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Planning and Costing of Radio and Television Facilities

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The information to follow should be used for general planning and cost estimating of facilities. Many factors determine the initial budget, as well as final cost figures at the time of actual completion. Proper planning and project coordination by the owner's representative is mandatory if a well-built, cost-effective facility is to be produced, by the date required. During nearly 30 years' experience, the writer has been involved with numerous large and small broadcast facility projects, all having one major thing in common: the fact that time begins to run out before you are really finished. This may not actually be so bad, as otherwise, what else could ever stop the additional requests and change-orders that keep on coming—broadcast personnel being what they are?

GENERAL PLANNING CONSIDERATIONS

The early planning of a broadcast facility usually involves a number of factors such as: consideration of the market to be served; site selection; radiated power; tower height; station policies; personnel; programming; hours of operation; and available capital. First and foremost of the decisions to be reached is whether the studio and transmitter are to be combined under one roof or are they to be in separate locations.

In the past few years there has been a trend toward combining the studio and transmitter rather than housing them in separate facilities. However, with the advent of remote control, there is a movement once again to separate the studio and transmitter.

It is generally agreed that wherever practical it is most economical to combine the studio and transmitter. The initial equipment requirements are less, but more important is the fact that the day-to-day operating expenses are lower. With the plant "all under one roof" there are savings in heating, air conditioning, building maintenance, travel time, and personnel. A combined operation, however, is not always possible.

When a combined operation is not practical, the second approach is of course to operate the transmitter by remote control from the studio. By utilizing remote control, a transmitter site can be selected that is most advantageous from a coverage standpoint, and the studio can then be placed in the most convenient location. The building requirements at the transmitter can be the very minimum, requiring only space for the equipment, a small work area, and a small heating unit. The studio then could contain both the programming and business functions.

Facility Planning

The initial step in station planning is to develop an outline of requirements that will form the basis upon which future decisions are made. Such an outline for broadcast facility planning may be developed as follows:

OUTLINE FOR BROADCASTING FACILITY PLANNING

1. Site Selection

a. Adequate space for immediate building needs plus anticipated expansion.

b. Adequate parking space for employees, guests, and studio audience (if latter is being considered).

c. Trucking access and adequate loading area—loading dock, if possible.

d. Accessibility from high speed or uncongested roads (mobile units, audience, convenience of employees).

e. Transmission—tower space or line-of-sight for microwave.

f. Zoning—use of towers, antennas, identification or advertising signs.

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g. Possible use of helicopters for news and traffic reporting.
h. Relation of site to environmental elements: (i) noise, (ii) weather, (iii) drainage.

2. Building Program (Space Arrangement)

a. Proper flow and/or separation of studios, related technical spaces, craft shops and storage, programming and engineering, talent and dressing, administrative offices and mobile units.
b. Entrance arrangements for employees, guests, VIPs, and audience.
c. Relation of studios to loading areas.
d. Relation of parking areas to employee and audience entrances.
e. Security—inside, outside.

3. Building Construction

a. Selection of structural system, taking into account local conditions, codes, availability of materials, flexibility for future changes, special loading conditions and spans, degree of fire resistance and effect on fire insurance rates. Careful study of fire code requirements.
b. Partitioning—types to afford relatively good sound isolation, yet flexible enough for ease of removal or relocation. Better to make rooms larger in beginning and subdivide later if necessary.
c. Ceilings—high degree of accessibility for multitude of communications wiring; good acoustical value; cleanability, ease of electronic repairs.
d. Wall materials—extreme durability in technical and production areas, due to frequent moving of equipment and supplies.
e. Floor materials—durable yet resistant to traffic sounds. (*Note:* Floor slabs for TV studios must be extremely level for proper camera movement.)

4. Engineering

a. Availability of incoming HV power service.
b. Separate unit substations for: (i) air-conditioning, air handling and other facility motor loads, (ii) general illumination, (iii) studio production lighting, (iv) technical loads.
c. Lighting in general—fluorescent, 100-foot candles in working areas, dimmer controlled incandescent in control rooms.
d. Studio production lighting system—dimmer racks, patch panels, control consoles, etc.
e. Cable trays—master control to studio control, studios, computer suite, etc.
f. Emergency generator to handle essential loads when normal power fails.
g. Miscellaneous systems—telephone (technical and commercial), public address, watchman's tour, door security, closed circuit TV and fire alarm.
h. Air conditioning—heavy studio loads (TV), low velocity for sound control, stand-by AC for master control rooms, separate exhaust system (air purging) for TV studios.
i. Compressed air system for video tape machines—cleaning, painting, etc.

5. Acoustics

a. Sound isolation within areas.
b. Sound transfer from area to area.
c. Quality of sound within spaces (room acoustics).
d. Special doors, viewing windows, wall, floor and ceiling treatments.
e. Low-velocity air and duct linings, sound traps.
f. Isolators for machinery and piping.

6. Security

a. Control of audiences (where received).
b. Control of all points of entry.
c. Closed circuit TV systems, watchman's tours.
d. Electrified gates and doors.
e. Separation of 9:00-5:00 areas from 24-hr. areas.
f. Night lighting.

AM/FM STUDIO FACILITIES[2] EQUIPMENT PLANNING

While the technical equipment required for an AM or FM radio facility is determined basically by station size, layout and programming, it should be remembered that the operating flexibility of the station depends to a great extent on the equipment selected.

An extra measure of versatility in the studio equipment may greatly promote program speed, accuracy and creativity, enhancing the station's audience and advertiser interest. Certainly, the transmitter plant with the highest efficiency and reliability will place the strongest and most consistent signal where the people are. More than just economy, therefore, each piece of equipment should offer all the added benefits of value and performance that modern technology allows.

Too many times the costly assumption is made that all broadcast equipments, if FCC type-approved, are basically the same "under the hood." So, all you have to do is to find the supplier with the lowest price. Several mismatched units and thousands of dollars later, however,

[2]Source material Radio Corporation of America.

price is very often found to be closely related to the quality and reliability of components, as well as the attention and service that can be expected from the manufacturer after the sale.

Audio Equipment

Since no two broadcast stations have the same operating requirements, the selection and arrangement of microphones, audio tape systems, turntables, consolettes, amplifiers and other equipment will differ for each installation. Many stations choose to have their control equipment tailor-made to the station's requirements.

Control Consoles

Usually the most important reason for the addition or replacement of a control console or consolette is the need for more input channels. This can be brought about by the addition of a new studio (and thus additional microphones) or by adding FM stereo facilities. It is convenient to be able to leave telephone lines connected to the "board," and thus as the number of remote programs increase, the telephone input requirements will increase. A consolette may also be added to a station in order to increase the flexibility of recording facilities. Many stations use a small board in a "production" control room where they make commercials and station promotion recordings. Another requirement for the addition of a small audio consolette is for the remote pickup of programs such as at sporting events, auditoriums, churches and nightclubs. In general, as a station increases its program variety and flexibility, its requirement for audio input facilities also increase.

Consolettes of the highest quality employ computer grade components throughout. In these equipments, components are selected for their long life and dependability. For example, the best consolettes use telephone type switches for their superiority over wafer types, and step attenuators rather than carbon pots. They are fully transistorized using the most advanced state-of-the-art circuitry. Plug-in modular design provides complete accessibility with interchangeability of subassemblies and quick, convenient servicing. Reliability of equipment is a priceless ingredient in the design of today's successful broadcast system in view of the increasing shortage of competent technical maintenance personnel.

Custom Audio Equipment

In addition to offering a comprehensive line of standard audio control equipment, leading equipment manufacturers specialize in custom designing and building complete speech input systems to meet individual needs of stations and networks. Their engineers have worked closely with the nation's leading broadcast engineers in the design, production and installation of many custom equipments. Studio control systems such as these are tailor-made, combining just the right facilities for the control of program operations and the reproduction of high-fidelity sound. This custom service is not limited to large stations and networks, it is available to everyone. Broadcast station engineers, in some cases, may wish to lay out and design the system themselves. In these instances, specifically built units or modified standard items can be supplied to meet these specifications. Or, as some stations may desire, a study of station requirements can be made with detailed layouts and specifications drawn up for the equipment needed.

Tape Recorders

Program material on magnetic tape provides extra flexibility in scheduling, simplifies program operations and reduces the cost of program production. Modern stations utilize every possibility offered by the medium—mono or stereo, cartridge and reel-to-reel, 2-track and 4-track stereo, manual and automatic equipment. Cartridge tape systems permit the immediate playback of recordings without cueing and threading. They provide precision timing of program segments, and the program material will be exactly the same every time a passage is repeated. They offer the most convenient storage medium and the quickest and easiest access to selected segments of material. The system of cue tones makes the equipment readily adaptable to automatic or semi-automatic systems. Multi-cartridge tape systems, designed essentially for the heavy traffic station, reduce the load on operating personnel by automatically handling a series of short (or long) program segments through start/stop and audio switching sequences in rapid errorless succession. Two hours of material can be programmed with one multi-cartridge unit, which can be teamed with as many other units as needed. Tape systems may be remotely controlled.

Reel-to-reel tape machines, on the other hand, take full advantage of the editing ease and speed that tape offers. Reel-to-reel machines can operate at various speeds so that the material can be tailored to program needs. Super thin tapes can be used to permit hours of programming on a single reel, and the equipment features portability for interviews and news stories. Manually operated and self-cueing versions are available.

Signal Processing Equipment

Audio signal processing equipment is available to automatically control audio peak and average levels into the transmitter, as required, to prevent overmodulation with consequent adjacent channel interference or even possible damage to the transmitter.

Automatic gain control (AGC) amplifiers, with their slower attack and recovery times, are used in control rooms and studios to maintain a constant average audio level. Peak limiters, with their faster attack times are normally used at the input of the transmitter because of their ability to limit the amplitude of high speed transient peaks.

In FM, however, a 75 μ sec pre-emphasis network normally installed at the transmitter input produces a high-frequency boost which tends to cause overmodulation. This overmodulation can be prevented by high-frequency rolloff, or by peak *clipping* after pre-emphasis or by a combination of both. Peak *limiting* after pre-emphasis is not usually desirable because the high frequency peaks will cause a serious reduction in gain and consequent lowering of the average modulation level. High-frequency rolloff, too, is obviously undesirable because of the degradation of the received signal. Peak clipping is the recommended method since it provides absolute protection against overmodulation without reducing signal gain and with no audible degradation of the signal. Signal processing units are used in tandem for stereo.

Tape Automation Systems

An audio tape programmer combining solid state and relay switching is available to automatically program multievent sequences from several different tape systems with an absolute minimum of attention from station personnel.

For use with both monaural and stereo systems, the device is designed to select from several audio sources and sequence them in any preset pattern as consecutive events. It is particularly advantageous to stations requiring separate programming for AM and FM. The operator who may be handling both programs can preset the system to sequence the FM events during times when live broadcasts or program changes must be made on AM.

Microphones[3]

Careful thought should go into the selection of type and quality of microphones for AM and FM facilities. Too often the microphones selected do not complement the quality of other equipment. This can seriously impair overall performance.

There is considerable overlap in the uses of available broadcast microphones, of the many types, but each has attributes for specific applications. High quality broadcast-type microphones have performance features that make them ideal for AM and FM use, such as smooth frequency response over the audio range, low distortion, high output levels, and well shielded (and sometimes shockmounted) output transformers to prevent hum and noise pickup. Certain types have selectable directional patterns useful in high noise areas. Public address microphones, on the other hand, are designed to offer additional economy. Frequency range and sensitivity are sacrificed to some extent for ruggedness and lower cost. Response limitations should always be considered when these microphones are used for broadcast applications.

RADIO STUDIOS—ON A LOW BUDGET

Considerations Involved in Building an AM or FM Station with Less Than an Optimum Budget

It would be easy to apply one set of standards for the construction of radio station facilities everywhere in the country. Unfortunately, the difference in cashflow of a 50,000-watt clear channel in a major market and a 250-watt daytime or Class A FM in a rural area dictate that the small market station is going to be quite different than its big city counterpart. In most cases, the selection of a studio site in a small market is dictated by what it costs to get the space. It is not unusual for space to be traded out in part or in full for advertising.

In many cases, the chief engineer will be presented with an existing suite of offices, a store front or even an older house that must be converted to a studio. The first thing to do in this situation is call a meeting of management, sales, and programming to see what they expect of the facility. If it is a typical small market station, it will fall within the following requirements.

1. Record shows—combo operation. Announcer playing records, taped commercials.
2. Direct airplay or recording beeper reports for later use in newscasts, farm reports, high school news.
3. Facility for picking up remotes from high school or college athletic events, church remotes.
4. Capacity of recording and dubbing commercials for later airplay.
5. Capacity for originating a live music program from your studio. (Quite often a church

[3]See separate section at the end of this chapter entitled "Microphones: Their Application and Operation."

will use a studio to do a small service rather than invest in phone lines and remote equipment!)

6. Delayed programming such as a telephone talk, call in forum or swap shop show.

7. Remote off-air pickup of other AM and FM stations for rebroadcasting regional networks.

8. Remote pickup of mobile units and portable transmitters for news actualities and other events.

If the station is a new or growing operation and cannot afford the equipment to do all of the above, at least consider what functions may be required at a future date. For this reason plan now for what might be needed in two years.

Physical Layout

This will depend largely on what is available. The bare bones minimum control room known to be used was 6 ft. wide by 7 ft. deep. There was barely enough room for an operator, two turntables, cartridge machines, and a console. *It worked.*

The operation was well constructed, well maintained and well utilized. The technical quality of the programming was as good as many large operations in major markets, so it can be accomplished *with small space.*

When laying out studio location, do the following:

1. Draw a sketch of the available floor space and existing walls.

2. Make a number of copies of this floor plan and start drawing in studios, offices, reception areas and the like. Make three or four.

3. The first items you want to place are the main studio and control room. In smaller operations these are one and the same. Naturally they must be quiet, so keep them away from noisy areas such as underneath heavily traveled stairways, air conditioners, and front windows opening on busy streets. The control room floor should be very solid. The most desirable material to use if you are building a studio is reinforced concrete. If you are stuck with a wooden floor try and select a location that does not bounce. People walking on such a floor will cause the floor to move. This motion is transmitted to the turntable cabinet to the tone arm where it is picked up and sent over the air. In extreme cases, a heavy person can cause the needle to jump out of the groove. Sandbags or bricks in the base of the turntable cabinet will sometimes improve a bad situation.

Another item that will determine placement of the control room is visibility of the meters on the transmitter and its associated monitoring equipment. FCC rules and regulations have recently changed regarding this requirement and undoubtedly will change in the future. Check the rules before you build. If you are fortunate enough to be putting in your own walls, stay away from designing perfectly square rooms. A room that is 8 by 8 by 8 ft. is going to have a very definite resonance. Strive for 6 by 8 by 10 ft. or dimensions in this proportion. Sound locks while desirable are not essential. Doors of solid construction with weatherstripping can be used effectively.

4. Measure some typical office furniture and cut out cardboard desks, file cabinets, counter tops and record cabinets to scale. Put in your furniture and see how it fits. Is there room for people to move around? Did you leave room for doors to open and close? Remember not to have doors open out into busy hallways where people will walk into them as they pass by. Doors come in all sizes. The average door in most stations is 3 ft. wide. If you get into a space problem this can be reduced by 6 inches or even a foot. But remember that you will be moving furniture and equipment in and out of that door and you should provide room for it to go in and out and be turned once it's in the room.

The narrowest hallways should be no less than 3 ft. 6 in., preferably 4 ft. Also be aware that hallways take up space. For every square foot of hallway you eliminate you get an equal amount of space that can be used for something productive.

Equipment

In a low-budget situation remember this rule of thumb, "Is what I am about to buy going to pay for itself and make the station money?"

The purchase of a $200 directional microphone to do a one time remote broadcast when being paid only $100 for the whole job is poor business.

Use this logic when equipping the station. As mentioned earlier, create a list of those functions you will have to perform, spend only what is needed to get on the air and function. However, do plan for the future. Design around a console with enough inputs to accommodate these anticipated needs. A four potentiometer board is not enough for most operations. Even the smallest stations should have six or eight pots. A four pot board will be satisfactory today but two years later it will not. If the station is a one studio operation, how will the console be replaced while on the air? It makes good sense to purchase the proper console in the beginning.

Do not forget the patch panel. There is a growing tendency among engineers today to eliminate this important switching center. All high level inputs and outputs should appear here. Even console inputs should show up. This also applies to all recorders, tuners, and other audio sources. This practice makes for a very versatile operation and can save the embarrassment of dead air time if the console should fail. If this happens, the recorder can be patched directly to the transmitter, bypassing the defective elements in the system.

Fig. 1 shows the audio flow in a typical small market radio station with the bare essentials. This was installed at WBME-AM in Belfast, Maine. It should be considered a minimum installation. One cartridge tape machine, one reel tape, audio processing equpment and a transmitter. This system can be expanded to include other program sources as the station's needs grow.

Figs. 2 and 3 show the audio flow and physical layout of a Class C FM station designed and built by McBee Laboratories, Inc., in Topeka, Kansas. Note the versatility here. The studio can be operated through the automation system as a source. In the event of an emergency, the announcer can remotely connect the output of the console to the STL, bypassing the automation system. In the event of an STL failure, the audio can be patched directly to the transmitter via the remote control system line.

In selecting equipment for a small station, one usually considers used equipment. U.S. made broadcast equipment is built to last. It is not unusual to see transmitters in regular use after 30 years. The same can apply for consoles, amplifiers, and some other audio equipment. However, if you purchase something this old, the chances are that the manufacturer will no longer be able to supply spare parts. Most equipment suppliers will maintain spares for 20 to 25 years. Do not get the impression that spare parts are no longer made, they just are not stocked by the equipment manufacturer. In many cases, it will be necessary to seek out the item wanted from the original component manufacturer.

Special items such as modulation and plate transformers can be rebuilt or fabricated; it can be costly but it can be done.

When buying a piece of used equipment, try and get the previous owner to throw in his spare tubes and other parts. Also obtain a history of the unit and where parts can be obtained. It is also advisable to find other owners of the same type of unit.

Before purchasing anything of this nature take a long hard look at it.

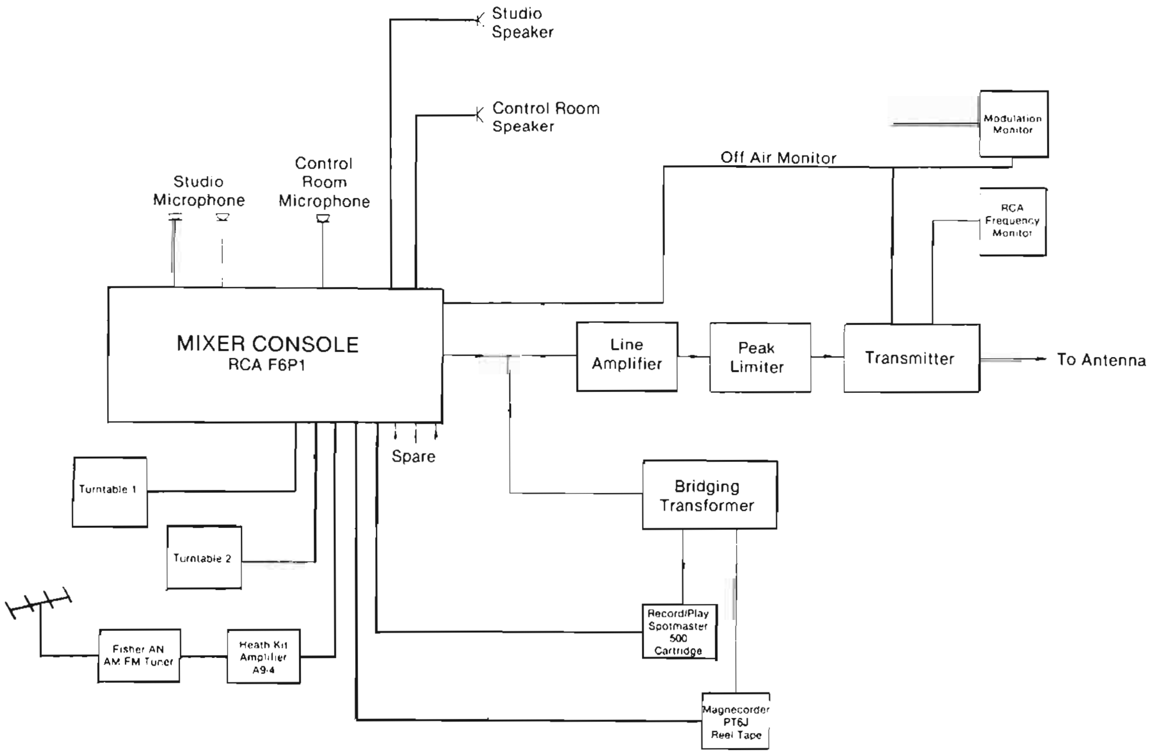

Fig. 1. Audio flow diagram from station WBME-AM.

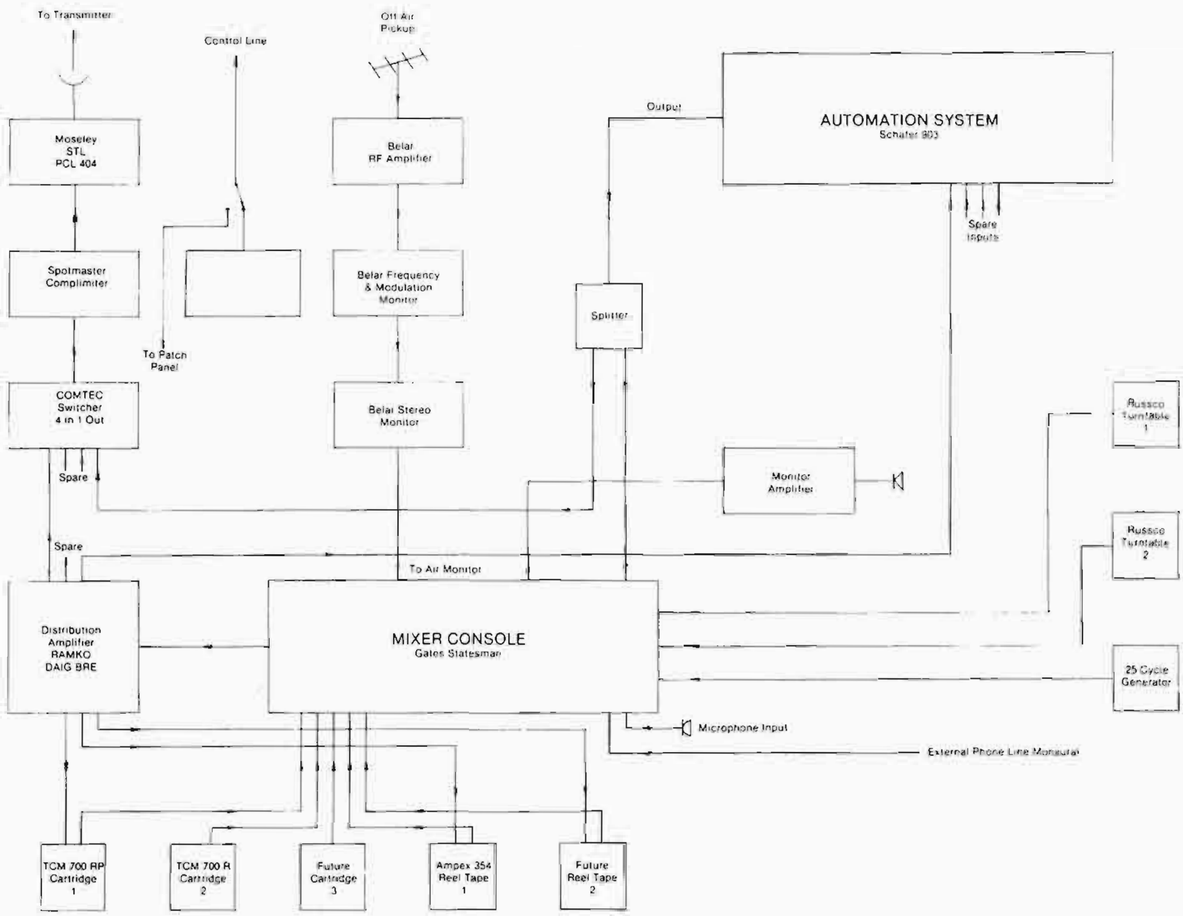

Fig. 2. Audio flow diagram from station KTPK-FM.

