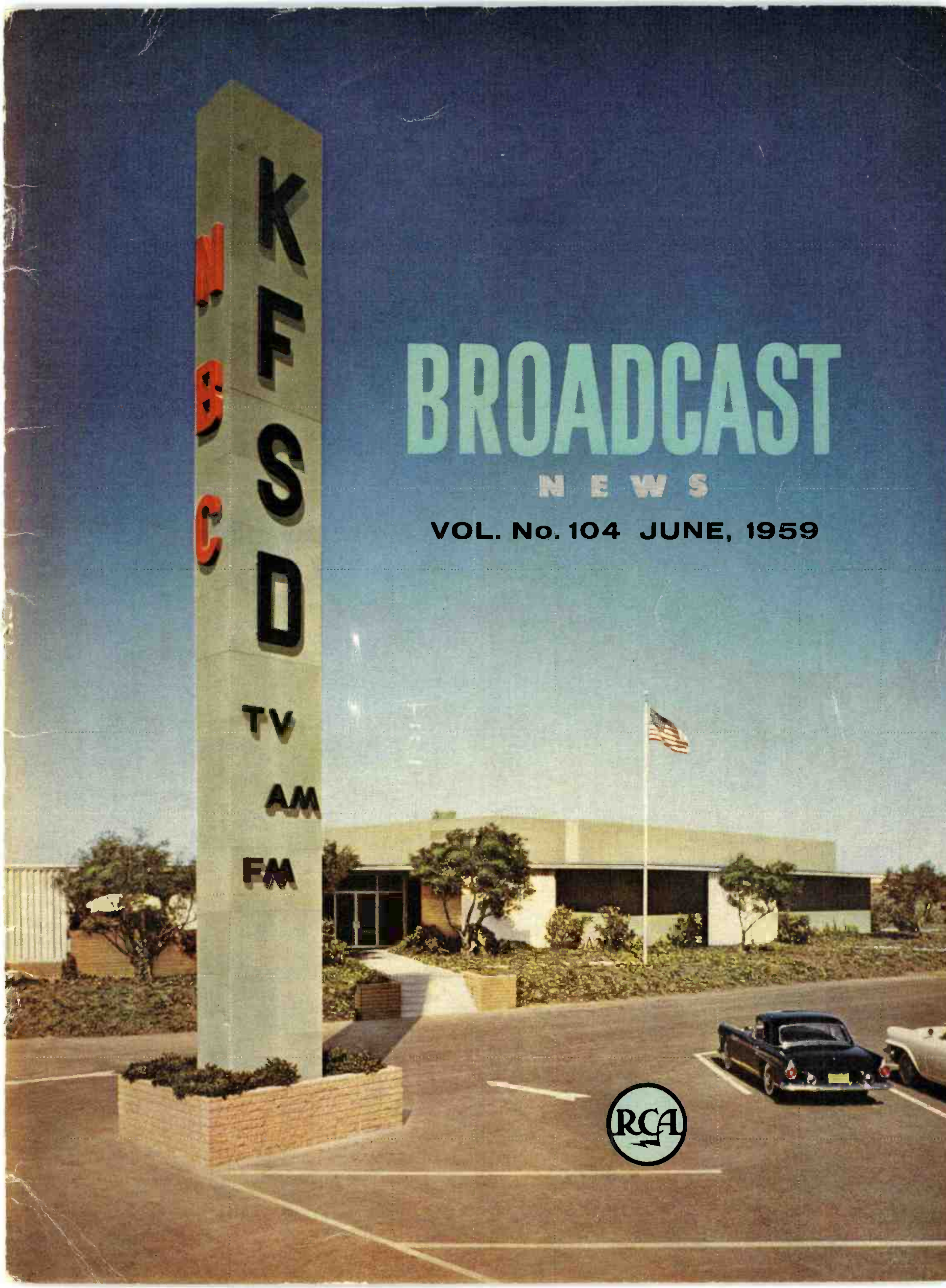
BROADCAST NEWS

VOL. No. 104 JUNE, 1959



ASSURING THE MOST FOR YOUR EQUIPMENT DOLLAR RCA

new RCA magnetic disc recorder

combines advantages of tape and disc!

A great new tool for broadcasters . . . makes possible fast recording and playback of commercials and announcements

The Magnetic Disc—extremely rugged, not easily damaged, and with a life expectancy equal to or greater than tape. Information already recorded can be erased easily, permitting re-use of disc.

Type BQ-51A/BA-51A Magnetic Disc Recorder and Recording Amplifier

This new Disc Recorder, a completely self-contained unit, meets the broadcaster's requirements for fast recording and playback of commercials and announcements. Extremely simple in operation, it minimizes the skill required to produce a professional recording. Grooves for recording are molded into the blank disc. No cutting mechanisms, optical devices and heated styli are needed; the same equipment serves for recording and playback. All of the advantages of magnetic tape recording are retained in the magnetic discs, yet winding, splicing, cuing and other tape handling problems are eliminated.

A recording time of 70 seconds is obtained from each side of the magnetic disc, which includes 10 seconds for "cue-in" and "trip-out" cue tones. The magnetic discs are recorded at 33⅓ rpm.

The magnetic head used in the system consists of two C-shaped laminations made of a material that is extremely hard physically, but with very high permeability. A newly designed tone arm which accommodates standard MI-11874-4 (1 mil) and 11874-5 (2.5 mil) pickups also can be handled by means of a plug-in socket arrangement. It can be used for reproducing standard transcriptions and phonograph records up to 12 inches in diameter at 33⅓ or 45 rpm.

Magnetic Recording Head. The magnetic pole pieces which do the recording protrude through the narrow slot (see arrow).

The Magnetic Disc Recorder can be the first of the building blocks in preparing for automatic programming. For complete information on the Disc Recorder and companion units call your RCA Broadcast Representative. In Canada: RCA VICTOR Company Limited, Montreal.

RCA Tmk(s) ®

RADIO CORPORATION of AMERICA

BROADCAST AND TELEVISION EQUIPMENT

CAMDEN, NEW JERSEY

Vol. No. 104 | June, 1959

BROADCAST NEWS

published by

RADIO CORPORATION OF AMERICA

BROADCAST & TELEVISION EQUIPMENT DIVISION

CAMDEN, NEW JERSEY

issued quarterly

PRICE *in U.S.A. - - - - - $4.00 for 4 issues*
outside U.S.A. - - - $5.00 for 4 issues

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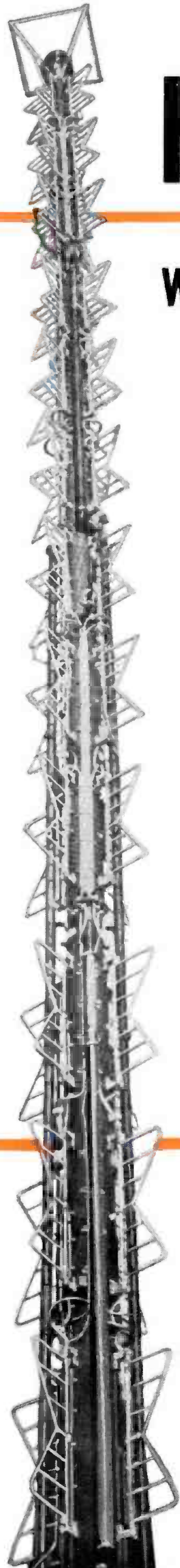
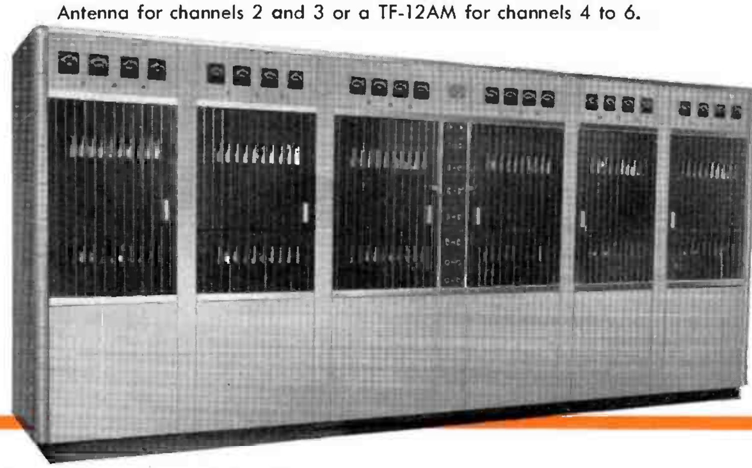


How to Get Coverage

with RCA Transmitter-Antenna Combinations

10 KW TRANSMITTER with 12-Section Antenna

An RCA TT-10AL Transmitter for low-channel operation, used with a TF-12AL Antenna for channels 2 and 3 or a TF-12AM for channels 4 to 6.



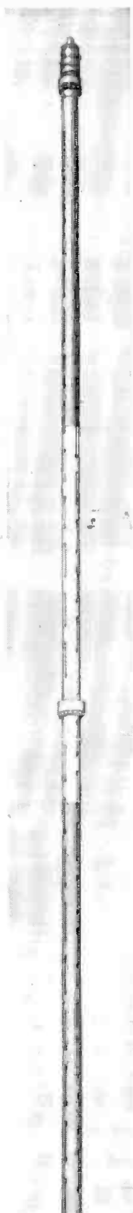
The above combination assures:

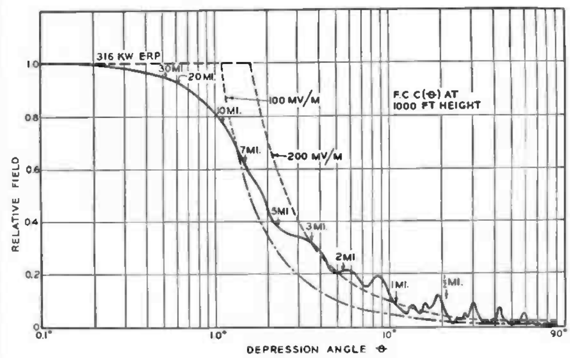
More uniform coverage . . . without wasting it.
Low operating cost.
Minimum space requirements.

Other combinations:

In locations where ERP is limited by antenna height, a number of combinations can be provided utilizing RCA Transmitters with powers from 2 KW to 25 KW and RCA Antennas with gains from 3 to 12.

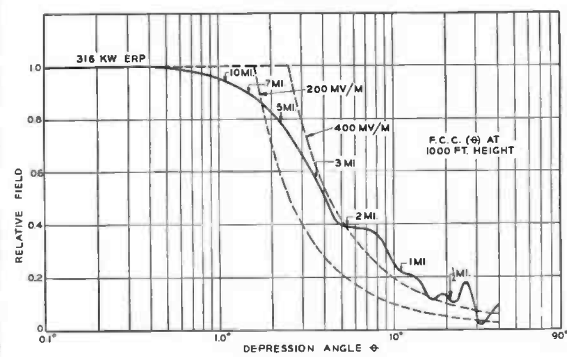
New "Traveling





CHANNEL 10

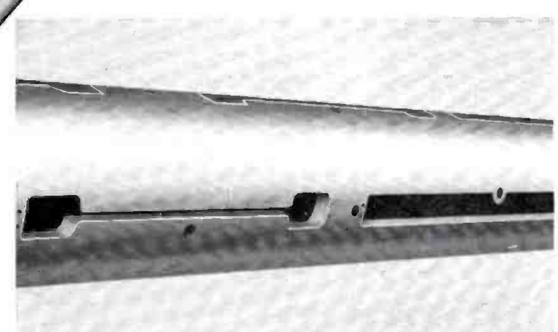
GAIN OF 18 ANTENNA PATTERN (CALCULATED)



CHANNEL 7

GAIN OF 8 ANTENNA PATTERN (MEASURED)

FOR HIGH-BAND VHF OMNIDIRECTIONAL SERVICE



CLOSE-UP OF ANTENNA SHOWING UNIQUE SLOT RADIATOR DESIGN

RCA Tmk(s) ® ***RADIO***

Wave" Antenna

Combines Improved Electrical Characteristics with Mechanical Simplicity and Economy . . . for High Power TV Applications

Here is a VHF high-band antenna that has an inherently low VSWR and produces better patterns. A new design, based on slot radiators, results in improved circularity. This new antenna also features low wind resistance and better weather protection.

INHERENTLY LOW VSWR

The traveling-wave nature of the feed results in a low VSWR along the antenna. This characteristic inherently gives the antenna a good input VSWR without any compensating or matching devices. The input tee has been broad-banded to provide a smooth transition from the transmission line to the antenna.

ALMOST IDEAL VERTICAL PATTERN

A vertical pattern is obtained which is an extremely smooth null-less pattern—see accompanying patterns. This provides the service area at most locations with a uniformly high field strength. Gains from approx. 6 to 20 at VHF high band can be obtained.

IMPROVED CIRCULARITY

The individual patterns produced by slot radiators when added in phase quadrature result in an over-all pattern with improved circularity. In addition, there are no external elements in the field. This design combines radiating elements, feed system and antenna structure in one unit, giving excellent horizontal circularity.

LOW WIND RESISTANCE AND WEATHER PROTECTION

The smooth cylindrical shape of the antenna is ideal for reducing wind load and has high structural strength. It is designed to withstand a wind pressure of 50 psf on flats, or 33⅓ on cylindrical surfaces. In addition, the absence of protruding elements minimizes the danger of ice damage. The steel outer conductor is hot-dip galvanized for better conductivity and protection. The inner conductor of the antenna is rigidly supported at the bottom end without having to rely on any insulator type of support to carry the dead weight. The pole is designed for tower mounting with a buried section extending into the tower. The pole socket carries the dead weight of the antenna. Polyethylene slot covers are fastened to the pole over every slot.

SIMPLIFIED FEED SYSTEM

The feed system is completely inside the antenna, hence any effects on the pattern have been eliminated. The feed system is a simplified one consisting of a large coax line and coupling probes.

The RCA "Traveling Wave" Antenna can provide you with the answer to your need for a VHF High Band Antenna which combines mechanical simplicity and economy, especially in high-gain, high-power applications. Your RCA Broadcast Representative will gladly help with TV antenna planning. See him for details on this new antenna. In Canada: RCA VICTOR Company Limited, Montreal.

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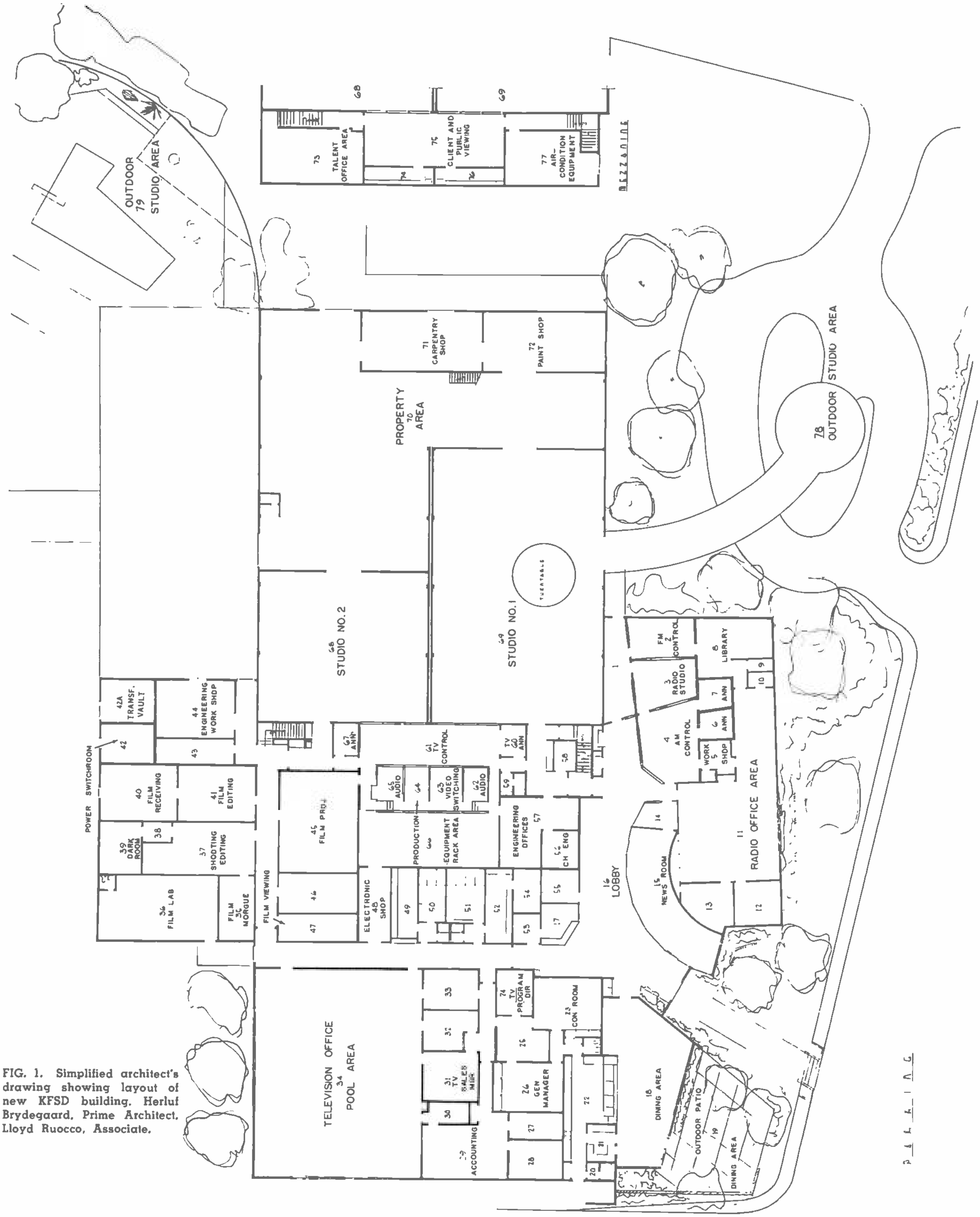

FIG. 1. Simplified architect's drawing showing layout of new KFSD building. Herluf Brydegaard, Prime Architect, Lloyd Ruocco, Associate.

THE KFSD DESIGN FOR A MODERN, EFFICIENT BROADCAST OPERATION — with built-in expansion for tape and live color

by LEROY A. BELLWOOD, *Vice-President and Chief Engineer*

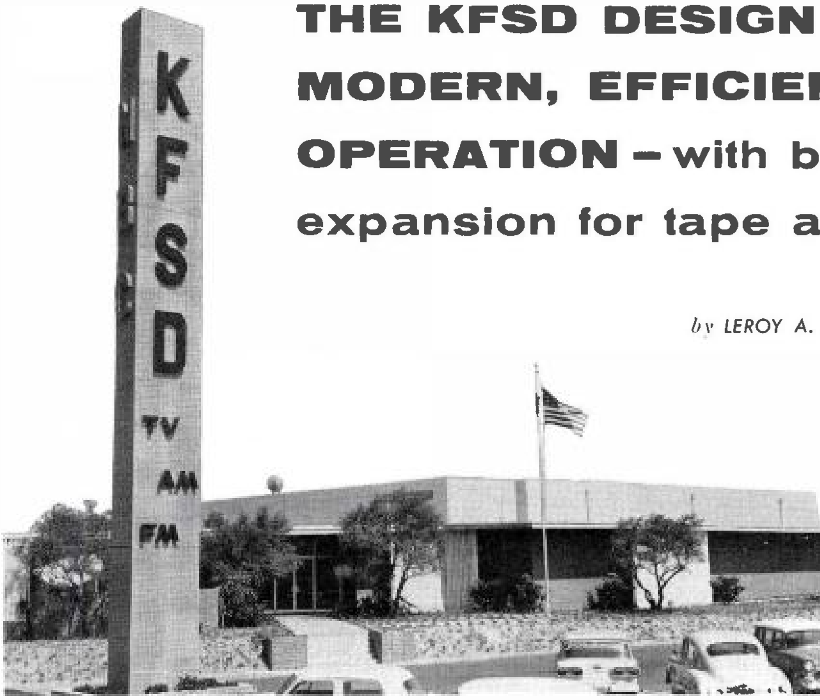

FIG. 2. Front entrance at million-dollar Broadcast City of KFSD-TV-AM-FM. In the rear is the outdoor studio area.

BROADCAST CITY of San Diego, housing the combined studio facilities of KFSD-TV-AM-FM, was dedicated on May 25, 1958 by the Honorable Goodwin J. Knight, then Governor of the State of California. This signified completion of a most modern and efficient broadcast operation.

This attractive one story broadcast facility is located four miles east of downtown San Diego beside the new six lane Highway 94 freeway at 47th Street. The 43,000 square feet building is centered on a 7 acre site, situated on a knoll that lies above the surrounding area. The site is spectacularly visible from the freeway and its position is unobstructable. The KFSD location is bordered on the south by the existing freeway, Federal Boulevard on the north, city property dedicated for a future crosstown freeway on the west and company owned land on the east.

The television transmitter is located on 8 acres atop Mount Soledad to the north of downtown San Diego and overlooking world-famed La Jolla. The AM-FM transmitters are located one mile east of the Broadcast City location on a 31 acre tract atop Emerald Hills.

KFSD Radio, 600 kc, is one of the west's pioneer stations. It has been an NBC affiliate since 1926. KFSD-TV was activated September 13, 1953, operating on Channel 10, also as an affiliate of NBC. KFSD-FM, 94.1 mc has been in continuous operation since 1949, and for the past three years its broadcast day has been programmed as San Diego's fine music station offering light and classical concert, stereo, opera and verbal arts. The three stations are operated by KFSD, Inc.

The KFSD operation affords an excellent example of new plant construction

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◄

1. Entry Hall
2. FM Control Room
3. Radio Studio
4. AM Radio Control Room
5. Work Shop and Storage
6. Radio Announce Booth
7. Radio Announce Booth
8. Transcription Library
9. Record Audition Booth
10. Storage Closet
11. Radio Office Area
12. Radio Program Director
13. Radio Sales Manager
14. Teletype Room
15. News Room, Radio and Television
16. Lobby
17. Reception Desk
18. Dining Area
19. Outdoor Patio Dining Area
20. Coat Room
38. Film Storage
21. Dish Washing and Disposal Area
22. Cafeteria Kitchen
23. Conference Room
24. Television Program Director
25. Secretaries
26. General Manager
27. Vault
28. Comptroller
29. General Accounting Office
30. Supply Storage
31. Television Sales Manager
32. Sales Service
33. Public Service Director
34. Television Office Pool Area (Promotion, Traffic, Salesmen, Directors, Announcers, etc.)
35. Film Morgue
36. Film Laboratory
37. Commercial Shooting and Editing
39. Photo Dark Room
40. Film Receiving and Storage
41. Film Editing
42. Power Switchroom
42A. Transformer Vault
43. Janitor Storage
44. Engineering Work Shop and Remote Equipment Storage Area
45. Film Projection Room
46. Mimeograph and Mailing
47. Film Viewing
48. Electronic Shop
49. Men's Dressing
50. Men's Rest Room
51. Ladies' Rest Room
52. Ladies' Dressing
53. Storage
54. Ladies' Lounge
55. Client's Conference Room
56. Chief Engineer
57. Engineering Offices
58. Announcer's Rehearsal
59. Announcer's Make-Up
60. TV Announce Booth
61. TV Control
62. Audio Control
63. Production and Video Switching
64. Production
65. Audio Control
66. Equipment Rack Area
67. Announce Booth
68. Studio No. 2
69. Studio No. 1
70. Property Area
71. Carpentry Shop
72. Paint Shop
73. Talent Office Area
74. Auxiliary Dressing
75. Client and Public Viewing
76. Auxiliary Dressing
77. Air-Conditioning Equipment
78. Outdoor Studio Shooting Area (front)
79. Outdoor Studio Shooting Area (rear)

FIG. 3. Studio 1 in use during election returns.

that embodies several interesting innovations and makes suitable provisions for an expanding broadcast business.

Studio Building

The seven acre site was chosen to give plenty of space for outdoor studios, parking, and future building expansion. Prime architect, Herluf Brydegaard, and associate, Lloyd Ruocco, chose an exterior of rough brick and plaster, in complimentary shades of green, accented with glass facade-panels and white louvered wood verticals. Semi-tropical plantings and full-grown olive trees set the mood for the landscaping done by Harriett Wimmer. The building was constructed by the M. H. Golden Company. A paved parking area in front will accommodate 150 automobiles. Outdoor lighting adds dramatic appeal to the structure.

The building is designed for quick access to different functions from the lobby. Radio is a separate unit, as are TV office area and administration. Film processing and commercial filming are located beside receiving and editing rooms—directly across the hall from projection. Delivery trucks are able to unload directly into receiving where film is unpacked, taken to editing, then across the hall to projection.

Paint shop, carpentry shop, and property area are located immediately behind the studios. A truck-height loading dock, behind shops and property area, facilitates loading and unloading.

Studio 1

Studio 1, 49 by 79 feet, is accessible from the main lobby through a sound lock—which serves also as entry into engineering department, control room and basement. Acoustical treatment for all studios and announce booths was done by Dr. R. W. Young of the Naval Electronics Laboratory. In the tv studios this consists of acoustical tile on the ceiling with spun glass PF board on the walls. The acoustics can be varied slightly by use of draperies, hanging from the 12-foot 6-inch level around the walls. The drapes are broken up into 14-foot sections so that they may be adjusted to suit individual setups.

The walls of the studio are concrete, since the building is tilt-up concrete construction. The walls were formed by pouring panels 20 feet wide directly on the floor slab, then lifting them into place by a large crane. Some of these panels weigh as much as 30 tons.

For structural, and sound isolation purposes, there is a double wall between the two large studios. Each wall is six inches thick with a 6-inch air space between them. Another interesting note is that the beams supporting the roof structure in the studios are of pre-stressed concrete, carrying the load, not only of the roof, but the lighting grid, fixtures, and air-conditioning ducts.

The lighting grid consists of pipes at the 18-foot level spaced 5 feet apart. Suspended by chains from the grid are 14-foot batons, which carry the outlet strips and fixtures. A custom built jack and dimmer panel contains 256 jacks and 16 dimmers. There are 95 scoops, 36 2-kw spots, 6 1-kw spots, and 16 lighting strips. The lighting was planned to accommodate live color. For monochrome studio shows, 100 to 150 foot candles of illumination are used.

The studios, along with the other parts of the building, are served by 80 tons of air conditioning. Large blowers supply a constant stream of 68-degree air to the studios, and during production this rises about 10 degrees. All duct work has been lined with sound deadening material and "egg crate" obstructions are installed at various intervals in the ducts, to cut down the noise of air velocity.

The studio is designed to accommodate four live cameras, having outlets at convenient locations around the walls (see Fig. 5). Four camera connections, four microphone connections, and intercom connections are available at each location. Cable for these outlets is housed in an 8-by-8-inch 3-compartment duct, with a lid, to prevent cable damage. As many as nine microphones can be used at one time in the studio. Usually there are four microphones and two cameras in use. One camera is a studio type, the other has a portable dolly.

The studio also features a 20-foot turntable, variable speed and reversible, for automobiles and other commercials. Provision is also made for a rear screen projector for background purposes.

Control Rooms

The television control area is located at the end of the studios, arranged in an unusual but completely practical way (see Fig. 6). Immediately in front of Studio 2 is the master video switching and video control position (see Fig. 6). In the center

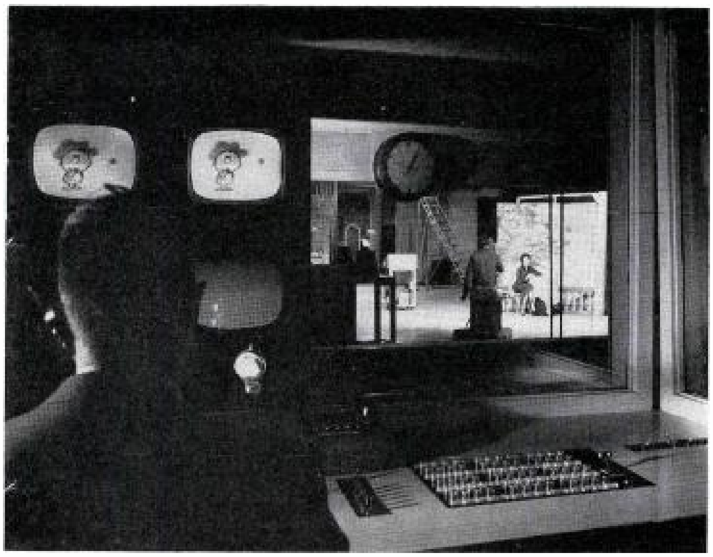


FIG. 4. Production booth for Studio 1, showing monitor rack and second video switching position of the dual TS-21 system.

FIG. 5. Camera, intercom, and microphone outlets in Studio 1. To the right are storage hooks for intercom and cable equipment.

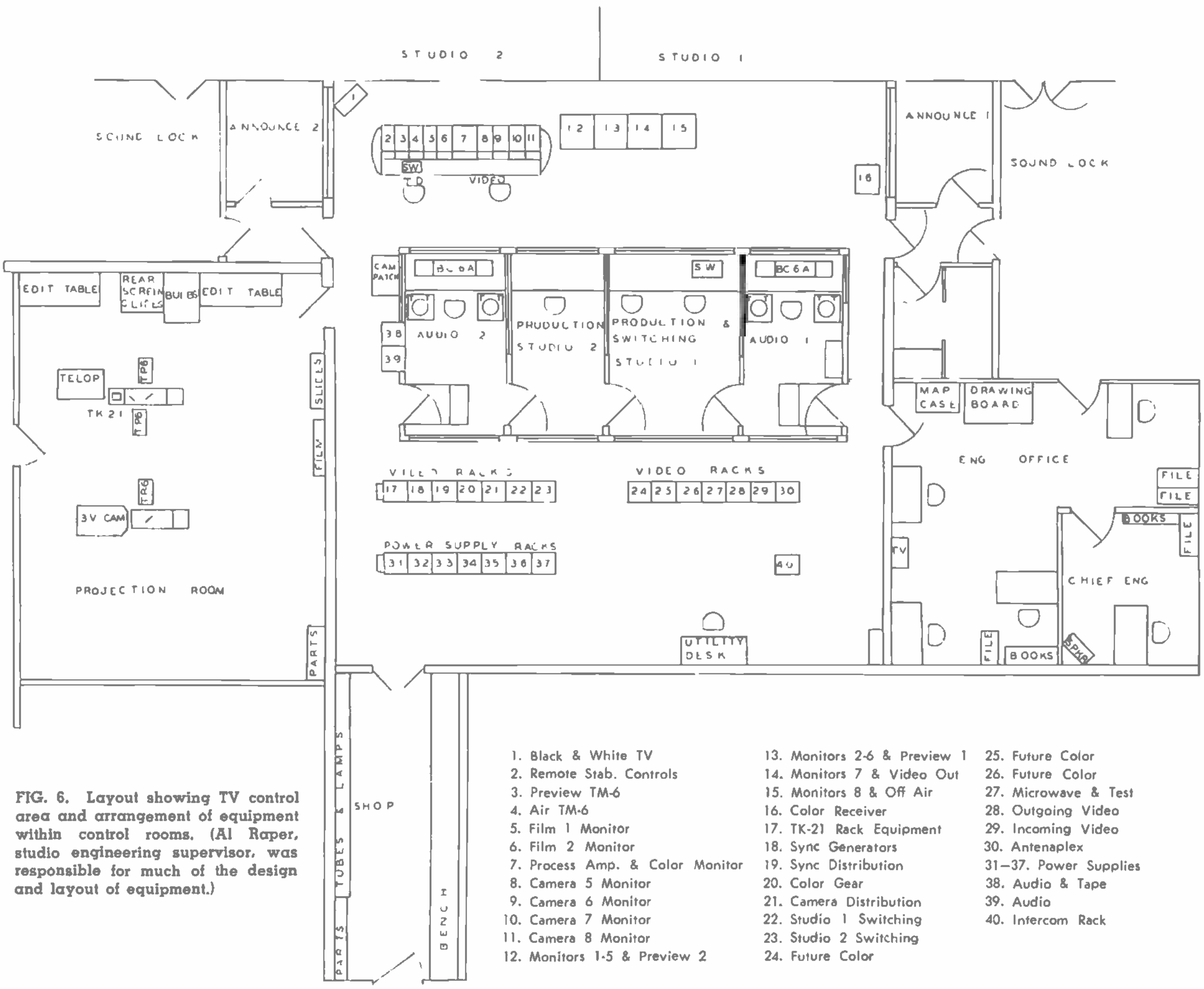


FIG. 6. Layout showing TV control area and arrangement of equipment within control rooms. (Al Raper, studio engineering supervisor, was responsible for much of the design and layout of equipment.)

1. Black & White TV
2. Remote Stab. Controls
3. Preview TM-6
4. Air TM-6
5. Film 1 Monitor
6. Film 2 Monitor
7. Process Amp. & Color Monitor
8. Camera 5 Monitor
9. Camera 6 Monitor
10. Camera 7 Monitor
11. Camera 8 Monitor
12. Monitors 1-5 & Preview 2
13. Monitors 2-6 & Preview 1
14. Monitors 7 & Video Out
15. Monitors 8 & Off Air
16. Color Receiver
17. TK-21 Rack Equipment
18. Sync Generators
19. Sync Distribution
20. Color Gear
21. Camera Distribution
22. Studio 1 Switching
23. Studio 2 Switching
24. Future Color
25. Future Color
26. Future Color
27. Microwave & Test
28. Outgoing Video
29. Incoming Video
30. Antenaplex
31–37. Power Supplies
38. Audio & Tape
39. Audio
40. Intercom Rack

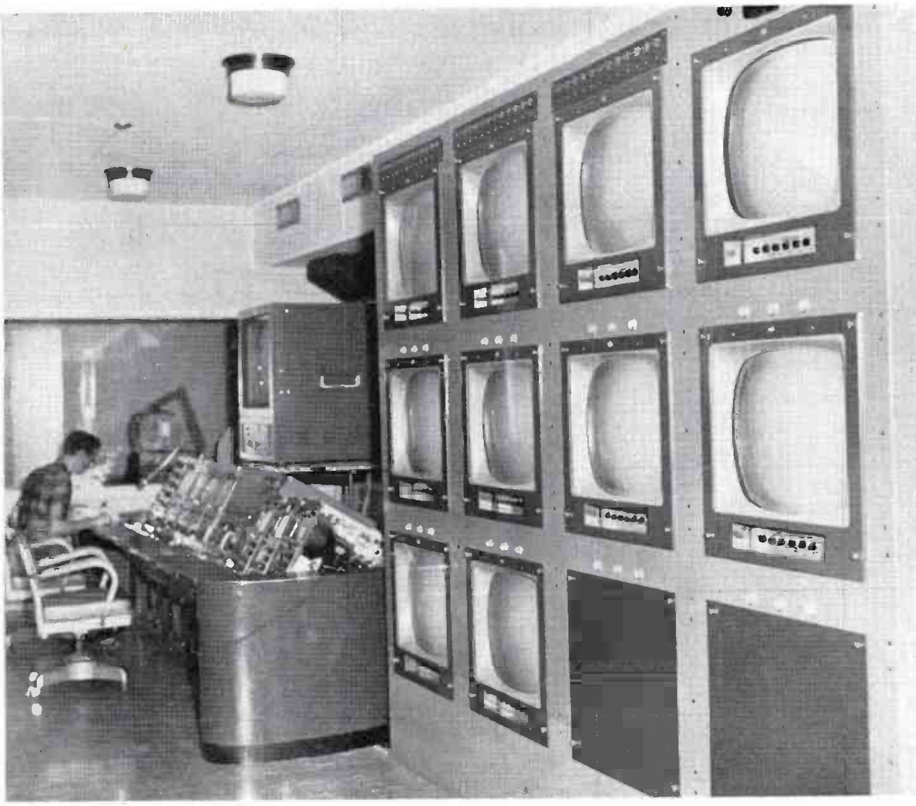


FIG. 7. Production monitor rack. Monitors on bottom row are for two film chains. The four monitors across the middle are for four live cameras. The first two monitors in the top row are for preview. No. 3 top row is outgoing line to the transmitter. These monitors have tally light system immediately above to show which camera is on preview or on the air. Monitor top row extreme right shows signal coming back from transmitter. To the left can be seen the main TD switcher video position. No. 2 Announce Booth in background.

is a monitor rack used by the people working in the audio-production booths (see Fig. 7). Two end control booths are audio and the two center, production. On the Studio 1 side in the production booth is a TS-20 Video Switcher so that each studio may be controlled separately, both for video and audio, or both studio operations can be controlled from one side. However, it is advantageous to move the audio man across to the audio booth of that studio which is in operation. Since there is glass between all positions, there is very good visible communication between the various people working in the control area.

