JUNE 1959

Covering all phases of . . . . AM FM TV

BROADCAST ENGINEERING

THE TECHNICAL JOURNAL OF THE BROADCAST INDUSTRY

In this issue . . .

Stellavox

MINIATURE TAPE RECORDER,
TRANSISTORIZED, BATTERY OPERATED.

Type SM 4

Technical Specifications.

Frequency response:

Recording: ± 2 db within a range of 30 — 14000 cycles

Play back: ± 3 db within a range of 60 — 14000 cycles

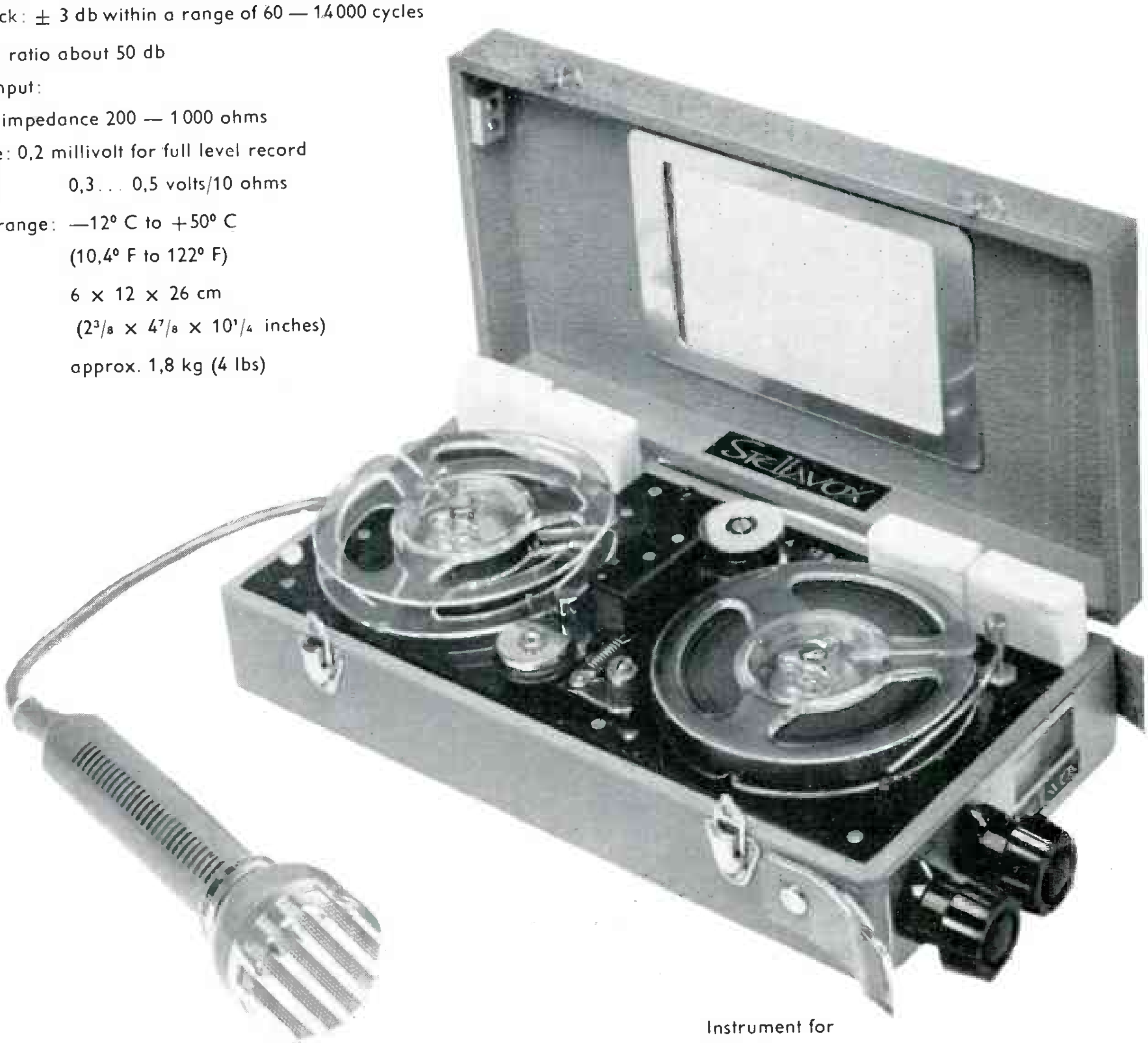
Signal to noise ratio about 50 db

Microphone imput:

Source impedance 200 — 1000 ohms

Voltage: 0,2 millivolt for full level record

Reproduction:	0,3 . . . 0,5 volts/10 ohms
Temperature range:	—12° C to +50° C (10,4° F to 122° F)
Dimensions:	6 × 12 × 26 cm ($2^3/_8$ × $4^7/_8$ × $10^1/_4$ inches)
Weight:	approx. 1,8 kg (4 lbs)



Instrument for

Recording level (during recording)

Battery control (during play back)

Pilot lamp for electronic speed regulator

The professional portable Tape Recorder

Electronic Applications

194 Richmond Hill Avenue, Stamford Conn.

in Canada, Viditon Corp. Ltd., Ottawa

JUNE 1959 Vol. 1 No. 2

BROADCAST ENGINEERING

CONTENTS

DEPARTMENTS

COVER STORY

The operator points to the brightness level on the monitor during the "Operation Videofilm" workshop held in New York. An exclusive report is published in this issue of BROADCAST ENGINEERING which tells how to obtain the best results using film for TV.

Editor and Publisher — D. E. Mehl

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BROADCAST ENGINEERING, P. O. Box 93, Kansas City 41, Missouri

Sounding Board

Readers are invited to submit their ideas and opinions pertaining to the field of broadcast engineering.

Editor:

I have received the first issue. The articles concerning multiplexing were most interesting to me. I would like to see a really good series concerning the new high-fidelity setup at WLW—details of actual brands of equipment used, station modification made, pickups and tape playback machines used, program sources, etc. M. C. Bowers, Jr.
Owner
W B L U
Salem, Va.

Editor:

Am very pleased to have a brand new trade magazine such as Broadcast Engineering. We are all hoping for a long and successful period of publication.

Would like very much to see an article or at least a good schematic in the near future of a good electronic circuit for producing the echo effect or reverberation, such as is produced by many of the tape recorders, which could be wired into the console of the small broadcast stations, and which could be cut in or out of operation by pressing a spring loaded switch.
Chief Engineer Harry L. Albers
K L U K
Evanston, Wyo.

Editor:

My sincere congratulations to Broadcast Engineering and its staff for what I feel is the finest technical journal today in the broadcast industry. Needless to say, I am extremely pleased to be a subscriber to Broadcast Engineering and strongly urge that everyone should subscribe likewise. Peter Russett
Asst. Chief Engineer
W S R O and W I - I W K Radio
Marlboro, Mass.

Editor:

How much for a Life Subscription? Looks like a good magazine! Glad to see it appear and fill a long felt need for a publication for pros and not hi-fi fans. F. C. Harvey
W H K W
Chilton, Wis.

Editor:

Stereo is causing so much consternation among the multiplex boys that care must be exercised in where it is ultimately placed. If it gets into the homes via one of the sub-channels, I shudder to think of what it will do to the 132 holders of S.C.A.'s. W. C.

Editor:

Have just looked over Volume No. 1 of BROADCAST ENGINEERING. Keep up the good work!

We have long needed a journal such as this. One has neither the time or money to pour through all of the other technical magazines to find the few items relating to broadcasting. My hope is that you will manage to maintain a balance between AM, FM and TV broadcasting. So much play has been given TV in the past few years that one still in radio feels left out and forgotten. I. A. ELLIOT
Manager
K A T L
Miles City, Mont.

(We have many articles planned which will be of special interest to people in AM radio.—Editor)

Editor:

I have just received the first issue of BROADCAST ENGINEERING and I am glad to find a magazine that intends to concentrate on the current broadcast (AM, FM and TV) technical developments and ideas rather than a fuzzy group of electrical fields. I am looking forward to the "Short Circuits" and "Technical Hints" departments in the next issue. CARY FITCH
Chief Engineer
K A N N
Sinton, Tex.

("Short Circuits" will start in July. Readers are asked to send in technical questions for publication in this department.—Editor)

Editor:

I have just read and enjoyed the May issue of BROADCAST ENGINEERING and think it fills a real need in the industry. I have asked the station manager to subscribe to same.

The only suggestion I have is that FCC Regulations Section is a waste of space. I can't imagine a station that doesn't have a copy of FCC Regulations concerning broadcasting. However, changes in existing regulations would be appreciated. GEORGE W. MORRISON
Chief Engineer
K P L K
Dallas, Ore.

Editor:

I received my first issue of BROADCAST ENGINEERING and thank you.

Congratulations on a fine magazine. I enjoyed every page of it. It is informative, well-written and nicely presented. The boys and myself at KRBI agreed that it is a good practical magazine for anyone in or otherwise connected with the broadcast engineering field.

Lots of good luck and may your circulation continue to grow. WILBUR H. RAU
K R B I
Henderson, Minn.

This Month the Following New Departments Start in . . .

BROADCAST ENGINEERING

SOUNDING BOARD

The industry thinking on technical topics will be reflected in the letters from our readers. Send in your ideas on how improvements can be made in broadcast equipment, standards, allocations or operations.

TECHNICAL HINTS

If you have developed an unusual, easier or improved technique which may be helpful to other broadcasters, send the details for publication. Five dollars is paid for each technical hint published.

NEXT MONTH—SHORT CIRCUITS

Another new department which will help find answers to your technical broadcast problems will start with the July issue. Readers are invited to submit technical questions which will be published for possible solution by others in the industry.

(Your name will not be used if you prefer.)

Send all letters to . . . .

Editor
BROADCAST ENGINEERING
P. O. Box 93, Kansas City 41, Mo.

Editor:

Enclosed is our subscription card for your magazine.

Broadcast engineers certainly need such a publication and I fervently hope that they will all support your effort to such an extent that it will be a howling success.

Manager for Engineering — Guy C. Rauer
WEJL
Scranton, Pa.

