The House that

Built

NBC

THE HOUSE
THAT RADIO BUILT

By
O. B. HANSON

A story of the experience and research which went into the building and equipping of NBC's Radio City studios, by the man responsible for their designing and completion, NBC's Chief Engineer.

BROADCASTING HEADQUARTERS

NATIONAL BROADCASTING COMPANY, INC.

A Radio Corporation of America Service

NEW YORK WASHINGTON CHICAGO SAN FRANCISCO

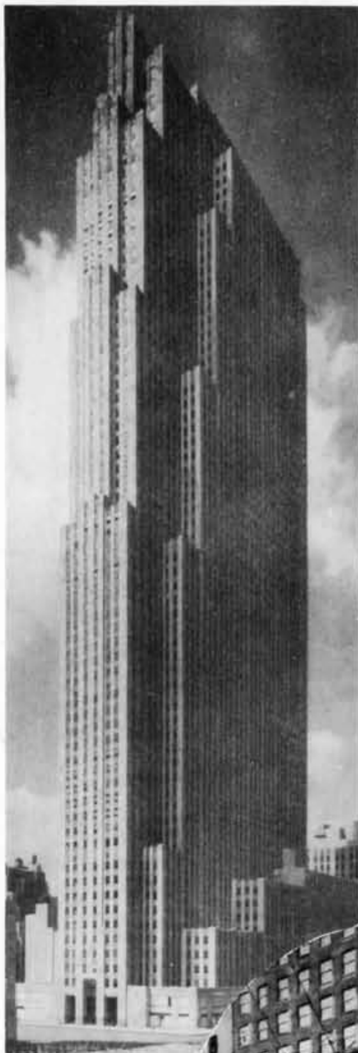
FOUR STRIDES IN MAINTAINING *Leadership*

IT has been said often—and bears repeating—that radio has come a long way since the days of the handful of amateurs with their crude transmitting and receiving equipment. When we think back to the early days of KDKA, to its birthplace in a garage at Pittsburgh, in 1920, and then encompass the panorama of Radio City—verily, radio has traveled far!

In 1921, Westinghouse Electric and Manufacturing Company opened WJZ as an experimental station at Newark, New Jersey. A small building was erected on the roof of a large factory building for the purpose of housing a 500-watt transmitter. An erstwhile cloak-room, draped with a few odds and ends, including old rugs and furnished with nondescript chairs, tables, a rented piano and a phonograph, became the studio. Later the Radio Corporation of America acquired WJZ and transferred the studios and transmitter to Aeolian Hall, New York City.

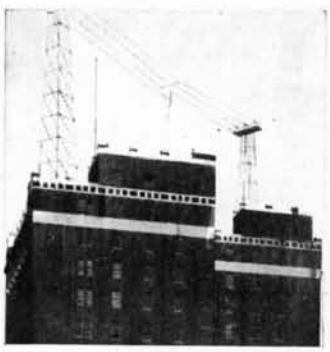
In August, 1922, a year later, The American Telephone and Telegraph Company, anxious to study the possibilities of radio broadcasting, inaugurated station WEAF in New York City and presented the first of a never-ending flow of programs.

In October, 1927, the newly formed National Broadcasting Company, combining the facilities of WJZ and WEAF, moved "uptown" to the northeast corner of Fifth Avenue and Fifty-fifth Street. Again in the short span of six years, NBC's quarters became cramped, and in the fall of 1933, the company moved to Radio City.



***1933**—NBC's new Radio City home utilizing the first ten floors of the mammoth RCA Building. The world's finest broadcasting studios and equipment are housed in this building.*

***1927**—Programs were first broadcast from the 711 Fifth Avenue building on October 1, 1927.*



***1922**—The birthplace of WEAF at Walker Street, New York. Here in August, 1922, one year after WJZ went on the air from Newark, New Jersey, The American Telephone & Telegraph Company inaugurated Station WEAF.*

***1923**—Larger facilities for Station WJZ were established in Aeolian Hall in 1923.*

O. B. HANSON ★ ★

Mr. O. B. Hanson, Chief Engineer of the National Broadcasting Company has, since radio's inception, been a very large contributor to its technical development. Many of the outstanding engineering achievements for which radio has been noted have been due largely to his knowledge and efforts.

Mr. Hanson's radio career began in 1912 when he attended the Marconi School in New York, now continuing as the RCA Institute. Completing his course in "wireless" he obtained his operator's license and went to sea. From 1917 to 1920 he worked in the testing department of the Marconi Company, becoming Chief Testing Engineer. In 1920 he took another turn at sea.

When radio broadcasting came into being Mr. Hanson became associated with WAAM, a pioneer station in Newark, New Jersey. In 1922 he accepted a position as assistant to the Plant Engineer of WEAF, then owned and operated by the American Telephone and Telegraph Company. With the formation of the National Broadcasting Company in 1926, Mr. Hanson went with the new company and since that date has directed technical operations and engineering activities for NBC.

He supervised the designing and construction of the NBC studios at 711 5th Avenue (vacated when NBC moved to Radio City), and the NBC Chicago studios in the Merchandise Mart. Both of these installations were, at the time of their building, the last word in technical efficiency as well as pleasing design.

When the time came for creating the NBC studios at Radio City Mr. Hanson was well-equipped to carry out the ambitious plans laid down. The results of his work have attracted worldwide interest both on the part of technicians and laymen. In this story of "The House That Radio Built," Mr. Hanson reveals many of the interesting details and problems which he and his staff were called upon to solve and carry out.

THE NBC STUDIOS AT RADIO CITY

The Engineering Accomplishment
Why the Constantly-Growing NBC Audience
Receives the Finest Quality Broadcast Entertainment

★ ★

By O. B. HANSON
Chief Engineer, National Broadcasting Company, Inc.

The RCA Building—NBC's New Home

On November 11, 1933, the new studios of the National Broadcasting Company were officially opened in the RCA Building, Radio City's imposing central structure towering 836 feet above street level, and containing 2,113,000 square feet of rentable area in its seventy floors. Seventy-four high-speed, signal controlled elevators, twelve of which are reserved exclusively for the use of the NBC, serve tenants of the building.

The steel work at the base of the tower is necessarily massive and closely spaced, and this fact had a direct bearing upon the location of the NBC Studios. A building intended for broadcast studios must be designed with large column-free spans, a requirement which obviously could not be met in the base of the RCA Building tower. An addition to the building was especially designed and constructed, therefore, immediately west of, and contiguous with, the lower part of the tower. This special section, occupied exclusively by NBC above the street floor, is 11 floors high and contains 22 studios, 5 audition rooms, 8 switching booths, and such other space as is requisite to the functioning of the complicated mechanism that is the modern broadcast plant.

The three million cubic feet of air in the special studio section is conditioned by what is regarded as the most intricate air conditioning plant ever constructed. Outside windows were omitted because of sound insulation requirements on all but two floors in the studio section, and thus air conditioning became a necessity so that proper temperature and humidity conditions could be maintained within the otherwise tightly sealed sound insulated rooms. Operating offices on the second and fifth floors are the only rooms in the studio section with outside windows.

A giant knife sliced through NBC's new home would reveal a cross-section of floors like the one shown in Figure 2. Of the entire NBC space of approximately 386,500 square feet, some 278,000 square feet is located in the studio building. The remainder of the space is devoted to offices, and is in the base of the tower continuous with the third, fourth, fifth and sixth studio floors.

It is a perfectly natural question to be asked by even those fairly familiar with radio production problems: "Why is so much space, especially in the studio section, necessary for daily operations?" In the first place, NBC has two basic networks: WEAF Basic Red and WJZ Basic Blue; this means that during the broadcasting day two studios are in use at the same time, except in cases of programs originating outside of New York City, or by remote control in New York City. Statistics show that for every hour of actual broadcasting, an average of seven hours of preliminary studio work is required. In other words, while one studio is in actual use, six others are being used for rehearsal purposes, and still another is being prepared for the following program. The two NBC networks, therefore, require a minimum of sixteen studios.

Several studios more than this minimum are practically essential, however, because productions vary in size and type, and because in network broadcasting it is frequently necessary to split networks, that is, to originate programs

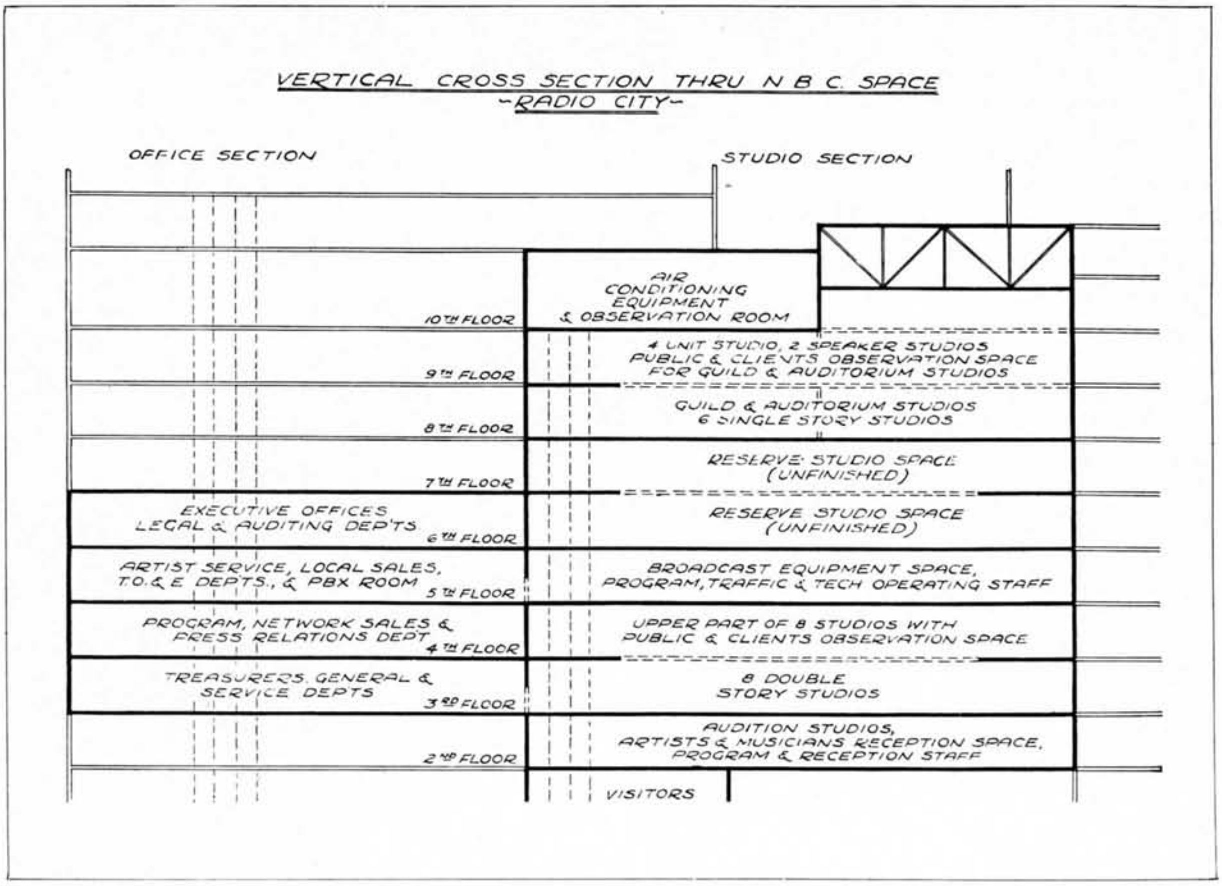


Figure 2

in these studios for both networks and at the same time one or more programs for local stations which are not connected to the network. Thus, three and sometimes four programs must be simultaneously transmitted. Furthermore, at times both networks may be split into several groups calling for six or more simultaneous independent programs, all from Radio City.