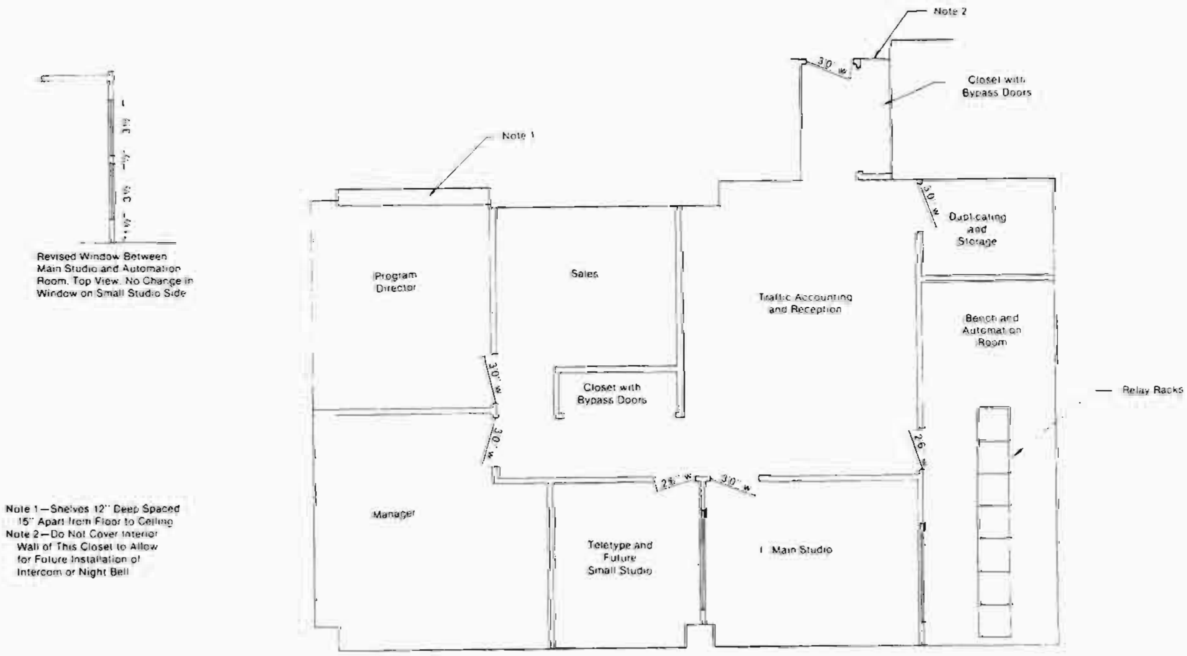

Fig. 3. Studio layout for station KTPK-FM, Topeka, Kansas.

Go through this checklist:

1. Is it clean, is there dirt on the inside of the insulators which are subject to high voltage? Does it appear that any insulators have started to break down?
2. Are any capacitors or potted transformers leaking? Look for discoloration due to heating.
3. Is the wiring brittle as though the unit has been poorly ventilated? Unit might require re-wiring.
4. Look at the tubes—are they still obtainable or will the unit require modifying to something still obtainable?
5. Is whatever you are buying still operating and if it is required, will it still meet equipment performance requirements of the FCC?
6. Is the unit still type approved or type accepted for licensing by the FCC?
7. If unit is a recorder what is condition of heads and motor? Are the belts flexible or dry and cracked? Do brakes appear worn?

Nothing will be 100 percent perfect, but if the equipment is examined carefully, it will be evident what problems to expect when putting it into operation.

It is important to remember that with used equipment there is no manufacturers guarantee and the buyer is on his own in making it work. The one consolation is that unlike much home consumer type equipment, broadcast gear is built to give many years of service and can be easily repaired.

There is yet another place to turn to for inexpensive equipment especially recorders and tuners. A broadcast type reel tape recorder costs between $900-$3,500. This is a healthy amount of money. A comparable home recorder, if connected to your system through the proper matching transformers, will give very good results for a lot less money, generally $100 to $300. Remember though that quite often these units are susceptable to RF pickup from the stations' transmitter. Also remember that many of these units have an unbalanced input or output at other than the standard 600-ohm impedance; so investigate before you buy.

This type of recorder will not last as long as the professional machine and spare parts may be difficult to obtain. When building a station, the judicious use of home high-fidelity equipment can substantially lower the cost of getting on the air.

The high-fidelity equipment store can also be a source of high quality used equipment such as equalizers, monitor amplifiers, speaker enclosures at a fraction of the cost of the same equipment from a broadcast supply house.

In conclusion, when a small market broadcast facility is under construction, it is sometimes necessary to cut costs to a minimum through the use of existing buildings not designed for that purpose. Such structures can, with minimum alterations, be made to function adequately as studios, transmitter locations, and offices.

It is possible to cut construction costs through the careful use of selected home high-fidelity products and used broadcast equipment. The reliability and life expectancy of the resulting installation will be less, but in many locations this is justified by the lower cost.

As mentioned previously in some instances, the licensee either has an available structure or wishes to take advantage of an existing structure to use as the nucleus of his broadcase facility. In such cases, the existing structure is usually a house or a desirable piece of property that can be easily expanded or converted into the studio/transmitter building.

An excellent example of this concept is station WNHV, White River Junction, Vermont, that expanded upon an existing building to develop a very efficient and workable broadcast facility. Fig. 4 depicts the changes which were made to the existing building with the resulting added floor space.

The nucleus of this building was a nondescript, small house which was ultimately camouflaged behind additions and beneath new materials. Much attention was given to sound conduction, natural and artificial lighting, and controlled ventilation. Aluminum was used extensively throughout in conformance to the licensees needs. The modification added a total of 1,120 sq. ft., compared to 864 sq. ft. in the existing structure.

Fig. 5 is a photograph showing the addition to the original structure. Note roof peak of old original house in the background.

The News, Broadcast and Production studios are depicted in Figs. 6, 7, and 8 and contain the following equipment:

News Studio

1 reel-to-reel deck;
1 four-channel board;
1 recording cartridge machine.

Broadcast Studio

2 12-in. turntables;
1 8-channel board;
3 playback cartridge machines;
1 control rack to meter and control transmitters and monitor modulation.

Production Studio

2 12-in. turntables;
1 5-channel board;
1 reel-to-reel deck;
1 playback cartridge machine;
1 recording cartridge machine.

Fig. 4. Additions and alterations to WNHV radio station, White River Junction, Vermont.

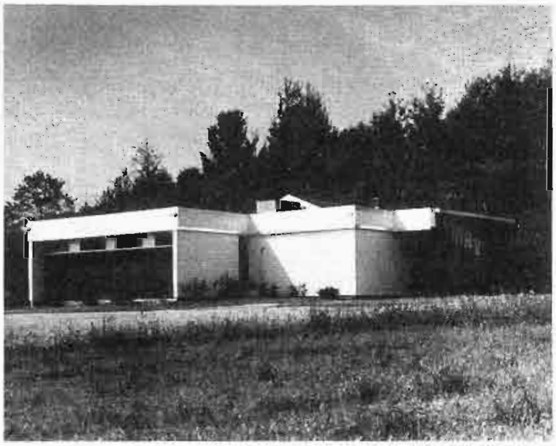

Fig. 5. View of remodeled station, WNHV in Vermont.

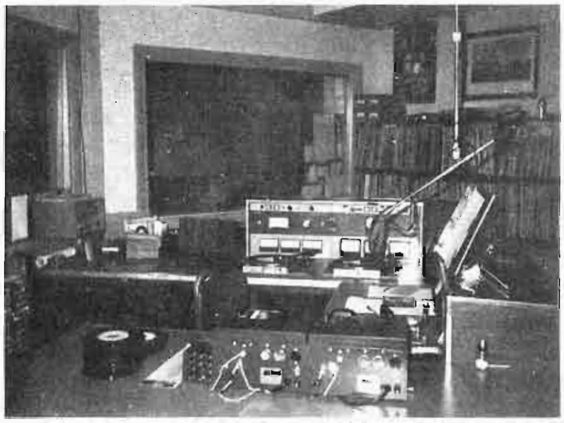

Fig. 7. Broadcast control room and announcing studio.

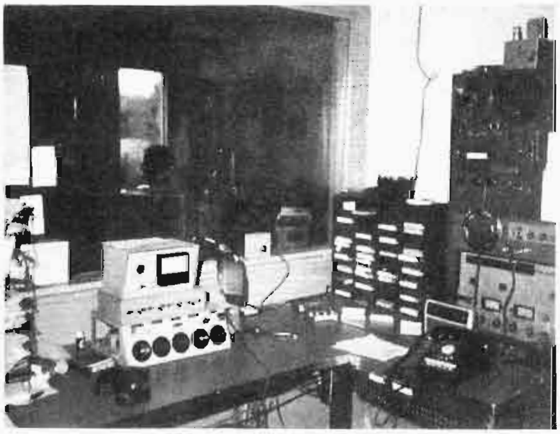

Fig. 6. News studio.

Fig. 8. Production studio.

BUILDING PLANS[3]

One of the prime requisites for a successful broadcast station is the careful layout of studio, production, and administrative areas to achieve maximum effectiveness of space and personnel. The following are four typical layouts depicting a small market minimum staff facility to an arrangement suitable for a large metropolitan operation employing a full complement of personnel. Each floor plan is handled differently according to the needs of different size stations.

Control room, studio, and production facilities for each station are in a centrally located CORE AREA. The suggested sizes of these areas should be considered as minimum from an operating standpoint with normal equipment complement. The layouts are presented as a guide for planning a modern, functional radio facility with considerations given to size of market, staff and programming requirements.

Plan One

With approximately 1,800 sq. ft., this floor plan provides adequate space for the small AM or FM station with a minimum staff. Since smaller staffs have several responsibilities, partitioned general office space is omitted in favor of a large news, transcription storage, and general-use area at the rear of the building.

The transmitter or workshop area is next to the control room, with a window recommended for a clear view of the transmitter meters. Alternate CORE AREA layouts are shown.

The building is of brick and plaster fascia, and includes a glass curtain wall. The building price will vary considerably depending on area construction costs; but a typical figure is $36,000. (See Fig. 9.)

Plan Two

In medium size stations, office space requirements for sales, promotion, and programming activities exceed the need for a substantially larger technical CORE AREA. This floor plan expands the "small station" layout to approximately 2,500 sq. ft., providing more room for the sales staff and clerical help, and an impressive office for the general manager. Studio and control room space is slightly larger in anticipation of more equipment and activities in these areas. The news director, transcription library, and chief enginner gain office space. Alternate CORE AREA layouts may be employed, and a few suggestions are indicated.

The building includes brick walls, weathering steel columns, and fascia, with dark glass entrance and glazing strips. Cost is approximately $55,000, but may vary considerably, depending on construction costs in your area. (See Fig. 10.)

Plan Three

In Plan 3, the technical CORE AREA is adequate for two full-size control rooms, each with a large associated studio. Control rooms are separated by the transmitter, automation, or workshop area. This floor plan includes approximately 3,150 sq. ft. and is suggested for stations planning both AM and FM operations. Additional office space is also allocated for the larger staff in this station. See alternate CORE AREA floor plans for additional layout ideas.

The mirror glass curtain wall building is set in a reflecting pool and costs approximately $70,000. *Note:* building cost may vary greatly, depending on the area in which it is built. (See Fig. 11.)

Plan Four

This 4,300 sq. ft. studio/office complex is an impressive broadcast center. Of primary importance is the location of all control room and studio space in the center of the building, eliminating the problem of outside traffic noise in a metropolitan area.

Operating personnel are assigned to the rear office areas, and the news room is strategically located near the control rooms and an outside exit to the newsmobiles.

The building is of exposed concrete, with a dark glass curtain wall. Building price is approximately $90,000, but may vary greatly from area to area, depending on material and labor costs. (See Fig. 12.)

CONTROL ROOM ANNOUNCE BOOTH DESIGN

Many present-day radio control rooms are not only used for this purpose but also act as announce booths where most of a station's announcing is carried on. In many cases the control room may be the only studio area in a station, and it will contain all the audio equipment of the station. Frequently, a transmitter and record library will also be located in the control room. This makes the problem of acoustics

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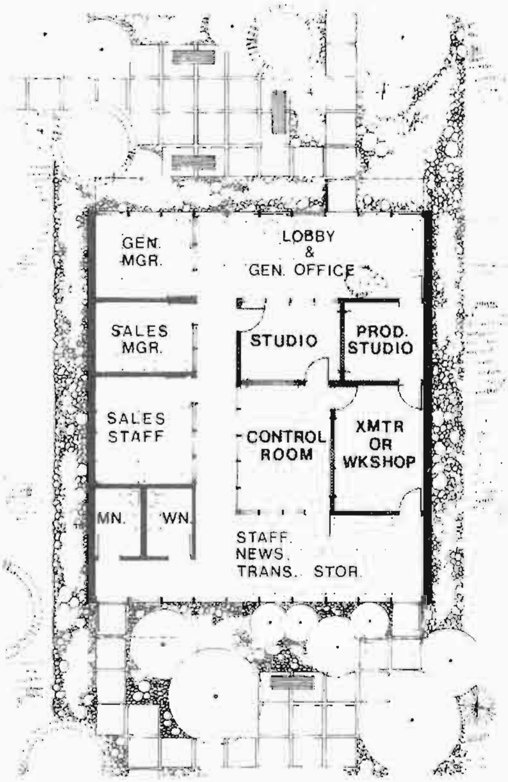
[4]Plans courtesy of Harris Corporation, Quincy, Ill.
In the following plans, transmitting and antenna equipment are not listed since they vary with power and pattern.



SMALL MARKET MINIMUM STAFF

Fig. 9. Small size AM station equipment list (Plan One).

Studio equipment (monophonic):

1	8-Mixer Console, mono
2	12" Turntable
2	Integrated Circuit Equalized Preamplifier, mono
2	12" Tone Arm
2	Stereo Cartridges (Outputs connect in parallel for monaural operation)
3	8'' Loudspeaker
3	Speaker Matching Transformer
3	Wall cabinets for Speaker
1	Cardioid Microphone
2	Dynamic Omnidirectional Microphones
1	Boom Stand
1	Desk Stand
1	Clamp-on Mike Stand
4	Wall Receptacles for Microphone
4	Microphone Plugs
4	Connectors
100'	2-Conductor #20 Microphone Cable, jacketed
500'	Shielded Miniature Audio Cable
1	Headphone
1	Phone Plug for Headphone
2	Studio Clocks

Studio equipment options (stereophonic)

1	Stereo Console
2	Stereo Equalized Preamplifier

Remote Broadcast Equipment:

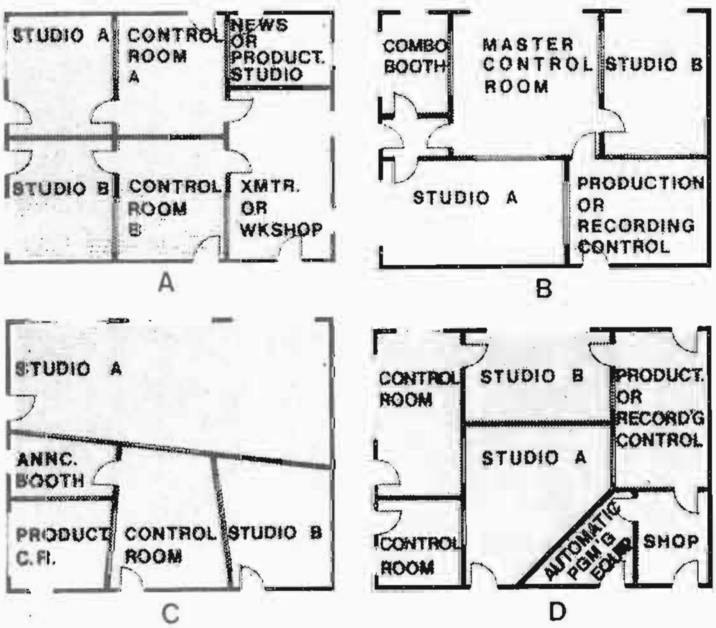
1	4-mixer Transistor Amplifier, Less Batteries
1	Battery Kit
1	Headphone
1	Plug for Headphone
1	Dynamic Microphone with 18 Ft. Cable
1	Plug for Microphone

Tape Recording Equipment:

1	Half-Track Portable Tape Recorder, 7½'' per sec.
2	Cartridge Playback, mono
1	Recording Amplifier for above, mono
24	Cartridges, 40 Sec.
24	Cartridges, 70 Sec.

Remote Control Equipment for Unattended Operation:

1	Remote Control System for unattended operation
1	RF Amplifier with Antenna
1	Rack Cabinet



alternate "core area" plans

MEDIUM MARKET NORMAL STAFF

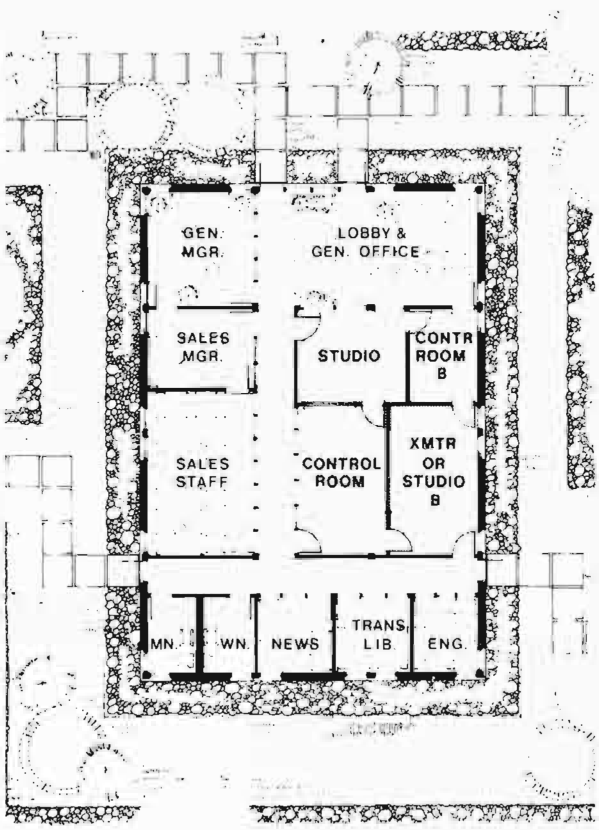


Fig. 10. Medium Size AM Station Equipment List (Plan Two).

Studio Equipment:

1	8-Mixer Console, Monaural
2	12'' Turntables
2	Integrated Circuit Turntable Preamplifier
2	12'' Tone Arm
2	Stereo Cartridge (Outputs connected in parallel for monaural operation)
3	8'' PM Type Loudspeaker
3	Speaker Matching Transformers
3	Wall Cabinets for Speakers
1	Cardioid Microphone
2	Dynamic Omnidirectional Microphones
1	Boom Stand
1	Desk Stand
1	Clamp-on Mike Stand
4	Wall Receptacles for Microphone
4	Microphone Plugs
4	Connectors
100'	2-Conductor #20 Microphone Cable, Jacketed
500'	Shielded Miniature Audio Cable
1	Headphone
1	Phone Plug for Headphone
2	Studio Clocks.

Remote Broadcast Equipment:

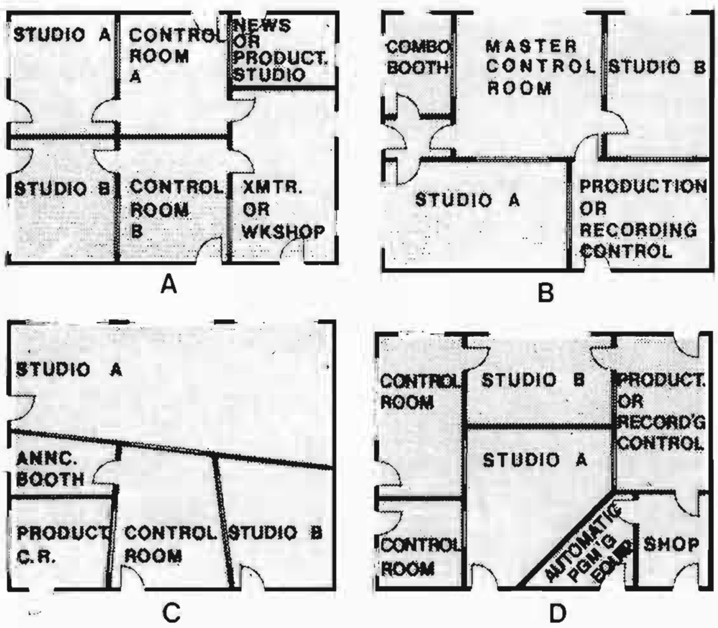
1	4-Mixer Transistor Amplifier, less batteries
1	Headphones
1	Phone plug
1	Omnidirectional Microphone

Tape Recording Equipment:

1	Half-track Portable Tape Recorder, 7½ in. per sec.
1	Cartridge Playback Unit and Recording Amplifier, one tone, desk mount
1	Cartridge Playback Unit, Desk Mount
24	40 Sec. Cartridges
24	70 Sec. Cartridges

Remote Control Equipment for Unattended Operation:

1	Remote Control System for unattended operation of transmitter
1	RF Amplifier with antenna
1	Rack Cabinet.



alternate "core area" plans

AM-FM OR DUAL CONTROL ROOM OPERATIONS

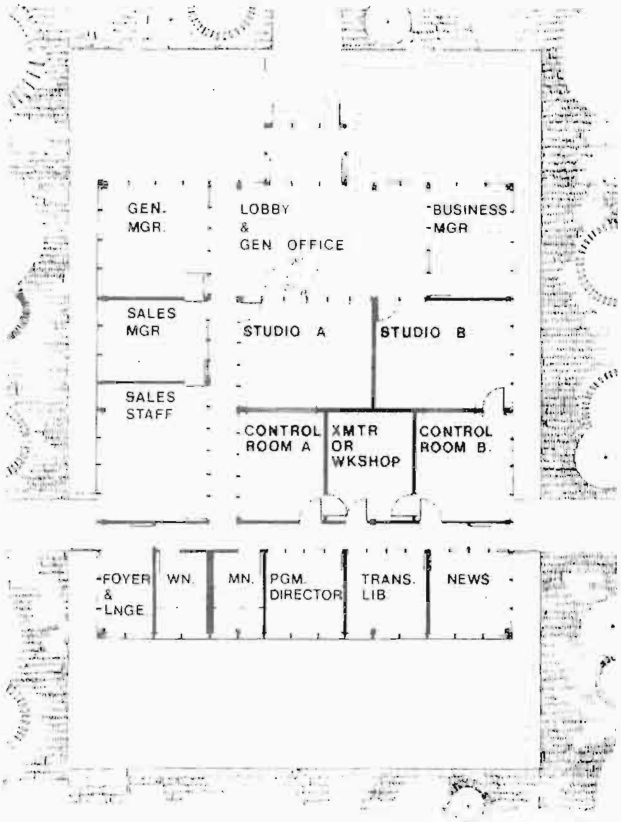


Fig. 11. AM/FM Dual Control Room Equipment List (Plan Three).