Editor:

Congratulations on your excellent journal, long needed by the broadcast industry. Best wishes for a long and prosperous future.

Chief Engineer — Henry N. Fones
WDIA
Memphis, Tenn.

Our sincere thanks to all of our subscribers, advertisers, manufacturers, contributing writers and others who have cooperated generously to make this publication possible.

We are doing everything possible to justify this faith and to furnish an informative and helpful technical journal to the broadcast industry.—Editor.

SEND YOUR VIEWS and IDEAS to SOUNDING BOARD

Paul Kaufman, vice-president, DuArt Film Laboratories, Inc., New York, discusses graphs of exposure vs. density of film. Graph on monitor shows a curve representing the gradation of density from blackest black at bottom to whitest white at top.

OPERATION

HIGHLIGHTS TECHNIQUES WHICH INSURE

Panelists, from left to right—E. G. Hamilton, Director of Engineering, ABC; John Stott, Assistant Manager of TV Programming, Eastman Kodak Co.; Paul Kaufman, DuArt Film Laboratories; Peter Keane, Technical Director, Screen Gems, Inc.; and Ed Warnecke, Assistant Chief Engineer of the East Coast Division, Motion Picture Film Department, Eastman Kodak Co.—answer questions from the audience.

To the video engineer at his waveform monitor, the cameraman who shot the original film footage going out over system seems far away. Bringing the cameraman's product—film footage — closer to what the video engineer must have to put out a top notch picture was one of the reasons the New York Section of Society of Motion Picture and Television Engineers and the National Television Film Council jointly staged "Operation Video-film" March 11 at Farkas Film Studios, New York.

In a two-part presentation — shooting session March 11 followed by closed circuit screening of the results April 29 — "Operation Videofilm" pinpointed ways in which the people responsible for shooting film for TV can simplify the video engineer's job of producing a top-notch picture on the home receiver.

Terms such as "reference white," "reference black" and "proper brightness ratios" were guideposts at the initial "see-it-yourself" shooting session, as the words were translated into camera action for a standing-room-only audience of professional movie and TV technicians, engineers, agency men, sponsors and actors.

E. G. Hamilton discusses grey scale shown on monitor. (Hamilton is Director of Engineering, American Broadcasting Company.)

VIDEO-FILM

TOP NOTCH TV PICTURES FROM FILM

By

ROBERT GROSS

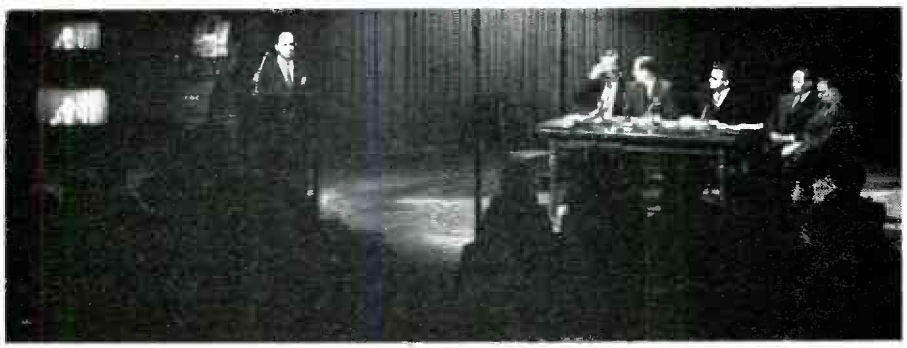
President

National Television Film Council

In the first shooting session, the audience was given the unique opportunity of observing a full-fledged filming session, with the unusual proviso that questions could be asked during the work which normally precludes even a whisper.

The purpose was to answer this question: What are the basic principles of shooting film for television?

The techniques presented at this session, interestingly enough, were not really new to many in the audience. The terms "reference white" and the concept of critical film-for-TV brightness ratios are new, however — though many cameramen in

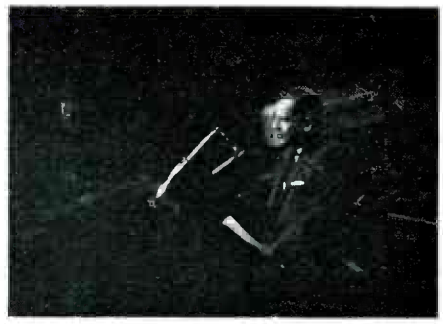


Robert Gross, far left, with panel members. (Gross is President of the National Television Film Council.)

Ed Warnecke at the microphone. (Warnecke is Assistant Chief Engineer of the East Coast Division Motion Picture Film Department, Eastman Kodak Co.)

Eastman Kodak Co.; John Whittaker, television film engineer, Columbia Broadcasting System; Peter Keane, technical director of Screen Gems, Inc.; and John Stott, assistant manager TV programming, Advertising Department, Eastman Kodak Co.

Asked at the earlier session was: What makes a film shot for showing in a motion theater not necessarily ideal for reception on a home television receiver? Answer: Motion picture film is capable of recording a



John Stott addresses the audience. (Stott is Assistant Manager of TV Programming, Eastman Kodak Co.)

Engineer points to the wave form monitor which indicates the brightness values from black to white in the scene being telecast.

the audience had in everyday filming for TV employed similar techniques by instinct. But rarely had these techniques been singled out for individual examination and evaluation. Completely unique was the opportunity given to the audience of firing questions during the shooting and subsequently at the screening to people like Ed Warnecke, assistant chief engineer, East Coast Division, Motion Picture Film Department,

brightness range in excess of 100 to 1. Though such contrast comes across well on the movie screen, it is beyond the capabilities of the television system. Film destined for showing on TV should be shot with a brightness ratio of 20-1 — because the TV system "electronically averages" brightness ratios exceeding 30-1. (Reason for the apparent discrepancy between the 30-1 range the TV system can handle and the suggested shooting of the film at 20-1 brightness ratios: A 20-1 brightness range recorded by the original taking film is translated into a 30-1 brightness ratio in the print due to product gamma of negative* and print film which provides a 1.5x multiple factor from exposed film to TV print). For example, in a low key, high contrast scene with a print brightness ratio in excess of 30-1, the TV system would electronically average the scene, yielding a fade to gray — not originally intended by the cameraman or director.

As John Stott put it at the April 29 screening session, "As an example, the producer may be striving to emphasize or accent some object in his film — such as the product in a commercial. Unless certain precautions are taken by the film producer, the video operator may misinterpret his intentions and set video levels such that the product is reproduced badly on the home receiver while the pretty girl demonstrator looks great. This may please the Screen Actors' Guild, but it generally reduces advertising people to apoplectic fits.

"Actually the Video operator is limited by FCC rules and regulations to operate within stringent limits; *therefore the correct detail must be on film!* Here, then, is the breakdown in communications between the film producer and the video operator. Where is this means of communication to be found if not in the picture on the monitor? Surely this should be the proof of the pudding. But, to repeat, what the video operator sees when the spot whisks past his eyes during the frenetic activity at the time of station break, may not be what the film producer wants the home viewer to see!

*camera and projector "lens flare" is also a factor.

ABC-TV engineer at the switcher coordinates the video elements of the "Operation Videofilm" telecast.

"The video operator gets much of his information from the wave-form monitor that is located generally beneath the picture monitor in the television control room. But let me say that this wave-form monitor, being something of an analyzer of the picture in terms of electrical transmission characteristics, shows just how the picture is being transmitted. In fact, the video operator cannot exceed certain levels on his wave-form monitor, regardless of what his incoming signal is — say in this case from a film — without seriously upsetting the transmission.

"This isn't all! Films that may look great when projected on a screen may look bad indeed when transmitted through a television system. In general, with a good projector-screen system — that is a bright light source in the projector and a good white screen which will yield a standard screen brightness—brightness ranges of more than 100 to one can be perceived easily. This means that detail in white objects and detail in black objects can be seen when the relative brightness from white to black is 100 to one. In other words, detail in the nuances of 'whiteness' in, say, a white curtain can be seen at the same time, that the differences in 'blackness' of a man's tuxedo can be seen — and the relative 'whiteness' of the curtain is 100 in respect to the 'blackness' of the tuxedo of '*one*'.

"In contrast to this, the television system is capable of handling a scene or signal brightness range of only 30 to one. This is influenced by many things including the *optical and electrical characteristics of the television system, charactertistics of the television receiver, and the fact that most television viewing is done with much more ambient room light than is found in a viewing room.*"

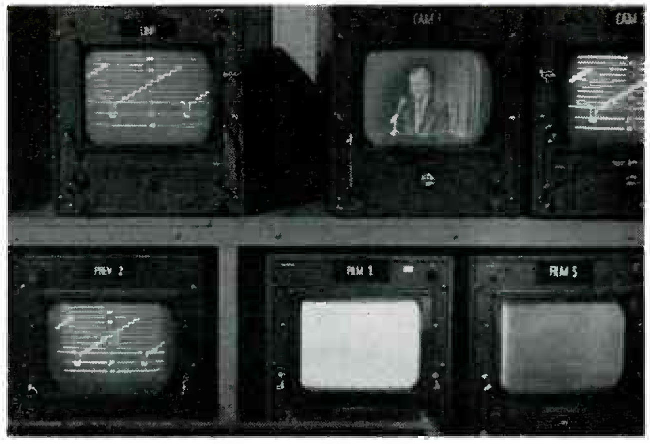
An additional factor to be borne in mind is the lack of DC restoration circuitry in television sets manufactured in the last seven or eight years. Since the black level in these sets is not fixed, the image will tend to be averaged out. What looks like a perfect fade to black on the studio monitor turns into a fade to grey on the home set. It is interesting to note here that all color television sets come supplied with DC restoration and that manufacturers are thinking now of putting this sort of circuitry back into black-and-white sets.

The contrast factor is basic, but is it really enough for a lighting director to make sure that the 20 to 1 proportion exists in his lighting? It was this aspect of television filming that most interested the conference. The answer was shown to be a definite no.