The control booths are elevated 18 inches above the studio floor. This was done for two reasons: To give better visibility into the studio, and to provide space under the floor for cable race-ways.

This operation is designed for a minimum crew of two men, a TD (video switcher) and an audio man. Most of the time, however, a projectionist is also employed. When live cameras are in use, a video control man is required.

Studio 2

Studio 2 is 44 by 49 feet, approximately half the size of Studio 1 and is used for afternoon children's programs, filmed commercial productions, and special shows. It will be used for future tv tape productions. The Century lighting equipment and control panel were moved from the former location. Microphone and camera connections in this studio are the same as in Studio 1. The rear wall of Studio 2 is of semi-permanent construction, so that it might be easily moved to enlarge the studio. Acoustical treatment in Studio 2 is somewhat less than that in Studio 1, since the lower portion of the concrete walls are not covered with acoustical material, but depend completely upon the drapes. Above the drapes is the same Fiberglas material as used in Studio 1; on the ceiling and

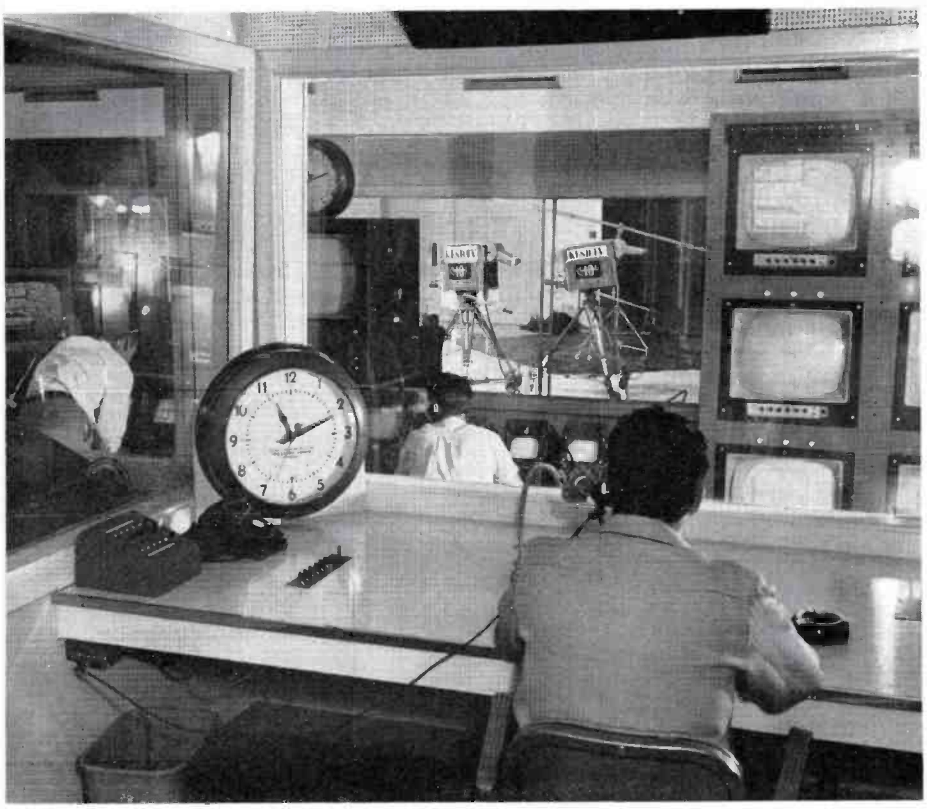


FIG. 8. Looking into Studio 2 from the Production Booth for this studio: to the left is the audio booth; in front is the video switching-control position. Production monitor rack is to the right. Note tally lights above monitors.

control. The projectionist loads the film and slides into the equipment, sees that they are functioning properly, and maintains proper focus. At other times, the projectionist is checking or cleaning film and otherwise keeping things in order.

"Snooper" Intercom System

One problem of a large tv plant is that many areas need tv receivers. KFSD installed an RCA Antenaplex system to distribute closed circuit and off-air signals to the various points. For closed circuit positions, an RCA Monitran system is used.

An elaborate intercom arrangement permits the two studios to function independently of each other—at the same time permits close coordination between director and staff (see Fig. 13). Two separate mag lines are included, one for each studio. Each mag line provides for a maximum of 18 sets, including eight wall outlets in the studio, two outside the studio, four cameras, technical director, director, announce booth, audio and video. A studio line consists of wall outlets in the studio, outside connections, the announce booth associated with that studio all tied permanently together. The technical director and director for Studio 1 or Studio 2 are switchable to either studio line.

The production intercom jacks on all cameras tie to one mag system and the engineering side of all cameras to the other mag system. If a camera in Studio 2 is to be used to show cards as a part of a Studio 1 show, the cameraman merely moves his phone connections from left to right side of camera. In event of camera failure during rehearsal or on-air, cameraman and video man switch over to an unused intercom—without disturbing others of the crew.

Two facilities are provided for feeding amplified director or technical director to all positions that are served by conventional program phone circuits. The program jacks of all cameras plus program jacks audio, announce booth, video and technical director positions are switchable to amplified intercom from either director's booth. Amplified intercom is provided also at the adjacent jack in the conventional two jack system at all studio outlets. Double headsets can be used, providing the wearer both mag and amplified circuits, or he can use single sets to provide either facility. If a listening circuit to the director only is needed, common earphones will suffice. Talkback to either studio and to projection room is provided for both directors and technical directors.

A switch is provided on each control room jack box to allow the operator to switch in a network program override on his mag set. Isolation is provided this monitoring facility by a BA-21A Amplifier on the incoming network line. This switch provides an excellent failure indication on incoming audio.

FIG. 14. Automobile commercials are among the live productions which can be done in two outdoor studios. Camera area is in the foreground. Cars are driven around the circular driveway. Doors to Studio 1 are seen in the background.

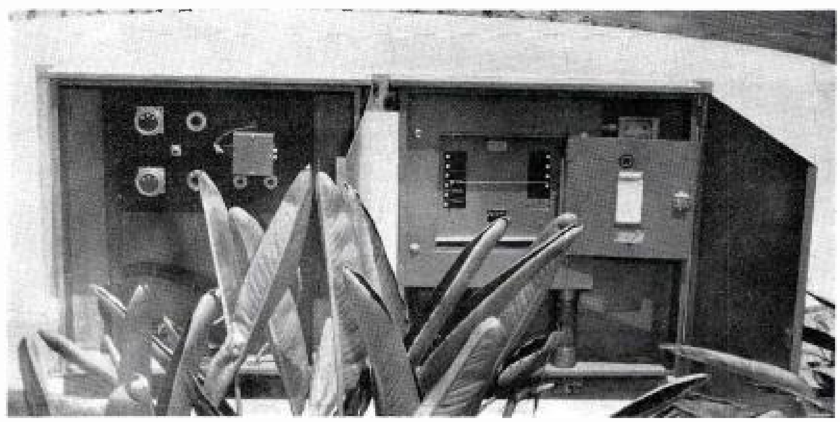


FIG. 15. Camera, microphone, intercom, and lighting outlet racks for outdoor shooting area.

Snooper speakers are provided in all booths, with a choice of either mag line. A speaker can be operated from the mag set in the same booth with no feedback problem because of the directivity of the speaker—which is mounted under the operating table. The speaker selected has rather thin tonal quality, allowing the director to distinguish the sound source as either program or intercom. The snoop speakers are Jensen AP-10 driven from converted RCA SA-10C Amplifiers. They are rack mounted and modified to include a second low-level input and to permit coupling to the mag lines.

The snoop facility was added to give a director freedom from wearing earphones. It has become a means of tying the crew together over a rather large operating area. Anyone wishing to reach a booth position can do so from the studio floor, or another booth, by using a mag set—even though the operator in the booth to be reached is not wearing phones. At each projector a relay actuating foot switch and microphone are provided. Projection room talkback shows up as a second input to all snooper amplifiers. A separate rack is provided for all intercom terminations, amplifiers and intercom dc supplies.

On two spectacular shows the entire system was tied together on one mag line. This was easily accomplished by tying retard coils of both mag systems together through a 2-mfd. condenser. It is planned to add a paging circuit for the amplified bus to dressing and property rooms. Switches were provided at the time of installation for these future circuits.

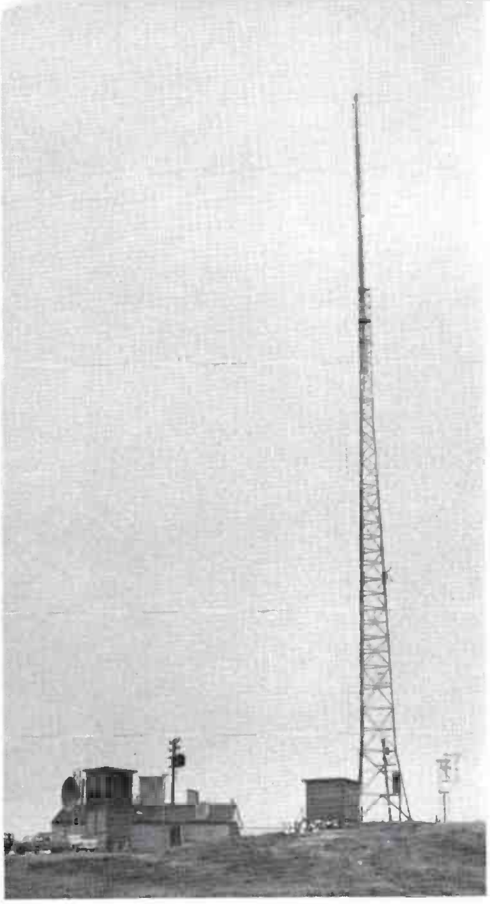
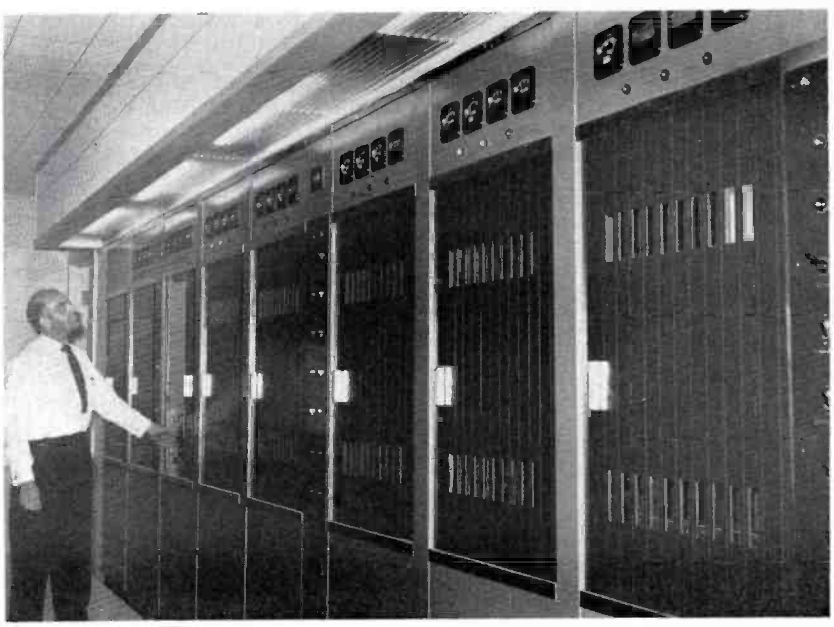


FIG. 16. KFSD-TV transmitter at Mount Soledad showing main building and microwave house together with Ideco self-supporting tower and TF-12BH Antenna. Main building is converted wartime radar transmitter building.

FIG. 17. Transmitter Supervisor, M. A. Robertis, adjusting control on aural position of TT-25AH Transmitter.



TV Transmitter

The KFSD-TV Channel-10 transmitter is located on Mount Soledad, overlooking the La Jolla area, northwest from downtown San Diego (see Fig. 16). Line of sight distance from studio to transmitter is 12 miles. This location was chosen because the other San Diego station was already here, thus it simplified receiving antenna orientation. The transmitter building is a converted army radar building of poured concrete construction, with walls some 12 inches thick.

Originally, KFSD-TV went on the air with a 10-kw transmitter; however, floor ducts and operation were arranged so that it was only necessary to set in place the 25-kw units when power was increased. A 2-by-2-foot air duct is constructed under the floor of the transmitter. This duct terminates in outside air pits located on each side of the building. In order to reduce vibration in the 10-kw transmitter, the blowers were lowered into a compartment adjacent to the air duct so that they are mounted on solid concrete. It is believed that the reduction in vibration has increased tube life substantially.

The operating console is situated at right angles to the transmitter. This, however, has not proved to be a bad feature since it is quite easy for the operator to read the meters and check the transmitter. The rack equipment is located immediately behind the operator so that it is quickly available to him for checking or adjustments.

The video signal is received via microwave (telephone company facilities) and the audio also arrives at the transmitter via a telephone company line. The network terminates at the studio. All switching is done at the studio, except when the transmitter is changing equipment due to emergencies. An 0.1 watt microwave system is used for standby on the STL telephone loop; also for some remotes. In general, remotes are handled by the telephone company, terminating at the studio.

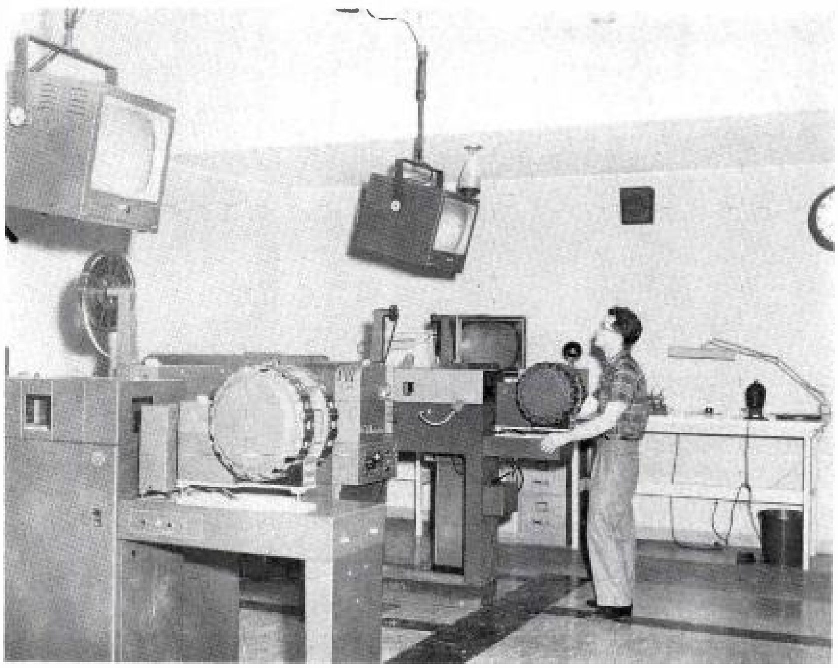
Video and audio cabling is done in floor gutters. These gutters are lined with a 4-inch copper strap, terminating in a ground pit—which is kept wet at all times. The rf co-ax lines out of the 10-kw transmitter terminate in a 2-position jack switch and the lines out of the 25-kw amplifier terminate in the co-ax switch, to permit by-passing of amplifiers in case of failure (see Fig. 19). Also, the input to the dummy load appears on the center position so that it is very easy to patch either the 10-kw visual or aural, or the 25-kw visual or aural output, into the dummy load for testing purposes. Since there were two large steel beams supporting the roof, it was advantageous to lay the sideband filter on its back and mount it near the ceiling, out of the way.

TV Antenna

A TF-12BH 12-Element Superturnstile Antenna was selected by consulting engineer A. Earl Cullum for San Diego terrain. It uses ¼ degree electrical, ¼ degree mechanical tilt. The antenna is fed out of a standard RCA diplexer with two 3⅛ co-axial transmission lines. The tower, an Ideco self-supporting structure, is located approximately 30 feet behind the transmitter building. Overall height of antenna is 252 feet, the tower itself being 179 feet. Height above MSL is 1049 feet.

Color TV

Management believed that KFSD-TV should go into the new building with some color equipment. Carrying all NBC color shows, it was felt that this should be augmented with local color film and slides. Along with RCA 3-V film equipment, there were installed a color bar generator and other test equipment. During test pattern periods, color bars are run for the benefit of TV servicemen and color viewers. The lighting equipment in Studio 1 is designed for live color originations, and sufficient space has been provided in equipment racks so that live color equipment may be installed. Engineering personnel have always attended RCA color TV seminars on the



The Film Room

The film projection room is located adjacent to the video master control position and directly opposite the film lab and film editing, so that the whole film operation is closely knit together.

The film projection room contains RCA 3-V color film and slide equipment, monochrome vidicon film chain, and TP-7 Slide Projector (see Fig. 12). Duct work in the floor has been extended into adjacent areas so that by putting in a door the tv tape area is accessible from projection. (It is designed for client and agency audition of tv tapes.)

The technical director changes slides and starts and stops the projectors by remote

FIG. 12. Film projection room. The operator is standing by the monochrome vidicon equipment. This consists of two TP-6A Film Projectors, a TP-7 Slide Projector, and TP-11 Multiplexer. To the left is RCA 3-V Color Film equipment (also used for monochrome). This consists of TP-6CC Film Projector, a TP-7 Slide Projector, and TP-15 Multiplexer. Ample space has been provided for expansion.

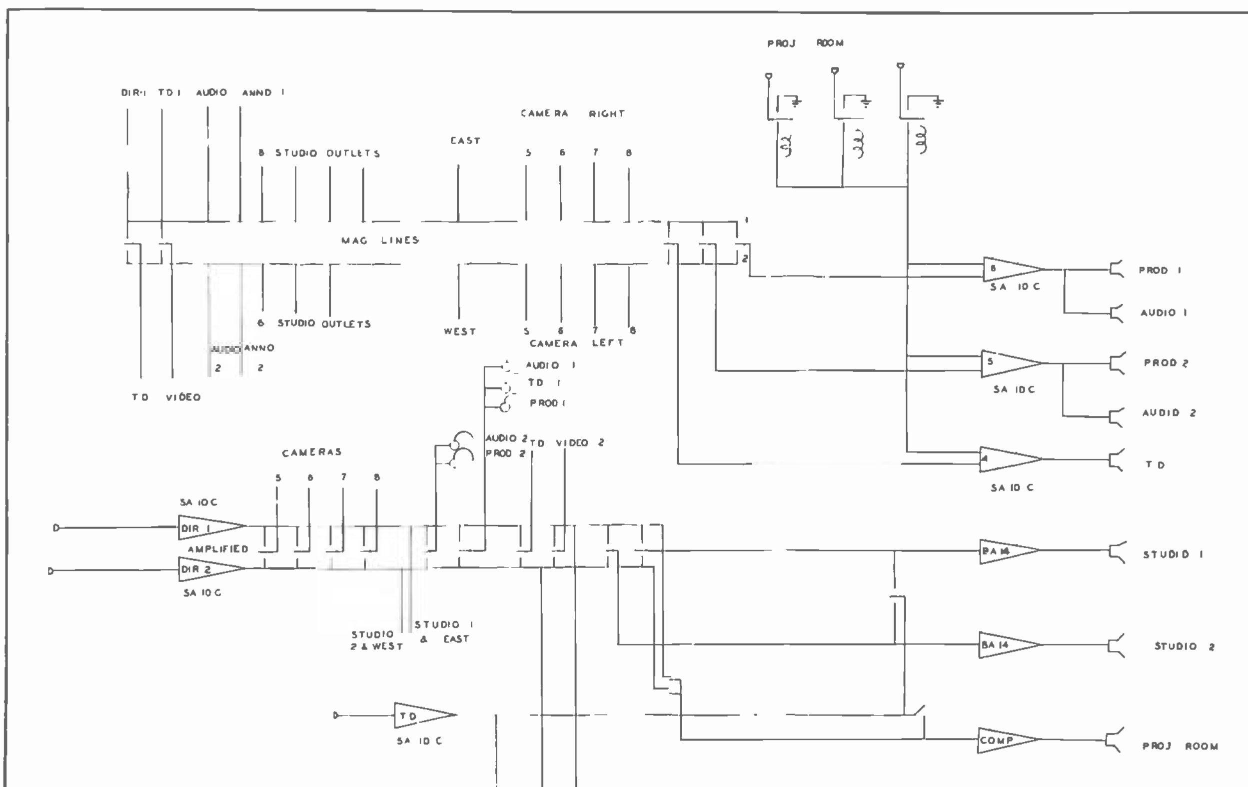


FIG. 13. Block diagram of studio "Snooper" intercom system.

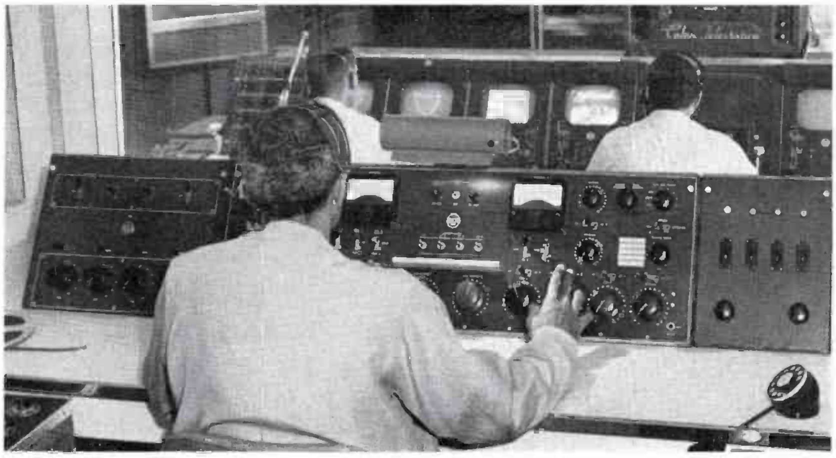


FIG. 9. Audio booth for Studio 2. Note main video switching and control position immediately in front of audio booth. Note BC-6 audio console.

part of the walls, acoustical tile is used. The ceilings in both studios were given several coats of acoustical plaster, then the tile was installed, to keep out the noise of aircraft flying overhead.

Master Control

The main video switching and control position is shown in Fig. 10. The basic video switching system is a dual TS-21 Relay Switcher. In Fig. 10 can be seen the remote stab amp control panel and projector control panels, used for controlling two TA-5C color-modified stabilizing amps and two TA-9A color-stabilizing amps. Projector controls are used to control three type TP-6 16-mm Projectors, two TP-7 Slide Projectors, and a Gray III Telop. Looking at Fig. 10, beginning at left, the TM-6 Monitor functions are as follows: first, Preview; second, Line. Monitor labeled No. 1 is No. 1 film camera. No. 2 is the 3-V color film system and above is the TM-21A Color Monitor. The right TM-6 Monitor is for TK-11 studio camera. Next are three field camera control units, used for both studio and field work.

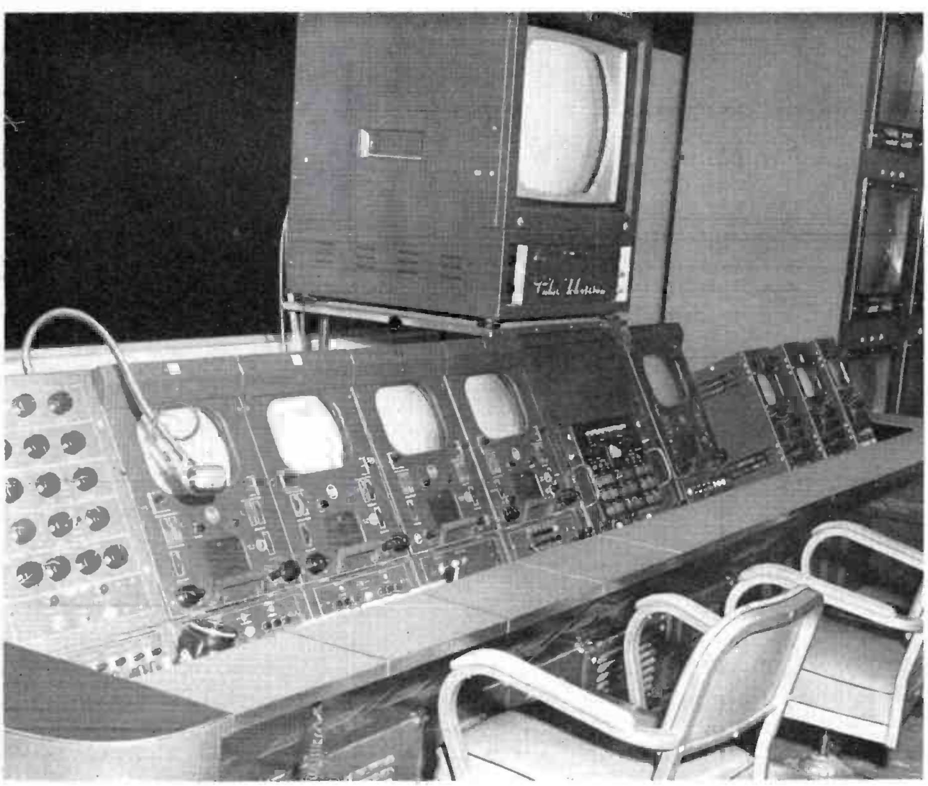


FIG. 10. Main video switching and control position.

FIG. 11. Camera patch panel enables any camera outlet in the studios, or out of doors, to be quickly patched into camera control equipment.

West Coast. KFSD cooperates with the local RCA distributor, his dealers, and tv servicemen participating in color tv meetings. The number of color receivers in the San Diego area is constantly increasing.

Radio Facilities

To consolidate KFSD operations, a radio section was incorporated in the new building. Offices, news department, control and studio areas are located here. The control room is newly equipped, including the BC-6 Console and its associated amplifiers (see Fig. 19). The combined radio-tv newsroom is adjacent to the lobby.

While radio and television are under the same roof, the competitive spirit between the two media remains. The radio transmitter is located about one mile east of the studios at Emerald Hills—the 31-acre site of a former golf course. Main transmitter is a BTA-5F, operating on a frequency of 600-kc with a power of 5000 watts, full time. The antenna system is a two-tower directional array. The towers are Ideco self-supporting, 416 feet in height. The transmitter building also houses the KFSD-FM transmitter, a BTA-10F, operating on 94.1 mc with an effective radiated power of 33,000 watts. The FM antenna is an RCA 3-Section Pylon.

The FM studios are located in the new building and both AM and FM signals are fed from the studio to the transmitter via telephone company leased lines.

For Present and Future

Management feels that it has completed a facility for KFSD-AM-FM and TV designed specifically for its needs, both present and future. Futhermore, with the stable San Diego climate, it has also been possible to develop such innovations as outdoor studio productions.

It is fortunate when a station is able to develop a complete plant in what is essentially a one-story structure. Furthermore, the KFSD building is so arranged that the main lobby is the focal point for all the various operations. The traffic flow within each operation is so controlled that a minimum number of steps are necessary.

After operating in this new facility for a year, no major flaws have been encountered; therefore, this type layout can be recommended as both efficient for the present and suitable for future expansion into live color and tv tape.

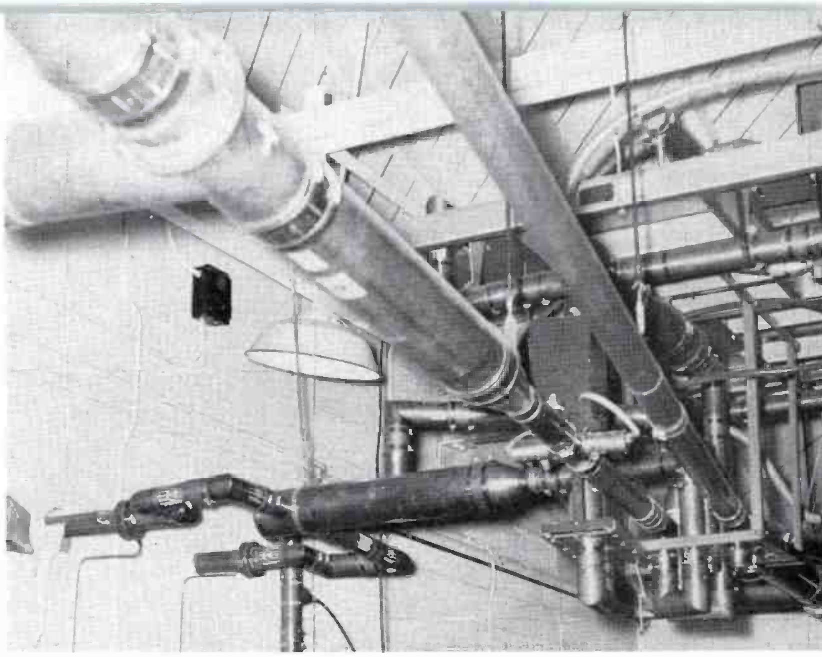


FIG. 18. Area at rear of transmitter showing sideband filter, suspended from ceiling. Also note co-ax switching system and diplexer feeding antenna. Below are high voltage transformer, dry air unit, and dummy load.

FIG. 19. Radio control position looking into radio station. Announce booth is to the right. In the background is control room of KFSD-FM.

Mr. James G. Rogers
President

William E. Goetze
Executive Vice President
and General Manager

Mr. LeRoy A. Bellwood
Vice-President and
Chief Engineer

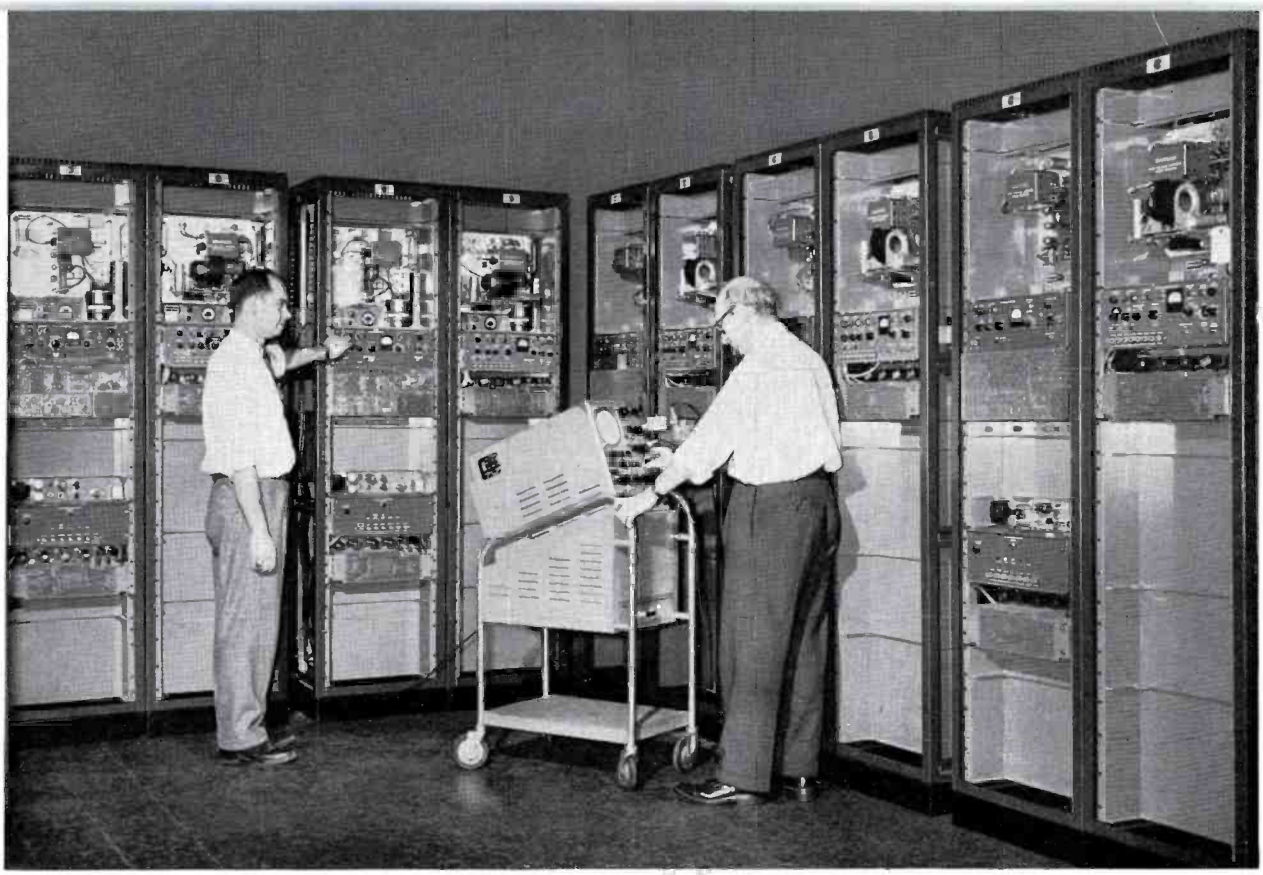


FIG. 1. TVM-1A Microwave Equipment set up for testing simulated 8-hop, 243-mile path of the TV microwave system soon to be installed for Radio Tupi, Brazil.

PRETESTING OF 8-HOP, 243-MILE MICROWAVE SYSTEM DEMONSTRATES CAPABILITIES OF TVM-1A EQUIPMENT

Differential Phase and Gain Measurements Indicate Satisfactory Performance for Systems Up to 16 Hops

by JOHN S. BULLOCK, VERNE S. MATTISON, JOHN H. ROE *Broadcast and Television Equipment Division*

Recent testing of a TVM-1A Microwave System for use in Brazil, indicates that this equipment can be used in systems of 8 to 16 hops, covering distances of several hundred miles. Prior to delivery, the equipment for Radio Tupi, Brazil, was set up at RCA engineering laboratories in Camden where it was operated in a system simulating the path conditions of the actual 243-mile route. The results establish the success of such an operation. The system delivers high-quality television pictures with good performance characteristics and little deterioration of picture quality. The engineering evaluation of this system will be of interest to the broadcaster considering a microwave installation because it demonstrates the performance reserve and reliability inherent in the TVM-1A Microwave Equipment.

8-Hop Reversible System

The installation in Brazil is to be reversibly interconnected between Rio de Janeiro and Belo Horizonte, a total distance of 243 miles. This is covered in 8 hops, the longest of which is 42 miles. A diagram of this installation is shown in Fig. 2.

The completed system will link four television stations. Terrain is predominantly mountainous, and the system is unique in that the lowest equipment site (Mt. Sumare) is at an elevation of 2397 feet, while the highest (Ouro Branco) is at 5111 feet. The sites were chosen with sufficient elevation and path clearance to avoid the need for high towers at any point in the system.

Both picture and sound signals are sent over the microwave system. A TSD-3A Sound Diplexer frequency modulates the sound on a 6.2-mc subcarrier and then mixes the subcarrier with the picture signal.

The Radio Tupi system makes extensive use of a line of new accessories available for unattended microwave repeater stations. These accessories provide various functions including fault sensing and reporting, remote control, rf switching and multiplexing. It also includes an 8-hop installation of RCA MM-5 Radio Relay Equipment, operating in the 450-mc band, to provide a service and control channel.

