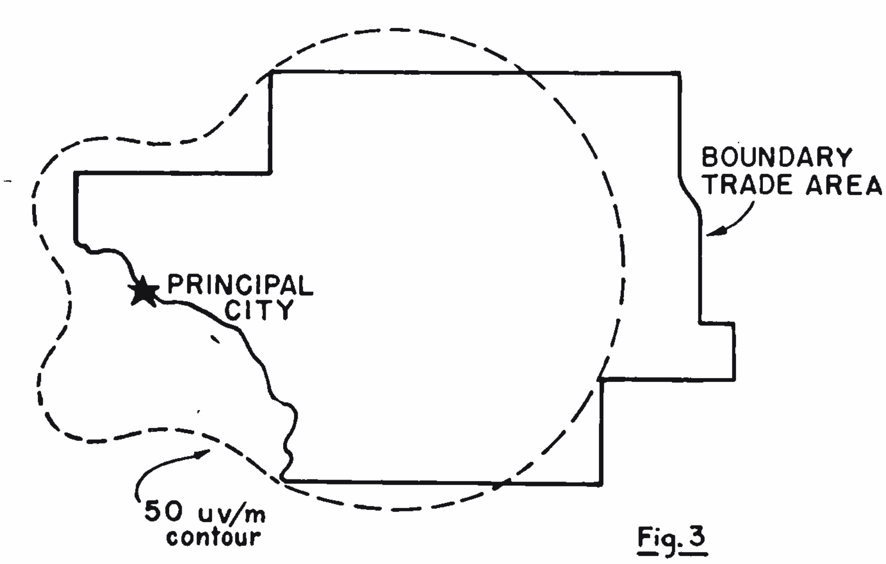


FIG. 3. *Directive antennas which will "tailor" the coverage pattern to the area are possible, but are usually to be avoided because of the added problems they entail.*

Antennas which give radiation patterns of special configuration, such as shown in Fig. 3, can be designed and some of these have actually been built for FM broadcast purposes. (They are common, of course, in point-to-point communication service.) It is difficult, however, to combine in one design both high gain and special directivity. Moreover, such designs involve complicated mechanical arrangements and almost preclude standardized manufacture (since each one would be different). That directive antennas will in the future be used to some extent seems fairly certain. However, at the present state of the art, most engineers prefer not to recommend them. That this also reflects the feeling of the Commission is indicated by the following statement which Mr. George Adair, Chief Engineer of the FCC, made at a recent FMBI meeting in answer to a question on directive antennas:

"The Commission has no requirement as far as a circular pattern is concerned. There is data available on directional antennas for the 40 to 50 megacycle band as well as other bands. However, in my opinion, I believe it is advisable wherever possible to stay away from directional antennas. It is feasible, technically, to employ them and the Commission has no requirement against them. Their use is generally dictated by the

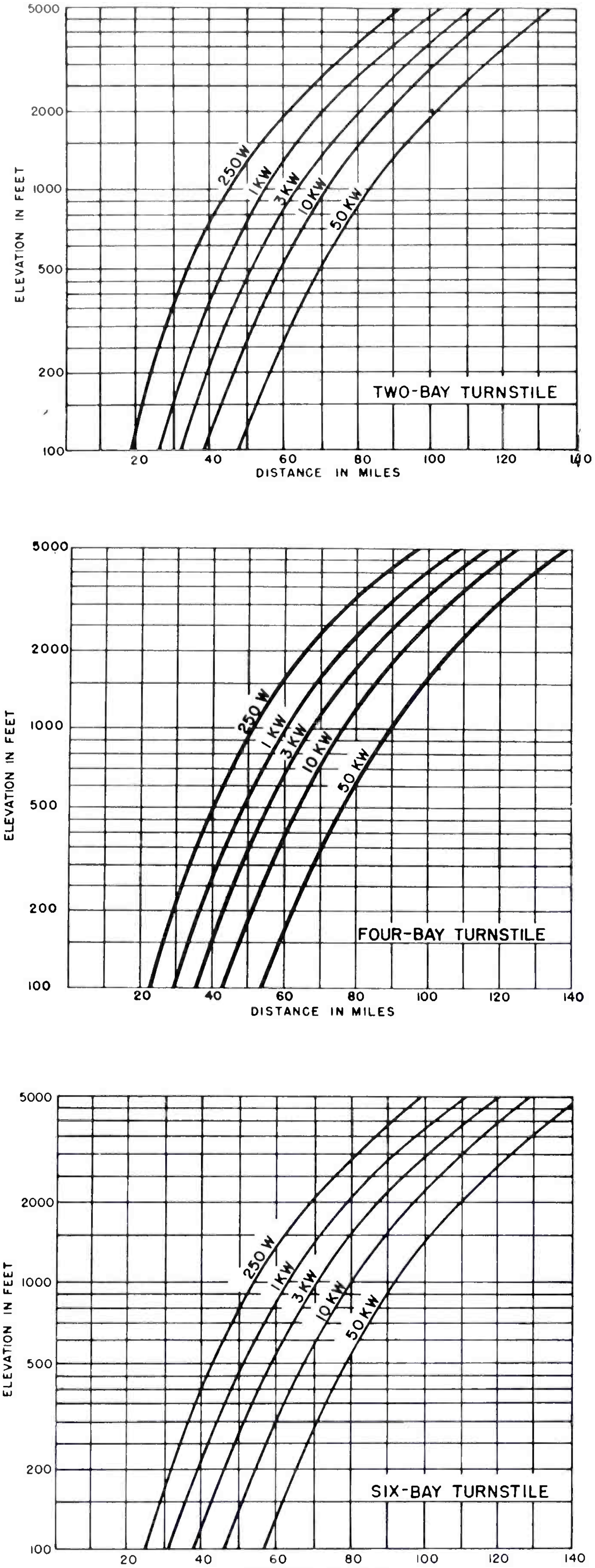


FIG. 5. *Curves showing the relation of height, power and distance to the 50 microvolt line for several types of antennas.*

circumstances, but it adds a little complication in some cases to the installations."

What, then, should be done? The answer, so far as it can be given now, seems to be (a) use non-directive transmission, (b) locate as near the center of the area as is practical, (c) cover as much of the area as possible under the circumstances. In some cases (see Fig. 4) it will simply not be economical, and perhaps not even possible to cover the whole area.

The FMBI in recommendations recently made has suggested that the principle of allocation by service area be retained, but that rigid coupling of service area with trade area be discontinued in favor of recognizing the "natural" service area of a practical installation. This suggestion, if adopted, would help to solve the problem of unsymmetrical and irregular trade areas. Note, however, that it would not reduce the desirability of central location, other things being equal.

Importance of Height

If an appreciable area is to be served by an FM station it is necessary that the antenna be mounted at an elevation well above the general level of the surrounding area. Radio waves travel along the line-of-sight at FM broadcast frequencies. Thus the area served (assuming that the installation has sufficient power) will be only a little greater than that which can be seen from the antenna. (It will be a little greater because some bending of the waves occurs near the horizon.) In obtaining increased coverage, height of the antenna is more important than power of the transmitter.

Fig. 5(a) shows height vs. distance (to the 50 microvolt/meter contour) for transmitter powers from 250 watts to 50 KW, assuming that in each case the antenna is a six-bay turnstile, which has a power gain of 4.3 times. Study of the curves will show the advantage of height in any specific case. For instance, with such an antenna a 1 KW transmitter at 200 feet covers 39 miles; at 400 feet it will cover 48 miles; and at 1000 feet, 65 miles. To cover 48 miles from the 200-foot height would require about 4 KW and to cover 65 miles from 200 feet, about 50 KW. Thus, in this instance, a two-to-one increase in height equals a four-to-one increase in power; and a five-to-one increase in height, a fifty-to-one increase in power. (Note that these ratios are correct only for this particular example, since the relation of height to power varies with height, power and distance.)

Height has another advantage which, in some instances, is as important as the increase in coverage; viz., the ability to overcome the dead spots and areas of poor reception which are caused by the "shadows" of intervening elevations. Fig. 6 shows how a transmitter at a relatively low elevation may have areas of poor reception or even dead spots due to intervening hills, even though these hills are lower than the antenna. As Fig. 7 shows, it may not be possible to avoid shadows altogether in any event; however, the higher the antenna, the less the effect and the smaller the area effected.

It should hardly be necessary to point out that for small areas, in relatively level country, height is not quite so important. Such areas can be covered with medium power and relatively low antennas, provided there are no nearby buildings of greater height. On the other hand, for covering areas greater than 50 or 60 miles in radius, or even less than this in rough country, high elevations are essential.

Practical Considerations

Height, despite its great desirability, should not be allowed to become a fixation. Every site selected as meeting the foregoing

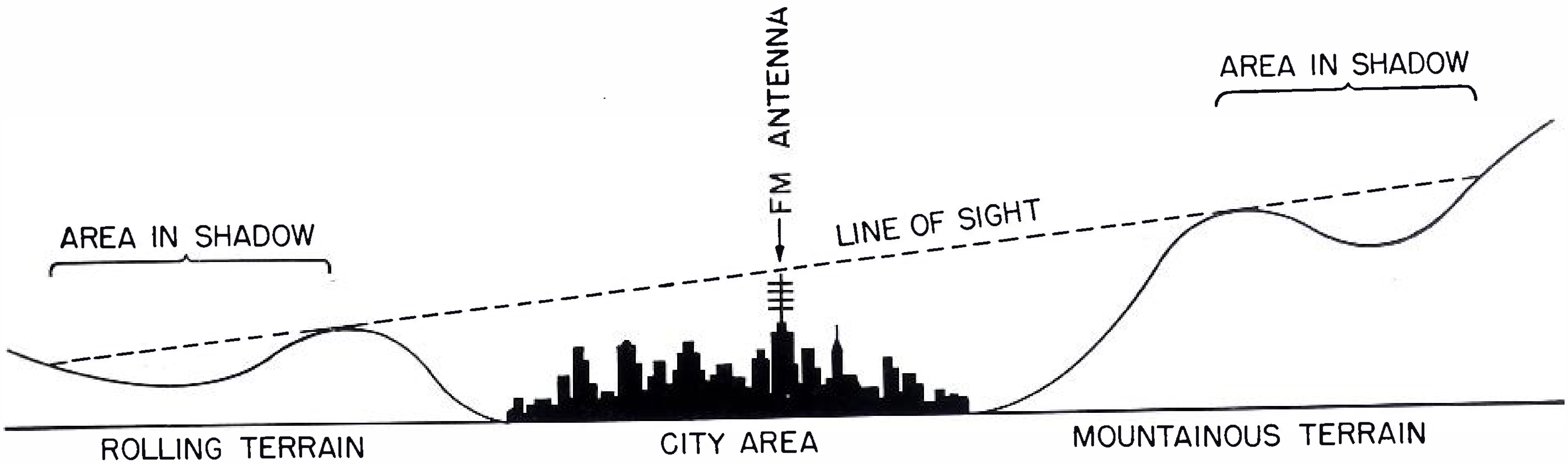


FIG. 6. *In cases of irregular terrain, the coverage of a station at low or medium elevation may contain "shadows" caused by intervening elevations. These shadow areas may receive a poor signal or, in extreme cases, no signal.*

two requirements, that is, of central location and of height, should be subjected to a careful consideration as to its practical merits. It is foolhardy to plan a mountain-top installation to obtain height if the installation cost will be prohibitive. It is equally foolhardy to select a tall building only to find that it will not support an antenna of reasonable gain.

There are certain practical requirements which a site must meet. These should be checked when preliminary consideration is being given to the site rather than after the construction permit is granted and the use thereof becomes almost a necessity.

In the case of a transmitter located on a tall building, the first thing to determine is whether a multi-element antenna of reasonably high gain can be mounted on the building. A six-bay turnstile antenna weighs about 3500 pounds complete and is supported by a pole which projects 64 feet above the roof. This pole is 12 inches in diameter at the butt. In order to have adequate support it should go down into the building some 15 feet. If the building has a flat roof a frame can sometimes be bolted down and the pole braced in this manner. In any event the possibility of supporting the antenna must be carefully considered.

Other things to be determined are whether there is space in the building for the transmitter, a floor structure which will support the weight of the equipment and the necessary power supply available. Because the transmitter will often have to be located in a tall tower or in a loft above the level of freight elevator service, some consideration should be given as to how the equipment will be gotten into place. All of these considerations become particularly important when powers above 3 KW are concerned.

In the case of "mountain-top" locations, equally pertinent questions should be asked. In this case the first consideration is that of accessibility. A 10 KW transmitter involves single units weighing approximately 1200 pounds; a 50 KW transmitter, single units weighing some 2000 pounds. These will have to be trucked to the location. A good road is also desirable from the operating standpoint. A location which is inaccessible by car for days or weeks at a time is extremely unhandy from a maintenance and operating viewpoint.

Another important consideration for "mountain-top" locations is the availability of power. In most cases power lines will have to be built to the location. The cost of this must be considered, particularly if the location is very remote. Telephone lines also will have to be built or a radio link established. Finally there is the building itself to consider. This building must house the transmitter, provide living space for operators, storage space for spares and, preferably, provision for originating recorded programs in an emergency.

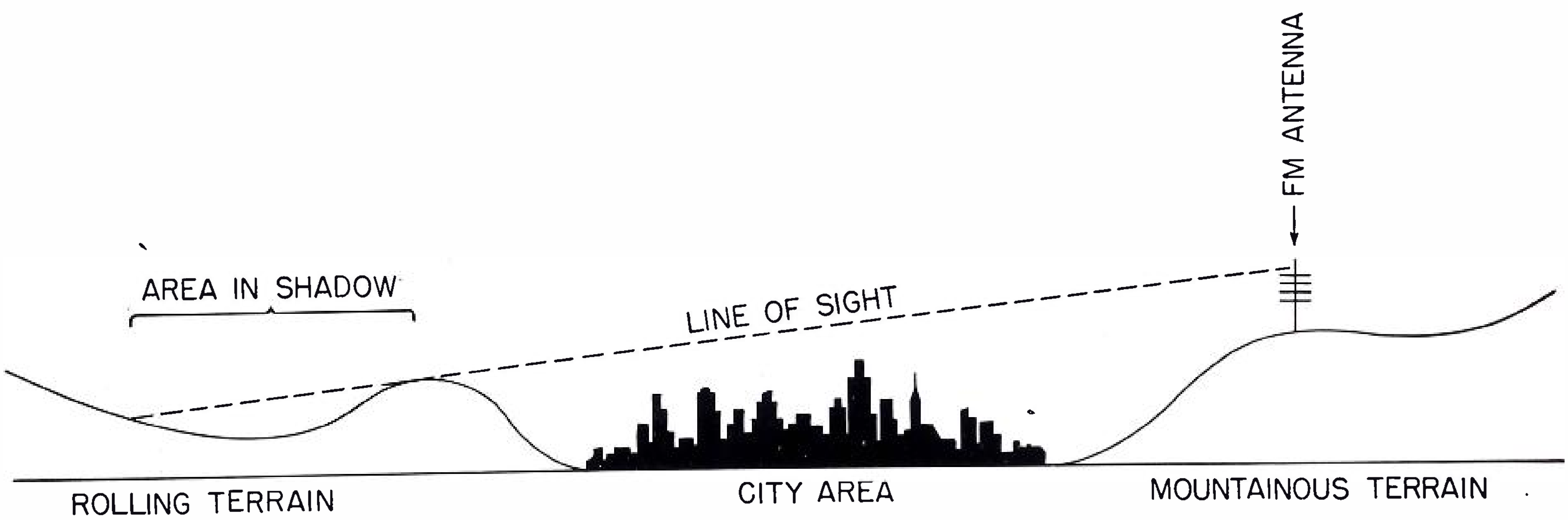


FIG. 7. *The coverage of a station at a high elevation is less subject to "shadows." There may still be areas below the line of sight, but the effect on signal strength will generally be less noticeable.*

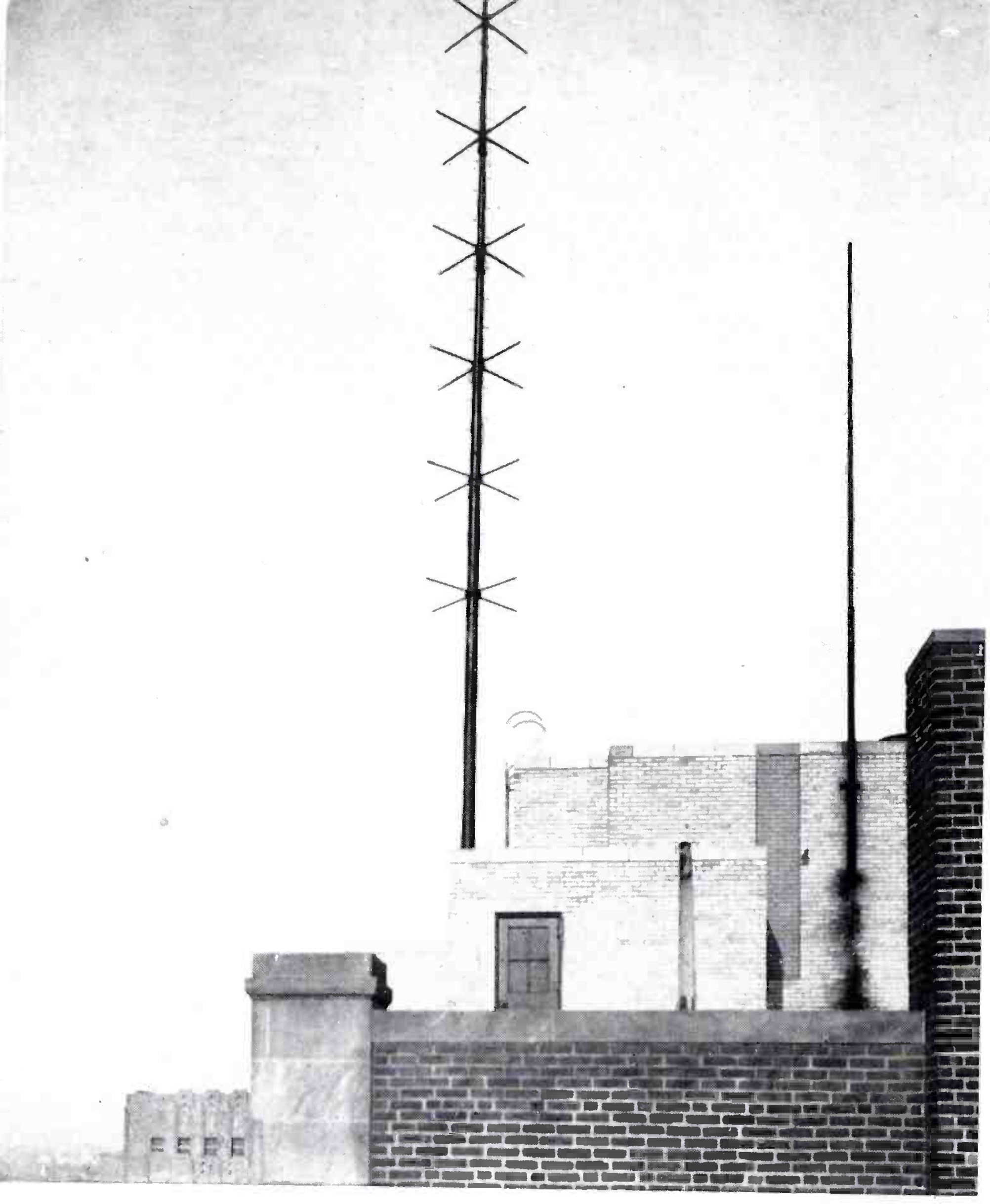


FIG. 8(a). ON A TALL BUILDING. *This is the six-bay turnstile at WCAU-FM, Philadelphia.*

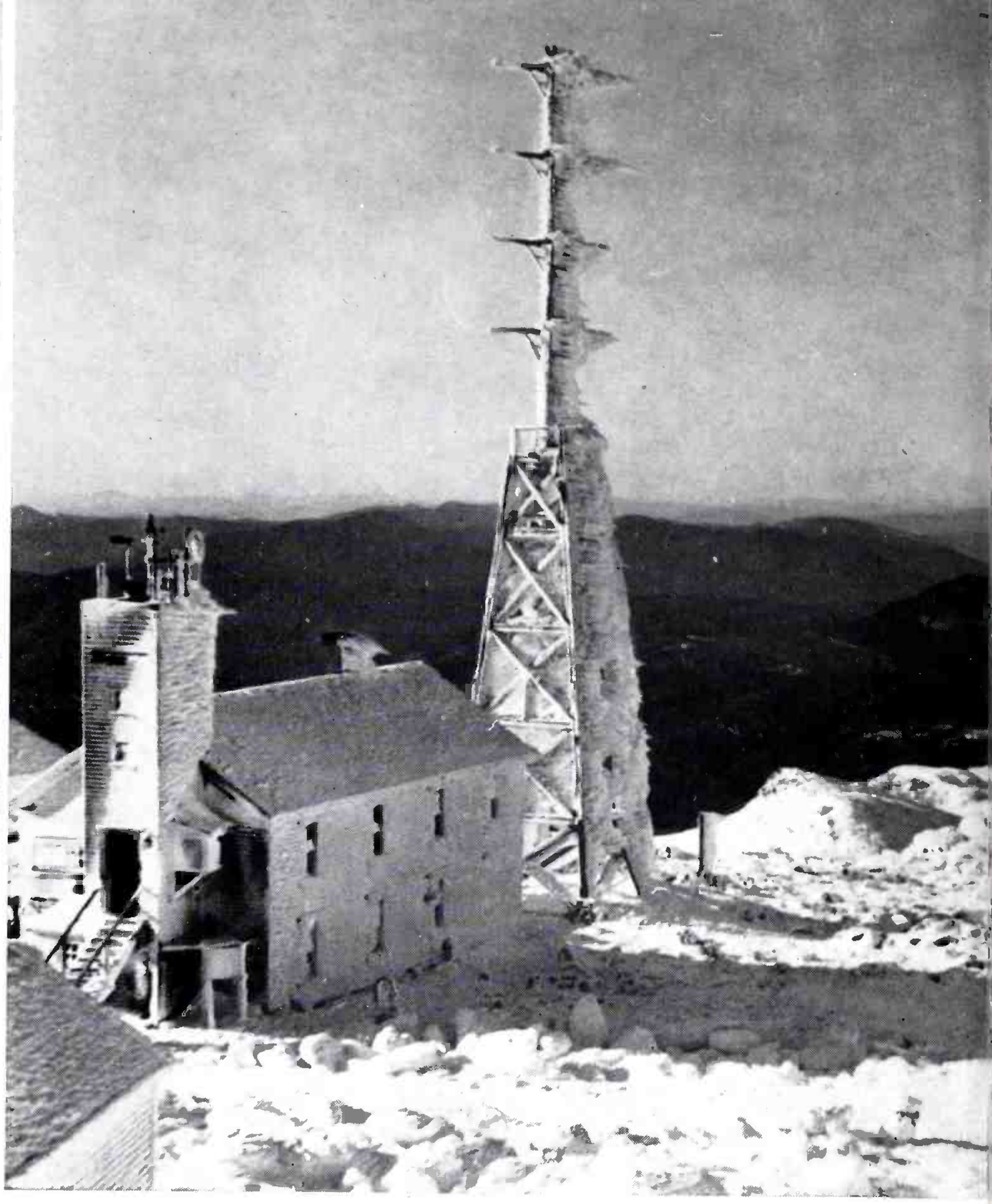


FIG. 8(b). ON A MOUNTAIN TOP. *The antenna of pioneer station WMTW, of the Yankee Network, on Mt. Washington.*

Still another consideration—one which may apply whether the antenna is mounted on a building, a tower or a mountain top—is the question as to whether the Civil Aeronautics Authority will give the necessary approval. In some locations—near airports or on airways—the CAA has set certain maximum heights which cannot be exceeded by any structure.