The video engineer sitting at his wave-form monitor controlling the quality of the image transmitted to the home receiver has very little other than the pattern on his cathode-ray tube to tell him the appearance of the image desired by the producer. A moody, sombre scene, carefully lit and staged, may be washed out to an uninteresting grey, or a model's face become unrecognizeably dark unless the man at the controls has some indication of where the various values of grey belong on the total scale. It was pointed out that a film made for television by a director of photography who is alert to the need for contrast values will

ABV-TV cameraman adjusts camera to pick up graphs of exposure vs. film density.

Second session of "Operation Videofilm" was telecast via closed circuit TV using live cameras.



Close-up of monitors.

contain what is called "reference white" and "reference black." These are the two necessary means of communication "built into" the film image that make possible the viewer's seeing the image as the producer intended it.

Given these two guide posts, the video engineer can place them at the extremes of the scale on his waveform monitor and be secure in the knowledge that the image being transmitted is a good one, both technically and aesthetically. The former in terms of the television system, and the latter the producer. Session participants noted that the contrast range must conform to that set by the FCC and not to exceed a black of .1 of a volt and white of 1 volt. Any film that exceeds these limits must necessarily be distorted or compressed into the broadcast limits.

As was re-emphasized at the screening session, ultimate purpose of "Operation Video-film" was to point out ways in which the film producer could insure that what he wants to illustrate — the effect he wants to create — comes across on the home receiver. To do this, the film producer must have a common code language which can be readily interpreted by the video engineer. Simply stated, the key code word or concept can be "white reference." Then, rather than have to make a snap value judgment as to what the film producer wanted to illustrate, the video engineer can simply set "white reference" at one volt and feel reasonably sure that the producer's message is coming through crisp and clear on home receivers.

For the lighting demonstration at Operation Video-film a variety of special tools and techniques were used to insure exactness in the tests. Since most television commercials are in the form of prints made from dupe negatives, it was decided to do the same for the material shot at this session. Extreme care was taken with the film stocks used and the subsequent processing, since it was obvious that unless these precautions were taken the tests might not have given comparable results. All the raw stock was pre-tested and an ideal film speed assigned to it. Under carefully controlled conditions, processing of negative and preparation of print and masters was handled at DuArt Labs in New York. Opticals were handled by the K & W Service Corp., New York.

In order to insure these standards, DuArt ran sensitometric tests by printing test strips of carefully calibrated grey scale steps onto a piece of film stock. By plotting via densitometer the densities that these grey steps have in the developed film, the lab was able to determine the gamma for the film.

To insure precise light readings, a spot brightness meter* which reads in units of reflected light, called foot lamberts, was used throughout the demonstration. Even keeping within the accepted ratio of 20 to 1, a surprising number of different lighting set-ups were shown to be possible. Both acceptable and questionable lighting set-ups were tried and recorded on film.

The first set-up consisted of a normal evening scene, indoors, such as comes up in almost every motion picture. A young lady, whose facial expression would be the most important part of the scene, posed in a set which also contained a table lamp and a picture frame. Using the table lamp as "reference white" or the lightest thing in the scene and the girl's dress as "reference black" the light readings of the scene in foot lamberts were:

Table lamp	100
Flesh tones	50
Dress	8

*See Box No. 1.

Box No. 1

The brightness range can be measured accurately with a flare-free telescopic type brightness meter (or more commonly, the spot brightness meter). This type instrument permits the measurement of an extremely small area with the added advantage of permitting the user to be far enough from the scene to prevent the obstruction of any light falling on the subject. Several such brightness meters are now being manufactured. Heretofore, the use of such meters was limited to the laboratory; however, with the present-day demands on over-all image quality, the use of spot brightness meters is becoming more and more widespread throughout the industry. Their intelligent use will insure the photographer that the range of brightness recorded on the film will fall within the acceptable range of the television system.

By carefully controlling the proportion of light between his reference white and the fleshtone, the lighting director insured that the important details of expression on the girl's face would not be lost in either overbrightness or obscurity. During screening on closed circuit TV, the video engineer was able to place the light of the table lamp at the top of his wave-form monitor and the girl's dress at the bottom. It was carefully pointed out that the reference white must be a fairly large part of the scene in order to function properly. Ten per cent of the total area, it was suggested, is about right.

ABC-TV engineers control video portion of closed circuit telecast. Monitor shows grey scale with black level at bottom and white level at top.

The lighting was then changed as below to show what would happen when reference points are ignored:

Table lamp	100
Flesh tone	20
Dress	10

This scene still looked right because of the averaging action of the human eye, but when set on the wave-form monitor as before, the girl's face was lost in the scene. A mistake in the other direction, removing the table lamp and letting the light on the girl's face go up into the range of 50 foot lamberts, proved to be even worse. Without white reference, the video engineer set his brightest white, now the girl's face, to the top of his monitor and the face went pale white, detail in it completely washed out. Keeping a reference white in every scene, it was noted, is not an insurmountable problem for the careful lighting director. In animation, where white and black reference is equally important, it was stated that even greater efforts must be made to introduce these guide posts logically.

John R. Whittaker, left, CBS Television Film Engineer, with Robert Morris, ABC-TV Engineer.

What happens, it was asked, in scenes involving refrigerators and other highly reflective white objects? Here, the important object in the scene is white, and it is not always possible to paint it a pastel color. Again, the lighting director must create a reference white to keep the detail of the refrigerator out of the reference white area. And the young lady in the scene who carefully opens the door must not look any more sunburned than the client would like. (Must not, that is, have her face go too dark because of a too white "reference white.")

In setting up just such a situation, the Video-film session created a light from an artificial sky coming through a window. The foot lambert readings were like this:

Sky in window	125
Refrigerator	90
Fleshtones	50
Dark suit	4

The reference black which becomes more important as the scene tends towards "high key" illumination was supplied by the dark suit of a gentleman who appeared with the young lady. This scene also, was tried with different proportions of light.

Next, the "sky in window" was gradually darkened as the camera rolled. Result was that when the brightness value of the "sky in window" dropped below the 100 brightness value of the refrigerator, the refrigerator itself became "reference white," thereby losing considerable detail.

Sky in window	180-50
Refrigerator	100
Fleshtones	50
Dark suit	4

Processed and printed by the laboratory all these takes were shown on a closed circuit television demonstration April 29. There the points covered in the first meeting were reviewed and the results shown on two sets of monitors, one with and the other without DC restoration.

As Ed Hamilton of A.B.C. pointed out at the demonstration, most film shot for television is of excellent quality, perhaps even 90 per cent of all the footage shown. This is due to the fact that most cameramen hold to these relationships by experience and instinct, (although using light meters different from those used in this demonstration, measuring in foot candles rather than foot lamberts.)

Suggestions made at "Operation Video-film" were in no way intended to restrict the creative efforts of people working with film — just the opposite. Said Robert Gross, (American Film Producers), president of the National Television Film Council, "We don't look upon such considerations as proper brightness ratios and 'white reference' as cramping a cameraman's or director's creativity. To the contrary, if such considerations are overlooked, the best creativity may be crimped before the viewer has a chance to witness the results."

CROSSTALK IN FM MULTIPLEXING

By

DWIGHT "RED" HARKINS*

Harkins Radio, Inc.

DURING the development of commercial FM multiplexing, probably the most disturbing problem was the elimination of crosstalk in the transmission system. Crosstalk is the condition caused by the main channel audio products intermodulating the subcarrier which is also being transmitted over the same system. In order to provide a commercially usable service in the multiplex subcarriers, the main channel program should be unnoticeable to listeners of the subcarriers.

Although the problem of crosstalk, intermodulation, or cross modulation is common to all parts of a multiplex system, this paper will deal specifically with the transmission end of the system.

Before making an analysis of individual parts of the system which cause crosstalk we shall first analyze the basic FM theory that is used in the transmission of all the signals. First, let us examine the actual transmitted FM carrier. As the carrier is modulated by the audio for normal broadcasting purposes, the carrier shifts in frequency, yet the total power radiated is unchanged. Although the radiated power remains the same, it is divided into many side carriers or side bands which appear above and below the unmodulated carrier in frequency The energy or power in the main carrier is divided up into the many side carriers created during modulation. At times, the carrier itself disappears and all the energy is divided up among the many side bands. The position of these side carriers and their amplitudes is a direct relation between modulation frequency and the amount of carrier deviation in frequency. This is known as the modulation index and is determined by dividing the amount of carrier deviation by the modulating frequency.

The point of 100 per cent modulation is established in the FM system by standards rather than limitation of the process. For example, 75 Kc deviation is considered 100 per cent for the FM broadcast band, while 25 Kc deviation is considered 100 per cent for the TV aural transmission.

FM Compared to AM

In comparing FM with AM we can show that the AM carrier develops an upper and lower side band of energy directly related to the audio frequency being transmitted. In AM, the total power being transmitted varies directly with the modulation and is not constant. One hundred per cent modulation in the case of AM is considered that point where the audio wave has caused the AM carrier to instantaneously go to zero on one half of the cycle and to twice carrier amplitude on the other half of the audio cycle. Modulation beyond the 100 per cent point causes severe distortion. The actual energy of an AM signal varies directly with the modulation. In correctly operating FM systems, however, the total energy transmitted remains constant regardless of modulation.

In the case of AM, the side bands generated due to modulation are found to be existing in pairs, one above and one below center carrier, and are further found to be 180 degrees out of phase with each other. Modulation of the FM transmitter causes many side bands to be created above and below the unmodulated center frequency. The FM side carriers are 90 degrees out of phase with each other. At any given instant the individual side carrier above the unmodulated carrier is 90 degrees out of phase with its mate which is found below the carrier. The side bands

*4444 East Washington, Phoenix, Ariz.

CROSSTALK MAY OCCUR IN:

- EXCITER
- POWER AMPLIFIER
- ANTENNA

KEYS TO SUCCESSFUL MULTIPLEXING ARE:

- GOOD ENGINEERING PROCEDURES
- PROPER ADJUSTMENTS
- MAINTENANCE

created by frequency modulation are a subject of endless fascination.