Setting Up the Tests

To determine experimentally the actual performance characteristics of the Radio Tupi 8-hop system, the transmitter, receiver, and sound diplexer units were set up in the laboratory to simulate the actual installation. Since the anticipated average input level to the receivers is −65 dbw, this condition was simulated by coupling each transmitter to the next receiver through a 70-db attenuator (actually exceeding the expected signal attenuation). With all eight hops connected in series (see Fig. 2), measurements were made of over-all amplitude-frequency response, 60-cycle square wave response, video signal-to-noise ratio (S/N), video signal-to-hum ratio (S/H), differential gain and differential phase.

Tests of differential gain were made using a Type WA-7C Linearity Checker with an appropriate filter network. Differential phase was measured with a linearity checker in conjunction with a WA-6A Color Signal Analyzer. Video frequency response was measured with the use of a Kay Lab Megasweep. Signal-to-noise ratio was measured by a specially designed meter which compares peak-to-peak signal directly with peak-to-peak noise. The resultant reading was converted to peak-to-peak signal/rms noise by the addition of an 18-db conversion factor. Signal-to-hum performance was measured with an oscilloscope, using a low-pass filter to exclude random noise.

Results of the Tests

Performance of a single hop is shown in Table 1. By extrapolating these figures, it is possible to predict performance over eight hops. Results of such extrapolation are shown in the first column of Table 2. Measured data taken from the 8-hop system is shown in the second column of Table 2. Discrepancies between predicted and measured values of differential gain and phase may be attributed partly to the measuring equipment which is not accurate in measurement of the very small values associated with a single microwave equipment and partly to the use of increased pre-emphasis (see below).

In addition to measuring the parameters described, a good quality color picture was sent through the 8-hop system and ob-

FIG. 2. Simplified diagram showing number of hops and distances covered by the Radio Tupi microwave installation.

TABLE 1

SINGLE-HOP PERFORMANCE SPECIFICATIONS TVM-1A MICROWAVE SYSTEM

	−64 dbw Input[1]	−70 dbw Input[2]
Video S/N, $\frac{\text{P to P}}{\text{RMS}}$	60.5 db[3]	55 db[3]
Video S/Hum, $\frac{\text{P to P}}{\text{P to P}}$	46 db	46 db
Differential Gain	8-db network 0.5 db 12-db network <0.25 db	0.5 db <0.25 db
Differential Phase	8-db network 1 degree 12-db network <0.5 degree	1 degree <0.5 degree
Video Response at 6 mc	0 to −0.5 db	0 to −0.5 db
Audio Response		
db down at 50 cycles	1	1
db down at 15,000 cycles	2	2
Audio S/N, $\frac{\text{RMS}}{\text{RMS}}$	73 db	73 db
Audio S/Hum, $\frac{\text{RMS}}{\text{RMS}}$	68 db	68 db

[1] Corresponds to 30-mile hop with 6-foot dishes.

[2] Corresponds to 60-mile hop with 6-foot dishes. This length of hop is not considered practical with 6-foot dishes because there is not adequate fading margin. The tests were made using 70-db attenuators because they were available.

[3] Unweighted, 10-megacycle band.

TABLE 2

8-HOP PERFORMANCE SPECIFICATIONS

70-DB Attenuation Per Hop

Equivalent to 60 Miles Per Hop with 6-Foot Parabolas

	Predicted[1]	Measured
Video S/N, $\frac{\text{P to P}}{\text{RMS}}$	46 db	46.5 db
Video S/Hum, $\frac{\text{P to P}}{\text{P to P}}$		
8-db Network	28 db	29 db
12-db Network	36 db	36 db
Differential Gain	4 db[2]	0.5 db[3]
Differential Phase	8 degrees at 50 percent APL[2]	Less than 2 degrees at 50 percent APL[3]
Video Response to 4.5 mc/s	±0.5 db	+1 db

[1] Predictions made by extrapolating from single-hop measurements of Table 1.

[2] Using standard 8-db pre-emphasis networks.

[3] Using 12-db pre-emphasis networks (APL, average picture level).

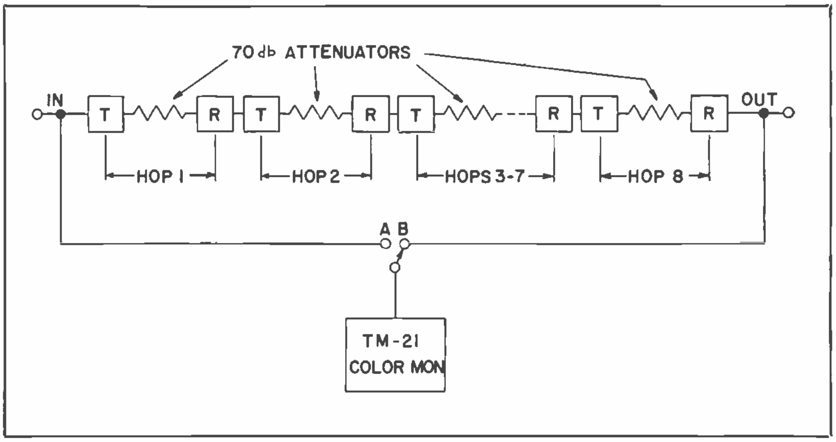


FIG. 3. Block diagram of the pretest setup of the 8-hop microwave system.

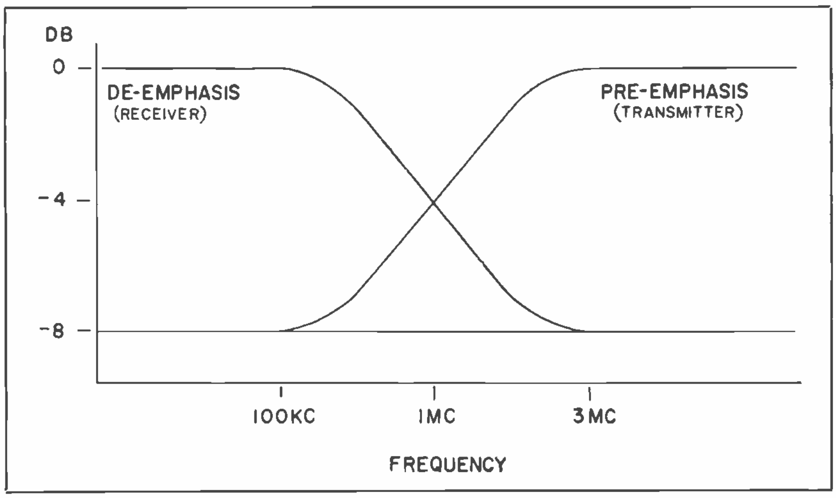


FIG. 4. Characteristic curves of a standard 8-db pre-emphasis network.

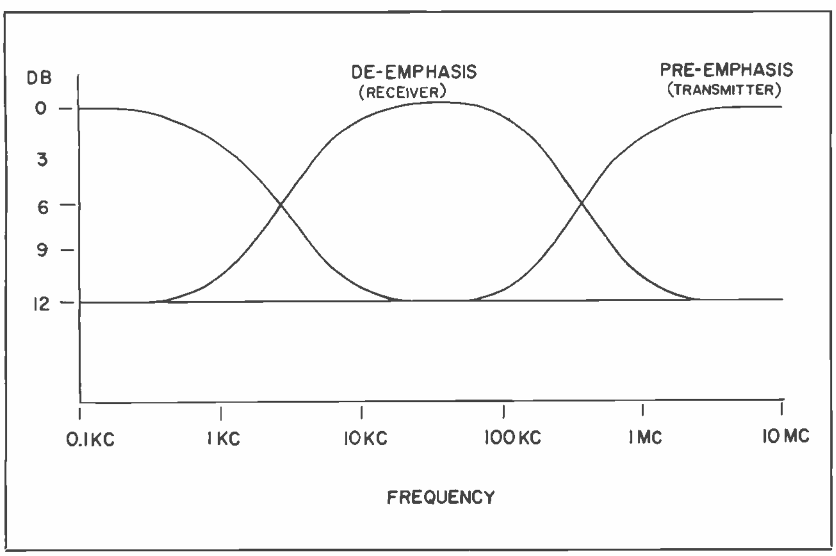


FIG. 5. Characteristic curves of the 12 db pre-emphasis network used in the 8-hop system.

served on a TM-21 Color Monitor connected for an A-B (input-output) test as indicated in Fig. 3. Observations of this picture by a large number of people indicated no observable change in picture quality after going through the system.

Use of Pre-Emphasis Networks

These networks are normally used with television FM microwave equipment as a means of reducing differential phase and differential gain. This is accomplished by reducing the frequency deviation between tip-of-sync and peak white level. Normally, 8-db networks having a response characteristic as shown in the diagram, Fig. 4, are used with the TVM-1A. This network results in a 3-to-1 reduction in differential phase and a somewhat smaller reduction in differential gain.

For extended multi-hop service, 12-db networks are utilized having a response characteristic as shown (see Fig. 5). This greater pre-emphasis results in a further improvement in both differential phase and differential gain in the order of 2-to-1. In addition, an improvement in signal-to-hum ratio is achieved by not attenuating the low-frequency signals in the pre-emphasis network. Thus, hum internally added to the signal is actually de-emphasized by the restoring network in the receiver.

Good for 240-Channel Telephone Service

The TVM-1A was designed primarily for use as a carrier of television signals. Its use in this service has proven so successful that studies have been initiated to evaluate the performance that might be expected from it in multi-channel telephone service.

A transmission system, used for a large number of narrow multiplexed channels, must have extremely good linearity to avoid crosstalk between channels. A widely used method of determining the performance of a system for this kind of service is to apply a flat-spectrum noise signal to the input through a filter which traps out a narrow band of the noise at a selected frequency. By means of a complementary filter at the output of the system, the received noise is measured in the narrow band only. Whatever noise exists there is the result of intermodulation, or other crosstalk effects. By making such measurements at different frequencies and noise levels, it is possible to predict the multi-channel performance of any system.

Noise-loading tests conducted on the 8-hop TVM-1A System indicate that it meets

CCIR[1] specifications for a 240-channel system. The significance of this result is that the equipment is highly suitable for as many as eight hops in multi-channel telephone service.

Satisfactory Performance for 16 Hops

Experimental justification has been achieved for the use of eight hops of TVM-1A equipment in a high-quality, color-relay system. The most encouraging results of the measurements are the 2-degree figure for differential phase and the 0.5-db figure for differential gain. On the basis of these alone, it should be possible to predict satisfactory performance over 16 hops with no more distortion of this type than is commonly encountered in the transcontinental microwave links used in network programming.

Signal-to-noise ratio (S/N) is sufficient so that there is no apparent addition to the original camera noise. It should be noted that the —70 dbw input is considerably lower than the input power normally used. It corresponds to transmission over a 60-mile path using only 6-foot dishes. If the path were reduced to 30 miles, which is more typical of a case where 6-foot dishes might be used, the resulting S/N would be 51.5 db. Addition of S/N for X identical hops is given by S/N overall = S/N per hop —10 log X.

The merit of increasing the pre-emphasis from 8 to 12 db is apparent in the low values of differential phase and gain obtained. The use of the band-pass pre-emphasis networks illustrated in Fig. 5, as compared to the simpler networks of Fig. 4, yields a substantial improvement of 7 db in signal-to-hum ratio, with a final value of 36 db for eight hops.

It is significant that the tests conducted on the Radio Tupi system have shown widened horizons for equipment of this type where there is demodulation to base band and remodulation at each repeater. Successful operation in many medium-distance systems (200-300 miles) can be expected.

Multiple-Hop Installations

The principal features of the TVM-1A Microwave Equipment—increased power (one watt), excellent stability, excellent differential gain and phase characteristics, transmitter AFC, and wideband transmitter picture monitoring—have made it ideal for multi-hop applications. One of the first installations was a 3-hop system installed by WHIS-TV[2] between Roanoke, Virginia, and Bluefield, West Virginia. Its successful operation stimulated other installations of similar magnitude (see Table 3). Most of these link widely separated broadcast station facilities; but some, such as these for Microwave, Inc., and Midwest Video Corporation are the arteries feeding community antenna systems. In any event, the successful use of these microwave systems, demonstrates for the broadcaster a practical and economical means for distribution of television programs.

[1] CCIR—Consultative Committee, International Radio.

[2] "WHIS TV Three-Hop Microwave System," *Broadcast News*, Vol. No. 87, Feb., 1956.

TABLE 3

MULTIPLE-HOP INSTALLATIONS OF TVM-1A EQUIPMENT

Customer	From	To	No. Hops	No. Channels	Features	Hop Lengths, Mi.	Application
WHIS, Bluefield, W. Va.	Roanoke, Va.	Bluefield, W. Va.	3	1		15, 38, 12	TV Bdcst.
WDMJ, Marquette, Michigan	Stephenson, Michigan	Marquette, Michigan	3	1		28.5, 31, 23	TV Bdcst.
KLTV, Tyler, Tex.	Dallas, Tex.	Tyler, Tex.	3	1		28.5, 36, 28	TV Bdcst.
Microwave, Inc.	Spearman, Tex.	Liberal, Kans.	2	2	Separate Ant.	32.5, 40.8	Community Ant.
KAYS, Hayes, Kans.	Chase, Kans.	Hayes, Kansas	2	1		30, 35	TV Bdcst.
Saskatchewan* Gov't Tel. Regina	Greenfield, Sask.	Yorkton, Sask.	3	1	Diversity on First Two Hops. Branch from Trans-Canada Net.	39, 26, 1.3	TV Bdcst.
British Columbia* Tel. System	Hendly, B.C.	Kamloops, B.C.	4	1	Hot Standby	37, 40, 33, 15.5	TV Bdcst.
	Hendly, B.C.	Kalowna, B.C.	2	1	Hot Standby	30, 24	TV Bdcst.
KGLD, Garden City, Kansas	Hanston, Kans.	Garden City, Kans.	2	1		36, 37	TV Bdcst.
Midwest Video Corp.	Pine Bluff, Wyo.	Rapid City, S. Dak.	5	3	RF Multiplex into Single Antenna.	39, 44, 38, 80, 29	Community Ant.
WBTV*	Charlotte, N. C.	Florence, S.C.	4	1	Reversible	14, 26, 27.5, 26	TV Bdcst.
WMTW, Mt. Washington*	Boston, Mass.	Mt. Washington, N.H.	4	1		8, 25, 50, 63.5	TV Bdcst.
WCYB, Bristol, Va.	Knoxville, Tenn.	Bristol, Va.	3	1		32, 32, 47	TV Bdcst.
Radio Tupi, Brazil*	Rio de Janeiro	Belo Horizonte	8	1	Reversible	1.5, 40.5, 42, 25, 30.5, 28.5, 33.5, 41.4	TV Bdcst.

* In process of installation.

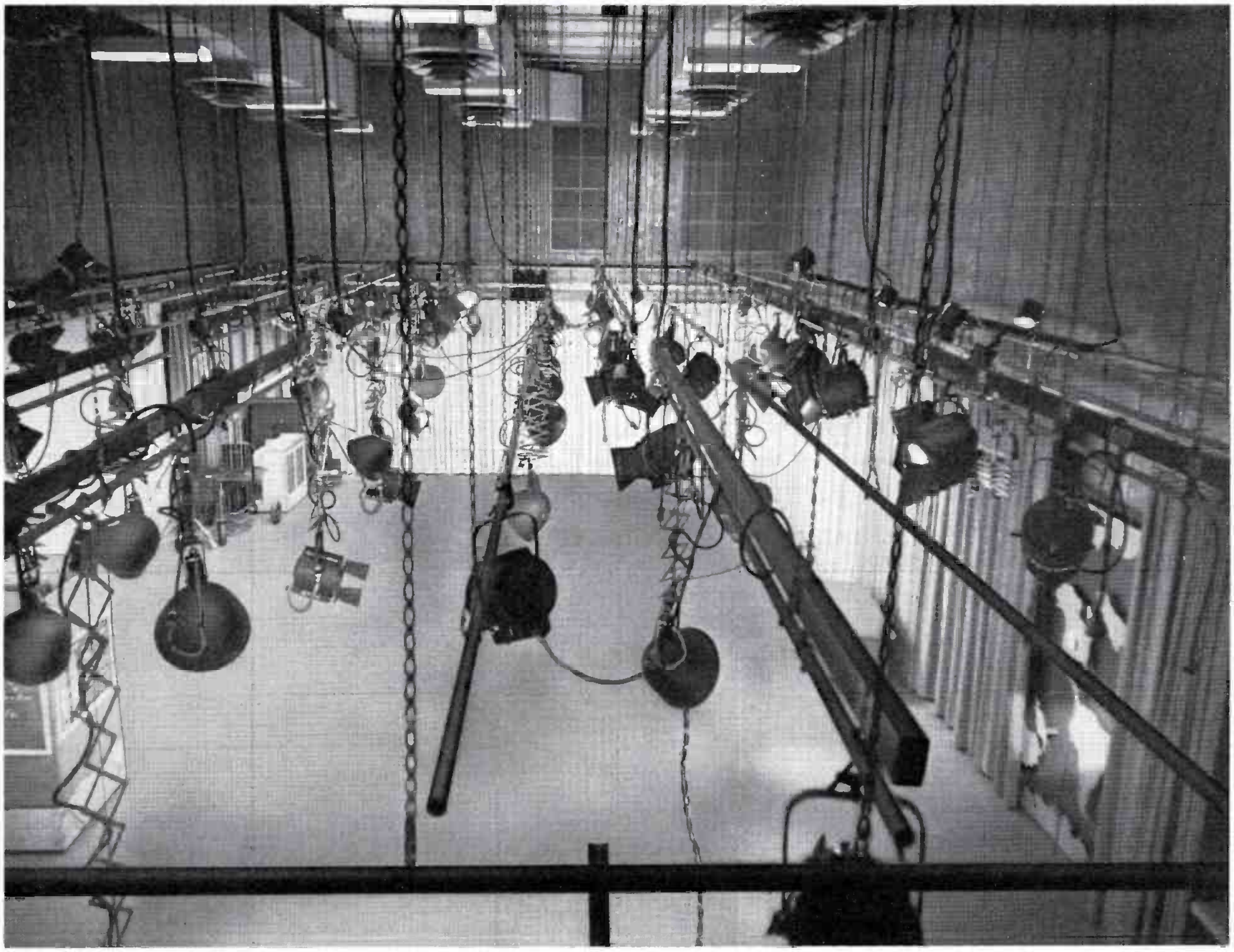


FIG. 1. Studio view looking down through chain-suspended grid. Although this studio is capable of handling modest color now, all-color operation will require the alternate pipes (which now have no outlets) to be equipped with connector strips similar to the ones shown. Note the clean, neat lines of the grid installation.

ADAPTING STUDIO LIGHTING FOR COLOR TV

by HERBERT R. MORE
Kliegl Brothers, N. Y.

Television station operators who are now formulating plans for live color productions, will be interested in methods by which they might adapt existing black and white lighting facilities and techniques for color. Experiences of TV stations who have made the adaptations show that they can be accomplished quite easily and with very little obsolescence of present equipment. This article presents the planner with a practical analysis of how to adapt a monochrome lighting installation for color. It presents basic considerations in planning, introduces new equipments, and discusses how several TV stations have colorized their lighting facilities. Actual conversions from monochrome to color as well as new color installations are discussed and illustrated.

Light Intensity

In general color requires greater light intensity than black and white. Stations have found that two to three times as much intensity is needed, depending on individual station preferences. This requirement can be satisfied by any one or a combination of the following methods:

1. By raising the wattage of the existing fixtures using higher wattage lamps wherever available. For example, the 18-inch Scoop from 1000 to 1500 or 2000 watts; the 6-inch Fresnel from 500 to 750 watts, the 8-inch Fresnel from 1000 to 1500 watts—to 2000 for some units on the market.
2. By adding more fixtures of the same type and wattage. This is especially desirable in low-ceiling studios (12 to 14 feet).
3. By adding higher wattage fixtures. For example, where 2000-watt spots are used in black and white, 5000-watt spots are used in color. These larger wattage units are most applicable in high-ceiling studios (20 to 30 feet).

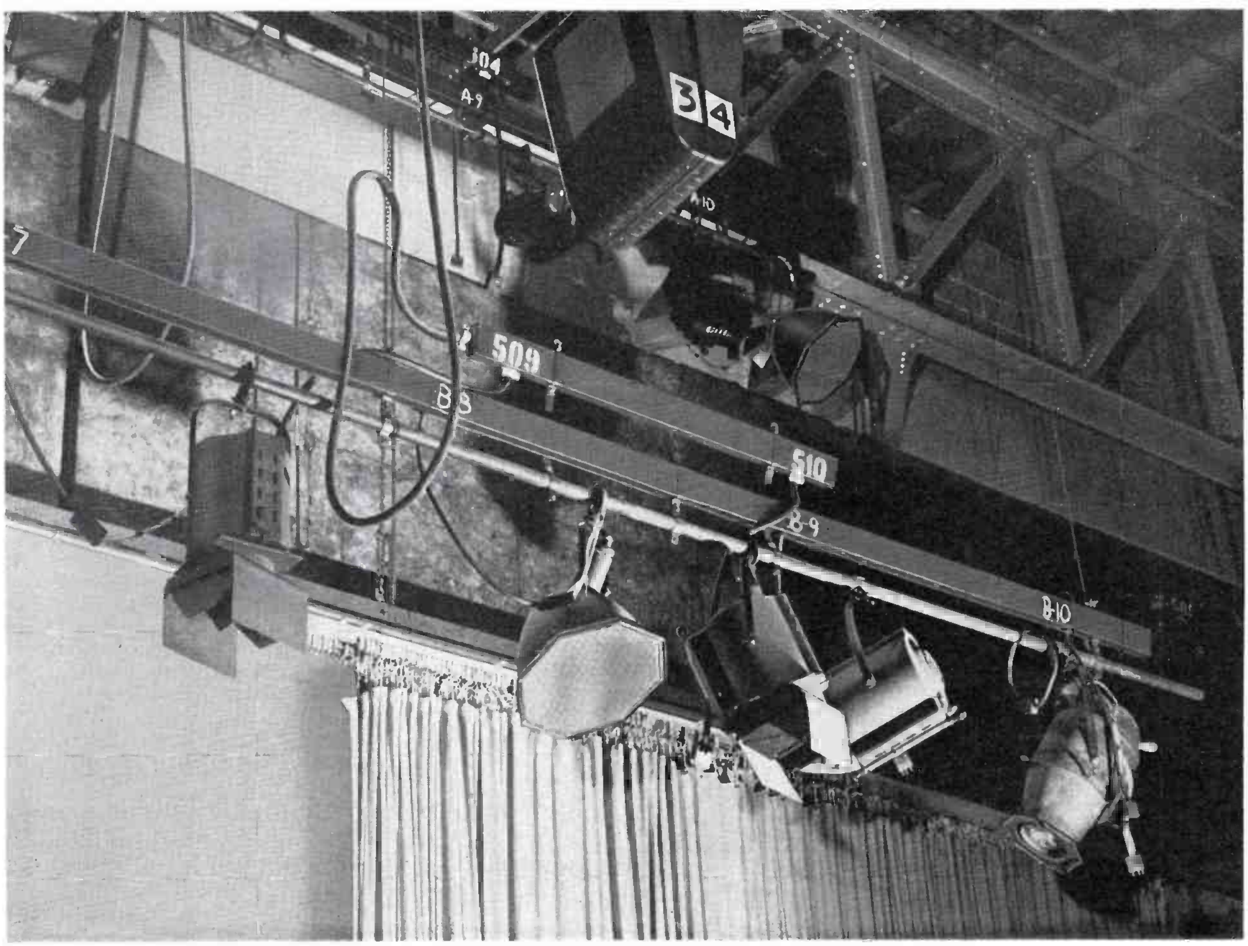
Using the same quantity of lighting fixtures and increasing lamp wattage will mathematically increase lighting intensity. However in practice it has been found that excellent color pictures result from evenly lighted scenes. In order to get this picture quality, light beams should overlap to cover acting areas with an even distribution of light. To accomplish this, it may be necessary to install additional fixtures more closely spaced along the lighting grid.

In the final analysis no one of the foregoing methods is used exclusively; rather a combination of all serves the most practical purpose. The exact proportions of each will depend upon the ceiling and grid height of the studio. For example, high ceiling studios use more 5000-watt units than low ceiling studios.

Number of Receptacles

The size and number of lighting receptacles should be checked to make sure they will accommodate lighting fixtures to be installed. Extra outlets can be conveniently supplied in a number of ways. Additional electric battens can be mounted between existing ones as shown in Fig. 1; or the batten may be installed above an existing one as shown in Fig. 2. In any case these extra outlets are very easy to install.

FIG. 2. When this studio went to color, all the available pipes had been filled with connector strips containing 2000-watt outlets. The 5000-watt outlets required for color in such a high ceiling studio were furnished by the double battens such as the one shown, (outlets Nos. 509 and 510).



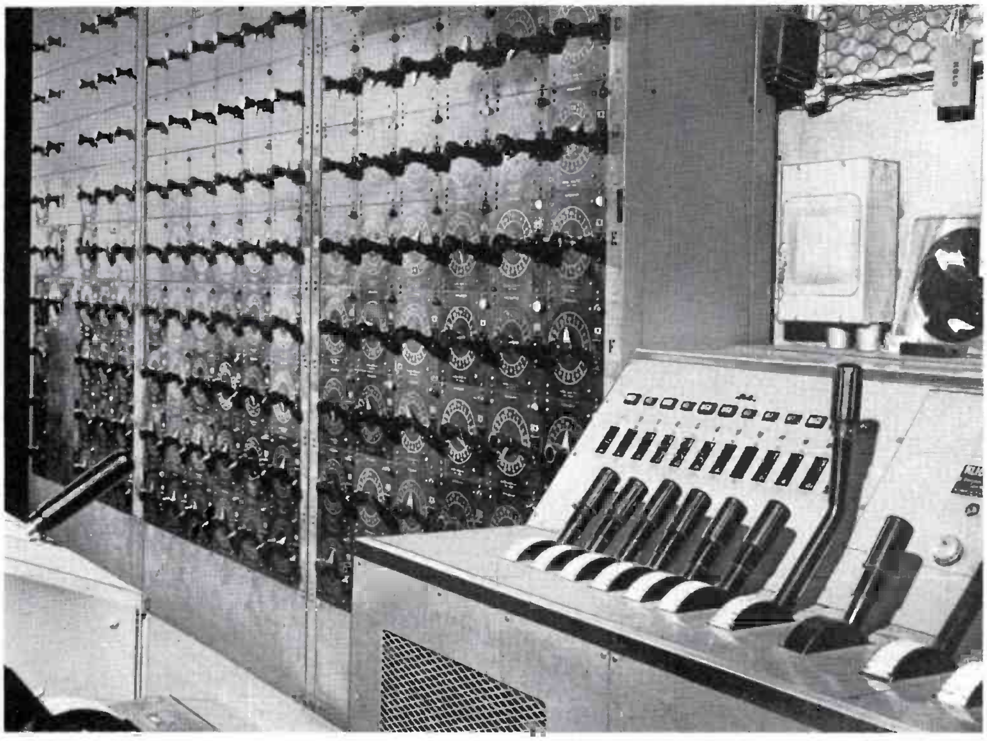
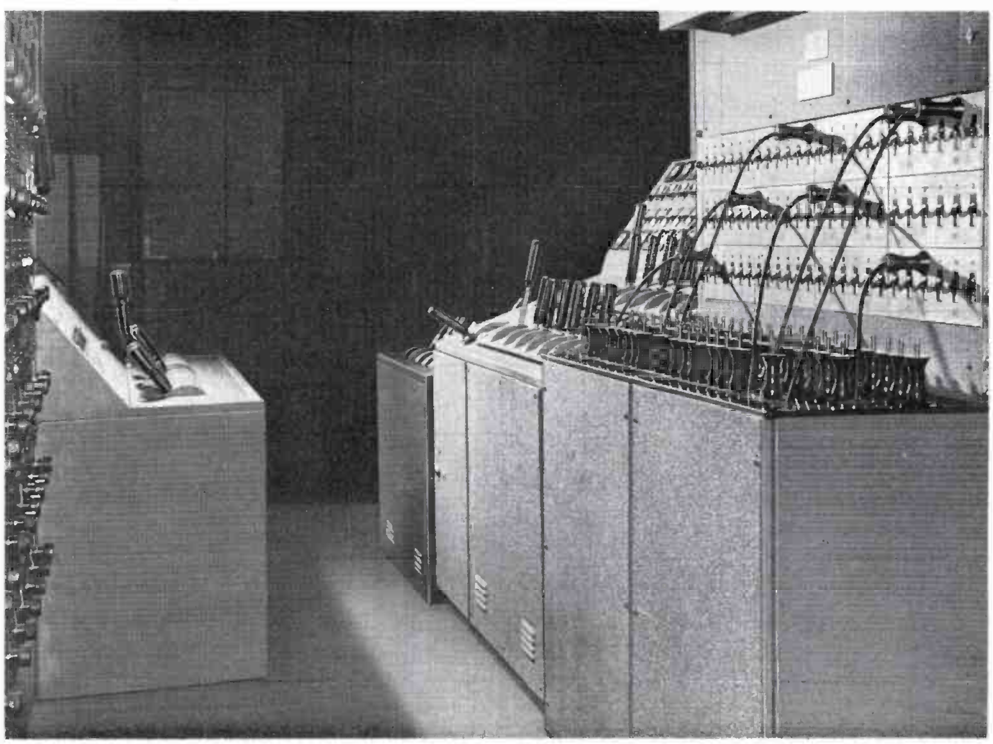


FIG. 3. Original lighting board containing 108 20-ampere Rotolectors, 12 40-ampere non-dim circuits and 12 4000-watt dimmers. Forty-one additional Rotolectors (upper left) and six 5500-watt dimmers (lower left corner) were added for the transition to network black and white. A second bank (lower left corner) shows part of the dimmer bank added for color.

FIG. 4. Same board as shown in Fig. 3, but viewed from the opposite direction. On the left are the original Rotolectors and dimmers. Far right of center is the dimmer bank added for network black and white. From back to front are the dimmer bank with 12 6000-watt dimmers and 12 6000-watt non-dimmers and the Saf-patch cross-connecting panel containing 70 5000-watt male plugs and 72 5000-watt female jacks, added for color.



Lighting Control

Existing Patch or Rotolector cross-connecting control panels should be checked to be sure they will adequately handle color requirements. Modifications can be accomplished by adding to the existing unit; i.e., installing another Rotolector or Patch board. Figures 3 and 4 illustrate how a network installation moved from a standard black-and-white setup to heavy-load network black-and-white and ultimately to color by block building of control units.

In new studios, adequate wattage in the dim and non-dim circuits is obtained by using any of the following.

1. 6000-watt dimmers (see Fig. 5),
2. 7000-watt Thyratron electronic dimmers,
3. 10,000-watt Magnetic Amplifier (Mag. Amp.) dimmers,
4. 10,000-watt Silicon Controlled Rectifier (SCR) dimmers.
5. 100 ampere non-dim circuits.

The recently introduced SCR and Mag. Amp. types are the only dimmers which can handle loads of 10,000 watts and higher. Both also offer the advantage of preset control.

Dimmers

In black-and-white telecasting dimmers serve a variety of functions. They are rarely used for overall fading of the entire set, but rather for *adjusting the contrast between front, back and side lighting*. They are also used for effects lighting to create silhouettes, transitions, and so forth.

Dimmers can be equally useful in color telecasting. In color, *subject lighting* is rarely dimmed except for unusual dramatic effect. This is the case because any drop in Kelvin temperature (which takes place as lights are dimmed) will result in hue shifts of subject color. However, dimmers can be used on *background* and *base lights* to (1) show changes in the time of day (accomplished by dimming down the background and base lights until the desired effect is obtained); (2) complement the action or mood by means of dimmers and colored filters (Cinemoid), to change background color; (3) cut down scenery construction costs (using the same set for several scenes by merely changing background color); (4) make smooth transitions from one scene to another (in medium and long shots, the entire scene may be dimmed—with good effect).

By using dimmers in the manner described, they become a useful production tool to provide dramatic effects while preserving the excellent quality of the color picture.

Power

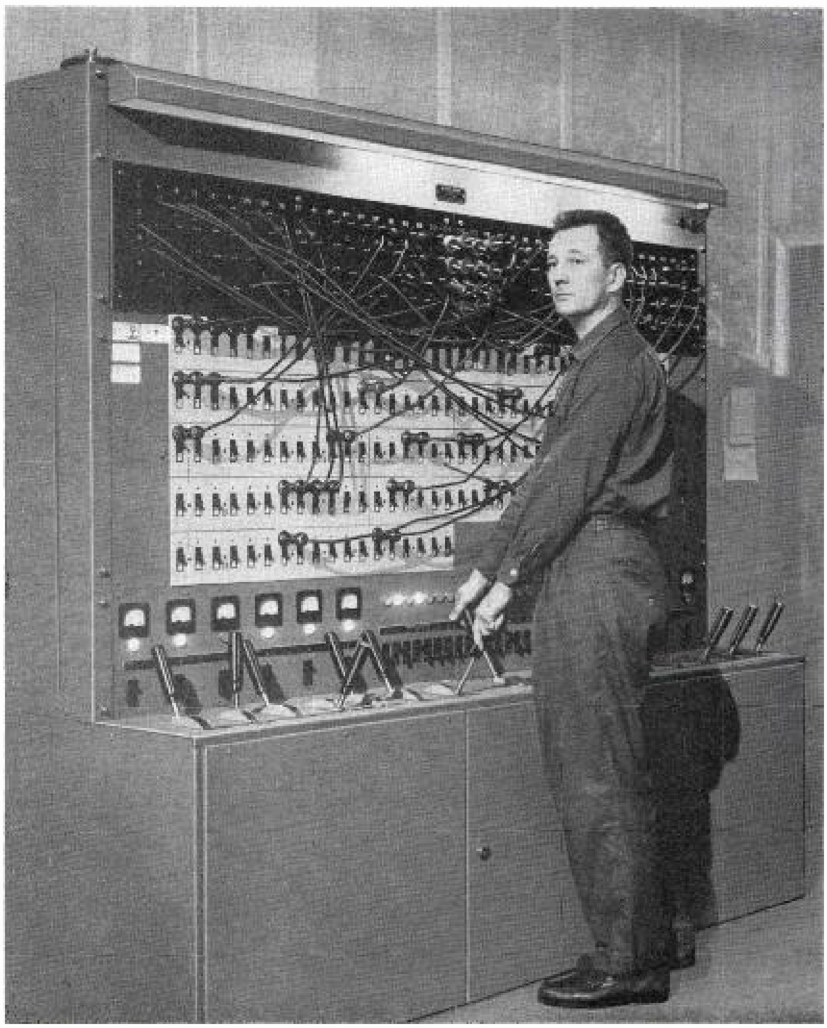
Power facilities should be checked to see that they will handle the heaviest color load. A good rule of thumb is: "Twice the load—twice as many amperes." For example, if the heaviest black-and-white load is determined to be 200-amp. 3-phase, you may expect the color load to be 400-amp, 3-phase. This power can be obtained by either installing a full color-size feeder immediately (see Fig. 5) or using a conventional monochrome-size feeder for the present and providing additional empty conduit for future color use.

Although three times as much light may be used, in practice only twice as much power need be provided. The reason for this apparent discrepancy is that the operating personnel seem to be more careful to turn off settings not in actual use. Fewer sets are left lighted and burning than is the case in black and white. Also the lumen per watt increase that comes from using higher wattage lamps gives additional efficiency.