II. THE VARIOUS TYPES OF FM SITES

There are various kinds of locations which may meet the requirements of an FM site as listed above. These break down into four general categories which may be described as follows: (a) locations involving use of a tall building, (b) locations on mountain tops or high natural elevations, (c) locations at the site of AM transmitter plants with the FM antenna mounted on the AM tower, and (d) locations involving the use of low buildings on which a steel tower is erected to give the required height to the FM antenna.

Which of these types will represent the best choice depends on local factors. Usually one or two of the above alternatives will be immediately eliminated. If the FM station is not connected with an AM station obviously (c) above, is not a consideration. Again, in many cases, no high natural elevations are available so that this possibility is eliminated. In some instances, at least, no suitable tall buildings will be handy.

The type of station will also have an important bearing. For instance, a station to cover a limited trade area or a small basic trading area will usually not justify the cost of a remote mountain-top location. Stations to cover moderately large basic trading areas will do so only if the high elevation used is very near and very advantageous. A station to cover a large rural area, on the other hand, must almost of necessity be so located, since only by having a high location can the designated minimum area of 15,000 square miles—for this type of station—be covered.

Some of the advantages and disadvantages of the four types of locations—as well as particular considerations to be applied in considering each—are as follows:

(a) Locations Using Tall Buildings

The most popular type of location is on a tall building in the center of the "principal city." The transmitter is usually located on one of the top floors and the antenna erected on the top of the building. (See Fig. 8a.) For such use, the buildings chosen are usually 300 to 600 feet tall (with a few, of course, even taller). If the surrounding countryside is reasonably level, an antenna located on such a building will provide very effective coverage. Moreover, the field pattern of such an installation is highly advantageous in that it automatically results in the highest signal strength in the center of the built-up area, where interference (such as ignition noises) is also strongest. The signal decreases going away from the downtown area, as does the interference noise, with the result that signal-to-noise ratio is of the same order throughout the service area. (See Fig. 9).

Installation on a tall building has the further advantage that no land need be purchased, no transmitter building need be built, there are no power lines to erect to a remote spot and no so-called studio-transmitter-link is required (since for the short distances between studio and transmitter satisfactory telephone lines are usually available). Thus, the first cost of a location of this type is low. The eventual cost depends on the rental. If this is high, the long-time cost may exceed that of a site and building owned outright by the station.

FIG. 8(c). ON AN AM TOWER. *FM antenna of WSBF mounted on one of the towers of AM station WSBT, South Bend, Ind.*

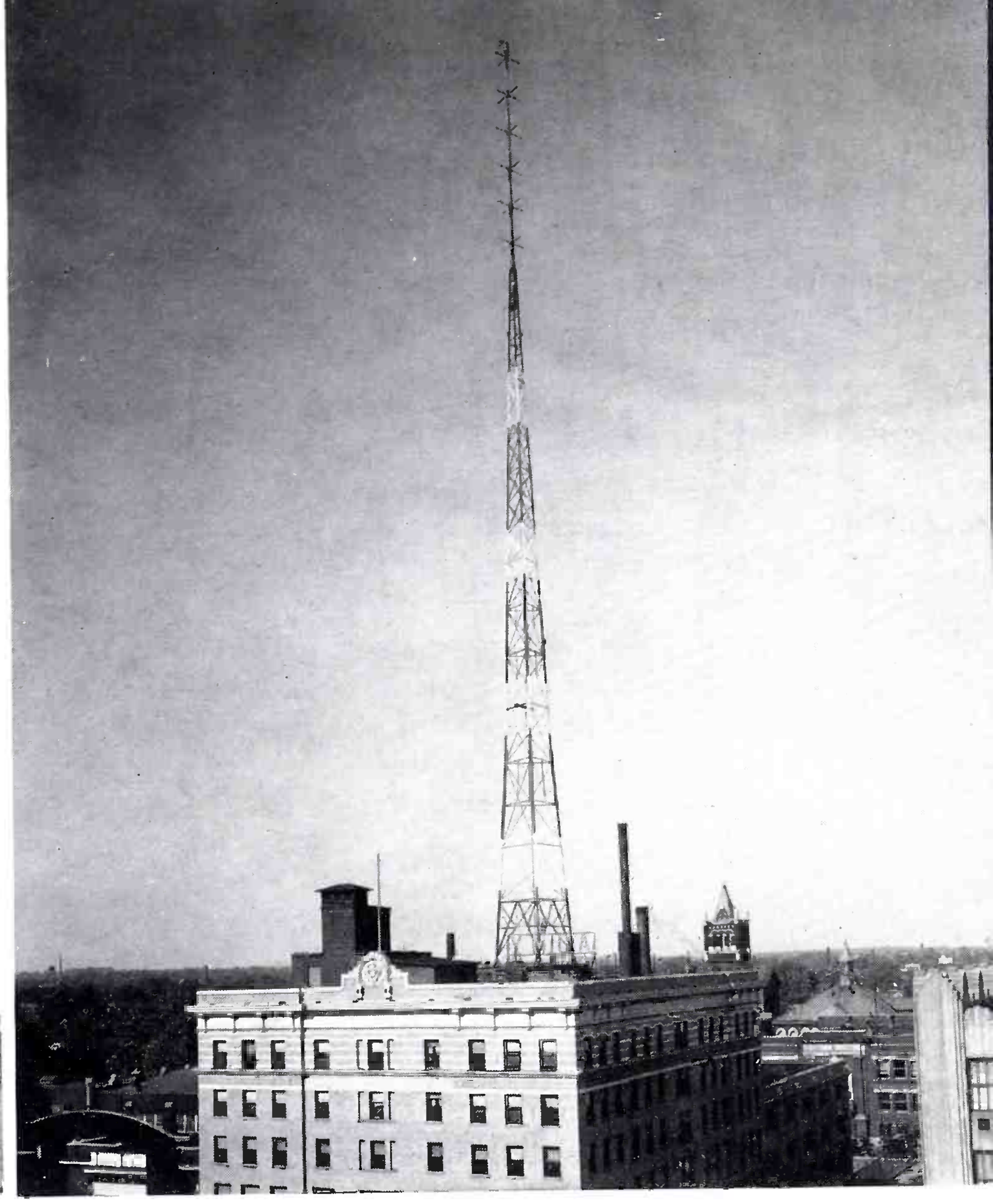


FIG. 8(d). ON A TOWER ERECTED ON A BUILDING. *This is the antenna of WMLL, Evansville, Ind.*

In the way of disadvantages, there is the fact that buildings are only so high and in many instances will be surrounded by nearby hills. In this case, "shadows" may exist behind the hills. Even nearby buildings of greater height have been known to cause shadow patterns. Another common drawback is that it is often not possible to erect a multi-layer antenna, so that desirable "antenna gain" must be sacrificed. Finally, there are the usual difficulties entailed in making a fairly complicated and elaborate installation in a building owned by another party.

Summarizing, the particular things to note in surveying a possible building location are: first, the space available for the transmitter; second, the means by which the equipment can be brought into place; third, the availability of public utilities; and, last but not least important, whether the roof construction of the building will support the type of antenna it is desired to erect.

(b) Locations on Mountain Tops

Quite the other extreme, in so far as the cost and labor of installation go, are the locations on mountain-tops or high hills (Fig. 8b). Such locations have just one advantage, namely, height. As noted above, the effect of height on coverage is striking. By locating the transmitter on a mountain or other natural elevation it is possible to obtain coverage not practical by any other means. This factor alone justifies such locations where large rural coverage is required.

The disadvantages of mountain-tops are several. They entail the purchase of land and the construction of buildings, power lines and other services under the most difficult conditions. The locations are remote, inconvenient and often almost inaccessible. The signal distribution is bad in that the signal is greatest where it is little used and much less (ordinarily) where it is most used. It should be noted that the competitive situation (where there are other stations located in the principal cities) suffers in this respect. As Fig. 10 shows, the station in town has a strong signal where most of the audience lives; the mountain-top station, if very far away, is much weaker. If the stations should, by chance, be only a few channels apart, actual interference may result, although it will not if the separation is sufficient.

The above conditions, of course, apply only to remote mountain-tops. In some cases, moderately high hills exist on the edge of town, or even in the town. These are natural sites for FM stations if procurable. In the cases of very hilly cities, they will be almost a necessity.

(c) Use of AM Tower

When the FM station is to be under the same ownership as an existing AM broadcasting station, there is a third possibility which is sometimes worth considering, viz., location of the FM transmitter in the same building with the AM transmitter. The FM antenna may then be mounted on top of one of the AM towers. A number of installations of this type are in operation. That of WSBF at South Bend, Ind., is shown in Fig. 8c. This consists of a four-bay turnstile mounted on the top of one of the three towers which form the directional antenna system for WSBT's 1 KW AM station.

The big advantage of this type of installation is the saving affected, not only in first cost, but in operating cost as well. First costs are low because there is no land to purchase, no building to erect, no extra cost for running in power lines, etc. Operating costs are lower because of the centralization of operating and maintenance facilities.

There are several disadvantages to this type of installation. For one thing, the location is usually not the very best and some sacrifice of coverage is entailed. For another, mounting the FM antenna on the AM tower is a tough mechanical job (see Fig. 11). Unless the tower has been especially designed for the purpose, it will usually not support an elaborate array. (One way to get around this is to remove part of the existing tower, leaving the turnstile section replace it approximately as to weight and wind resistance.) Again, a problem occurs in bringing the FM transmission line around the tower insulators (if of insulated type), although this can be handled by installation of suitable blocking circuits. Finally, there is the fact that the tower is usually several hundred feet from the building, which, together with the height of the tower, makes for a rather long transmission line with losses which may run to 20 or 30 per cent of the transmitter output.

Despite all of these drawbacks, this type of installation has much to commend it. For those AM stations which wish to start in FM on a small scale—to crawl before they walk—it will, because of the cost savings feature, be very attractive.

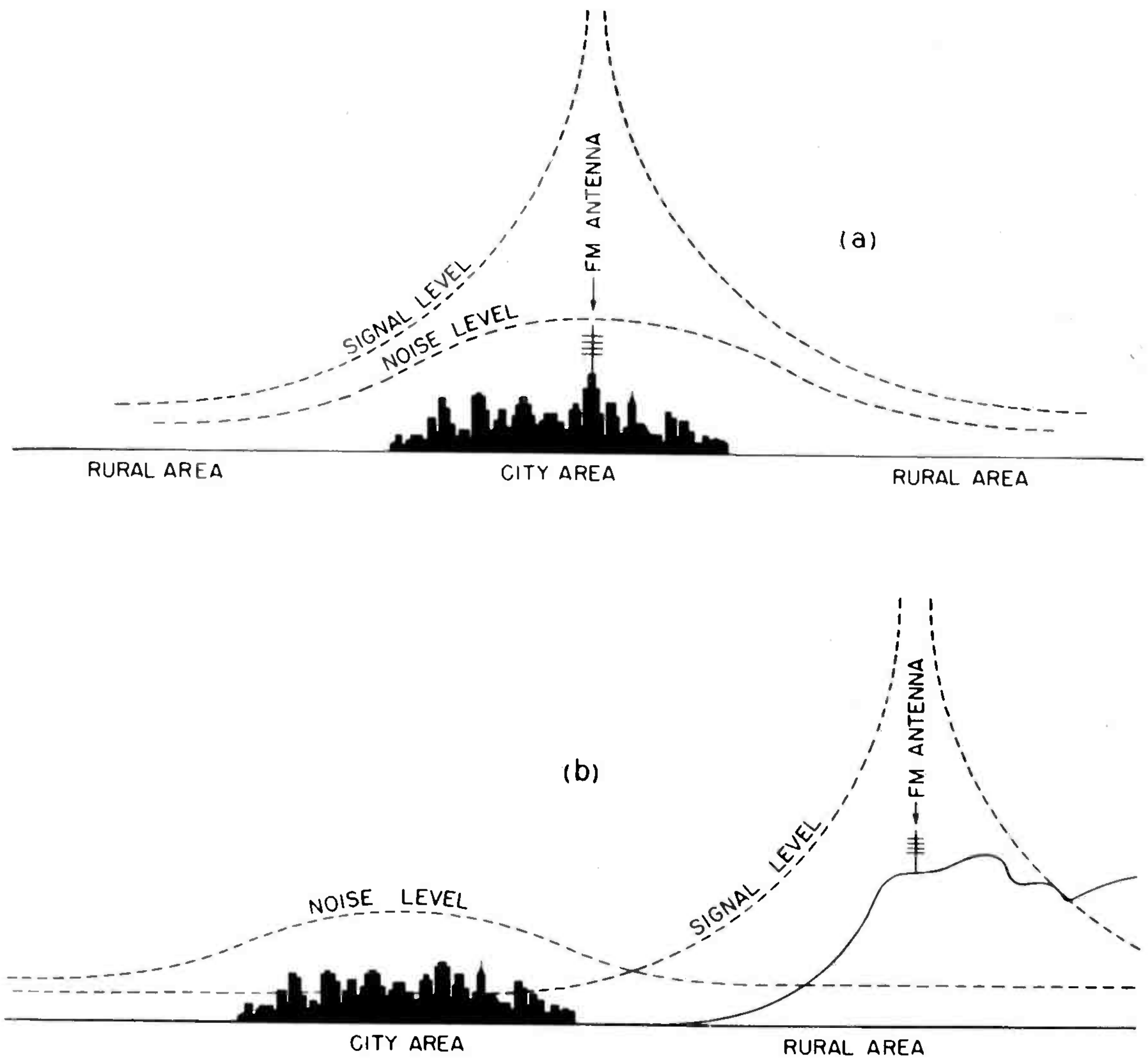


FIG. 9. *An FM station located in the principal city has the advantage of high signal level over town (where the noise level is ordinarily highest) whereas a station located remotely has its highest signal level where least needed.*

(d) Use of Special Structures

If there are no mountain tops or other high elevations within reasonable distance—and no sufficiently high buildings available—only two alternatives are left. One, of course, is to make the best of lower points, using increased power to make up the difference and hoping that the shadows will not be too bad. The other, and better alternative, is to erect a special structure to support the FM antenna. Usually this will be a steel tower of the self-supporting type. In extreme cases, this tower may rest on the ground itself; more usually it will be erected on a building of medium height. The antenna shown in Fig. 8d illustrates this type of installation. The building in this case is less than 100 feet in height. As it is surrounded by several higher struc-

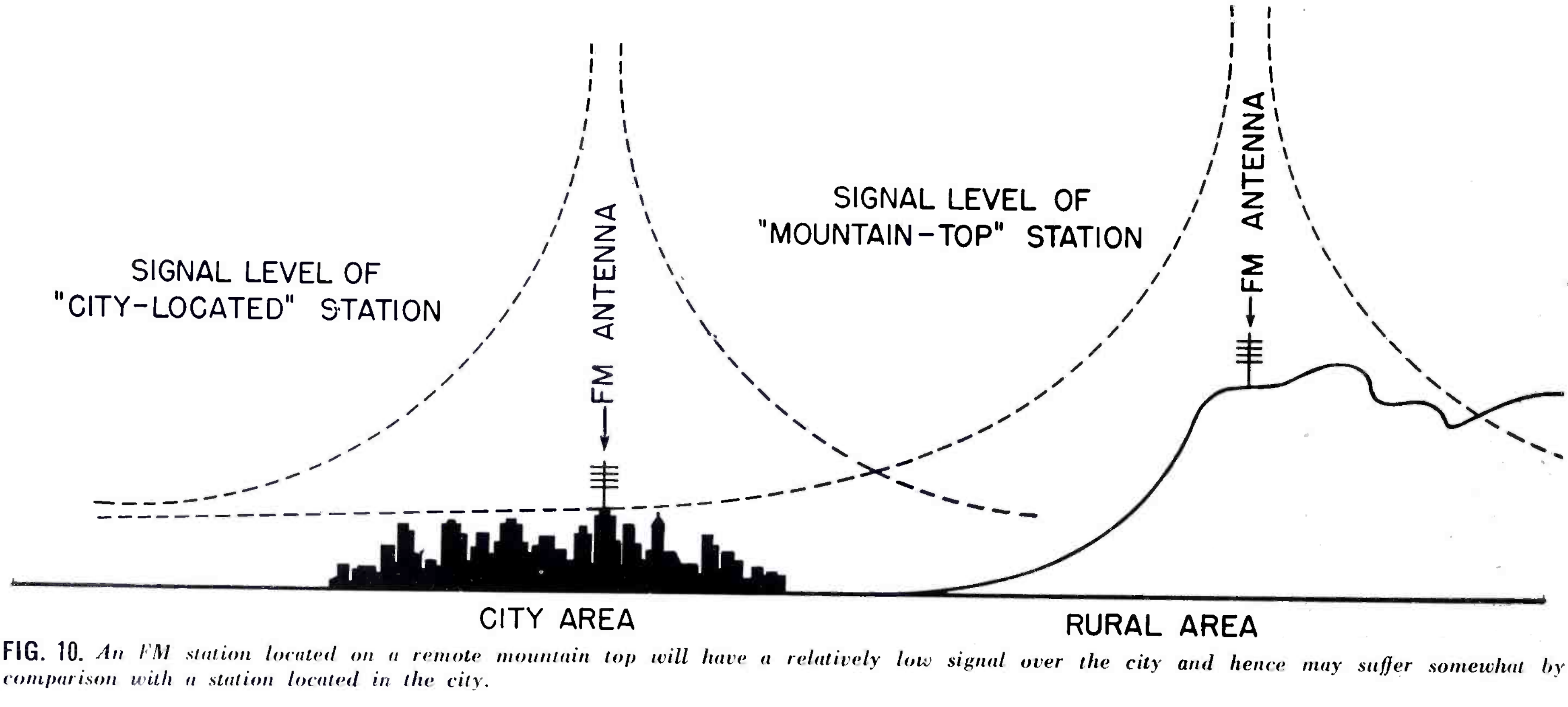


FIG. 10. *An FM station located on a remote mountain top will have a relatively low signal over the city and hence may suffer somewhat by comparison with a station located in the city.*

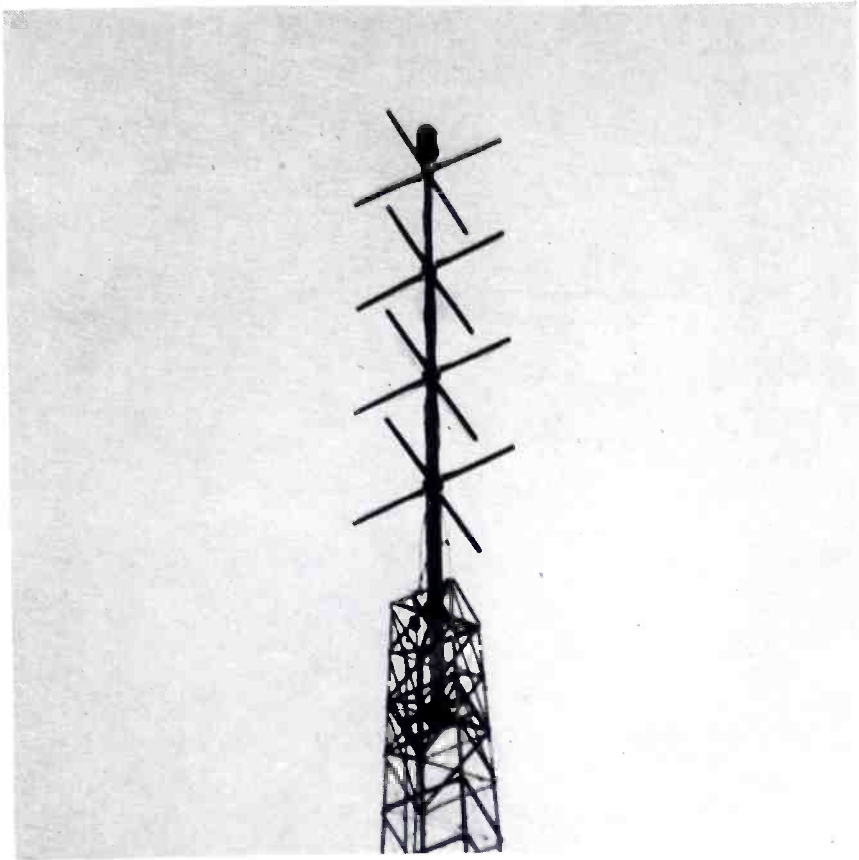


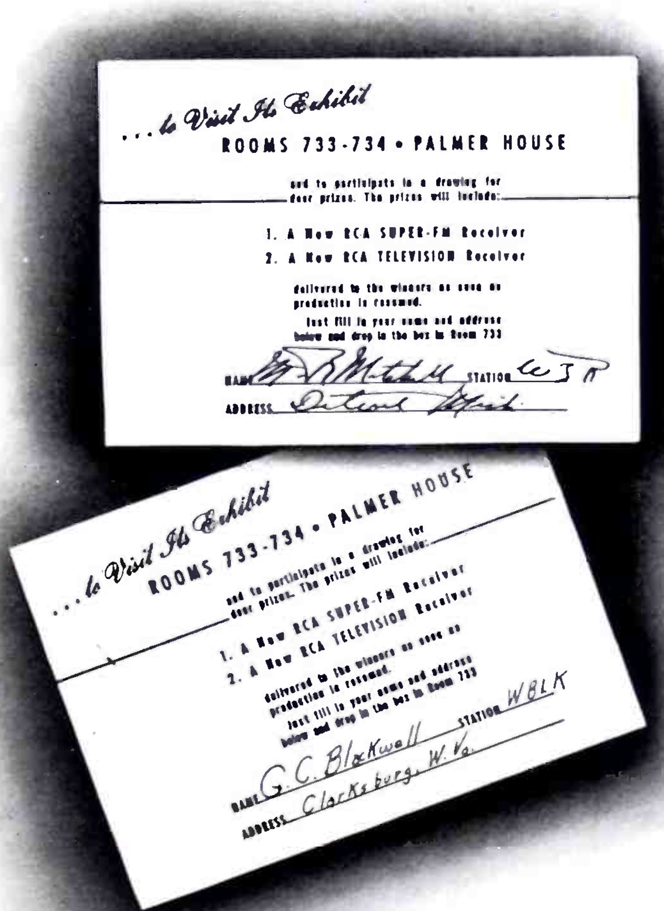
FIG. 11. *Closeup of the 4-bay turnstile at WSBF, South Bend. The "flagpole" which supports the turnstile elements must extend some distance down into the tower.*

tures, an FM antenna mounted at roof height would have suffered serious handicap. To overcome this, the FM antenna was mounted on a steel tower of some 200 feet in height which was erected on top of the building. The four-bay turnstile on the top of this tower is, therefore, about 300 feet above the street. In this case, this tower is also used as the radiator for an AM station. Towers used only for supporting an FM antenna can be of even simpler construction.