In comparison to the transmitted AM signal, the FM transmission is much more complex. If a 500 cycle tone modulates the FM rig 100 per cent we would find several hundred new carriers created above and below the center frequency carrier. The strength of each of these carriers can be computed mathematically using Bessel functions. Those side carriers that fall more than 75 Kc above and below center carrier are usually considered insignificant for undistorted reception of the audio signals between 30 and 15,000 cycles per second in the case of our FM broadcast transmitter.

This explanation of the events that occur during modulation of an FM transmitter is necessary to understand the crosstalk problem. The FM signal is complex and occupies much more space above and below center carrier than the AM signal. The band width of the transmission system must be ample to permit all of the desired components to reach the point of detection. Two things can happen to the signal that deterioriate its quality at the point of reception:

(1) A restriction of bandwidth in either the transmission system or the receiver would cause portions of the signal to be lost.

(2) We must preserve in the system the correct phase relationship between all of the transmitted products.

Prior to multiplexing, the bandwidth and phase linearity of the transmission and reception circuits was ample for the reception of high fidelity audio up to 15,000 cycles per second. The low distortion and excellent frequency response of the FM transmission system made it quite attractive. The quality of an FM broadcast was measured in terms of low harmonic distortion and low residual noise.

With the advent of multiplexing, however, intermodulation distortion reared its ugly head. The typical FM transmitter had very low intermodulation distortion throughout the audio range ending at 15,000 cycles per second. The intermodulation caused by an audio tone to a supersonic tone on the order of 25,000 cycles per second or higher, however, was found to be intolerable. A new set of conditions now exist where we are not only transmitting audio frequencies but also are transmitting the supersonic audio frequency above the range of hearing which must get through to the receiver without being subjected to intermodulation by the lower audio frequencies.

With the thought in mind from the previous explanation that we are not to narrow the bandwith or alter the phase relationship of the transmitted signal, let us now examine, piece by piece, the various parts of the transmitter that are used in creating a signal for multiplexing.

THE EXCITER

All existing FM transmitters have one thing in common. They do not transmit on the same frequency at which the modulation process occurs. All existing FM transmitters create the modulation at a lower frequency than the transmitted carrier and through the use of multiplier stages end up at the transmitting frequency. In those transmitters which use direct FM by means of a reactance tube controlled oscillator, the multiplication factor is on the order of eleven to sixteen times. In transmitters which use phase modulation or "indirect FM", the multiplication factor is as much as 1000 times.

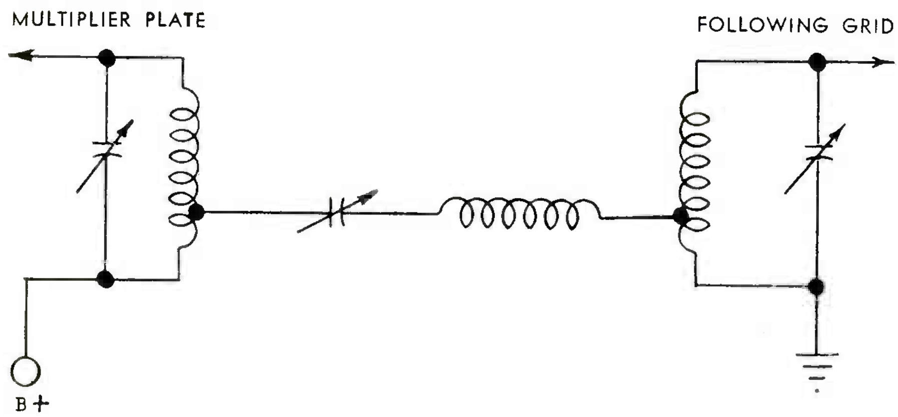


FIGURE I

PHASE LINEAR MULTIPLIER COUPLING

Although the main channel modulation process and frequency control may take place at a frequency as low as 100 Kc, the subcarrier is usually not introduced until the signal has been multiplied to the order of approximately 10 Mc. Disregarding the methods used to introduce the subcarrier to the modulation processes already created for the main channel audio, it must be understood that all portions of the system which follow the point of subcarrier injection must meet the requirements we have set forth. In other words, all stages which contain both the main channel modulation and the subcarrier must have no restriction of bandwidth and must be phase linear.

Even though the subcarrier is introduced to the multiplier string at the 10 Mc stages, it was found that the normal methods used for interstage coupling were creating serious phase distortion. Here, then, is the first point in a transmitter where special circuits must be used to prevent crosstalk if good multiplexing is to result.

Phase Linear Coupling

The circuit of Figure 1 is used to provide phase linear passage of the signal between multiplier stages. The parallel resonant circuit of the plate and grid end are coupled together at a low impedance by the series tuned circuit. The circuit is tuned to have a pass band of at least 500 Kc.

This circuit was found to have excellent phase linearity. On either side of center frequency, the change in phase shift as the frequency changes was found to be a linear function. In the regular single tuned circuit it was found that the change in phase shift was more rapid above center frequency than it was below center frequency which does not occur in this circuit. With the phase shift being linear throughout the range of frequencies occupied by the many side bands generated by the FM signal, no intermodulation results. Regeneration can exist in the power amplifiers due to improper neutralization, tubes which have become too old, or by RF feedback from an improperly terminated antenna. In all cases the effect of regeneration is a narrowing of the bandwidth and a condition which causes non-linear phase shifts throughout the passback.

Another common fault that contributes to a high measure of crosstalk in the power amplifier stages is improper coupling between stages. It is common practice for the exciter to drive a 250 watt amplifier, which in turn drives a 3 Kw amplifier, which may in turn drive a 10 Kw amplifier and in some rigs, may continue to drive a 25 or 50 Kw amplifier. In all cases, the coupling between stages is quite important. Some means must be provided for the stage being driven to behave as if it were a pure resistance load on the stage before. If there is any reactance whatsoever existing between the two stages the familiar situation is created that causes unequal phase shift on either side of center carrier. The side bands are altered from their original relationships to each other.

Figure 2 shows a coupling arrangement between a driver plate and the following grid circuit. L-1 and L-2 are link coils. The reactance is successfully turned out by adjusting C-2. The amount of drive can be adjusted by controlling C-1. If a reflectometer is inserted at point X, positive correct coupling can be ascertained when zero reflected power is observed.

In any case, correct tuning can be ascertained by observing the dip in the driver plate current. The dip in the driver plate should correspond with the peak in the following stage grid current. If it does not, reactance is present in the circuit. Regardless of how good the earlier stages of the transmitter are functioning, if inproper coupling exists between the power stages, cross-talk will result. As mentioned before, the result in the receiver is exactly the same since all crosstalk sounds alike.

THE TRANSMITTING ANTENNA SYSTEM

Now we come to the most neglected portion of the transmitting system. At many stations I have found FM transmitting antennas that have been installed for over 10 years yet they have not been checked once to see if they were correctly tuned. Since the procedure usually cannot be conducted by station personnel it is assumed that everything is going all right. For the same reasons outlined earlier, the transmitting antenna must present to the transmitter a load without a reactive component. If the

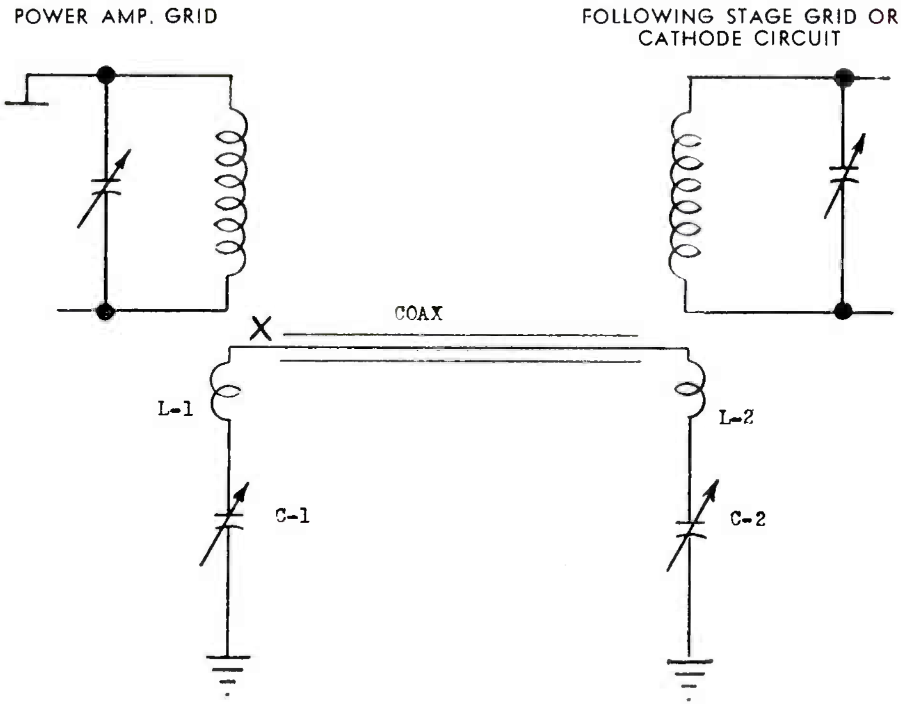


FIGURE 2

INTERSTAGE COUPLING FOR POWER STAGES

antenna is detuned or anything in the transmission system, such as a tower base isolation arrangement, is detuned then we are in trouble again. In cases where the antenna is not correct, the troubles are multiplied. The effects of an improperly terminated antenna are very misleading.

First, there will be unwanted RF present around the transmitter itself. Due to a bad standing wave ratio the reflected power appears in the form of standing waves around the transmitting equipment itself. This will often manifest itself in the form of regeneration in the earlier stages of the transmitter. It will be impossible to obtain correct neutralization. It will be impossible to adjust coupling between stages. Even portions of the exciter will pick up the RF that is standing in the transmitter room.

In other words, the effects of an improperly terminated antenna can cancel out all of the precautions that have been previously taken to insure good multiplexing. There are quite a few different types of transmitting FM antennas in existance. Some of them are very difficult to tune. Any of the antennas will work correctly if they are properly tuned to the station's operating frequency. Some of the newer types offer extreme ease in tuning of the various elements.