WBKB Preparations for Color

A novel way of preparing for the 5000-watt outlets and increased feeder capacity that may be required for future color is

FIG. 5. Lighting control center for the 40 by 70-foot studio shown in Fig. 1. This studio contains 144 20-amp and 15 50-amp counter-weighted male plugs and 12 20-amp and 42 50-amp female Saf-patch jacks. Although six to eight dimmers might suffice for black and white, the additional capacity for color was obtained by furnishing a total of 12 6000-watt dimmers. A full size 600-amp feeder with silent acting main switch is located in the center of the board. The 15 non-dims are of the 100-amp size.



used by ABC in its new studios in Chicago. Two conduits are brought into the light control center, with sufficient capacity and copper for monochrome or color use. The busses in the dimmer bank are sized for present as well as future loads. The Rotolector cross-connecting panel is wired throughout with 50-amp wire. Twenty of the group master busses are stepped up from the usual 50-amp size to 100-amp, and four more to 200-amp. The circuit breakers in each Rotolector, however, are kept at the current 20-amp size; the thought being that when the studio goes to color, any or all of the Rotolectors can be made into the 50-amp size by merely changing the circuit breaker.

Overhead in the studio, the connector strips feeding the spotlights are internally wired for 50-amp capacity, although the present pigtail is of the 20-amp size. The strip is further specially designed so that a 50-amp pigtail can be substituted for a 20 using only a screwdriver. In this convenient manner any pigtail can become 50-amp in size. Since the larger outlets can now be located anywhere in the ceiling, it will never be necessary to use unsightly and costly No. 6/3 extension cables to feed the 5000-watt spotlights. Program and operations people will not complain about the location of the outlets because of this built-in adaptability. Figure 6 shows details of the connector strip as well as a plan view of one of the WBKB studios.

Air Conditioning

The load for air conditioning in black and white is calculated on the basis of 20-to-40 watts per square foot of studio, in color, 60-to-80 watts per square foot. The determining factors in the variations are the size of the studio and the ceiling height. Large, high-ceiling studios use 20 watts per square foot for black and white and 60 for color. Small, low-ceiling studios use 40 watts per square foot for black and white and 80 for color. The reason for this is that all of a large studio is not used at the same time. Also the heat can collect in the upper portions of high studios and be drawn off over a period of time. In small, low-ceiling studios usually all of the studio is lit at the same time. Also, since the heat from the lights cannot rise very far it must be removed immediately.

One method of cutting down the size of the air conditioning plant is that used by WFGA, Jacksonville, Florida. The Anemostats in the studio ceiling are of the adjustable type that can be raised and lowered. In practice they are lowered to come just below the lighting units. The cold air now goes directly down to the acting areas without passing over the hot lights, and the radiant heat from the housings of the lighting units goes straight up into the upper ceiling by natural convection and is exhausted from the building. With this method, only the heat from the light beams has to be dealt with in determining the size of the cooling system.

A new device which affords a partial solution to the heat problem is the infrared reflecting lens. This device removes 65 percent of the infrared from the light beam, fits into the color frame slot in standard barn doors, passes 85 percent of the light without distortion and is modestly priced. For studios that cannot increase their cooling plant this device can be very useful.

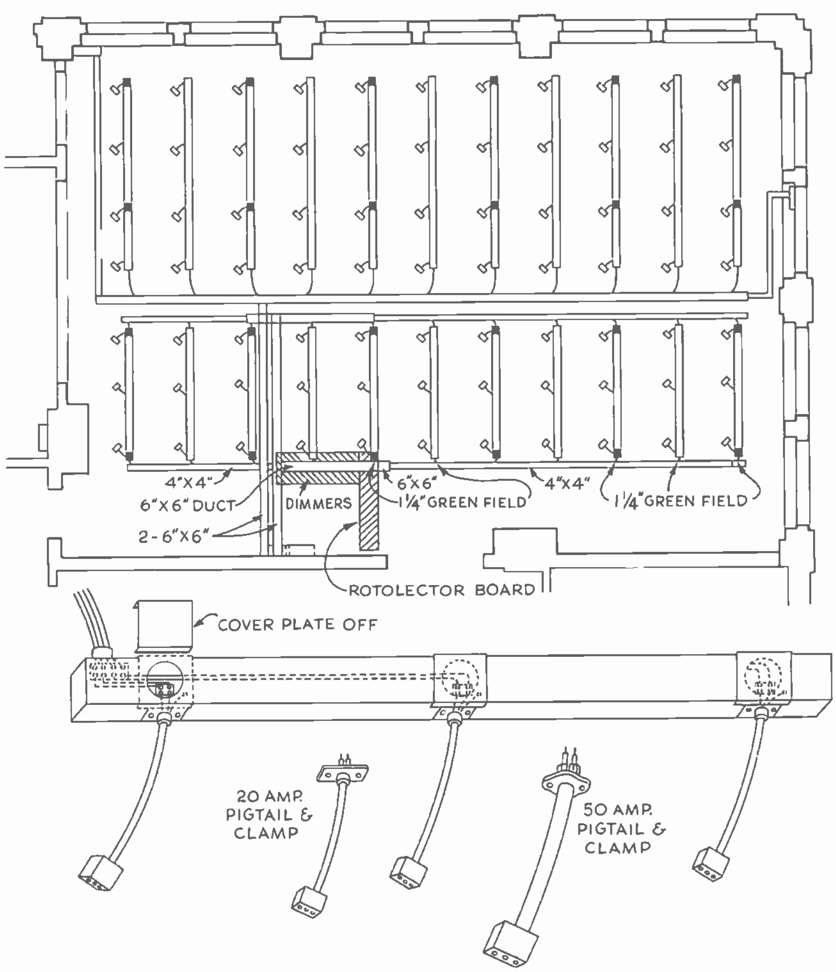


FIG. 6. Lighting plan of one of WBKB studios. Detail in the lower third of this drawing shows how a 50-amp pigtail can replace a 20-amp in the connector strip. Note that each pigtail has its own terminal block and access plate. In this installation every lighting unit is equipped with its own pantograph hanger to provide individual height adjustment from the fixed pipe grid.

Lighting Costs

It should be interesting for prospective color-casters to learn that no additional personnel are required for lighting color operations. The same size crew that hangs a black-and-white show will do the job.

How much extra time, then, is required by the standard crew to hang a color show? Surprising enough it is neither three times as much, nor twice as much, but only one-third more time. This is good news, based not on estimates, but on the operational figures of those who are actually telecasting in color today.

Therefore, with proper thought and preplanning, the transition from black and white to color can be a smooth operation that is not excessive in cost, nor wasteful of present equipment.

The Magnetic Disc Recorder is shown in operation in the WDAS Control Room. Observing the operations are (left to right) Jerry Grove, Program Director of WDAS; G. C. Weilenmann and Paul Wildo of RCA; F. Unterberger, Chief Engineer and J. Reese, Engineer (seated) of WDAS . . . Mr. Grove (left) is comparing the conventional transcription with the new magnetic disc (in hands of G. C. Weilenmann, at right).

FIRST RCA MAGNETIC DISC RECORDING SYSTEM DELIVERED TO WDAS PHILADELPHIA

The first production unit of a magnetic disc recording system developed by the Radio Corporation of America for radio broadcasting has been delivered to station WDAS in Philadelphia.

The RCA magnetic disc system was designed to facilitate the recording and playback of commercial announcements and similar radio material.

"The RCA system provides an economical method of preparing and presenting a vital portion of the average radio station's daily program," said E. C. Tracy, Marketing Manager, RCA Broadcast and Television Equipment Department. "The magnetic discs may be erased and re-used time and again. In tests conducted by RCA, discs have been replayed 10,000 times without any detectable wear or loss of quality."

The discs employed in connection with the RCA system are the same physical size as the 45 RPM records used on players in the home. Up to 70 seconds of material can be recorded on each side of the disc.

The WDAS equipment consists of an RCA BQ-51A Turntable with the BA-51A Record/Reproduce Amplifier, magnetic head, tone arm and magnetic eraser.

The discs may also be used on RCA's BQ-104 Automatic Turntable which has a capacity of 100 discs or a total of 200 sides. As many as ten automatic turntables can be incorporated in an RCA automated broadcasting system, which operates either through a master control panel or from a perforated paper tape. In an automated system, the magnetic discs bear special cue tones to permit automatic switchover to the next desired recording. The automated system can include up to ten combinations of turntables for playing standard records, or magnetic discs.

AUTOMATIC LIGHT CONTROL FOR COLOR AND MONOCHROME VIDICON FILM CAMERAS

Newly Developed Equipment Provides Smoother, Simpler Programming; Compensates for Widely Varying Film Densities and Helps Produce Better TV Pictures

by W. L. HURFORD, W. J. NEELY *and* A. REISZ, *Broadcast and Television Engineering*

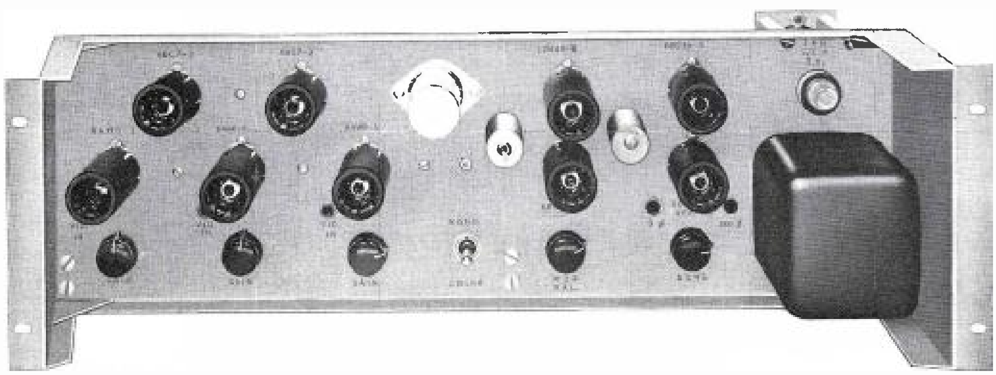


FIG. 1. The automatic light control amplifier is housed on a standard bathtub chassis for mounting in a 3V pedestal, TP-15 Multiplexer pedestal or a cabinet rack.

Vidicon cameras have become practically universal for the reproduction of monochrome and color film. The tube's relative simplicity, low cost, small size, essentially constant black level, nearly constant gamma, low noise, and excellent resolution capabilities have proved ideal for TV film applications. In order to realize the maximum benefit from such characteristics, camera equipment must be designed to take full advantage of them.

One especially important factor in realizing these benefits is the need for careful control of the light reaching the vidicon. On the one hand, there should be enough to assure good signal-to-noise ratio, and on the other hand, the light must be kept below the threshold where distortions in focusing and registration occur. A recently developed RCA automatic light control equipment fulfills the requirement for both black-and-white and color film camera chains.

Why Automatic Light Control?

Although it may appear desirable to use video AGC for controlling the output signal level from a vidicon film camera, the use of video AGC to compensate for a wide range of film density can lead to unsatisfactory signal-to-noise ratio in one direction, and to image distortions in focus and geometry in the other.

Because film processing is not adequately standardized, the highlight transmission of film material varies over a wide range. Some control to make it appear reasonably constant to the vidicon is therefore required. Experience has shown that extremes of film highlight transmission may have a density variation of nearly 2.0 (from almost clear to about 1-percent transmission). While there is considerable effort toward better control in the preparation of film for TV, it is reasonable to assume that there will be more variation than the vidicon can accommodate for a considerable time to come.

Variations in highlight transmission are also encountered in negative films, where the highlights in the film correspond to transmitted picture black. These variations in transmission then give rise to a highly unstable black level. A light control system which acts to stabilize white level when positive film is used will automatically stabilize black level when negative film is used, with no change of connections or adjustments. Conditions in both cases will correspond to proper operating light levels on the vidicon.

Adjusting the lens iris to cover such a range is impractical because vignetting or imaging of the filament of the projector lamp results with the use of too small an aperture. Light-intensity control by adjusting the lamp filament voltage is reasonably satisfactory for black-and-white systems but results in color-temperature variation and color unbalance in a color system. While control of target voltage of vidicons is a practical means of controlling signal level for monochrome. this method is not suitable for color because it would be very difficult to track the three individual channels.

An approach which meets the requirements of both monochrome and color is therefore to interpose an adjustable neutral density filter in the light path between the source and camera. Density varies smoothly and linearly in a band about the periphery of the disc. Manual control from the operating position supplies correcting information to a servo amplifier. which delivers power to a motor and disc assembly. Thus. the disc may be rotated until the desired peak white video level is achieved. In either a black-and-white or color chain. properly set up. this is the only major operating control requiring frequent attention. If this function is made automatic, reasonable performance under unattended operation is feasible and an operator can be freed from a tedious task to concentrate on other aspects of operation.

Requirements of an Automatic System

In order to provide optimum performance in practical TV film programming, a satisfactory automatic light control (ALC) system must have the following basic characteristics:

1. It must act rapidly to re-establish intelligence after a transition involving a large change in highlight transmission such as may occur between slides or at film splices.
2. It must not act so fast as to create rapidly fluctuating background brightness (color saturation shifts in a color reproduction) as a function of changing proportions of white.
3. It must hold peak level within an acceptable tolerance for best utilization of the television systems limited contrast range of about 20 to 1 and for prevention of system overload. In particular, transmitter modulation must not approach zero carrier level for any significant interval lest "intercarrier buzz" become annoying. Any reasonable duty cycle should give rise to nearly nominal level.
4. It must approach correct level with a minimum of hunting to avoid noticeable "winking" of the reproduction and still provide a rapid attack rate.
5. It must provide selective level setting in a color system wherein the highest primary signal level controls the light.
6. It must provide override control for cases where human intelligence might select a more suitable adjustment.
7. It must provide for manual operation in case the automatic control fails, or to permit convenient setup, introduction of special effects such as a deliberate fade, or the use of precise manual adjustment when a skilled operator is available with carefully previewed material.
8. It must function ahead of other signal processing controls such as master pedestal, gamma, shading, etc.

Equipment to Meet These Requirements

The RCA automatic light control equipment is designed to meet the foregoing requirements and function with existing black-and-white and color film camera chains, projectors, and multiplexers. Neutral density disc and servo-motor assemblies are available in the TP-35CC and TP-6CC Projectors, and also available as accessories for use with the TP-3, TP-7, and TP-8 Slide Projectors. Manual controls presently used with these disc equipments may be replaced with the automatic system.

Application of the ALC system to a TK-26, 3-V Color Camera is illustrated by Fig. 2. Here the ALC amplifier samples the three color signals from the camera. It selects the information from that one of the three channels which has the highest level and from it derives an error (or correcting) signal which is fed to the ALC remote control unit where a switch selects an *automatic* or a *manual* error signal. The selected signal is fed to the relay control unit, which, actuated by the multiplexer,

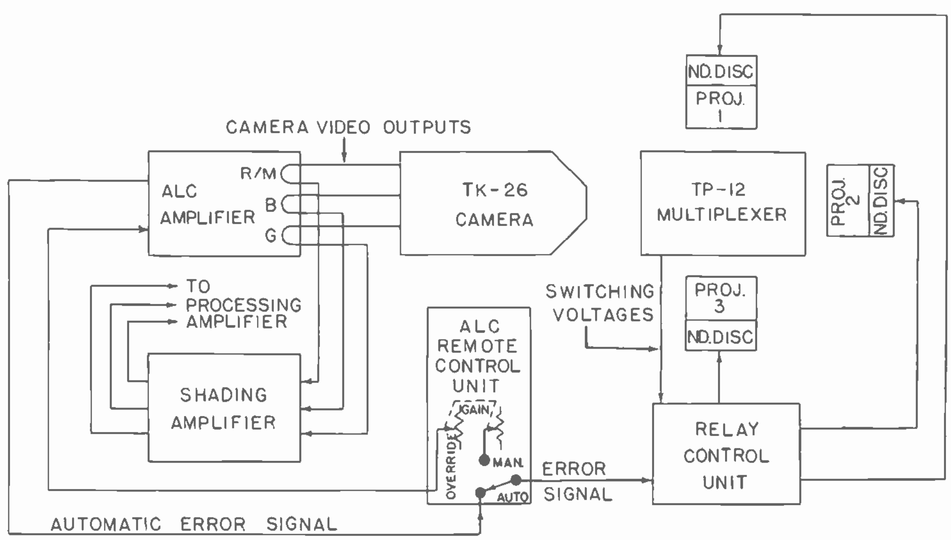


FIG. 2. Functional block diagram showing operation of automatic light control equipment in a color film system.

feeds the error signal to the servo amplifier and motor on the neutral density disc assembly. In turn, the disc rotates until the video signal is restored to a predetermined standard level. The relay control unit also provides controls for individually presetting the positions of the discs of projectors which are not on the air.

Application of the ALC system is applied to a combined color-monochrome (TK-26/TK-21) arrangement illustrated by Fig. 3. In this case, two ALC amplifiers and two ALC remote control units are used—one of each for each camera. The relay control unit now permits simultaneous and independent automatic control

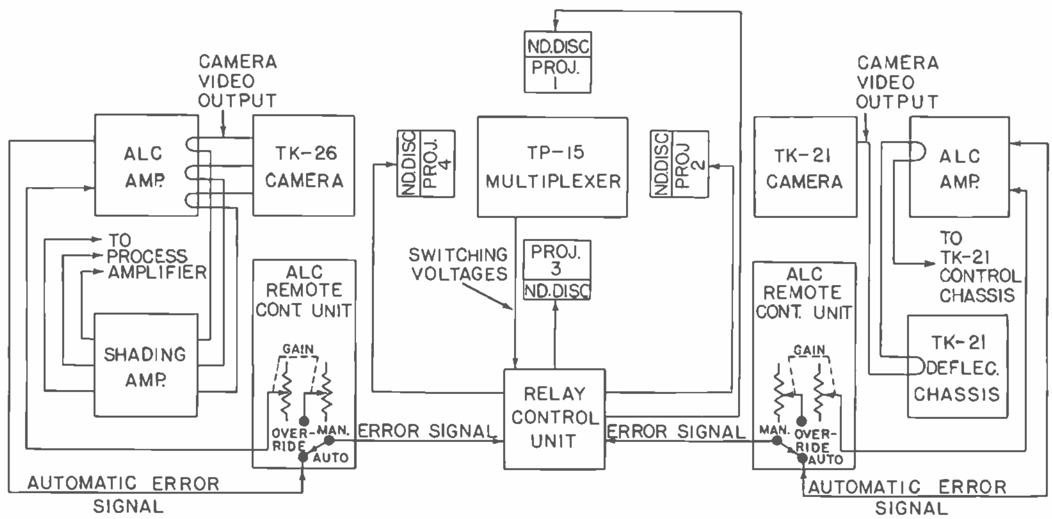


FIG. 3. Functional block diagram showing operation of automatic light control equipment in a combination color and monochrome film system.

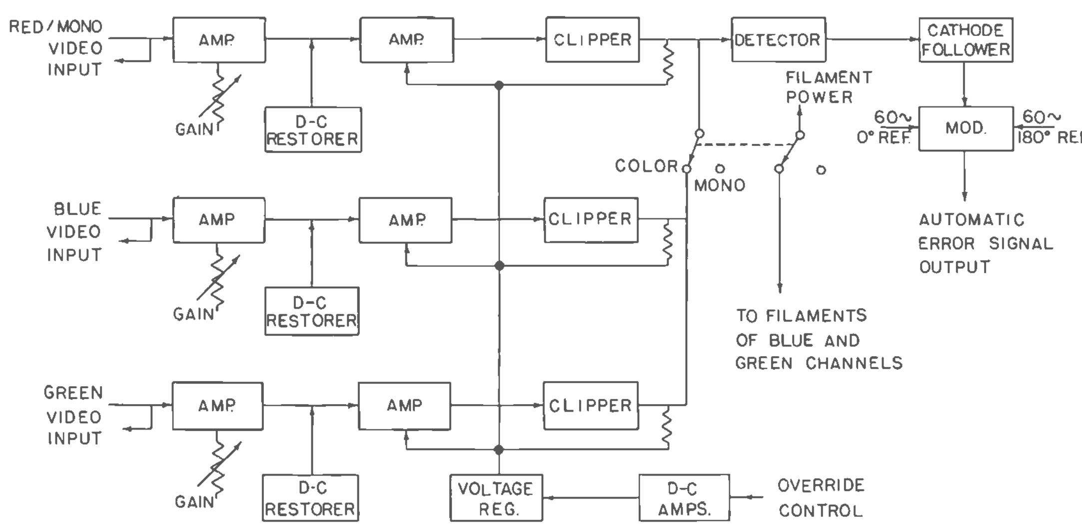


FIG. 4. Functional block diagram of the automatic light control amplifier.

of the light intensity from whichever two of the projectors are acting as light sources for the two cameras.

How ALC Works

The functions of the ALC amplifier are shown in Fig. 4. The three video signals from a color camera, at a nominal level of 0.5 volt, loop through the input terminals. In a black-and-white system, the one video signal is looped through the red channel terminals only.

The signals are first amplified and then clipped in linear clippers with associated dc restorers. The clipper outputs, which are actually just the white peaks of the original signals, are added together and fed to an "infinite impedance" detector. Emphasis of midband gain ahead of the detector helps to improve response to small-area whites in the picture. This provides control on the basis of approximate peak white level rather than average signal level. When used with a color camera, gain controls in the three channels permit adjustment so that each signal from a black-and-white scene contributes equally to control of light. When this same camera is generating color signals, one of the three will normally be larger than the others and will contribute the major portion of the control information. When the ALC amplifier is used with a black-and-white camera chain, the blue and green channels are switched off, and the corresponding clippers are disconnected from the detector, thus providing sensitivity equal to that for the color mode of operation.

The filtered output of the detector is a varying positive voltage — higher than a preset standard when too much light is available—lower when too little light is present. The peak video level required to generate the preset standard is adjustable over a range of ±20 percent by the remote over-ride control, which adjusts the common clipper reference voltage. A high degree of filtering is required since the ultimate correction signal is a 60-cycle sine wave of reversible phase, and any 60-cycle component not filtered out of the video signal would limit the accuracy of control by adding to the desired signal. Frequency selective division of this output provides error and "null-approach" information to a cathode follower. As the proper disc position is approached, braking action is applied to minimize overtravel.

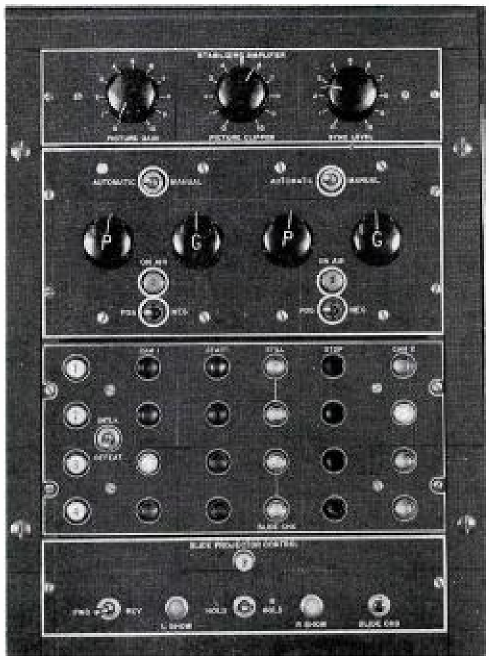


FIG. 5. ALC remote control units (second panel from top) may be mounted in a standard console along with other remote control panels. An adaptor faceplate accommodates two of these units at this position. Manual pedestal and gain controls are also located at this panel for convenience of operation.

The output signal of the cathode follower acts to unbalance a balanced modulator. The grids are fed with 60-cycle signals 180 degrees out of phase with each other, and in the absence of an input error signal, there is no output from the common cathode terminal. Unbalance produces a 60-cycle signal of one phase or the other. This is the correction signal which is coupled to the servo amplifier driving the quadrature phase of the servo motor to bring the disc to the required position.

The ALC amplifier is mounted on a 5¼-inch bathtub chassis. Power required includes 100 ma at 280 volts and 28 watts ac. The unit can be readily mounted in the 3V pedestal for color, or in the multiplexer or a standard rack for monochrome operation.

Optimum Performance from TV Films

The ALC system provides a significant step toward smoother, simpler, and largely automatic film programming. The system is not perfect for there is no human intelligence to decide what is to come. However, tests with material containing slow and abrupt changes in highlight transmission have demonstrated very satisfying performance. Slides containing extreme ranges of duty cycle (large white area, or many small spikes of white) have been handled with good results. Observing the waveforms on an IRE roll-off display, the peak whites range from 80 to 100 percent of normal white level. Sudden transitions to dark scenes are smoothly brightened.

The one situation where the system does not approach ideal performance occurs when an abrupt change to excessive highlight transmission leaves some areas momentarily undischarged in the vidicons because of lack of beam current. However, if the camera is adjusted properly as to uniform lighting and beam alignment, the beam can be adjusted to discharge whites to a point where a video level only slightly above 100 percent is produced, thus preventing transmitter overload during the short period when light is excessive. Of course, if the system also contains an AGC amplifier or some other type of limiting device such as a white clipper, overload prevention is assured.

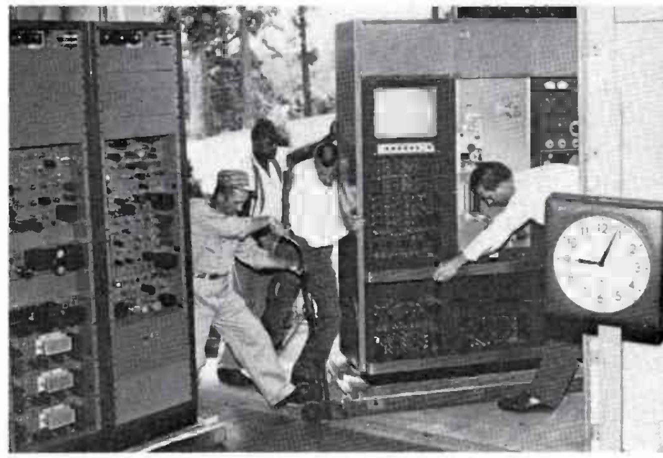
Previewing of material for the purpose of establishing light level requirements is not required when employing an ALC system. Furthermore, no situation can arise where the operator is busy elsewhere while thin film produces complete overloading (blank raster) or dense film produces low level for moments at a time. Possibilities for human error are largely eliminated, and personnel are freed for more attention to other aspects of operation. The net result is an improvement in efficiency of operation as well as an increase in overall picture quality.

ADVANCED TV TAPE RECORDER INSTALLED

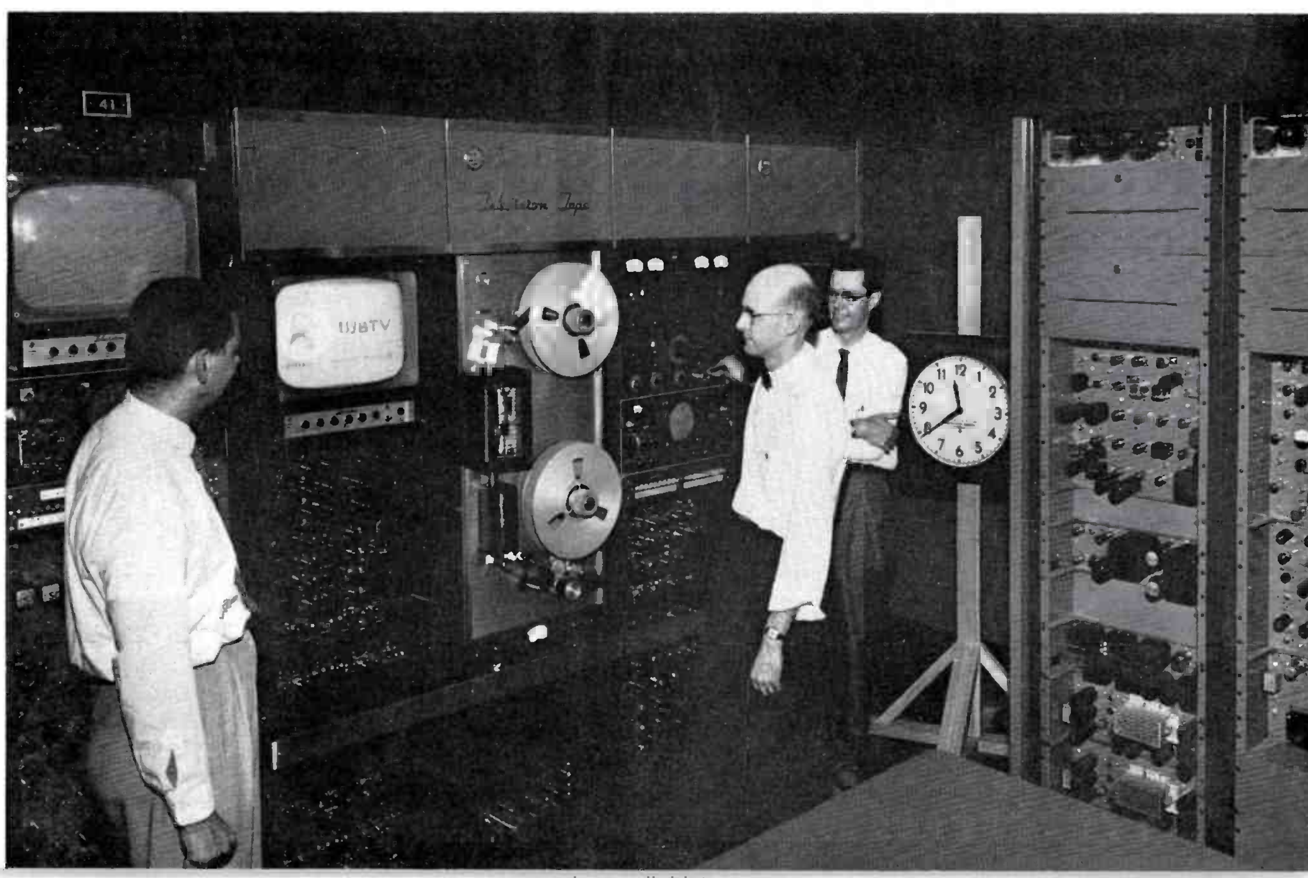
176 MINUTES FROM LOADING DOCK TO

The day, May 13; the time, 9:04 A.M.; the place, WBTV Charlotte, North Carolina. The TV Tape room has been readied—power and video sources available. Outside at the loading platform, RCA's first production model of its advanced TV Tape Recorder is being unloaded. In 2 hours, 56 minutes, this new equipment will be in place ready to play back a 15 minute WBTV program.

A test of men and equipment, this TV Tape installation has proved out newly developed factory testing, packing and shipping techniques. These will be employed by RCA in delivering TV Tape equipment. Photos shown on these pages depict key stages of installation: unloading, positioning, initial check-out, recording and finally playing back. A clock has been included in each of the photos to show the time schedule for the completed installation.

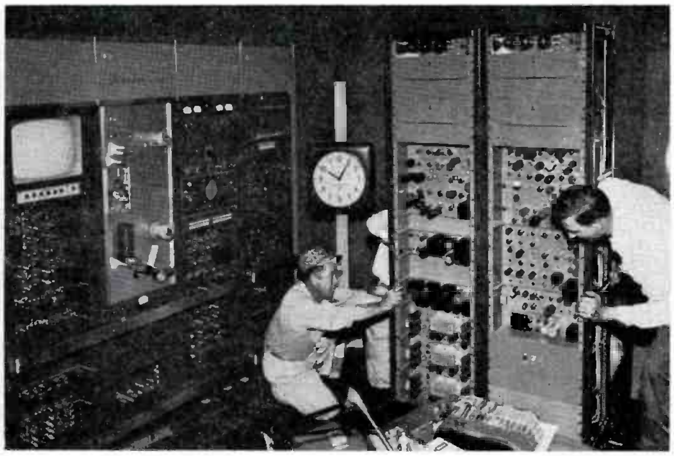


9:04 A.M. Operations center racks, which have been pre-wired and completely tested, are removed from the van. Two racks of auxiliary equipment (left) have been skidded as a unit and completely checked out. A single rack of color processing equipment, still on the van, completes the equipment complement.

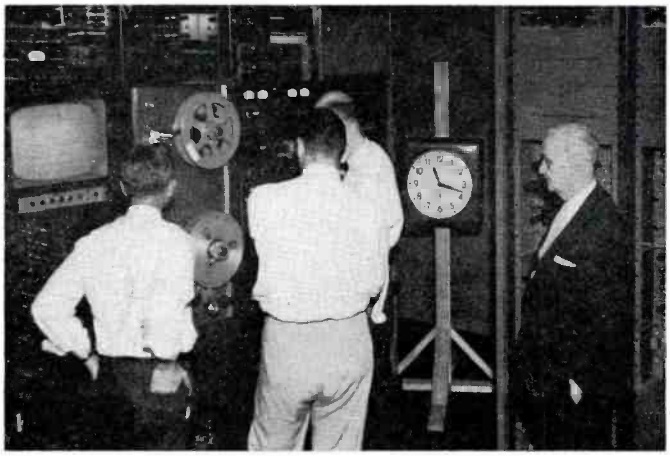


BY WBTV IN RECORD TIME:

PLAYBACK OF FIRST PROGRAM



10:06 A.M. Last of the equipment racks are being set in place over trenches in the TV Tape area. The complete color tape recording facility includes (left to right) operations center (3 racks), color processing equipment (1 rack), auxiliary and power equipment (2 racks).