Transmitter Audio Equipment:
1 Rack Cabinet
1 AM Solid State Limiting Amplifier
1 FM Solid State Limiting Amplifier

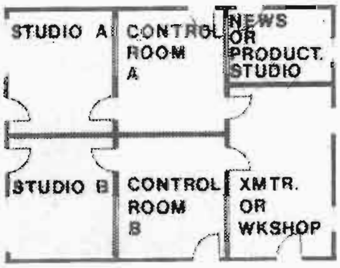
Monitors:
1 AM Modulation Monitor, Solid State
1 EBS Monitor
1 FM Modulation Monitor

Studio Equipment
1 8-Mixer Console, Monaural
2 12'' Turntables
2 Integrated Circuit Turntable Preamplifier
2 12'' Tone Arm
2 Stereo Cartridge (Outputs connected in parallel for monaural operation)
3 8'' PM Type Loudspeaker
3 Speaker Matching Transformer
3 Wall Cabinets for Speakers
1 Cardioid Microphone
2 Dynamic Omnidirectional Microphones
1 Boom Stand
1 Desk Stand
1 Clamp-on Mike Stand
4 Wall Receptacles for Microphone
4 Microphone Plugs
4 Connectors
100' 2-Conductor #20 Microphone Cable, jacketed
500' Shielded Miniature Audio Cable
1 Headphone
1 Headphone Plug
2 Studio Clocks.

Remote Broadcast Equipment
1 4-Mixer Transistor Amplifier, less batteries
1 Headphones
1 Phone Plug
1 Dynamic Omnidirectional Microphone

Tape Recording Equipment
1 Half-track Portable Tape Recorder, 7½ in. per sec.
1 Cartridge Playback Unit and Recording Amplifier, one tone, desk mount
1 80 Cartridge Playback Unit, Desk Mount
24 40 Sec. Cartridges
24 70 Sec. Cartridges

Remote Control Equipment for Unattended Operation
1 Remote Control System for unattended operation of transmitter.



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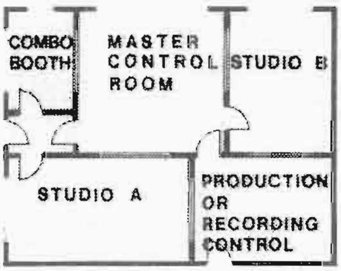

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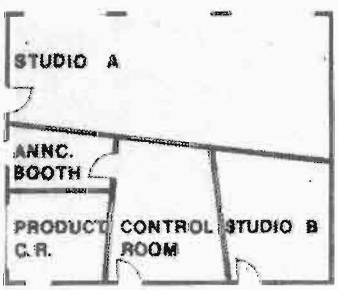

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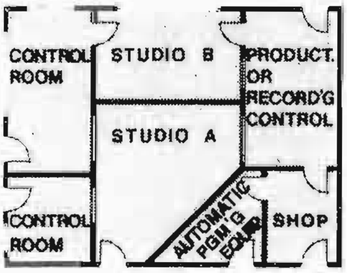

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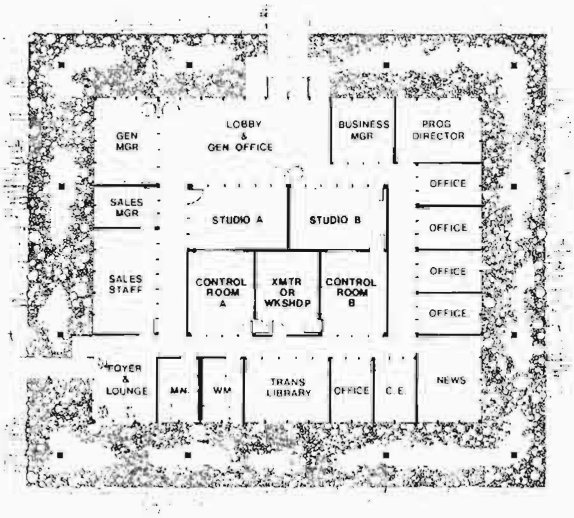
alternate "core area" plans

METROPOLITAN MARKET FULL STAFF

Fig. 12 Metropolitan Market Full Staff (Plan Four).



Transmitter Audio Equipment (monophonic)
- 1 Rack Cabinet
- 1 FM Solid State Limiter

Monitors
- 1 FM Frequency Measuring Unit
- 1 FM Modulation Monitor
- 1 EBS Monitor

Stereo Options
- 1 Stereo Generator
- 2 FM Solid State Limiters, matched
- 1 Stereo Modulation Monitor
- 1 19 kHz Pilot Frequency Comparator

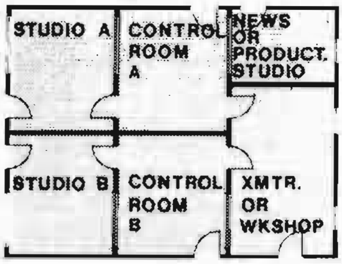
Studio Equipment (monophonic)
- 1 8-Mixer Console, mono
- 2 12'' Turntable
- 2 Equalized Preamplifier
- 2 12'' Tone Arm
- 2 Stereo Cartridge (Outputs connect in parallel for monaural operation)
- 3 8'' Loudspeaker
- 3 Speaker Matching Transformer
- 3 Wall Cabinets for Speaker
- 1 Cardioid Microphone
- 2 Dynamic Omnidirectional Microphones
- 1 Boom Stand
- 1 Desk Stand
- 1 Clamp-on Mike Stand
- 4 Wall Receptacle for Microphones
- 4 Microphone Plugs
- 4 Connectors
- 100' 2-Conductor #20 Microphone Cable, jacketed
- 500' Shielded Miniature Audio Cable
- 1 Headphone
- 1 Phone Plug for Headphone
- 2 Studio Clock

Studio Equipment Stereo Options
- 1 Stereo Console
- 2 Stereo I.C. Equalized Preamplifier

Remote Broadcast Equipment
- 1 4-mixer Transistor Amplifier, Less Batteries
- 1 Battery Kit
- 1 Headphone
- 1 Plug for Headphone
- 1 Dynamic Microphone with 18 Ft. Cable
- 1 Plug for Microphone

Tape Recording Equipment
- 1 Half-Track Portable Tape Recorder, 7½'' per sec.
- 2 Cartridge Playback, mono
- 1 Recording Amplifier for above, mono
- 24 Cartridges, 40 Sec.
- 24 Cartridges, 70 Sec.

Remote Control Equipment for Unattended Operation
- 1 Remote Control System for unattended operation
- 1 RF Amplifier with Antenna
- 1 7 Rack Cabinet



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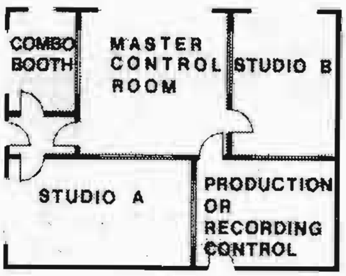

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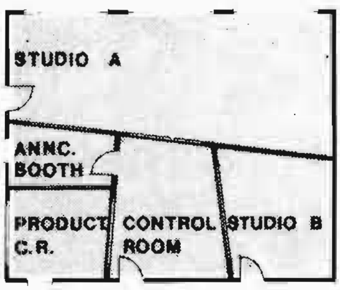

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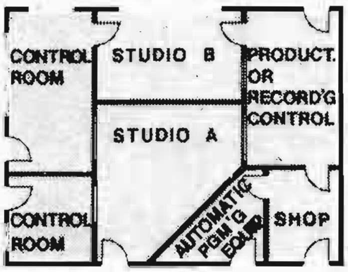


D

alternate "core area" plans

more complex, but since radio sells with sound, good acoustics are a must when the best sound possible is desired.

Design Factors

Combination control rooms are at best a compromise of the several design factors. In the design of this control room, consideration must be given to the following:

1. Location of the control room within the studio building;
2. Isolation—elimination of unwanted sound and noise, both internal and external;
3. Construction—dual wall, floating wall, single wall;
4. Reverberation control, elimination of unwanted reflections, and floor treatment;
5. Ventilation and air conditioning;
6. Size and arrangement of equipment.

Location

The combination control room must be located so that it is convenient to the office areas, but traffic in and out of the room should be minimized in order to reduce distractions to the announcer. The location selected must have as little external acoustical and electrical noise as possible. The control room should be located away from street noise or noise that may be generated in other parts of the building because it may become difficult and costly to reduce unwanted noise that enters through the floors and walls. Air-conditioning compressors and other rotating machinery should be well isolated and kept as far away from the control room as possible.

It is not wise to locate a control room next to a power-transformer vault or other large electrical equipment that may produce strong electrical fields. These strong electrical fields may cause noise problems in audio equipment. If the control room contains the transmitter, great care should be given to the grounding of all audio equipment, including equipment racks, consolettes, turntables, pickup arms, and other metal objects. In some cases, it may be desirable to shield the control room with copper screen to reduce noise generated from high-power RF fields of the nearby transmitters and antennas.

Isolation

Ideally, a control room should be a sound-isolated room within a room. Cost considerations in a small station may make such construction impractical, but it should be considered when possible. The floors and walls should be built from materials that will minimize the transfer

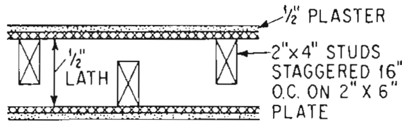


Fig. 13. A cross section of a sound-insulating partition. Wooden walls should be constructed in this manner to reduce external noise.

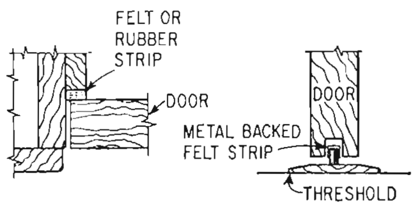
of sound into the control room. Many new stations use concrete block walls and concrete slab floors that are isolated from the building walls with asphalt-impregnated glass fiberboard. This type of floor construction is very practical, since it reduces outside vibration in the control room floor. A stable floor will improve turntable operation by reducing vibration that enters the pickup system from external sources.

Construction

The ideal control-room wall would consist of either a dual masonry wall or a masonry wall with a sound-isolated floating inner wall. In the smaller stations, cost considerations usually preclude this type of construction. A single wall of masonry, cement, gypsum, or pumice block is a good compromise, which is completely satisfactory where external noise is reasonably low.

Wood-wall construction should not be used unless double walls are used. Staggered 2 by 4 in. studs can be set on 16 in. centers on a 2 by 6 in. plate for the double-wall construction (see Fig. 13). Rock-wool bats can be interlaced between the studs for additional sound isolation. There should be at least 2 in. of rock wool or other sound-absorbing material above the ceiling surface, and if external noise is of large magnitude, the ceiling should be sound isolated.

If care has been given to the location of the control room in a given building, the offices and other quiet areas surrounding the control room may screen it from unwanted sound. Control-room doors should be the heavy soundproof type (see Fig. 14), or double doors should be



METHOD OF SEALING DOOR CRACK AGAINST SOUND LEAKAGE

Fig. 14. Normal methods for sealing the control-room door. The door itself should be of a heavy type to improve isolation of the control room.

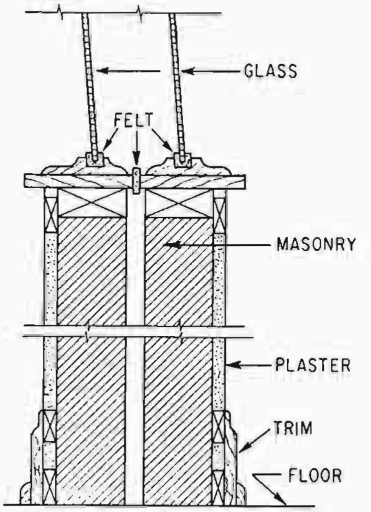


Fig. 15. Sound-insulating window construction showing structural separation of double wall. Glass windows in studios and control rooms should be off about 10°, and they should be mounted as shown on a double wall.

used. Observation windows should be kept to a minimum. Each such window should consist of two panes of heavy plate glass of different thicknesses to break up resonance conditions. The glass plates should be set in rubber or felt gaskets, and usually the glass plates are set about 10° off vertical (see Fig. 15).

Reverberation Control

Some form of reverberation control should be employed within the studio. If a studio has too long a reverberation period, the sound may blur and speech may lack intelligibility. Such sound characteristics are not pleasing to the listener. Generally a studio should have an approximate reverberation time of 0-4 sec. for a volume of 1,000 cu. ft. rising to 0.6 sec. for 10,000 cu. ft. (see Fig. 16). The reverberation time should be about the same from 100 to 5,000 Hertz, but it may rise slightly at 5,000 Hertz (see Fig. 17). This type of studio characteristic helps eliminate low-frequency boominess. An acoustical consultant should design the studio and supply the proper materials.

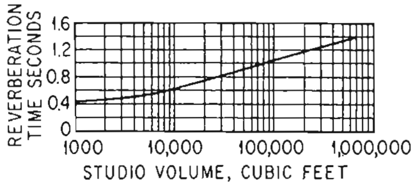


Fig. 16. Variations in reverberation time as the size of the room increases with a 512-Hz reference signal.

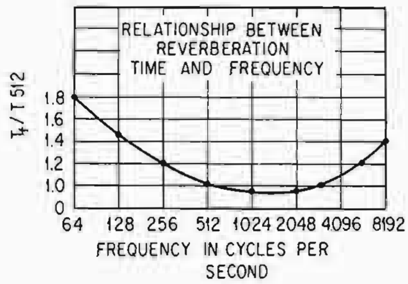


Fig. 17. Morris-Nixon curves showing the relationship between reverberation time and frequency. Reverberation time should remain fairly constant between 100 and 5,000 Hz.

Consideration should be given to all wall and equipment surfaces in the control room in order to eliminate unwanted reflections. Perforated hardboard or Transite can be used for wall coverings with rock or glass wool placed behind it for sound absorption (see Fig. 18). Hardboard may be painted, and it is easily maintained with occasional washing. The hardboard can be used for wall panels set at various small angles of 5 to 10° to produce greater diffusion of sound.

All glass surfaces should be set on an angle to reflect sound into the sound-absorbing surfaces of the ceiling. Glass surfaces should be kept to a minimum, and large corner areas of glass should be avoided. The floor covering should be of a soft material, such as cork or vinyl tile, to reduce surface noise. A rug may be necessary to produce the required deadening in control rooms having many glass surfaces and other reflecting areas. The surface of the operating table should be made of a soft material such as linoleum or vinyl. This will reduce table-top noise.

Microphone Requirements[5]

A good microphone with proper directional characteristics is important in the control room. A microphone operated in a unidirectional pattern has excellent properties. The distance between the speaker and the microphone will be determined by the acoustics of the control room; however, good microphone technique is important for all personnel if natural reproduction is desired.

Ventilation

To do a good selling job, an announcer must sound alive. It is important to provide air conditioning and ventilation so that announcers have a good environment in which to work. A central air-conditioning system is recommended. The

[5]See section entitled "Microphones: Their Application and Operation."

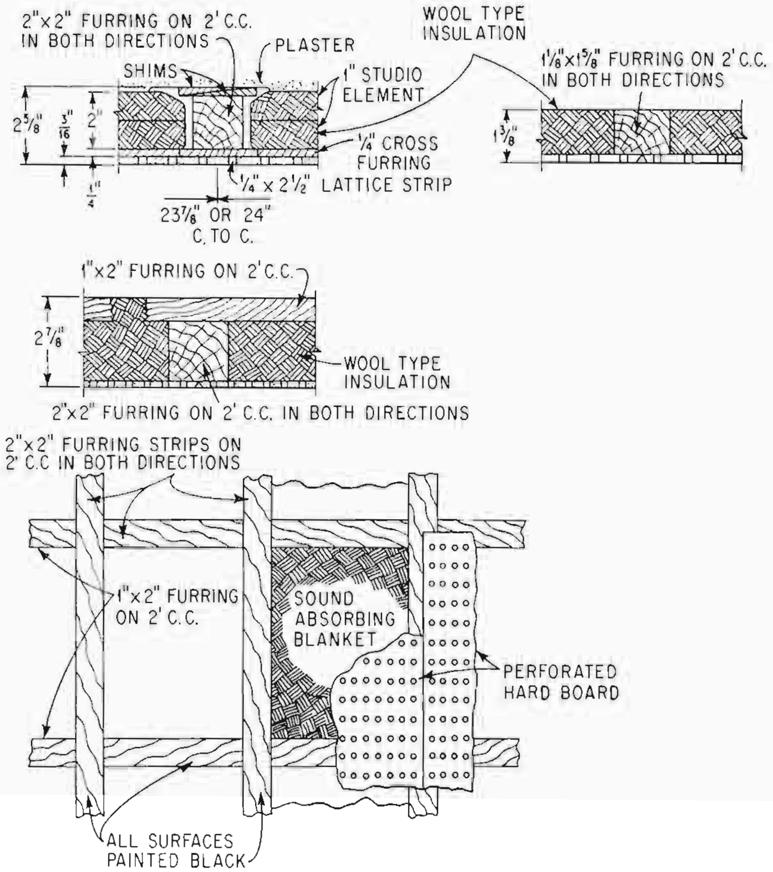


Fig. 18. Typical acoustical panels and how they are mounted. Excellent isolation can be obtained if this type of wall material is backed up with glass or rock wool.

air is brought in through ducts from the coolers. The air ducts should be lined with a sound-absorbing material for a distance at least twenty times the average width of the duct. A separate duct should be run to each studio and to each control room to avoid sound transfer through the ducts. Low-velocity air should be used to prevent air noise from the duct openings.

If the control room contains a transmitter, it is usually possible to exhaust hot transmitter air to the outside and to cool the transmitter with spent room air. If this is not possible, the transmitter should be partitioned off from the control room, and a separate source of air should be used to cool the transmitter. The transmitter can be remotely controlled if it is in another room some distance from the control operation. Such a procedure will save many dollars in construction costs and also eliminate a source of noise in the control room.

Equipment Arrangement

The equipment selected will, to a large extent, determine the physical aspects of the control room. The control room should be large enough to contain all required personnel and equipment. At the same time thought should be given to possible future expansion, and extra space should be provided with this in mind. A control room that is a little larger than necessary at the outset makes it easily expanded later. Furthermore, it is always more difficult to treat a small room acoustically than a large room.

Planning It Right

A good architect should be consulted when planning a studio-control room. After a general station plan is formulated and equipment selected, the architect and the consulting engineer should work out the specific construction details for the station. Careful acoustical planning combined with good equipment will enhance the sound of any station and make its sound sell more.

Exclusion of Noise

A studio with good acoustics has its walls insulated against the transmission of outside noises

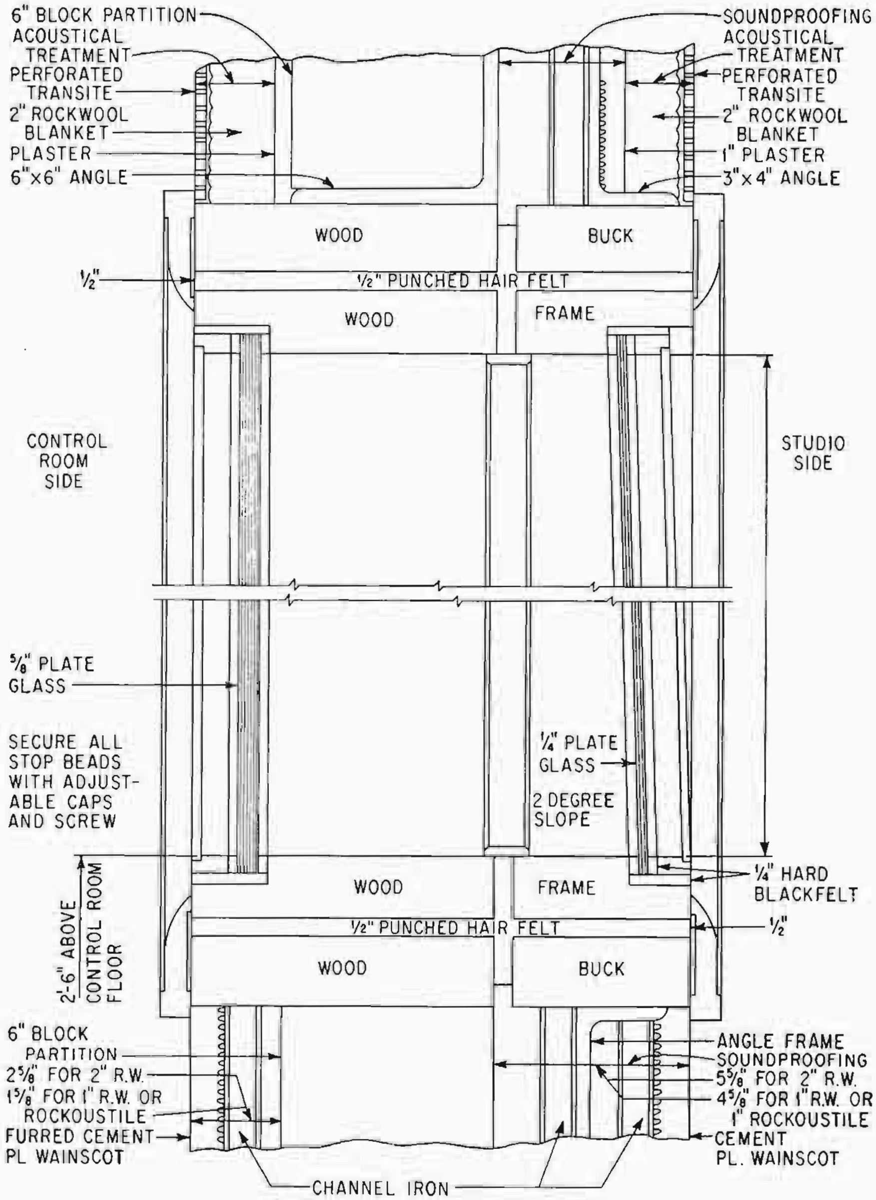


Fig. 19 Sound-insulated window.

into the studio. The transmission of sound is of two kinds: (1) aerial and (2) structural. Small openings due to doors, windows, etc., transmit sound to a great degree. Thus, all the joints between walls, doors, windows, etc., should be made as airtight as possible.

Likewise, transmission of sound through structures, such as the noise from vibrating motors and machinery, should be minimized by using massive walls and floors and by separating all vibrating bodies from their supporting structures by sound-insulating materials such as cork, lead, or rubber.

Massive walls are not always necessary to obtain sufficient sound insulation. A double wall of fairly light construction will give good sound insulation provided the two walls are not closely coupled mechanically by nails or cross members, that is, provided the walls are kept isolated or separated from each other.

A noise survey of the proposed studio site should be made by a qualified acoustical engineer before plans are drawn. From the viewpoint of excluding outside noises and building vibrations it is essential that during erection all joints and openings between panels, etc., shall be fully caulked to give a continuous and sealtight enclosure and furthermore that the entire wall structure shall be floated on cork, rubber, or other suitable material in order to isolate the

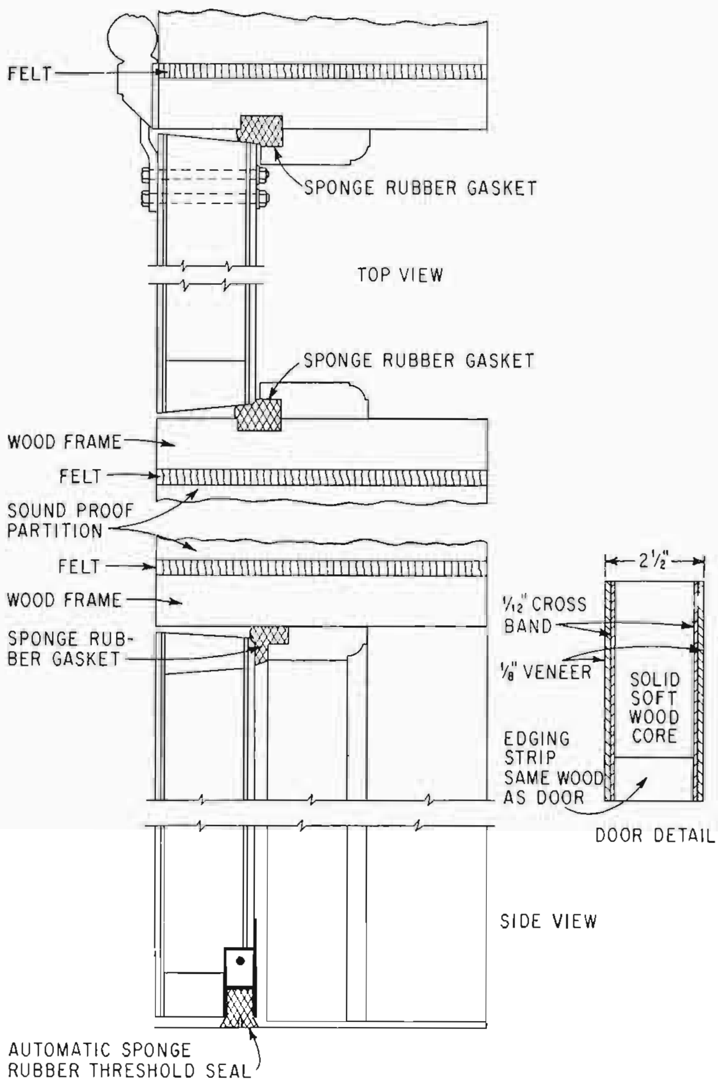


Fig. 20. Sound-retarding door.

walls completely from the main building structure. This precaution is extremely important, since a single mechanical bridge or solid connection between the inner and outer shells caused by nails, pipes, ducts, etc., can almost completely nullify the sound insulation by setting the inner structure into vibration. Any bracing between inner and outer walls which may be necessary for structural reasons should receive individual isolation treatment to break the continuous mechanical connection. The various methods employed in building practice and patented methods for vibration isoltion are too numerous to treat in these specifications. The underlying principle for preventing transmission through solids is to avoid a continuous medium (reinforced concrete, brick, etc.) or solid connection (wood, metal, etc.) by interposing a resilient or less dense material (cork, rubber, felt, air, etc.) in the link between the source of vibration and the reception point. In general the greater the number of such discontinuities (dense to less dense medium and vice versa), the greater the isolation effect. The ceiling and floor structure should receive similar caulking and vibration-isolation treatment.