A correctly tuned antenna system will offer a VSWR close to unity. A further test of good antenna tuning is to sweep it out and measure the change in reactance with change in frequency. If the antenna is working correctly for multiplex purposes, the curve representing the changes in reactance will be symetrical on either side of operating frequency.

In summarizing the relationship of the transmitting antenna to good multiplexing, do not take for granted that the antenna is operating correctly. It must be measured and adjusted. This is especially true in installations that have been in operation for some number of years which are now adding multiplexing to the old transmitter system. Since the entire transmission line system and the FM antenna is exposed to the weather, systems which have been installed for 10 years or longer often have defects that go unnoticed until multiplexing is attempted. Fortunately, this is a matter that needs to be looked into only upon rare intervals.

We have outlined here the major causes of trouble encountered in the transmitting end of multiplexing. From our experience with some 50 different transmitters located in various parts of the country using every conceivable type of antenna system, we feel that any existing system can be made to deliver commercial multiplexing if the elements of the system are one by one correctly adjusted. Once the transmitting antenna is operating correctly, the rest of the equipment will fall in line quite easily. Some of the existing transmitters offer very poor means for adjusting and tuning the coupling between power amplifier stages. However, if all other elements of the system are operating correctly some compromise is permitted before the commercial use of the subcarrier is lost.

The problems confronted while multiplexing can very easily be compared to those present in the TV transmission system except that the multiplex requirements are not nearly so extreme. Any station that follows good engineering procedure in converting their FM transmitter to allow for multiplexing will be rewarded with excellent results.

The Author

SPECIAL EFFECT OPTICS

A ROTATING INVERTING PRISM USED IN AN UNIQUE ELECTRONIC APPLICATION TO CREATE UNUSUAL EFFECTS

By

FRED PRIESLER JR.*

KMBC-TV

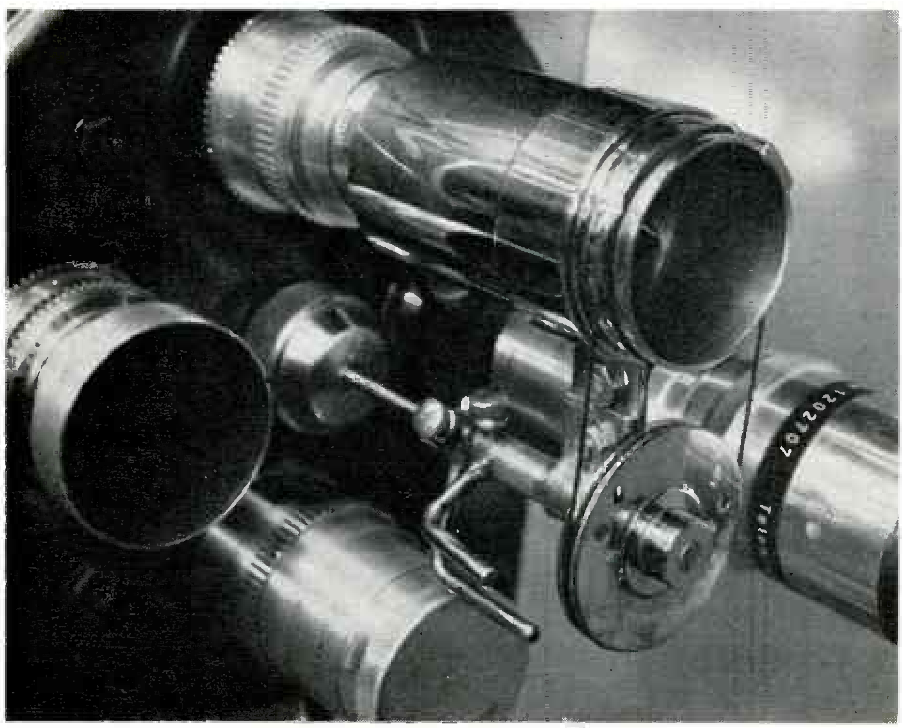


Figure 1

Camera turret with prismatic lens and rotating device.

*11th and Central, Kansas City, Mo.

As a serious amateur photographer I am frequently driven by an insatiable desire to explore the ready adaptability of the electron camera. This optical observation which will be shared with you is the product of one of those adventurous moments.

We all know that the use of a prism on the television camera is not a new concept; however, my application and selection of a type is somewhat unique.

In Figure 1, at the top of the turret, we see a device coupled to the 90mm objective lens. It is this unit and its behavior that I will try to explain. The device was constructed primarily of brass tubing. Rigidly attached to the lens, a rotator within supports the prism, and rotation is accomplished through coupling to a pulley-rod assembly. The rod is passed through the camera turret channel to operating position. A knob is installed.

A 90mm lens was selected for two reasons: In the first place, it would

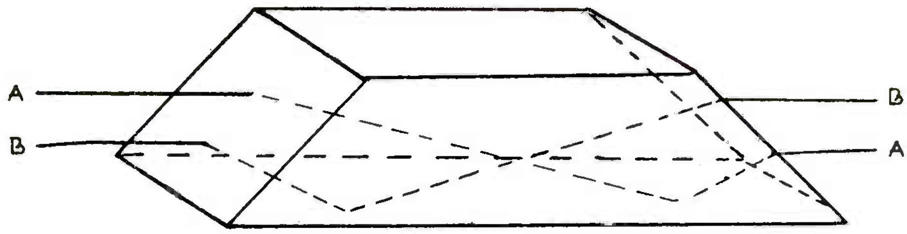


Figure 2

The diagram illustrates the optic path of light rays in the Dove prism.

Figure 4

Harvey Brunswick spins around in continuous rotation in a scene from a horror movie series called "Shock". The effect is produced by the rotating prismatic lens illustrated in Figures 1 and 2.

not destroy camera technique. Should the effect be desired, the cameraman could frame favorably wide shots as well as reasonably close views. Secondly, the physical dimensions of the prism that I had available met the requirements of the angle of acceptance, or angle of view for this lens.

The properties of this prism are most interesting. (Fig. 2) It is a Dove or inverting type and belongs to the family of total reflection prisms.

When radiant energy (light) travels from one medium to another, energy is lost . . . such as air to glass . . . as is true in this case. So the term total reflection is used in the sense that loss occurs because of absorption, not reflection.

It takes a bundle of rays to make a beam of light. A and B (Fig. 2) are individual rays of light, and if the Dove prism is rotated about its longitudinal axis it will interchange these rays and they will rotate around each other at twice the angular velocity of the prism. If you observe an image and rotate the prism once the image will have turned around two times.

To realize the effect . . . the camera is trained on a scene, the center of the frame becomes the hub, and the composition revolves around it several times in either clockwise or counter-clockwise rotation. As a production aid this alone is limited in scope. Pictorial effectiveness is augmented by careful selection of subject matter, by the use of subordinate (preferably infinite black) background, and by superimposition with another camera.

Probably the most profound effect is the result of a phenomenon called *video feedback*. The optical activity is begun with a physical arrangement as shown in Figure 3. Ambient light or room illumination is kept below the brightness level of the monitor. The brightness and contrast of the kinescope should be the more influential in "triggering" the feedback than some of the other variables. These rushing oscillations come in a variety of sizes and shapes, (Fig. 5-14). With the slight-