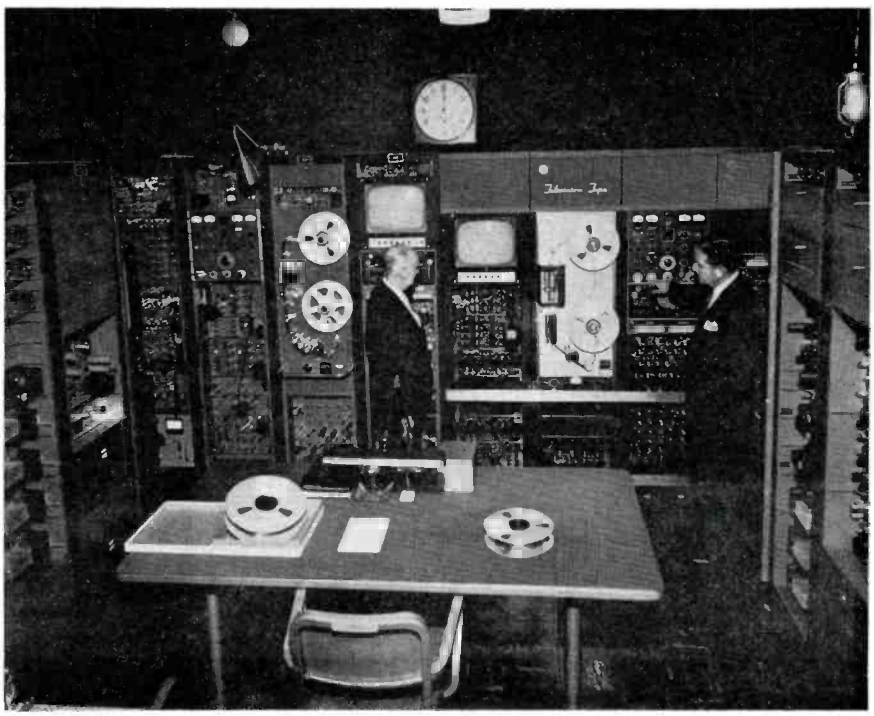


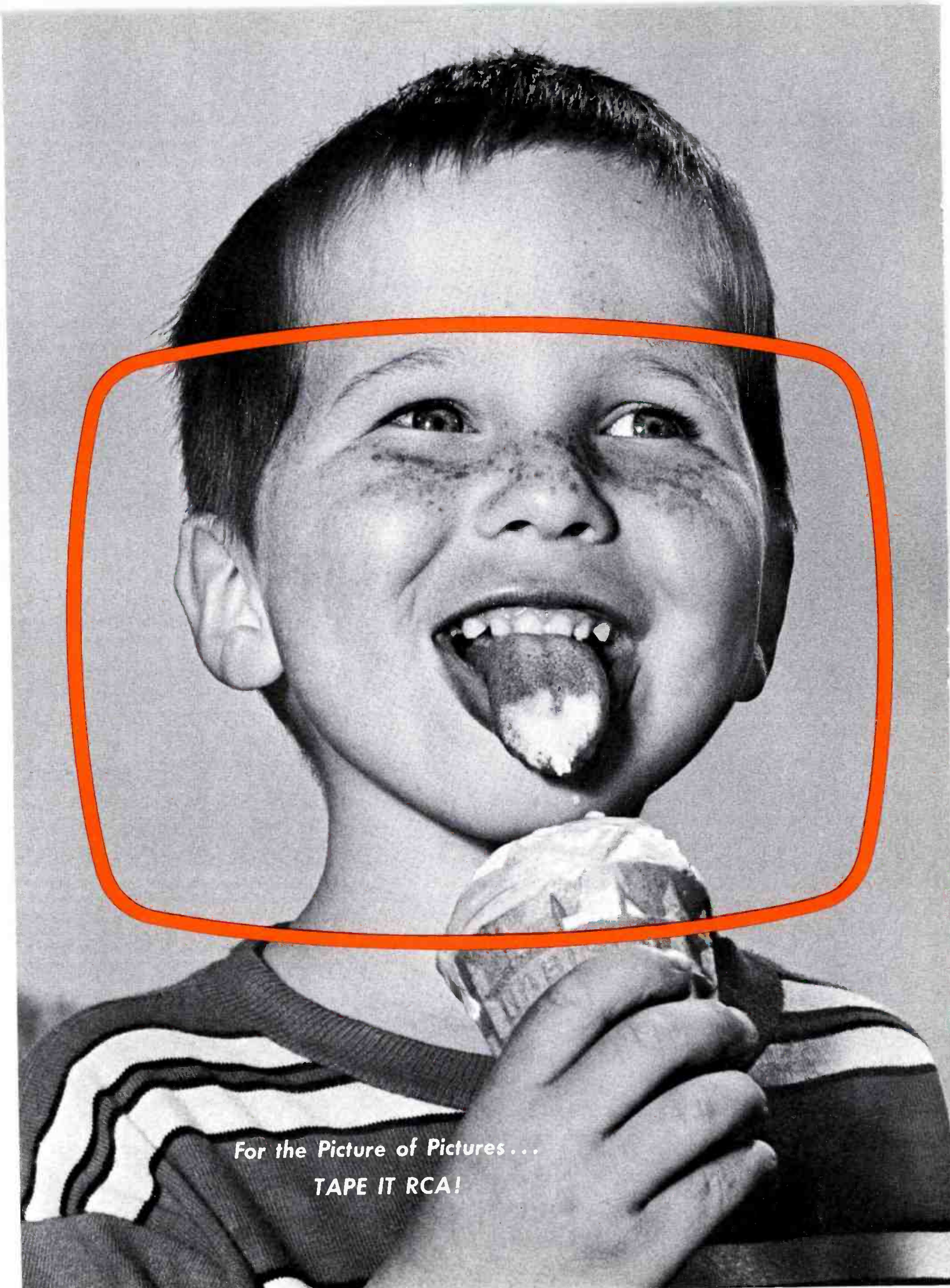
11:18 A.M. All racks have been interconnected, power has been turned on, and the equipment made ready for the initial run of alignment and test tape. Tom Howard, Vice President of Engineering and General Services, Jefferson Standard Broadcasting Co., looks on as RCA engineers make the trial run.

◀ **11:38 A.M.** Checkout and alignment have been completed, and the initial recording of a 15 minute program begun. RCA engineer Roy Marion is at the controls. Henry Klerx of RCA, (left) and Frank Bateman of WBTV look on.

▶

12:00 Noon. The PLAY button is punched by Charles H. Crutchfield, Executive Vice President and General Manager, Jefferson Standard Broadcasting Company, initiating the playback of the first program to be recorded on the new equipment. Note that this is the second RCA TV Tape Recorder to be installed by WBTV. The first, a preproduction model, is shown at left.




For the Picture of Pictures...
TAPE IT RCA!

FOR THE

PICTURE OF PICTURES...

TAPE IT RCA!

The *picture's* the thing . . . You want your commercials to have the snap, sparkle and punch characteristic of superb pictures. By "taping it RCA" you get live picture quality. All the freshness, all the life-like detail comes back to you on RCA tape—thanks to advanced, built-in, quality-control features of the RCA TV Tape Recorder. Unlike older designs, this newest of TV Tape Recorders makes it easy to get and keep highest quality pictures. Your programs and commercials stand closest scrutiny because they are transcribed "live" from the very first breath. Compatible in every respect, the RCA TV Tape Recorder also has built-in features for superior color rendition that become an added bonus for monochrome. Ask your engineer to explain the picture-plus advantages of RCA's *electronic quadrature adjustment, sync regeneration, four-channel playback equalization*, and *built-in-test equipment*, or see your RCA Representative. For complete particulars, write to RCA, Dept. TR-2, Building 15-1, Camden, N.J. In Canada: RCA VICTOR Company Ltd., Montreal.

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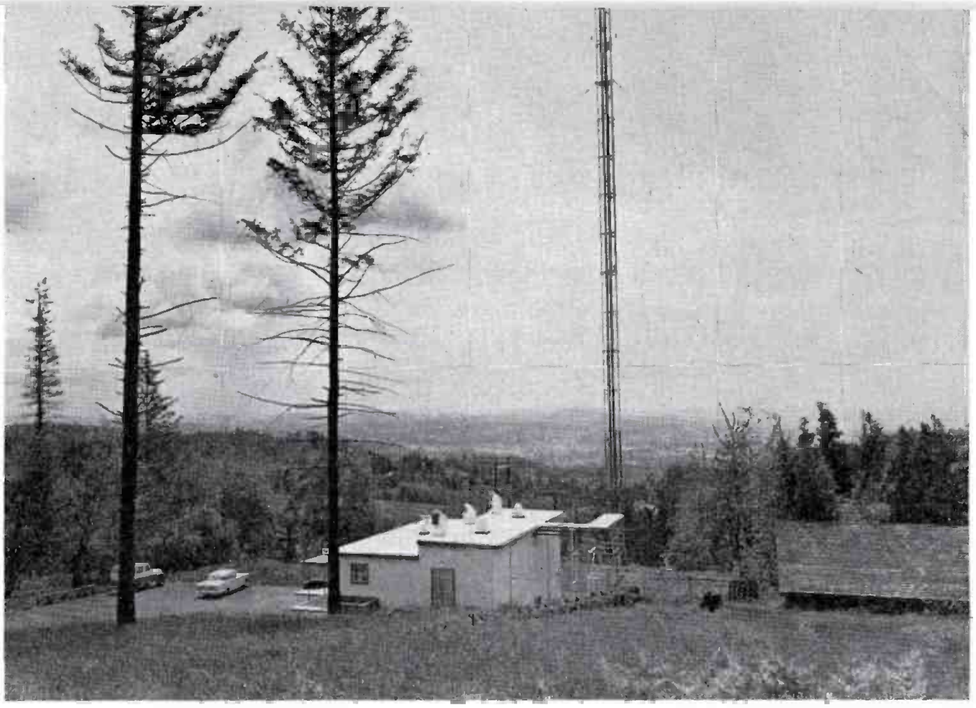
RADIO CORPORATION of AMERICA

BROADCAST AND TELEVISION EQUIPMENT

CAMDEN, N. J.

FIG. 1. This view of the KGW-TV tower and transmitter house was taken from an adjacent hilltop, the highest point in Multnomah County. The city of Portland is located down the valley to the right. Elevations in the area range from a few feet to 1250 feet above sea level.



KGW-TV TACKLES TOUGH TERRAIN AND SPECIALLY DESIGNED

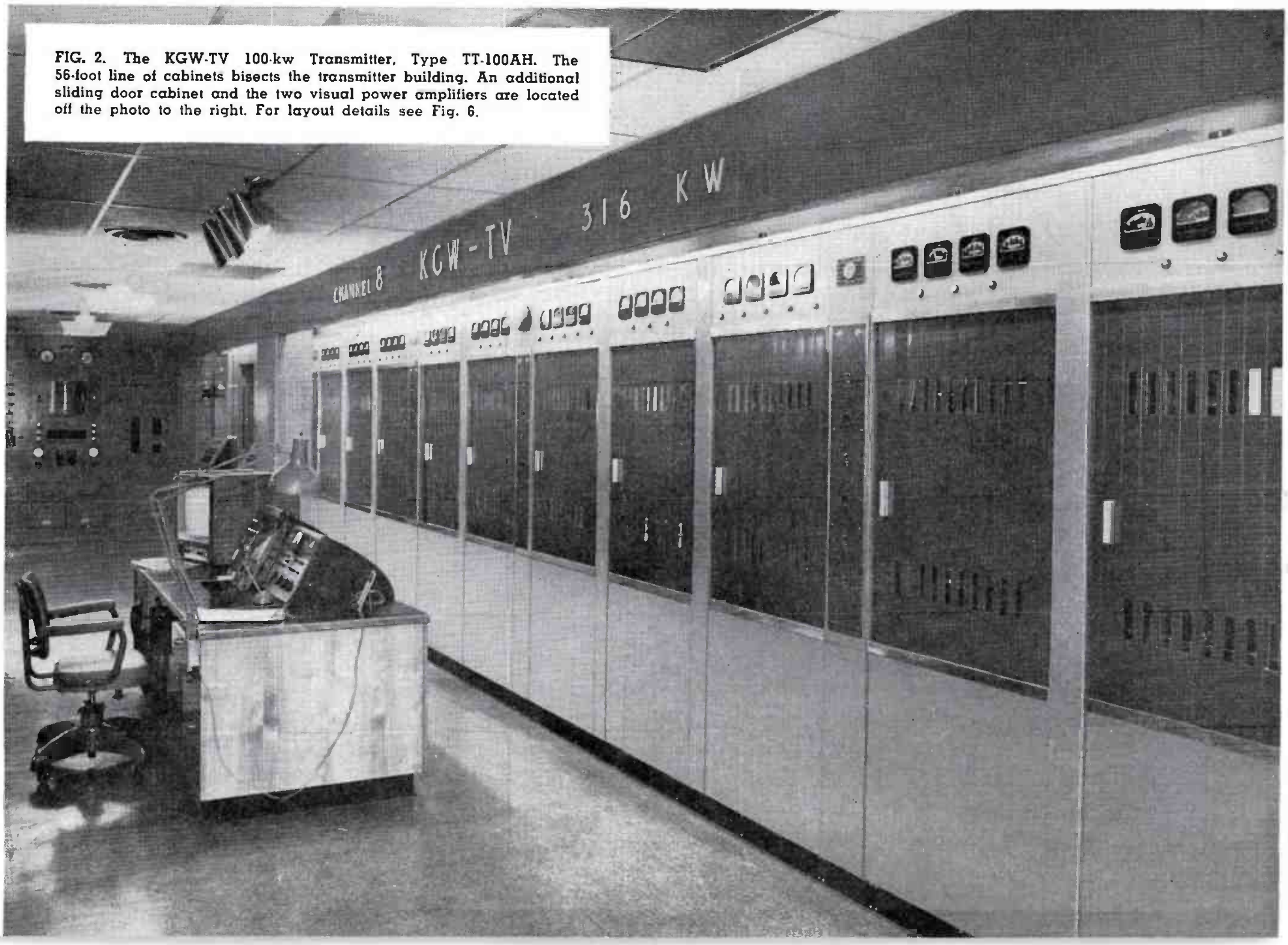


FIG. 2. The KGW-TV 100-kw Transmitter, Type TT-100AH. The 56-foot line of cabinets bisects the transmitter building. An additional sliding door cabinet and the two visual power amplifiers are located off the photo to the right. For layout details see Fig. 6.

PROBLEMS USING 100-KW TRANSMITTER LOW-GAIN SUPERTURNSTILE

by C. H. HANAWALT,* *Chief Engineer, KGW-AM and TV* and J. L. MIDDLEBROOKS, *Director of Engineering, King Broadcasting Co.*

Using the technique of high transmitter power combined with low antenna gain to produce a broad vertical plane radiation pattern, KGW-TV has been successful in bringing many TV viewers in Portland and surrounding areas virtually out of the shadows and into the light of excellent high-channel TV reception. This method, previously available only to low-channel operators, was made possible by the development of an RCA 100-kw television transmitter, Type TT-100AH, for use on channels 7 through 13.

KGW-TV, operated by the King Broadcasting Company, Seattle, Wash., is licensed to operate on Channel 8 with 316 kw erp at an effective antenna height of 1550 feet above average terrain. Operations began on November 8, 1956 with the first regular transmission of test pattern. Results obtained in almost three years operation have borne out the success of this technique in the Portland area.

High Power Decision

Early in the planning stage it became apparent that the authorized maximum erp could be achieved with greatest advantage at KGW-TV by utilizing a transmitter-antenna combination rare among upper channel VHF stations—a combination that featured high actual transmitter power and lower than usual antenna gain. A newly-introduced transmitter, the TT-100AH, plus a specially designed TF-8AH Superturnstile antenna were selected. The transmitter has a visual peak rating of 100 kw and an aural peak rating of 60 kw. Coupled with an antenna gain of only 3.6, authorized transmission of 316 kw erp is obtained.

The decision in favor of high power, low gain was based upon belief that the varied terrain types in and about Portland could best be served by a broad vertical plane radiation pattern. Whereas East Portland is predominantly flat, the land West Portlanders call home is very rugged—characterized by high hills and steep-sided ravines. The city varies in elevation from a few feet to 1250 feet above sea level. An examination of the vertical plane radiation pattern of the KGW-TV antenna shown in Fig. 4 reveals no nulls. Even at 25 degrees below the horizontal plane, the relative field strength is still maintained

* The authors wish to acknowledge the assistance of Carol Saling, Assistant Chief Engineer for Transmitter, and express their appreciation for his contributions to a successful TT-100AH installation.

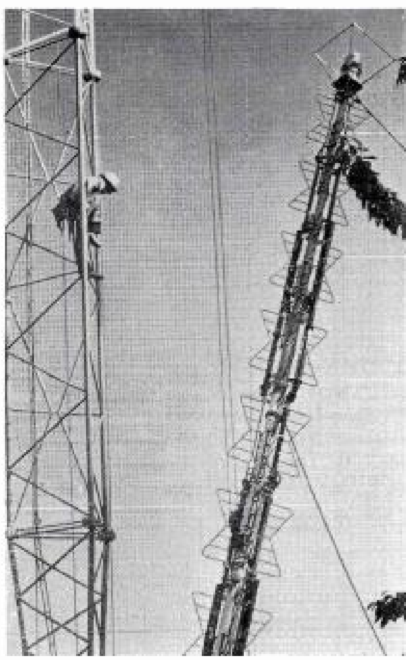


FIG. 3. Custom antenna, Type TF-8AH, about to be lifted to the top of the KGW-TV tower. In normal operation the upper four batwing sections function as the visual antenna, and the lower four as the aural antenna. Each antenna is fed by two 3⅛-inch transmission lines from a power dividing tee at the top of the tower.

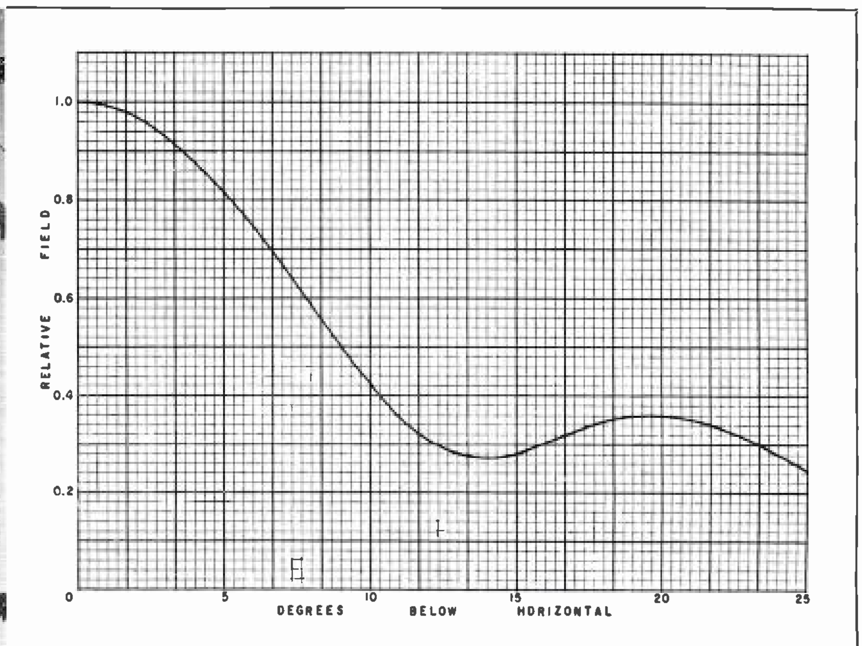
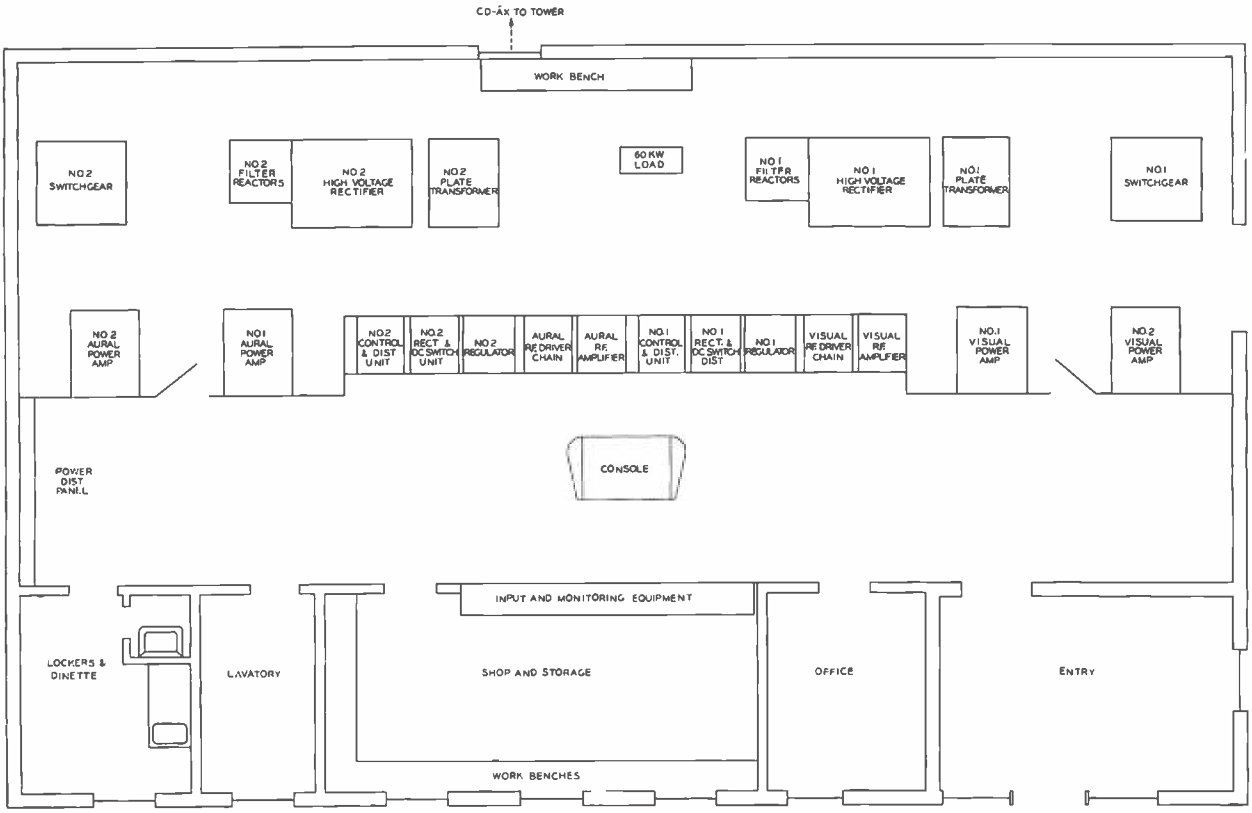


FIG. 4. Vertical plane radiation pattern of the 4-section visual antenna. Note that even at 25 degrees below the horizontal plane, the relative field strength is still maintained at 25 percent of that available at the horizontal plane.

FIG. 5. The transmitter building is constructed of poured concrete and has 3200 square feet of floor space.

FIG. 6. Plan view of the transmitter building showing the first floor layout of offices, equipment and work areas.



at 25 percent of that available at the horizontal plane. This pattern has provided excellent coverage characteristics. Not only is the difficult Portland area filled in, but field strength measurements also show that western and central Oregon and southern Washington receive a useable TV signal, topography notwithstanding.

Ghost-Free Pictures

On November 8, 1956, the first regular transmission of test pattern from KGW-TV was aired. To a group of TV engineers plagued with construction fatigue, there is probably no moment in their engineering experience more electrifying with anticipation than when they start out with TV receiver and portable power to see what the very first transmission looks like in and about the principal city to be served. In the KGW-TV case results were very gratifying. The first ravine sampled gave a satisfactory ghost-free test pattern. Viewing at other test sites was equally successful.

The target date for programming permitted 37 consecutive days of test pattern transmission. This afforded the viewing public more than ample opportunity to orient receiving antennas and make receiver adjustments using a transmitted test pattern. It also presented station engineers a wonderful opportunity to compare predicted with actual coverage prior to programming.

Judging by mail reports coming in from as far as California, 250 miles to the south, and Canada, 250 miles to the north, it was apparent the 100-kw transmitter and low-gain antenna combination was successfully living up to expectations.

Transmitter Site

The KGW-TV tower and transmitter building are located on NW Skyline Boulevard near the top of the highest hill in

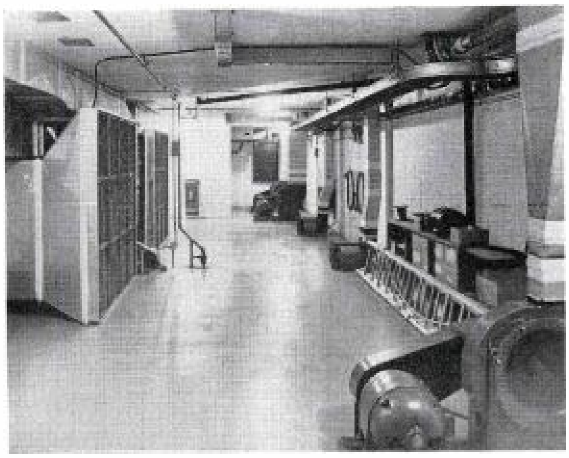


FIG. 7. Air plenum chamber. Six high velocity blowers draw air from this basement room and circulate it throughout the driver and amplifier cubicles overhead.

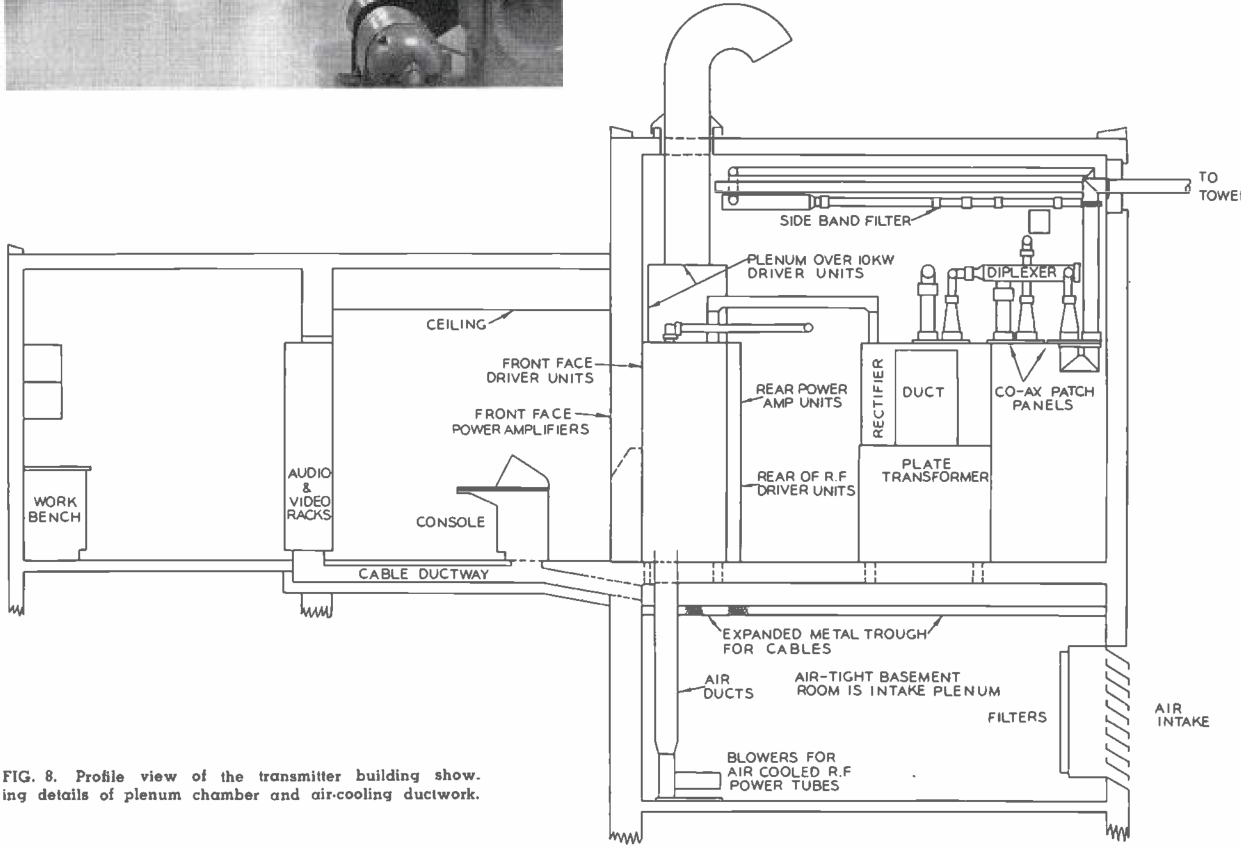


FIG. 8. Profile view of the transmitter building showing details of plenum chamber and air-cooling ductwork.

Portland's Multnomah county. Ground elevation at the tower base is 1,162.5 feet above average mean sea level. The TF-8AH, 8-section Superturnstile antenna is mounted atop a 600-foot tower. The topmost four sections normally serve as a visual antenna while the lower four sections serve as an aural antenna. The visual radiation center is 637.5 feet above ground or 1,800 feet above average mean sea level. This same point is 1,550 feet above the average elevation of terrain within two to ten miles of the transmitter.

The single-story, rectangular-shaped transmitter building is constructed entirely of poured concrete, enclosing some 3200 square feet of floor space. It is bisected lengthwise by a 56-foot lineup of transmitter cabinets placed side by side. In front of the transmitter are located the monitoring console and input terminal racks. Behind the transmitter are located all the higher level coaxial lines and switches, dummy loads, sideband filters, diplexers, power combiners, high power rectifiers, transformers and switchgear, (see Fig. 6).

Beneath the half of the building housing the transmitter is a daylight basement which functions as a large air plenum. Here six high velocity blowers are positioned directly under the driver and power amplifier cabinets. These blowers draw air from the basement room and force it into the units overhead. Clean air is drawn through 84 square feet of Dollinger dry-glass media filters placed in the basement wall. Two 3-horsepower blowers are used to cool two drivers; and four 7½-horsepower blowers to cool four power amplifiers.

Sheet metal plenums located over the transmitter cabinets collect heated air. Automatically controlled dampers allow this air to escape through roof ventilators

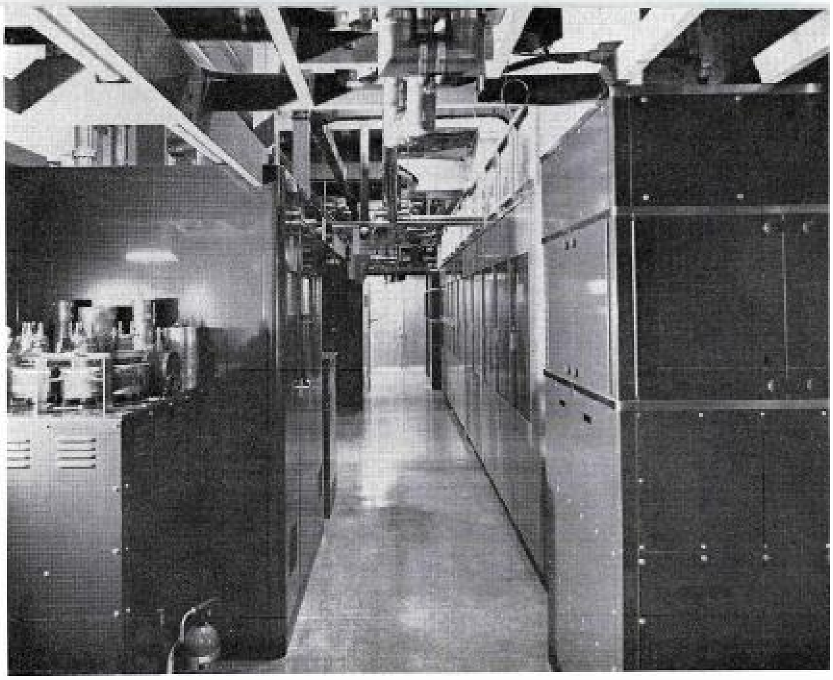


FIG. 9. Rear view of transmitter lineup. In this area all higher level coaxial lines and switches, dummy loads, sideband filters, diplexers, power combiners, high power rectifiers, transformers and switchgear have been installed.

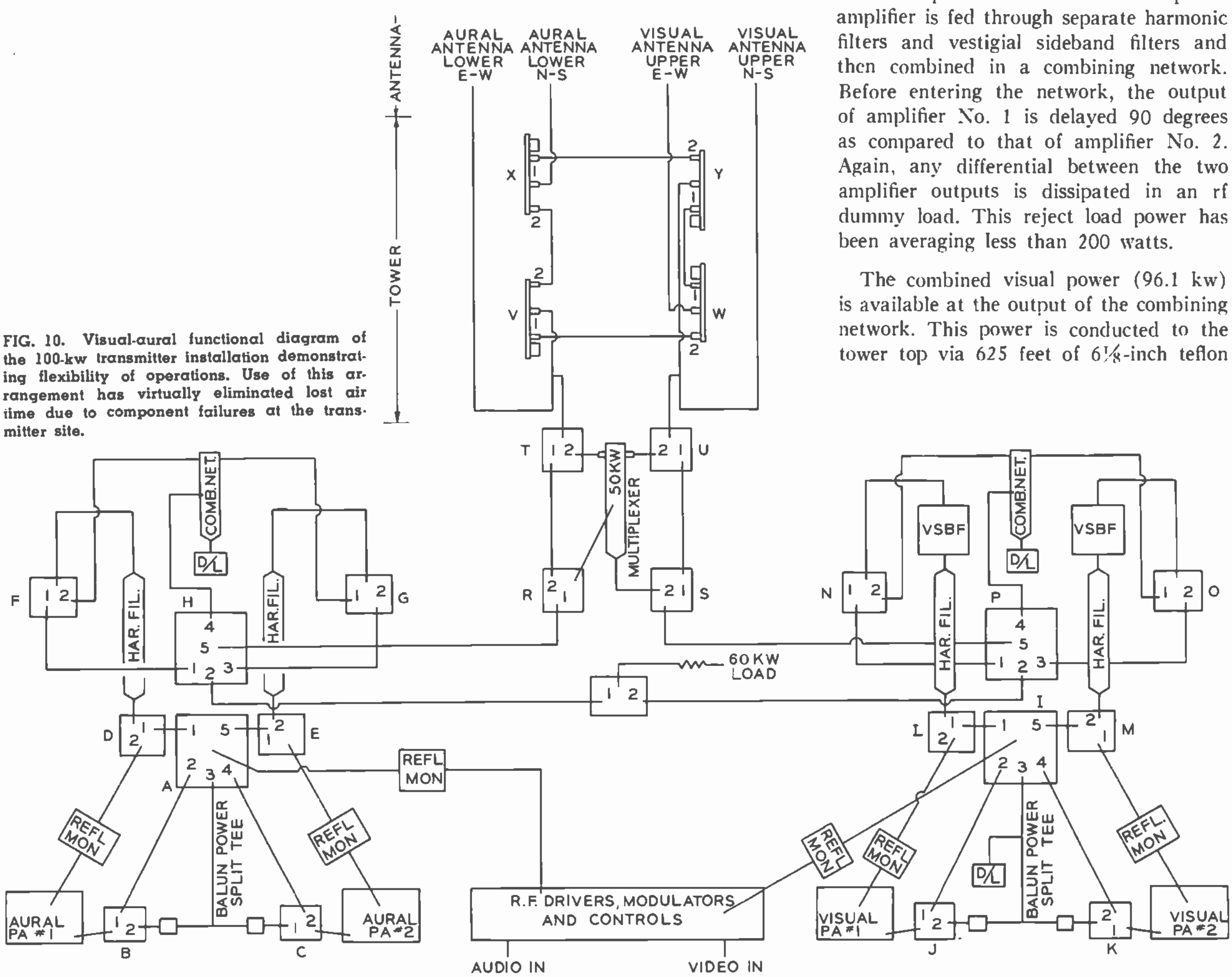


FIG. 10. Visual-aural functional diagram of the 100-kw transmitter installation demonstrating flexibility of operations. Use of this arrangement has virtually eliminated lost air time due to component failures at the transmitter site.

or direct it back into the basement for recirculation during colder weather.

Visual and Aural Functions

Essentially the TT-100AH, 100-kw Transmitter is similar to the Type TT-50AH except that it includes one additional 30-kw aural amplifier, one additional 50-kw visual amplifier, power facilities for these amplifiers, rf input and output combiners and the necessary monitoring, protection, control and power indicating circuitry. In the visual transmitter the output from a standard TT-10AH, 10-kw driver-amplifier is split by a balun type power dividing network as shown in Fig. 10. The two outputs of this network drive the two 50-kw visual power amplifiers. The output driving visual amplifier No. 1 is delayed 90 degrees by means of an additional line section. A dummy load connected to this network dissipates any differential between the powers delivered to the two amplifiers.

The output of each 50-kw visual power amplifier is fed through separate harmonic filters and vestigial sideband filters and then combined in a combining network. Before entering the network, the output of amplifier No. 1 is delayed 90 degrees as compared to that of amplifier No. 2. Again, any differential between the two amplifier outputs is dissipated in an rf dummy load. This reject load power has been averaging less than 200 watts.

The combined visual power (96.1 kw) is available at the output of the combining network. This power is conducted to the tower top via 625 feet of 6⅛-inch teflon coaxial transmission line. There it is divided in a power splitting tee. One of the tee outputs drives the north-south batwings of the top 4-section antenna. The other tee output is delayed 90 electrical degrees and drives the east-west batwings of the same antenna. Power available at the tee, 96.1 kw minus transmission line loss, and antenna gain (3.6) result in an effective visual radiated power of 316 kw.

The aural transmitter is similar to the visual. The output of a 6-kw driver modulator is split by a power splitting tee. The tee outputs drive two 30-kw aural power amplifiers in phase. The output of each aural amplifier is fed through separate harmonic filters and thence into a combining network. The power differential between the two network inputs is dissipated in an rf dummy load. The combined power output of the network (normally 57.49 kw) is then transferred to the aural antenna (lower four sections) via a second 6⅛-inch transmission line exactly as described for the visual output. An effective aural radiated power of 189 kw results.