Apart from the studios, audition rooms have been provided for the convenience of the Program Board. In these rooms many "hearings" are conducted each year as the board searches constantly for new talent.

The switching booths provide facilities for various purposes such as amplifying equipment for local outside pickups, equipment for network switching, equipment for especially rapid switching from one to the other of several outside pickups, and special devices such as automatic chimes.

Studios require a number of adjoining rooms for maximum utility. Aside from the control room which is a part of every studio and audition room, practically every studio has a client's room where the program sponsors, their advertising agencies, and their guests may witness the broadcasts and hear them with much the same quality of tone fidelity as they are heard in the homes of radio listeners.

Each of these rooms is acoustically treated, and is provided with a sound-insulated glass partition permitting visibility into the studio. In addition, each client room is equipped with a high quality loudspeaker and with appropriate furnishings for comfort and convenience. Many of the studios also have mezzanine observation rooms in which permanent theatre-type seats are installed. Visitors may sit comfortably in any such room and witness a broadcast through a sound insulated glass partition. Conversation may be carried on in the room without being picked up by the studio microphones.

SOUND INSULATION

A study of the sound insulation system of the studios makes evident the fact that untold advances have been made in methods of controlling sound. In fact, NBC's studios, control rooms, etc., are as nearly "soundproof" as engineering genius can make them.

The sound insulation comprises not only the sound resistant doors and glass partitions, but also the system by which all studios and their adjoining rooms are insulated from the building frame on all six surfaces (ceilings, floors, and walls) by means of spring clips and hair-felt isolators. A typical example of sound insulated floor construction is illustrated in Figures 3 to 7 inclusive. These illustrations show five steps in the construction in one of the studios.

Five Steps to Studio Silence

In Figure 3 may be seen the floor channels which rest on hair-felt-covered spring clips properly spaced to carry the anticipated load. Each clip includes two anchor legs which are firmly held to the floor by cement blocks as can be seen in Figure 4. The space between the channels is filled with loose rockwool as shown in Figure 5 to prevent hollowness and drum-like action in the floor.

Rockwool is made from a soft-grade Indiana limestone, melted in a blast furnace, and played upon by a jet of steam as it escapes through an opening in the bottom of the furnace. The material deposited after this process is known as rockwool; it is fireproof and closely resembles glass wool to which it is chemically similar.

After the space between the channels is filled with rockwool, a layer of black building paper is placed over the entire floor. On this is laid the wire mesh over which the concrete is to be poured (Figure 6). The finished floor, ready for linoleum, is shown in Figure 7.

Wall and Ceiling Sound Insulation

The sound insulation of walls and ceilings is somewhat different. A series of illustrations,

Figure 3. Sound insulated floor construction, showing channels, spring clips, and anchor legs.

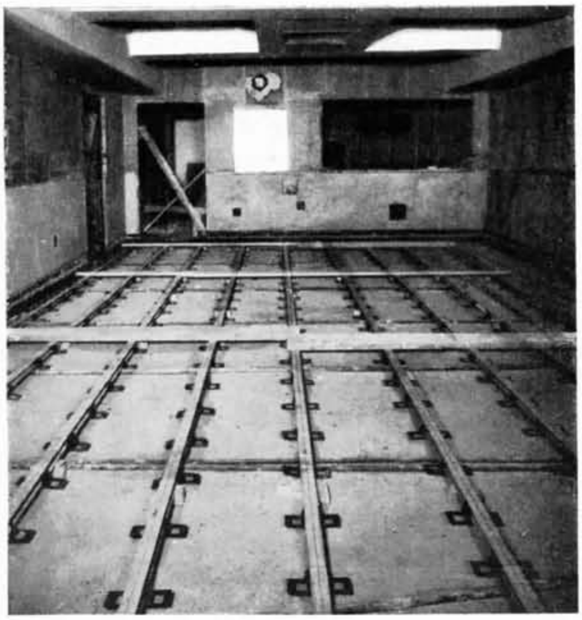


Figure 4. Anchor legs fastened to floor by cement blocks.

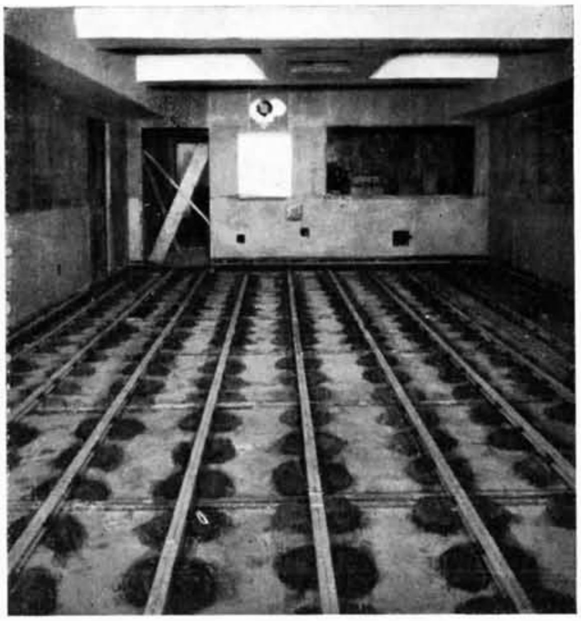


Figure 5. Rockwool between channels, and black building paper covering.

Figure 6. Wire mesh laid over black building paper, ready for concrete floor.

Figure 8 through 10, illustrate the differences. The first stage (Figure 8) shows the spring clips fastened to the wall and the hair-felt insulation inside the clips insulating the horizontal steel members or furring channels, as they are called. The vertical furring channels are fastened to the horizontal members by means of wire, and are thus held well clear of the building wall.

The ceiling construction is similar except that the channels are held by insulated clips which in turn are hung from the slab above by links of the proper length.

Over the furring channels, and fastened by means of wire, is placed the wire mesh which is to receive the plaster. This is illustrated in Figure 9. It will be noted that the black paper

Figure 7. Finished concrete floor ready for linoleum.

covers have been folded down to prevent the plaster that may fall through the mesh from dropping on the hair-felt insulation. A little thing, perhaps, but one isolator short circuited by plaster would render the entire sound isolation system inoperative, and the condition would be extremely difficult, if not impossible, to locate and correct after the plaster was applied.

As shown in Figure 10, the plaster is placed over the wire mesh, three coats, namely: scratch, rough brown, and white for finished walls; two coats: scratch, and rough brown for walls which are to receive acoustical treatment.

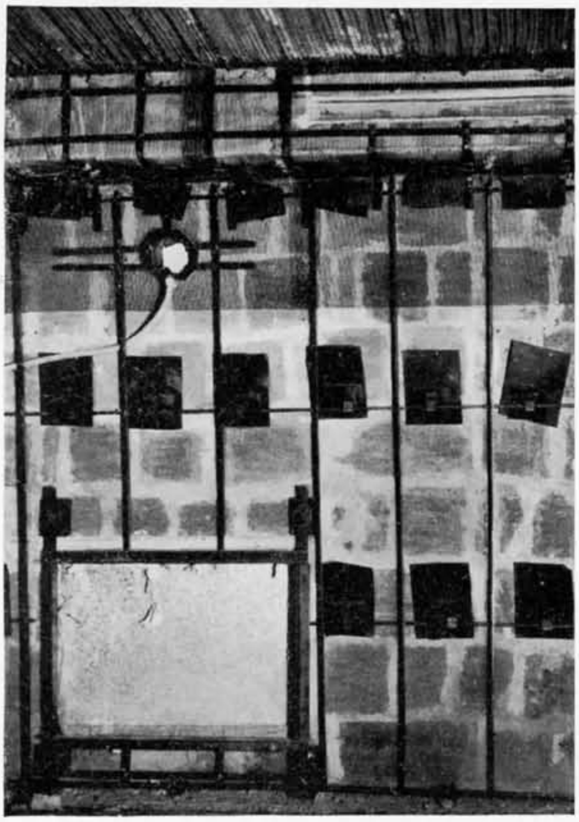


Figure 8. Sound insulated wall construction, showing wall clips holding horizontal furring channels to which vertical channels are wired.

Figure 9. Wire lath in place ready for plaster coats.

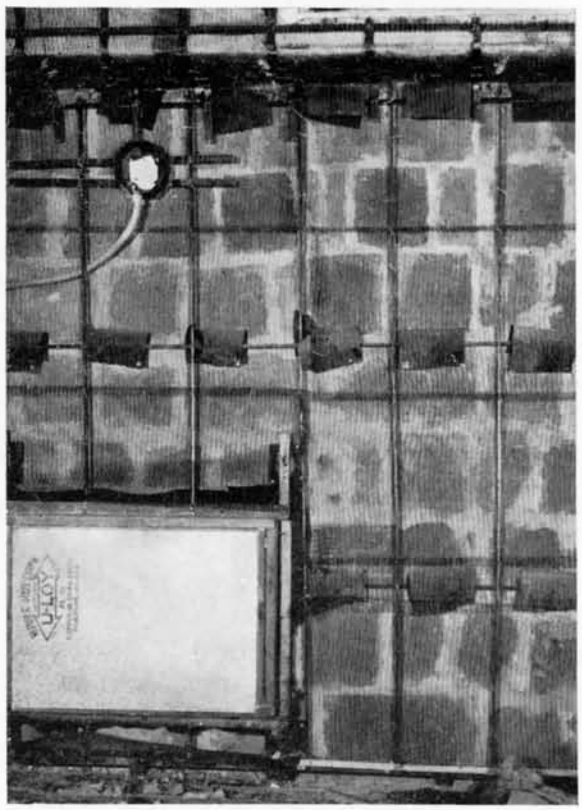


Figure 10. Rough plaster surface ready for acoustical treatment.

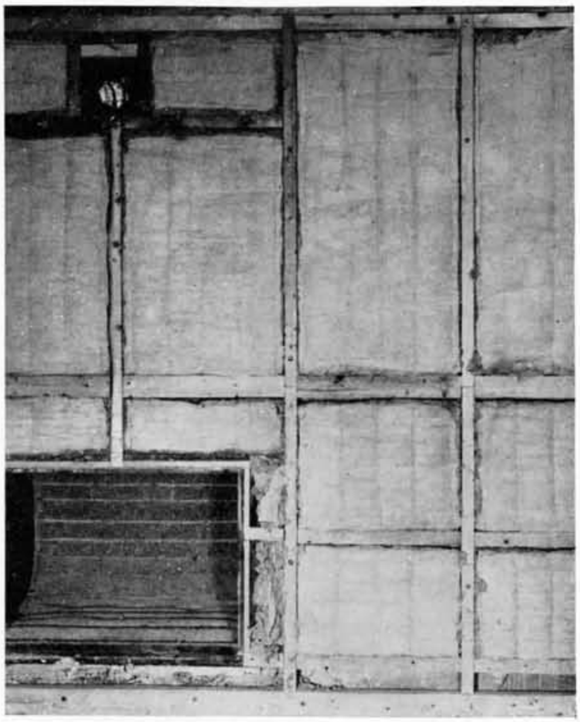


Figure 11. Application of acoustical treatment, showing rockwool blanket between wooden uprights. Observe the sound absorbing lining in the duct at the left.