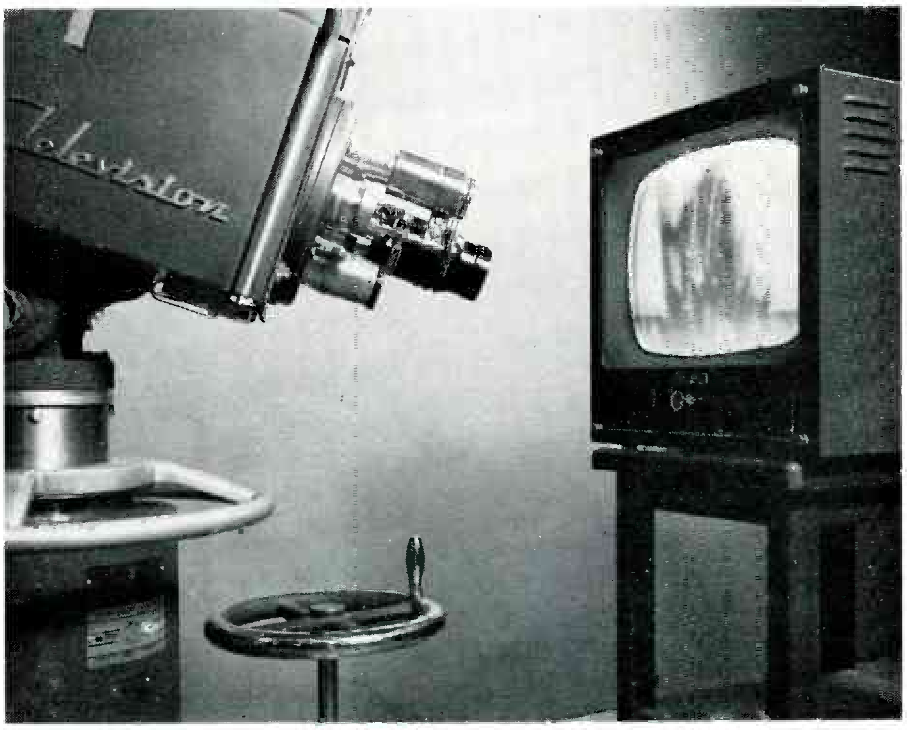
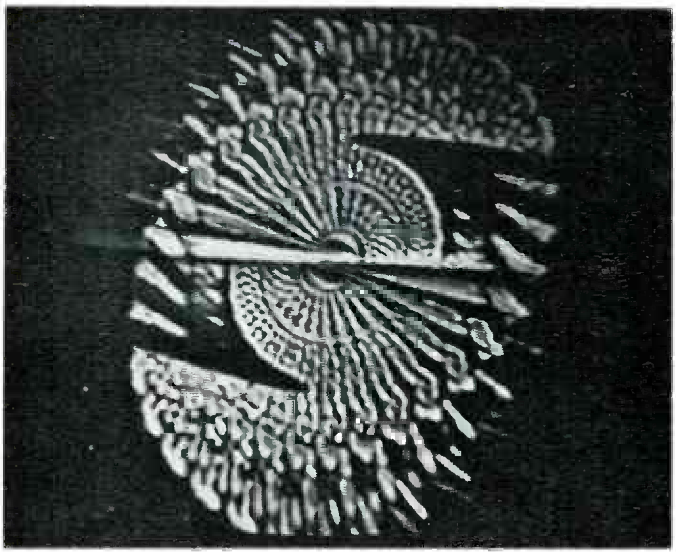
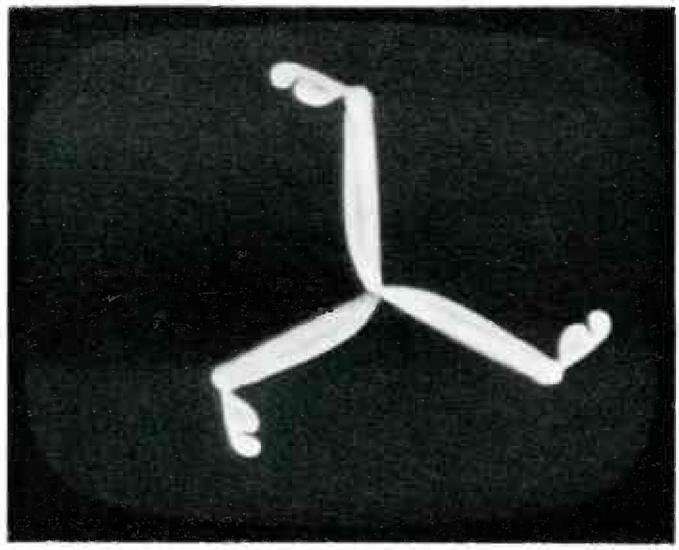
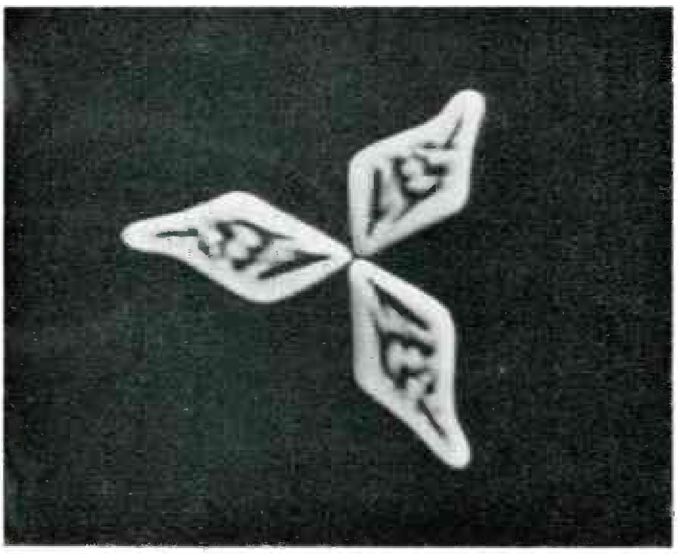


Figure 3

The camera is trained on the monitor to develop "video feedback" and produce the patterns shown on the following pages.



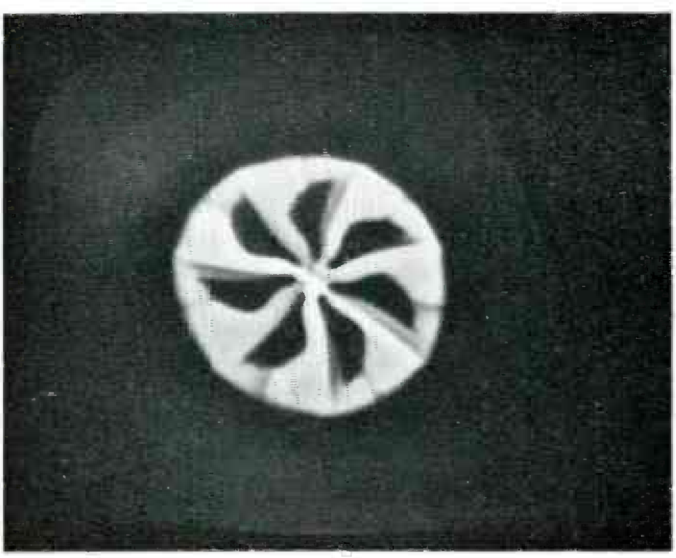


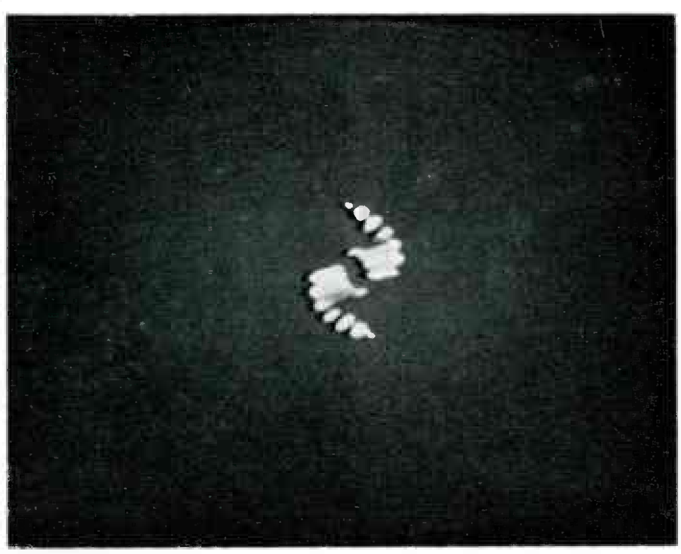


est advance in rotation of the prism, the abstract designs take on a completely new look.

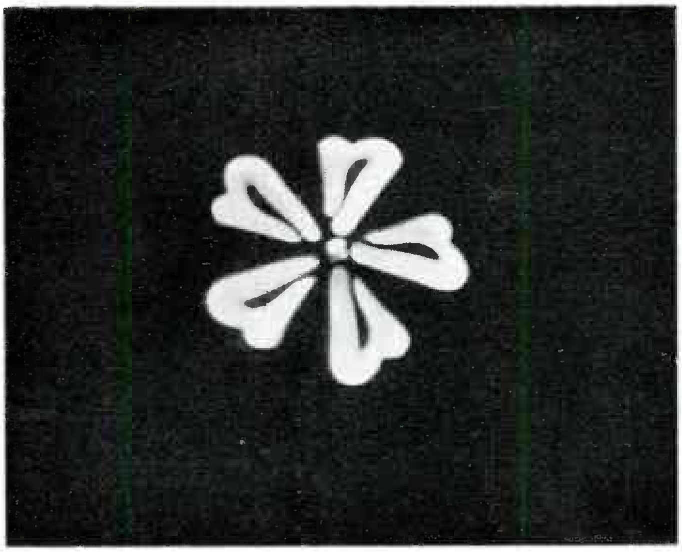
For a graphic description I would relate video feedback to the parallelism of two mirrors. Two parallel mirrors repeat an image to infinity.

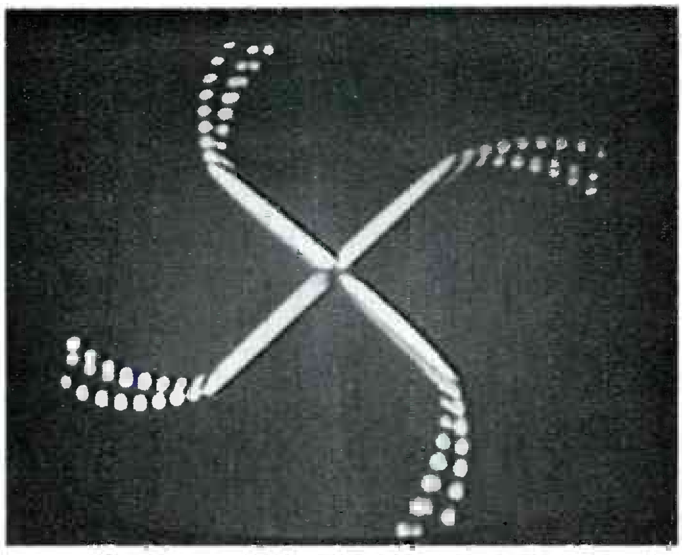
With the output signal of the camera present at the monitor, the scanning rate of the camera becomes its own image. The rotation of the prism introduces an angular displacement of this electronic parallelism. Visualize two parallel lines in a horizontal plane, intersected by two vertical lines . . . at the junction there would be four intersectional points. I believe that it is here where the whirling acceleration begins. Theoretically, we may assume that there would be 525^2 or 275,625 possible oscillations.





Figures 5 to 14 on these pages show the transitional patterns produced by the system described in this article. The pattern may be changed by rotating the prism.