Operational Flexibility

The transmitter can be operated as a 10-kw, a 50-kw, or a 100-kw transmitter. This makes it possible to maintain transmitter operation despite trouble in any of the four power amplifiers, their input-output circuitry, or power supplies. This transmitter flexibility has been fully utilized at the KGW-TV installation. It has also been extended by the employment of an antenna system offering a choice of two gain figures: 3.6 or 7.2. Thus, despite failures in the power amplifier equipment of both aural and visual transmitters, transmission at full erp is attainable by doubling the antenna gain so long as one power amplifier in each is operable.

Features of the transmitter installation which have provided additional flexibility are as follows:

1. The rf input and output connections to most major equipment units, beginning with and including the aural and visual driver amplifiers, are brought to overhead interchange patch panels where any desired transfer of connections can be quickly accomplished using U-shaped sections of 3⅛-inch or 6⅛-inch coaxial line.
2. A unique "master mind" control system covering the entire transmitter makes it possible to simply and quickly preset all necessary power and interlock circuits for any of 15 possible modes of operation as shown on the accompanying table.

   These modes range from normal full transmitter power down to that of the driver-amplifiers alone. The mode to be selected depends upon the location of the failure. The 15-position rotary switches act to automatically remove high voltage from the by-passed equipment and to set up interlock connections so non-operating equipment becomes accessible for repair. This switch also prevents operation if incorrect coaxial patches have been made for the operational mode selected.
3. A motor-operated, remote-control, 3⅛-inch coaxial switch is located on the tower at the base of the antenna. This switch permits two modes of operation.
   a. to connect all eight antenna sections to function as a single antenna with a gain of 7.2 or,
   b. to operate the eight sections so that the upper four sections will operate as one antenna and the lower four sections as another—each antenna having an individual gain of 3.6.

TRANSMITTER CONTROL SYSTEM

Position of Power Selection Switch	TRANSMITTER Aural	Visual
1	100 KW	100 KW
2	50 KW #1 AMP	100 KW
3	50 KW #2 AMP	100 KW
4	50 KW #1 AMP	50 KW #1 AMP
5	50 KW #2 AMP	50 KW #2 AMP
6	50 KW #1 AMP	50 KW #2 AMP
7	50 KW #2 AMP	50 KW #1 AMP
8	10 KW Left Path	100 KW
9	10 KW Right Path	100 KW
10	10 KW Left Path	50 KW #2 AMP
11	10 KW Right Path	50 KW #2 AMP
12	10 KW Left Path	50 KW #1 AMP
13	10 KW Right Path	50 KW #1 AMP
14	10 KW Right Path	10 KW Right Path
15	10 KW Left Path	10 KW Left Path

Antenna Operational Modes

When the antenna system is operated as a single combined 8-section radiator, it is necessary to use a multiplexer to combine the two transmitter outputs. The two multiplexer outputs then connect to the two 6⅛-inch antenna transmission lines. Should failure occur in any of the eight sections, their feed lines or in either 6⅛-inch transmission line, operation can be resumed at reduced power by setting the coaxial switch for operation with two separate 4-section antennas.

That 6⅛-inch line which leads to the fault is then disconnected from the multiplexer and an rf dummy load substituted in its place. In this case the aural and visual transmitters run at half power, and the still operative 4-section antenna radiates the combined visual-aural signals at one-quarter effective radiated power.

Duplicate Power Sources

A great measure of protection is afforded by duplicate 3-phase power services each derived from separate power substations. A bank of six 167-kva transformers located just outside the transmitter building drop the two 11,000 volt services to 480 volts for connection to the changeover switch located in the transmitter building. Total power usage at the transmitter site (principally due to transmitter demand) has averaged 166,000 kwh monthly. At this usage level, the hourly cost for power has approximated $1.93.

Added Investment Pays Off

Results obtained in almost three years of broadcasting have more than justified the original investment in high power equipment. The reliability inherent in the transmitter design and installation features have more than paid for themselves in the elimination of lost air time. In addition, operating costs of the TT-100AH have been less than might be expected. Operating this transmitter at full rated power has not increased component failures or substantially affected tube life. The hourly 100-kw transmitter power cost at KGW is approximately 30 cents more than the cost of operating a 50-kw transmitter. The 100-kw transmitter low-gain antenna combination has placed into the hands of KGW-TV a power package which has solved tough terrain problems effectively to meet the coverage aims of the station.

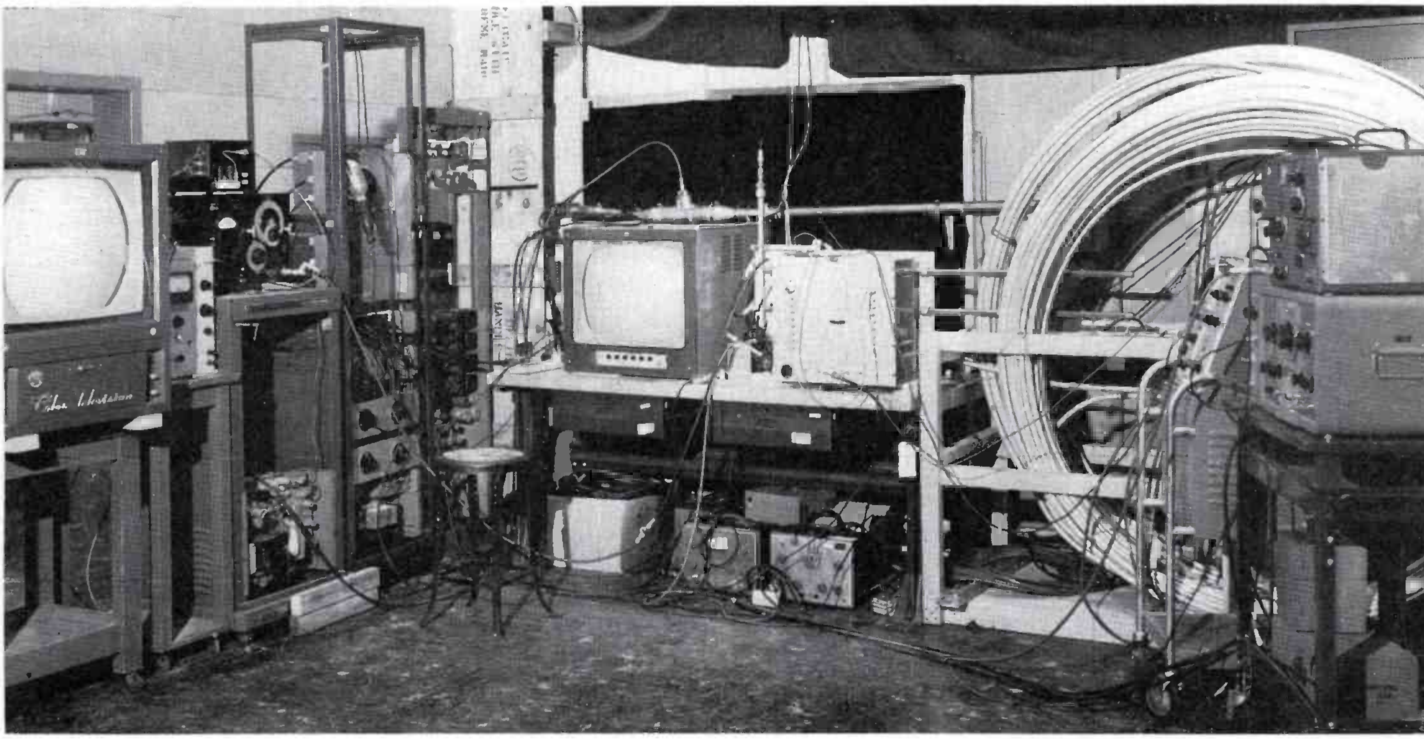


FIG. 1. This is the test setup at RCA Laboratories, Princeton, New Jersey. A TV system is used in the tests, and the long transmission line used is shown coiled at the right.

PROPOSED IMPEDANCE REQUIREMENTS FOR TELEVISION ANTENNA SYSTEMS

Pulse Response Specifications Are Offered In Place of Existing VSWR Specifications

by DONALD W. PETERSON, *RCA Laboratories, Princeton*

The relationship between the present electrical specifications of the transmission line and termination of a television broadcast antenna system, and the picture performance leaves much to be desired. Meeting specifications does not necessarily mean good performance, and conversely the system may perform well without meeting specifications. A new simplified method of positively determining antenna system specifications is proposed to relate picture quality with satisfactory system performance.

Consider a television broadcasting system for which both the transmitter and the antenna have been well engineered. The electrical performance of each can be fully described and technical specifications written which will convey to the broadcaster a satisfactory understanding of the expected performance. After delivery, installation, and test, the transmitter can be demonstrated to have fulfilled the electrical specifications. Similar proof of performance would be desirable for the antenna too, and if we consider the entire antenna sub-system, specifications to assure the desired quality of performance fall into two natural areas. The first is related to the radiation characteristics of the antenna, an area beyond the scope of this paper. The second has to do with the antenna as the terminating impedance of a long transmission line and the performance of the line itself (see Fig. 2). In the belief that the present kind of transmission line and termination specification has become inadequate, a new approach will be proposed which is capable of relating picture performance and specification simply, positively, and unequivocally.

Malfunctioning Antenna Systems Can Affect Picture Quality

Normally the only picture effect of the long line is the introduction of time delay of the echo voltage from the antenna. An abnormal line may introduce any of three effects: (1) ghosts images from discrete reflections with appreciable time delay (2) smear from many reflections distributed along the line (3) edge effects from reflections near the line input, such as misregistration of chrominance and luminance information in a color picture. An electrical specification to assure that none of these effects will be visible in pictures is desirable for the antenna system.

The Antenna System Specification

An antenna impedance and transmission line specification should satisfy two simple requirements: (1) the quantities specified should be a measure of the picture quality of the signal which reaches the antenna: (2) success or failure in meeting the specification should be capable of proof.

The specification now in use sets a limit on the voltage standing wave ratio for components and sometimes for the over-all system. The present VSWR specification approach is no longer capable of coping with changes and improvements of the television system. This is known from field experience with systems. The reasons are readily apparent upon examining the VSWR Specification approach.

In seeking a satisfactory specification approach two possibilities have been considered. The first was to alter the present kind of VSWR specification to make it more effective. There are several reasons for alteration. Among these is the well known fact, that a small line reflection near the transmitter can be less objectionable than the same reflection at a greater distance, since the first appears as distortion in a brightness transition and the latter as a ghost image. This fact and others should be recognized in a proper specification. Nevertheless, there is no doubt that a revised VSWR specification can be prepared which, when satisfied, will assure quality picture performance.

The difficulty is the inability to measure VSWR vs. frequency and distance from the long line input. The VSWR's that can be measured after installation of the antenna system are not a satisfactory measure of expected picture quality. It is difficult, if not impossible to prove by

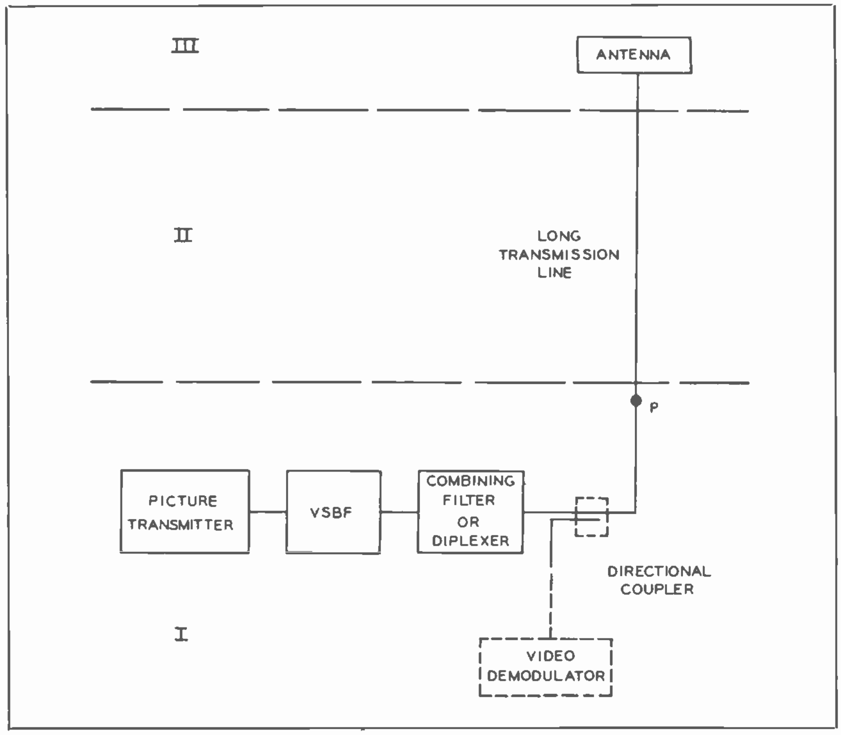


FIG. 2. This shows the three basic sub-systems of a television transmitting system. First (I) is the transmitter system, second (II) the long transmission line; and third (III) the antenna.

VSWR measurement that the picture performance of a long line and its antenna termination will be up to standard. Neither can one always prove by this method that picture performance will be below standard. Systems which meet electrical specifications but perform badly and systems which fail to meet specifications but perform well, are anomalies which can be expected even if highly refined VSWR specifications were to be used. Furthermore, trouble shooting by VSWR measurement in a system which is suspected of transmission line or termination trouble, can be quite baffling when there are several undesired reflections from line faults—along with a multitude of normal small reflections.

R-F Pulse Specifications

Line faults of significant magnitude can be easily located and evaluated with r-f pulses. This suggests an approach using pulses in the specification. Before trying to draft a specification based on pulses, it is well to review a few relevant facts about the antenna system.

Distortion of the radiated signal, which is introduced by either the transmission line itself or by reflection from the line termination, can be observed at the line input. The initial wave which propogates from transmitter to antenna through a normal line is virtually undistorted by the line. Reflected power from line discontinuities and the line termination introduce the only significant distortion. The reflected power propogates back to the transmitter, is partially reflected by the transmitter output impedance, and again propogates to the antenna to be radiated as distortion. Essentially the same r-f envelope exists at both the transmitter and the antenna terminals. This fails to be true when there are severe line discontinuities. As the reflection voltage from a line discontinuity is increased from an invisible level, the first effect to be seen in the picture is the delayed image, followed at a much higher reflection voltage level by distortion of the initial wave.

The transmission line and its termination will have done their job very well indeed if the r-f envelope at the long line input is the same as the envelope when the modulated r-f is applied to a pure resistance, equal in value to the line impedance. Modulation waveforms can be

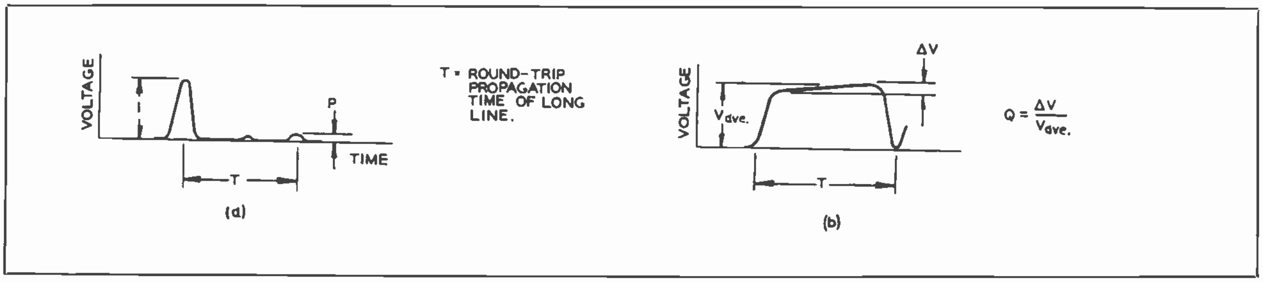


FIG. 3A. The reflection voltage from either the antenna or the transmission discontinuities should be less than P percent as shown here. P is based on subjective picture tests.

FIG. 3B. Here the flatness of the pulse is measured with a resistive load substituted for the long transmission line.

chosen to make such a test sensitive to all possible kinds of distortion. Since a faulty long line and its termination can introduce delayed ghosts, smears, and edge distortion, tests for these effects will be described. The tests are given only as examples since many variations are possible.

R-F Pulse Tests

A test can be made to see that ghost images from either the termination or line discontinuities will be below visibility. For this test the shortest r-f pulse which the system will pass can be applied to the input of the long line. The line will be terminated with the antenna impedance. The relative reflection voltage as shown in Fig. 3A returning from either the antenna or line discontinuities should be less than P percent, with the choice of P based on subjective tests with pictures. This will detect line faults which may occur during installation and show all that needs to be known about the antenna impedance after installation.

There is a remote possibility that many discontinuities may be more or less uniformly distributed along the entire line length as a result of manufacturing or installation defects. These, for example, may be the result of accidental periodic dents. If all reflections happen to add in phase, such line trouble will appear in the picture as a short smear with length equal to the round-trip propagation time T of the long line. This type of distortion can be detected with a flat-topped r-f pulse slightly shorter than T. Flatness of the demodulated pulse, Fig. 3B, in comparison with the test pulse observed with a resistance substituted for the long line, is a measure of the distortion. The $\Delta V/V_{ave}$ should be less than Q percent with Q to be determined by subjective picture tests.

R-F Pulse Tests for Color

To learn if faults of the line will cause edge distortion such as, misregistration of color picture chrominance and luminance information, another r-f pulse test can be made. One approach here would be to modulate with a dc pulse, which has superimposed the color sub-carrier frequency. The distortion will be apparent in the demodulated waveform.

Another possibility is to do all tests simultaneously with the modulating waveform of Fig. 4. The relative reflection voltage of the antenna is measured by the step at T microseconds. An accidental discontinuity of the line causes a similar step in a lesser time interval. The rise time is a measure of the edge distortion. Multiple distributed line discontinuities are evaluated by the flatness of the waveform between the initial rise and the step of the antenna. For this test the modulating pulse must be longer than T.

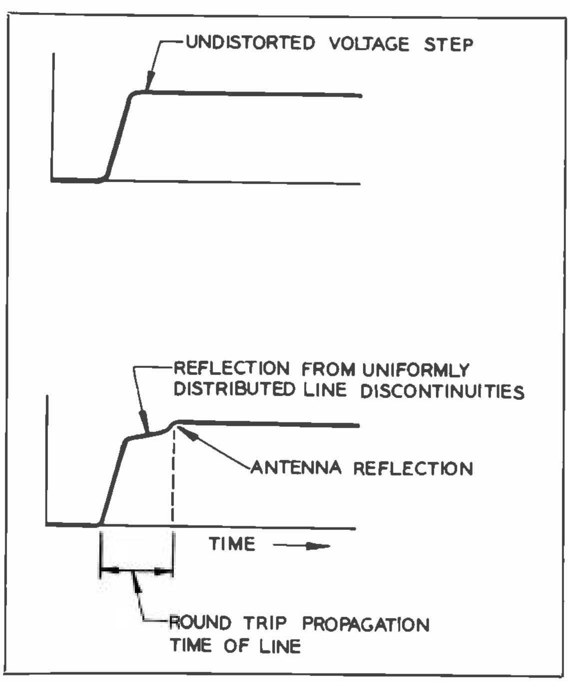


FIG. 4. When a suitable modulating waveform is used all tests may be performed simultaneously. The undistorted voltage is compared with the reflected voltage. Round trip propagation time (T) is an accurate measure of the line discontinuities.

Acceptable Specification Limits

In terms of the tests which can be made to prove performance, the long line specifications to assure that ghosts, smear, and misregistration will be kept below acceptable limits are threefold.

1. A maximum permissible relative reflection voltage P from line discontinuities and the line termination,
2. A required flatness Q of a test pulse slightly shorter than the round-trip propagation time of the long line,
3. The maximum permissible distortion in a step voltage of minimum rise time.

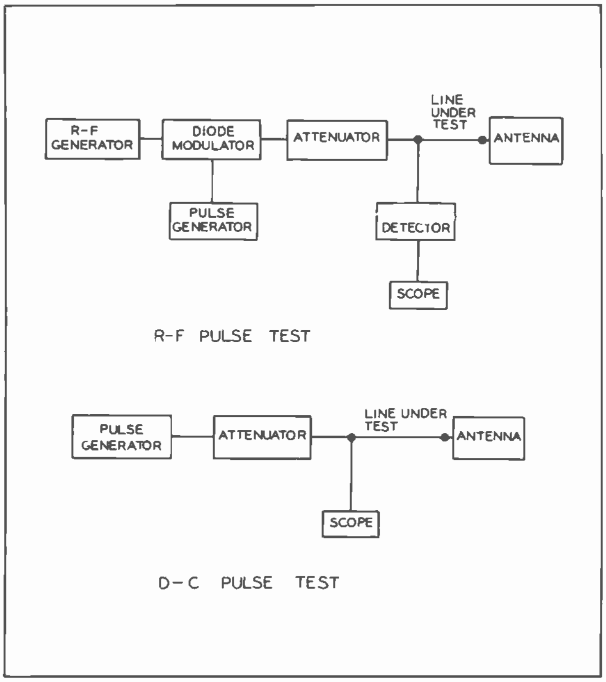


FIG. 5. The typical test setups for pulse trouble-shooting are shown here. The r-f pulse tests can be used to determine approximate location of defects by viewing initial and echo pulses on an oscilloscope. The detector used for r-f tests must have a standardized receiver selectivity characteristic. The extremely sensitive dc pulse tests are used to determine the exact location of transmission line discontinuities.

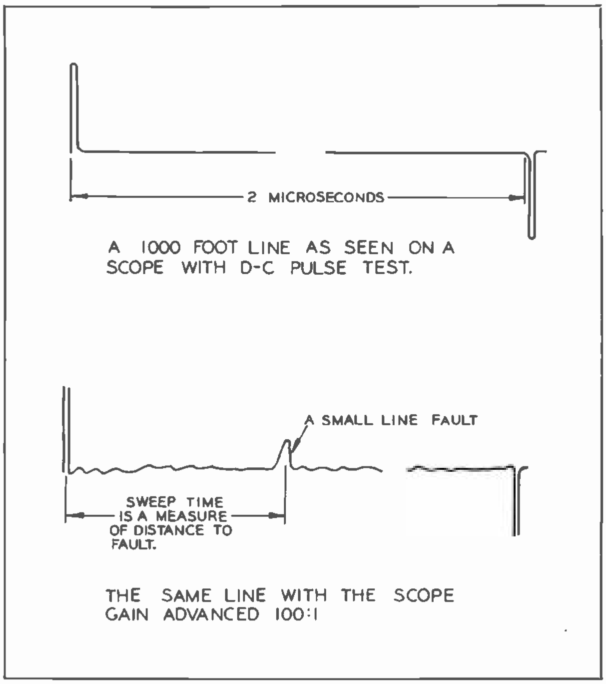


FIG. 6. This is the scope waveform obtained from a 1000-foot transmission line under dc pulse tests. The echos are displayed on a time scale which is linearly related to distance along the transmission line, thus exact location of echoes is readily determined.

The critical numbers P and Q must be chosen on the basis of subjective tests with a complete TV system and on the basis of theoretical considerations.

It should be recognized that a variety of factors will influence the actual specification numbers P and Q. First, the transmitter does not fully reflect the incident power returning from the antenna or line discontinuities so the relative reflection voltage from the transmitter output impedance will affect the values chosen as acceptable. Second, reflected power must propagate through all or part of the long line two extra times, therefore, line attenuation is a factor. Third, visibility of echo voltages in pictures depends upon detector linearity. There is a tendency with the usual envelope detector to compress low percentage black echoes and slightly stretch low percentage white echoes. Fourth, the linearity (gamma) correction introduced in the camera to pre-compensate for the kinescope light intensity nonlinearity with input voltage obviously does not operate on echo voltages which occur in the system beyond the camera. Therefore, kinescope non-linearity also tends to compress black and stretch white echoes. All of these factors combine to determine the acceptable relative level of echo voltages.

Experience with the new specification approach with our laboratory TV system, Fig. 1. has already shown great promise. This complete television system will be used for subjective tests for the purpose of choosing the necessary critical values for the specification. These will be chosen with the cooperation of the TV industry.

Pulse Trouble-Shooting

When performance of an installed system falls short of the specification, the reason can be found with pulse tests as shown in Fig. 5. By the use of short r-f pulses (about 0.1 microsecond), line faults can be roughly located by viewing initial and echo pulses with an oscilloscope, such as the Tektronix 545 at the line input. Then with 10 milli-microsecond dc pulses such as generated with the EPIC 200A Square Pulse Generator the faults can be accurately located. The dc pulse measurement is so accurate and sensitive that the causes of echoes well below objectionable level can be located within a few feet. Multiple echoes, which have caused considerable difficulty in diagnosis of line troubles by VSWR measurement, are no problem since individual echoes are displayed on a time scale which is linearly related to distance along the transmission line to the fault as shown in Fig. 6 Multiple echoes 20 feet apart can be resolved. Pulse trouble shooting is straightforward and can be done with readily available apparatus.

The Future

The proposed pulse response specification is capable of making antenna system specifications more definite. The broadcaster will benefit immeasurably by adoption of this new approach, and in the long run the manufacturer must also gain because the approach is simple in conception and straightforward in practice. The initial preparation of the new specifications will be done in the laboratory and in the field. Comments and recommendations are invited from the broadcast industry.

This is the 50,000 watt "Ampliphase" Transmitter now in operation at 12 major stations.

PRINCIPLES OF OPERATION OF THE *Ampliphase* TRANSMITTER

A Combination of Phase Modulation and Regulation of RF Drive to Produce 50 KW Output

by A. M. MILLER *and* J. NOVIK, *Broadcast and Television Equipment Division*

The *Ampliphase* system of modulation has been commonly described as a "Phase to Amplitude" process. It is that plus application of some additional circuit techniques. Otherwise, performance in accordance with the rigid specifications could not be achieved. Hence, performance records of the *Ampliphase* 50-kw Transmitter at 12 major stations point to three very specific benefits: economy of operation, increase in program coverage, and improved sound.

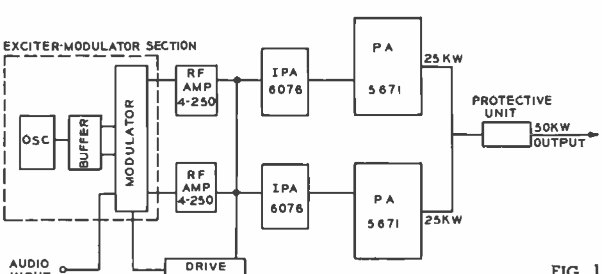


FIG. 1

Basic Operation

The general block diagram of the transmitter (see Fig. 1) shows the layout and various designations of the blocks; this should be studied carefully. If the modulator and drive regulator blocks are omitted, the remaining stages are shown in Fig. 2.

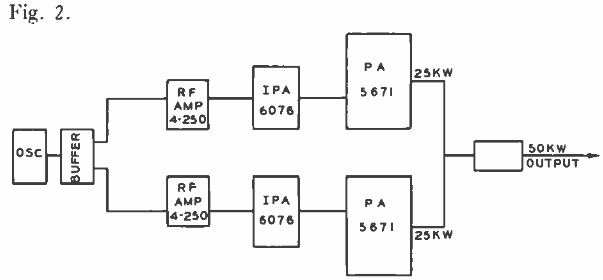


FIG. 2

An oscillator and buffer stage is followed by three broadband amplifier stages, with three identical ones running in parallel, forming a second rf amplifier chain or channel. Then note that the channel outputs are connected to make the equivalent of two 25-kw transmitters operated in parallel to produce 50-kw of output power.

Exciter Modulator Section

Returning to Fig. 1, the complete block diagram, take from it the simplified exciter-modulator section, and unfold it in the form of another block diagram (see Fig. 3) and add to it, for the moment, a small combining network at its output, and consider it operable as a unit.

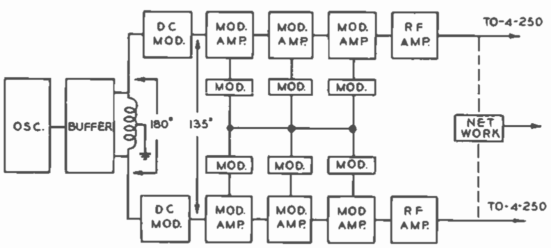
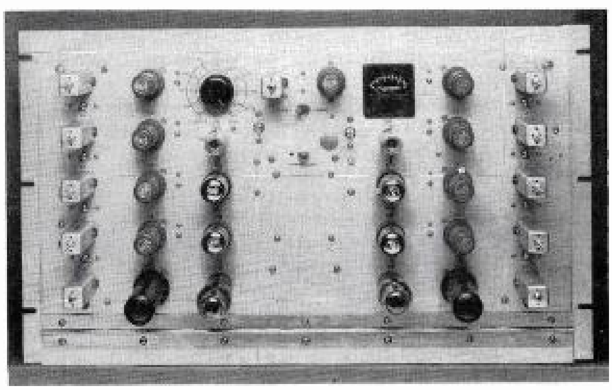


FIG. 3

Here a single crystal oscillator followed by a buffer amplifier stage, with the rf output divided by center-tapping the tank circuit to ground is shown. Then by connecting both ends of the coil to independent, identical rf channels, it becomes obvious that these two signals would be 180 degrees out of phase; furthermore, if the signals are recombined, zero output would result. Thus, there is a need for another stage in the respective signal paths, to provide appropriate phase shift that will prevent cancellation of the signals, and to provide an output of some desired value. This is accomplished by the stages designated as "dc modulators." They have been given a phase shift to 135 degrees. Following the "dc modulators" in each channel are three stages marked "Modulated Amplifiers," and a fourth, marked "rf Amplifier." The three modulated amplifiers in each channel are identical in circuit and function.



This is the exciter modulator unit, each channels separate components are mounted on the same chassis. In the Ampliphase transmitter two of these exciter-modulator units are provided, and duplication of these low power stages increases transmitter reliability.

Phase Relationships

The simplest approach to understanding the system is through vector analysis. Figure 4 shows vector "OC" representing current, and "OA" and "OB" representing the phase relationship of channels "A" and "B", thus the output is zero.

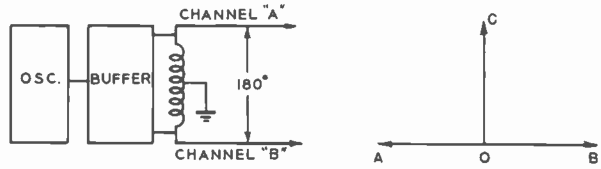


FIG. 4

However, if the phase difference between the two channels is shifted to 135 degrees (see Fig. 5), a certain amount of output current will result, as indicated by vector "OC_1".

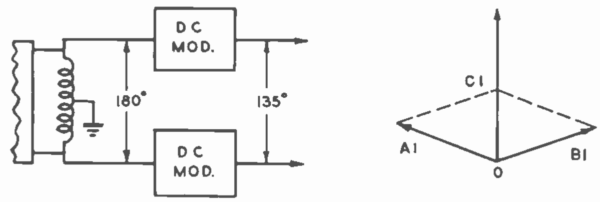


FIG. 5

Continued shifting of the phase on to a 90 degree difference, as shown in Fig. 6, causes the output current to double, as represented by vector "OC_2".

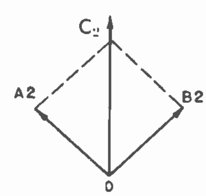
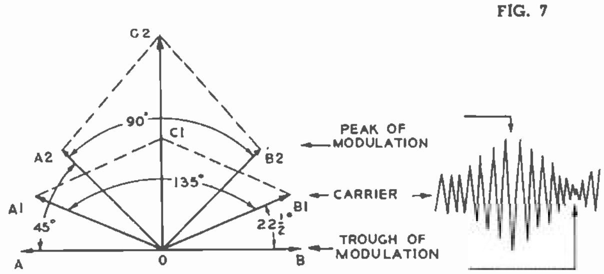


FIG. 6

A combination of the three vector drawings (Figs. 4, 5, and 6) provides a composite vector (see Fig. 7).

FIG. 7



Here a 180-degree phase difference produces zero output, and this corresponds to the trough of modulation. A shift to 135 degrees would provide a given current that can represent the carrier. Then, on to 90 degrees, note the load current is double with respect to 135 degrees. Doubling the current or increasing the power by four times produces a condition corresponding to the peak of modulation. If a phase difference of 135 degrees is designated as carrier, and an excursion in each carrier of ± 22.5 degrees is utilized, then conditions of no output can be produced (corresponding to trough of modulation), and through a point where the load current will double (corresponding to 100 percent modulation).

Phase Shifting Circuitry

The block diagram of the exciter (see Fig. 3) shows that the phase shifting requirements can be readily accomplished. The methods used can best be explained by an examination of the circuitry in each contributing stage.

Figure 8 shows a simplified circuit diagram of dc modulator stage.

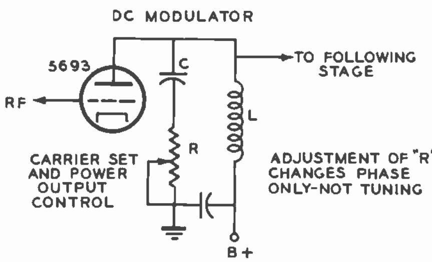


FIG. 8

It is simply an rf amplifier with a variable resistor in a low "Q" plate tank circuit, and the phase can be controlled by adjustment of this resistor. The values of "L" and "C" are selected so that a change in "R" does not change impedance, only phase.

Figure 9 shows how the two dc modulators are utilized together, with variable resistors on a common shaft to control the carrier.

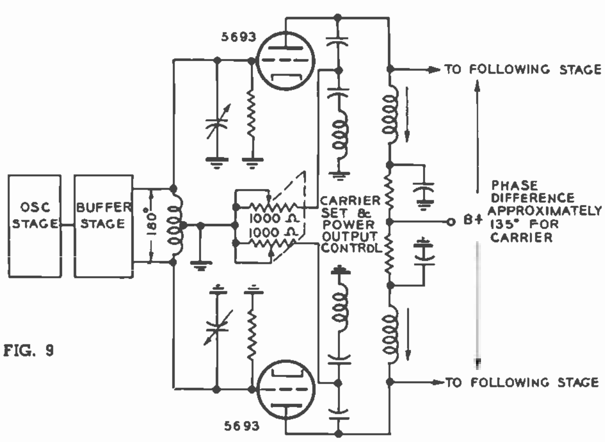


FIG. 9

Modulated Stages

Following the dc modulators, there are three identical stages in each channel, designated as "Modulated Amplifiers." Each stage is almost identical to the dc modulator, except that instead of a variable resistor in each plate tank circuit, a triode tube is substituted which serves as a variable resistor capable of variations at audio frequencies (see Fig. 10). As an audio signal is applied to the grid of the modulator tube, a phase modulated signal is produced in the tank circuit.

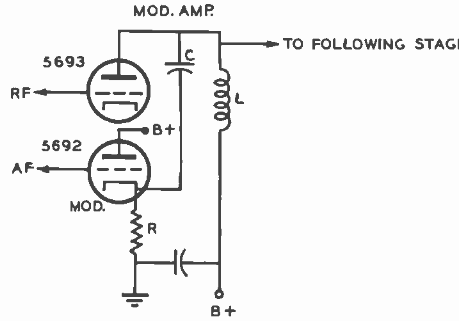


FIG. 10

Figure 11 shows how the two modulated amplifiers are connected in their respective channels.