What are the advantages of this type of installation? The most obvious, of course, is that it offers a much greater latitude in the choice of the building to be used. Not only does this allow the selection of a good space for the transmitter, but also it may allow the studios to be located in the same building as the transmitter, or vice versa, if the studio site has already been decided on.

The disadvantage of this type of installation is the added cost of the steel tower which must be erected. In most cases, the roof will require extra reenforcing (usually a frame of I-beams) which, together with the difficult working requirements, tends to make erection costs a sizable item. Obviously, the first and most important thing to check when considering an installation of this type is whether the roof will support the tower and what the cost is likely to be.

The NAB Winners . . .



WINNERS of the FM and Television receivers offered as "door prizes" at the NAB meeting in Chicago were Mr. M. R. Mitchell, Chief Engineer of WJR, Detroit, and Mr. G. C. Blackwell, Manager of WBLK, Clarksburg, West Virginia.

Participants in the drawing wrote their names on the stub of their invitations and dropped these in a box at the entrance to the RCA display. At the end of the three-day meeting the box was well-tumbled, to insure mixing up the contents, and two cards drawn from the several hundred deposited. The drawing was made by Mr. Milton B. Sleeper, Publisher of FM-TELEVISION Magazine. The first card drawn by Mr. Sleeper (shown above) was that of Mr. Mitchell, thereby entitling him to receive one of the first RCA Super-FM receivers to come off the line after the war. The second was that of Mr. Blackwell, which entitles him to a new post-war RCA Television receiver. Both will receive these receivers just as soon as production is resumed. To the rest of you, better luck next year.

FIG. 1. *The former home of Senator Arthur Capper—now housing the WIBW Studios.*

ORCHIDS TO STATIONS' GIR

by JUD
Assistan

During a visit to the Capper Stations in Kansas State, recently, it occurred to me that women are playing a big part in radio these days. I had known they were doing an important job in the entertainment field, but I soon found that their activities in radio didn't end there—their work extends to the transmission of the programs, too. What's more, they love this technical work!

Calling on Station WIBW, where the offices of Mr. Ben Ludy, general manager of the Capper Stations (WIBW in Topeka and KCKN in Kansas City) and Mr. Karlton "Pug" Marquadt, chief engineer of both stations, are located, was a very enjoyable experience. The studios are located in the home of Senator Arthur Capper and the Senator's library and some of his furnishings have been retained which gives it a charming, home-like atmosphere. The programs which originate here are of the friendly, family type, making WIBW one of the most popular stations in rural Kansas.

The control room operators at WIBW are typical of the modern American girl who has taken the responsibility of positions which were formerly held by men. Miss Barbara Colvin and Mrs. Zelda Briggs, who have been handling this job, have won the admiration and cooperation of their co-workers by the intelligent way they've handled the complicated duties involved in this work.

The girls at WIBW's sister station, KCKN, have also been making a name for themselves. They've been operating the control board and turntables since KCKN moved their quarters to Kansas City, Missouri from Kansas City, Kansas last March—and have been doing a swell job, too, according to Mr. Ellis Atteberry, manager of KCKN and Mr. Maxell Williams, engineer-in-charge.

Much of the credit for smooth operation right from the start goes to Mrs. Hazel Gingery, a former KCKN announcer, who

FIG. 2. *Barbara Colvin and Zelda Briggs at the WIBW controls.*

FIG. 3. *Mary Louise, popular M.C. and announcer for KCKN.*

THE CAPPER
OPERATORS

ALESI
itor

FIG. 6. *Dorothy Findley, Martha Sue Crawford and Marybeth Malsie in action at the KCKN studios.*

trained the girls just before they moved. Previously, the announcers handled the turntables, as well as their scripts. This was quite a feat so it was natural, when the station's facilities were enlarged, to affect the present allocation of work.

The girls learned their jobs quickly and thoroughly and proved to be very efficient. Most of them have 3rd class operators' licenses and are so enthusiastic about their work that they plan to study further. The staff includes Mrs. Helen Fraser, Miss Dorothy Findley, Miss Pat Gordon, Miss Martha Sue Crawford and Miss Marybeth Malsie.

KCKN's foresight is also evident in their choice of a girl announcer. Miss Mary Louise, attractive M.C. of a program called "Private Smiles" (tips to servicemen in that area on where to go and what to see), leads one to believe they had Television in mind when they hired her. She is one of the few women holding a full-time announcer's job on the air today.

To complete the cycle necessary to give KCKN's many listeners the popular programs they listen to, another woman is also on the job—Miss June Robinette, transmitter engineer. Miss Robinette has the distinction of being the only woman in a union of radio engineers. She was accepted as a full-fledged member due to the merit of her work during the seven years she has spent as a radio station engineer. There's no question about Miss Robinette's enthusiasm about her work; at one time she devoted 80 hours per week to it by holding two full-time jobs for many months.

The story that newspapermen have printer's ink flowing through their veins is a familiar one; my trip to the Capper stations convinced me that radio waves and electronics effect radio technicians in the same way.

FIG. 4. *Helen Fraser at the KCKN turntables.*

FIG. 5. *A full-fledged, licensed transmitter engineer—June Robinette of KCKN.*

. . . WWV . . . WWV . . . WWV . . .
Broadcasting Frequency Standards with RCA Type ET-7285 Transmitters

by R. J. NEWMAN
Transmitter Engineering Section

Covering the United States and reaching into the far corners of the world, the standard frequency and time interval services of the National Bureau of Standards are providing both audio and radio-frequency standards which have an accuracy, as transmitted, that is better than one part in 10,000,000. Under the direction of Dr. J. H. Dellinger, head of the Bureau's Radio Section, Radio Station WWV, Washington, D. C., is operated to furnish this standard frequency broadcast service. WWV passed the one-year mark this summer in its new home which is completely equipped with new and expanded facilities. Directly charged with planning, engineering and operation of this station is Mr. W. D. George and his assistants, Messrs. G. H. Lester and M. C. Selby.

The transmitter building, shown on this page, which was especially designed and built to house the radio transmission activities of the Bureau of Standards, is the home of the WWV transmitting plant. Constructed of brick with a steel frame and poured concrete floor and ceiling, this single story building measures approximately 93 feet long, 43 feet wide and 22 feet high.

This transmitter plant, located at Beltsville, Maryland, is equipped with four RCA Type ET-7285 High-Frequency Broadcast Transmitters. Operating on any one of six carrier frequencies, 2.5 mc., 5.0 mc., 10 mc., 15 mc., 20 mc. or 25 mc., at least three of these transmitters are on the air at all times to maintain the continuous 24-hour schedule. In service over a year and operating for weeks at a stretch, without shutdown, these units have given new proof of the ruggedness and dependability of RCA transmitting equipment.

The ET-7285 Transmitters were originally designed for a power output of 7.5 kw. at 20 mc. Subsequent tests and actual operation proved this value was conservative and could be considerably exceeded at all carrier frequencies. These transmitters are now operated by the Bureau at a nominal output of 10 kw.

At least three of these transmitters operating on separate carrier frequencies are on the air at all times to insure reliable coverage. The radio frequencies now in use are:

2.5 megacycles (2500 kilocycles) per second broadcast from 7:00 P.M. to 9:00 A.M. EWT (2300 to 1300 GMT).

5 megacycles (5000 kilocycles) per second broadcast continuously day and night.

10 megacycles (10,000 kilocycles) per second broadcast continuously day and night.

15 megacycles (15,000 kilocycles) per second broadcast from 7:00 A.M. to 7:00 P.M. EWT (1100 to 2300 GMT).

The lowest frequency provides service to short distances, and the highest to great distances.

Two standard audio frequencies are used to modulate the r-f carriers. Both 440 and 4000 cycles per second are broadcast continuously on 10 and 15 megacycles. Both are also on the 5 megacycle carrier in the day time, but only 440 is used from 7:00 P.M. to 7:00 A.M. EWT. Only the 440 signal is on the 2.5 megacycle carrier.

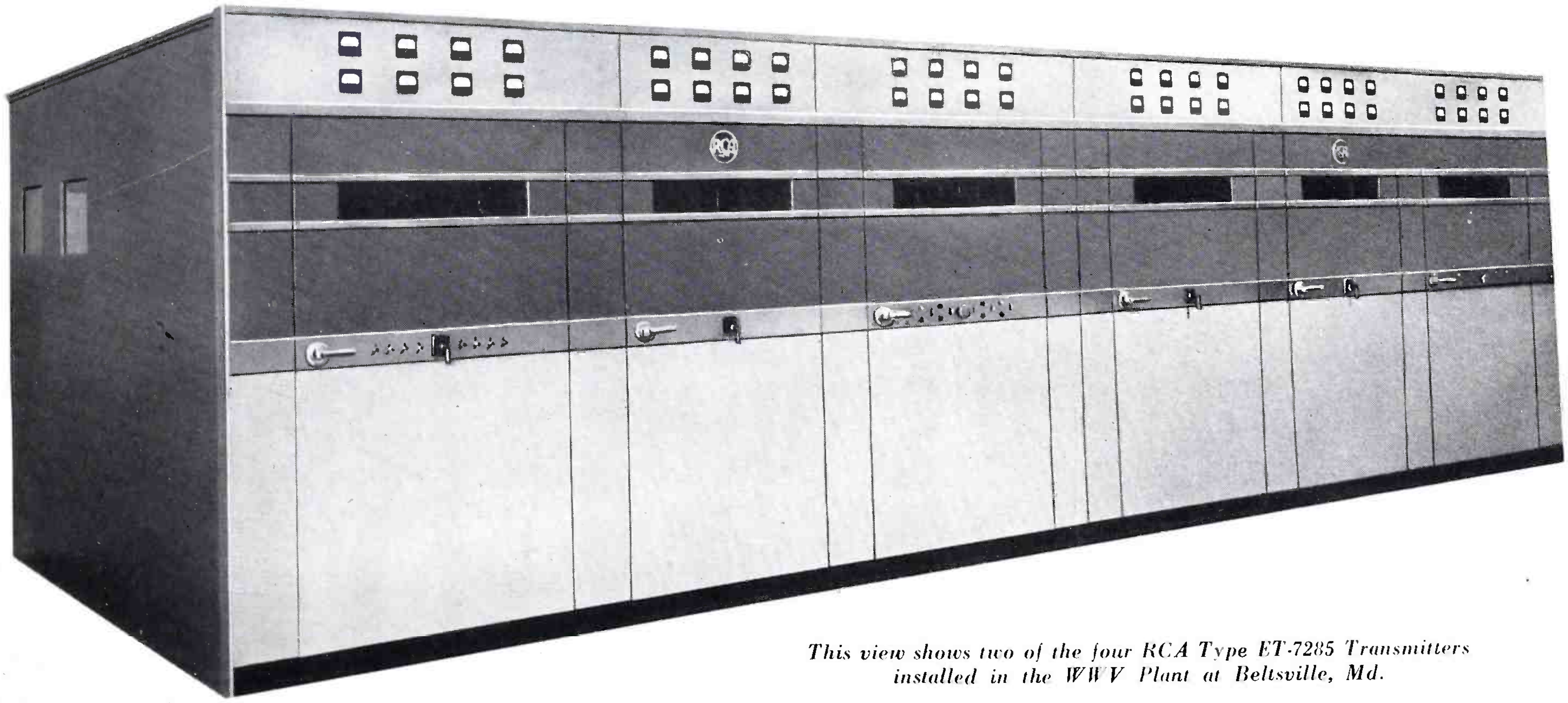
The 440 cycle note is the standard musical pitch, A above middle C; the 4000 cycle note is a useful standard audio-frequency for laboratory measurements. In addition, there is superimposed on all carrier frequencies, a pulse of 0.005 seconds duration which occurs periodically at intervals of precisely one second. The pulse consists of five cycles, each of 0.001 second duration, and is heard as a faint tick when listening to the broadcast; it provides a useful standard of time interval, for purposes of physical measurements, and may be used as an accurate time signal.

A unique feature of these transmitters is the fact that they possess no oscillator. A primary frequency standard located in a vault 20 feet underground supplies one watt of r-f energy at 2500 kilocycles per second to the 1st amplifier of each transmitter. This 2.5 mc. signal is then multipled by two harmonic generators to produce the desired carrier frequency.

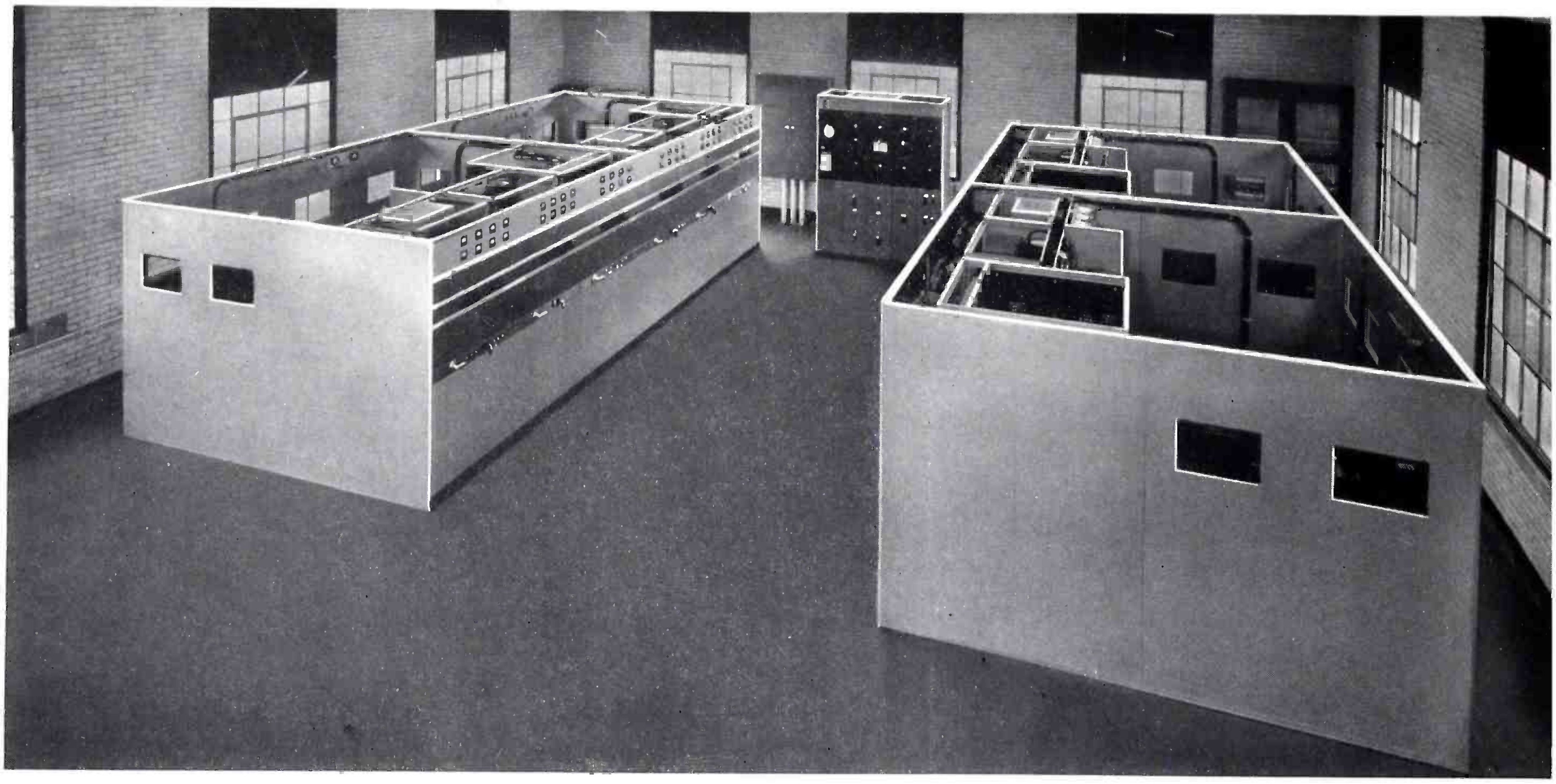
Such features as automatic starting and stopping of the transmitters in accordance with a preset schedule and dual operation of two equipments wherein the failure of modulation or carrier of the transmitter in operation will automatically shut it down and start up a stand-by unit, play a vital part in the maintenance of the rigid broadcast schedule.

A large share of credit is due to the engineers who operate the transmitters, Mr. G. H. Lester, and his assistants, Messrs. J. M. Shaull and E. C. Wolzien. Their strict maintenance program includes a service period of three days per transmitter during which the entire equipment is gone over with a fine-tooth comb. The fact that WWV can boast a record of a single momentary outage during an operating period of three months, for all transmitters combined, is due not only to the equipment, but also to the station's rigid maintenance policy. A front view of two of the transmitters at WWV is shown below.

Complete isolation of each transmitting equipment within individual partitions provides a pleasing and finished external appearance and, at the same time, maximum safety for the operating personnel. To prevent accidental opening of any of the interlocked access doors (which would, of course, shut the transmitter down), specially designed electric locks secure these doors when the high voltage switch is closed. A detailed description of the arrangement of these units and of the units themselves will be found on the following pages.



This view shows two of the four RCA Type ET-7285 Transmitters installed in the WWV Plant at Beltsville, Md.