Fig. 19 shows a cross section of a typical window of the sound-retarding type. Fig. 20 shows a cross section of typical sound-retarding door such as the Riverbank door used by broadcasting stations and other sound studios. Fig. 21 illustrates construction of a typical sound-insulating wall in accordance with principles stated by Bagenal and Wood in their book "Planning for Good Acoustics."

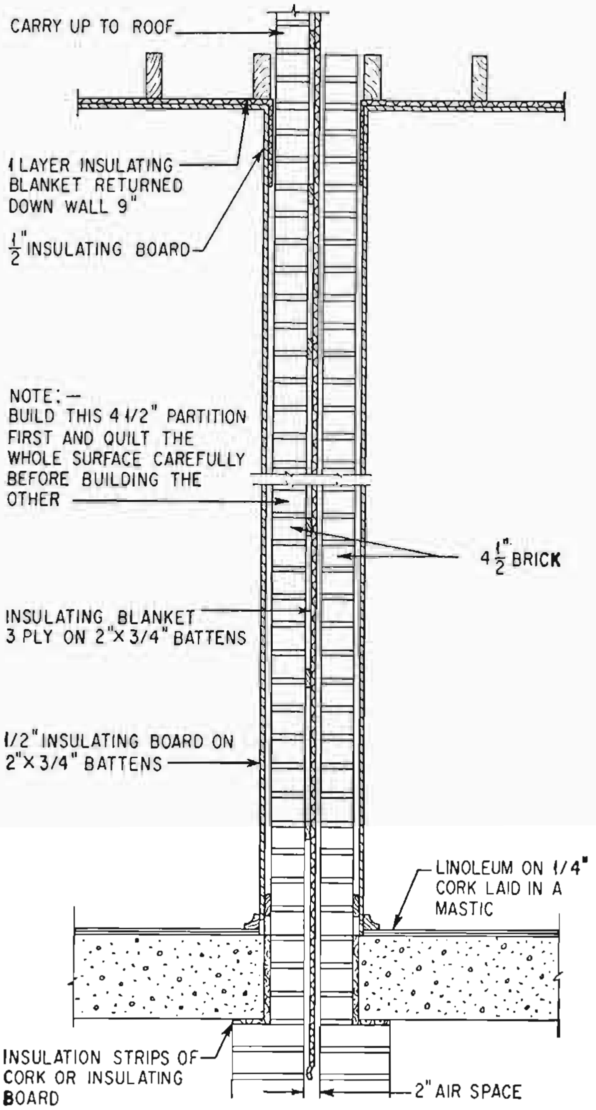


Fig. 21. Sound-insulating wall construction.

TV STUDIO FACILITIES—GENERAL

Staging and Production Areas Proper

Access to studios for vehicular and pedestrian traffic must be efficient for people and materials handling, since this is a final, live production point in the plant. Type of construction and materials will vary, depending upon local conditions, availability, and cost factors. A relation of costs of the various elements to one another should be established in order to facilitate the inevitable compromises that must be made. Dimensions will vary depending upon requirements; however, three typical sizes are as follows: 70 X 110/7700 sq. ft., 40 X 55/2200 sq. ft., and 20 X 35/700 sq. ft. Structural beam heights and lighting grid heights depend upon whether a new structure is built or an existing building is to be utilized. Maximum clearance is always desirable, with a lighting grid to floor minimum of 15 ft. and practical upper limit of 30 to 35 ft.

Types of finishes used on floors, walls, and ceilings can have much bearing on the production quality possible in a given facility. After many experiences, it has been determined that gray deck linoleum is a fine floor surface covering, having a good wear factor, low fatigue, good sound and color features. Wall and ceiling acoustic treatment is desirable; however, this must be determined by the scope of the operation and budget considerations. Air conditioning and ventilation must be afforded in the required amount and volume, yet without being an uncontrollable noise factor. Heating must not be overlooked as a necessity in climates where there is that temperature requirement.

Traffic flow in and out of the studios is an extremely important matter for efficient operation. Doorways should not be planned in more than one or two of the studio walls, as there is a direct reduction in the amount of usable staging space where entry ways reduce the floor and set areas. The space matter, notwithstanding proper recognition, must be given to fire exits and safety measures for the protection of employees and visitors.

A proper talent and preprogram checkout assembly area or room is needed outside the studios which are being prepared for use. This allows careful briefing of all parties prior to air or production starting times. Dressing rooms, prop areas, and security storage locations must be in appropriate proximity to the actual studio/staging locations. Depending on the scope of an operation, these areas may be more or less critical in nature.

Lighting

Studio stage-lighting grid systems are of two basic types: (1) long pipes that can be raised or lowered by counter-weighted rope arrangements; a number of lights are attached to each light and the whole unit is moved and (2) fixed grid systems of steel beams with a track attached (known as "unistrut"). In this system, each light can be moved horizontally in the track and raised or lowered by a hanging device known as a pantograph.

A lighting suspension system for an average size (40 X 60 ft.) studio should begin with a 1¾ in. or 2 in. pipe grid, spaced approximately 4 ft. apart, across the width of the studio. This type of grid seems to give the most flexibility as to hanging devices and fixture arrangement. The fixtures are usually hung on an adjustable pipe (ranging from 4 ft. off the floor to full grid height). This pipe is anchored to the grid by means of a pipe clamp. The use of pantographs as hanging devices are no longer popular because of their size, weight, and bulk. *Unistrut* material used for grids is novel but has definite disadvantages in their hanging and locking devices, which become increasingly difficult to actuate with age and use.

Lighting control systems today are made up basically in three units: (1) SCR dimmers and racks, (2) patch panel and cords, and (3) low-voltage control console. In studio planning it is not necessary to include the dimmer racks in the studio. They can be placed nearby in a convenient place for venting, thereby reducing the noise and temperature levels in the studio. The patch panel and control console should be part of the studio lighting design, although a second remote control console can be placed in the control rooms or at the video position. This gives the lighting director or technical director versatility in making on-air changes or adjustments. The control console should also be versatile enough to handle various presets and scene-to-scene changes. Of major importance is the evaluation of the total amount of wattage required for optimum studio versatility, that is, multiset lighting and major full studio production numbers.

TV lighting fixtures come in many shapes and sizes today but they are broken down into four basic types. Key lights are the main source of illumination on a subject. This is usually a focusing type lamp with a Fresnel lens, ranging in lens size from 6 in. to 20 in. In wattage, that would be 500 w, 750 w, 1,000 w, 2,000 w, 5,000 w, and 10,000 w. In most studios the 1,000 w, 2,000 w, and 5,000 w lamps are used as key lights. This type of lamp is used as backlite, which will be discussed later. Fill lights used exactly as their name implies, fill in the shadows created by the key lights. These fixtures are usually large lensless, diffused sources of illumination. Typical of this type of fixture is the scoop and cone lamp. Becoming increasingly popular is the line of reflected light sources known as soft or shadowless lamps. The fill lamps are usually 1,000 w or 2,000 w in the scoop-type lamps and up to 8,000 w in the shadowless reflected type fixtures. Effects or projection type lamps such as the elipsodials have a lens system and are used to project patterns or can function as a follow-spot. Its beam can also be cut to various shapes (by means of individual shutters) and sizes.

Last but not least are the cyclorama lights, which are used to illuminate the cyc-from-floor level. In cases where added versatility is needed, and/or high cycs, additional cyc strips are placed at grid height, illuminating the cyc from above. Usually these strips have two or three individual circuits. Colored glass frames are supplied with each circuit, thus offering numerous possibilities for colored cyclorama effects. A large amount of wattage is needed to successfully illuminate an average size cyc. Careful consideration should be given to this area of studio lighting.

In determining the types of bulbs to be used in the previously mentioned fixtures, serious consideration should be given the line of Tungsten-Halogen bulbs. Basically, the difference between the T-H bulbs and the incandescents is that the Halogen gases act as a catalyst to recycle the burned-off tungsten, thus maintaining a constant Kelvin temperature throughout the life of the bulb. The T-H bulb is now available in all the popular base configurations such as medium and mogule bipost, twist bayonet, screw mogule, etc.

In an effort to attain a pleasing and technically acceptable picture through lighting, several basic factors must be practiced. First of all, a light level of approximately 250-foot-candles must be maintained. Contrast ratios exceeding 2 to 1 should be avoided except in cases where highly dramatic effects are requested. Brightness ratios on sets, props, and wardrobe should not exceed 20 to 1. This can be maintained with the use of cutters, flags, dots, barndoors, etc., or better yet, careful set planning. Back lighting is used to give separation and dimension to a subject. It is difficult to set a definite level on this lamp; it should be set by looking at a monitor to avoid video clipping or polarization. An overall base light or fill light level should be used as often as possible at the suggested ratios. This base level tends to minimize video noise and assures the video operator of relatively flat pictures. It cannot be stressed strongly enough about the part played by the video operator and the lighting director working together in solving various problems. Communication between all participants is a must.

Sound Pickup

Four types of microphones are in general use:

a. The mike mounted on a large boom with the ability to roll the boom from place to place within the studio.

b. The desk or stand mike.

c. A small mike hung around the neck and resting against the chest.

d. The hand-held mike.

There are wireless mikes in use today but the quality of these units is inferior.

Storage of microphones is best accomplished in sectionalized cabinets or drawers lined with soft material. The mikes should be stored in or near the studio. It is convenient to keep the mike cables in the same cabinet.

Video Pickup

Television cameras are generally mounted on fixed bases with wheels. These are of a size that one man can move and steer the base and at the same time operate the camera. Recent technology has brought the zoom lens into wide use. This lens allows the operator to obtain a closer or wider picture (while remaining in focus) without moving the camera. If large dramatic productions are planned, a crane-type camera-mount may be needed. This is a two-man operation: one running the camera and one pushing or guiding the crane.

Accessory Devices

The connection of cameras, mikes, and cueing devices to control areas is best accomplished by fixed terminal connectors on the studio walls. Camera and mike cables can then be unpluged if needed elsewhere. The same applies to any picture monitors within the studio proper.

Clocks and cueing devices can be mounted on the base holding the movable picture monitor or on the studio walls. If the latter, be sure location is visible from all working areas of the studio.

If economy permits, automatic prompter devices should be included in the studio equipment. With these units, the talent may read previously typed scripts while looking almost directly into the camera lens. The readout unit is normally mounted on the camera (above or below the lens) and the reading speed selected by the talent or regulated by someone on the studio floor.

Projection Devices

Projection equipment used within the studio for onset effects (a filmed scene or chart appearing behind the talent, for example) can be purchased in a variety of configurations. The two basic designs are front projection and rear projection. Using these devices, a screen is placed behind the talent and scenes projected onto the screen. The camera then frames the talent and the scene projected. Care must be taken to allow room (particularly rear-screen projection) for the necessary equipment.

Audience Considerations

Provision should be made for audience seating. This can vary from foldout bleachers to standard, fixed theatre seats. Local fire codes generally specify arrangements and configurations permitted.

Acoustics

Care should be taken in planning the acoustics in the studios. The engineer planning the studios should specify the allowable sound transmission through walls, doors, and windows (measured in dB units), and the reverberation time (measured in tenths of seconds). If wall treatment is desired, it can be glued, tacked or sprayed onto studio walls. Studio ceilings are not usually treated, but hung battens may be needed to improve the reverberation characteristics.

Operational Control Facility

There are several possibilities concerning control-room location. If the engineering staff is limited in number, it is wise to have the air control room adjacent to the Master Control area. This will allow technicians responsible to Master Control observance to set up the control room and still be in view of transmission areas. A folding door can be installed and closed when quiet in the control room is necessary. This configuration requires that the control room be between the main studio and Master Control.

In a large operation it is desirable to have control rooms separate from Master Control and adjacent only to the studio. The advantage to this layout is that recording and production tasks do not go on in the same area as on-air tasks. This layout results in less confusion between the two operations.

If two studio/control areas are needed, the control rooms should be side-by-side and separated with a block wall and a medium decibel-rated door.

The ability to see from control room to studio is important and sound windows should be installed. Arguments can be made for "blind" operation or the use of closed circuit cameras, but these are generally unsatisfactory for the production personnel.

Access from control area to studio should be direct. This allows production people to enter the studio to discuss items with the talent or to give directions concerning set location, etc., to the operating personnel.

There seems to be little difference in operation between elevated or ground level control rooms. Budget and building layout will dictate the best choice.

Even though separate viewing rooms are planned, it is a wise idea to allow space within the control room for clients and VIPs. Special seating or counters should be constructed *behind* the operating personnel. If this is not done, these people will hang over and interfere with the director.

The majority of monitors in the control room can be small black-and-white units. It is wise to include a large color monitor with line, or off-air signal; one monitor for each source is preferable to any monitor switching arrangement in the control room. The proper number of video waveform monitors should also be allocated for level and balance checking. Location of the monitors (on the counter or over the window) is a matter of overall control room layout. It is not necessary to worry about the director's view being blocked by monitors provided he can see into the studio when standing.

Control counters can be purchased in modular metal form but custombuilt wood counters covered in formica are generally more attractive and lend themselves to flush mounting with clocks, intercom controls and mikes, and control switches. Construction should be sturdy, with 2 X 4 braces covered with back and end panels of formica-covered plywood. Be sure the panels are removable for wiring access.

The general finish of the room is important to the efficiency and quality of the production. Wall finish should be of sturdy wallboard up to 42 in. from the floor, and then acoustic tile to the ceiling. Industrial carpeting of a dark, patterned shade is desirable. Both wall and floor covering help with sound characteristics of the room. Room lighting should be of the incandescent type and adjustable as to intensity. Air conditioning should have a separate thermostat for the one or two control rooms. Avoid placing air-conditioning outlets over the heads of operating personnel. Use sufficient air-conditioning outlets within the room to avoid noise from air flow.

When purchasing items used by the operating personnel such as chairs, headsets, and timing clocks, spend what is necessary to get sturdy equipment that will take a beating and not break. These items are pushed, shoved, dropped, thrown, banged, and yelled at.

In deciding whether to place the audio operator at the same counter with video switching and the director or in a separate room, proposed program plans must be considered. If the operation is to be mainly from program sources sent in by others (films, videotapes) and if the programs recorded in the station are mainly discussion or light entertainment productions, no separate audio room is necessary or desirable. However, if classical music or large musical or dramatic productions are planned, a separate sound-treated room should be planned. Always include off-air audio monitoring in the audio control room.

The ideal configuration of counter and equipment layout for the audio operator is a U shape. Careful consideration should be given to location of each piece of equipment the operator will use. He should be able to reach the audio console controls comfortably, also the cartridge load slots, reel-to-reel tape recorder, record turntables, and intercom buttons. Avoid configurations using remote controls if the actual equipment to be loaded is to be placed out of reach. If something malfunctions, the operator can have great difficulty correcting the problem and still maintain control of the operation.

All equipment should be permanently mounted, if possible; roll-in turntables, etc., have a tendency to be broken and poorly maintained. Standard equipment racks, placed to the side or rear of the audio operator, should be used. Equipment requiring periodic service should be mounted on sliders. Leave 24 to 36 in. behind each rack to allow space for wiring and removing or service of the equipment. It is wise to leave 25 percent of the audio rack space unused for expansion purposes.

The location of audio equipment is very important. Drawings, mockups, and discussion with an experienced audio operator will help to insure the efficiency of the finished design.

Interconnection wiring of audio sources throughout the facility are dependent on budget and degree of backup and flexibility desired. Whatever the final audio routing arrangement may be, all sources should come to a designated position of the patch panel in the audio control racks. This allows for flexibility, both in audio source rerouting or emergency substitution. These panels are small and can generally be installed in the audio racks. It simplifies installation and servicing if the audio wiring is first brought to a terminal block on the rear of the rack and then to the front-mounted patch field.

If the audio operator is to be in a separate room, he must be able to view the director, the studio, and all preview picture monitors. Direct communication (not part of the overall intercom system) with the director is desirable. The audio room should have a separate clock, timing clock, and picture monitor. The monitor should be patchable to off-air and studio video sources.

Audio consoles generally have cue positions which allow the operator to preview audio sources without affecting air operations; however, these speakers are normally small and give poor quality. Installation of two high quality speakers in the audio room is recommended. One is connected to air or studio audio and the second switchable to preview the various audio sources within the station.

Space should be included for storage of cartridge and audio tapes. Allow space for seating of two extra people and/or some expansion space.

In considering viewing rooms, an evaluation must be made as to types of guests expected. If groups from the general public are to be invited, access to the viewing rooms should be as direct as possible from the main entrance for security reasons. In no case should guests walk through the studio or control areas to reach these rooms. Rest rooms and drinking fountain should be close, and, if possible, separate from station personnel facilities.

Wall coverings, floors, and furniture should be of durable materials and easily cleaned. Picture monitor and audio amp should be permanently mounted, with access to all controls except volume locked and to be adjusted only by station personnel. A phone to the receptionist should be installed.

It is generally advisable to have viewing rooms elevated and to install large windows with tempered glass starting about 24 in. from the floor. In many cases, children will be guests and the unbreakable glass may avoid injury. Include a large coat closet in the room if weather conditions of the location dictate.

It is possible that station people may wish to use the viewing room for clients or VIPs. If furniture used for general guests is removable, the room decoration can be upgraded by substituting lounge chairs and carpet for the special occasion guests.

Recorded Material Origination Area

Film/Motion Picture

In planning a television operation, a good deal of programming will originate on film. This film will be run on motion picture projectors, of which there are three basic types: 8 mm, 16 mm, and 35 mm. A standard television operation uses 16 mm projectors due to ease in shooting, processing, editing, screening, and storage of 16 mm film. In large operations, where major motion picture film is shown, special 35 mm projection equipment is used to a minimum. (8 mm film is rarely used in broadcast transmission, due to the nature of the film itself.) Since clarity or resolution in motion picture film is of utmost importance, normally 16 mm film will be used. In total, the philosophy and scope of a television operation will determine the projection equipment to be used.

When planning an area to house the projection equipment, careful layout must begin from the ground up. Basically it must begin with a well-constructed floor. Since most of the projection ear is so complex, a proper foundation will insure that the projection machines will remain stationary, allowing its parts to function normally. Picture alignment is also critical, thus firm foundation is essential.

Since space costs money, most television stations save space by installing multiplex units in their projection areas. The multiplexer is a device that houses a small television camera and a complex set of mirrors and prisms. By aligning as many as two film projectors and a single slide projector to this one unit, it is possible to program three separate film sources in any individual order one wishes. But whether a multiplex system is called for or separate motion-picture machines, the projection area must house a uniform audio and video monitor control panel. The control panel is the heart of the project area. Here, individual monitors will enable the projectionist to preview what film or slides he may have programmed on a particular film or slide machine. It is this same preview device that enables the projectionist to catch any errors in loading, which may have occurred before the film source is aired. A well-constructed preview control panel also enables the projectionist to roll or show his film from a sitting position. Thus, time and energy are saved. This same panel may also be wired for an automated film system, whereby a programmed master unit will roll or show slides via remote control. In a small operation, this is highly desirable, since the projectionist can load, double-check his work, and then be available to cover another position in the Master Control area.

With a well-planned projection area, the storage of film becomes an important factor. Only those films that are to be run each day should be placed in the operating area on a special rack. Loose standby films (varying in program length) should also be readily available, but not clutter the operations area. All other films in the station should be placed in a properly humidified and temperature-controlled room near the film shipping and film-editing rooms. Again, efficiency in handling film saves time and money.

Included in an efficient projection area are important miscellaneous items: (1) an air-hose gun with sufficient length and air pressure is needed to clean dirty film while it runs on the air; (2) both video and audio alignment films are needed to test the film equipment daily for possible malfunction. All equipment should be stored in a central working table which also contains the numerous slide trays; (3) small tools and spare projection lamps should also be stored in order to repair or replace needed items quickly.

Film/Still

In a television operation the projection area will also house another program source called a slide. A slide simply is a single still picture. This still picture is made with a special 35 mm-slide camera, the film is then developed, the individually selected pictures are then mounted and shown on a slide projection device. The device, normally called a slide drum (which may hold as many as 36 individual slides) is connected to a multiplex unit (see above). A special beam of light will pass through the slide/film and its image will be recorded by the small television camera in the multiplex system.

The slide is an important program source and can be used in television for many purposes. A series of similar slides tells a simple visual story. A single slide can either identify something or be used as a simple program transition device. Whatever the case, slides are important and must be shown correctly.

When planning your projection area, at least one slide projector should be attached to each film island containing a multiplexer unit, a film projector and slide projector. A film island may consist of as many as two slide projectors and one motion picture camera, or vice versa. When planning a film island, one also must keep in mind whether the system can be compatible, that is, able to be shown in both black and white, and in color.

Whether the station owns a film island or not, each slide projector should be connected to preview control panel. As in the case of the motion picture projectors, the preview panel will save time, mistakes, and money. For utmost operational efficiency, the slide projectors may be wired to the panel for automated commands. Once again, the projectionist may load a series of slides, preview them, reset for air, and walk away to cover another position in Master Control.

As important as slides are, they are of little use if they cannot be found readily. Within the projection area, slides should be kept in slide trays in a systemized order. The slide trays should frequently be examined for duplication, loss, and old program material. Part of this duty will lie with the promotion, commercial operations, and programming departments.

Keeping in mind what has been discussed regarding the projection area, a television station can find this area the simplest and most trouble-free area to work in.

Videotape

Generally speaking, the on-air tape center of a television station is best situated near the projection area in Master Control. Being housed in one large room, the Master Control technician may have complete command within a short walking distance of film or videotape areas. Depending upon the operational size of a station, a minimum of two machines should be used.

Careful consideration should be given to the positioning of such machines in the assigned area. Normally, a 2 in. videotape machine size is 4½ ft. by 6 ft. high and each machine is placed side by side. Plenty of room should be allowed, not only in the direct working area but also behind the machines themselves. Frequently a videotape technician must repair the machine from the rear and there is not sufficient space, thus necessitating moving a heavy, but very delicate instrument. Chances are that once you move a 2 in. tape machine, readjustments have to be made. In addition to providing ample work space around the 2 in. videotape machine, the general environment plays a major role in the efficiency of machine re: wear and operation. Due to the complex nature of a videotape machine, proper ventilation is needed to keep the machines running cool. Air ducts should be provided in the ceiling over the machines. But where there is ventilation there is dust. Dust is the major cause of wear on the life of a videotape head (the system that translates magnetic tape information from the tape itself to electronic impulses that, in turn, produce visual pictures and sound). With today's modern technology, special devices called "dust curtains" may be installed directly over the machine to reduce the amount of dust. Carpeting has also been found to be a deterrent to dust. Thus, it should firmly be considered in planning a videotape area. Environmental noise in the videotape area is another problem; proper ceiling and wall tile should always be considered in planning a videotape area. With less noise, there are generally less human mistakes made.