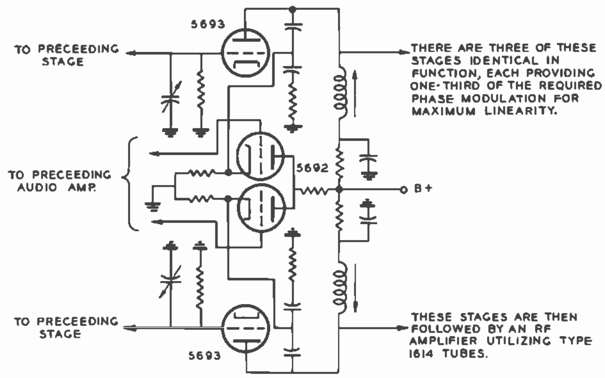


FIG. 11

There are three modulated amplifiers in each channel, making a cascade modulator. This circuit technique makes it possible to produce a phase modulated signal by the simple plate resistance method with negligible distortion. As mentioned earlier, a phase change of ± 22.5 degrees is desired. A phase excursion of this magnitude in a single stage would result in distortion beyond specifications. By doing it in the cascade, the phase excursion is less than ± 8 degrees per stage and after three stages produce a resultant ± 22.5 degrees, with low distortion. Following the modulated amplifiers a conventional amplifier stage is used to provide isolation and drive to the first intermediate power amplifier. In the BTA-50G the output of each channel from the exciter modulator is fed to a series of three conventional broadband amplifiers, providing the necessary power gain to produce the desired 25-kw in each channel. These are combined for the 50-kw output.

Drive Regulation

To achieve a high degree of efficiency during modulation, and a high peak modulation capability with minimum carrier shift and distortion, a "Drive Regulator" is added. This technique contributes to a "Phase to Amplitude" system of modulation the element that completes the *Ampliphase* concept.

It produces a practical modulation process for high power AM transmitters that is both reliable and economical. The "Drive Regulator's" location with respect to the system is shown in Fig. 1. The simplified diagram of Fig. 12 shows how the output of the "Drive Regulator" is applied to the grids of the IPA stages.

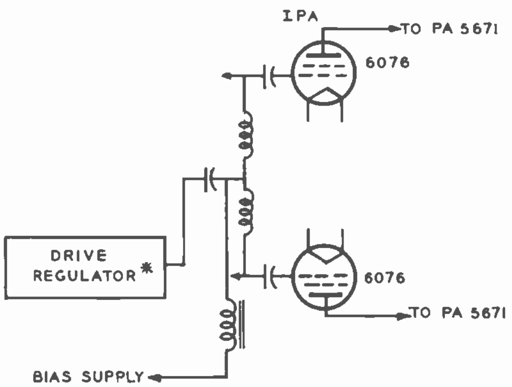


FIG. 12

The drive regulator is an audio amplifier with a cathode follower type output, utilized as a "dynamic bias control," functioning synchronously with the modulation process. It provides a variation of drive to the final PA stages, controlling the output currents in direct relationship to the load requirements at the various percentages of modulation. Consequently, the efficiency at average modulation is essentially the same as at carrier.

Consider for a moment, operation without drive regulation. At the peak of modulation (100 percent), each output tube must supply two times its carrier load current, while at the trough of modulation (100 percent), no load current is required. Therefore, the output tubes see an apparent impedance varying over a wide range during the modulation cycle. Under these conditions the rf plate voltage on the output tube would obviously not be constant. In result, the modulation peaks would not raise to the required value, and conversely, at the trough of modulation, the tubes would be over-driven as related to the output current requirement.

Vector Relationships

Again, a family of vectors can be used to illustrate and compare the current and phase relationships, depicting what happens to the vectors when drive regulation is applied. Not only is the phase location of the respective vectors controlled but their length (magnitude) as well.

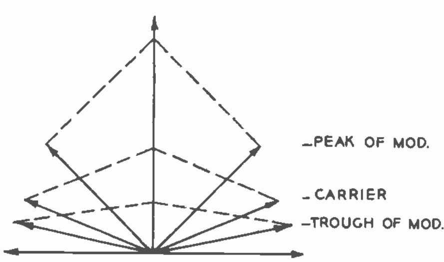
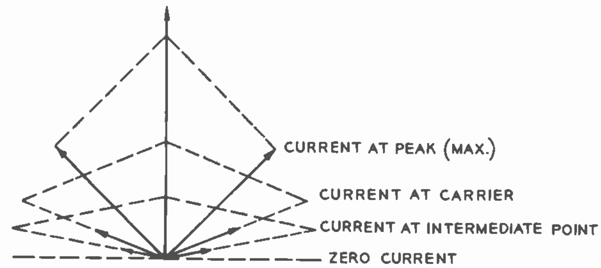


FIG. 13

In a constant current vector presentation as shown in Fig. 13, again it is obvious that from the trough of modulation (100 percent) to the peak of modulation, or the power change from zero to four times carrier, the rf plate voltage would swing from a very low to a very high value. However, if the current is varied along with phase, not only is a proper relationship of current and voltage to load achieved, but an improvement in efficiency is acquired as the drive is controlled to supply current only as needed. The vector presentation (see Fig. 14) depicts the variable current as well as the phase relationship.

FIG. 14



Linearity Control

Figure 15 shows a simplified diagram of the drive regulator stage. Note that it utilizes two intermediate stages in parallel, one with adjustable bias and adjustable input to allow increased output on audio peaks; and it is called a linearity stage. By the

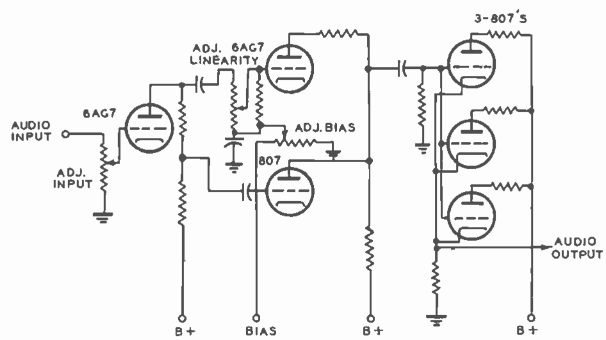


FIG. 15

adjustment on this stage, compensation for normal tube characteristic non-linearity can be achieved (see Fig. 16A). A slight increase on peaks makes up for this discrepancy, and provides a resultant as though the tube curve was straight, as indicated by the dotted line (Fig. 16B).

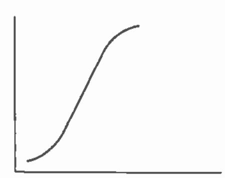


FIG. 16A

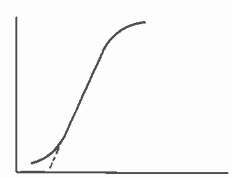


FIG 16B

Feedback

A small amount of overall feedback is used in the system. This is accomplished by sampling the rf output at the reflectometer in the transmission line. The reflectometer employs a balanced germanium diode detector, and is compensated to prevent regeneration across the audio spectrum. One further precaution is taken in that an adjustable diode limiter circuit is built into the phase modulator so that if high peaks or transients should occur, the phase shift will never exceed optimum or cross over on the peaks of modulation to change the feedback polarity.

INTRODUCTION TO JUNCTION TRANSISTORS

PART III — High-Frequency Operation, Pulse Operation, and Temperature Considerations

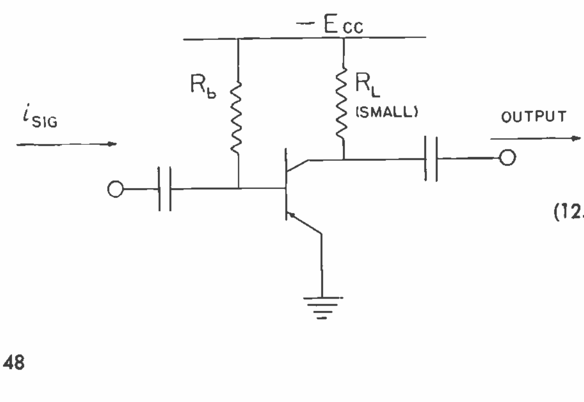
by R. N. HURST,† *Broadcast and Television Engineering*

Previous articles in this series have presented the three basic transistor configurations—the common-emitter, the common-base, and the common-collector—and have briefly described their characteristics. In all these descriptions, it was assumed that the signal frequencies were in the audio region, the signal amplitudes small, and the ambient temperature around 70 F. If any or all of these assumptions are not true, the transistor's behavior cannot be predicted from the simplified descriptions of the first two articles. This article will extend those descriptions to show transistor behavior at high frequencies, at high temperatures, and in highly non-linear operation.

Present-day transistors are not capable of providing high-frequency operation and wide bandwidths with the same ease that vacuum tubes can provide such performance. However, proper choice of transistor, transistor configuration and associated circuitry can result in very good video amplifiers and tuned high-frequency amplifiers, with performance equal to that of conventional tube circuits. The circuits and configurations necessary to obtain these results will now be considered.

High Frequency Operation

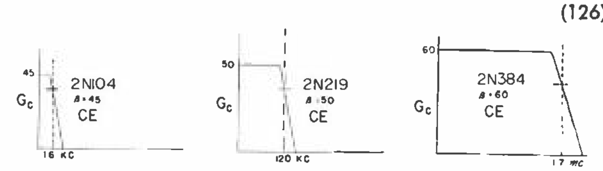
The high-frequency performance of a transistor circuit is strongly influenced by the type of transistor employed. A given circuit will provide widely different high-frequency responses with different transistors. For example, a simple current-driven CE amplifier:



(125)

will provide a bandwidth of about 16 kc for a 2N104; about 120 kc for a 2N219, and about 1700 kc for a 2N384:

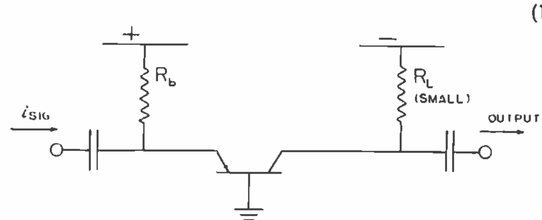
(126)



(These bandwidths ignore stray capacities shunting the load resistor.) Over most of the bandwidth shown, the transistors give current gains of beta—45, 50 and 60, respectively—which fall off to gains of about 70 percent of beta at the specified frequency. This frequency is known as the *beta cut-off frequency*, f_β, and is an important parameter for describing a particular transistor's potentialities as a high-frequency device.

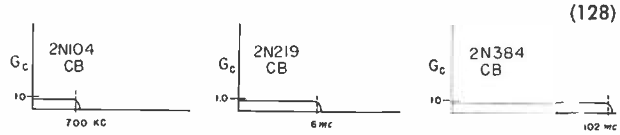
Much better high-frequency performance can be obtained from a transistor in the common-base configuration:

(127)



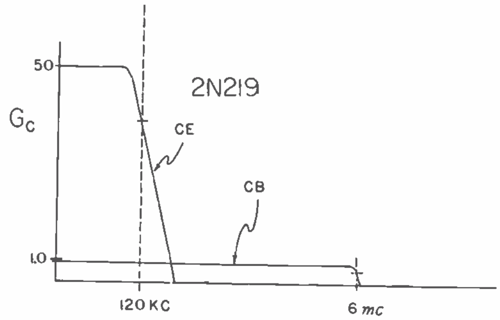
In this configuration, the 2N104's bandwidth is extended from 16 kc to 700 kc; the 2N219's bandwidth from 120 kc to 6 mc; and the 2N384's bandwidth from 1.7 mc to 102 mc:

(128)



† This series of articles is abstracted from a group of transistor lectures given jointly by the author and Mr. A. C. Luther. The author wishes to acknowledge the fact that many of Mr. Luther's valuable contributions to the lectures have been retained in these articles.

Although these are impressive bandwidths, note that in each case, the current gain has dropped from beta (around 50) to alpha (less than 1). That is, going from CE operation to CB operation extends the bandwidth by a factor of beta, but at the same time reduces the current gain by the same factor:



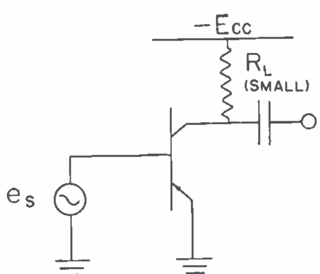
(129)

In the common-base case, the frequency at which the current gain is down 70 percent (6 mc for the 2N219) is called the *alpha cut-off frequency*, f_α. It is the frequency most commonly given in transistor data sheets, and is related to f_β by the expression:

$$f_\alpha = \beta f_\beta \qquad (130)$$

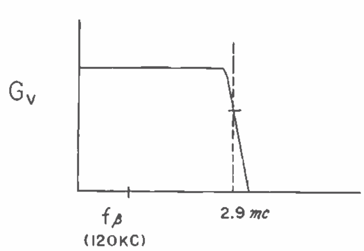
For maximum gain, it is necessary to operate a transistor in the common-emitter configuration; yet this configuration gives poor frequency response. There is a need, therefore, to arrive at some configuration or circuit arrangement which will yield better frequency response without sacrificing all of the common-emitter's gain capabilities.

A simple circuit arrangement which gives better frequency response is the common-emitter amplifier driven from a voltage (low-impedance) source:



(131)

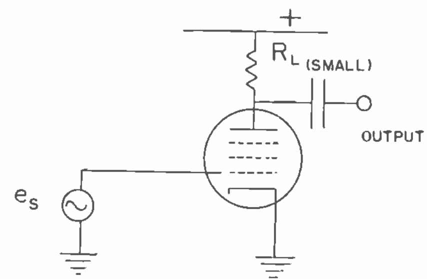
For the 2N219, this circuit arrangement extends the frequency response from 120 kc to 2.9 mc:



(132)

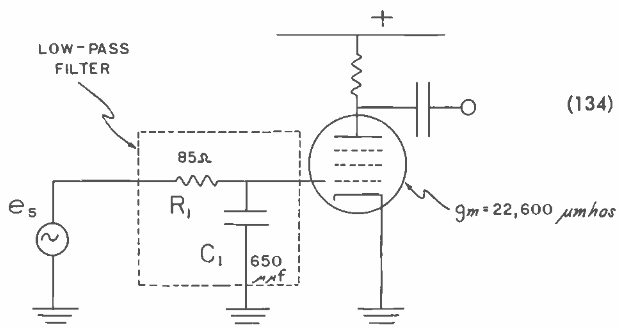
At this point, it is interesting to compare this CE amplifier with a vacuum tube amplifier. We may do so easily, since the CE emplifier is a voltage amplifier, and vacuum tubes are also normally considered to be voltage amplifiers.

A typical pentode vacuum tube in the same circuit



(133)

would have a bandwidth several times greater than the transistor bandwidth, but its gain would be only one-half to one-third as great. It would be possible to make a tube circuit which would behave almost like a 2N219, but to do so would require a pentode with a high transconductance—more than 22,000 μmhos —and would also require the use of a low-pass filter in the grid circuit, to simulate the poor frequency response of the transistor:



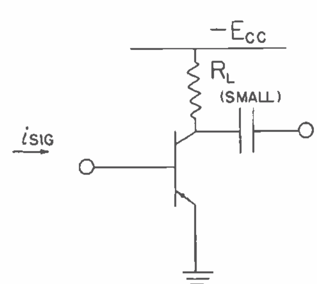
(134)

The 70 percent response point of the low-pass filter is at a frequency

$$f = \frac{1}{2\pi\ R_1C_1} = \frac{1}{2\pi\ (85\Omega)\ (650\ \mu\mu f)} = 2.9\ \text{mc} \qquad (135)$$

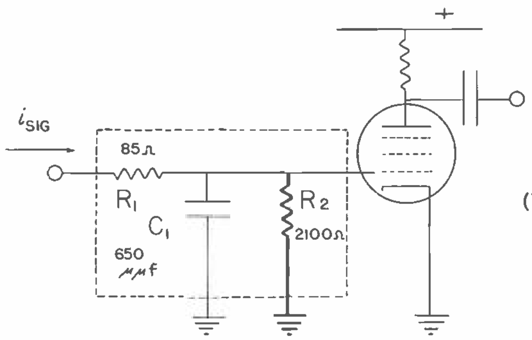
which is the cut-off frequency shown in figure 132.

It is possible to extend this comparison circuit to the case of the current-driven amplifier



(136)

merely by adding another resistor, R_2:



(137)

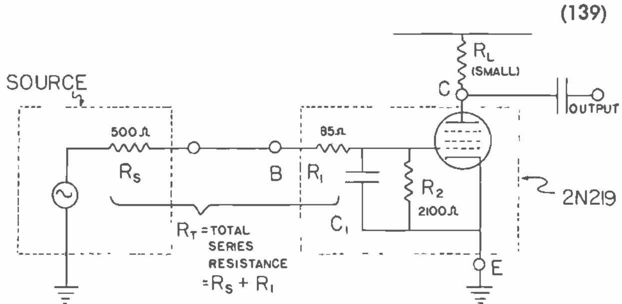
In this case, the low-pass filter cuts off at

$$f_\beta = \frac{1}{2\pi\ R_2\ C_1} = \frac{1}{2\pi\ (2100\Omega)\ (650\ \mu\mu f)} = 120\ \text{kc} \qquad (138)$$

which is the frequency given above as f_n for the 2N219.

In practical cases, transistors are not driven from perfect voltage sources (zero internal impedance) or from perfect current sources (infinite internal impedance), but from sources of some definite impedance. For example, a possible source for a 2N219 could have an internal impedance of 500 ohms:

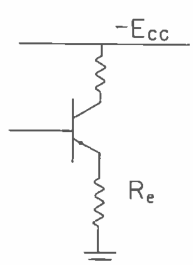
(139)



In this case, it can be shown that the original f_β bandwidth is improved by a factor of 4.6:

$$\begin{aligned} f' &= f_\beta\left(1 + \frac{R_2}{R_T}\right) \\ &= 120\ \text{kc}\left(1 + \frac{2100}{500 + 85}\right) \\ &= 120\ \text{kc}\ (4.6) \\ &= 550\ \text{kc} \end{aligned} \qquad (140)$$

Another simple circuit which extends bandwidth considerably is the circuit which includes an unbypassed emitter resistor:

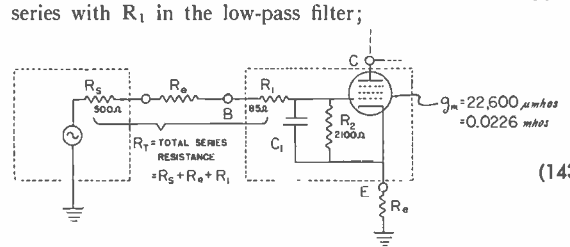


(141)

In this case, the beta cut-off frequency is extended by an even larger factor, as shown in this expression:

$$f' = f_\beta\left(1 + \frac{R_2}{R_T} + g_m\, R_e\, \frac{R_2}{R_T}\right) \qquad (142)$$

Note that this expression is the same as (140) above, except for the addition of one more term in the parentheses. Moreover, adding R_e in the emitter causes a "reflection" of R_e to appear in series with R_1 in the low-pass filter;

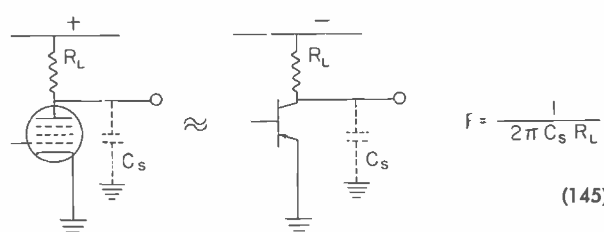


(143)

which means that a resistance equal to R_e must now be included in R_T, the total series resistance. If the value of R_e is, for example, 300 ohms, the new bandwidth is:

$$\begin{aligned} f' &= 120\ \text{kc}\left(1 + \frac{2100}{500 + 300 + 85} + \right. \\ &\qquad \left. (0.0226)\ (300)\ \frac{2100}{500 + 300 + 85}\right) \\ &= 120\ \text{kc}\ (1 + 2.36 + 16.0) \\ &= 2.33\ \text{mc} \end{aligned} \qquad (144)$$

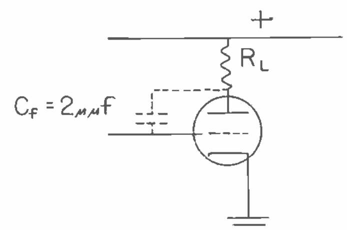
In all the foregoing discussion, the load resistor, R_L, was clearly tagged "small", in order to avoid, temporarily, the additional complications which arise when the load resistor is not small. The first complication is familiar to anyone who has used a vacuum tube in a wideband amplifier—stray capacity across R_L enters as an important bandwidth-limiting factor:



(145)

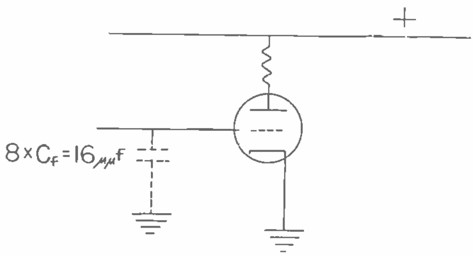
Just as in vacuum-tube practice, the effects of this capacity may be counteracted by an appropriate peaking network.

The other complication is also familiar to vacuum-tube users —the so-called "Miller Effect". In a vacuum tube, a small feedback capacity—typically about 2 $\mu\mu$f—appears between grid and plate:



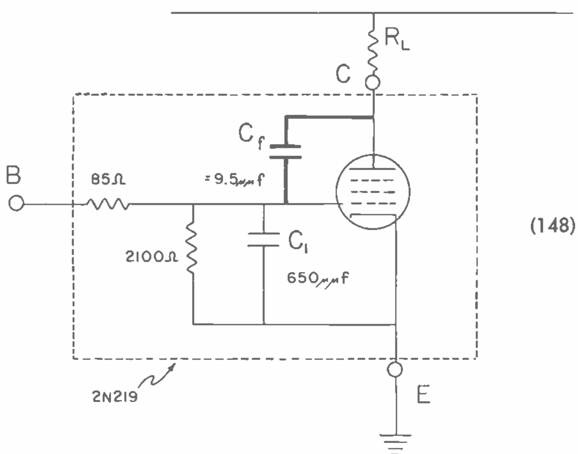
(146)

If the load resistor R_L is large enough to give this tube a gain of 7, for example, the small capacity C_f is multiplied by 1 + the gain, and appears as an 8-times larger capacitor shunting the input:



(147)

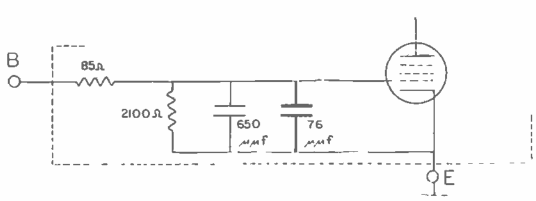
In transistors, a similar effect takes place. If the load resistor is large enough to give a useful gain, then a feedback capacity C_f which appears in this manner;



(148)

is magnified by a factor 1 + the gain, and appears across C_1. If the gain is 7, for example, then the magnified capacity is

$$(1 + 7) \times 9.5\ \mu\mu f = 76.0\ \mu\mu f \quad (149)$$



which affects the transistor's bandwidth the same as would an increase of C_1 from 650 $\mu\mu$f to 726 $\mu\mu$f.

The preceding examples used the 2N219. By present-day standards, this is a transistor of moderate frequency response, designed principally to be used as the mixer in transistorized broadcast-band receivers. The examples may be converted to show the behavior of a 2N104 or a 2N384 by substituting the appropriate values in this table:

(150)

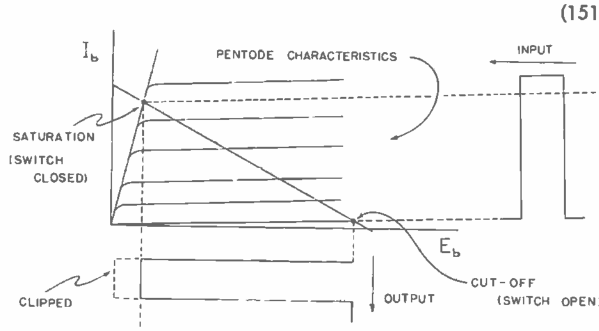
Equivalent Circuit Parameter	*2N104*	*2N219*	*2N384*
R_1	290Ω	85Ω	50Ω
R_2	1380Ω	2100Ω	1040Ω
C_1	6900 μμf	650 μμf	90 μμf
C_f	40 μμf	9.5 μμf	1.3 μμf
g_m	32.000 μmhos	22,600 μmhos	56,800 μmhos

The reader is invited to make the substitutions to extend his familiarity with the frequency response of various transistors.

Pulse Operation

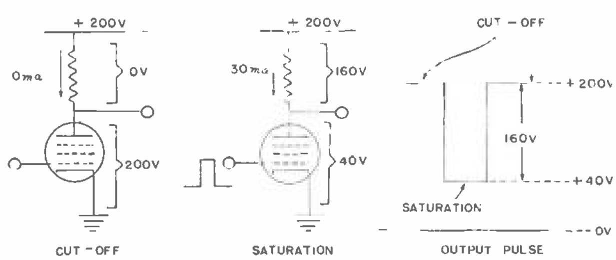
When a pulse is to be amplified, linearity is not a requirement of the amplifier. Consequently, the tube or transistor which is used as a pulse amplifier can be used as a switch, by driving it from cut-off to saturation:

(151)



The output pulse is very large under these circumstances. Its peak value is very nearly equal to the power supply voltage:

(152)



Note that even in saturation, the tube still has a 40-volt drop across it. Since it draws 30 ma in this condition, the power dissipated by the tube during the pulse is

$$P_p = IE = (30\text{ ma})\ (40\text{ volts}) = 1.2\text{ watts} \quad (153)$$

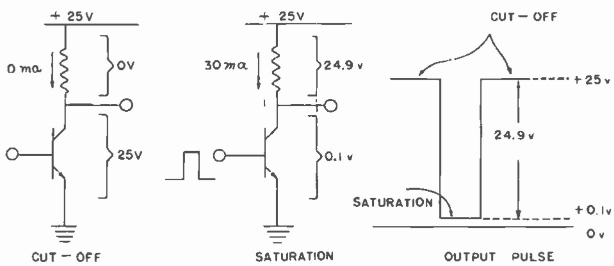
and the power switched (peak pulse power) is:

$$P_s = (30\text{ ma})\ (160\text{ v}) = 4.8\text{ watts} \quad (154)$$

which is 4 times as large as the tube dissipation.

A transistor can be used in much the same manner, but with two major differences: the ouput voltage is limited to (typically) 25 volts, and the drop across the saturated transistor is typically 0.1 volt:

(155)



In this case, the transistor dissipates (during the pulse) only

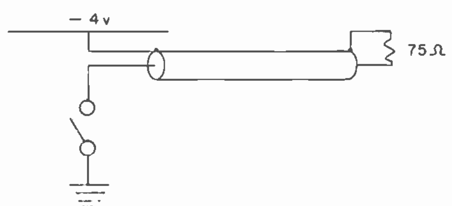
$$P_c = IE = (30 \text{ ma}) \ (0.1 \text{ v}) = 3.0 \text{ milliwatt} \quad (156)$$

while the peak pulse power (power switched) is

$$P_s = IE = (30 \text{ ma}) \ (24.9 \text{ v}) = 747.0 \text{ mw} \quad (157)$$

While the tube switched only 4 times as much power as it dissipated, the transistor switched 249 times as much power as it dissipated. The transistor is obviously a very efficient switching device.

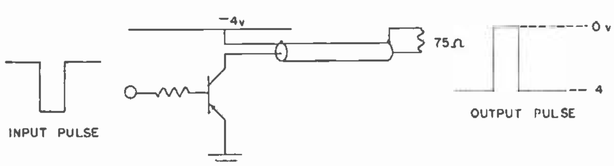
The excellent switching characteristics of transistors make them very useful in such applications as driving a 4-volt pulse into a 75-ohm coaxial cable in video pulse distribution systems. In this application, the transistor behaves in the same manner as the switch in this circuit:



(158)

Every time the switch is closed and then opened, a 4-volt pulse appears across the 75-ohm resistor. If the switch is replaced by a transistor which is driven into saturation by an input pulse,

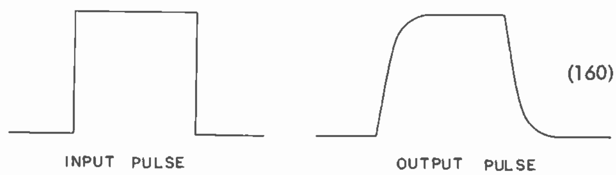
(159)



the transistor will open and close like a switch, alternately disconnecting and connecting the battery and the coaxial cable, and thereby causing a pulse to appear across the 75-ohm terminating resistor.

One of the most attractive features of this circuit is that the transistor's excellent switching efficiency makes it possible to drive 4 volts into a 75-ohm line with a tiny, low-power transistor. The simple circuit shown has a number of drawbacks, such as failing to provide sending-end termination for the coaxial cable. However, this fault and others are easily remedied by more sophisticated circuitry, so circuits similar to it will no doubt find wide use in video pulse distribution systems.

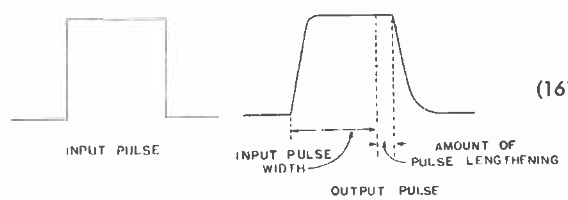
Whenever a pulse is amplified—whether by tube or transistor —there is a tendency for the amplifier to degrade the pulse somewhat. In a tube amplifier, the stray capacities tend to degrade the rise and fall times of the pulse, in a manner shown exaggeratedly here:



(160)

In a transistor amplifier, this action is worsened by the various internal capacities of the transistor. These capacities were discussed in the preceding section of high-frequency amplifiers, although the exact values given there are not valid for large signal swings such as are commonly found in pulse amplifiers.

In a *saturated* transistor pulse amplifier, another degradation enters in the form of *pulse lengthening*, which distorts the input pulse in this manner:



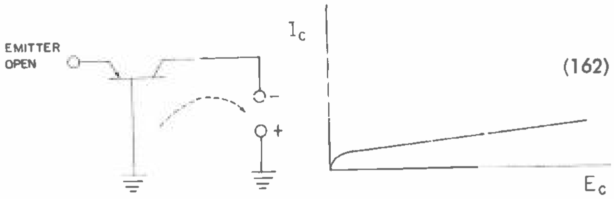
(161)

The degree of lengthening depends upon how hard the transistor is saturated. If the pulse width is not critical, a fair amount of lengthening can be tolerated. However, if the input pulse must be faithfully reproduced at the output, careful engineering is needed to minimize the lengthening. The engineering problem is eased considerably by the availability of switching transistors which are constructed to minimize this effect.

Temperature Effects

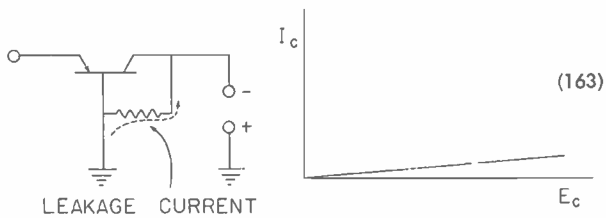
In the first article of this series, the transistor was introduced as an extension of a junction diode. It was shown that the reverse-biased collector junction passed a small current, just as would be expected of any junction diode:

(162)



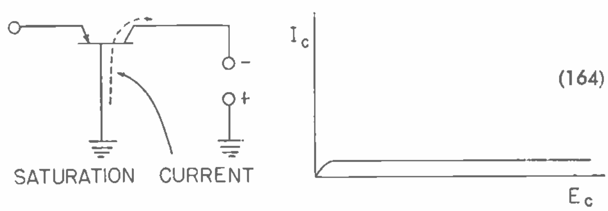
This current has two components. The first component results from simple resistive leakage paths.

(163)



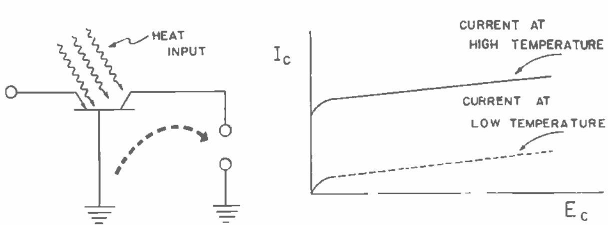
and the second component, called *saturation current,* results from a semiconductor action:

(164)



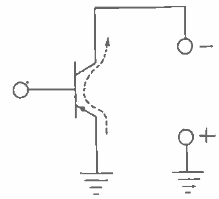
Although the saturation current is little affected by changes in collector voltage, it is extremely sensitive to changes in temperature. As junction temperature is increased, the saturation current increases:

(165)



The increase is very rapid; the current doubles about every 9 C. However, even at the highest operating temperatures, this relatively small current does not often cause trouble *as long as the base is grounded.*

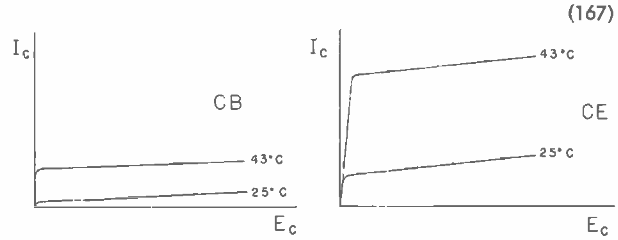
However, the transistor is often operated with the emitter grounded. In this configuration, the tiny reverse[1] current must pass through the base-emitter junction as well as the base-collector junction.



(166)

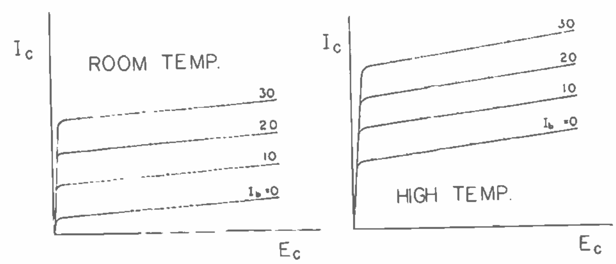
and in so doing, becomes amplified by the current-amplifying mechanism of the transistor. Consequently, the reverse current for the CE configuration is beta times greater than the reverse current for the CB configuration. With this larger current being doubled for every 9 C temperature rise, the high-temperature reverse current becomes a factor deserving serious consideration.

(167)



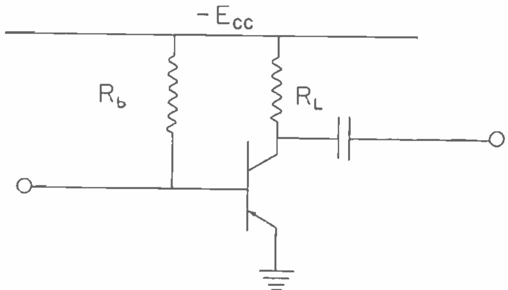
The family of curves is not distorted by the high-temperature reverse current, but merely displaced, intact, to another area of the graph:

(168)



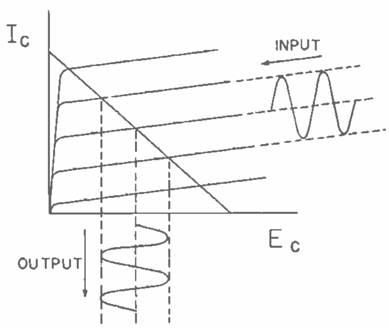
This displacement can seriously disturb the functioning of an amplifier. Consider the effect that elevated temperatures would have on this simple CE amplifier:

[1] Since the temperature problems are tied to only the saturation component of the total reverse current, the resistive (leakage) component will be ignored in this discussion, for the sake of simplification.