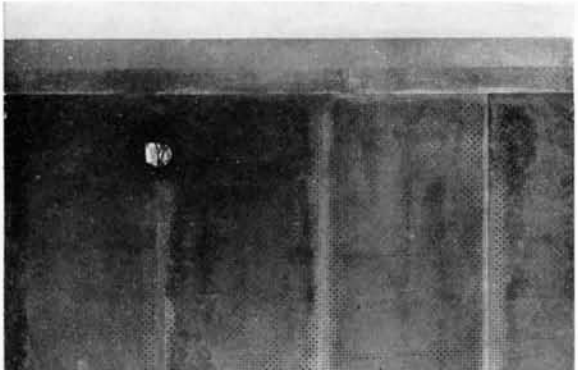


Figure 12. Perforated and plain transite covering in place over rockwool blanket, ready for decorative fabric.

ACOUSTICAL TREATMENT

The experience of talking first in a room without furnishings and wall hangings, and then later in the same room fully furnished, brings out very striking acoustical differences. In the first case the voice is loud, unpleasant, and reverberant with resultant overlapping of syllables; in the second case it is soft with the reverberation much reduced, and is considerably clearer. The same condition exists in studios. Hard plaster walls are much too live for satisfactory broadcasting, and for this reason it is necessary to use considerable acoustical treatment. The amount depends, of course, upon the characteristics desired in each studio.

Of the several kinds of acoustical treatment in the studios, rockwool made up in blanket form (2″ or 4″ thick) is most extensively used because it has less tendency to absorb overtones and more tendency to absorb medium and low frequencies, than any previously used material. In other words, its absorption characteristics are an approximation to the engineers' established ideal for broadcasting. Figure 11 illustrates how the 2″ or 4″ blanket is placed on the wall between wooden uprights, and Figure 12 shows the 3/16″ perforated transite (highly compressed mixture of cement, asbestos, and linseed oil) covering. The protective wainscot is solid ½″ transite. Decorative fabric over the transite completes the wall surface.

In Figure 13 are shown typical absorption characteristics for 2″ and 4″ rockwool blanket covered with 3/16″ transite and linen fabric. It is clearly evident that the 4″ treatment has a much greater percentage absorption for low frequencies.

Figure 14 illustrates the frequency-reverberation time characteristic for one of the smaller studios. It is interesting to observe that this curve shows the reverberation time to be lowest at frequencies for which the human ear is most sensitive.

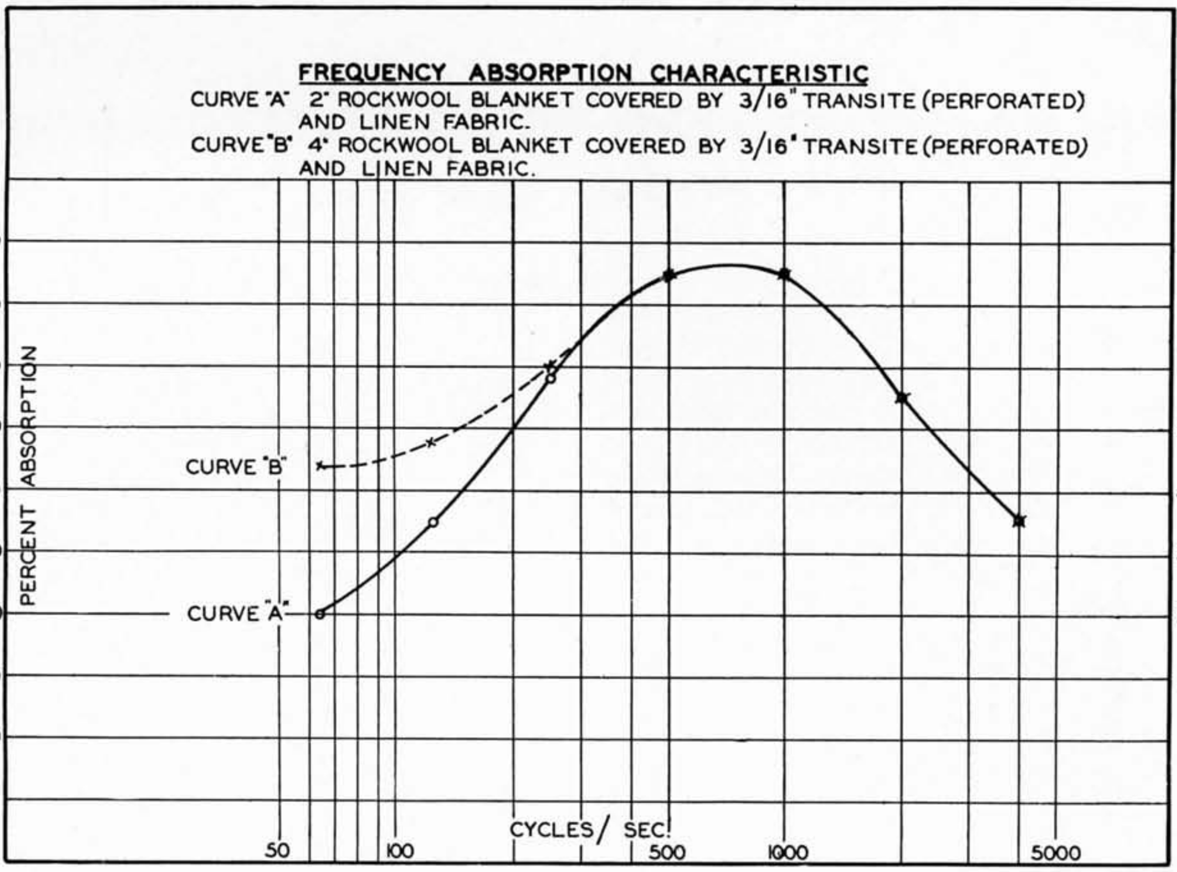


Figure 13

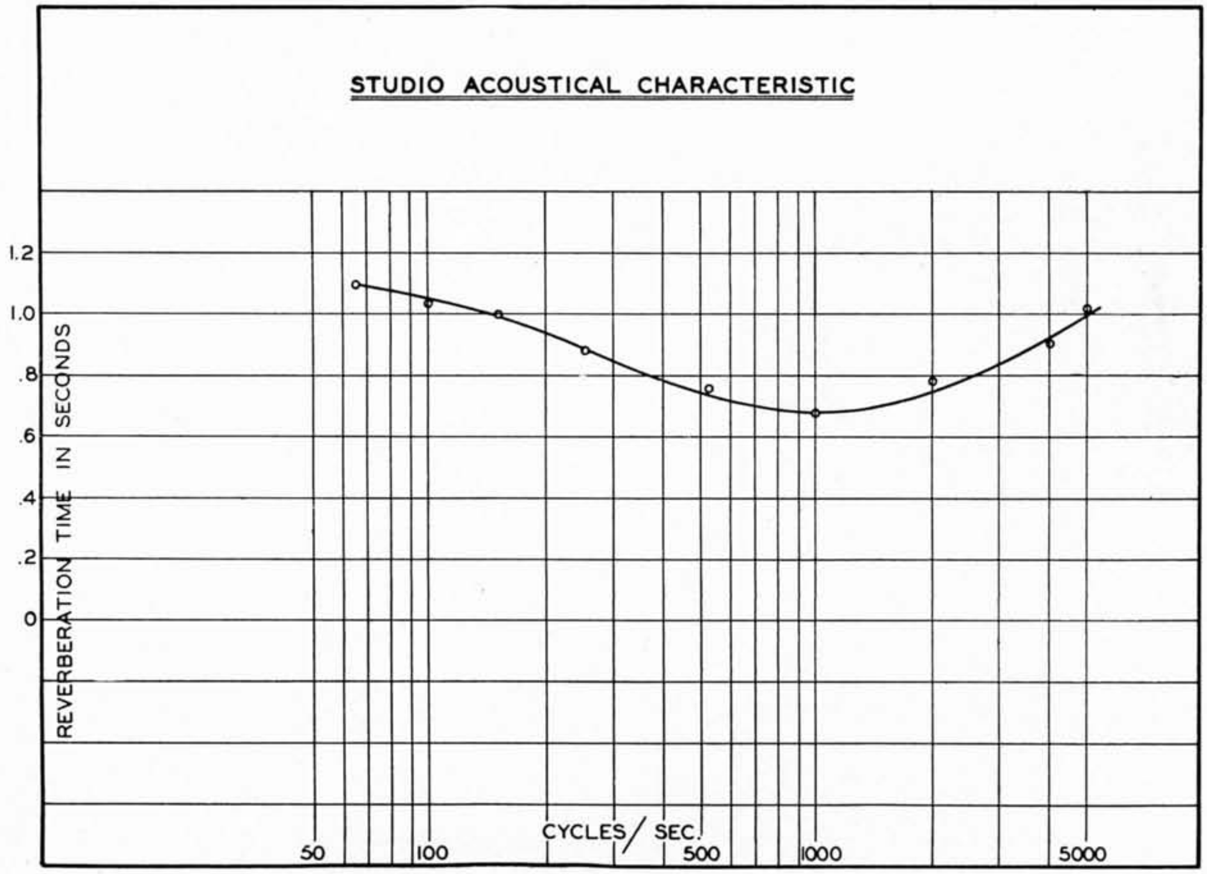


Figure 14

STUDIO PLANNING TO MINIMIZE NOISE, CONFUSION, AND DELAY

A study of Figures 15 and 16, showing the floor plans of the third and fourth floors of NBC's studio structure, indicates how the studios have been planned to avoid the end columns of the tower steel work which are grouped about the central stairway.

Each studio is so arranged that members of the staff can reach the studios and control rooms by means of private staff elevators and corridors. Gone is any semblance of confusion and delay.

Whether entrance to the studio is from the public or private corridor, it must in either case be through first one door opening into a vestibule and then through another door opening into the studio. The vestibule is in reality a sound lock.

Sealing Sound Out

The sound-lock is essential to reduce to a minimum the intensity of extraneous sound that finds its way into the studio, especially as the doors are opened. This object is accomplished because usually the first door has closed automatically before the second door is opened. Furthermore the vestibule is acoustically treated, and as a consequence acts like a muffler for any sound which gets past the first door.

Each sound insulated door is equipped with a dual automatic device which lowers into place against the sill when the door closes. This forms an effective seal, and prevents the sound leakage which would occur with the conventional door sill construction.