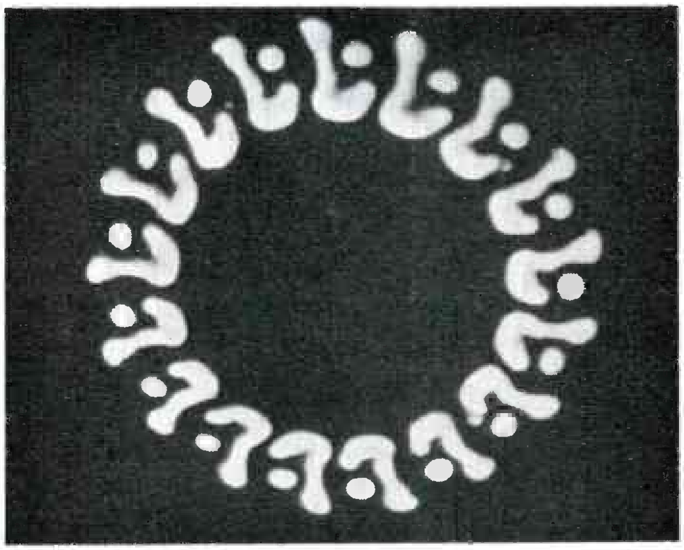


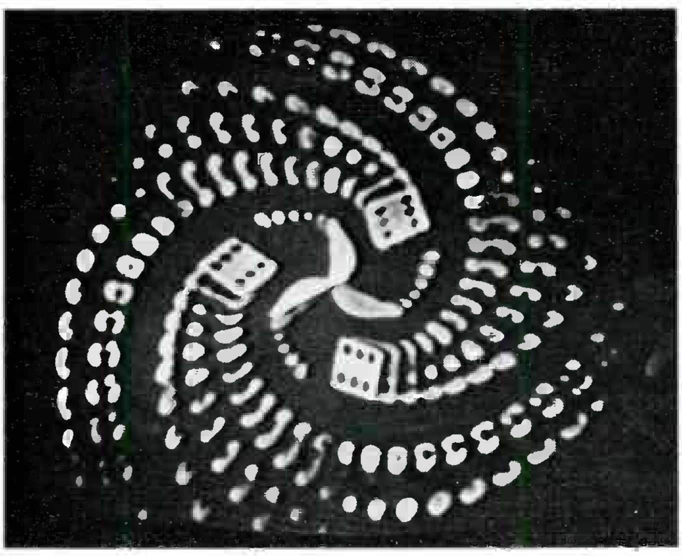


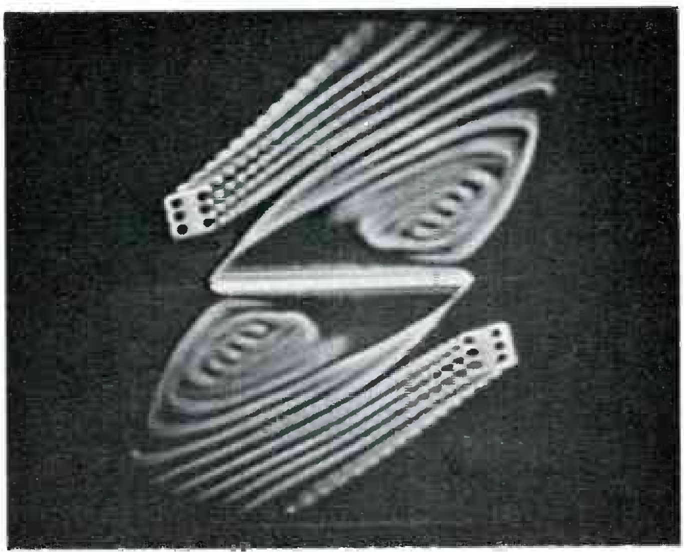
There are several practical applications. Around the studio we have used it to glamorize station ID's. Bill Hare, a director, was instrumental in organizing a dance routine based on the optical ability of the prism. Its fundamental simplicity is presented photographically through multiple exposure in Illustration 4.

People with a watchful eye on the changing pattern display varied reaction. Most viewers show amused interest, for some . . . wild enthusiasm, and a few stand victim to a filmy-eyed sleep.

My concluding statement is an expression of appreciation to Frank Young of KMBC for permitting me to employ his superior mechanical skill and sincere interest in this project.







The bottom two photographs show the effect of one dice positioned on the monitor face. The dice appears to be in continuous motion.

The Ampex Videotape Cruiser wheels into the driveway at the Fontainebleau Hotel, Miami Beach, during the taping of a special telecast for WPST-TV (Channel 10), Miami. Note cameraman in action atop the Videotape Cruiser. A completely self-contained, mobile tape studio with two TV cameras, power unit and Videotape television recorder, the Ampex unit was in Miami for the Society of Motion Picture and Television Engineers convention. The special telecast recorder with the Videotape Cruiser featured a tour of Miami Beach's famous hotel row.

NEW HORIZONS for

A mushrooming of uses for the mobile Videotape* recording unit was forecast by the two Ampex engineers who designed and supervised construction of the first such unit.

J. Bryne Hull and Hal G. Hummel, in their technical paper delivered before the Society of Motion Picture and Television Engineers convention, said that most of the applications of the mobile taping facility will be invented by the customers rather than by the engineering laboratories.

As a part of their discussion, Hull and Hummel described the many considerations involved in the design of the Ampex Videotape Cruiser. The latter unit was on display at the convention headquarters (Hotel Fontainebleau) all of the week. Its crew, supervised by Bob Day, Ampex's video promotion manager, held demonstrations for delegates and produced a special 15-minute taped show featuring this resort center's hotel row. The show was telecast over WTVJ, Miami.

*TM Ampex Corp.

In conceiving the Videotape Cruiser, Hull and Hummel said they envisioned "live" television on an endless cable. For that reason, the entire unit was designed to permit Videotape recording with the cruiser in motion.

An available bus chassis was selected, the pair said, because of such advantages as air conditioning, better riding qualities, speed and maneuverability and more satisfactory crew communication during mobile operation. An RF link phone system also was installed. The ability to phone to and from the cruiser, they said, has given the traveling production facility all the flexibility in scheduling that a producer or broadcaster might need.

As to interior arrangement of the equipment, Hull and Hummel said they positioned the Videotape television recorder forward in the bus, with enough room around it for a scope, and far enough from the monitor console for operator convenience.

"Normal vehicle vibration proved to have no effect on the performance of the recorder," they said. "However, both the recorder's console and electronics racks are firmly attached to the floor with heavy duty shock mounts, both to keep them in place during vehicle acceleration as well as to prevent such factors as chuckhole jolts from overstressing the equipment's mounting attachments."

Other features pointed out by Hull and Hummel:

1. Floor partitions lift for easy installation and possible maintenance requirements of cabling.

2. The complete camera chain is bolted to a subframe which is shockmount attached to the bus floor.

(Continued on page 43)

Charles P. Ginsburg (left), inventor of the Videotape recorder, and Neal K. McNaughten, manager of Ampex's Professional Products Division, inspect the new VR-1000B recorder.

TELEVISION TAPE

By

ROSS H. SNYDER

Video Products Manager

Ampex Corporation

(Editor's Note: The following article consists of highlight excerpts from papers delivered by Mr. Snyder before recent conventions of the National Association of Broadcasters and the Society of Motion Picture and Television Engineers.)

FROM the earliest to the most recent Ampex VR-1000, a larger number of changes have been made. Thanks to the generosity of the broadcasting industry, whose engineers have offered unlimited time and effort to report in detail to the Videotape recorder's designers their new findings, new uses, and solutions to problems as they arose, it has been possible to revise and update all machines.

Service Bulletins Key to Continuous Improvement

A series of Service Engineering Bulletins has been issued, as internal changes have been made in the design and circuitry of the VR-1000. These have given detailed instructions, step by step, on the means of making the same changes in previously-manufactured recorders. For example, last summer in the laboratory a method of improving the horizontal stability of the reproduced Videotape picture was developed. After the manner of the alteration had been reduced to its simplest form, it was ordered into then-current production, and a Service Bulletin issued. Where horizontal stability had been in some cases marginal, it could be shown a few months ago that this was no longer a problem. The whole improvement however was not made by the circuit changes. Head improvements were also involved.

Improvements in Heads

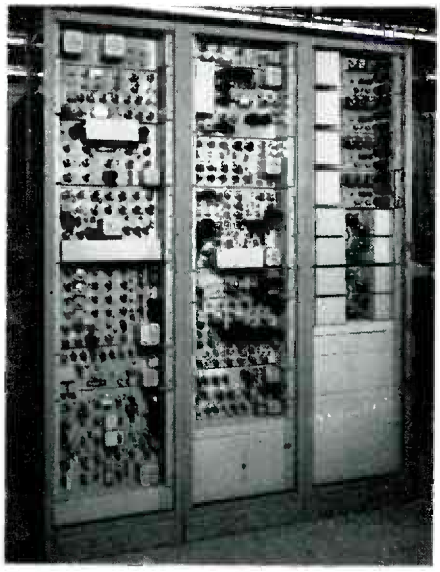
Central to the performance of any rotary-head television tape recorder is the head, itself. More than 2500 of these have been manufactured. The first heads were hand-assembled, from pieces fabricated under a microscope lens. In today's terms, they were crude samples, but the experience gained in making them was the key to their quantity production, during the year just past.

The entire Videotape head assembly is a plug-in device, which is periodically returned to the factory, and exchanged there for a completely reconditioned assembly. The limited life of the 14,400 rpm head structure probably has been a blessing in disguise, for much the largest part of the improvement which has taken place in television tape recording performance has been accomplished through refinement in the construction of the heads. Because these do return to the factory, on a sure and steady basis, it has been possible to incorporate automatically into every recorder in service, the very latest improvements as the laboratory released them.

The improvement in horizontal stability which was widely noticed last fall was largely the result of improvements in the dynamics of the rotary head structure, first intensively checked in the laboratory, then ordered into production, then automatically incorporated into all head assemblies, as they were exchanged.

Even such basic performance parameters as signal-to-noise ratio are deeply and vitally affected by head construction. The specification on signal-to-noise ratio, at the beginning of Videotape recorder production, was 30 decibels, peak-to-peak video to r.m.s. noise. While most early-production machines were *somewhat* better than this, a recent check of machines in field service proved that the average recorder is now delivering 36 decibels, with a minimum of 34 in the survey. The highest figure obtained was 40 decibels. Much the largest part of this improvement is the result of changes in the head structure, although very great credit must also be given to those who have steadily improved the tape, itself.

The latest changes to be made in the head structure are in the control-track assembly. A new and more rigid mounting has been devised, specifications have been further tightened on vertical location, tilt, and azimuth alignment, and a new chisel-shaped head has gone into production. The effect of the change in shape is to increase the unit pressure at the point of recording and reproduction, so as to increase the uniformity both of the recorded and reproduced signal.



Color equipment adds only one rack (left) to basic VR-1000 electronics, forms integrated whole recorder-reproducer, capable of precision performance in color or monochrome.

Detailed changes have also been made in the audio head structure. The main purpose of the alteration in the configuration of the head supporting posts has been the reduction of maintenance. It was found that oxide particles, gradually accumulated from the passage of tape over the head posts, if not removed regularly, were capable of scratching the finely-finished surface of the tape, and producing disturbances in the picture. Several dozen of the VR-1000's in the field are in operation as much as fourteen hours each day. The necessary maintenance for these might not always be conveniently possible. The arrangement now is such that less oxide accumulation occurs, and the necessary period between cleansing is very much longer.