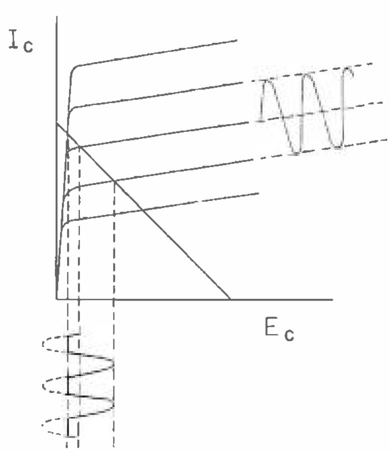
(169)

At normal operating temperatures, a sine wave input gives relatively distortion-free output:



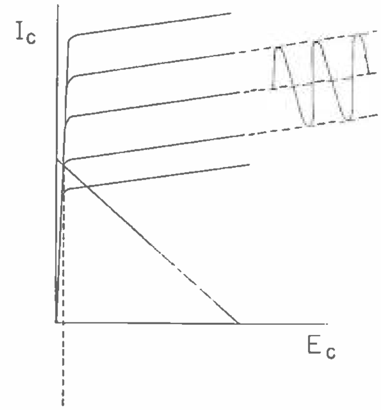
(170)

If the temperature is raised, however, the curves shift upward, and the amplifier begins to clip:



(171)

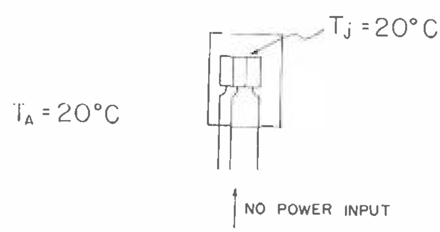
At a sufficiently high temperature, the signal is completely clipped,



(172)

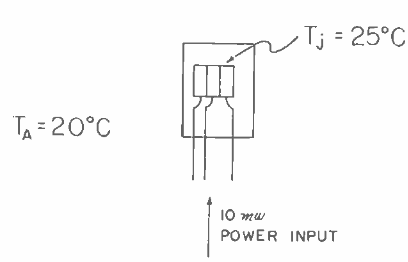
and the transistor is said to be saturated. Since no amplification can be obtained when the transistor is saturated, this situation must be carefully avoided, either by avoiding high temperatures, or by improved biasing circuitry, or both.

Note that the temperature referred to in all this discussion is *not* the temperature of the transistor's environment, but is rather the temperature of the collector junction itself. If the transistor is not drawing any current (as might be the case if it were in dead circuit or in storage) the junction temperature T_j and the ambient (environmental) temperature are the same:



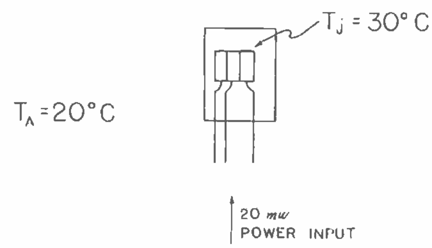
(173)

However, when there is a power input, the heat dissipated at the junction will raise the junction temperature above the ambient temperature. For example, a 10-milliwatt power input might raise T_j by 5C,



(174)

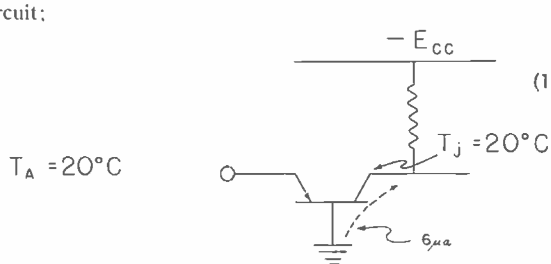
and a 20-milliwatt power input, by 10°C.



(175)

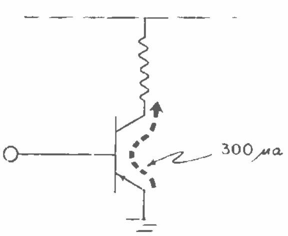
It is correct to deduce from these two cases that every 1 milliwatt of power input will cause a 0.5°C rise in junction temperature for this particular transistor. This characteristic of a transistor is called its *thermal resistance*, and would be listed in the data sheet of this particular transistor as having a value of 0.5°C/mw.

The thermal resistance of a transistor is one of its more important characteristics. It enables the transistor user to compute the temperature of the junction itself, and, using this value of T_j, to compute the temperature-induced reverse current. For example, if a transistor has a reverse current of 6 μa in this circuit;



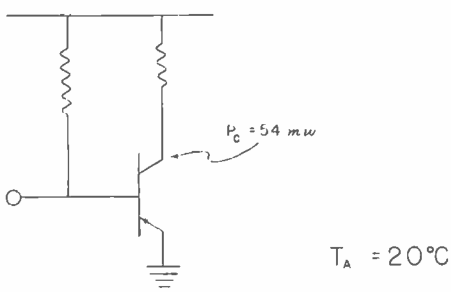
(176)

it will have a reverse current of $\beta \times 6\ \mu a = 300\ \mu a$ in this circuit:



(177)

If the simple single-resistor biasing technique is used (to exaggerate, for this example, the effects of temperature), and the circuit is adjusted for 54 mw dissipation,



(178)

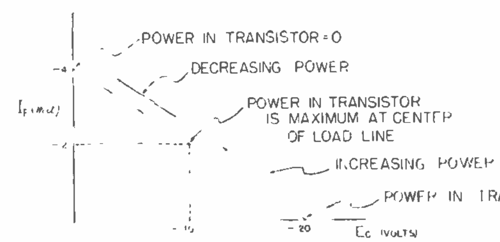
then a thermal resistance of 0.5°C/mw tells us that the junction temperature is higher than the ambient by

$$0.5°C/mw \times 54\ mw = 27°C; \qquad (179)$$

and the actual T_j is $27° + 20° = 47°C$. Since the reverse current doubles every 9°C, it will be eight times larger in this 27° change, causing the 300 μa reverse current to become 2400 μa, or 2.4 ma.

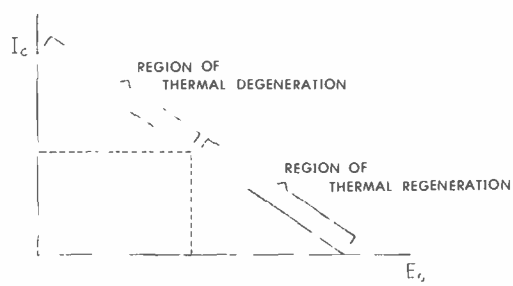
The presence of this additional 2.4 ma could increase the dissipation to more than 54 milliwatts, thereby causing more heating of the junction, which would result in even more reverse current, thereby causing even more heating, and so on. This mechanism, which is called *thermal regeneration*, can have a number of undesirable effects. In its milder forms, it can cause the operating point to be unduly sensitive to ambient-temperature changes. More serious cases can drive the operating point into the high-current region, with the consequent possibility of clipping and distorting the signal. The most serious result of thermal regeneration, however, is *thermal runaway*, which is a thermal regeneration resulting in the transistor's self-destruction. Proper design can prevent both of the serious effects, and can also make even the mild effect completely negligible.

Thermal regeneration is not inevitable in transistor circuits. It occurs only when an increase in collector current causes an increase in collector power. This is true only for operating points falling on the lower half of the load line:



(180)

When the operating point is on the lower half of the load line, an increase in current causes an increase in power; this is thermal regeneration. When the operating point is on the *upper* half of the load line, an increase in current causes a *decrease* in power; this is *thermal degeneration*.

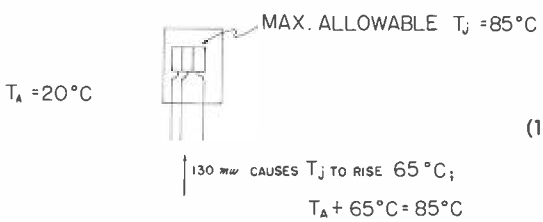


(181)

It might seem that transistor circuits should always be biased into the degenerative region as a safety precaution. However, this is usually not necessary. Proper circuit techniques make the regenerative region so stable that it is commonly used, particularly since it is the low-current region of the load line and therefore minimizes the current drawn by the equipment.

Maximum Power Dissipation

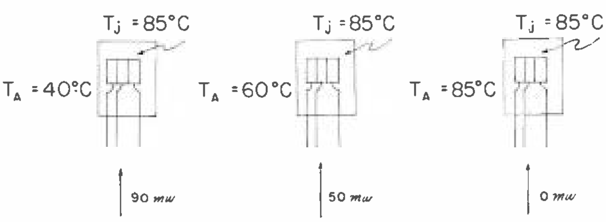
The thermal resistance given in a transistor's data sheet may be used to compute the maximum power dissipation allowable at a given ambient temperature. A typical small germanium transistor usually has a maximum allowable junction temperature of 85 C. If its thermal resistance is 0.5 C/mw, and the ambient temperature is 20 C, it can tolerate only enough power to raise the junction from 20 to 85 C, a change of 65 C. Since each milliwatt contributes 0.5 C, 130 mw will give a rise of 65 C:



(182)

At this ambient temperature, 130 mw is the maximum allowable power input. At higher ambient temperatures, the maximum allowable power input is less than 130 mw:

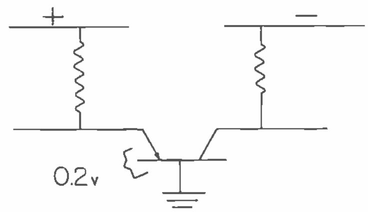
(183)



or, to put it another way, if this transistor has a 50-mw power input (for example), the ambient temperature must not rise above 60 C, or the junction temperature will exceed 85 C. Moreover, at an ambient temperature of 85 C, the transistor cannot be operated at all, since it cannot tolerate any power input.

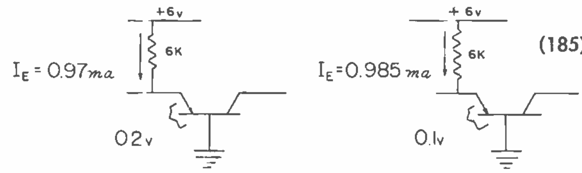
Emitter-to-Base Voltage

The reverse current is a temperature effect related to the reverse-biased collector junction. There is another temperature effect related to the forward-biased emitter junction. This junction, which at normal temperatures has a voltage drop of about 0.2 volts across it,



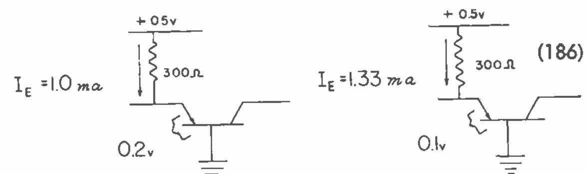
(184)

at higher temperatures has a smaller drop. This effect is of no consequence when the emitter is current-biased,



(185)

but as voltage-biased conditions are approached, the bias currents can change appreciably with temperature:

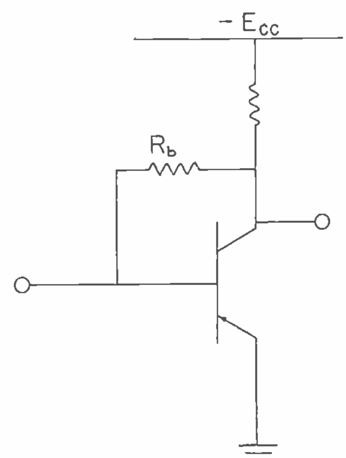


(186)

In general, voltage-bias of the emitter should be avoided, unless the circuit can accommodate the changes in operating currents without giving improper operation.

Stabilizing Circuitry

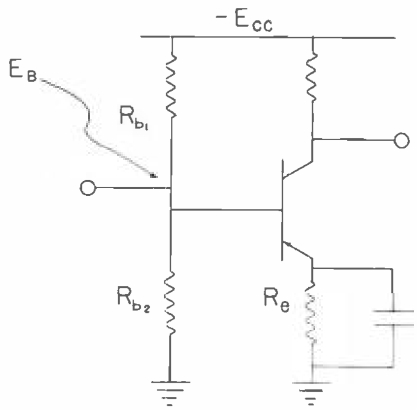
The temperature dependence of transistors can be minimized by the proper circuitry. For example, the performance of the simple common-emitter amplifier can be improved by moving the biasing resistor from the power supply to the collector:



(187)

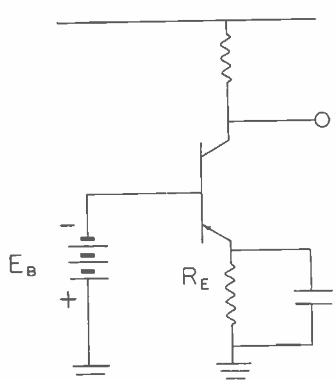
In this arrangement, any increase in collector current causes the voltage at the collector to decrease, thereby decreasing the bias current flowing through R_b into the base. When base current decreases, the collector current also decreases, thereby tending to restore the original operating condition.

A transistor may also be stabilized by the use of this circuit:



(188)

Here the fundamental requirement is that the bleeder current flowing through R_{b_1} and R_{b_2} be so much larger than the base current that changes in base current cannot influence the voltage at the midpoint of the R_{b_1}/R_{b_2} divider. Under this circumstance, the base voltage cannot change, and the circuit behaves like a biased-up common-base amplifier, insofar as the bias currents are concerned:



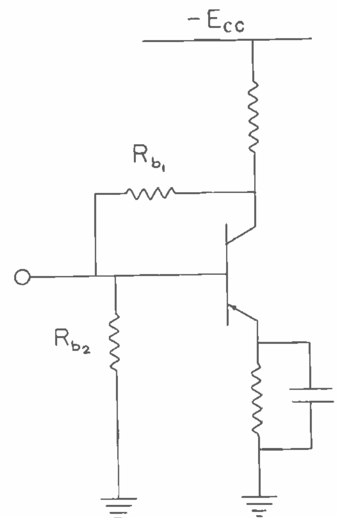
(189)

The emitter current (and therefore, the collector current) is determined principally by the "battery" voltage and the emitter resistor:

$$I_E = \frac{E_B}{R_E} \qquad (190)$$

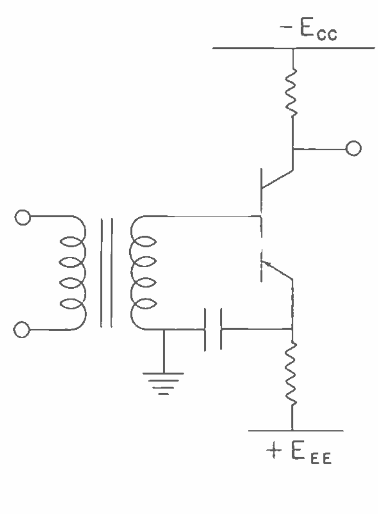
(This expression assumes that the "battery" voltage is much greater than 0.2 volts across the emitter junction.) The operating point is therefore almost independent of temperature, since neither E_B nor R_E is influenced by temperature.

The two foregoing circuits are sometimes found combined in a single circuit for increased stability:



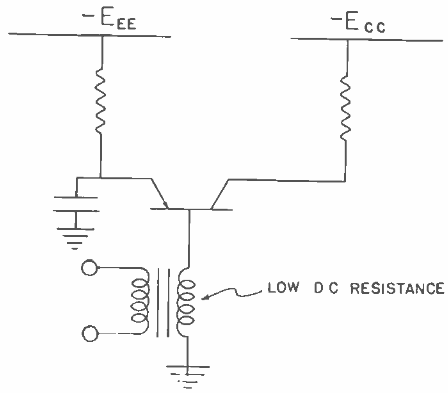
(191)

The common-base amplifier with current bias exhibits the best obtainable single-stage temperature independence. However, it lacks the gain capabilities of the common-emitter configuration. Some circuits can be arranged to make use of the good features of both the CE and CB configurations. This is accomplished by making the amplifier a CE configuration for signal currents:



(192)

and a CB configuration for bias currents:



(193)

Conclusion

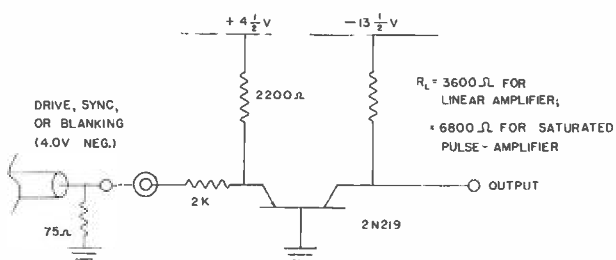
The information given in this series of three articles can be considered as nothing more than a narrow introduction to a broad subject. The material in these articles, properly assimilated, will facilitate a more detailed study of transistors, using one of the many excellent texts currently available (see the bibliography at the end of this article).

The appendix which follows presents a few easily-constructed circuits to illustrate some of the principles discussed in the articles. Some of these circuits assume that the standard television pulse waveforms—sync, drive, blanking, and video—are available to the constructor. The other circuits require less elaborate facilities.

APPENDIX

The following circuits have been designed to illustrate some of the principles of transistors. A 2N219, which is relatively inexpensive, will give very good results in any of the circuits except where noted otherwise. The potentials were chosen as those obtainable from two inexpensive batteries: the VS028 (4½ volts) and the VS304 (13½ volts).

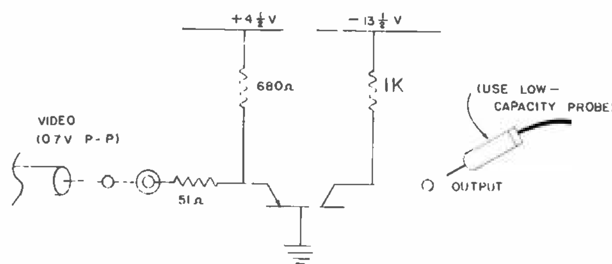
1. *A common-base amplifier*



Remarks: The 2N219 shown here can be replaced by almost any PNP transistor, although audio-type transistors (such as the 2N109) will give poorer pulse performance. To use an NPN transistor, change the −13½ volts to +13½ volts, and the +4½ volts to −4½ volts. For saturated operation with an NPN transistor, omit the 2200-ohm resistor and the 4½-volt bias supply.

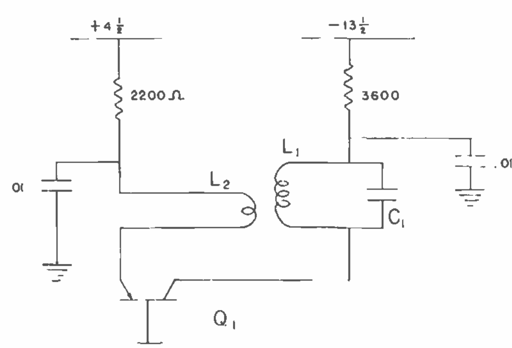
This amplifier has a gain of 1.8 as a linear amplifier (Gv = 3600/2000). As a saturated pulse-amplifier, its output is 13½ volts of pulse.

2. *A common-base video amplifier*



Remarks: The transistor used here should have an alpha cut-off frequency somewhat greater than the desired bandwidth. As shown, a low-capacity probe should be used to view the waveform. An NPN transistor may be used by reversing the polarity of the power supply voltages.

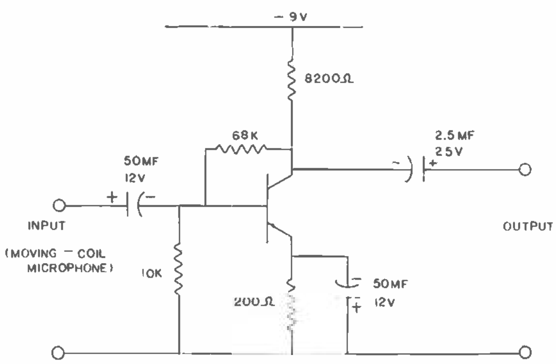
3. *A common-base oscillator*



Remarks: This simple oscillator will operate over a wide range of frequencies. For example, it will oscillate on the broadcast band if L_1 is a North Hills brown dot (105-200 mh), C_1 about 180 mmf, L_2 about 20 turns of #26 wire wound between the pies of L_1, and Q_1 a 2N219. The circuit should oscillate to at least 12 mc with the 2N219, with appropriate changes in the resonant tank L_1 - C_1 and in the feedback winding L_2. (L_2 should have about one-sixth the number of turns of L_1). With a 2N247, oscillations can be obtained to at least 60 mc, and with a 2N384, to at least 150 mc.

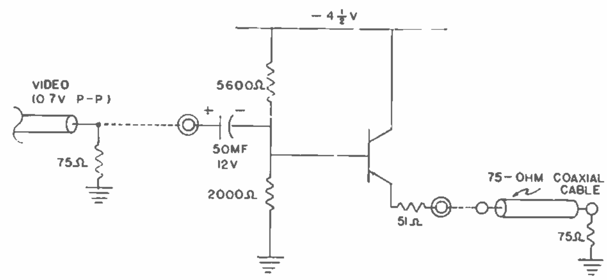
If the circuit does not oscillate, try reversing the leads from L_2.

4. *A common-emitter microphone preamplifier*[1]



Remarks: This circuit illustrates the temperature stabilization discussed on page 57 of Part III. The original circuit used a 2N109, but almost any PNP transistor should perform adequately. The circuit was designed to use an RCA 239S1 2⅛" speaker as a microphone. In such operation, one of the holes in the back of the speaker should be covered with cardboard having a 1/32" hole drilled in it. The remaining holes in the back of the speaker should be covered with felt, and the speaker mounted in a baffle or case.

5. *A common-collector line driver*



Remarks: This line-driver provides proper terminations for a 75-ohm line. It has a gain of one-half. Its bandwidth can be calculated from expression (142) in Part III.

[1] Circuit and speaker-modification information courtesy of RCA Semiconductor Division, Somerville, N. J.

BIBLIOGRAPHY

The list which follows does not include many important transistor books, but will serve to guide the reader to these and other references:

1. Lo, Endres, Zawels, Walhauer, and Cheng. *Transistor Electronics.* Prentice-Hall, 1955.
2. *Transistors I.* RCA Laboratories, 1956.
3. Riddle and Ristenbatt. *Transistor Physics and Circuits.* Prentice-Hall, 1958.
4. Hurley. *Junction Transistor Electronics.* John Wiley & Sons, 1958.
5. Hunter (ed). *Handbook of Semiconductor Electronics.* McGraw-Hill, 1956.

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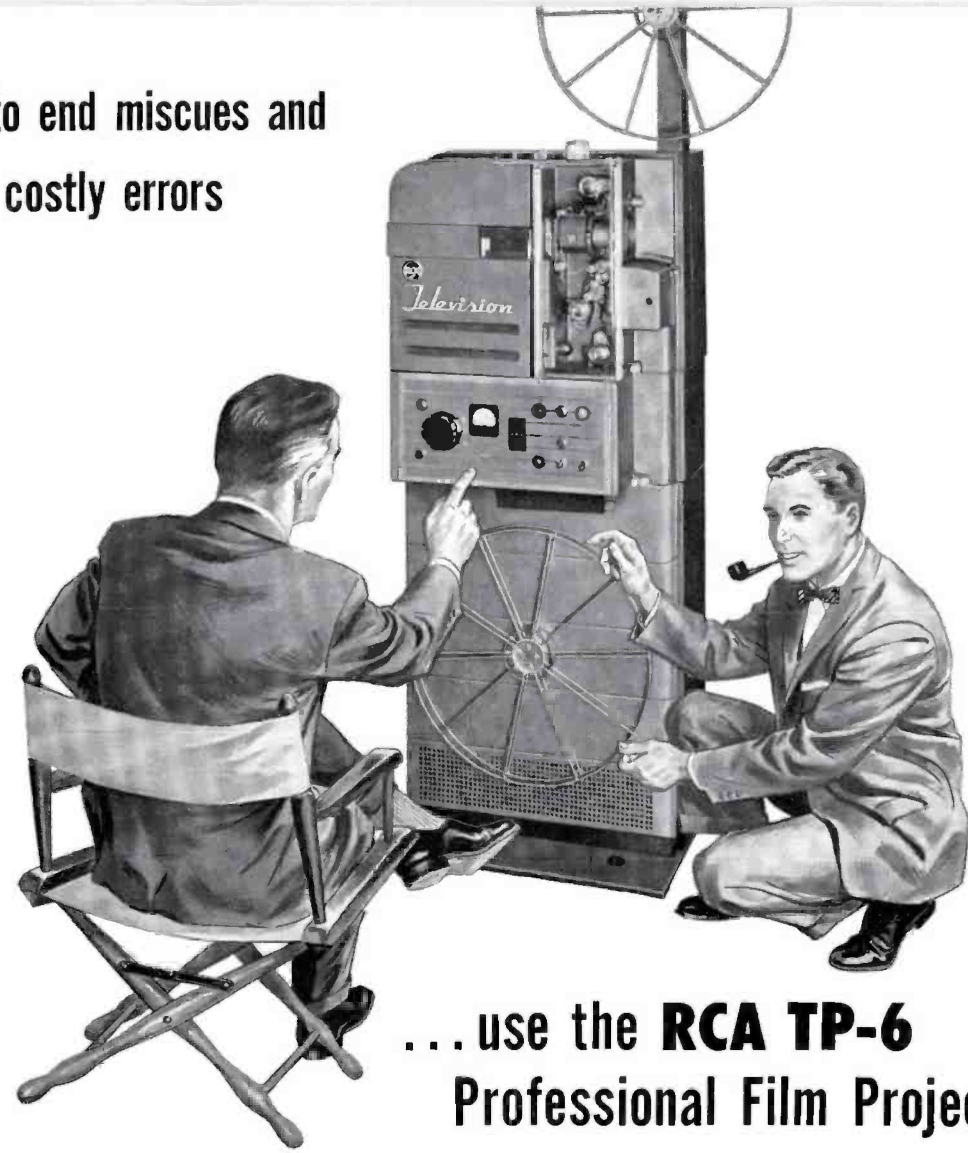

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RCA

BROADCAST SERVICE

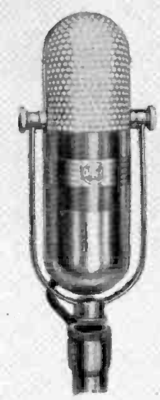
RCA SERVICE COMPANY

A Division of Radio Corporation of America
Camden 8, New Jersey

Tmk(s) ®

Type BK-1A Pressure Microphone—High-fidelity "Commentator" pressure microphone, non-directional in character. An ideal announce mike for speakers. It assures clear, crisp speech and is well suited for remote pickup.

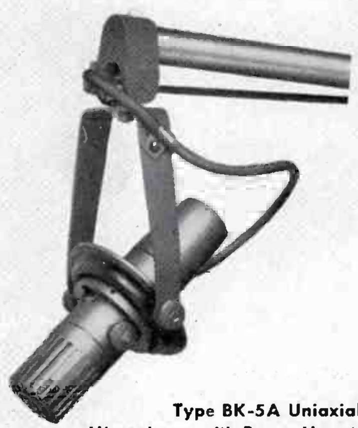
Type BK-5A Uniaxial Microphone with Desk Stand—Standard of the television industry, highly directional, with high front to back ratio. Unidirectional characteristic simplifies microphone and camera placement. (See boom-type below.)



Type 77-DX Polydirectional Microphone—Excellent for both voice and music. The standard of the broadcast industry. Variety of directional characteristics, with high sensitivity over entire frequency range, assures high quality reproduction.

A Microphone

Immediately Available from RCA!



Type BK-5A Uniaxial Microphone with Boom Mount. Specially engineered for the television industry to reduce camera noise and interference. Newly designed boom mount combines superior mechanical isolation with rugged durability. Also available with wind screen for outdoor use.

Whatever your special microphone requirements, RCA can meet them exactly.

Look at the variety of models now offered. You can get pressure-type microphones—such as the BK-1A, SK-45, or BK-6B—and velocity-types—the BK-5A, 77-DX or SK-46. There are microphones for radio or TV station use; for intercom, paging, or PA use. Also mikes for announce, music, or both; for desk, boom, personal use—unidirectional, bidirectional, polydirectional.

Also A Complete Line of Microphone Accessories...

Type SK-45 Pressure Microphone—Rugged, announce microphone of the dynamic type, suitable for talk-back or cue-in purposes. Economical, light in weight, small in size. Designed for high or low impedance use.

Type BK-6B Miniature Microphone—Small but tough, this new personal microphone is easily concealed in hand or clothing. Only half the size and weight of previous models. Offers excellent speech balance when talking "off mike." Wide range frequency response.

Type SK-46 Velocity Microphone—Good low-cost studio velocity microphone for speech or music. Provides bidirectional characteristic over wide frequency range. Designed for high or low impedance use.

for Every Need...

For the finest microphones that money can buy, or for quality, low-cost, utility microphones... when you come to RCA, you know the microphone will be right—whatever the type. It has to reflect the standards for which the RCA symbol has long been famous.

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BROADCAST AND TELEVISION EQUIPMENT

CAMDEN, N. J.

Tmk(s) ®

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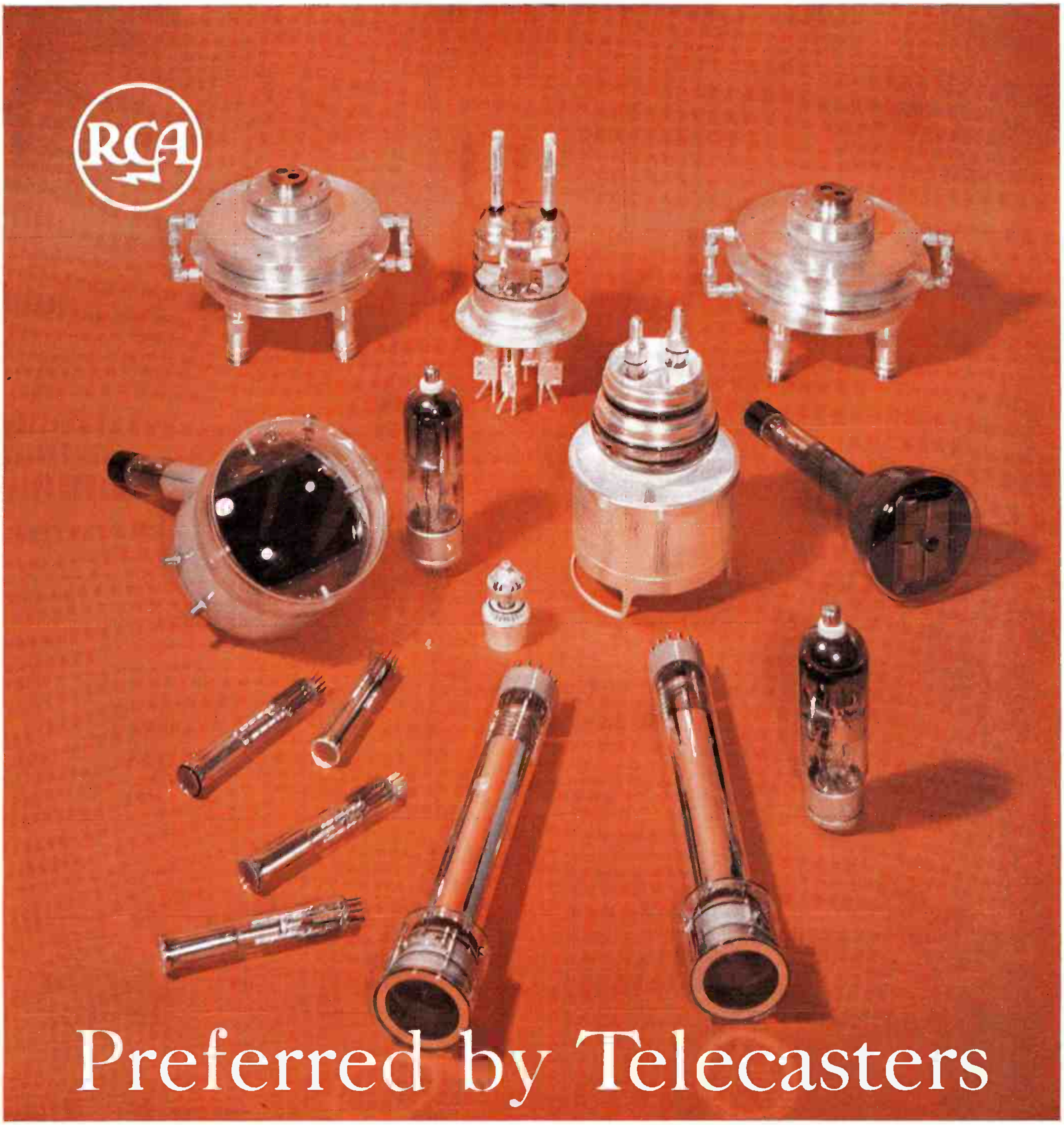

For high-quality aural and visual signals...and for maximum ON-AIR continuity...it pays to use RCA time-proved tube designs across the board. No finer tubes are made for monochrome *or* color. Your RCA Electron Tube Distributor has the tubes you need—for cameras—transmitters—film systems—camera chains—audio equipment—power supplies. He is at your service day and night. Just call him for fast delivery.

RADIO CORPORATION OF AMERICA
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NEW 5000-WATT AM TRANSMITTER

Type BTA-5R/5R1

INTRODUCES ADVANCED SILICON HIGH VOLTAGE RECTIFIERS

The compact BTA-5R/5R1 is available with a choice of tube rectifiers or new long-life silicon rectifiers. Only two tuning controls make this transmitter ideal for reliable remote control operation. Instantaneous Conelrad frequency switching is also available. Vertical chassis construction provides easy front and rear access to all components.

Silicon rectifiers, tested in a pre-production model of the BTA-5R1, were subjected to aging, estimated to be equivalent to 20 years, while the remaining portions of the transmitter also met severe tests. All of them proved the ability of these transmitters to perform over long periods under adverse conditions. The reliable silicon type of rectifier is ideal in remote control applications. The transmitter will operate within ambient temperatures from —4 to +113 degrees F. and to 7500 feet above sea level.

A unique exciter features plug-in crystal oscillators (this is the exciter proved in the BTA-500R/1R). Three switchable crystal positions are provided for: (1) an operating crystal, (2) a spare on the main channel, and (3) provisions for optional instantaneous Conelrad switching. High-fidelity performance is assured with the new 3X3000 F1 modulator tubes that *do not draw grid current* to modulate the two long-life 5762 PA tubes. Overall AF response is ±1.5 db from 30 to 10,000 cycles.

For further information about these and other transmitters, call the nearest RCA Broadcast representative. Or write to RCA, Dept. UB-22, Building 15-1, Camden, N.J. In Canada: RCA VICTOR Company Limited, Montreal.

OUTSTANDING FEATURES

- Built-in provision for remote control
- Unique exciter with plug-in oscillator
- Instantaneous Conelrad frequency switching (optional)
- Silicon rectifiers (optional)
- Only two tuning controls
- High fidelity performance

RCA Tmk(s) ®

RADIO CORPORATION of AMERICA

BROADCAST AND TELEVISION EQUIPMENT

CAMDEN, NEW JERSEY

The second most prized possession of Don Budge

Pardon us if we make you feel old. But it's now over 20 years since Don Budge made the Grand Slam of tennis—the British, Australian, French, and American men's singles championships (with a couple of doubles titles for good measure).

That unprecedented feat won the A.A.U. Sullivan Memorial Trophy, his most prized possession. You see it above, with his second most prized possession, his Color TV set.

Today Don Budge is still in sports—President, Budge Tennis Corp. And he still loves action and excitement. That is why Don Budge prizes Color TV so highly. He likes its exciting difference, the stunning color picture, the year-round enjoyment, the pride in owning the finest television there is. Good reasons why Color TV appeals to more and more people like Don Budge. People who lead the colorful life.

Today, Color TV is right and ready for *you*. See your RCA Victor dealer for a demonstration. See the wonderful difference Color TV makes. Prices as low as $495.

5TH ANNIVERSARY OF COLOR TV: A LIFETIME OF PROGRESS IN 5 SHORT YEARS

Service is no problem. See your local dealer, serviceman, or nearest RCA Service Co. office. Nat'ly advertised list price shown, optional with dealer. UHF optional, extra. Price, specifications subject to change without notice.

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