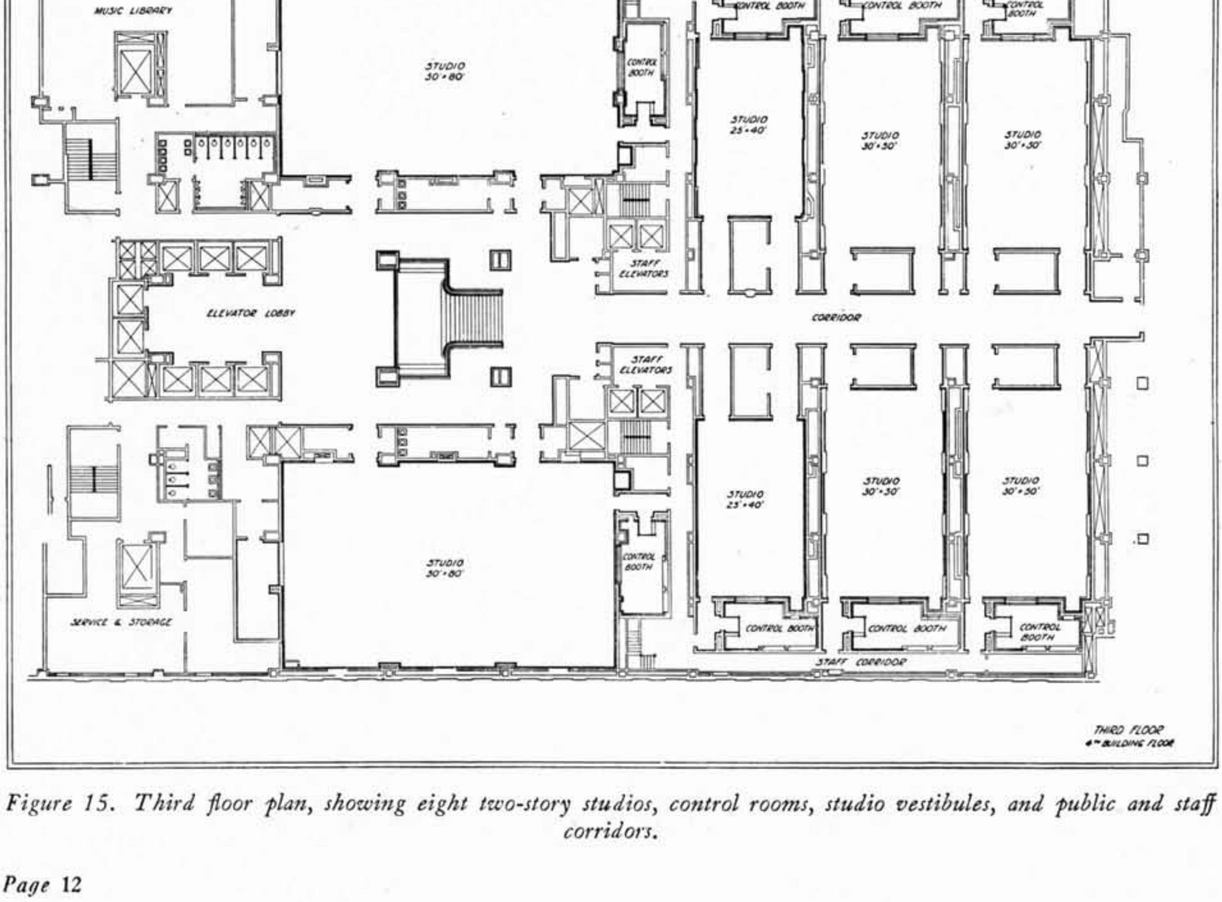


Figure 15. Third floor plan, showing eight two-story studios, control rooms, studio vestibules, and public and staff corridors.

TRANSPARENT SOUNDPROOF PARTITIONS

Someone remarked, on an inspection tour through NBC's studios before they were officially opened for use: "You people seem to have delighted in making it hard to build!" Such a remark, true in every sense, is nevertheless a compliment to the engineering which is responsible for Radio City. Take the cross-section illustration, Figure 17, showing a typical three-panel glass partition as installed between a studio and its control room.

The panel facing the studio control room is a part of the control room floating wall, and is isolated from the middle pane. Each pane is isolated from the others, and, in addition, each is sealed around its edges with soft rubber and cement. To keep the inside surfaces of the glass free from dust, this rubber seal was made complete so that the space between panes is airtight except for an especially constructed outlet tube or "breather," leading from the space between the panes to the studio control room. The "breathers" equalize air pressures on opposite sides of each pane, preventing fractures due to excessive barometric pressure differentials. The air that enters the space between the panes is filtered through four layers of felt placed at the end of the "breather" tube.

Figure 18 illustrates Studio 3A, one of the 50′ x 80′ x 18′ third floor studios. There is a stage at one end which facilitates the proper placing of the various orchestral components, and which also makes it possible, due to the elevation, for an audience to see all of the performers without difficulty.

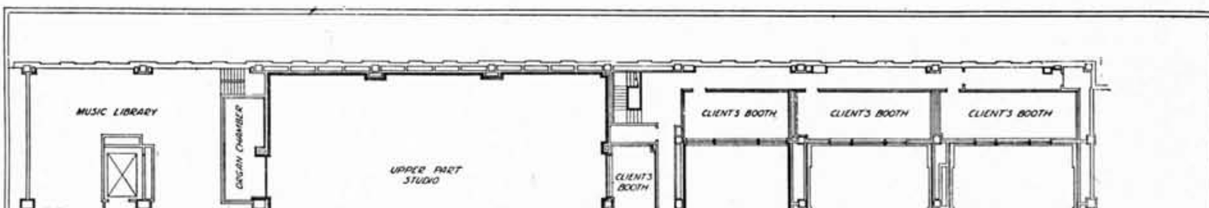


Figure 16. Fourth floor plan showing observation and clients rooms.

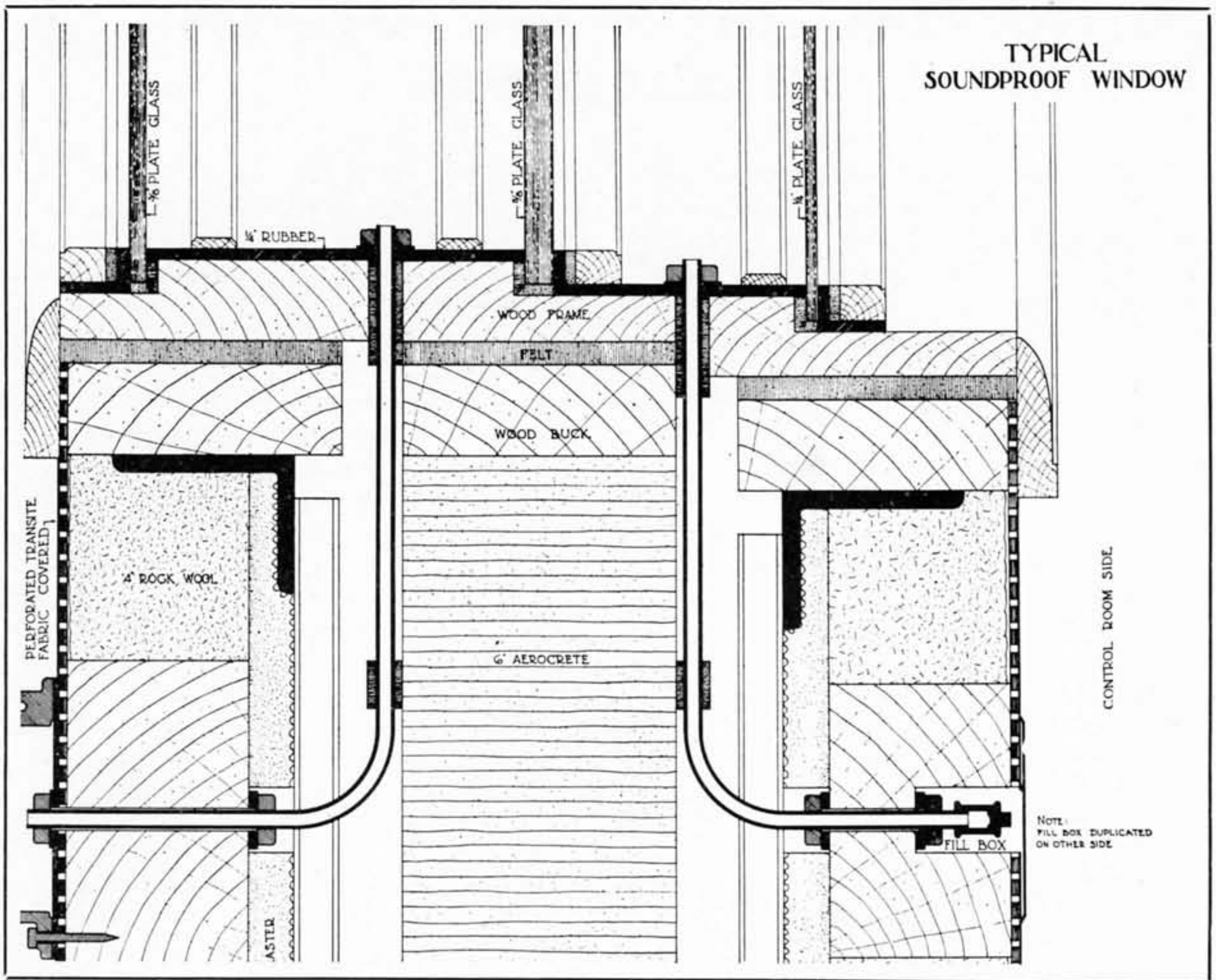


Figure 17. Cross-section of a three thickness sound insulated window, showing the rubber and felt mountings for the glass, and the "breather" for equalizing atmospheric pressures.

Figure 18. One of the 50′ x 80′ x 18′ studios on the third floor, showing the stage at the far end.

MEETING DIFFICULT LIGHTING PROBLEMS

Even one who has never had the satisfaction of seeing the inside of any of the Radio City studios could tell from looking at illustrations of studio interiors that one of the striking features is the type of illumination provided. In general, as far as broadcasting studios are concerned, there are several requirements which the illumination system should be designed to meet. In the first place, the illumination intensity must have a value of 15 to 20 foot-candles so that music, notes, and scripts may be read with ease and speed. Secondly, there must be no glare within the normal lines of vision. Thirdly, there must be no sharp shadows anywhere in the studio. Fourthly, the illumination intensity in a given studio must be as uniform as practicable. All these requirements have been met by the system installed at Radio City.

Controlled Lens Lighting

Controlled lens lighting, the name by which this particular system is known, is direct illumination, and is one of the most efficient yet devised on a watts per foot-candle basis. The foot-candle is the illumination engineer's yardstick. It represents the illumination at a point on a surface which is one foot distant from, and perpendicular to, the rays of a one candle-power light source. A high efficiency in watts per foot-candle is an important requirement in buildings in which air is conditioned since the refrigerating plant must take away all heat energy above the value necessary for the required temperature condition. Obviously, the higher the efficiency of the lighting system, the less the heat that must be absorbed and, thus, the smaller the required capacity of the refrigerating plant.

The type of lens used in the luminaires is interesting. On one face there is moulded a series of concentric annular prismatic corrugations, deep at the outer edge, and decreasing progressively in depth toward the center, which are so shaped that the light distribution therefrom simulates, except for greater dispersion, the distribution obtained with a plano-convex lens. The effectiveness of this method of illumination is evident in a number of the illustrations, especially Figure 21, the giant Auditorium Studio where the illumination is remarkably uniform and free from shadows and glare; another good example is shown in Figure 18. The luminaires are flush with the ceiling, and, therefore, do not interfere with the acoustical properties of the studio, or with the free movement of studio equipment such as microphone booms and acoustical screens.

In most of the studios flush luminaires are installed in single units spaced uniformly over the ceiling, or they are grouped in sets of two, three, or four units with greater spacing between groups, where ducts and conduit in the ceiling would not allow the installation of the more closely spaced single units. The essential difference between this system of direct lighting and other systems is that the light beam is controlled and directed with a lens instead of being generally diffused.