Thus far we have concentrated on the on-air videotape area. Little is normally mentioned concerning the videotape machines used for editing or screening. In large operations it is best to place these machines in an adjacent but ample size room. The reasons are many: videotape editing is a skillful but painstaking process. A minimum of two machines are normally required. If the video machines are not spacially separated, the tendency is to use the extra machine for air operations. This is fine, but when editing or screening of videotape material msut be done, there is no machine available and this costs the station money. Confusion may also exist between on-air or off-air videotape personnel if the machines are placed in one large area. Since the needs for a machine are so diferent (editing, screening, versus on-air playback), the space allocated should be different.

Although we have discussed the standard 2 in. videotape machine used in major television stations, we should note that there are two other types of machine available: 1 in. videotape plus cartridge videotape.

The 1-in. videotape machine is a baby unit. It is slightly larger than standard broadcast audiotape recorder, but quite versatile. Mainly, it can be used to store the same tape information found on 2 in., but in less space. Although it is not used for standard broadcast transmission, programmers and salesmen alike may delight in previewing and selling products stored on 1 in. tape. The operator may play back or even tape an event practically anywhere. The size alone speaks for itself.

The videotape cartridge machine, used for television, is another wonder of our age. The increasing trend in broadcasting toward short recorded messages on both tape and film (especially during station breaks) have created monstrous problems. With this new system, a short message may be recorded on a videotape cartridge and placed in the proper television log format. The machine is programmed automatically through Master Control, and all the station's tight commercial breaks are executed cleanly and on time. There is also less tape handling involved, less tape storage, and less chance for mistakes. Future station planning should seriously explore the purchase of the versatile videotape cartridge machine.

Master Timing, Transmission and Central Control

Master Control is the central control point for the entire plant and some consideration should be given to its location with relation to the other branches. If the broadcast facility's location is such that elevation permits the transmitter-antenna tower on the premises, then it is desirable to have the transmitter and its control area located in the Master Control area. This will minimize personnel requirements and make for better communication and coordination between the technical personnel involved. Obviously, if geographical and other considerations require the transmitter-antenna to be located some distance from the production area (in order to attain elevation for the transmitter and its antenna and ease of access to the production facility) then the above-mentioned desirable situation is unattainable.

Other factors in connection with Master Control location are its proximity to various production studios, studio control rooms, and their video-audio control points, recording areas (video and audio), and the maintenance or shop area for maintenance of the technical apparatus.

Location of the video control point in this area expedites the pinpointing of deficiency in video signal transmission, allowing corrective measures to be taken in a minimum of time. Also, it allows for more uniform cable lengths, which eases the burden of sync timing, cable equalization for high-frequency roll-off, etc.

The shop or maintenance area should be in close proximity to Master Control, for it is here that uniformity of transmission standards are determined; monitors and other measuring instruments must be periodically calibrated in order that all personnel involved with video and audio transmission may maintain the standard signal level. This close proximity to Master Control also permits sharing of the more expensive pieces of test equipment and makes for closer communication between Master Control personnel, who detect equipment deficiencies, and the maintenance personnel, who correct them. Also, the Master Control of a modern plant will have various special video waveform-generating devices which should be readily available at the shop facility.

There remains three other areas to be considered that should be located within Master Control area but are of secondary importance as to location in relation to areas mentioned above.

A videotape recording area is a must with a separate videotape recording area with facilities for reel-to-reel audiotape and facilities for live booth audio recording and audio cartridge recording. Also desirable in this area would be a simple video-audio switcher to handle a limited number of video and audio signals for making promotional spot announcements, film-to-tape transfers with slide titling information superimposed, editing, assembling, and duplicating videotape.

The location of this area in relation to Master Control is not critical except as regarding cable lengths and their high-frequency rolloff. Balancing this argument in favor of close proximity to Master Control is the noise factor that will be connected with this recording room facility. If utilized, it will be a noisier location than desired for Master Control.

If economics do not permit a separate recording facility in the plant, then it will be necessary to utilize the videotape playback area for recording. Also, if for the same reason the spot-announcement production cannot be incorporated, then it will be necessary to utilize the main production control facilities (audio and video mixing and switching) for this purpose.

The Studio Control location in relation to Master Control is not critical, assuming a good intercommunication system exists, since the only video cables routed to this area will be monitoring circuits for picture monitors. Assuming also that the audio control area is in, or adjacent to the video control area, no audio distribution problems should be encountered since these circuit lengths are not critical for practical distances and may be easily equalized if necessary. Actually, it should be located above Master Control level to allow it to be an observation point overlooking the studio floor, which should be on the same level as Master Control shop area to allow cameras to be wheeled into the shop area for servicing without encountering steps or needing elevators.

Illumination in Master Control should be balanced between sufficient light to read jackfield labels, monitoring apparatus control function designations, etc., and subdued enough to make the displays on picture monitors and waveform monitors stand out with clarity. Some operational positions in this area, such as video switchers where a program log or other instructions must be easily read, will require a higher level of illumination and may be provided the additional light by devices of the semispot variety.

Closely related to the illumination in the Master Control area is the finish on the racks, walls, and ceiling. These finishes should be a neutral, semimatte finish of medium reflectance.

Since a broadcast plant's product is metered by time, a good central time system is highly desirable. This should be a master clock, preferably located in Master Control (in order that technical personnel may periodically check it against the national time standard and correct it if necessary), for supplying drive pulses to slave clocks throughout the plant. This allows switching between various inplant (and out-of-plant) sources of program origination on a split-second basis.

Another timing factor in the production of video material is the synchronizing generator which should be in Master Control, along with the distribution facilities for its various timing signals. A common sync generator for all camera and other video generating systems makes for ease of timing, phasing, and mixing of these devices throughout the plant. The sync generator should have provision for locking on a color basis to a video signal generated remotely from the plant to allow for mixing of locally generated signals with remotely generated signals, thereby greatly expanding production potential. This sync generation, distribution, and phasing facility should be in close proximity to the proper monitoring facilities such as a good vectorscope and waveform monitor, unless the equipment used has provision for remoting these phasing functions in which case this test equipment could be shared with other monitoring functions.

A central video processing point is highly desirable, as well as its location in the Master Control area. This reduces the outlay for monitoring equipment and the stringent requirements of timing the various synchronizing and video signals to a common point and makes for simplification in camera substitutions and other patching requirements. A jackfield is also desirable in this area to facilitate patching and monitoring, as well as distribution of the video signals throughout the plant.

A well-layed-out jackfield of good design for video distribution is a must in a plant where maximum flexibility is to be achieved. Better still is a Master Control jackfield for the termination of all video switchers throughout the plant (as well as incoming out-of-plant signals) in conjunction with a jackfield adjacent to the in-plant video encoding and processing equipment. Assuming all video cable lengths and timing signals have been previously adjusted, this makes for great flexibility of camera and/or switcher substitutions and additionally gives the video control area control of in-plant signal levels, and the Master Control jackfield distribution and level control of in-plant and incoming out-of-plant signals.

In connection with video distribution and associated jackfields are the distribution amplifiers, which should be located near the jackfield and monitoring point, in order to standardize level adjustments. These distribution amplifiers should be of good design and preferably of modular plug-in construction, adding further to the flexibility of equipment substitution.

The video-mixing devices under the control of the studio control area should be located in Master Control to minimize cable lengths, as well as putting their maintenance adjustments in the technical personnel area. Location of these units near a jackfield monitoring point is desirable but not essential.

If automation is to be utilized in the plant, it should be located in Master Control and its video handling circuitry treated the same as a studio switcher. The audio inputs and outputs of this device should be routed through an audio jackfield, the location of which should be adjacent to the main audio distribution point. The audio jackfield location is not critical but should have communication and monitoring facilities nearby.

The control circuits for automation such as film and tape preroll, etc., being dc are not critical as to length or location. A degree of additional flexibility could be achieved by having the control circuits patchable, so that control pulses to the various machines could be routed to other machines to eliminate changing the input information to the automation device in case of a machine failure. If this is incorporated into the system, video and audio should be on the same patch cable, to minimize error.

A great number of audio feeds from any one source in a broadcast plant are required if maximum flexibility is to be achieved. Each source of program material, videotape, studio control area, etc., should be able to monitor what the other sources are doing, as well as the ability to switch into and integrate that source into the program being produced. This requires one or more distribution amplifiers for each source of audio material in the plant. The location of these distribution amplifiers is not critical except as noted previously as to jackfield and level monitoring.

One or more announce booths will be required, the location of which is not critical as long as there are good communications and monitoring facilities. Audio signals may be routed as any other audio source would.

While it is assumed that each audio control area will have its own reel-to-reel and cartridge tape facility, it is worthwhile to incorporate a cartridge machine with the automation device for various purposes, apologies, audio tags on spots, etc., to relieve the announce staff of these duties. Also, a reel-to-reel device in Master Control will be found to be valuable at times.

A good intercommunication system is a must for any effort that involves as many people as at many different locations whose actions must be synchronized to the degree called for in the production of a television program. In actuality, two such systems are desirable. One is a loudspeaker type for directions and cues to personnel in areas where considerable movement is required and wearing a headset would be tiring and cumbersome. The second type, of course, would be the headset type, which is necessary for cameramen and other studio personnel where the directions and cues would be picked up on the open studio microphones.

The loudspeaker system will require message routing buttons in order that person-to-person communication may be achieved without disturbing other personnel. The message routing function may be done with solid state matrix selection or relays, the solid state being preferred due to avoiding periodic cleaning of relay contacts to prevent failure.

The headset type has become standardized to such a degree that it makes interfacing within camera intercommunication circuitry very easy. The other stations that use headset type communications, as in the announcing booth, etc., could have selection of the control area to maintain station flexibility. This would require a communication line for each studio control area that announcers, studio floor manager, etc., could switch to at their respective stations. The video operators should be able to patch a camera's intercommunication circuit to any studio control area's communication line.

Location of the intercommunication system's common apparatus, amplifiers and switching matrix in the case of loudspeaker system and retard coils and patch points in the headset system, should be located in Master Control area accessible to technical personnel.

Rock layout in Master Control area will be dictated by access requirements of the various equipment. Also some operation positions in Master Control should have a countertop affixed to the rack at that position for program logs, cue sheets, etc. Video handling circuitry should be grouped as close together as feasible due to cable length and timing considerations previously cited. Jackfield racks should be located at points previously indicated. Audio equipment and devices whose adjustment functions can be remotely controlled, perhaps should be given a "back row seat," as long as monitoring of their performance is convenient. Besides video circuitry grouping and adjustment monitoring, the remaining consideration for a good rack layout is accessibility, front and rear. A minimum 4-ft. clearance is recommended.

Since the television art is such a rapidly advancing science, some consideration should be given to future modifications to an expansion of the plant facilities. There are miles of coaxial cable, shielded audio cable, and control circuit cable in a modern television plant. Provision must be made for routing this cable through the plant in a manner that will not obstruct operating personnel movement nor subject the cabling to abuse. Also, it should be easily installed, removed, or rerouted. Though possibly not as neat in appearance as floor trenches and wall ducts, the overhead tray method will be found to be very convenient if fulfilling the stated requirements. The cost factor and effort to reroute should also be less. Since the trench duct method must be incorporated in the design of the building, modification to it by unforeseen developments would be prohibitive from a cost standpoint.

Maintenance and Project Area

Due to the complexity of television equipment, it may be anticipated that considerable maintenance will be required to keep it in top condition. This maintenance may be divided into routine and emergency. Experience will show that the more of the former the less of the latter will arise. Most routine maintenance may be done with the equipment in its normal position by passing standard signals through it and observing departure from this standard. If monitoring facilities and the waveform generators mentioned earlier are incorporated into the plant, this routine checking can be easily done. Marginally, operating equipment may be detected and corrected in this way. There will be times, however, when there will be equipment that in circuit adjustments will not correct and equipment must be removed for more extensive checks in the shop to determine the nature of the failure. Maintenance logs should be kept on all the major equipment and routine maintenance results noted. These case histories can be of great value. Records should also be kept of consumable items of considerable expense, such as camera pickup tubes, videotape heads, etc. These will be of value in preparing engineering budget requirements, as well as catching items that are in the manufacturer's warranty, thus retrieving at least part of their cost.

A good shop facility should have a routine servicing procedure, starting with tagging the equipment received for repair, stating nature of trouble, location in plant from which removed, urgency of repair, etc. There should be available in the shop the standard waveform signals (mentioned earlier in connection with the synchronizing generator), a complete updated set of manufacturer's service manuals for the equipment, and the necessary test equipment to service any device in the station.

When a sufficient number of a certain device is used throughout the plant to justify its construction, a test-jig is a great convenience. This would include video distribution amplifiers, audio distribution amplifiers, etc., which require a separate power source that must be available for testing.

In addition to the aforementioned items, the shop should have on hand an ample supply of spare parts. Technical personnel get frustrated spending hours finding a defective component and then have to wait weeks to get a replacement. The records mentioned above will be of great value in determining frequency of failure and inventory required for various equipment parts.

A well-lighted shop, with sufficient floor space to wheel in a defective camera and still have room to walk around it, is desirable. The light should be controllable in intensity since certain television equipment maintenance is best done in subdued lighting conditions. This would include color picture monitor conveyance and oscilloscope waveform observation.

Any aggressive television station will find a need for some devices to make the task of producing a television program easier, which the broadcast equipment manufacturing industry did not anticipate. Development of these devices will be up to the Engineering Department of the plant. Due to the nonroutine nature of this, a special place should be allotted for this work where the parts and plans may be kept intact for the technical personnel involved.

News Center

Part of a television station's duty to its public is its ability to gather, assimilate, decipher, and report the news as accurately and quickly as possible. In order to do this, the news team must be given adequate facilities with which to work.

Basically, the written news is finally assembled in a newsroom. Proper planning would allow for a large newsroom, so that the reporters and writers may work informally together, but be near their producer, film editor, photographer, artist, and director. In order to accomplish this, the general news area should be situated adjacent to the film editing rooms, film library, the graphic department, and the film processing lab.

In addition, the newsroom can also serve as an instant news set. With proper planning, fast-breaking news may be reported on the spot. The key to this is a permanent set of hanging television lights, a full-time television camera, ready to go, and the reporter at hand to report what is happening now.

Finally, the newsroom should be equipped with adequate audio and video monitoring equipment for everyone to see and hear. If an event calls for a film crew, the assembling point is seconds away (a so-called hotline ready-room). The news cars are well equipped, and two-way communication is in full operational use. Thus, a properly planned news-gathering facility does bring extra dividends: (1) time saved, (2) money saved, (3) a high-working *esprit de corps,* (4) quality workmanship, and (5) possibly a greater listenership.

Program Screening and Rehearsal Rooms

Film and tape materials should be screened by station personnel before being broadcast. If economy dictates and machines are scheduled carefully, this can be done in the film and tape operations areas; however, a more efficient approach is to equip a room with film and tape viewing equipment separate from the broadcast equipment. Film projection and slide viewing equipment cost is nominal, but a videotape machine for this purpose may prove too expensive.

These programs should be checked for identification, quality, content, and accuracy of timing of segments. Some system of labeling with space for comments by the previewer should be implemented. This not only alerts the technician to possible trouble at air time, but gives the station a record of defects in films and tapes shipped in from other stations or sources.

A preshow meeting or conference room should be included near the studio. This room can be used for discussions prior to and during the rehearsal of the production. The room should be large enough to hold producers, directors, talent, technical people, and clients, and should be well ventilated.

Proper rehearsal requires the availability of all people involved in the production, all props and sets and all control room and studio facilities required during the actual production. Consideration must be given to rehearsal requirements in the design phase of a building if heavy production schedules are contemplated.

Traffic, Schedules, and Automation (Control Material Flow)

Location—Program Formats and Timing of Film and Tapes—Log Preparation, Automation and Special Feeds

The responsibility for preparation of schedules and logs generally falls to the Programming Department. One person is appointed to head up the Traffic Section and has perhaps the most difficult and important job in the station.

The coordination of films, tapes, slides, and live shows must be put on an operating log daily. Quality of the station's output and, in most cases, government regulation requires that the log be properly timed and accurate. Procedures must be set up to allow for late changes, including notification to the operating personnel of these changes.

Office space for the Traffic Department should be close to the operations area and the film and tape make-up area. The space can be a large room with a separate office for the traffic manager. Allowance should be made for large areas of counter working space. Film make-up and editing is a noisy operation; traffic operations require quiet areas for concentration on details. The two operations should not be in the same room but should be in close proximity.

A separate room should be assigned for receiving, shipping, and storing tapes and films. The handling of these materials is usually done by film editing personnel, but record keeping concerning the program flow may be done by traffic personnel if their work area is close to the Receiving Room. Because of the costs involved (film rental, videotape raw stock), accurate records of material in storage are essential. One of the major problems of material flow is timely discarding, erasing, or shipping program material no longer needed. This must be the responsibility of the Program Director.

Timing of programs (tape or film) is done by assistant or trainee directors. If editing to delete or change parts of the program becomes necessary, this information is given to the film or tape make-up people. The final times are then supplied to the Traffic Department for inclusion in the daily operating log. Films, tapes, or slides to be integrated within the program are selected by the Sales or Program Department and again entered on the log. This coordination of events of various times and sources leading to a finished program of stipulated length is put into effect by the Traffic Department.

The traffic people must also gather the various films, tapes, and slides, put them in orderly fashion, and deliver them to the operations people.

If automation of the air operations of the station is planned, the functions described above become more critical. If operations people are handling the various elements for broadcast, they may recognize and correct mistakes. This becomes more difficult with highly automated facilities. It should be noted, however, that once an automated broadcast operation is organized and working well, the on-air look is superior and the various facets of record keeping become more accurate. Automation puts an extra burden on the planning group but avoids the human errors in the implementation of those plans. A station considering automation will realize economies in the operational area but be prepared to re-spend some savings in additional programming, make-up, and traffic personnel.

MECHANICAL AND ELECTRICAL GUIDELINES

The following guidelines set forth the many mechanical and electrical considerations which should be considered when planning a broadcast facility:

Mechanical

A. General

1. Color television studios require special consideration in solving the many problems entailed in the mechanical design due to the high-lighting capacity, noise criteria, air distribution and emergency stand-by operation. Black and white, color television studios, and radio broadcasting facilities would require the same consideration, but some of the problems would not be as severe.

B. Design Conditions

1. The optimum summer and winter design conditions to be maintained by the air-conditioning system is 75°F dry bulb and 50 percent relative humidity. However, these conditions should be checked (in respective area with the owner's) since they may require slightly different criteria.

2. The outside design conditions are dependent upon the geographical location from data established by the US Weather Bureau.

C. Air-Conditioning Loads

1. Studio and production lighting for color television constitute the major portion of the heat gain and can exceed 75 percent of the total cooling load requirement. The unit lighting load requirement in the production area of the studio can equal 50-60 watts per square foot of floor area and in many cases this load can occur in any part of the studio since the production area and audience accommodations are flexible.

2. Transmission and solar heat gains are minimal since the exterior walls are well insulated and windowless.

3. Another contribution to the cooling load results from occupancy heat gain and the fresh air load. The fresh air requirement should be based on either 15 CFM per person, or the equivalent of one air change of fresh air, whichever is greater. It is also important to check and insure that the fresh air quantities conform with all code requirements.

D. Method of Air Distribution and Noise Control

1. Proper air distribution and air movement are of critical importance. Systems should be designed so that within a zone of 12 ft. above floor level, an air movement of 25 fpm is not exceeded. Air velocities exceeding the 25 fpm can cause movement of performer's hair, clothing, and stage props, which are usually highly expendable and flimsily built of thin canvas and light plywood.

2. The air supply should be introduced at a level above the movable lighting grid system to prevent interference with the closely spaced batten strips. Low-level return grilles located at the perimeter of the studio, in principle, would be desirable. However, due to the nature of studio operation, the grille could be blocked off by the cyclorama curtain or by studio props, which would result in an ineffective return air system. It could also be a possible source of noise generation. Locating the return air outlets at a level above the air supply will tend to relieve the neutral zone before it can heat the ceiling and radiate heat downward. Proper location of return air grilles and maintaining low velocities will eliminate any possible "short circuiting."

3. Noise criteria is of utmost importance and unless proper consideration is given to this problem, it can result in a nonproductive studio. Noise level should be within a range of NC 20 to NC 25, so as not to interfere with studio performance, particularly during scenes where there is no conversation and no background sound effects. Duct velocities should be designed for approximately 400 fpm within 10 ft. of diffuser or register opening, 525 fpm within 10-30 ft. from opening, 700 fpm within 30-50 ft. of opening, and 800 fpm within 70-90 ft. of opening.

4. All ductwork (supply and return) should be acoustically lined for sound attenuation and the sound power level of all outlets should be carefully checked to insure that it does not exceed the decibel rating at the end of the duct run, otherwise it will become additive (logarithmic) and negate a portion of the acoustically treated ductwork.

5. All piping should be insulated and all ductwork should be externally insulated to eliminate reflected sound in studios. Where ductwork and piping pass through walls or floor, the openings should be sealed with acoustical sound-deadening material. Ductwork and piping should be suspended from vibration isolators. Where ductwork and piping pass through studio walls, flexible pipe and flexible duct connections should be provided. Piping should be sized so that velocity of the medium transmitted is low enough to be inaudible.

6. Mechanical equipment should be located remotely from studio to eliminate transmission of sound and vibration. All equipment should be properly supported from vibration isolators. Sound traps for sound attenuation and flexible duct connections to prevent transmission of vibration should be provided for all air-handling apparatus.

E. Type of System and Control

1. Each studio should be served by its own air-handling apparatus and should consist of supply and return fans, filters, heating and cooling coils, sound traps and a purge exhaust system.

2. There are several schemes that can be utilized in the arrangement and selection of the component parts of the system, and this is somewhat dependent upon the economics, space conditions, and geographical location of the project. An "economizer" cycle utilizing 100 percent fresh air during intermediate season or a fixed percentage fresh air system can be used. The application of preheat coils is also dependent upon the percentage of fresh air and geographical location. Heating coils can be either steam or hot water type and cooling coils should be of the chilled water type. In areas where freezing outside temperatures are experienced, special conditions have to be considered to prevent possible "freeze-up" of preheating coils and chilled water coils.

3. A separate purge exhaust system should be provided to permit studio to be evacuated during periods when it is not in operation. During purge operation, the system should handle 100 percent outside air without attempting to maintain studio design conditions. Where an economizer-type cycle is provided, purging of the area can be accomplished by resetting controls to 100 percent outside air.

4. Control system should be arranged to control studio temperature, and where facilities are provided for audience participation, additional humidity control should be provided.

5. The installation of a Supervisory Data Center would provide operational supervision of the project and would include remote control for resetting of space temperatures and humidity, starting and stopping of air handling system, "read-out" of other pertinent air and water temperatures and alarm indication.

6. Pneumatic temperature control system should be provided with standby air compressor with automatic cut-in features.

F. Stand-By Operation

1. Due to the critical operation of the Master Control Room and Videotape Room, a separate air-handling system shall serve these areas with provisions for standby equipment in the event primary equipment fails. This can be accomplished by interconnecting the ductwork (properly dampered) with another air-handling system serving a noncritical area in the building (i.e., office areas), thereby permitting the Master Control Room and Videotape Room to be satisfied during an emergency period. Another desirable feature to be incorporated in the system is provision for handling 100 percent fresh air in the event refrigeration equipment becomes inoperative.

2. Multiple refrigeration equipment and boiler equipment should be provided so that in the event a single unit becomes inoperative, partial operation can maintain conditions in critical areas.