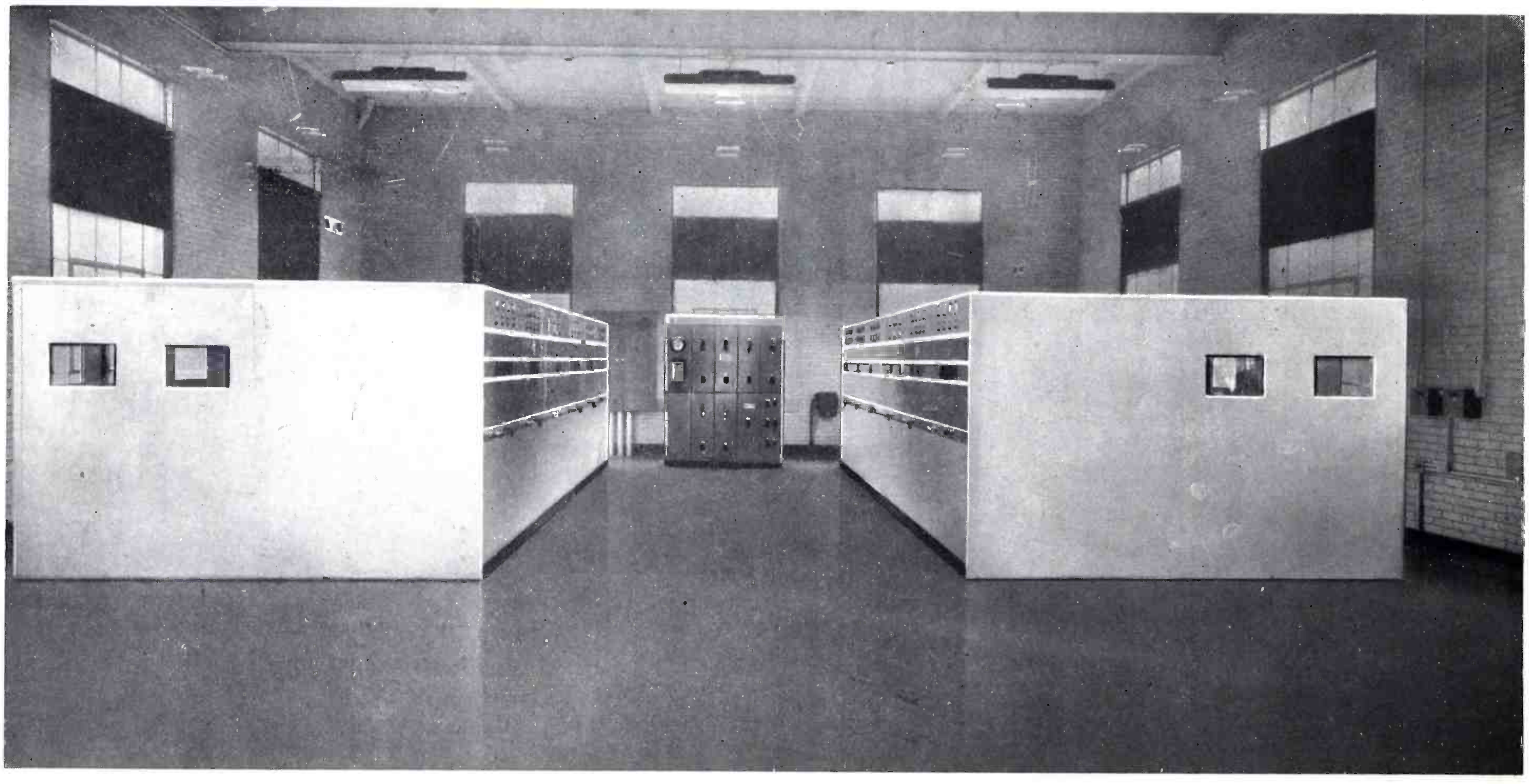


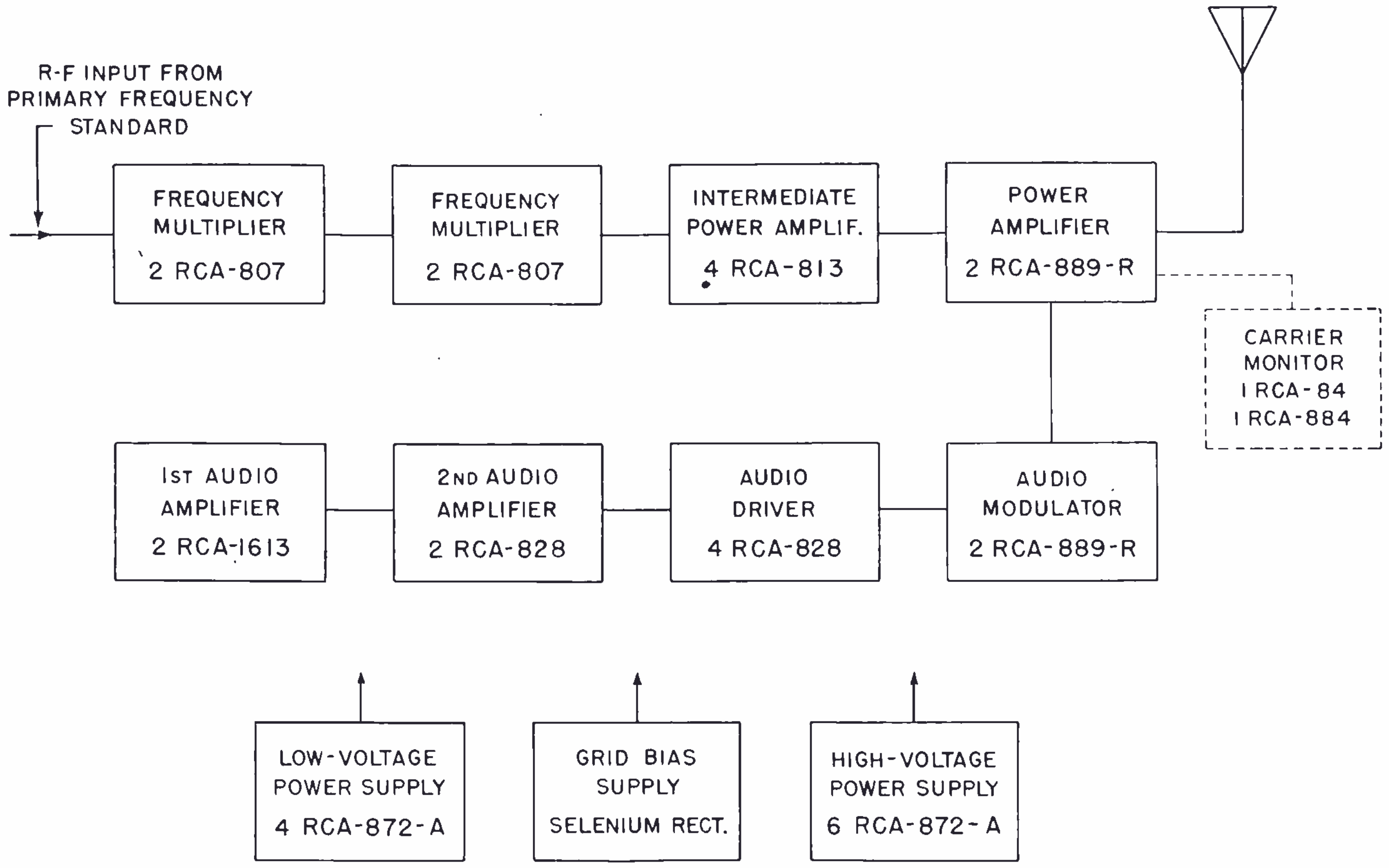
THE INTERIOR OF STATION WWV

The four RCA transmitters at WWV are installed in the west wing as shown in the photographs on this page. Additional space and facilities are provided for two more equipments to complete an ultimate plant of six transmitting units. By orienting transmitters, as shown in the accompanying views, a minimum of movement is required for the operator to check all four transmitters. Viewing ports in the front and rear enclosures assure complete visibility of all components.

Wire trenches, covered with metal plates (visible in the floor) feed into each transmitter all necessary external connections. The power distribution board at the far end of the room is the connecting link between the substation located outside the building and the individual transmitters. A twenty-pen Esterline-Angus recorder mounted on the left-hand side of this board provides a permanent record of all outages and power failures. The station derives its power from two independent sources. The feeders are tied into the distribution board through the automatic transfer switch contained in the panel mounted on the far wall immediately to the left of the distribution board.

The transmission lines, suspended just below the ceiling, couple the transmitters to any of the twelve antennas which are provided in duplicate for the six carrier frequencies.



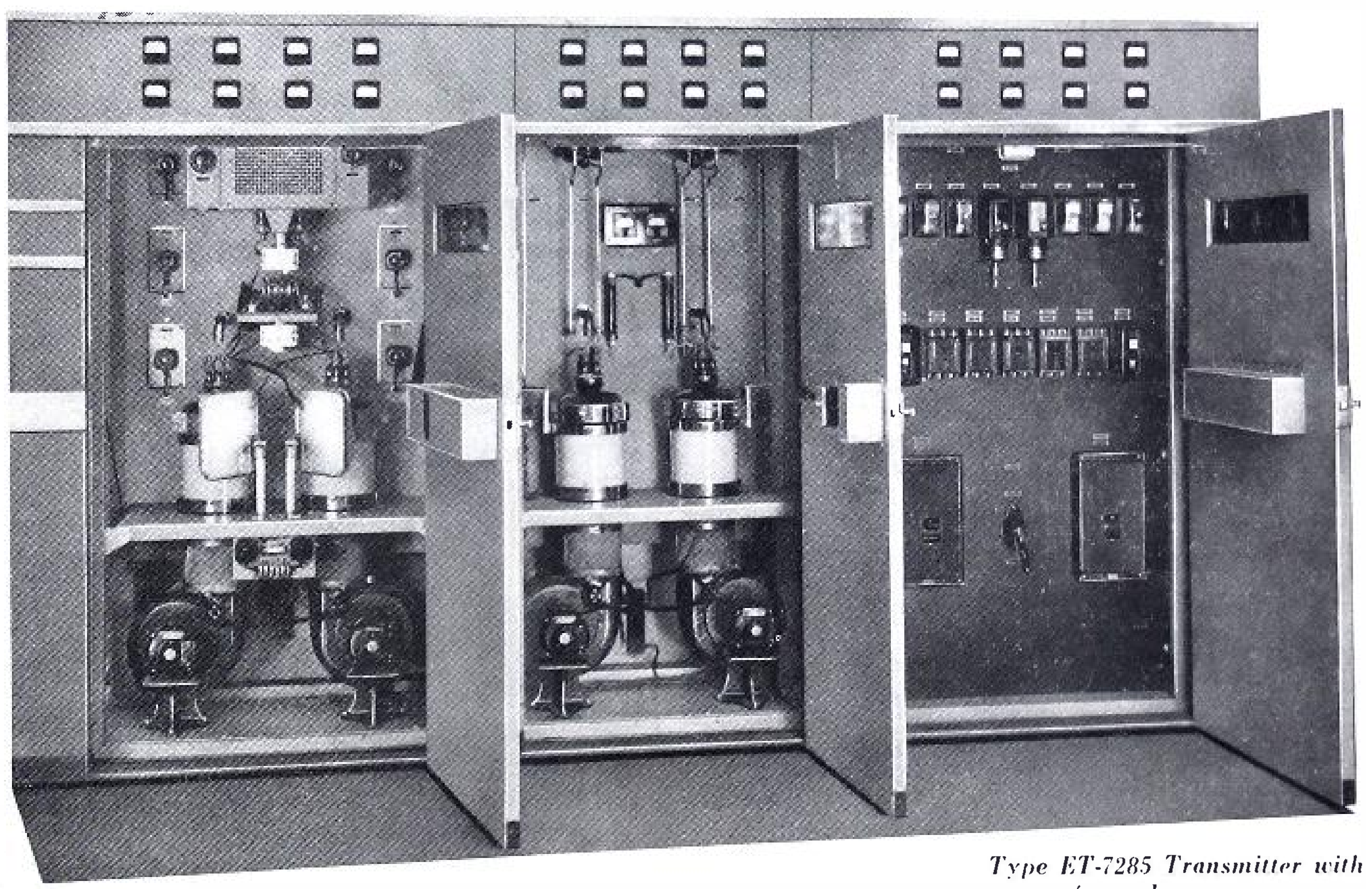


THE ET-7285 TRANSMITTERS AT WWV

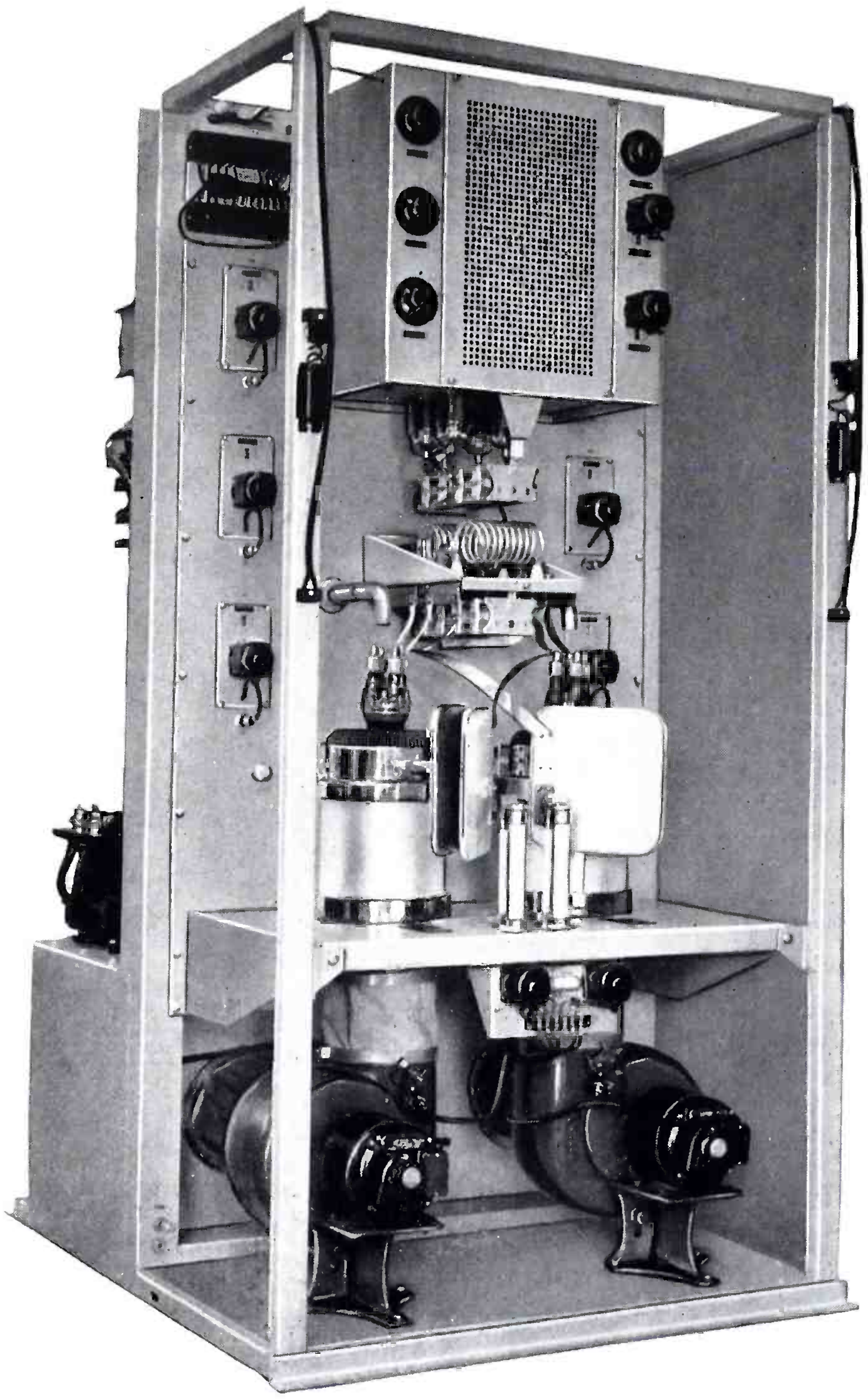
The arrangement of the ET-7285 Transmitter Equipment is one of functional design wherein the basic circuits for radio-frequency, audio-frequency, and power and control are each contained in an individual cubicle.

The various circuit components in each of these sections are mounted on vertical panels in the "vertical-chassis" style first introduced in RCA broadcast transmitters. These panels, in turn, are mounted behind a streamlined "unified" front. The radio-frequency section is located at the left of the assembly, the modulator and audio unit in the center, and the power and control cubicle on the right.

A block diagram of the ET-7285 Transmitter is shown above. Since 2.5 mc. excitation is supplied from precise standards located external to the transmitter, no crystal oscillator is required. The exciter comprises three r-f stages, the first two of which function as harmonic generators employing two RCA 807's per stage. All harmonics, including the fifth, are required to produce the several carrier frequencies. The third stage, which functions as the intermediate power amplifier, uses four RCA 813's in a push-pull parallel circuit and furnishes the driving power for the final amplifier consisting of two RCA 889-R's. All stages are operated Class "C." The power amplifier is plate modulated.



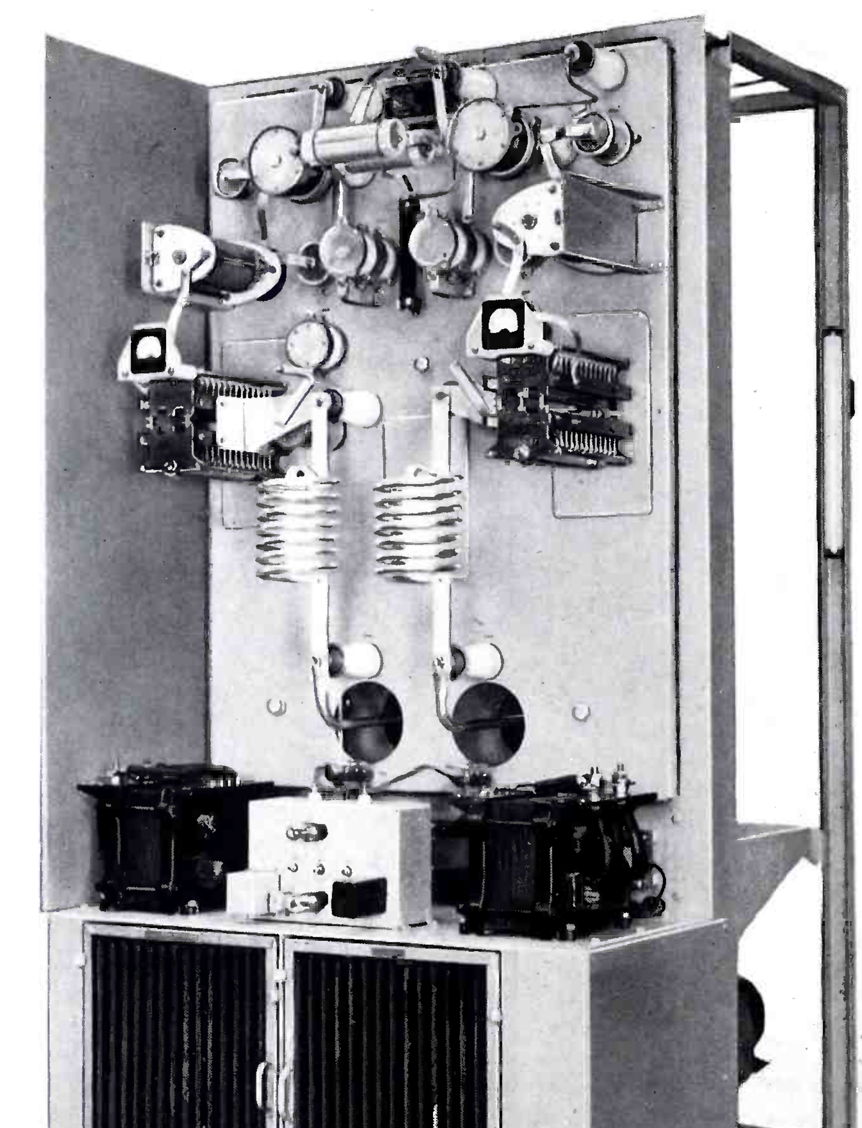
Type ET-7285 Transmitter with front doors open.



THE RADIO-FREQUENCY PANEL (left)

The radio-frequency unit which forms the left-hand cubicle of the transmitter is shown in the closeup view at the left. The first two r-f stages, which operate as harmonic generators, are mounted in a separate housing at the top of this unit. The four 813's form the IPA stage project from the bottom of this exciter housing. The RCA 889-R's which form the output stage are mounted in porcelain jackets through which air is blown by the blowers shown just beneath. This air is drawn from a "plenum chamber" in the rear. Just in front of the 889-R's may be seen the two sets of plates which form the neutralizing condensers. Motors mounted beneath the shelf provide the means of controlling the position of these plates from the front of the panel.

A noteworthy feature of this r-f unit is the use of motor drives which are coupled to the tuning elements of the resonant circuits. These motors are controlled from switches located on the front door of the r-f compartment. Close inspection will reveal the tuning indicators visible just above the respective motors on the main panel, and below the motors on the exciter unit. These indicators make possible the pre-tuning of the complete transmitter prior to the application of power.