In some of the smaller studios with low ceilings, the lens of the luminaires, instead of being flat as it is in the studios with high ceilings, is bowl shaped. It, too, has the annular prismatic corrugations. This type of lens causes the light beam to spread more widely than the flat lens, and consequently gives a much better light distribution in rooms with low ceilings where the working plane, i.e., the average level at which script and music must be read, is necessarily close to the source of illumination.

Looking Ahead to Television

Anticipating the advent of television, the entire lighting system in the studio section was designed to operate on direct current to obviate the possibility of stroboscopic interference from alternating current lighting. Five 750 KW motor generator sets in the basement supply the direct current lighting. A considerable portion of this generator capacity is intended for flood lighting, a further anticipated requirement of television.

ACOUSTICALLY ADJUSTING STUDIOS

By Means of Sliding Panels

Figure 19 illustrates one of the four 30′ x 50′ x 18′ studios equipped with six pairs of sliding acoustical panels. These panels are hung on tracks near the ceiling, and are operated by electric motors controlled by pushbuttons from a board in the studio control room. Each panel consists of a framework into which has been placed a rockwool blanket. A sheet of perforated metal and finally a decorative fabric covering, is placed over the rockwool. These panels, according to their setting, more or less cover the hard plaster wall. This wall is unusual in that it consists of a series of vertical V shaped flutes as illustrated in Figure 20. This type of plaster surfacing has been applied where hard surfaces are located opposite each other in studios.

Opposite hard surfaces when flat and parallel create a local echo area causing an effect known as "flutter" with a consequent impairment of sound quality. The V'd plaster surfaces break up the sound waves, dispersing them in such a way as to avoid this "flutter" effect. In other words, the studio can be acoustically adjusted to any desired condition, and when live does not have the objectionable "flutter" usually existent in live rooms.

These sliding panel studios were designed to permit a two to one reverberation time change. Specifically, the actual change realized in the reverberation period is from .65 seconds with the panels completely closed and hard plaster covered, to 1.20 seconds with the panels completely open and the hard plaster exposed. Reverberation time is the number of seconds or fractions thereof necessary for sound of a given steady state pressure value to decay to 1/1000 of this value. In dealing with acoustical problems, measurements such as this must be made at a number of frequencies in the audio spectrum to obtain the required data.

Figure 19. One of the 30′ x 50′ x 18′ studios on the third floor, showing the sliding acoustical panels partially open.

Figure 20. Typical V'd plaster construction.

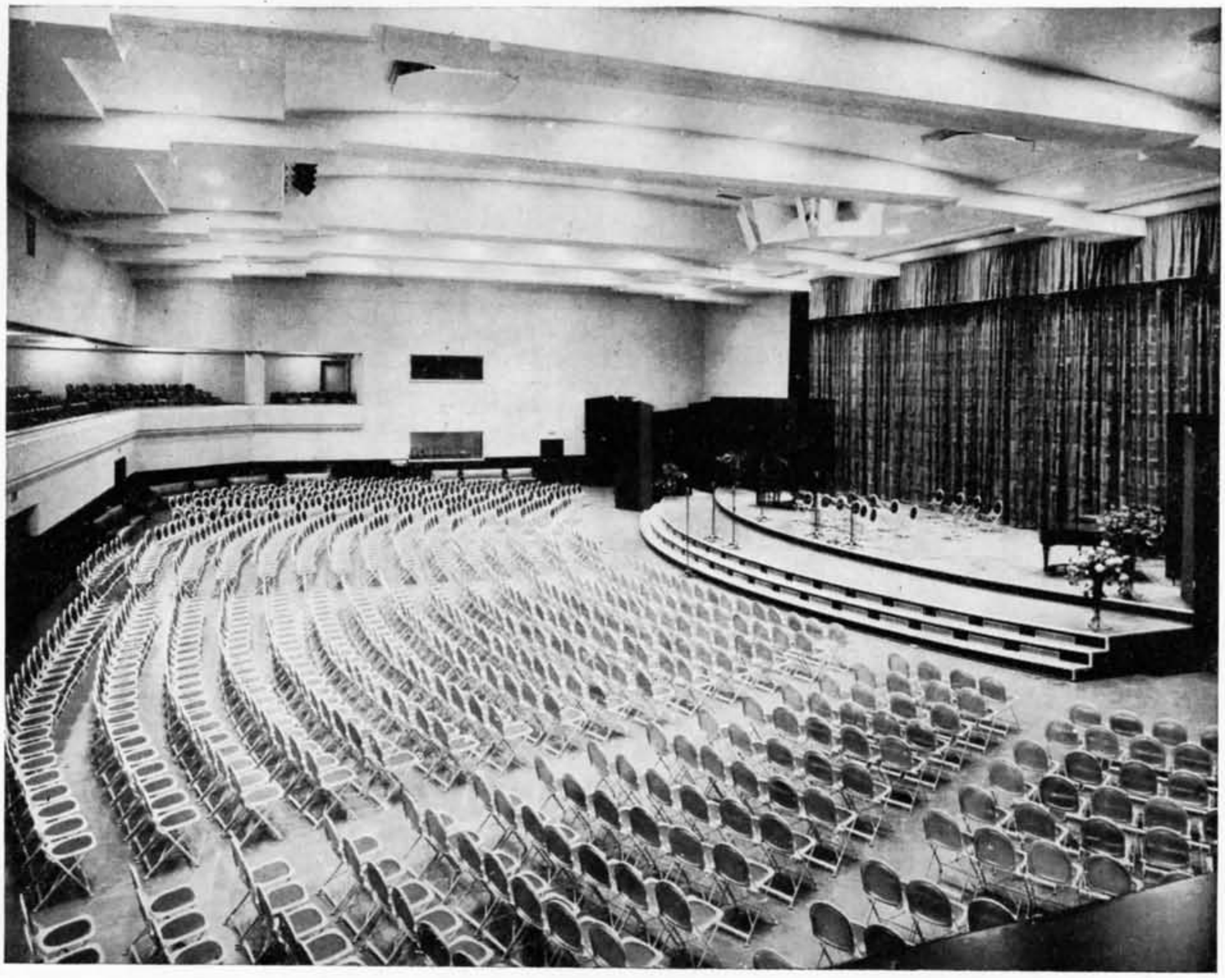


Figure 21. The immense auditorium studio, 78' x 132' x 30', seating approximately 1500 persons. The control room window can be seen on the first floor near the center of the picture. The loudspeakers of the public address system can be seen suspended from the ceiling over the stage.

LARGEST BROADCASTING STUDIO IN THE WORLD

NBC's Huge Auditorium Studio

On the eighth floor, most interesting floor in the NBC Studio Section, is located the mammoth Auditorium Studio, 8H. It is the largest broadcasting studio ever built, measuring 78′ deep, 132′ wide, and 30′ high. The illustration of it in Figure 21 gives some idea of how it looks to someone sitting in the southeast section of the balcony; its relative position on the floor is shown in the plan, Figure 22. About 1,200 seats can be placed on the main floor of 8H to accommodate clients' guests, and the balcony with its permanent theatre type seats, accommodates over 200 guests.

The studio has a number of unusual features. The stage, for example, is made in two sections so that the front and rear sections telescope. This allows considerable flexibility as to stage size.

There is a public address system which is used to reinforce the program picked up by the microphones. This is done so that those in the rear of the studio and in the balcony

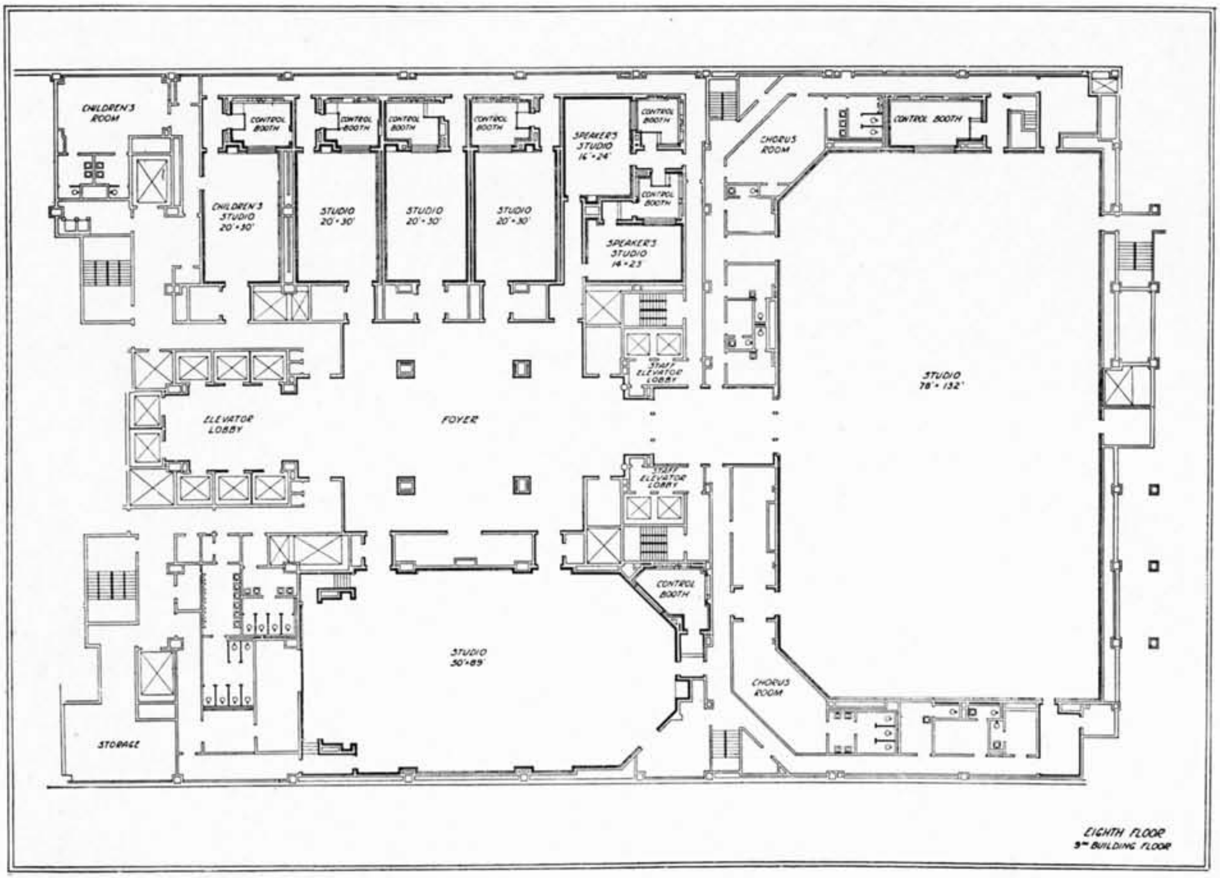


Figure 22. Plan showing the eighth floor, architecturally the most unusual in the building. Photographs of several of the studios on this floor are shown on the opposite page.

may hear without difficulty. The horns for this system may be seen attached to the ceiling over the stage.

The problem of properly air conditioning a studio of this size can be readily appreciated when it is pointed out that 309,000 cubic feet of air is necessary to serve the 1,500 potential seating capacity on the basis of a complete change of air approximately every ten minutes.