3. Compressed air system serving videotape machines should be provided with standby compressors to insure continuous operation. Compressors that are water cooled can operate off the chilled water system and arranged so that in the event there is a loss in chilled water pressure, the cooling system will automatically switch over to city water.

4. In the event of an electrical power failure, an emergency generator should start automatically to maintain operation of the boilers, heating pump, air-handling system serving the Master Control Room and Videotape Room, pneumatic temperature control air compressor and air compressor serving videotape machines.

Electrical

A. General

1. This outline description covers general electrical installations for large television broadcasting facilities.

B. Codes and Regulations

1. The complete electrical installations shall be provided in accordance with the latest revisions of the National Electrical Code and all other codes and regulatory agencies having jurisdiction. The installation shall be subject to the approval of the FIA.

C. Area Classification

1. All electrical installations, materials and equipment shall comply with the classification "General Purpose" except for hazardous areas which shall be designed for Class I, Group D, explosion-proof conditions.

D. Incoming Power Service and Metering

1. Incoming power service may be high voltage (4.16 kv or 13.8 kv) due to high load requirements.

2. Standby incoming service shall be provided with automatic transfer when normal service fails.

3. One point of primary metering shall be provided to obtain best possible utility rates.

E. Primary Distribution

1. Distribution within complex may be high voltage (4.16 kv or 13.2 kv) from a primary switchgear to unit substations located as close as possible to the center of the loads served.

2. Separate unit substations shall be provided for different type loads, as follows:

   a. With secondary 120/208 v to handle equipment and motor loads and all fluorescent lighting;

   b. With secondary 120/208 v to handle receptacle, incandescent lighting and small equipment loads;

   c. With secondary 120/208 v to handle studio production lighting only;

   d. With secondary 120/208 v to handle technical TV loads only.

3. Each unit substantion shall include components as follows:

   a. Primary compartment with Hv fused load break switch;

   b. Open dry type transformer with Hv primary delta and secondary 120/208 v or 277/480 v, 3 phase, 4 wire. Sound rating of transformer shall be best possible;

c. Voltmeter, ammeter, and selector switches;

d. Main secondary air circuit breaker;

e. Moulded case feeder circuit breakers and spares.

F. Secondary Distribution

1. Power shall be extended from unit substations with cable and conduit to automatic circuit breaker panels and motor control centers.
2. Motor control centers shall be Class I, Type B, with combination magnetic, full voltage starting, circuit-breaker-type motor starters or circuit breakers only for 480 v, 3-phase operation. Each starter shall have 3 thermal overloads.
3. Power panels shall be designed for 480 v, 3-phase, 3-wire service. Panels shall be of the dead front type with automatic circuit breakers of ampere rating as required.
4. Panels for receptacle and incandescent lighting loads shall be designed for 120/208 v, 3-phase, 4-wire service. Panels shall be of the dead front type with automatic circuit breakers of ampere rating as required.
5. Lighting panels shall be designed for 277/480 v., 3-phase, 4-wire service. Panels shall be of the dead front type with 20 ampere automatic branch circuit breakers. Panels shall be similar to Westinghouse Type NH1B-4.

G. Conduit

1. Rigid steel conduit asphaltum painted shall be used when installed in concrete slabs, below grade and outdoors above grade.
2. Rigid aluminum conduit shall be used for exposed installation in mechanical equipment rooms, damp locations and locations where exposed to mechanical damage.
3. Rigid aluminum or steel conduit shall be used for all feeder and subfeeder runs.
4. Steel EMT with compression weathertight fittings shall be used for all other branch circuit wiring indoors and above grade.

H. Wire

1. Hv cable shall be single conductor cross-linked polyethylene insulated and shielded.
2. Building wire shall be Type THW rated at 600 v-75 degrees C No. 12 AWG and smaller shall be solid copper. No. 8 AWG and larger shall be stranded.
3. Fixture wire shall be Type AF, 300 v insulation.
4. Minimum wire size shall be No. 12 AWG, except No. 14 AWG for control wires. Maximum wire size shall be No. 500 MCM.

I. Grounding

1. Electrical grounding shall be provided in accordance with the National Electric Code. Equipment enclosures, electrical service, transformer neutrals, outdoor lighting standards, and cable shielding shall be grounded.
2. Insulated bushings and double lock nuts shall be provided at all panel boards and pull boxes in feeder runs and pull boxes shall be bonded through with bare copper wire.
3. Separate technical equipment ground system shall be provided as required.

J. Switches, Wiring Devices, Wall Plates and Special Enclosures

1. Single pole switches shall be 20 amperes, 120/277 v, ac, quiet type.
2. Duplex receptacle shall be 20 amperes, 125 v, 2 pole plus U-slot ground.
3. Special outlet to be provided as required.
4. All wall plates for switch, receptacle, and telephone outlets shall be .06 in. stainless steel.

K. Telephone System

1. Two incoming underground services are required, one for technical use and one for commercial use.
2. Equipment room for the technical service shall be located close to Master Control and there shall be a cable-tray tie between the equipment room and Master Control.
3. The commercial system shall be complete, consisting of conduits from equipment room outlying telephone closets and interconnecting panels and thence to the various outlets as required. All installations shall be in accordance with the requirements of the local telephone company.
4. Interconnecting panels shall be of steel with plywood backboard, full opening door, latch, cylinder lock and trim.
5. Telephone closets shall be furnished with plywood backboard.
6. Conduits shall be ¾ in. minimum.
7. Telephone outlets shall be 4 in. sq. with bushed hole cover plate.
8. Equipment instruments and wiring shall be by the telephone company.
9. Some recent trends are for the broadcast station to actually own the telephone equipment. Should this be true, Items 1 through 7 are still to be used as a guide.

L. Public Address System

1. A complete PA system consisting of amplifiers, loudspeakers, and microphone shall be provided.

2. Loudspeakers shall be located in corridors throughout the complex and calls shall originate from the telephone operator's desk.
3. System shall be zoned as required.

M. Fire Alarm System

1. The fire alarm system shall be closed circuit zoned, consisting of control cabinet, gongs, manual stations and automatic fire detectors.
2. Manual stations shall be provided at each stair on each floor and at all ground level exterior doors.
3. Automatic thermal or smoke detector shall be provided in all areas except where sprinkler heads are installed.
4. Each sprinkler alarm valve shall indicate on the fire alarm panel zone annunciator as a separate zone when activated.

N. Video Cable Trays and Audio Signal Conduits

1. A system of cable trays and signal conduits originating from Master Control shall be provided to studio control rooms, studios, microwave rooms, electronic shop, program computers, etc.
2. In addition, a separate cable tray with antenna cables shall be provided from Master Control to all areas where antenna outlets would be required.

O. Studio Production Lighting System

1. Unit substation and dimmer board shall be located as close as possible to studio served.
2. Unit substantion shall include the following:
   a. Electrically operated main circuit breaker to permit remote control from studio floor.
   b. Transformer with 6-2½ percent taps, 3 above and 3 below rated primary voltage, to compensate for possible secondary voltage variations.
3. Other work shall be as follows:
   a. Wireway with wiring from load side of dimmers to studio floor patch panel.
   b. Studio grid wireways with load wiring to studio patch panel;
   c. Wiring under studio floor from studio floor "pockets" to studio patch panel;
   d. Control wiring from studio control console to dimmer board.
4. In sizing unit, substantions serving dimmer boards, a 50 percent demand factor may be applied to connect dimmer load.
5. An "on-air" studio warning light system be provided as required.

P. Security

1. The following security systems shall be provided:
   a. Supervision of all exterior doors on ground level, with control cabinet in guard room;
   b. Closed circuit TV cameras at key positions, with monitor in guard room;
   c. Manual nonwired watchman's tour stations located throughout complex;
   d. Electrically operated gates to control automobile traffic.

Q. Emergency System

1. Power for the emergency system shall be provided with a water-cooled diesel generator set with generator voltage 277/480 v, 3-phase, 4-w. The installation shall include all accessories such as automatic transfer switch, output switchboard, battery starting set, oil storage tank, fuel pump, mufflers, vibration isolators, etc.
2. Generator set shall automatically sense power failure or 80 percent undervoltage, start engine, attain and maintain speed, and transfer emergency load. Manual override of start and transfer of load controls should be provided.
3. Provide local transformer with primary delta 480 v, 3-phase and secondary 120/208 v, 3-phase, 4-wire to serve 120/208 v loads on emergency supply.
4. Loads on emergency supply shall include stair lights, exit signs, selected corridor lights, PA system and all technical lighting and heating, ventilating, and air conditioning loads required for transmission of live news programs and taped programs.

R. Lighting (277 v for Fluorescent, 120 v for Incandescent)

1. Lighting fixtures shall be completely installed with all required outlet boxes and accessories.
2. Lighting levels shall be in accordance with IES latest recommendations, with minimum 100 FC in working areas.
3. Fluorescent fixtures shall be used for general illumination. Fixtures shall be with 40 w RS lamps and HP factor ballast, with best sound rating. Fluorescent fixture types shall be as follows:
   a. Recessed with acrylic lens diffuser to be used in areas with hung ceiling;
   b. Surface or pendant mounted with wraparound acrylic lens diffuser to be used in stairs and other selected areas with exposed ceiling;
   c. Industrial RLM with porcelain reflector to be used in mechanical equipment rooms, storage rooms, etc.

4. Executive offices and conference rooms shall be provided with dimmer-controlled incandescent lighting using recessed fixtures.

5. Selected walls and art work shall be illuminated with recessed ceiling-mounted incandescent wall-washing fixtures.

6. Make-up room mirrors shall be illuminated with special bracket wall-mounted fluorescent fixtures. Dressing room mirrors shall be illuminated with special wall-mounted strips with incandescent bare lamps.

S. Outside Lighting

1. Outside lighting shall include illumination of audience concourses, entrances, parking lots, signs, building exteriors, planters, etc.

2. Lighting levels for all outside area illumination shall be strictly in accordance with IES latest recommendations.

T. Miscellaneous

1. Wall-mounted clocks operating on 120 v shall be provided complete with outlet in designated areas.

2. Clock system for technical use with master clock in Master Control and indicating clocks in studio control rooms, offices, etc., shall be provided as required.

3. Local office intercommunication systems shall be provided as required.

4. Local sound systems shall be provided for large conference rooms.

Cost Estimating

The following Checklist and Project Budget Form are designed for estimating the cost of station construction.

SUGGESTED CHECKLIST FOR COST ESTIMATING

Item

1. Land
2. Land tests
3. Site clearing
4. Architects' and engineers' fees
5. Permits
6. Special consulting fees (include interior decorator)

General Construction

1. Heating, ventilating and air conditioning
2. Plumbing
3. Electrical
4. Architectural
5. Special in-house cabling (TV, Music, PA)

Interior Finish

1. Wall covering (fabric or paint)
2. Floor covering
3. Special studio treatment

Furniture and Fixtures

1. Decorative office furniture
2. Standard office furniture
3. Office area built-ins
4. Working area counters, cabinets and built-ins
5. Draperies
6. Art work

Telephone

1. Broadcast line facilities
2. TWX or facsimile
3. Type of switchboard (owned or leased)
4. Office interconnection needs
5. Number of private lines
6. System—owned or leased

Miscellaneous Items (likely to be overlooked):

1. Xerox outlet (special power hookup)
2. Special ventilation for odor areas.
3. Building maintenance equipment closets.
4. Drinking fountains and vending machine areas.
5. Space for air conditioning subdistribution boxes, fans, etc.
6. Special waste water treatment for film darkroom processing, if local ordinances dictate.
7. Cable connection to roof for radio and television antenna system and two-way antenna.
8. Possible microwave antenna mounts.

PROJECT BUDGET FORM

Call Sign ______________________ Start Date ______________________

Service (Radio or TV) ______________ Finish Date ______________________

Type of Facilities: (Check as applies)

Office __________ Studio ______ ______________________________

Street address of project

Transmitter ______ Mobile ______

____

City, State and Zip

Item #	*Description*	*Estimate*	*Actual*
1.	Land purchase/lease	________	________
2.	Survey—property (and other)	________	________
3.	Title search/insurance	________	________
4.	Real estate broker/commission	________	________
5.	Architects/engineers—fees	________	________
6.	Permits and licenses (if separate)	________	________
7.	Consultants—acoustic structural, etc.	________	________
8.	Site preparation and demolition	________	________
9.	General construction and finish	________	________
10.	Optional construction items and finish	________	________
11.	Special construction and finish	________	________
12.	Furniture and fixtures	________	________
13.	Decoration—interior	________	________
14.	Landscape—exterior	________	________
15.	Special equipment—electronic (and other)	________	________
16.	Special equipment—installation of above	________	________
17.	Contingencies (including price increases)	________	________
18.	Other	________	________
19.	Other	________	________
20.	Other	________	________
	Totals	________	________

Prepared by ________________ Checked by ________________ Approved ________

CONSTRUCTION EXAMPLES

The five examples that follow illustrate three degrees of construction for radio facilities and two for TV stations. All stations are in large cities, with construction being completed between 1967 to 1973. Cost increases over the last few years have been continuous and are almost totally unpredictable in a general manner. They must be examined carefully by competent architects and construction engineers for the specific structure and area involved if there is to be any accuracy in budgeting the project.

Two major factors contributing to cost overrun on projects are inadequate initial plans and the resultant change orders during construction. Also, there must be an owner's supervisor highly involved in the project on a *daily* basis.

In each case, a general contractor was retained and coordination was handled by staff engineering personnel.

Electrical costs include power to all equipment, but not wages paid to staff technicians who installed the broadcast equipment.

Architectural and consulting fees are for outside help only. No attempt was made to estimate time spent by staff personnel in layout and planning.

Decoration fees include the services of an interior decorator and the cost of all decorative furniture (sofas, lounge chairs, etc.). This furniture was generally used in reception areas, conference rooms, and executive offices. The decoration costs also include the purchase and installation of carpet, the purchase (but not installation) of vinyl or paper wall coverings, and also draperies.

Special fees, permits and licenses are included in the general construction and architectural costs.

Cost of broadcast equipment is not included in the examples, but the "special woodwork, built-ins" section does cover the custom cabinetry and tables necessary to mount equipment such as audio mixers, video switchers, and producers' consoles.

Example I

This FM station, in Washington, D.C., had been a minimal facility. The decision was made to construct first-class office and studio space in the lower level of an existing six-year-old building. All furniture, fixtures, and equipment were to be new and an interior decorator was to coordinate colors and furniture in the office area.

The space selected had few existing partitions, but building air-conditioning was available. An additional 10-ton unit was added to serve the studios, Master Control, and the Newsroom, with both supplemental and emergency cooling.

The major part of the architectural layout and planning was done by engineering staff personnel. (This is why the architectural and consultant fees are relatively low.)

All equipment was new and installed by staff personnel. This station is a combo operation and no control rooms were necessary.

Cost figures are as follows:

Cost Figures

Total area	3,800 sq. ft.
Total cost of construction	$127,553
Cost per sq. ft.	$33.57

Component Costs		*Totals*	*Per sq. ft.*
I. General Construction			
a. Demolition	$ 543		
b. Concrete, masonry, plaster, and painting	3,850		
c. Partitions, doors, hardware	8,124		
d. Acoustical ceiling and studio wall acoustic	3,813		
e. Vinyl tile	764		
f. Carpentry, glass	4,727		
g. Contractor's labor, insurance, taxes	8,246		
h. Rental equipment & miscellaneous expense	6,882		
Total general construction		$36,949	$9.72
II. Electrical		30,017	7.90
III. Heating, ventilating & air conditioning		21,331	5.61
IV. Plumbing		4,500	1.18
V. Architect's fee		6,825	1.80
VI. Special woodwork, built-ins		4,712	1.24
VII. Decoration		11,572	3.04
VIII. Office furniture		11,647	3.07

Example II

This is an AM-FM station in Philadelphia, Pa. It was decided to completely remodel, rearrange and redecorate the entire station, in a 30-year old building. The studios, control rooms, Master Control, and the news operation were to be moved from the first floor to the third floor. It was necessary to construct six new studios (3 for AM, 3 for FM) in an area that was office space. This required demolition of the office areas and replacement with block-wall construction. Computer flooring was used in all studios, control rooms and in Master Control.

A complete new 35-ton air conditioning system was installed to serve the technical and studio areas and was designed for both supplemental and emergency use. Existing air conditioning was used for general offices.

In the office areas, about 15 percent of the partitions were removed, relocated, or built anew. New ceiling was installed throughout.

Most of the layou' and mechanical and electrical design work was done by an architectural firm. Decoration was done by an interior decorator and new furniture and fixtures were used throughout the building.

All studio and newsroom equipment were new and installed by staff technicians. The pulling of interconnecting wiring was done by electricians and is included in the electrical cost.

Cost figures for Example II are as follows:

Cost Figures

Total area	21,764 sq. ft.
Total cost of construction	$613,795
Cost per sq. ft.	$28.20

Component Costs		*Totals*	*Per sq. ft.*
I. General Construction			
a. Demolition	$20,121		
b. Concrete, masonry, plaster, ceramic, paint	53,929		
c. Partitions, doors	36,360		
d. Acoustical ceiling and studio wall acoustics	16,575		
e. Vinyl tile and floating floors	7,548		
f. Finish hardware & mis. metal	25,559		
g. Carpentry & millwork, glass	34,813		
h. Contractor's misc. expenses	6,841		
Total General Construction:		$201,746	$9.28
II. Electrical (large am't. already existing)		57,529	2.64
III. Heating, ventilating & air conditioning		117,709	5.41
IV. Plumbing		11,482	.53
V. Architect, electrical engineering, mechanical engineering		76,618	3.52
VI. Special woodwork & built-ins		12,825	.59
VII. Decoration		78,441	3.60
VIII. Office furniture		57,445	2.64

EXAMPLE III

This is an AM Radio facility in Oakland, California. The station was to be relocated in a completely different building to one floor of a newly rebuilt structure. Five studios were to be constructed (an allowance for growth of the station).

The existing floor was a shell. Building air conditioning was available but it was necessary to run all interior ductwork.

Dual wall studio construction was used. Computer floors were installed in Master Control and control rooms. To reduce solar heating and external noise problems, a peripheral isolation corridor was placed between studio and outside building walls. This also provided excellent traffic flow and good emergency exit measures.

All studio and newsroom equipment were new and installed by staff technicians. The pulling of interconnecting wiring was done by electricians and is included in the electrical cost.

Most of the layout and mechanical and electrical design work was done by an architectural firm. Decoration was done by an interior decorator and new furniture and fixtures were used throughout the building.

Cost figures for Example III are as follows:

Cost Figures

Total area	14,950 sq. ft.
Total cost of construction	$344,671
Cost per square foot	$23.07

Component Costs	*Totals*	*Per sq. ft.*
I. General construction	$126,176	$8.44
II. Electrical	71,549	4.79
III. Heating, ventilating, air conditioning	88,339	5.91
IV. Plumbing	21,322	1.43
V. Architect, electrical engineer, mechanical engineer	18,064	1.21
VI. Special woodwork and built-ins	19,221	1.29

Example IV

This is a UHF-TV station in San Francisco, California. The basic aim was to build an office and studio complex (two studios) for a reasonable cost. The station was not doing well economically and it was felt that live studio facilities might help to establish extra income.

A 20,000 sq. ft. former warehouse was leased. The first phase of construction was to remodel and decorate the small office area which had been a part of the former warehouse operation. All fixtures and furnishings were new.

An architect was retained on an hourly basis and much of the operation area layout work was done by staff engineering personnel.

The basic operating facility included total new construction in the open warehouse area of the two studios, one control room, Master Control, shop, newsroom and film-tape storage, and editing area. Future plans were to add a second control room and photo development area. The expansion area was left unfinished.

The warehouse had a minimum air conditioner for the office area, therefore, 40 tons of air conditioning was added for the studio and operations and office areas. This work was contracted for separately (not through a general contractor).

All equipment was installed by staff technicians, but electrical cost does include pulling of wiring for power to the equipment.

The cost figures do not include decorator items, furniture, or equipment.

Cost Figures

Total area	20,000 sq. ft.
Total cost of construction	$618,380
Cost per square foot	$30.92

Component Costs		*Total*	*Per sq. ft.*
I. A. General construction (walls, doors, floor, ceiling, glass, labor & materials, contractor's overhead & profit)	$189,334		
B. Painting & plaster	28,970		
C. Hardware	24,067		
D. Structural steel (includes lighting grid)	18,022	$260,393	$13.02
II. Electrical		152,026	7.60
III. Heating, ventilating, air conditioning		158,400	7.92
IV. Plumbing		16,000	.80
V. Architect, electrical engineering and mechanical engineering		24,468	1.22
VI. Special woodworking (built-ins and counters)		7,074	.36

Example V

This is a VHF-TV station in Los Angeles, California, completed in 1970. Construction here was a major project. Old buildings were removed, considerable site work was done, and a completely new and modern three-story structure was built. It is a good illustration of where we have utilized the "Suggested Checklist for Cost Estimating," illustrating the large number of items that must be considered in planning a project of this size. Also included here for this example is a night view photograph of the structure (Fig. 22) and plans for the three floors of the building (Figs. 23, 24, and 25).

Cost Figures

Total area	145,000 sq. ft.
Total cost of construction	$6,915,793
Cost per sq. ft.	$47.69

Component Costs	*Totals*	*Per sq. ft.*
I. Demolition, Site Work, Landscaping	$178,477	$1.23
II. Structural	873,476	6.02
III. General Construction	3,096,745	21.36
IV. Electrical	367,900	2.54
V. Heating, ventilating, air conditioning	930,125	6.41
VI. Plumbing	209,829	1.45
VII. Architect, electrical engineering, mechanical engineering, soil testing	497,695	3.43
VIII. Special acoustical (including ceilings)	263,893	1.82
IX. Special woodwork & built-ins	87,251	.60
X. Decoration	267,233	1.84
XI. Office furniture	143,169	.99

Fig. 22. Night View of KTTV.

TABLE 1

Comparison of Examples

	I	II	III	IV	V
	Move studios & remodel 21,764 sq. ft.	New station—from shell 14,950 sq. ft.	New station—from shell 3,800 sq. ft.	New station—from shell 20,000 sq. ft.	New building 145,000 sq. ft.
	Philadelphia	Oakland	Washington	San Francisco	Los Angeles
Demolition, site work, landscaping	—	—	—	—	$178,477/1.23
Structural	—	—	—	—	873,476/6.02
General construction	$201,746/9.28	$126,176/8.44	$36,949/9.72	$260,393/13.02	3,096,745/21.36
Decoration	78,441/3.60	—	11,572/3.04	—	267,233/1.84
Office furniture	57,445/2.64	—	11,647/3.07	—	143,169/.99
Heating, ventilating & air conditioning	117,709/5.41	88,339/5.91	21,331/5.61	158,400/7.92	930,125/6.41
Electrical	57,529/2.64	71,549/4.79	30,017/7.90	152,026/7.60	367,900/2.54
Plumbing	11,482/.53	21,322/1.43	4,500/1.18	16,000/.80	209,829/1.45
Architect, elec. & mech. engineering	76,618/3.52	18,064/1.21	6,825/1.80	24,468/1.22	497,695/3.43
Special woodwork & built-ins	12,825/.59	19,221/1.29	4,720/1.24	7,074/.36	87,251/.60
Special acoustical (including ceilings)	—	—	—	—	263,983/1.82
Totals per sq. ft. cost	$28.20	$23.07[a]	$33.57	$30.72[a]	$47.69

[a]These increase by approximately $6.00/sq. ft. if decorator and office furniture is added.