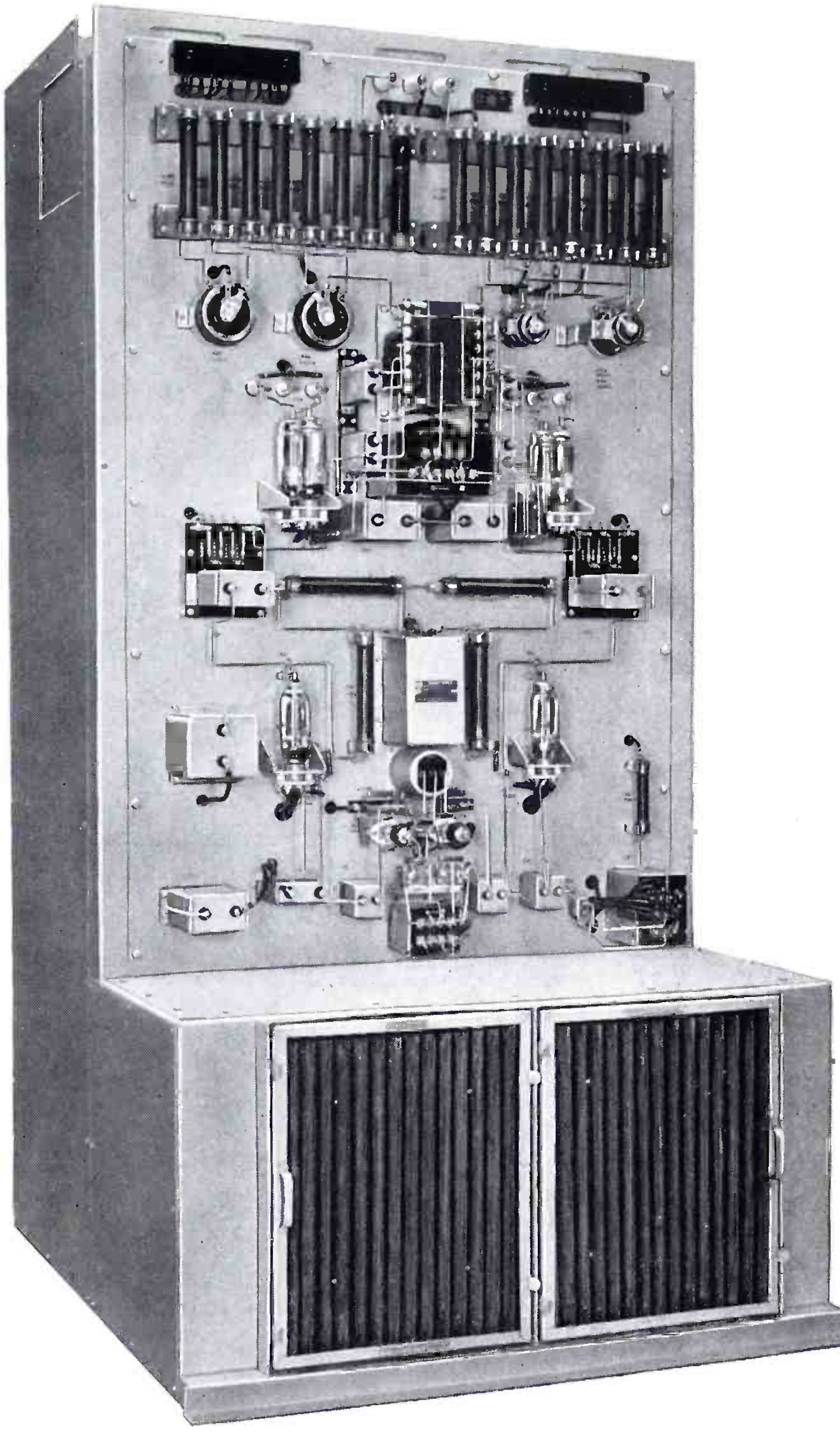


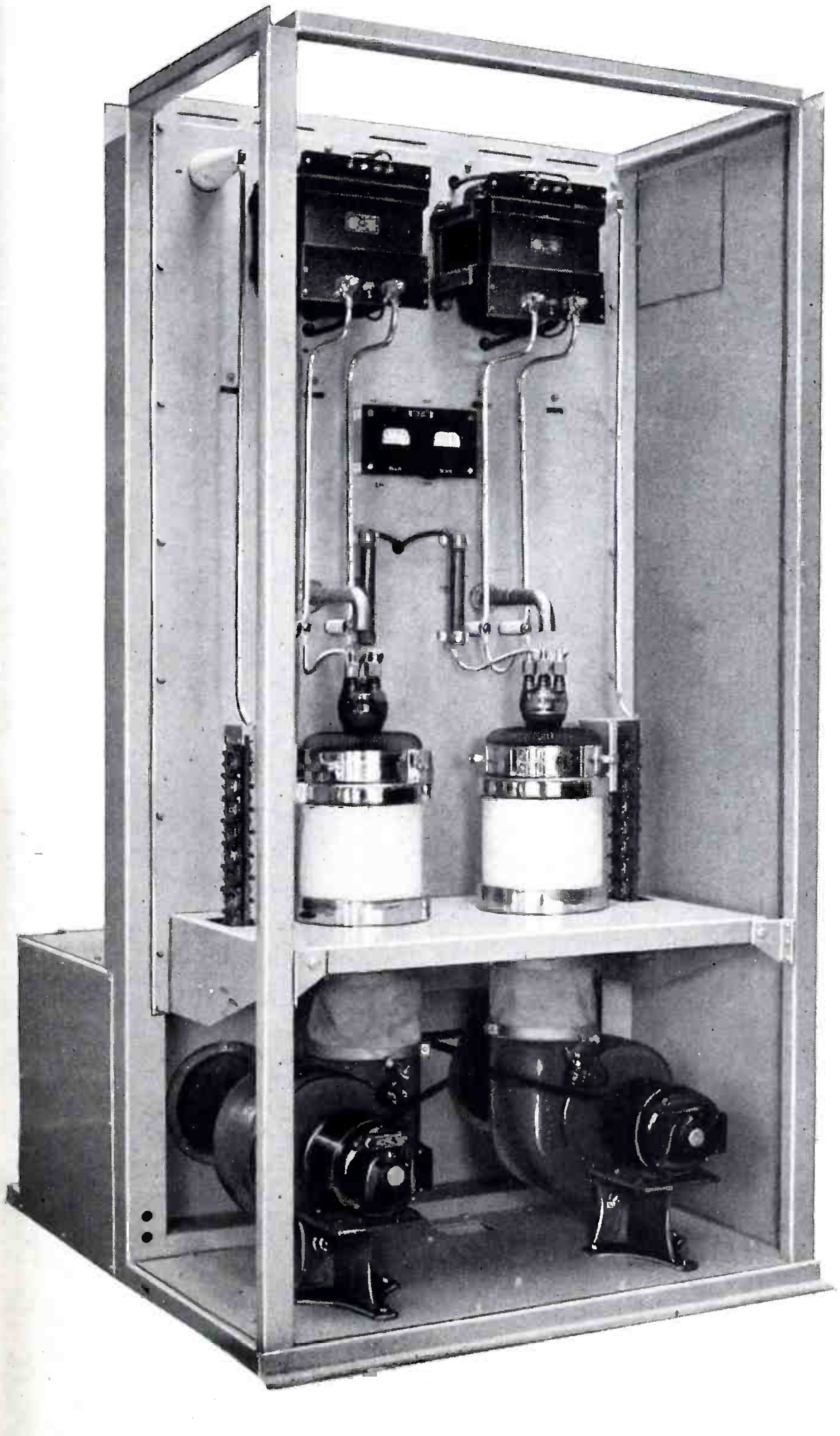
THE POWER OUTPUT PANEL (right)

The power amplifier plate tank circuit and harmonic attenuator are mounted on a panel insulated from the ground. The r-f return path to ground is supplied through a single by-pass condenser. This arrangement produces a circuit of high stability free from parasitics. The two r-f indicating instruments provide a visual check for balanced load currents. The output circuit feeds into a 600 ohm load balanced with respect to ground. High reactance filament transformers and the carrier monitor are mounted on top of the plenum chamber at the base of the unit. This carrier monitor is an "electronic watchman" which keeps constant vigilance over the transmitter output. Should the percentage of modulation or r-f carrier level drop below a specified level, the monitor provides the initiating action for ringing an alarm; or, in the case of dual transmitter operation, stop the "Main" unit and start up the "Stand-by" unit. Capacitively coupled to the PA plate tank circuit the monitor uses the picked energy to fire a thyratron which actuates a pilot relay. In case of (1) low or no modulation, (2) low or no carrier, or (3) failure of any of the monitor circuits, the transmitter in operation is shut down and the stand-by transmitter automatically put on the air.

THE LOW POWER AUDIO PANEL (right)

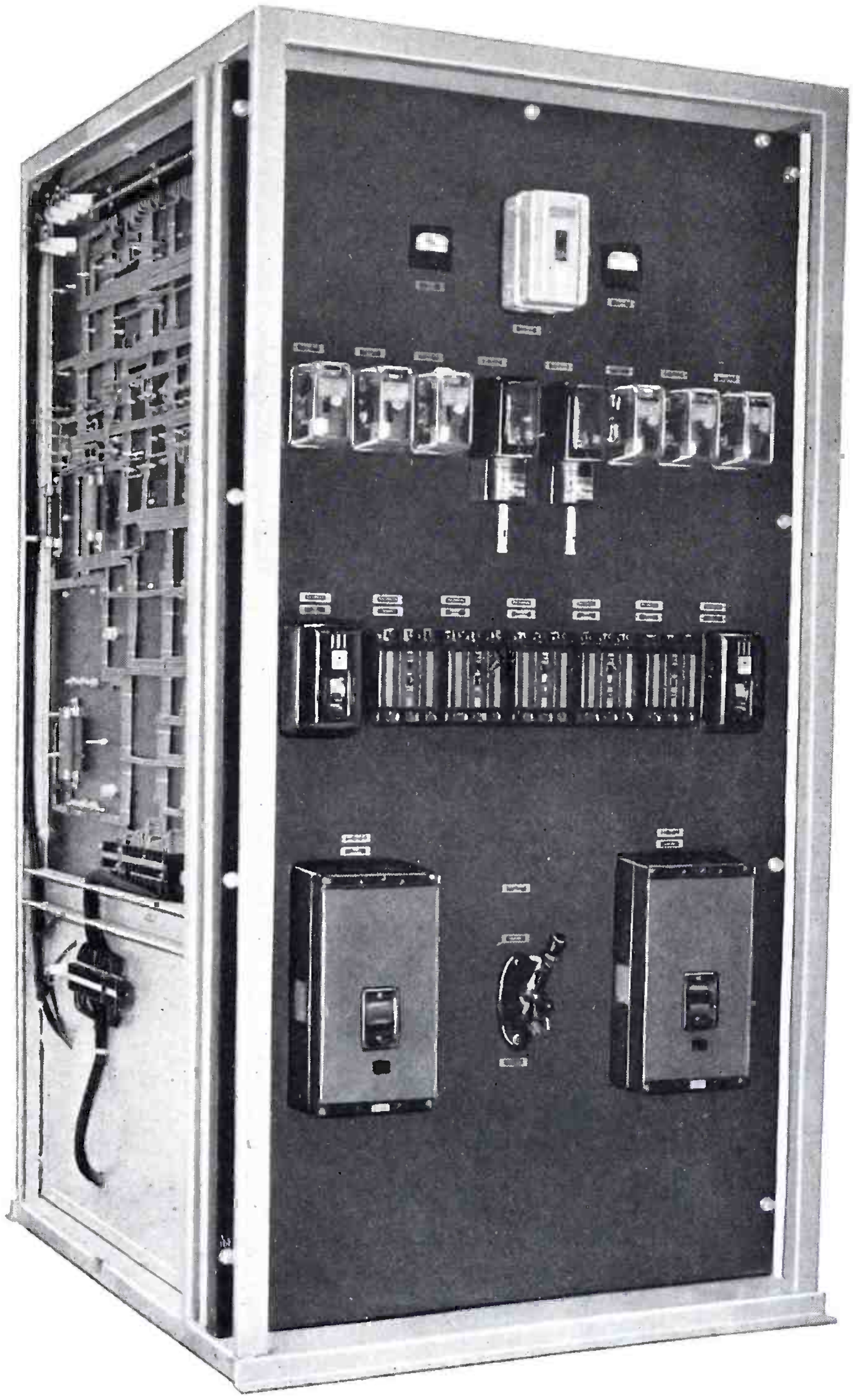
The audio components of the ET-7285 Transmitter are mounted on the rear side of an inverted "T" frame which forms the center cubicle of the transmitter. The circuit employed is the same as that used so successfully in the RCA 5 and 50-E Broadcast Transmitters. All stages, including the modulator, are connected push-pull. The input stage (just above the shelf) is a pair of RCA 1613's; the second audio stage employs a pair of RCA 828's; and the driver stage, four RCA 828's. The components of these stages are mounted in progressive fashion from bottom to top of this unit. All connections, except filament, are bus-bar. All terminals are in the clear and are plainly marked as are all components. The "vertical chassis" arrangement provides free air circulation and the accessibility of all parts makes for easy maintenance. A plenum chamber (bottom of the unit) supplies filtered air to the modulator tubes located on the front panel. An innovation in the ET-7285 Transmitter is the inverted channel at the top of the frame, which forms a wire duct. All interconnecting wiring between units runs in this channel and is connected into the three units through the terminal boards mounted at the top of the panels.





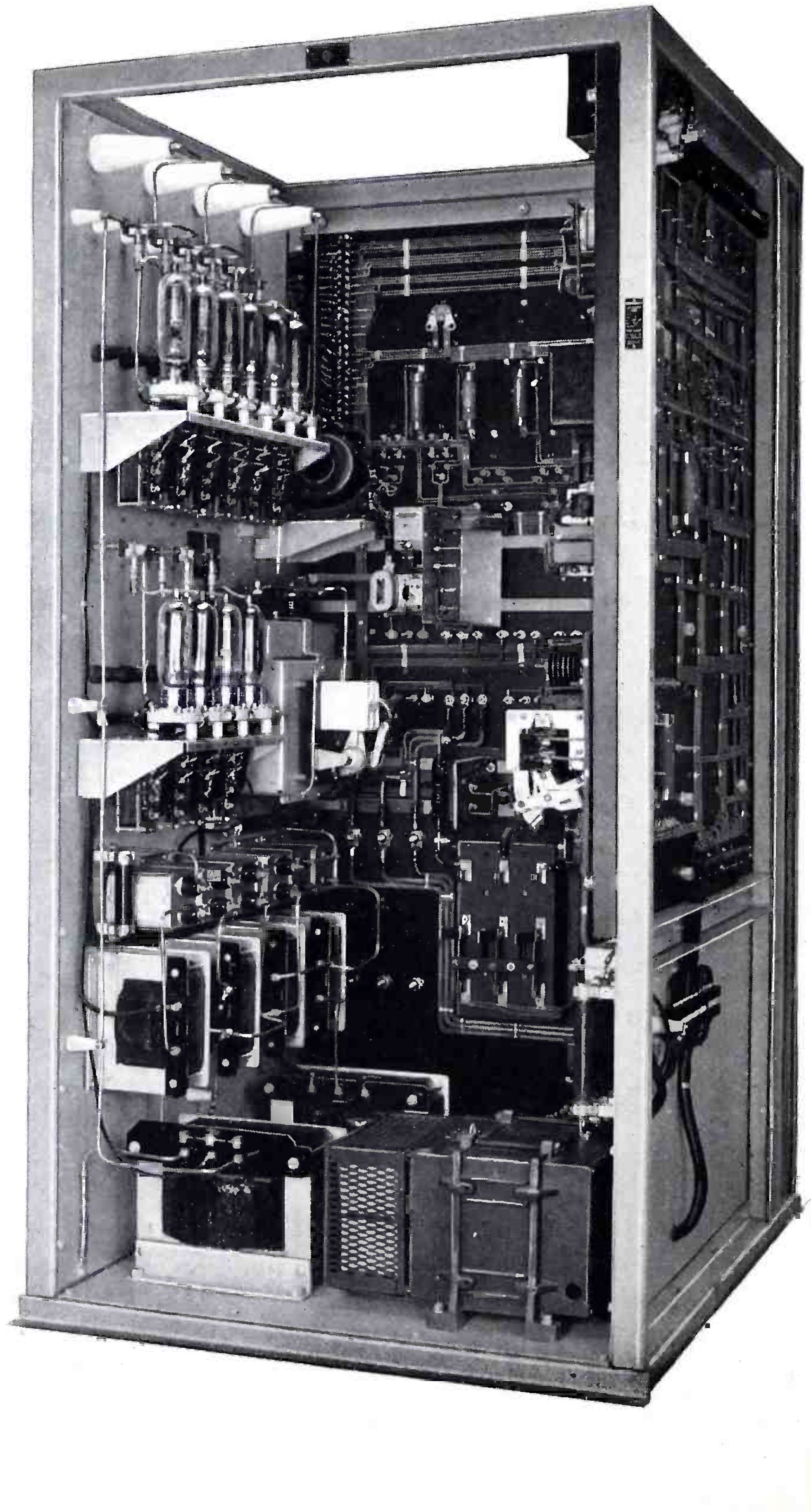
THE MODULATOR PANEL (left)

In the front part of the audio cubicle are located the two RCA 889-R's which function as a Class "B" modulator for the high-level modulated r-f power amplifier. These tubes, like the r-f amplifier tubes, are mounted in porcelain jackets through which air is forced by the blowers at the bottom of the unit. Tube protection from air failure is secured through the use of damper valves situated in the air stream. Mechanically coupled to mercury switches, these air-interlock devices prevent the application of any voltage to the tubes if proper cooling air is not available. Thermal protection incorporated in each blower motor serves to protect them from overheating or under voltage. The grid seals of the 889-R's are also cooled by a stream of air directed on them from above by small pipes. It is interesting to note that the use of 889-R's in both r-f amplifier and modulator reduces the number of tube types used and thereby simplifies maintenance of spares. High-reactance filament transformers mounted at the top of the panel limit the filament "starting" current to a safe value. The small panels at either side of the modulator tubes are the feedback "ladders."



THE CONTROL PANEL (left)

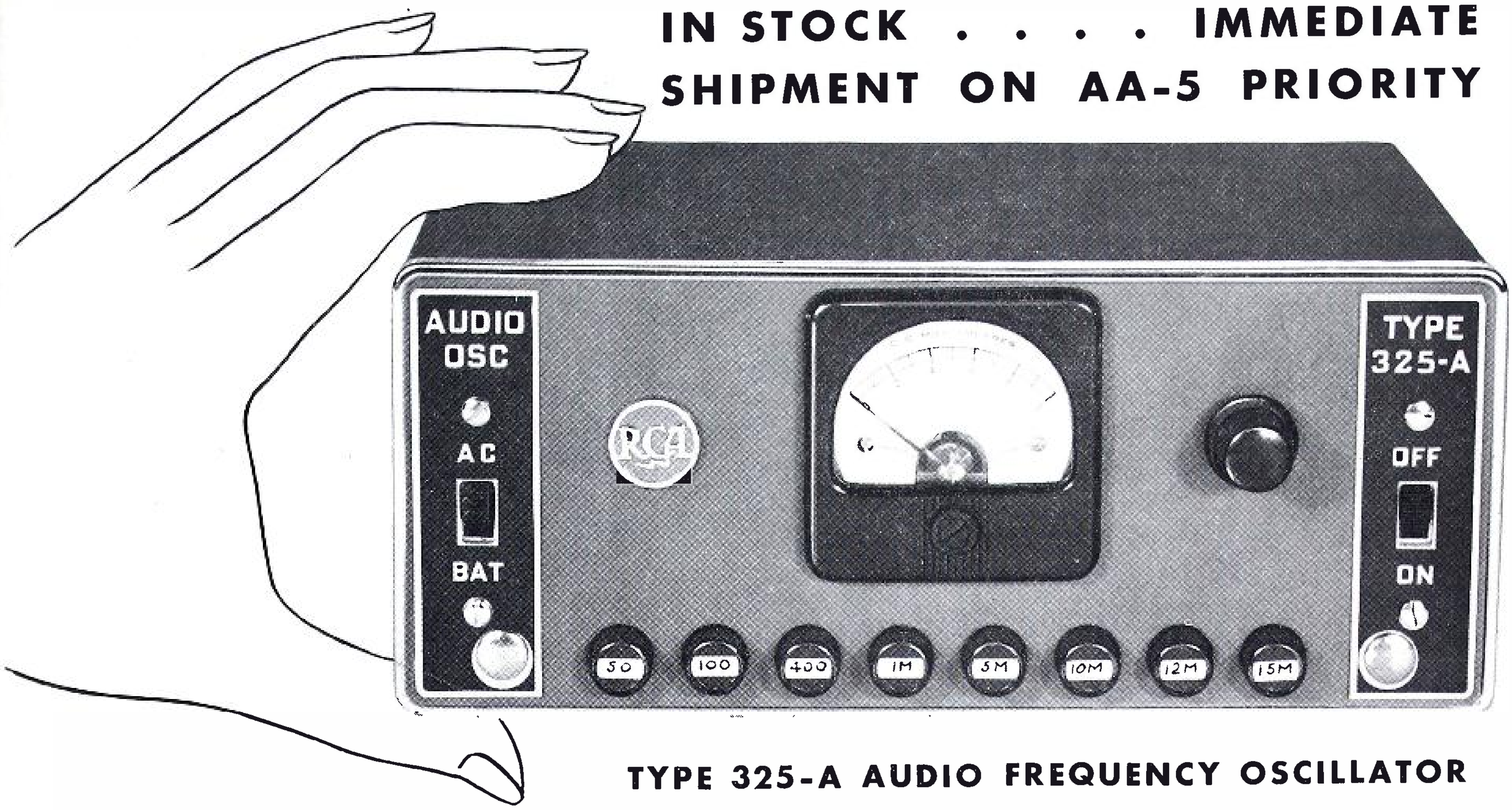
The ebony-asbestos control panel shown at the left is located behind a non-interlocked door in the righthand cubicle of the transmitter. On this panel are mounted all circuit breakers and overload relays. Each circuit fed by the main power supply bus is provided with one of these circuit breakers to isolate it in case of overload or short circuit. Full vision, high-speed overload relays protect the power amplifier and modulator tubes, the rectifier and main line. The dead front switch located in the lower center is the Hi-Low power change switch. An electrically operated time switch encased in the light metal housing at the top of the panel automatically starts and stops the transmitter according to a preset schedule. Other control relays and contactors are mounted inside this unit on a panel, the rear of which may be seen at the left in this view. Through the action of these relays and contactors, automatic "sequence starting" and "3-cycle overload recycling" are provided. All of these relays are energized by a three-phase rectifier provided especially for this purpose.



THE RECTIFIER UNIT (right)

The rear of the rectifier cubicle is shown in the view at right. A three-phase full-wave rectifier and a single-phase bridge-type rectifier are located near the top of the left-hand panel. A small blower located adjacent to this high-voltage rectifier supplies a temperature-controlled air-blast to the base of the RCA 872-A rectifier tubes. A thermostatically controlled heater element provides a warm blast for cold weather operation. Just below the blower may be seen the grounding switch which automatically grounds both high and low voltage filters when power is turned off. At the left of this switch unit is the low-voltage power supply unit consisting of four 872-A's in a single-phase full-wave circuit. This unit supplies plate voltage for all stages except the final r-f and the modulator. Grid biasing for all stages is provided by a selenium rectifier mounted on the right side of the cabinet (not visible in this view). All wiring in this power and control cubicle is of either "switchboard" or bus-bar type and all components are plainly marked. Thus, in case of failure, circuits are easily traced. A voltage stabilizer (on the floor of the unit) supplies voltage stabilized within ½ percent to all filaments, thereby insuring long tube life.