The Auditorium Studio presents a striking appearance to invited guests of NBC clients. The flame red and old gold colored back drop behind the stage serves as the central motif for the decorative treatment. The walls are corn colored, the wainscoting is black, and the balcony seats are covered in bright red leather. Against this decorative setting the aluminum finish studio chairs make a striking and very pleasing contrast.

Other Interesting Groups of Studios

Studio 8G is also located on the eighth floor. This studio constructed like a miniature theatre with about 270 permanent seats on the floor, has a small stage at one end which can be isolated from the audience by means of a glass curtain. This type of studio, illustrated in Figure 23, is well suited to solo broadcasts, vocal or instrumental. It is also suited to dramatic broadcasts where it is desired to accommodate more visitors than an observation room will permit, and at the same time obviate any possible interference with the artists. The glass curtain, when closed by electric motor, shuts out conversation and other audience sound which might otherwise be heard by the artists and be picked up by delicate microphones. Loudspeakers have been installed so that the

Figure 23. Studio 8G, 50' x 89' x 19', built like a miniature theatre. A glass curtain slides from the wings to isolate the stage from the audience.

audience may hear the program when the glass curtain is in the closed position.

The speaker's studio is another unusual type found on this same floor. An illustration of one, the Tudor Room, is shown in Figure 24. This studio is decorated so as to resemble a comfortable living room with an open fireplace, and is intended for speakers of prominence, especially those who might be ill at ease in a larger studio where visitors may be present, and where technical equipment is more in evidence. Practically all the equipment with the exception of microphones is concealed. Even the window in the control room is faced with a casement window of small square panes of glass. The atmosphere of this type of studio places a speaker quickly at ease. There are four of these studios, two on the eighth floor

Figure 24. One of the speaker's studios, the Tudor Room, 14' x 23' x 9', furnished like a comfortable living room.

and two on the ninth floor, each with decoration and furniture of a different period.

There are also four 20′ x 30′ x 9′ studios on the eighth floor. One is reserved for children's programs.

The floor plan of the ninth floor, illustrated in Figure 25, shows another interesting studio group. It will be observed that four small studios are arranged around a single central control room. There is a sound insulated, transparent partition from this control room into each of the four studios, and the floor of the control room may be converted into a turntable revolved by electric motor.

One purpose of this studio group is to allow, in sound broadcasting, for the separation of various performers. For example, the orchestra might be in one studio, the principal players in another, and the remainder of the cast in still another. The outputs from the three studios would then be electrically combined or "mixed." This arrangement allows the producer a more accurate control over the "balance" of the units involved.

Another purpose of these studios is to allow for rapid scene shifts in elementary visual broadcasting or television as it is more popularly known. This would be accomplished by simply revolving the control room floor so that the scanning equipment which would be mounted thereon, would face the desired studio. Thus, four scene changes could be effected, if necessary, within a very short time.

Besides the above group, there are the two speakers' studios on the ninth floor. Incidentally, these are the smallest actual studios in the building, the smaller of the two measuring only 14′ x 19′ x 8′.

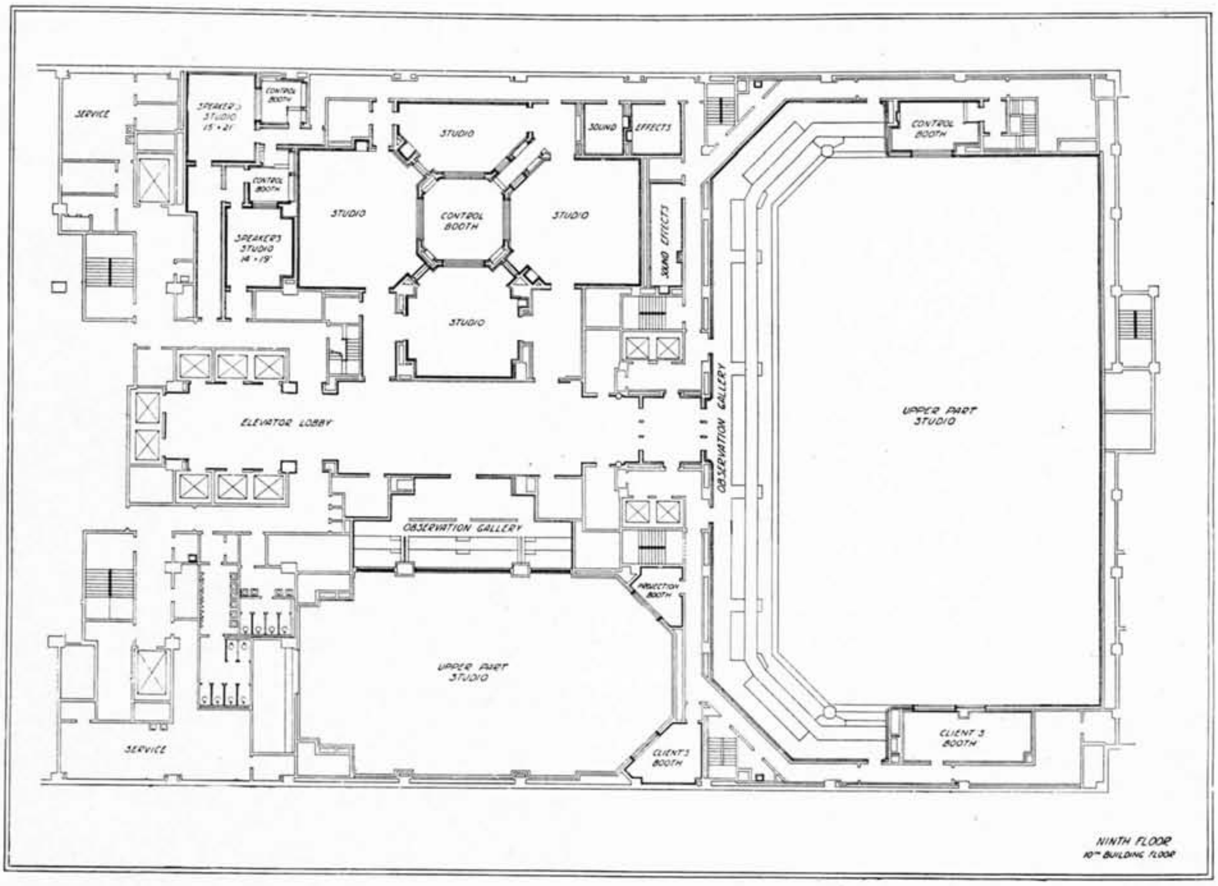


Figure 25. The ninth floor plan showing the observation gallery of the auditorium studio, and the "clover leaf" group of four studios with a common control room.

BROADCAST EQUIPMENT

Several desired objectives governed the design and layout of the broadcast equipment at Radio City. A very important one was the desire to realize the maximum practicable degree of centralization in order to simplify the problem of routine inspection and maintenance, and to facilitate the location and correction of trouble in the minimum possible time, if such an emergency became necessary. Then, too, the prospects of broadcasting both aural and visual had to be carefully appraised.

The ultimate aural requirements were met by providing speech equipment capable of uniformly transmitting the full range of normally audible frequencies. Thus, programs and auditions originating in the building may be heard in the building with an extremely high degree of fidelity.

The requirements of visual broadcasting were far more difficult to anticipate, due principally to the uncertain development of that branch of the art. Hence, the NBC engineers, in their effort to leave the way open for whatever television developments may take place, have provided room for expansion of facilities and the necessary spare conduit and lighting capacity.

Generally speaking, the broadcast equipment divides itself into two main classifications, namely: (a) equipment which is centralized on the fifth floor, and (b) equipment which was of necessity installed in studio control rooms and studios.

Some idea of the layout of the centralized technical equipment can be obtained from Figure 26, which illustrates the fifth floor plan. It will be seen that the master control desk is located in about the center of the floor.

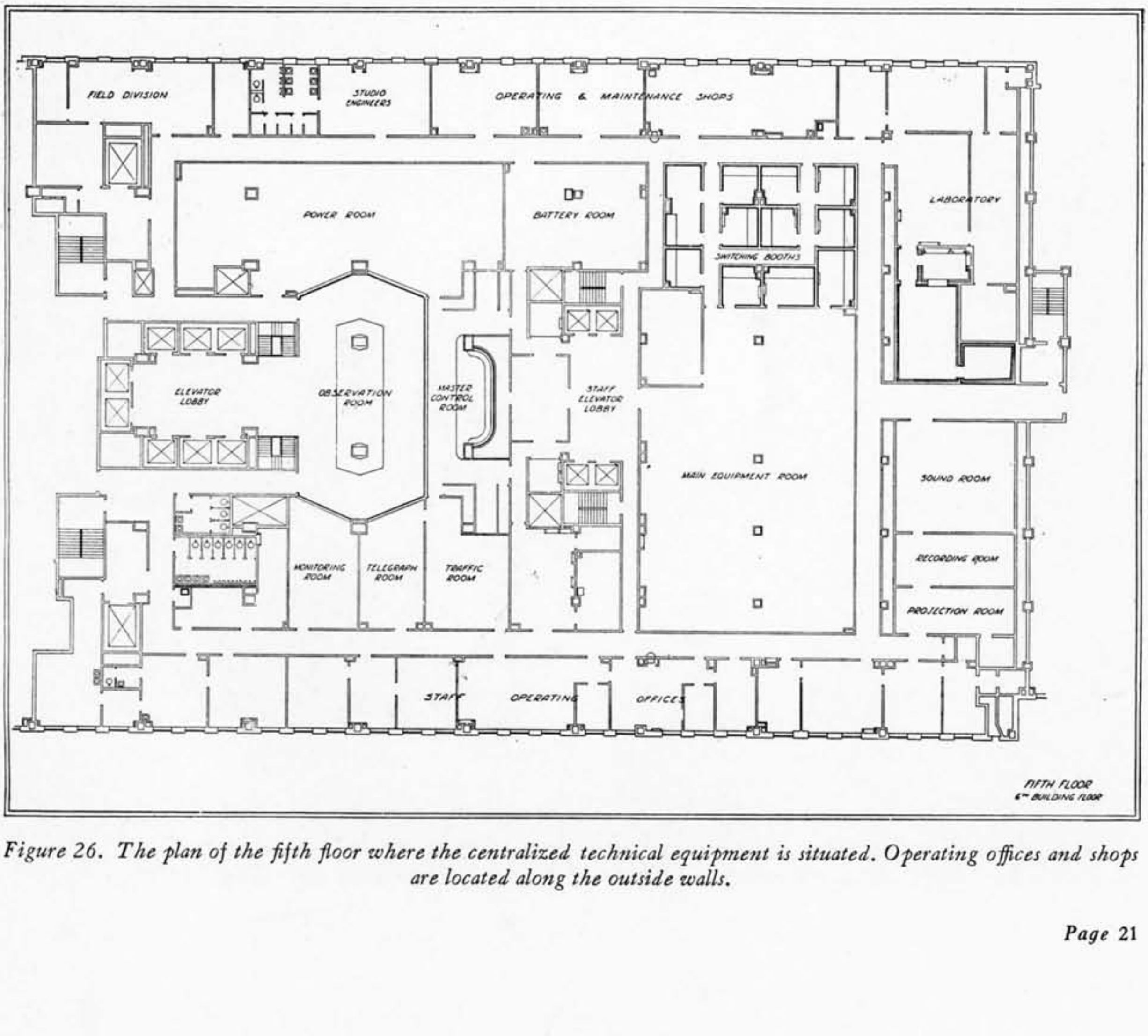


Figure 26. The plan of the fifth floor where the centralized technical equipment is situated. Operating offices and shops are located along the outside walls.