TABLE 2

Estimating Costs

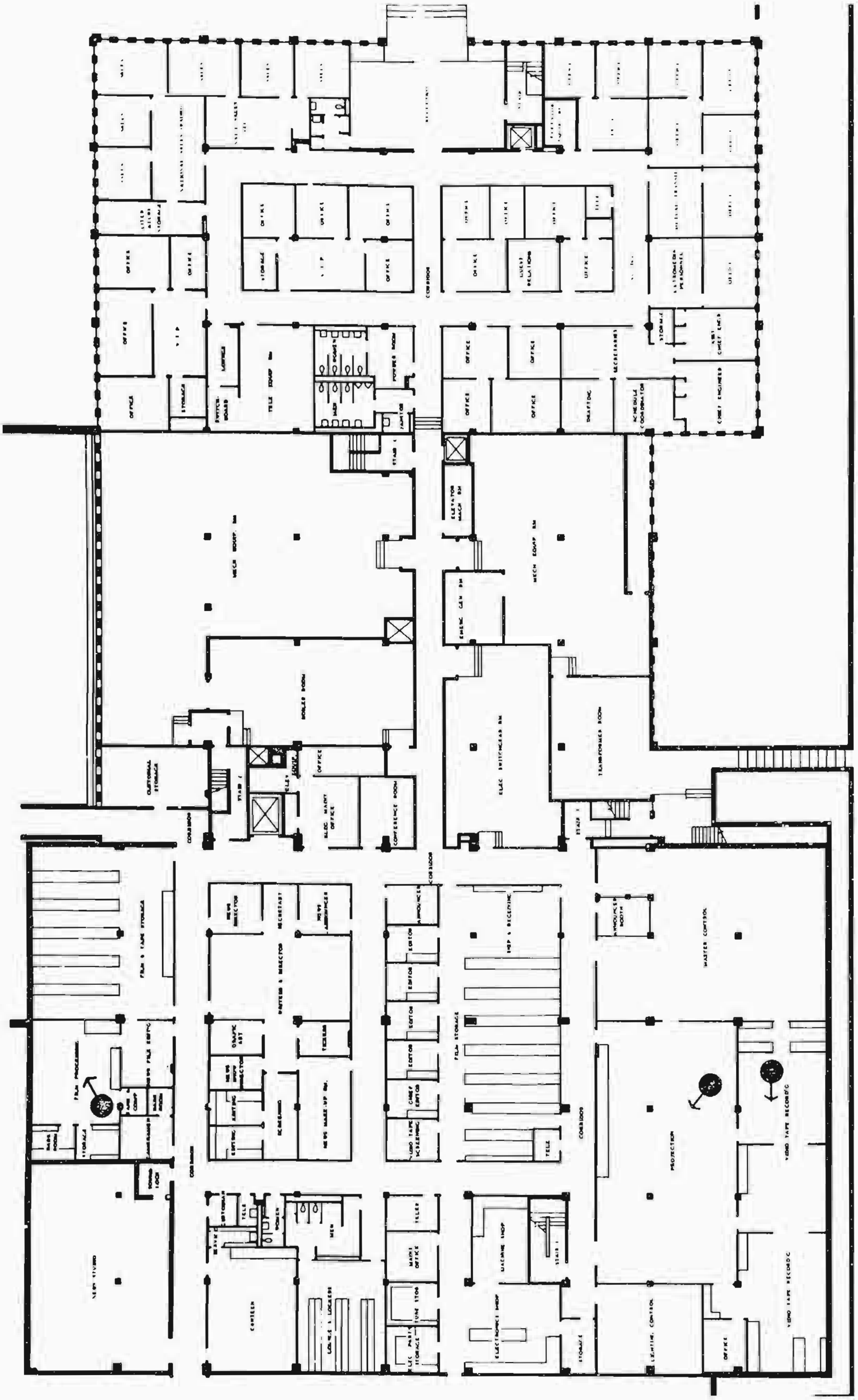
Totals

New studios and offices (complete new structure)	$40 to $60/sq. ft.
Conversion for studios & offices (in existing structure)	$25 to $35/sq. ft.
Transmitter building (new structure)	$25 to $40/sq. ft.

Separate elements

Demolition and site work	$1.00 to $1.50/sq. ft.
Structural	$5.00 to $7.00/sq. ft.
General construction	$10.00 to $25/sq. ft.
Heating, ventilating and air. cond.	$5.00 to $8.00/sq. ft.
Electrical	$3.00 to $9.00/sq. ft.
Plumbing	$0.75 to $2.00/sq. ft.
Arch & engineering fees	$1.25 to $3.50/sq. ft.
Special acoustical	$1.50 to $2.50/sq. ft.
Woodwork and built-ins	$0.60 to $1.50/sq. ft.
Office furniture	$1.50 to $3.50/sq. ft.
Decoration	$2.00 to $3.50/sq. ft.

Note: Electronic equipment installation and wiring not covered by any of above. A good general rule is to allow 10 percent to 20 percent for this in addition to basic equipment cost. Variation is due to location, personnel, working rules, etc.



1st FLOOR

Fig. 23. First floor KTTV-TV.

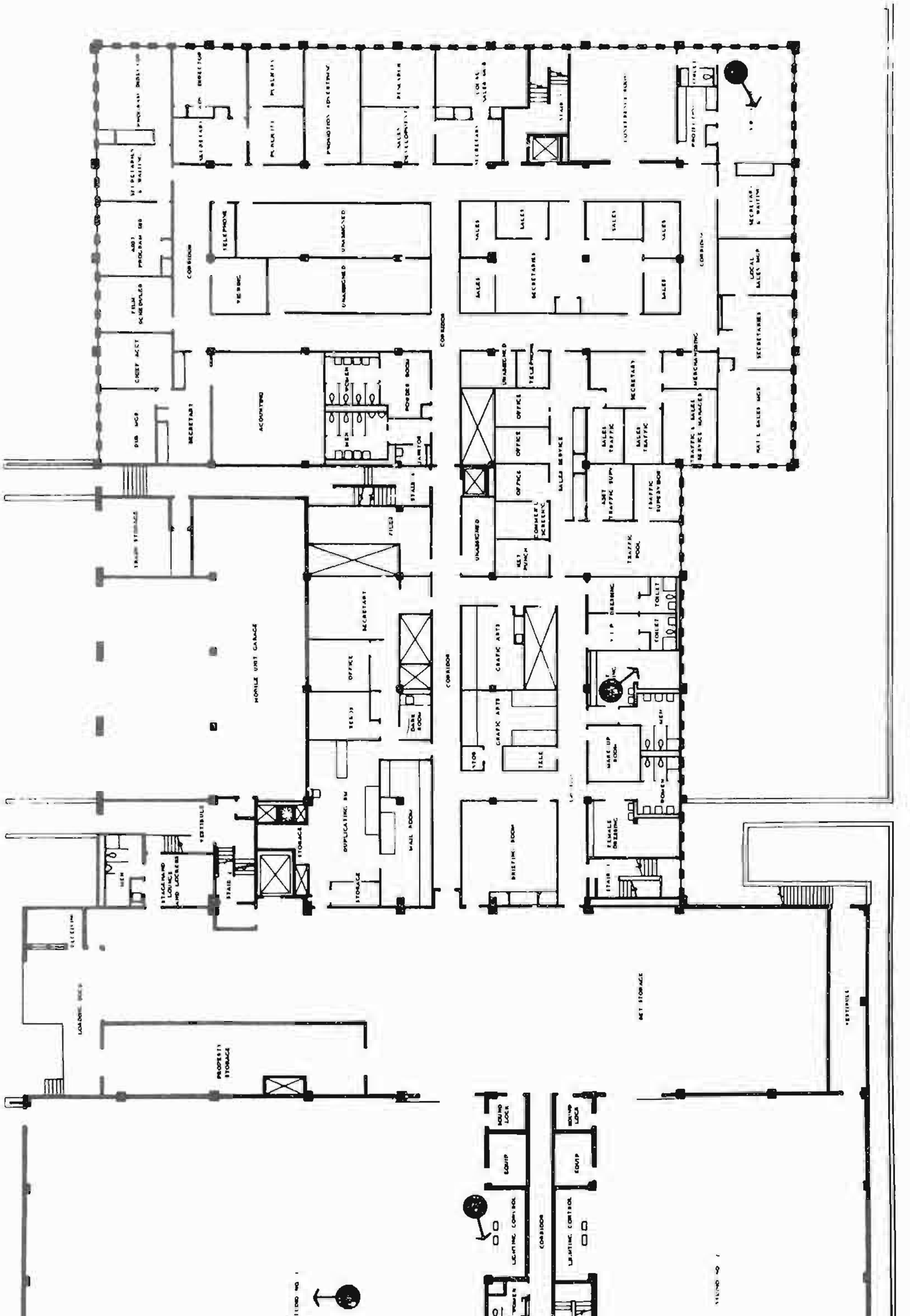


Fig. 24. Second Floor KTTV-TV.

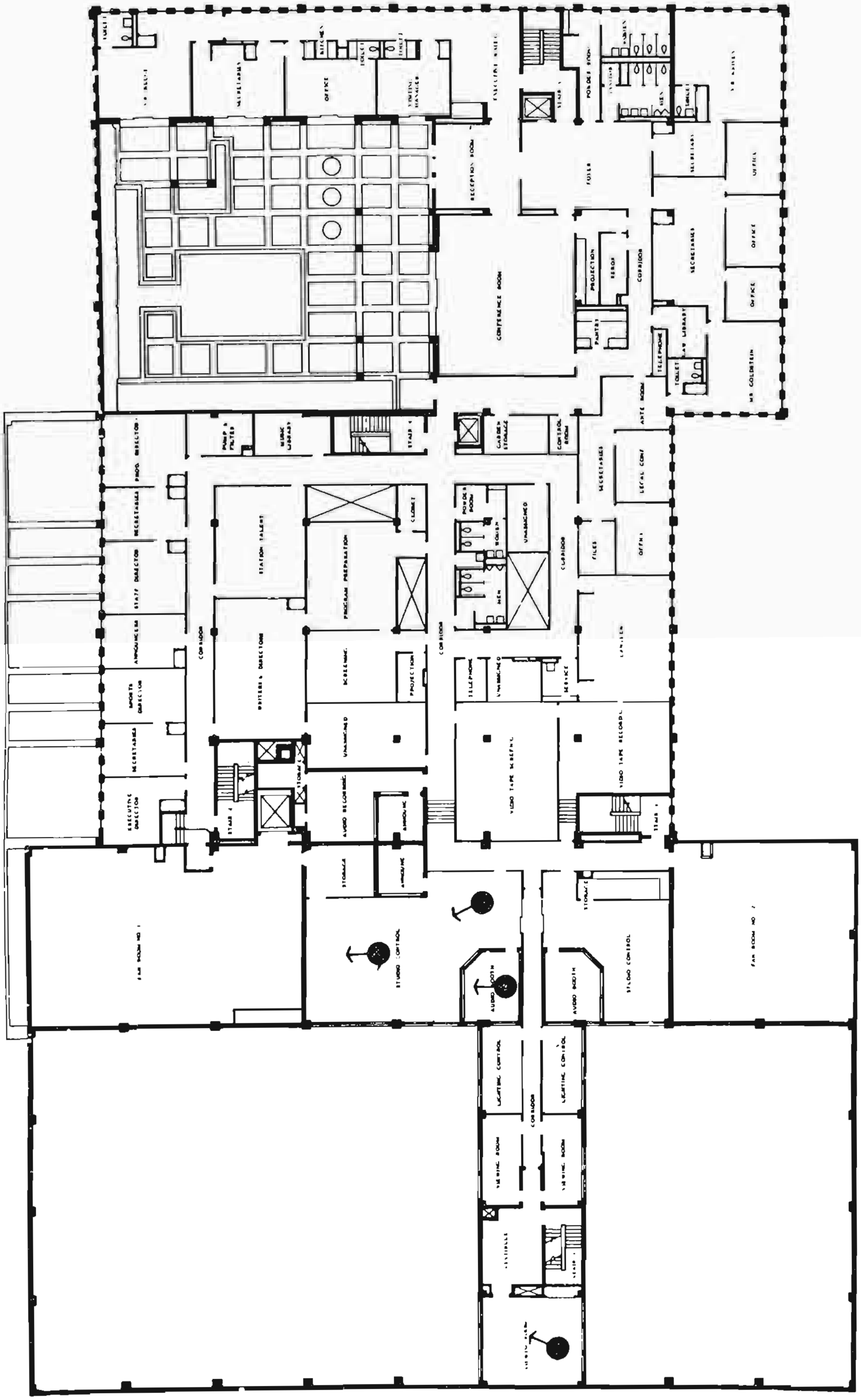


Fig. 25. Third Floor KTTV-TV.

MICROPHONES—APPLICATION AND OPERATION[6]

Things are not always what they seem. It takes a complete understanding of microphones and their operating parameters to make valid assumptions by looking at their specifications. Obviously, the real test comes when the microphone is used; however, by remembering some of the basics about microphones and their design, a more accurate guestimate can be made as to the performance of a microphone by carefully examining its performance characteristics from the data sheet.

As can be noted from Fig. 26, there are two response curves. One with the low frequency rolloff and a rather major high frequency rise in the 5 kHz area. The other curve is relatively smooth with the low end extended and the high frequency rise gone. These two response curves are from the same lavalier microphone. When used in the lavalier position the high frequency peak, because the user is off-axis, is reduced and the low frequency response of the microphone is increased because of the location of the lavalier in the chest cavity area.

The three types of microphones normally considered for professional applications are (1) condenser, (2) ribbon, and (3) dynamic. They are depicted in Fig. 27.

The normal pickup patterns for microphones are (1) omnidirectional, (2) unidirectional, and (3) bidirectional. The unidirectional or cardioid pattern has many variations such as supercardioid, hypercardioid, etc., but for discussion purposes, it is basically a microphone that picks up from the front and rejects from the rear.

An omnidirectional microphone is a favorite for general purpose use since it performs reasonably well. Without knowing the limitations of directional type microphones, the user is sometimes plagued with either handling, pop, or wind noise, and shies away from using a directional microphone even though it might provide superior performance for a particular pickup.

An omnidirectional microphone should, theoretically, pick up equally well from any direction; that is, however, not true. An omnidirectional microphone when rotated off-axis from the sound source will exhibit what is known as a shadow effect, and the high frequency response from the rear of the microphone is not as good as it is on-axis. Therefore, an omnidirectional microphone is only omnidirectional from mid and low frequencies.

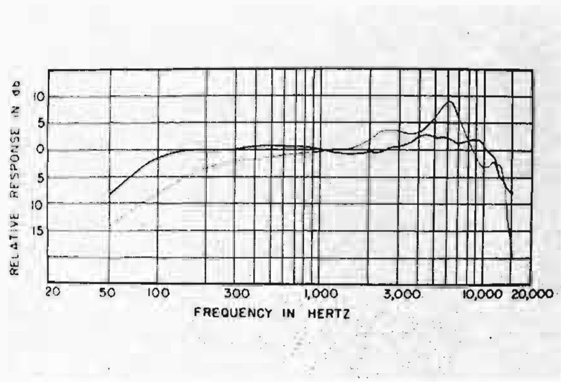


Fig. 26. Two response curves—one with low frequency rolloff and the other relatively smooth with the low end extended and the high frequency rise gone.

A bidirectional microphone, which normally is of the ribbon variety, has a pickup pattern that is sometimes referred to as the figure eight; that is, front and rear have equal pickup while the sides, top, and bottom have maximum cancellation. It was very common to see a large ribbon microphone hanging from a rope in radio studios over a desk with announcers on either side talking towards each other into the ribbon microphone. This particular arrangement, because of the cancellation at the top, bottom, and sides gave maximum rejection of the unwanted paper suffling noise on the desk below and, consequently, was an excellent choice for this type of application.

There are many sound reinforcement applications where a bidirectional microphone works extremely well, especially where ceiling loud speakers are fairly close to the microphone. The dead part of the bidirectional microphone can be pointed toward the ceiling loud speaker, and maximum rejection of the unwanted direct signal coming from the overhead system is then achieved.

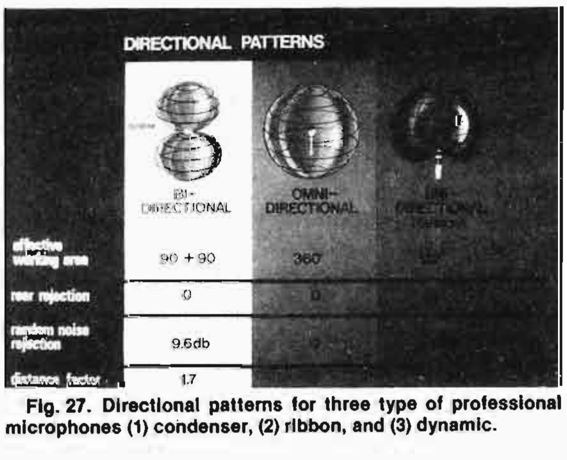


Fig. 27. Directional patterns for three type of professional microphones (1) condenser, (2) ribbon, and (3) dynamic.

[6] Written by K. K. Reichel, Shure Brothers.

'The unidirectional microphone on the other hand has maximum rejection from the rear, or slightly off-axis from the rear in the case of a supercardioid microphone, and has a front working angle of approximately 132°. This figure will vary with the type of pattern, but the data sheet for the microphone should state precisely what the front pickup angle is. This usually refers to its 3 dB downpoint, so the user can determine the proper placement of a unidirectional microphone. Note that the random noise rejection of the various microphones indicates that a bidirectional or unidirectional microphone has a 9.6 dB random noise rejection. This means that in many applications the comparison between a directional and an omnidirectional microphone, in a studio or stage environment, would indicate that the directional microphone is considerably quieter in terms of background noise than the omnidirectional microphone. When rejection of unwanted background noise is desirable, whether it be an air conditioner or audience noise, elimination of this noise is better achieved by using a directional microphone.

Not only does the directional microphone help reduce the unwanted background noise but also choosing the correct pattern, whether it be bidirectional or unidirectional, can be determined by the direction of the unwanted noise source assuming a direct radiation from the noise source. In other words, point the deadest portion of the directional microphone directly toward the noise that is in need of elimination. The distance factor relates very much to the same concept as does the random noise rejection and this simply shows that in comparison to an omnidirectional microphone, a directional microphone will allow the performer to work 1.7 times further from the microphone with the same effective background noise level in a room.

The concept of placing the unwanted signals outside the pickup pattern of a directional microphone is shown in Fig. 28. Here both guitar amplifier speakers and public address loud speakers are outside the 132° pickup angle of a directional microphone. If these loudspeakers were moved into the pickup pattern of the microphone, obviously, in the case of the sound reinforcement system, there would be a greater tendency towards acoustical feedback and in the case of the guitar amplifier, a greater amount of sound pickup by the microphone that eminated from the guitar amplifier loudspeaker. However, the performer may not be able to hear the sounds coming from the public address or guitar amplifier loudspeaker as well as he might like to; therefore, a solution is to use a stage monitor loudspeaker, which is normally placed at the foot of the performer pointing up into the deadest part of the undirectional microphone. This

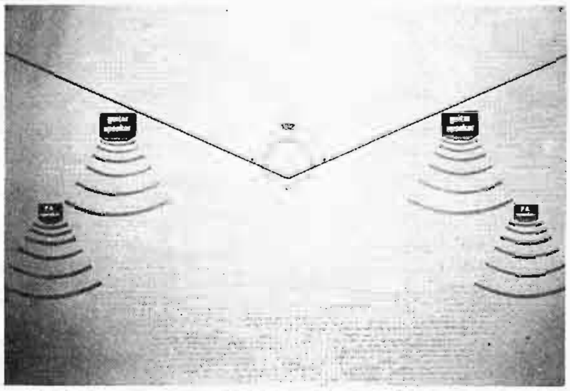


Fig. 28. The concept of placing the unwanted signals outside the pickup pattern of a directional microphone.

will then let the performer hear enough of the musical amplifier signal as well as his own voice to satisfy his needs and yet allow a good level in terms of gain before feedback and isolation of instruments from vocals.

All unidirectional microphones exhibit a phenomena called "proximity effect" which is depicted in Fig. 29. This means that as the performer gets closer to the microphone, the low frequency output of the microphone goes up faster than does the high and mid frequencies. This is neither good nor bad, but it depends on the application of the microphone as to what degree of proximity effect is desired.

Many recording studios and broadcast stations use microphones with appreciable proximity effect to increase the separation between musical instruments. As an example, in Fig. 29 the top curve (dotted line) represents the microphone when brought from 2 ft. to 6 in. If on the console the microphone is re-equalized so it has the same response at 6 in. that it had at 2 ft., the user can effectively gain the amount of isolation shown in the stripped area on the bottom of the curve in terms of added rejection from unwanted sounds from the rear of the microphone.

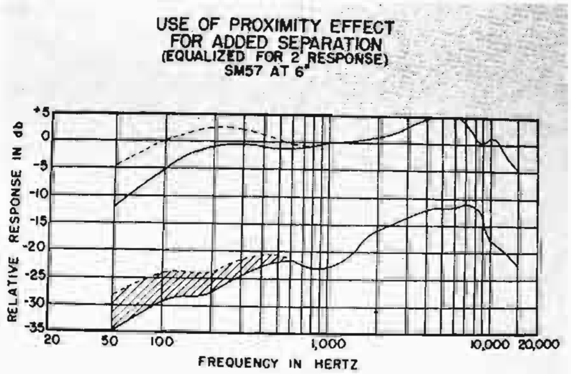


Fig. 29. Use of promimity effect for added separation.

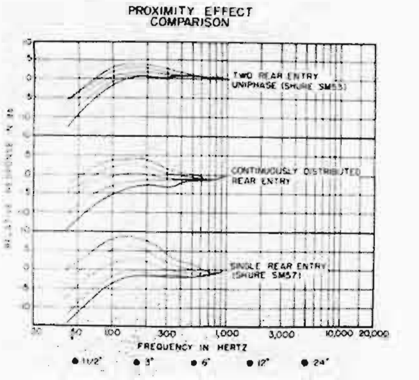


Fig. 30. Promimity effect comparison.

Take two microphones, one with more proximity effect than the other and listen only to that particular channel and compare the two microphones when set for the same level. The microphone with the higher degree of proximity effect would sound as if it had less pickup of the unwanted noise than did the microphone with less proximity effect.

Many performers use microphones with proximity effect to get an intimate warm sound. Many entertainers use this as part of their act and require the proximity effect to make their performance sound normal. Omnidirectional microphones do not exhibit proximity effect whereas bidirectional microphones typically have quite a bit of proximity effect.

Fig. 30 is a comparison of three types of unidirectional microphones and their amount of proximity effect. The curves are shown from 24 in. down to 1½ in.

Depicted on the lower curve is a single entry unidirectional microphone and the amount of proximity effect achievable. In the center curve is a continuously variable rear entry microphone and its associated proximity effect. The top curve is a two-rear entry uniphase microphone and the amount of proximity effect achievable.

In general, if a performer does not know how to use a microphone, he may be better off using a microphone with minimum proximity effect or an omnidirectional microphone which has no proximity effect. This may minimize microphone placement and the consequent result of having a differing tonal balance that is not coordinated with the performance.

There are certain single entry unidirectional microphones that have the low frequency response precontoured as shown in Fig. 31. The normal usage of the microphone, that is, close to the mouth, brings the low frequency back to nearly flat response; and when the microphone is picking up sounds at a further distance, the low frequency response is considerably rolled off thus yielding better rejection at low frequencies. This is not uncommon in hand-held unidirectional single-entry microphones.

In directional microphones, it is important that the off-axis response be the same as the on-axis response except to be lower in overall level. If this is not the case, the microphone will have a different frequency response depending on the angle the sound is coming from. This could mean that a vocalist using a directional microphone that was not linear in its off-axis response could have a band being picked up off the side or rear of the directional microphone that would sound very strange and possibly tinny. However, a microphone with uniform off-axis response would pick up the orchestra in its normal blend and simply be attenuated in overall level.

You will note from Fig. 32, that the 180° or rear response of the microphone is very similar to that of the front response and therefore would tend to sound the same on the front and rear. Only the level would be greatly attenuated.