IN STOCK . . . . IMMEDIATE SHIPMENT ON AA-5 PRIORITY



TYPE 325-A AUDIO FREQUENCY OSCILLATOR

If you are looking for a compact, efficient and economical portable audio oscillator for any purpose requiring a convenient, dependable audio frequency voltage source for checking frequency response on audio systems and circuits, the RCA 325-A will fill the bill.

You can equalize remote lines quickly and easily with this small, lightweight, inexpensive, portable oscillator. It weighs only 6½ pounds and operates from a-c or self-contained batteries (weight ½ pound). Push-button selection of 12 frequencies, and an output meter, make this instrument ideal for setting up remote pickups without tying up the remote amplifier equipment.

Available, in stock, for immediate shipment on AA-5 (or higher) priority orders—as long as the stock lasts. Price $55.00 net F.O.B. Camden, N. J. (less batteries). *Place your order now!*

"RADIO'S 100 MEN OF SCIENCE" . . . New Book by ORRIN DUNLAP

The future of radio and its unlimited opportunities for discovery and invention, mirrored against the fascinating background of the past, are graphically revealed in a new book "Radio's 100 Men of Science," by Orrin E. Dunlap, Jr., just published by Harper & Brothers. In 100 biographical narratives, each in itself an individual story of achievement, Mr. Dunlap interweaves the lives of the scientists with their discoveries and interprets the significance of their contributions to the advance of radio.

The history of radio, electronics and television unfolds as a progressive story extending from Thalos of Miletus, who first observed "elektron sparks" on through Faraday, Maxwell, Hertz, and Marconi, from Fessenden and DeForest to Zworykin and other contemporaries of television fame.

The story discloses how throughout the centuries Nature dropped the clues to wireless, and how each discoverer in turn received inspiration from predecessors; most of them began as Edison once remarked, "where the other fellow left off." An introductory chapter "The Genesis of Radio," reveals how radio is the creation of a long line of scientists whose work in the discovery of the laws of Nature and in designing instruments to harness the elusive forces of science, goes back more than 100 years.

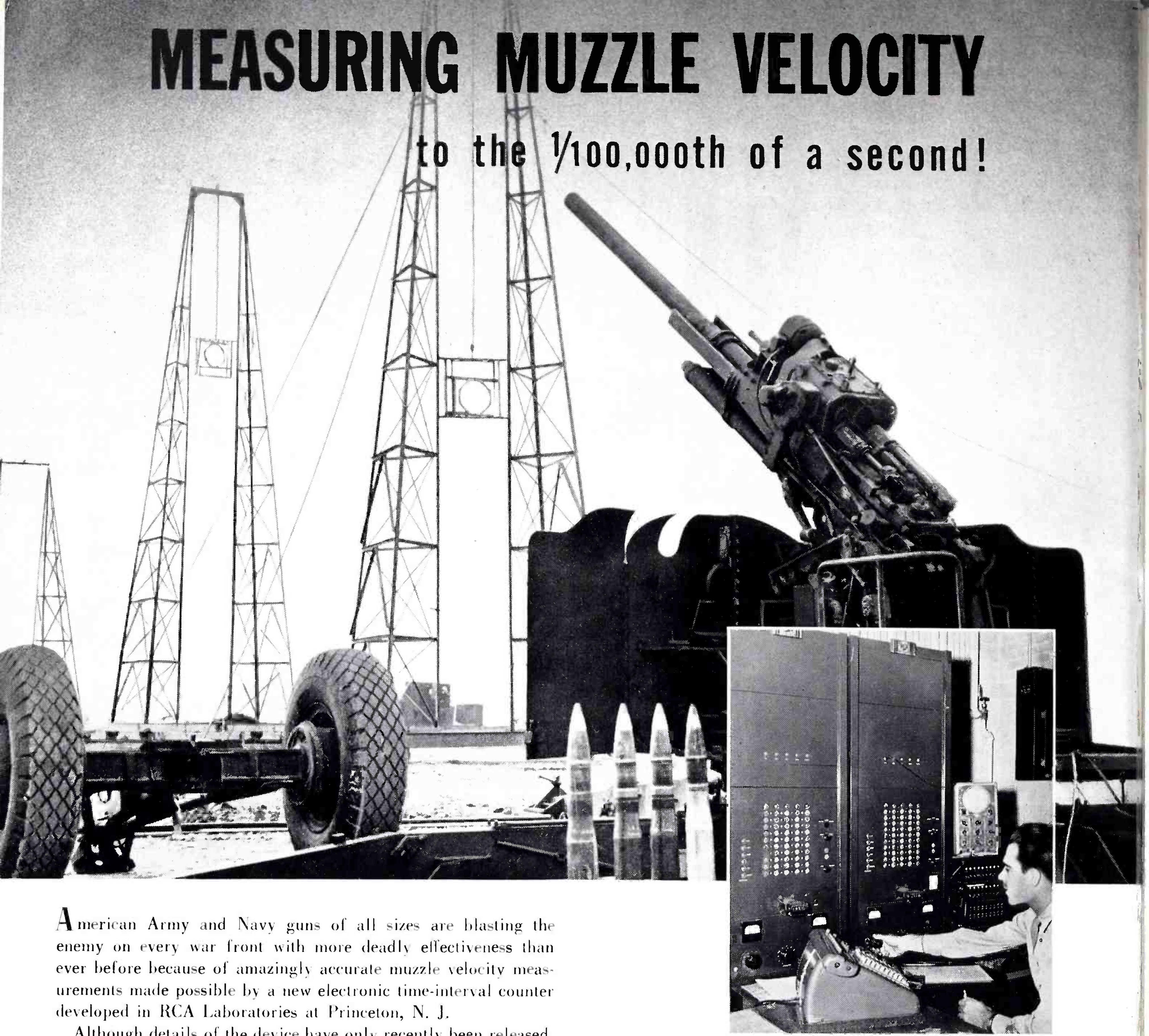
Although many pre-Marconi men experimenting in the realm of electricity believed that they had found clues to wireless, history discloses that they failed to recognize radiation as the key to success in signaling through space. Marconi grasped the idea and made electromagnetic radiation a practical means of electrical communication thereby gaining the title "Inventor of Wireless."

Of "Radio's 100 Men of Science" forty-six were born in the United States. Eighteen others came from foreign lands to seek freedom and opportunity under the Stars and Stripes: the majority, including Tesla, Pupin, Steinmetz, Alexanderson and Zworykin, became naturalized American citizens. In America they found encouragement, recognition of their talents and reward for their achievements. They pioneered and contributed to the advance of civilization.

"The Columbuses, Marco Polos, Cabots and Daniel Boones of radio have long since passed in the procession of shadows," says Mr. Dunlap. "New explorers are pioneering; they are charting new trails—microwave trails—into the future across the wondrous horizon of radio. Theirs is the heritage to keep alive the spirit of the pioneers—to continue onward, to achieve new triumphs that will serve the world and thereby unfold the saga of radio's second 100 men of science. There will come a day in the postwar era when new wonders will appear and with them wizards. Geniuses of tomorrow may be but boys today."

MEASURING MUZZLE VELOCITY

to the 1/100,000th of a second!



American Army and Navy guns of all sizes are blasting the enemy on every war front with more deadly effectiveness than ever before because of amazingly accurate muzzle velocity measurements made possible by a new electronic time-interval counter developed in RCA Laboratories at Princeton, N. J.

Although details of the device have only recently been released, these instruments have actually been in use for more than a year at the Aberdeen Proving Ground in Maryland and at other Government arsenals and proving grounds throughout the country. They supply instantaneously information upon which the performance of a given gun is established and the uniformity of its ammunition checked within a few seconds. It is equally effective with all types of guns—from small hand weapons to the Navy's most powerful 16-inch rifles.

The research on this device was brought to fruition, and a very practical device made available to the military services, through the work of Igor E. Grosdoff, RCA research engineer. Each range is equipped with two electrical coils, arranged so that a projectile will pass through them in succession. (See illustration above.) By magnetizing the projectile, a small electrical signal is generated by each coil as the bullet passes through. If the coils are 30 feet apart, and the time between the two signals is one one-hundredth of a second, the bullet is traveling 3,000 feet a second.

The counter consists of three essential parts: an oscillator, a gate, and the counter proper. The oscillator is controlled by a 100 kc crystal and thus delivers precisely 100,000 pulses each second. The gate, actually a vacuum tube circuit, passes these pulses into the counter, which counts them and finally, when the gate is closed, shows by indicator lamps the number of pulses that have passed through. These lamps are mounted on the panels of standard RCA equipment racks (see inset photo). They show the number of hundred-thousandths of a second from the time the gate opened until it closed.

In operation on the firing ranges, the counter gate is opened by the electrical signal from the first coil as the bullet passes through it, and is closed again by the impulse from the second coil. The operator records the time of flight between coils and computes the velocity. It is noted down along with the record of the particular gun and projectile being tested for subsequent analysis by ballistic experts. He then touches the reset button and is ready for the next shot, all in a matter of a few seconds.

TELEVISION COVERAGE CURVES FOR TURNSTILE ANTENNAS

★

MEANS FOR DETERMINING THE DISTANCE TO THE 500 AND 5000 MICROVOLT PER METER CONTOURS FOR AN ANTENNA POWER OF 4 KW, DIFFERENT ANTENNA HEIGHTS AND FOR 2, 4 AND 6 LAYER TURNSTILE ARRAYS

by R. D. DUNCAN, Jr.
Engineering Products Department

In the August, 1944, issue of BROADCAST NEWS, a series of graphs was presented which enabled the determination of distances to the 50 and 1000 microvolt per meter contours of an FM broadcast station when a "Turnstile" type of transmitting antenna was employed. A description of the turnstile antenna is given in the article referred to. The graphs gave the distances in terms of the antenna power, the antenna height and number of turnstile layers. They were for a single frequency, 46 megacycles, the mean of the present FM band, and were based on the propagation curves issued in 1940 by the Federal Communications Commission in the Standards of Good Engineering Practice.

A similar set of graphs has been prepared for estimating television coverage in the frequency range covered by the present first eight channels, and for four of the new channels recommended by RTPB Panel 2, all within the 50-168 megacycle band. These are based on the propagation curves supplied by the Commission with the Standards of Good Engineering Practice for Television Broadcast Stations, issued in 1941. The latter curves are for the three frequencies, 46, 105 and 165 megacycles.

Following the suggestion of the Commission, the distances to the 500 and 5000 microvolt per meter contours, corresponding to a given combination of antenna power, height and gain, may be obtained from the curves for the three frequencies in question. A curve then plotted interconnecting the three points will yield distances corresponding to intermediate frequency values. The accuracy of this method obviously depends upon the manner of variation of the derived curves between the three frequency points. Fortunately this is such as to yield reasonably accurate interpolated values.

While there is general interest in the coverage for any frequency within the band contained by the eight lower channels, more specific interest is with the coverage corresponding to the picture carrier frequency of a given channel. To provide this information in a readily usable form, a third set of derived graphs has been prepared, one for each channel picture carrier frequency, which correlate the distance to a specific contour with the antenna power, height and gain, or in place of the gain, the number of turnstile layers.

COVERAGE GRAPHS

Picture Carrier

Such a set of graphs is given in accompanying Figs. 1 through 12. These are for an antenna power of 4 kilowatts, and for 2, 4 and 6 turnstile layers, of conventional half-wavelength spacing between layers. They give the distance in miles to the 500 and

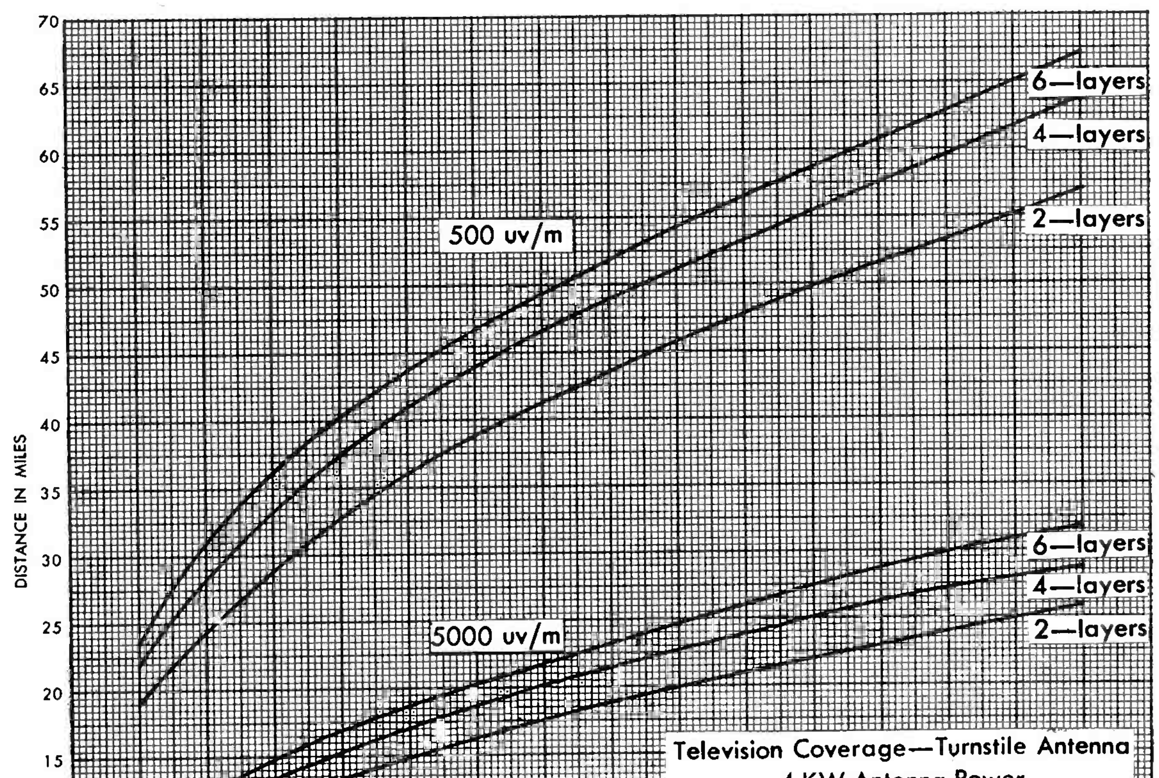


FIG. 1.

5000 microvolt per meter contours for a receiving antenna height of 30 feet and for transmitting antenna heights varying between 200 and 3000 feet. The carrier frequencies correspond to the picture carrier frequencies of each channel and are as follows:

Figure Number	*Present Channel Number*	*New Channel*	*Picture Carrier Frequency Megacycles*
1	1	—	51.25
2	2	—	61.25
3	3	—	67.25
4	—	1	73.25
5	4	—	79.25
6	5	—	85.25
7	—	2	91.25
8	6	—	97.25
9	7	—	103.25
10	—	3	153.25
11	—	4	159.25
12	8	—	163.25

In use the graphs are entered at the bottom scale corresponding to a given antenna height. By proceeding vertically upwards to the curve in either the 500 or 5000 microvolt per meter group, corresponding to a 2, 4 or 6 layer turnstile, and thence horizontally to the left-hand scale, the distance to the particular contour is read off. Obviously the reverse procedure may be followed, viz., the graph entered at the left-hand scale corresponding to a given distance and the combination of antenna height and number of layers determined to give this distance with 4 KW antenna power.

Sound Carrier

In accordance with present standards the sound carrier frequency of each channel is 4.5 megacycles higher than the picture carrier. In addition the unmodulated carrier power for sound must be not less than 50 percent nor more than 100 percent of the peak picture power. With the same radiated powers on the picture and sound carriers, it is to be expected that for equal picture and sound field-strength values, somewhat greater distances will be achieved with sound because of the slightly lower attenuation experienced by the higher frequency sound carrier during propagation.

With the sound power one-half of the picture power, the reduction in distance to a given field-strength contour theoretically resulting is of the order of 10 percent. It is therefore seen that for radiated sound powers varying between one-half of and equality with the peak radiated picture power, approximately equal field-strength coverages may be expected. Recalling that the minimum field-strength value specified for FM broadcasting is 50 microvolts per meter contrasted with 500 microvolts per meter for picture transmission, it is further seen that even with a substantial reduction in frequency deviation of the FM sound carrier, a good ratio of signal-to-noise should prevail for sound reception. It is to be concluded that on the basis of present standards, the coverage indicated for picture transmission will be more than sufficient for the accompanying sound channel.

TRANSMISSION LINE LOSSES

The power upon which the coverage graphs are based is that delivered to the antenna and is less than the power output of the transmitter by the losses incurred in the transmission line connecting the transmitter with the antenna.

In the article on FM coverage previously referred to, curves were submitted for four sizes of coaxial transmission line (70 ohm characteristic impedance), viz., ⅜, ⅞, 1⅜ and 2⅝ inches diameter, giving the ratio of *power out of* to *power into* the line, for a frequency of 46 megacycles. A method was outlined for determining the effect of line losses on coverage. This procedure will not be followed here because of the wide range of frequencies involved. Instead a table is presented giving the attenuation in decibels per 1000 feet, for the same four sizes of line, and for the eight picture carrier frequencies previously listed. The numerical ratio of *power in* to *power out* of the line, for any line length and for any particular picture frequency, may then be determined by usual procedures. The required transmitter power output is thereby determined.

TRANSMISSION LINE LOSS TABLE*

Frequency Megacycles	*Attenuation Loss in Decibels per 1000 Feet — Line Diameter in Inches* 2⅝	1⅜	⅞	⅜
51.25	0.72	1.37	2.39	6.35
61.25	0.78	1.49	2.61	6.93
67.25	0.82	1.56	2.74	7.26
79.25	0.89	1.70	2.97	7.89
85.25	0.92	1.76	3.08	8.18
97.25	0.98	1.88	3.29	8.74
103.25	1.01	1.94	3.39	9.00
163.25	1.28	2.44	4.26	11.30

* 70 Ohm Characteristic Impedance.

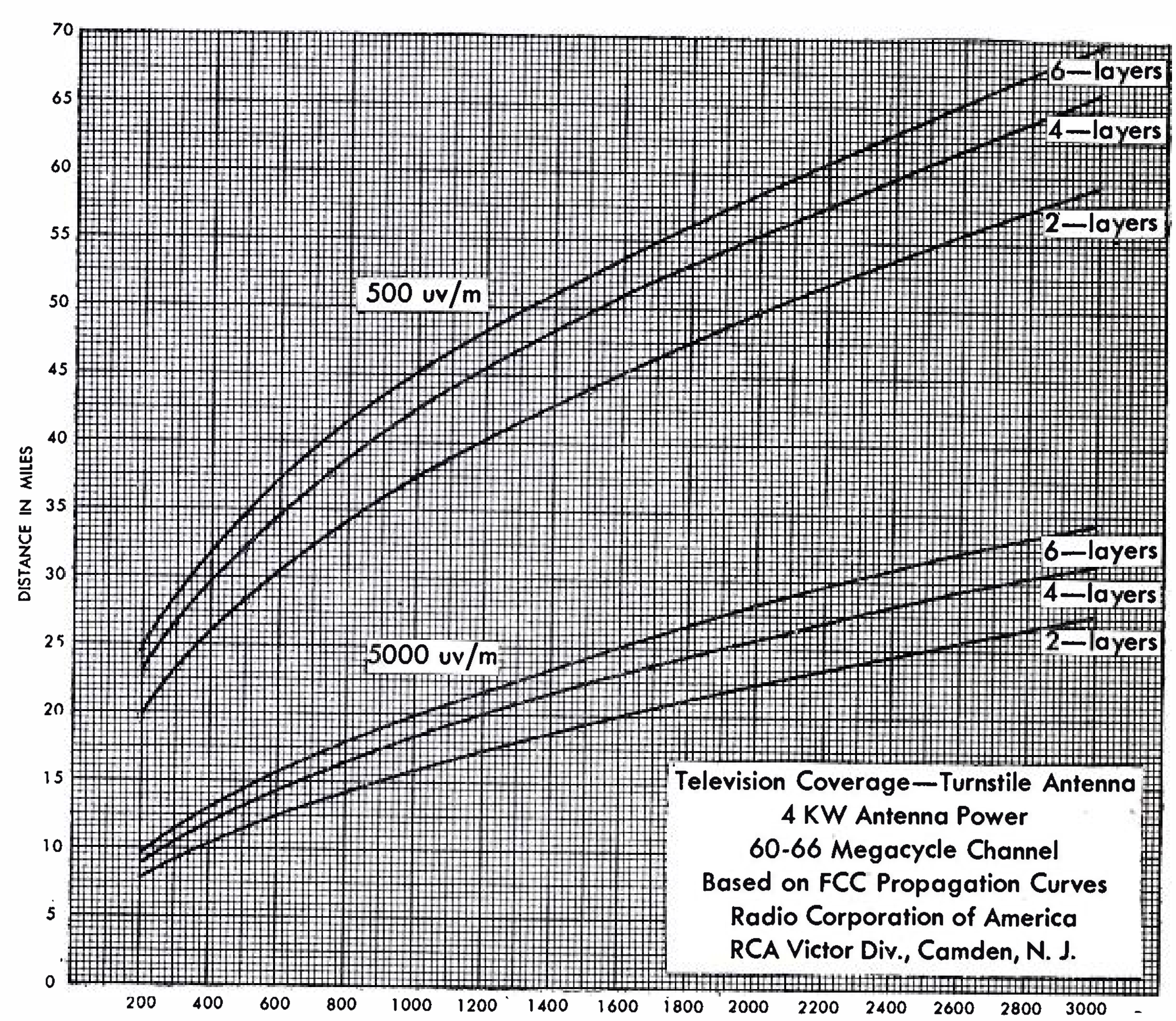


FIG. 2.

It is important to note that the spacing of the insulators of a coaxial line becomes of increasing importance as the frequency is increased. Each insulator forms a small capacity bridged across the two line conductors. At the higher frequencies these small capacities may set up reflections and standing waves will be developed along the line even though it is properly terminated. If the standing waves are sufficiently pronounced the line losses will show a substantial increase. The loss values in the preceding table assume proper insulator spacing and no reflections on the line.