Figure 27. The master control desk, the "nerve center" of broadcast activities at Radio City. The left and right sections of this desk are duplicates, the middle section is supervisory in function. On the panel near the ceiling may be seen the loudspeaker openings.

THE MASTER CONTROL DESK

The "Nerve Center" of Broadcast Activities at Radio City

The master control desk, excellently illustrated in Figure 27, is twenty-seven feet long and has approximately 3,700 lamps and keys mounted on its face. The desk consists of a middle supervisory section, and left and right sections which are duplicates. A more detailed illustration of this "nerve center" or "dispatching central" is shown in Figure 28.

The system that this desk controls consists basically of fourteen channels or circuits to which a program may be fed. Some of these are permanently assigned. For example, one channel always feeds WEAF and another always feeds WJZ; another feeds the Red network and still another the Blue network. There are other channels which are used for special auditions and such other purposes as occasion may demand.

Obviously some method must be provided for selecting these channels so that a program from a given studio may be correctly routed, and so that at switching time studios will drop and pick up the proper channels.

All this is done by means of relay switchbanks, of which there are sixteen in all, eight each for left and right sections. The keys and lights of these switchbanks are visible at the lower part of the desk panel. Each switchbank set has fourteen keys above each of which is a white light, the latter being numbered from one to fourteen to represent the fourteen channels. On the panels above are located the keys and lights for each studio. There are eight keys at each studio position with a colored light above each key. Each key and light represents a switchbank, the latter being identified by means of colored lights rather than by numbers.

The switchbank and channel settings for any studio are pre-set. This means that they are set up before they are actually required. Then, as the switching time arrives, the announcer in the studio to go "off" pushes a release button which drops all channels, and immediately thereafter the announcer in the studio to go "on" receives a green light. He, thereupon, presses a set-up button which automatically picks up through the particular switchbank that has been selected, the channels which have been pre-set. This same sequence of operation can be carried out at the master control desk. In other words, as far as the dropping and setting up of channels that have been pre-selected are concerned, the master control desk and the announcer's control panel in the studio, are in parallel. Two points of control are thus provided. This is essential as a means of correcting errors that may be made in the studio.

The middle portion of this large desk is set aside for the supervision of outgoing and incoming programs by the control supervisor who may check by means of push buttons, indicating lights, and loudspeakers, any program leaving or entering the Radio City unit. He also has at his disposal a small telephone keyboard with direct telephone lines to important locations.

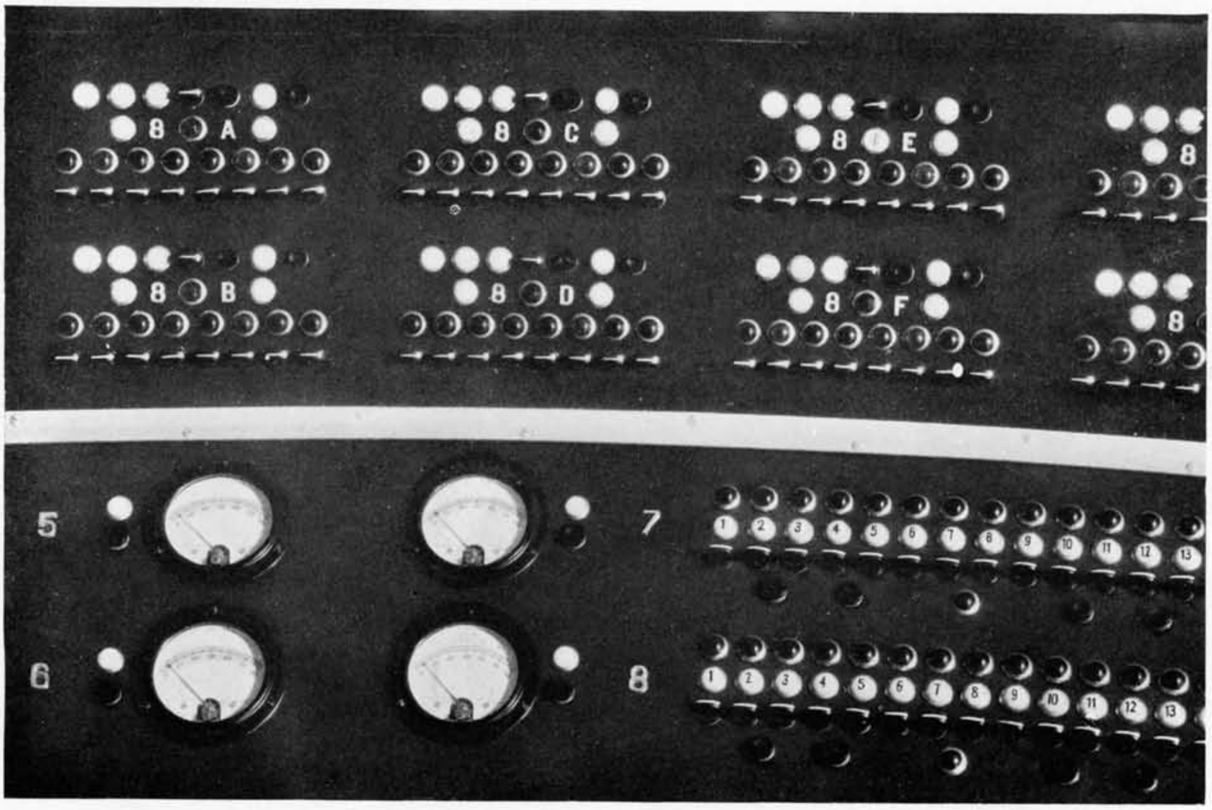


Figure 28. A closeup view of part of the left end of the master control desk. The two rows of 14 keys at the lower right are switchbanks 7 and 8 for selecting channels 1 to 14. Volume indicator meters for these switchbanks are immediately to the left. The groups of 8 keys above are switchbank selectors allowing any one of the switchbanks to be assigned to any studio.

THE MAIN EQUIPMENT ROOM

Studio visitors, and those who take the NBC Studios Tour, rarely are shown the equipment room located directly behind the master control desk. This room, however, contains as many marvels of compact, powerful engineering developments as can be found in any other part of the Radio City unit. A good part of the equipment which is controlled directly and indirectly by the master control desk is located here.

There are a total of 188 amplifiers, 140 of which are DC and 48 AC operated. Most of the latter are used to feed studio loudspeakers. Each of these AC amplifiers is remotely controlled by buttons on the particular studio control room console to which the amplifier is wired. The DC operated amplifiers serve various purposes. There are 28 channel amplifiers (regular and emergency for each of the 14 channels). There are 10 so-called headset monitoring amplifiers which feed a system throughout the studios whereby the announcer may listen to a program by means of a telephone headset (to determine when to switch and when to make announcements). There are also 19 studio racks of the type illustrated in Figure 29. Each of these has 3 amplifiers: one to feed the office monitoring system, one to which the output of the talk-back microphone in the studio control room is fed, and one for the program originating in the studio.

The relay system controlled from the master control desk is also in this main equipment room as are the radio sets for radio channel monitoring, the trouble alarm system, and miscellaneous test equipment.

Figure 30. Typical office monitoring installation showing high fidelity loudspeaker and dial program selector which permit the executive to listen to any studio in the building and to any of the more important local stations.

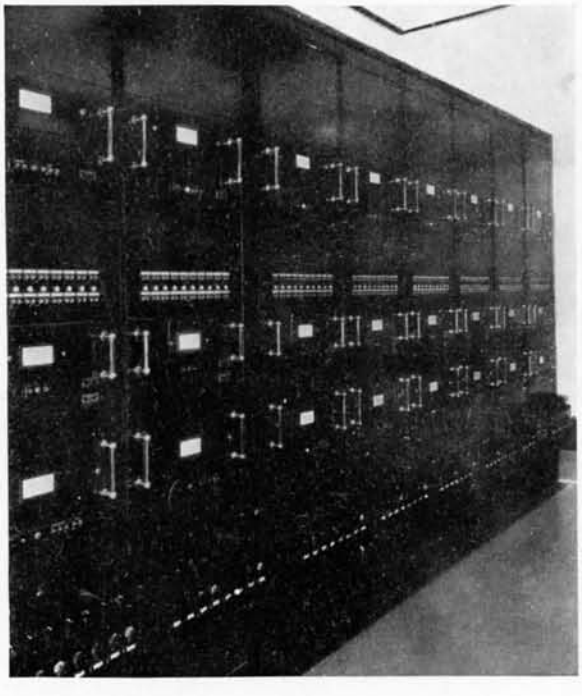


Figure 29. A row of amplifier racks in the main equipment room. Circuit breakers may be seen near the bottom of each rack.

THE POWER ROOM

Figure 31. The power room, the distribution point for all broadcast power in the Radio City plant.

Figure 33. Fifty tons of storage batteries, "A" and "B," which are operated float-charge with the motor-generator sets in the power room.

Figure 32. The power control desk showing the miniature supervisory equipment on the panels.

Located on the fifth floor is the power room, illustrated in Figure 31. Here are the motor-generator sets for charging the "A" and "B" batteries in the adjacent room, exciters for supplying field current to the generators, a 120 cycle clock system generator which serves to speed up the synchronous clocks when this is necessary, power distribution panels from which all "A" and "B" power is distributed, and finally, a power control desk (Figure 32). The power control desk has miniature supervisory equipment by means of which the operator on duty can observe at a glance the current and voltage values, which machines are on the line, and which lines are alive.

In the battery room, illustrated in Figure 33, are two main "A" batteries, each with a capacity of 1,000 amperes for 8 hours, two main "B" batteries, each with a capacity of 15 amperes for 8 hours, two other batteries: one service "A" and one service "B" (with 8 hour capacities of 300 amperes and 3 amperes respectively), and finally, two other small batteries used for special purposes.

STUDIO and CONTROL ROOM EQUIPMENT

Studio control room equipment is standard in all but a few cases. As Figure 34 shows, the equipment consists of: a control console where the microphone output is regulated, amplifier racks with one amplifier for each microphone fader position on the console, and a high quality loudspeaker. The console besides providing for microphone mixer control has also a number of test jacks that allow equipment to be patched out for testing purposes.

Briefly, the control operator in this room has facilities for a number of functions. He may listen to the program in the studio and vary the volume on each microphone, either ribbon or condenser, individually and on all collectively. He may speak to persons in the studio over a carbon microphone on the control console by pressing a button in the microphone base. He may communicate by means of a special interphone system with all important places in the studio section. He may turn a key on the control console panel and so allow anyone in the building provided with the proper monitoring facilities to listen to what is going on in the studio. He may allow another program to be fed to the studio loudspeaker for testing purposes, or for entertaining an audience before the studio goes on the air, and he may vary the volume on this speaker by pressing buttons on the console panel which in turn vary the volume control on the appropriate AC operated amplifier in the main equipment room.

Figure 34. A studio control room showing the loudspeaker, amplifier racks, and the control console.