Fig. 33 is a polar response curve of a directional microphone. Note that the polar pattern of the microphone is plotted at six different frequencies from low to high and that the microphone should have basically the same characteristics at all frequencies if it is to be considered a

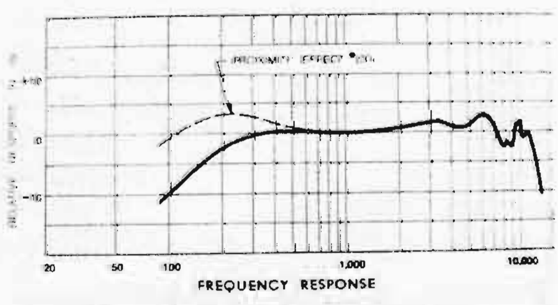


Fig. 31. Unidirectional microphones that have low frequency response precontoured.

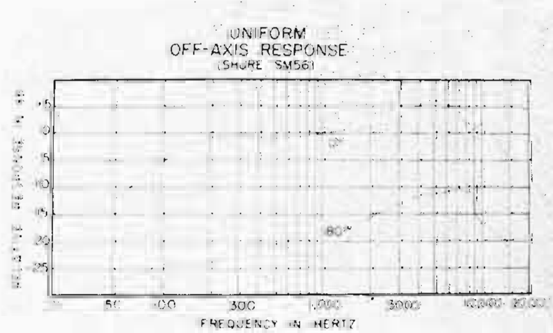


Fig. 32. Uniform off-axis response.

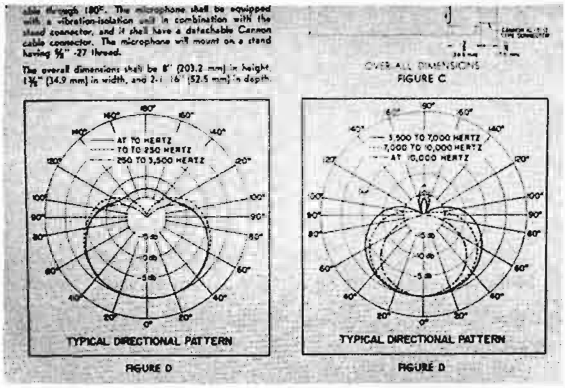


Fig. 33. A polar response curve of a directional microphone.

good unidirectional microphone. Remember, an omnidirectional microphone actually is not omnidirectional at high frequencies, and therefore its sound characteristic would change as one went off-axis. The low frequency and midfrequency content would be approximately the same but the sibilents or highs would be attenuated. A good unidirectional microphone should not display this characteristic and should simply attenuate the overall level of sounds reaching it from other than on-axis.

One can easily test this in several ways. In a very quite studio simply place a unidirectional microphone on a floor stand. If it should be a probe type microphone, place it parallel to the floor. Stand about 1 ft. from the microphone and talk into the front while slowly rotating the microphone in small increments, recording the output for playback later. When 90° off-axis the level should be down approximately 6 dB and as the microphone is rotated 180° the level should drop to 20—30 dB. When talking into the rear of the microphone, note that the room sound has appreciably increased. Should a great deal of low frequency content, above and beyond what was originally heard, develop it can be assumed that the rear rejection of the microphone is not good.

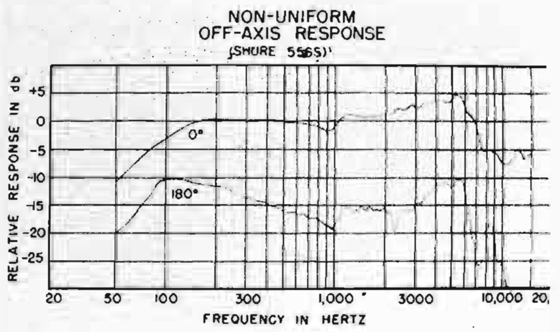


Fig. 34. Nonuniform off-axis response curve.

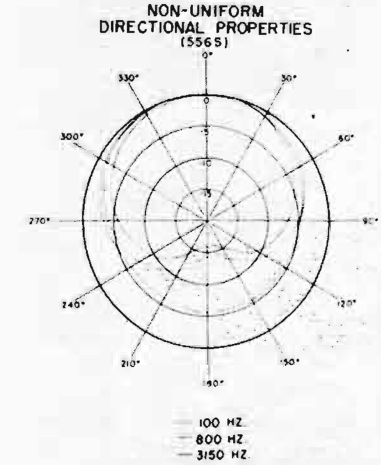


Fig. 35. Nonuniform directional properties of a Unidyne 2 microphone.

Another interesting test is to hold a unidirectional microphone horizontally and speak into it at its 90° axis. While speaking, rotate the microphone about its horizontal axis to see that the sound quality does not change. This test can become very enlightening on certain types of microphones.

As an example, Fig. 34 is a response curve of a Shure Unidyne 2 microphone. Note from the curve that the low frequency rejection is not as good as the midfrequency rejection and consequently when speaking into the rear of this microphone, one will note that it does not reject the low frequencies as well as it does the mid or high frequencies. This would give a problem in certain applications in terms of off-axis response.

Fig. 35 is the polar response curve of a Unidyne 2 microphone. Note the curve when plotted at three frequencies is not the same at all frequencies.

Originally in television broadcasting the microphone was seldom seen. Either booms or lavaliers were used and hidden under clothing. In dramas, microphones were hidden all over the sets to keep the viewing public from seeing a microphone. However, now the most common place to see a microphone is on the television screen and usually being hand-held by the performer. This means that microphone technology has had to change and considerations such as handling noise, pop, size and ruggedness have all become major considerations in the design of hand-held microphones.

New microphones as seen in Fig. 36 have built-in rubber isolation mounts to provide a maximum amount of mechanical isolation from the case assembly. This eliminates the banging

Fig. 36. New microphones with built-in rubber isolation mounts.

Fig. 37. New microphones showing the internal construction where a rubber isolation doughnut is used.

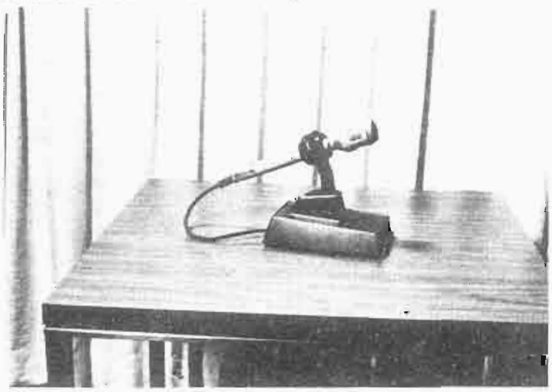


Fig. 38. Microphones without rubber isolation doughnuts can add this feature to mechanically isolate the microphone from the table as shown.

Fig. 39. Shows a boom microphone with the normal rubber band type mount.

and thumping sounds when the microphone is hand-held.

The internal construction can be seen in Fig. 37 where a rubber isolation doughnut is used to minimize both case coupling and handling noise of a microphone.

If microphones that do not have internal or adequate shock mounting characteristics are used, rubber isolation doughnuts such as seen in Fig. 38 can be used to mechanically isolate the microphone from the stand or the table. Another method of mechanical noise entry into the microphone is through the cable itself. A small 3-ft. cloth-covered isolation cable attached to the microphone minimizes all mechanical noise transmitted up into the microphone through the cable assembly.

This same concept works very well on boom microphones as seen in Fig. 39. This is the normal rubber band type mount that is used for boom mounting.

Another alternative as shown in Fig. 40 is to use the rubber isolation doughnut and the isolation cable to give maximum mechanical isolation. This minimizes the lighting and shadowing problems in television productions.

Fig. 41 is a curve showing the effect of the rubber isolation doughnut. Curve A is the natural mechanical resonance of the microphone when excited on a shaker table. By putting the microphone in an isolation mount, the mechanical resonance is shifted down to about 10 Hz as well as lower in amplitude. By activating the high pass filter in the microphone or using an external high pass filter, the overall mechanical noise can be reduced immensely. Another problem quite common in microphone applications is reflections from hard surfaces.

In Fig. 42 one sees a performer some distances from a microphone with two sound sources reaching the microphone—the direct wave and the wave reflected from a hard surface floor. The reflected wave is delayed due to the distance

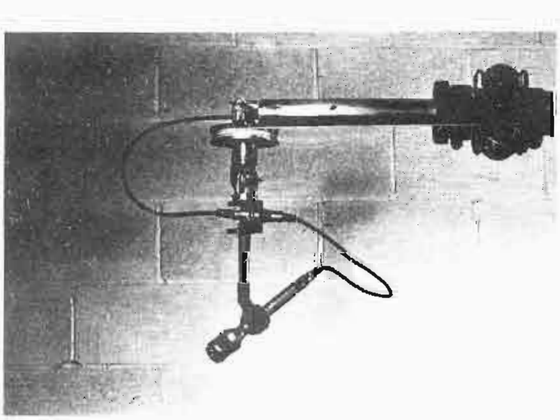


Fig. 40. Shown is a boom microphone using the rubber isolation doughnut and the isolation cable to give maximum mechanical isolation.

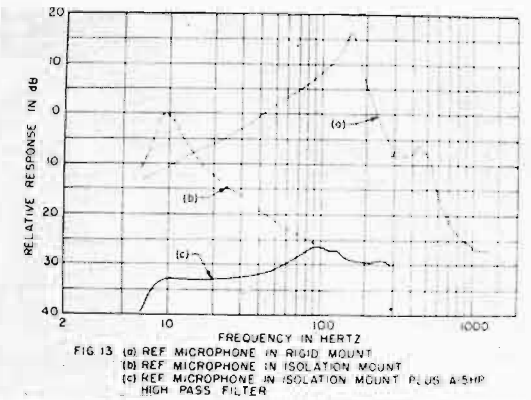


Fig. 41. Shown is a curve that demonstrates the effect of the rubber isolation doughnut.

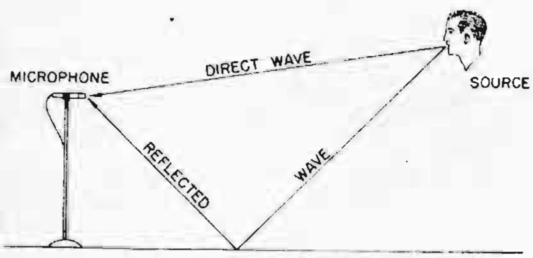


Fig. 42. A diagram showing a performer some distance from the microphone with two sound sources reaching the microphone.

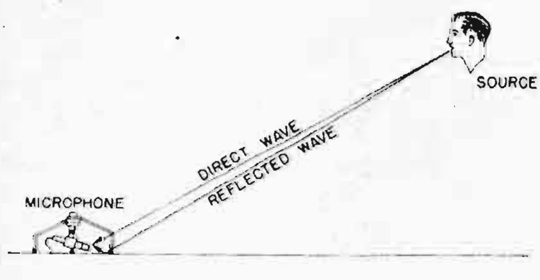


Fig. 43. A diagram of a performer with the microphone in position that the direct wave and the reflected wave reach the microphone simultaneously.

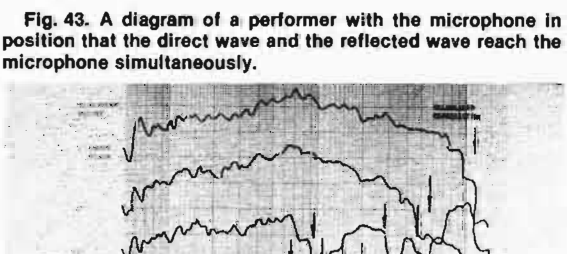


Fig. 44. Depicts the relationship between height variation when the sound source remains constant.

it travels and consequently phase cancellations will result.

To minimize this problem put the microphone in such a position that the direct wave and reflected wave reach the microphone simultaneously as suggested in Fig. 43. In this case, there is very little cancellation and the overall level and audio quality are improved.

Fig. 44 depicts what can happen to a microphone under varied conditions of height when the sound source remains constant and the microphone height is varied from 1-in. to 144-in. above the floor. As the microphone is moved up and down the reflective signal causes cancellations that vary with the height of the microphone off the floor. The same type of variation would take place if the performer moved back and forth or up and down.

This same principle applies to desk top applications as noted in Fig. 45. Here is an example of what can happen to the microphone in a desk top application due to the reflective signal, causing cancellation at certain frequencies. A good rule-of-thumb to follow is, when the distance from the performer to the microphone is greater than two times the distance of the microphone to the reflecting surface, more desirable results will be achieved by placing the microphone very close to the reflecting surface.

Fig. 46 is an isolation assembly that holds the microphone very close to the floor (reflecting surface) and uses the rubber doughnut method to provide mechanical isolation so that vibration or noises will not be transmitted into the microphone assembly.

Fig. 47 is a typical microphone placement when a podium is used, that is, one microphone on each side of the podium.

As long as only one microphone is in operation, there is no problem; however, if both are in use, the type of response curve as indicated in Fig. 48 will result as the individual moves off center of the podium. This phenomenon is another form of cancellation only this time the sound source is not reflected but directed from the speaker, and the distance between the speaker and microphone 1 and 2 are not necessarily equal. Consequently, some frequencies out-of-phase with each other cause this type of cancellation.

Fig. 49 is a polar response of this type of microphone mount shown at three different frequencies. Note that the smooth linear polar characteristics of the microphone are badly distorted.

One proposed solution is to place the microphones nose-to-nose as shown in Fig. 50.

This method indeed minimizes the frequency distortion as seen in Fig. 51 with a small loss of high frequency response.

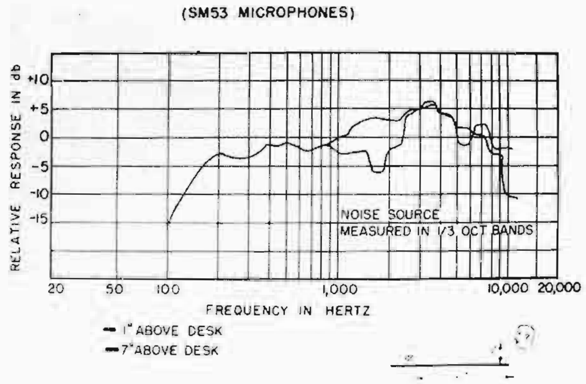


Fig. 45. Effect of microphone height on desk pickup.

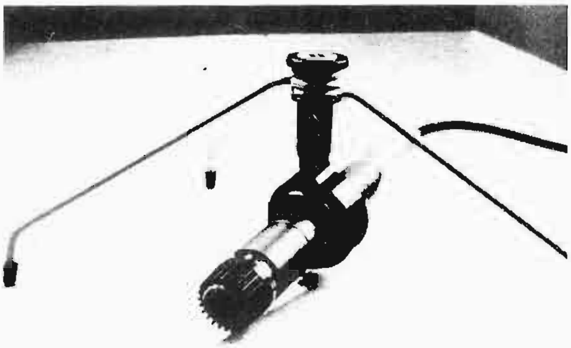


Fig. 46. An isolation assembly that holds the microphone very close to the floor, using the rubber doughnut method.

Fig. 47. Typical microphone placement when a podium is used.

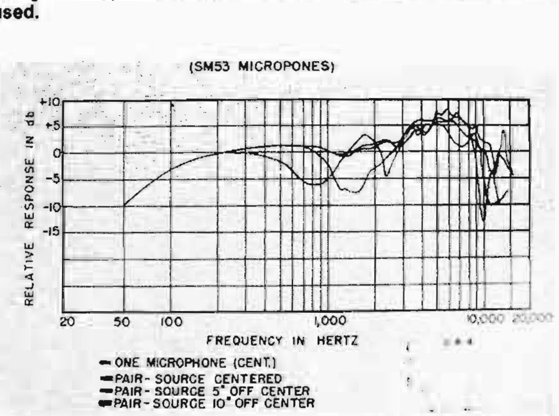


Fig. 48. Combined response of microphone pair spaced approximately 20 in. apart.

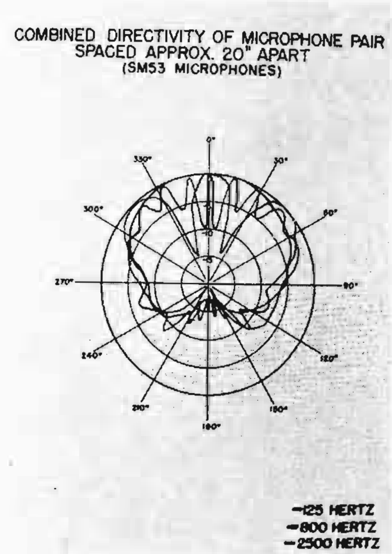


Fig. 49. Combined directivity of microphone pair spaced approximately 20 in. apart (SM53 microphones).

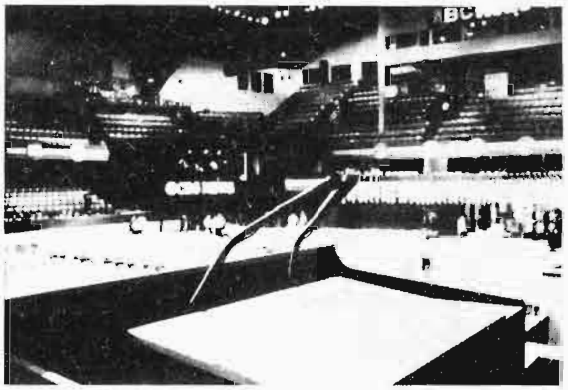


Fig. 50. Placement of microphones nose-to-nose.

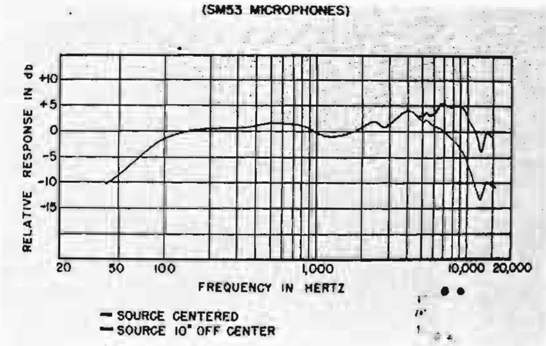


Fig. 51. Combined response of microphone pair grille spacing ½ in.-angled approximately 40 in. (SM53 microphones).

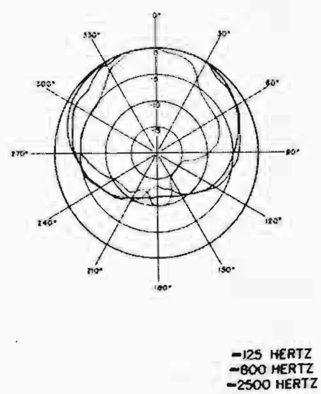


Fig. 52. Combined directivity of microphone pair grille spacing ½ in.-angled approximately 40 in. (SM53 microphones).

It can be seen in Fig. 52 that the polar response of the microphones are still not nearly as good as the microphones own polar characteristics and some rejection loss has occurred at the rear of the microphone. This leaves the possibility of either gain before feedback problems if sound reinforcement is used or not being able to minimize the unwanted sounds.

A vertical mounting of two directional microphones as suggested in Fig. 53 will minimize the bad effects of a dual microphone system and provide as wide a pickup angle as either of the other two methods mentioned before.

Many users assume that the "pop" characteristics of a microphone are always a good indicator of how well a microphone will perform in high wind applications. This is not necessarily true, and many microphones that have quite good on-axis pop rejection are quite susceptible to wind blowing into the side of the microphone. This can be easily checked by simply blowing into the side opening of a directional microphone and noting the amount of turbulence created. In the case of directional microphones with distributed or other low frequency entries in the handle, one must remember that these are just as susceptible to wind and pickup as the front of the microphone. By blowing or talkiing into the port entries of a directional microphone, the user will indeed find that it picks up sound. It is therefore necessary when using a directional microphone outside to make sure that all rear entries are completely covered by the porous foam windscreen.

Again, one advantage of single entry unidirectional microphones is that the entry is normally right around the top of the microphone, therefore, a small less obtrusive windscreen can be used to provide excellent wind and pop rejection.

Colored windscreens are now available for many microphones as shown in Fig. 54. The colored windscreens not only provide an interesting visual effect but also they are very handy in identifying hand-held microphones that are moved randomly. By color coding the mixer with little dots that match the colored windscreen, the audio operator can always tell which microphone is which without relying on colored tape wrapped around the bottom of the microphone or some other such method.

Fig. 53. Vertical mounting of two directional microphones.

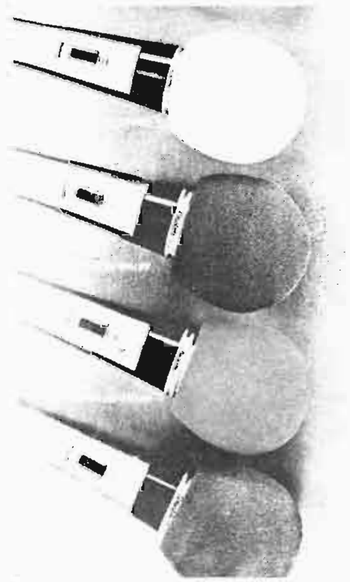


Fig. 54. Microphones with colored windscreens.

Windscreens should be checked for their acoustical properties and this again can be done in a studio by talking into the microphone while listening on a wide-range monitor loudspeaker systems and then sliding the windscreen over the microphone listening for any changes especially in the sibilence of the voice.

A final consideration is that of reflections back into directional microphones. In this case, four microphones were installed on a podium that had a light cavity. This is not an unusual type of podium but one which is in occasional use. Fig. 55 shows the response curves of the four microphones. The top curve is a single-entry unidirectional microphone. The second curve is an inexpensive omnidirectional microphone. The third curve is a distributed entry directional microphone and the bottom curve is a two rear entry uniphase system microphone. Those response curves were prepared from tests in an anechoic chamber and look very similar to those found on the data sheets for the particular microphones. However, when they are installed in a normal position in this lectern, it is interesting to note what happens to the response curve of the various microphones.

From the lower two curves in Fig. 56 it will be seen that the multiple entry directional microphones have picked up the 250 Hz resonance of the lectern light cavity. Since the rear entries are designed to be out-of-phase with the front of the microphone, the reflected signal causes a rise in the 250 Hz area which makes the microphone sound very muddy.

The omnidirectional microphone, as it picks up equally at all mid and low frequencies no matter what direction, sees the signal being reflected back from the light cavity as an out-of-phase signal with a resulting canceling effect at both the fundamental and its harmonics.

The top curve is the single entry unidirectional microphone. Since its entry is all the way towards the top of the microphone, it is least affected by the signal coming back from the lighting cavity and consequently gives the smoothest overall response in this particular application.

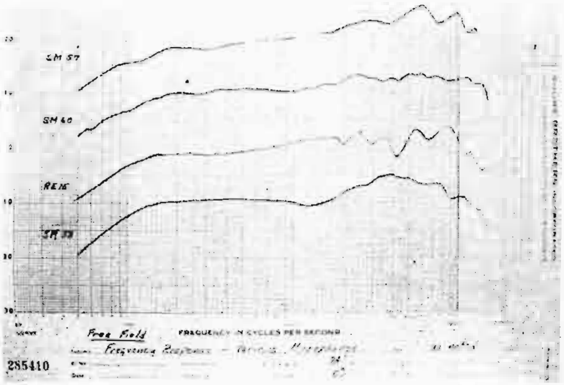


Fig. 55. Response curves of four microphones, from top to bottom: (1) a single-entry unidirectional microphone, (2) inexpensive omnidirectional microphone, (3) distributed entry directional microphone, (4) a two rear entry uniphase system microphone.

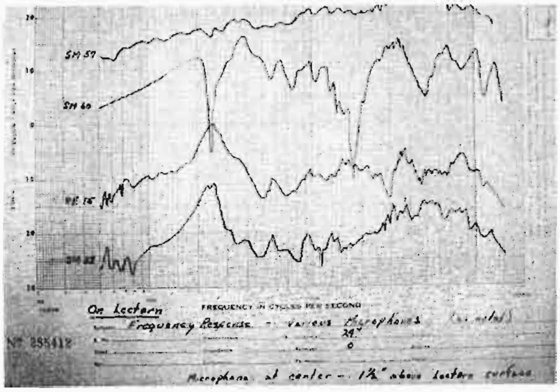


Fig. 56. Multiple entry directional microphones curves from a lectern showing a pickup of 250 Hz.