GRAPHS FOR HIGHER CARRIER FREQUENCIES AND HIGHER ANTENNA POWERS

As soon as suitable propagation information becomes available for the higher frequencies, coverage graphs will be presented for the television channels above 168 megacycles. Similarly, when higher transmitter powers have been more or less agreed upon, coverage curves will be made available for these powers and for as many channels as possible. October, 1944.

CORRECTION

In the article entitled "Coverage Curves for FM Antennas" which appeared in the August issue of BROADCAST NEWS, the following corrections and additions should be made to Figs. 10 and 11.

FIG. 10 *The four lowest curves, originally labeled* 500, 750, 1000 *and* 1500 *feet, should be instead respectively,* 750, 1000, 1500 *and* 2000 *feet.*

FIG. 11 *The loss curves are for transmission lines of* 70 *ohms characteristic impedance.*

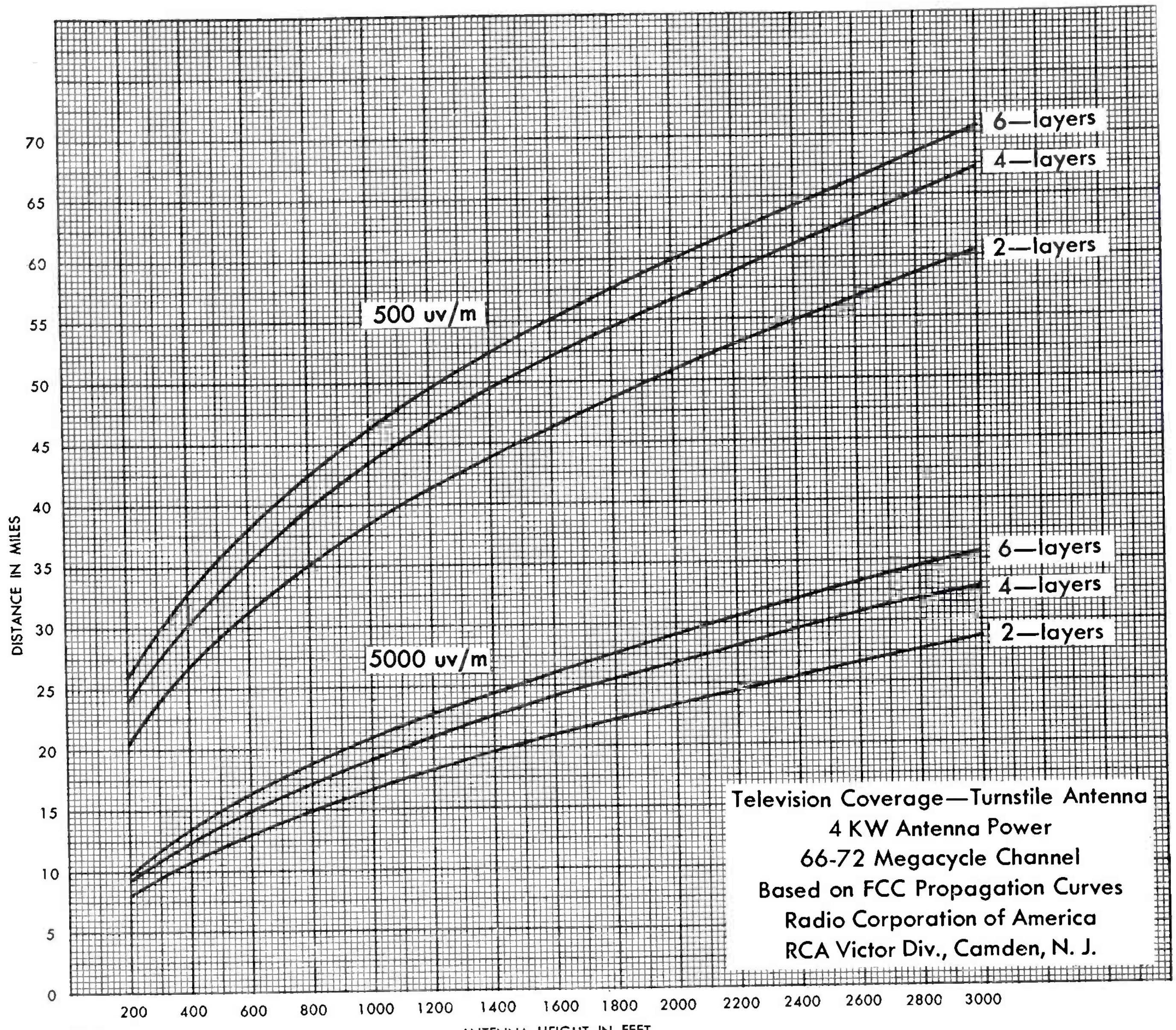


FIG. 3.

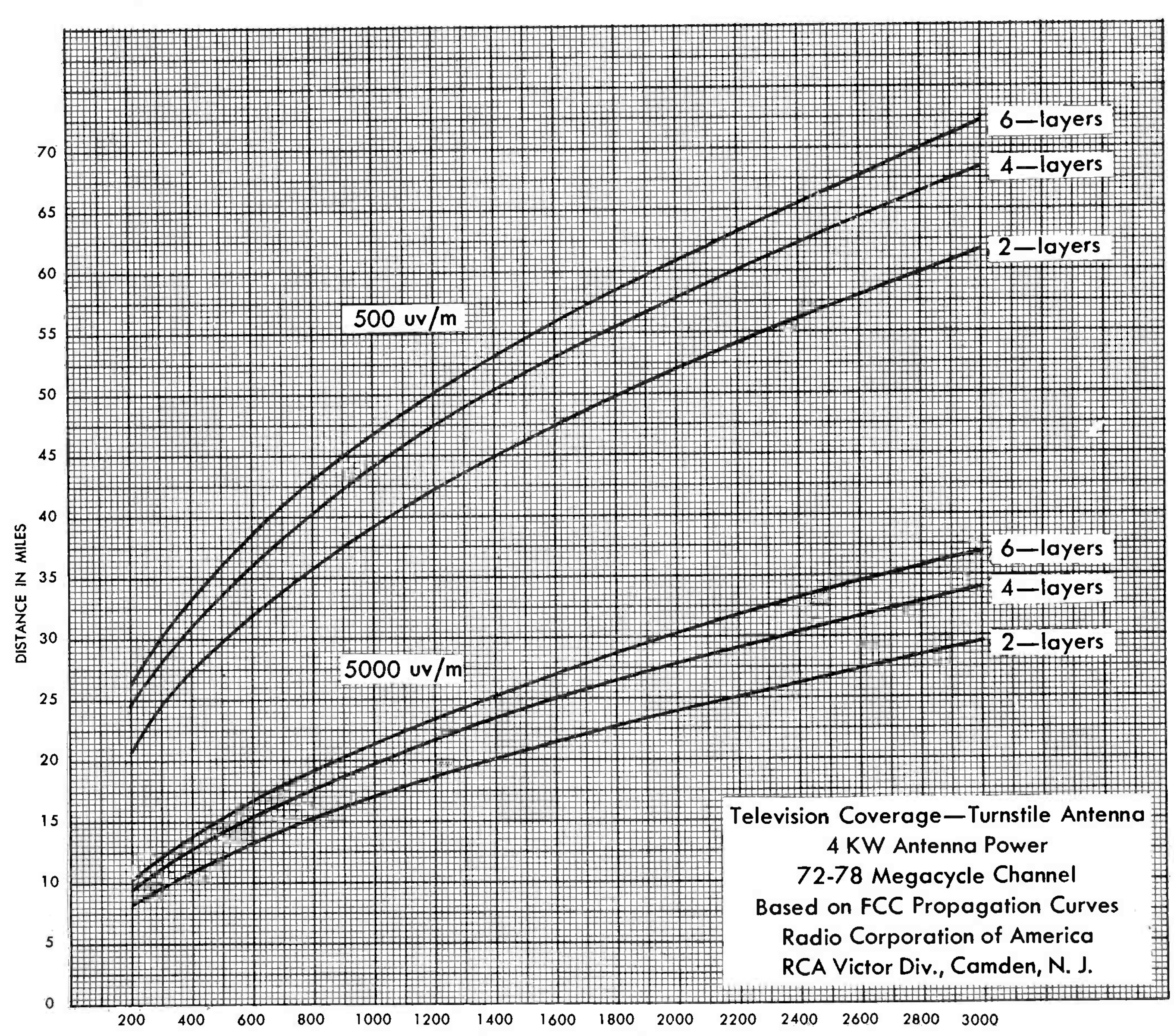
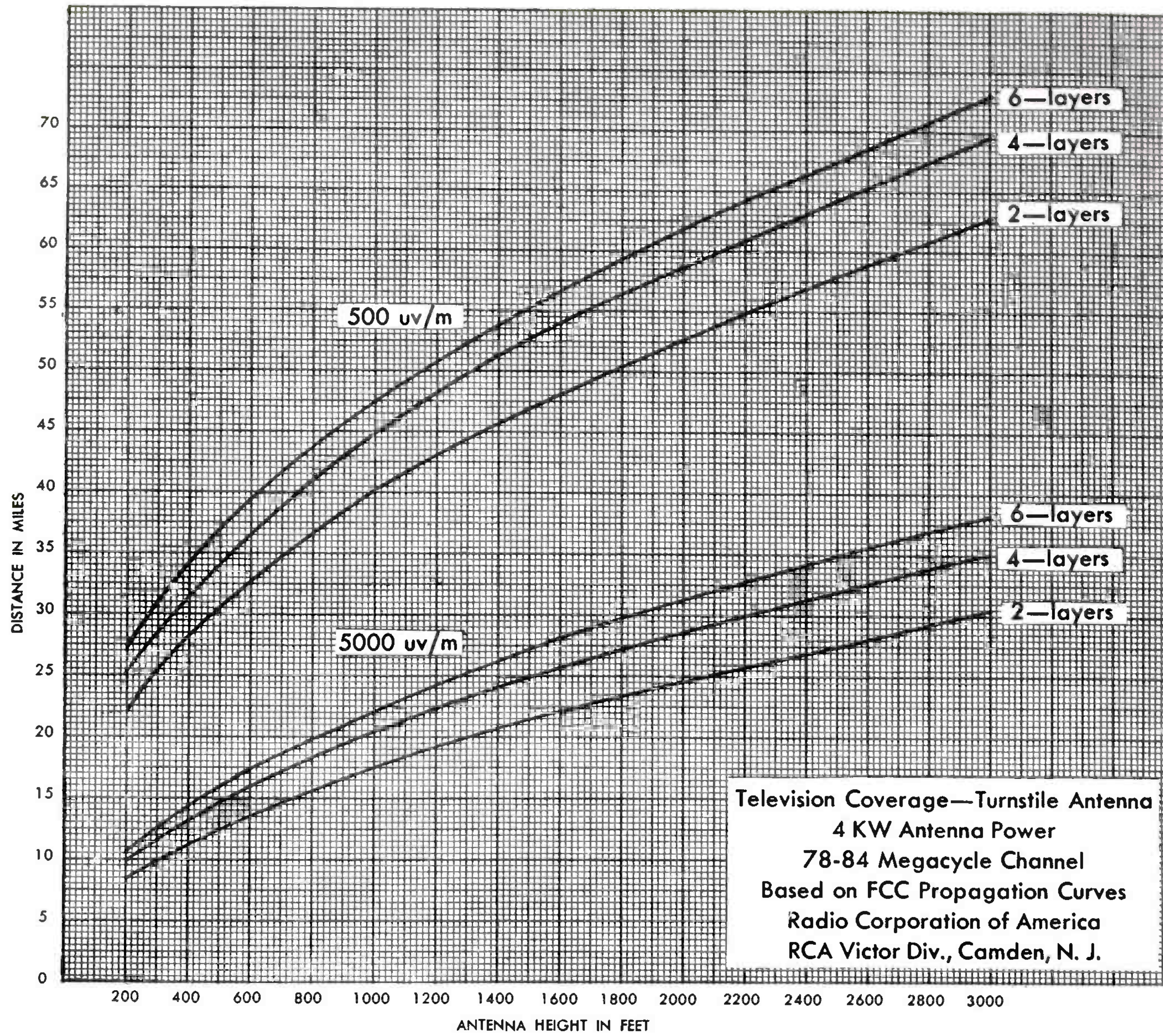


FIG. 4.

FIG. 5.


6—layers
4—layers
2—layers
500 uv/m
5000 uv/m
6—layers
4—layers
2—layers
Television Coverage—Turnstile Antenna
4 KW Antenna Power
78-84 Megacycle Channel
Based on FCC Propagation Curves
Radio Corporation of America
RCA Victor Div., Camden, N. J.
DISTANCE IN MILES
0 5 10 15 20 25 30 35 40 45 50 55 60 65 70
200 400 600 800 1000 1200 1400 1600 1800 2000 2200 2400 2600 2800 3000
ANTENNA HEIGHT IN FEET

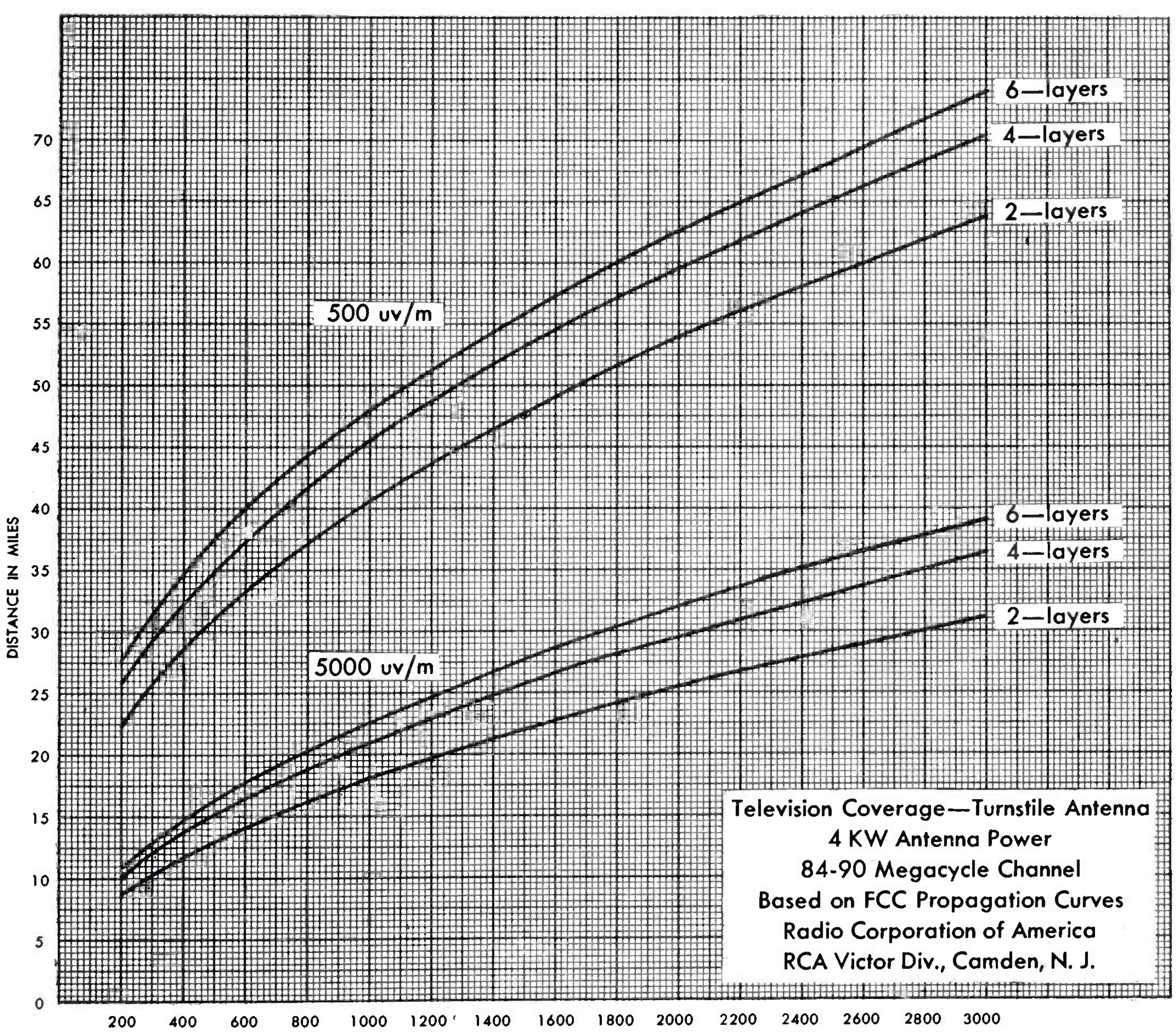

6—layers
4—layers
2—layers
500 uv/m
5000 uv/m
6—layers
4—layers
2—layers
Television Coverage—Turnstile Antenna
4 KW Antenna Power
84-90 Megacycle Channel
Based on FCC Propagation Curves
Radio Corporation of America
RCA Victor Div., Camden, N. J.
DISTANCE IN MILES
0 5 10 15 20 25 30 35 40 45 50 55 60 65 70
200 400 600 800 1000 1200 1400 1600 1800 2000 2200 2400 2600 2800 3000
ANTENNA HEIGHT IN FEET

FIG. 6.

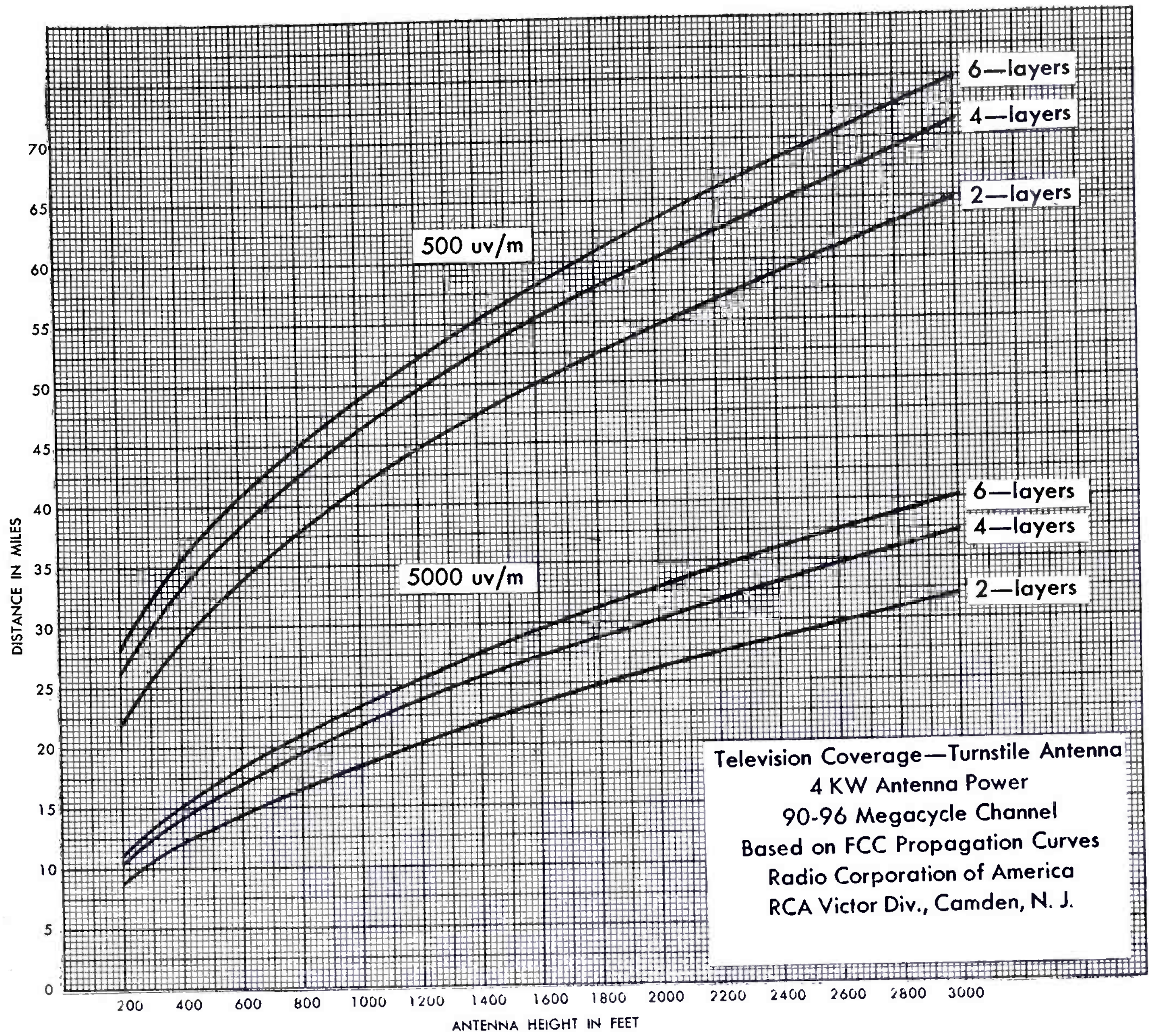
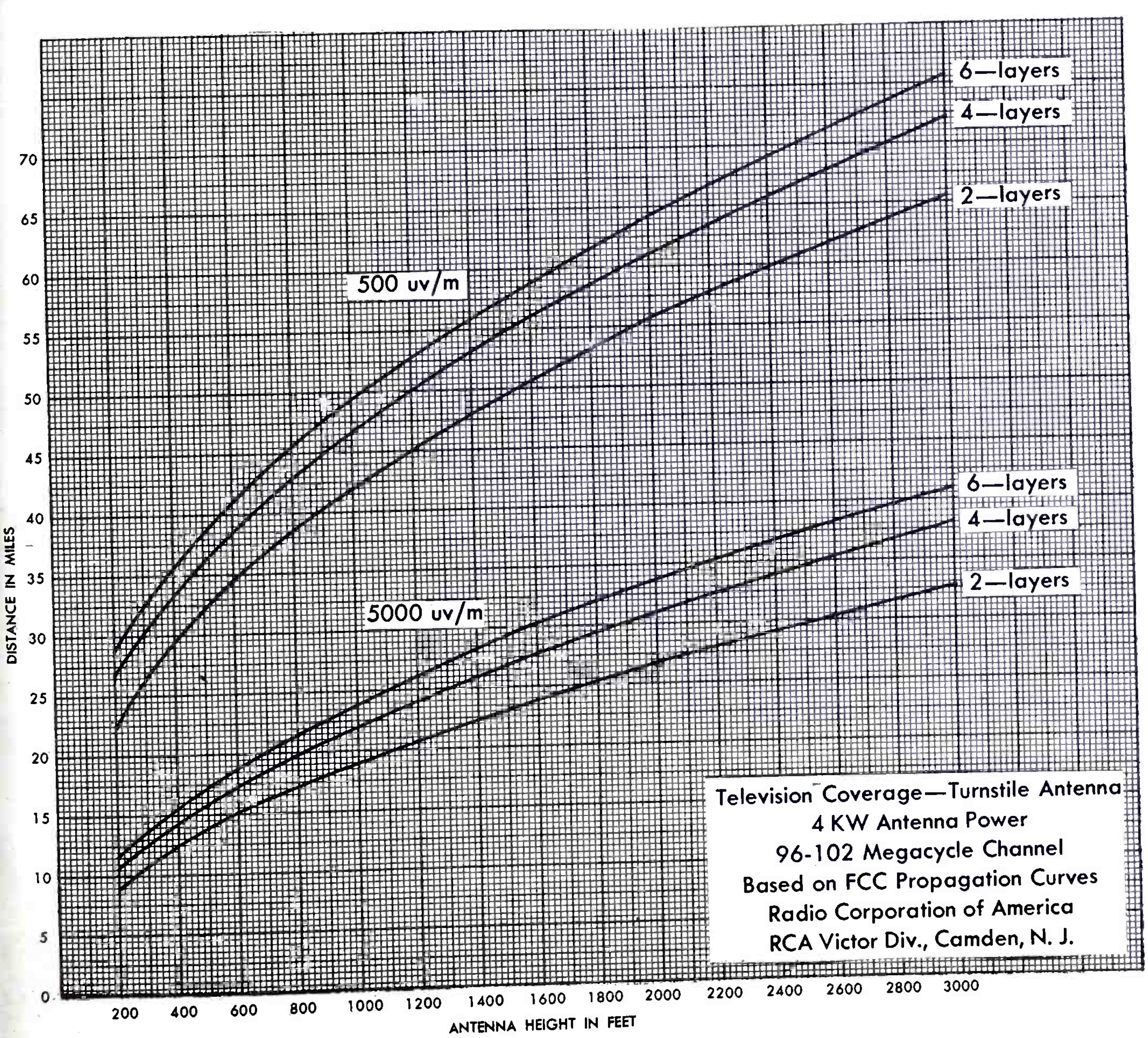