The announcer's control equipment is conspicuous for its simplicity and practicability. On each studio wall, at one side of the window into the control room, there is mounted a control panel like the one illustrated in Figure 35. The facilities provided by the panel allow the announcer, by depressing the proper buttons, to connect or disconnect the studio to or from whatever program channels have been pre-set

Figure 35. The announcer's control panel showing the control buttons and signal lights, and the headset monitoring jacks.

at the master control desk. He may make local announcements at switching time; he may depress a button which automatically sends the familiar "chimes" signal to the network; and finally, he may monitor any one of twelve so-called headset monitoring channels by means of a telephone headset, and thus follow what is going on in the studio immediately preceding him on the air. This feature is necessary in order that switching may be properly timed, and in order that programs may be transmitted in the smooth continuous flow to which the radio listener has become accustomed.

THE CLOCK SYSTEM
That Shows Split Seconds

The requirement of smooth continuous program flow demands accurate time. At Radio City the clock system consists of 275 synchonous clocks operated from the 60 cycle alternating current supply of the local public utility company.

The system is divided into four parts serving: (a) the studios, (b) the studio control rooms, (c) miscellaneous rooms in the studio section, and finally, (d) the office section. The purpose of having four divisions is to assure as far as possible, continuity of time service. If but one system were provided, any trouble therewith would leave the entire NBC quarters without time, which would seriously handicap all those concerned with program dispatching.

In order to provide means for resetting the entire system or any of the four parts of it, there is installed in the power room on the fifth floor (illustrated in Figure 31) a motor-generator set which converts the 220 volt, 60 cycle supply to 220 volts, 120 cycles. The clocks operate normally on 110 volts, 60 cycles. Thus by feeding 220 volts, 120 cycles, to the system, the speed of all clocks doubles, and the system as a whole or any of the four parts, may be advanced any number of minutes desired. When daylight saving time goes into effect each year in New York this method of resetting the clocks proves absolutely essential, as without it 275 clocks would have to be reset individually.

MADE-TO-ORDER WEATHER

As has already been stated, the air conditioning system is easily the most intricate ever built. The plant is, furthermore, one of the largest in New York City, having a capacity of 900 tons. Two major parts: (a) the cold water system, and (b) the air distribution system, make up the plant.

The cold water system comprises: (a) the four 300 HP, 225 ton refrigerant compressors located in the basement, (b) the centrifugal pumps and lagged cold water piping which feeds the water from the basement to the four dehumidifier tanks on the tenth floor, (c) the return piping from the tanks to the compressors, (d) the condenser water pumps, and the piping from the condensers of the refrigerant compressors to the roof where it connects with two water cooling towers each with a capacity of 1350 gallons per minute, and (e) the piping from the cooling towers back to the condensers.

The air distribution system comprises: (a) the complicated network of ducts for distributing air to the entire studio section, (b) the vapor actuated and electrical thermostats, (c) the compressed air operated and electrically operated dampers, (d) the steam and electrical air heaters, and (e) the main control board located on the tenth floor. Figure 36 illustrates this control board. There are a total of 64 graphic recording thermometers, most of which are also thermostat controls.

One of these instruments has two chief functions: (a) to keep a graphic record of the air temperature at a key location in the air distribution system, as for example, a studio exhaust duct, and (b) to provide thermostatic control of this air temperature. This control is effected by running a small diameter copper tube from the instrument to a thermostat in the duct. This tube is filled with vapor which expands or contracts as the temperature of the air in the exhaust duct rises or falls. A valve at the instrument on the control board is actu-

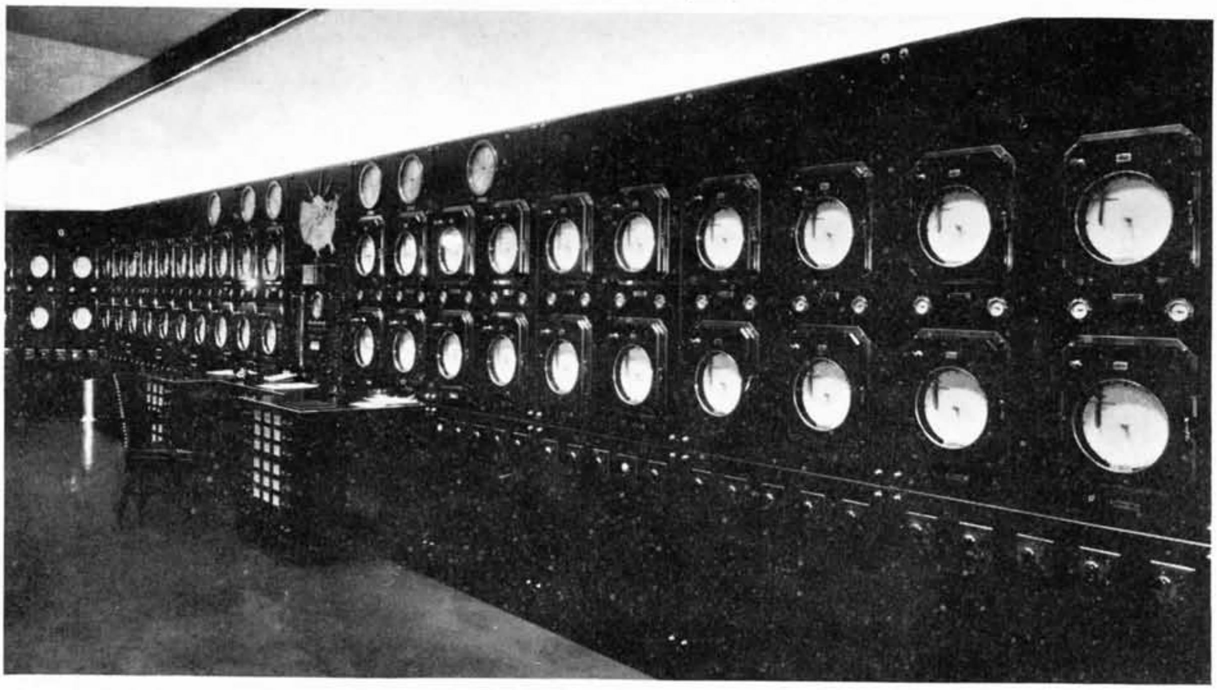


Figure 36. The control board of the air conditioning system, NBC "weather headquarters". The operator on duty here has, at all times, a knowledge of the temperatures at all key locations in the studio section. Sixty-four recording thermometers and a resistance thermometer system for fifty-five additional locations, make this possible.

ated by the expansion and contraction of this vapor in such a way that compressed air is admitted or shut off from copper tube air lines to three so-called "air motors" controlling: (a) a damper in the supply duct, (b) a steam valve to a radiator in the supply duct, and (c) a damper in the exhaust duct.

If, for example, the studio is too cool, the mechanism operates to shut off the compressed air to the "air motors" which in turn partially closes both supply and exhaust dampers, and at the same time admits steam to the duct radiator. As the temperature in the studio rises the steam is gradually shut off, and both dampers gradually open. The opposite sequence of operation takes place when the studio temperature is too high.

An adjustment is provided on each dial on the control board to allow for changing the normal temperature at which a studio is automatically maintained. Thus by simply moving a pointer on the dial, say five degrees, the normal temperature of the studio automatically changes by the same amount.

At some locations in the studio section, where individual control of the temperature of a small room is desired, electric thermostats, electric dampers, and electric duct heaters have been installed. These particular locations are not included in the 64 for which charts are kept, but the temperatures may be read by means of a resistance thermometer and two key switch panels located in the middle of the main control board. This set of key panels and thermometer enable the operator on watch to check the temperature at 55 locations in the building not included in the main group of 64 for which recording thermometers were provided. Immediately above the resistance thermometer are four red lights, each of which represents one of the refrigerant compressors in the basement. When a machine is running its particular light is illuminated on the control board.

Along the lower part of the control panel are a series of green lights, each of which represents a fan. When a particular fan is off, its light is illuminated, thus warning the operator that the fan is not running.

The ducts which are used to supply and exhaust the air to and from the studios and appurtenant rooms are ordinarily excellent sound transmitters, consequently, they must be lined to prevent sound transmission. Figure 11 illustrates this lining. The material used for this purpose is known as Cabot's quilt, and is in reality a seaweed known as *zostera marina*, found in the vicinity of Nova Scotia. It is dried, chemically treated, and finally enclosed in a paper or fabric covering. Thus prepared, it is a surprisingly effective sound absorber, so effective in fact that an observer stationed at one end of a 20′ length of 10″ x 10″ duct lined with 1″ thick Cabot's quilt, is barely able to hear a person at the other end of the duct speaking at normal voice level.

The volume of air circulated by the system at maximum load is approximately 224,000 cubic feet per minute, of which about 152,000 cubic feet per minute is recirculated air. Supply air, both fresh and recirculated, is filtered through petrolatum coated glass wool filters of which there are about 700 sections.

★ ★ ★

This, then, is "The House That Radio Built," truly NBC's house of radio magic, and indeed a phenomenal, almost incredible growth from the small tent on the roof of a Westinghouse building in Pittsburgh which in November 1920 afforded the only "broadcast studio facilities" in the United States!

★ ★ ★

STATISTICS—NBC STUDIOS—RADIO CITY

AIR CONDITIONING SYSTEM

Air volume circulated	224,000 C.F.M.
Blowers, total number	54
Compressors (refrigerant)—4, each 300 HP, 225 tons total capacity	900 tons
Dehumidifier tanks—4, each 725 gals. per min., total capacity	2,900 gals./min.
Dehumidifier spray nozzles, total number	1,366
Thermometers, recording, total number	64
Water cooling towers, 2, each 1,350 gals./min., total capacity	2,700 gals./min.
Electrical energy, estimated annual consumption	3,400,000 Kw. Hrs.
Steam, estimated annual consumption	15,000,000 lbs.
Water, estimated annual consumption	7,500,000 gals.

LIGHTING

Illumination level, average on working plane in studios	15-20 ft. candles
Power supply 5, 750 Kw. M-G sets, total	3,750 Kw.

MASTER CONTROL DESK

Desk length	27 ft.
Keys, total number	1,500
Lamps, total number	2,200
Relays, associated therewith, total	2,500

BATTERY ROOM

"A" battery—8 hour capacity	1,000 amps.
"B" battery—8 hour capacity	15 amps.
Storage battery groups, total number	8
Storage battery groups, total weight	50 tons

POWER ROOM

Load—"A" power at 14 volts	250 amps.
Load—"B" power at 400 volts	2.5 amps.
Motor-generator sets, total number	10
Switchboards, total number	8

SPEECH EQUIPMENT

Amplifiers, total number	300
Dial monitoring stations each allowing selection of 50 programs, total	120
Equipment racks, total number	330
Loudspeakers, total number	175
Radio receivers (dial monitoring system)	10
Vacuum tubes, total number	2,000

MISCELLANEOUS

Broadcast installation time	9 months
Cable, broadcast, miscellaneous sizes, total	470,000 ft.
Other miscellaneous broadcast wire	250,000 ft.
Cable, largest size used	1,800 conductors
Clocks, synchronous, total number	275
Conduit, miscellaneous sizes, total	660,000 ft.
Doors, sound insulated, total number	296
Fabrics, decorative	245,000 sq. ft.
Floor area, studio section	278,000 sq. ft.
Glass in sound insulated windows, total quantity	8,500 sq. ft.
Microphone outlets in studios, total	250
Rockwool acoustical treatment used	500,000 lbs.
Trench for cable, total length	1,500 ft.