6—layers
4—layers
2—layers
500 uv/m
6—layers
4—layers
5000 uv/m
2—layers
DISTANCE IN MILES
ANTENNA HEIGHT IN FEET
Television Coverage—Turnstile Antenna
4 KW Antenna Power
90-96 Megacycle Channel
Based on FCC Propagation Curves
Radio Corporation of America
RCA Victor Div., Camden, N. J.

FIG. 7.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4—layers
2—layers
500 uv/m
6—layers
4—layers
5000 uv/m
2—layers
DISTANCE IN MILES
ANTENNA HEIGHT IN FEET
Television Coverage—Turnstile Antenna
4 KW Antenna Power
96-102 Megacycle Channel
Based on FCC Propagation Curves
Radio Corporation of America
RCA Victor Div., Camden, N. J.

FIG. 8.

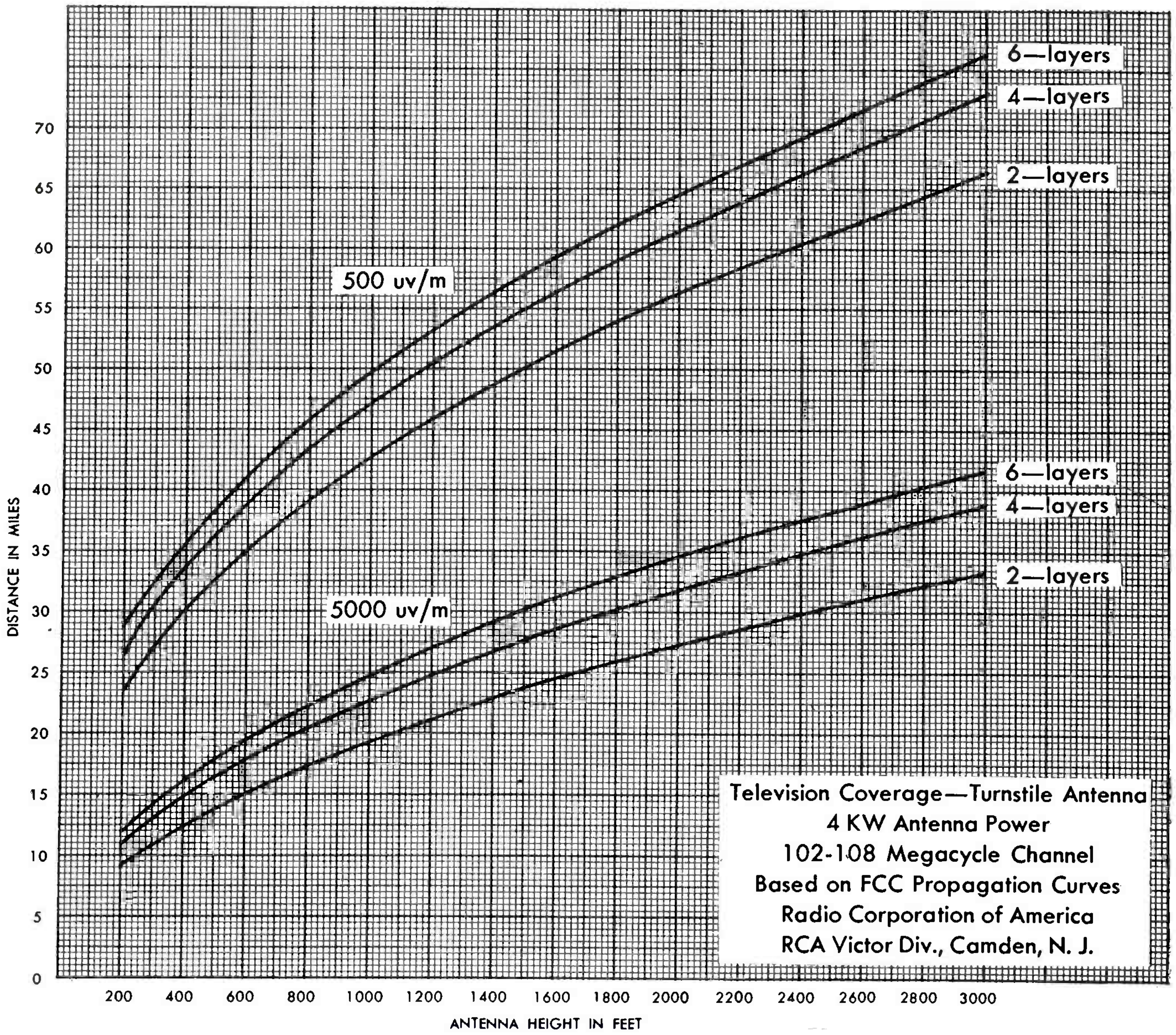

6—layers
4—layers
2—layers
500 uv/m
6—layers
4—layers
2—layers
5000 uv/m
DISTANCE IN MILES
ANTENNA HEIGHT IN FEET
Television Coverage—Turnstile Antenna
4 KW Antenna Power
102-108 Megacycle Channel
Based on FCC Propagation Curves
Radio Corporation of America
RCA Victor Div., Camden, N. J.

FIG. 9.

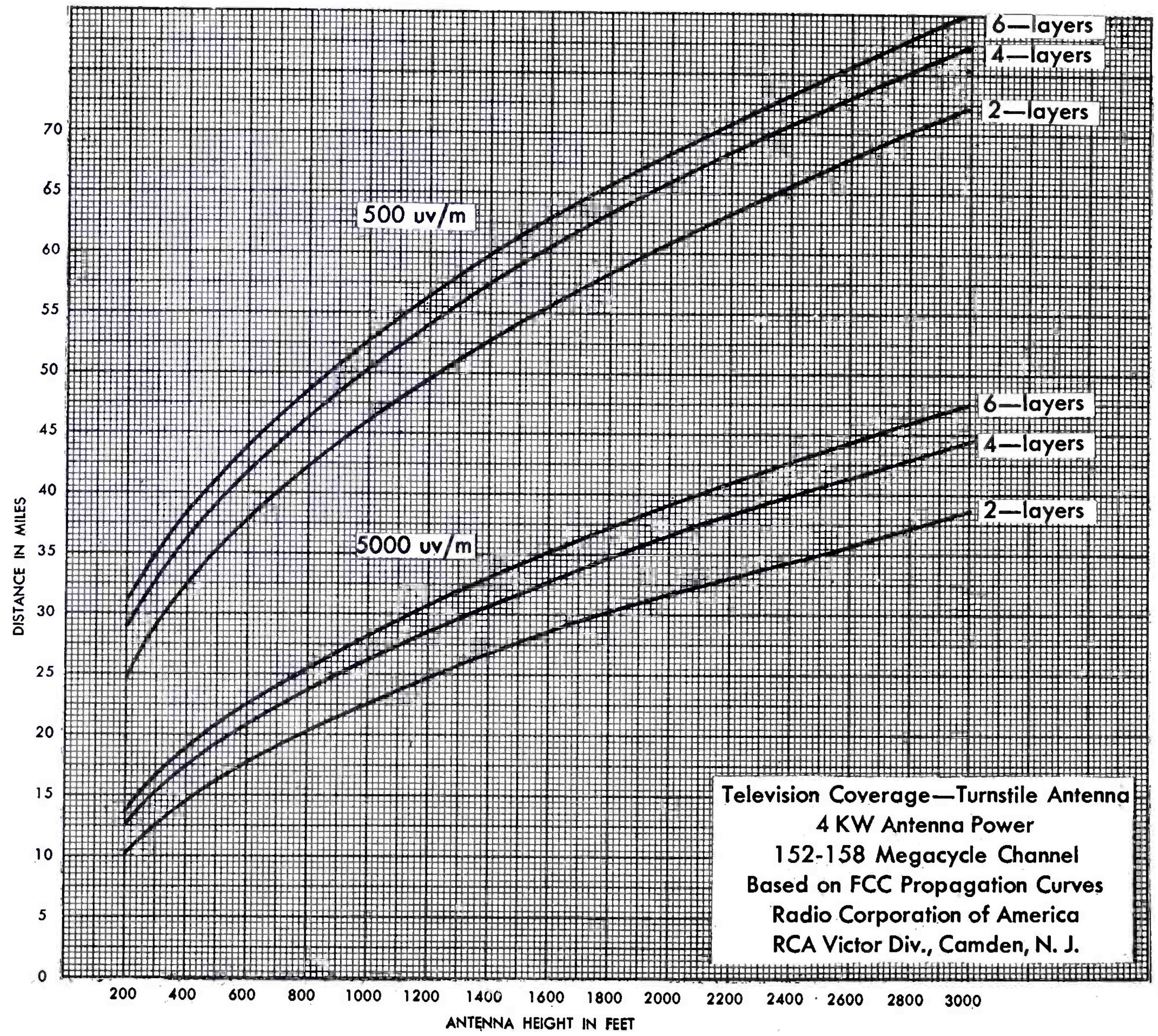
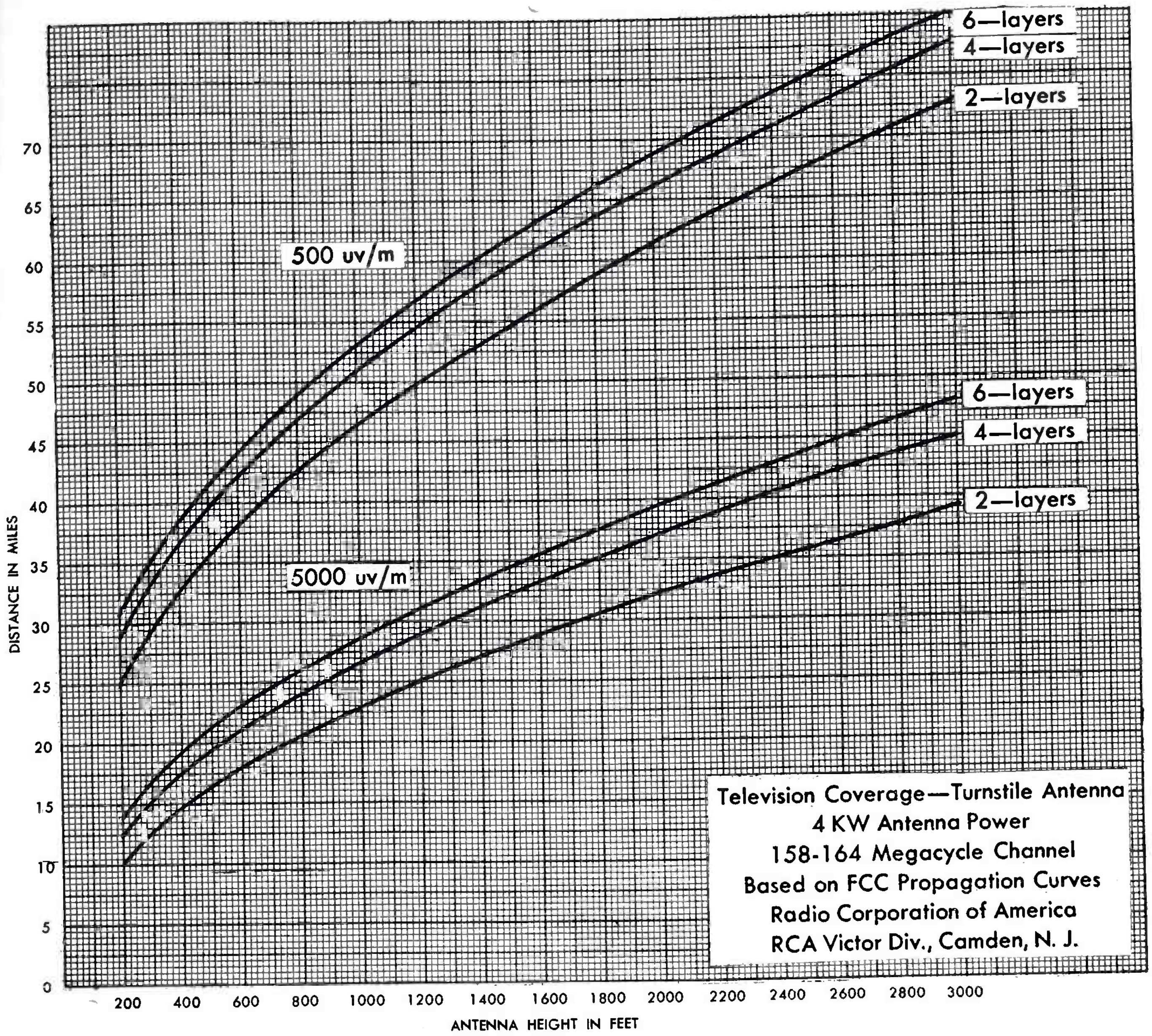

6—layers
4—layers
2—layers
500 uv/m
6—layers
4—layers
2—layers
5000 uv/m
DISTANCE IN MILES
ANTENNA HEIGHT IN FEET
Television Coverage—Turnstile Antenna
4 KW Antenna Power
152-158 Megacycle Channel
Based on FCC Propagation Curves
Radio Corporation of America
RCA Victor Div., Camden, N. J.

FIG. 10.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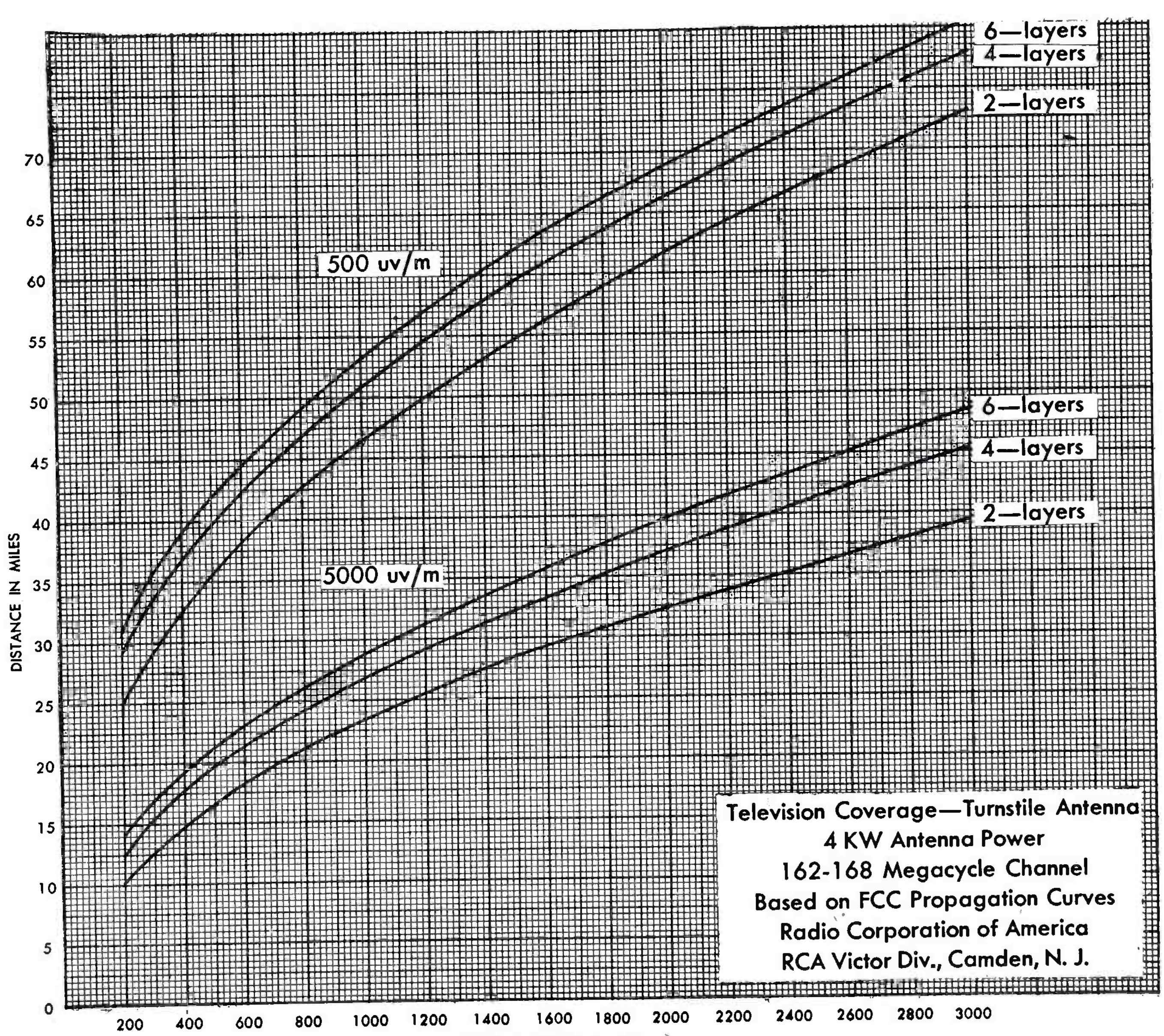
4—layers
2—layers
500 uv/m
6—layers
4—layers
2—layers
5000 uv/m
DISTANCE IN MILES
ANTENNA HEIGHT IN FEET
Television Coverage—Turnstile Antenna
4 KW Antenna Power
158-164 Megacycle Channel
Based on FCC Propagation Curves
Radio Corporation of America
RCA Victor Div., Camden, N. J.

FIG. 11.

FIG. 12.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4—layers
2—layers
500 uv/m
6—layers
4—layers
2—layers
5000 uv/m
DISTANCE IN MILES
ANTENNA HEIGHT IN FEET
Television Coverage—Turnstile Antenna
4 KW Antenna Power
162-168 Megacycle Channel
Based on FCC Propagation Curves
Radio Corporation of America
RCA Victor Div., Camden, N. J.

IN audio EQUIPMENT

FOR AM, FM, SHORT-WAVE AND TELEVISION

The RCA 44-BX Velocity Microphone and the 77-C Unidirectional Microphone—the finest in quality and the most widely used of all microphones.

The RCA 70-C Transcription Turn-table, most popular everywhere, one or more in every broadcast station—equipped with universal pickup head.

The RCA 64-B Monitoring Loudspeaker, widest frequency response and widest angle of high-frequency response of any standard model speaker.

IN studio speech input equipment RCA has led the field for the past ten years—in recent years by a wide margin.

RCA studio equipment predominates in the studios of all major networks and in a large proportion of the outstanding station installations—large and small.

All of the RCA studio equipment, and all of the RCA broadcast transmitting equipment, sold in the last ten years was designed from scratch by RCA engineers and built exclusively in RCA plants.

RCA experience in broadcast equipment—studio and transmitting—is unequaled.

And note especially—

All of the RCA studio equipment models current at the beginning of the war were designed for the wide response and high standards of FM broadcasting.

A number of commercially licensed FM stations *on the air today* are 100% RCA-equipped—from microphone to antenna.

RCA

RCA BROADCAST EQUIPMENT

RADIO CORPORATION OF AMERICA

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