These new audio stacks, like all other recently introduced changes in the machine, are made available to owners of earlier-production equipment, and plug into the same sockets as those previously used.

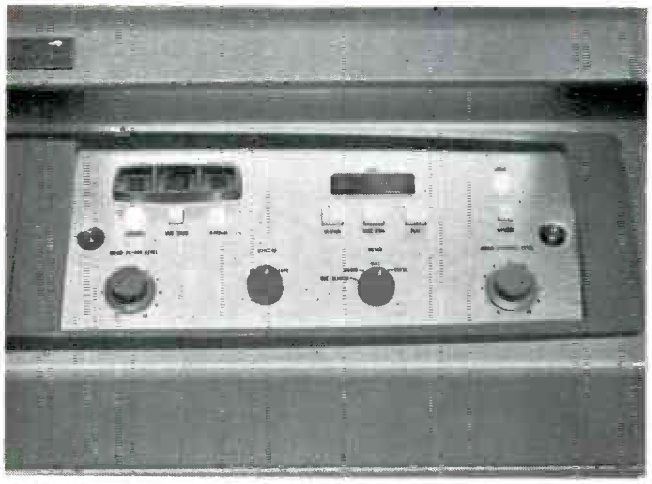
With the advent of the company's new VR-1000B, further improvement was made. All VR-1000B recorders carry a guarantee of 36 db or more on interchanged tapes.

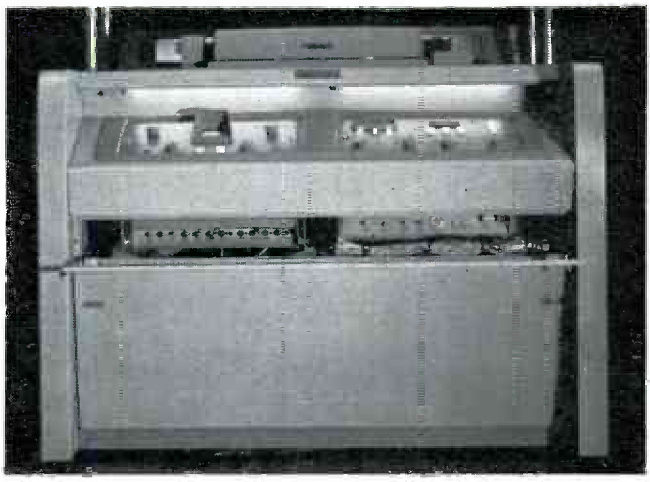
Improvements in Operation

Operation, too, has received special attention. The Videotape recorder, first used mainly for network clock-time delay, rapidly expanded in its applications. As the machines went into service in dozens of independent and affiliated stations, they began to be used for the recording of commercials, not only for insert into network programs, but also for repeated local presentation. It became obvious that, for this service, and for other new uses of the machine, it would be important to provide an accurate means of locating, within a given reel of tape, exactly the recording which might be desired at any given time. A precise means of measuring off the tape also appeared to be desirable. An optional accessory, therefore, was developed. This is the Tape Timer. It can be installed on new equipment, or as accessory to earlier-production equipment, like all other VR-1000 improvements. Installation requires only removal of the Right Hand Idler, drilling of a relatively uncritical hole for the locating pin, and installation of the Tape Timer in place of the Idler. The Tape Timer is accurate within fourteen-hundredths of one per cent, or five seconds in one hour. This degree of accuracy is maintained, even though the machine may be placed in fast-forward or rewind mode many times among readings. The scale reads in hours, minutes, and seconds, as befits a device whose purpose is to measure the stock in trade of television broadcasting, the hours, minutes, and seconds which represent the cents and dollars earned by the machine.

Cue and Erase Facility

The preparation of commercials and the assembly of programs likewise, it was felt, would be benefitted by the availability of a limited-quality separate sound-track, to be used for cueing or coding. The improvements in control-track, which have already been mentioned, easily permitted the insertion, between the bottom of the vertical video tracks and the top of the horizontal control track, a 20-mil directly-recorded sound-track. This Cue-Track, while of limited frequency and dynamic range, is entirely satisfactory for the recording of voiced instructions, which appear at their



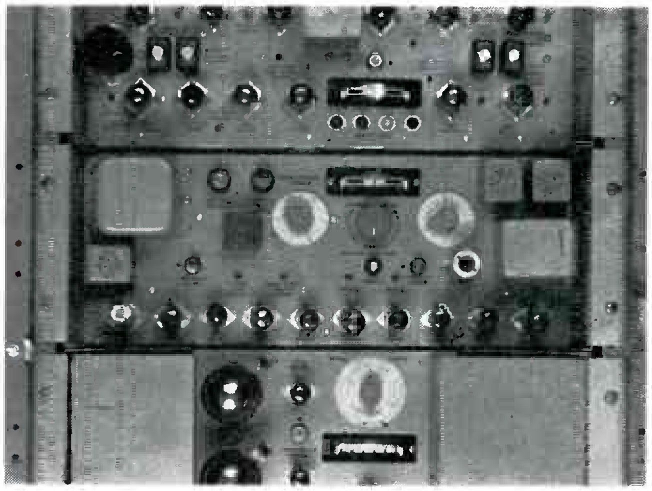


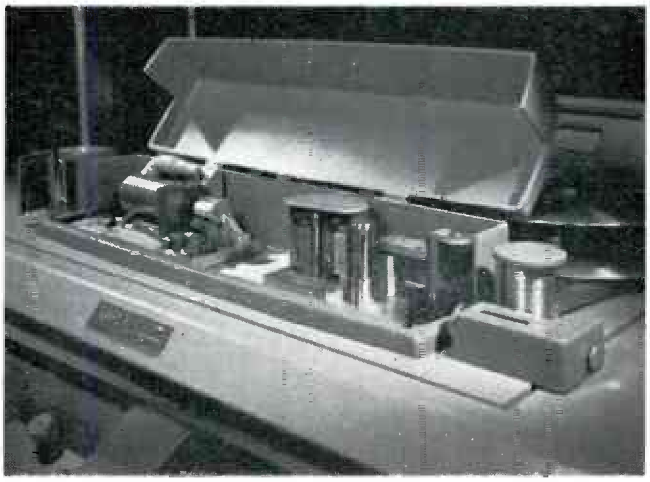
own separate output, and cannot be accidentally mixed with outgoing audio. It is felt that this cue track will also be useful with automatic relay devices, for the control of associated external equipment, or for automatic control of the Videotape recorder itself, as, for example, automatic rewinding, automatic recueing, and so forth. Applications of the cue track will come immediately to mind when it is realized that tones originally recorded at frequencies in the 400 cycle region can easily be reproduced, even at top rewind or fast-forward tape velocities. Suggested uses include the recording of a series of tone bursts for later control of the recorder in automatic replay, for example, four for rewind, three for fast-forward, and two for stop, in an automatic rewind and cue sequence.

The Cue Track is provided with its own erase head, located on the same head-supporting post as the audio erase head, and a record-reproduce head, on the same stack as the audio record-playback head. This equipment is supplied with the necessary recording current, and provided with the necessary playback amplifier, by a chassis which is mounted on the rack supports in the front of the console. This chassis also contains the high-power oscillator which provides current for an automatic two-inch erase head. The cue track and erase features are combined in a single optional accessory. The erase head, like the other equipment which has been added from time to time to the VR-1000 availability list, may be installed on previously-purchased recorders, or may be ordered installed on new equipment. Erasure is accomplished by means of a two-inch head in a housing at the left of the video head structure, replacing the Left Hand Idler. This housing completely encloses the erase head, the idler, and the necessary tape guides. It may be snapped open for cleansing, at the touch of a finger.

Operation of the erase head is automatic, upon engagement of the record button. It is possible to connect a separate over-ride switch which will activate the erase head independently of the record facility, although machines are not normally factory-assembled with this connection, in view of the obvious danger of accidental erasure. The erase facility is particularly valuable where a number of short takes have been taped, some of which have been accepted, and others rejected, and when it is desired to remove and replace undesirable recorded material. Both the cue and erase kit and the tape time may be installed on the same machine, erase head at the left of the tape transport, tape timer at the right. Each presents finished, matching appearance when installed.

As a further aid to operational convenience and space-saving, the video laboratory has designed an over-console monitor mount, designed to suspend at eye-level the picture monitor, waveform monitor, sound monitor, and a new monitor selector panel, with self-illuminating indicator pushbuttons.

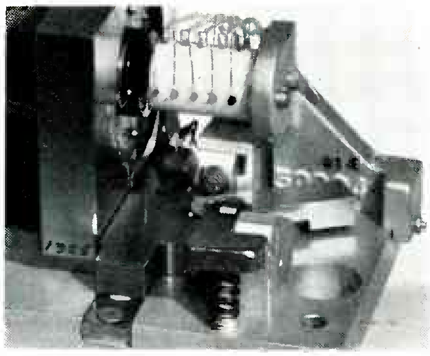




Videotape Commercials

These new facilities have made possible considerable expansion of the use of the television tape recorder in the production of commercials, first for network insertion, next, as machines became more widely used in individual stations, as often-repeated local commercials, and, more recently, as commercials of premium quality, but not of premium price, for placement by agencies on Videotape-equipped stations. Several firms, previously exclusively producers of film commercials, have equipped themselves with Videotape recorders, and are now syndicating commercials on tape. At least two new firms have been formed, which specialize exclusively in television tape recording. One of these, Videotape Productions of New York, Inc., demonstrated a startling cosmetic commercial in January of this year. With live television appearance, the girl in the commercial appeared before, during, and after use of the sponsor's product, *lap-dissolving* from "before" to "during", and from "during" to "after"! The sponsor, of course, was used to obtaining these effects with film but never with live television. Here's how it was accomplished:

The model as first taped in the "before" sequence, with a generous portion of black sync following the sequence; she then prepared herself for the **third** or "after" sequence, and, after a portion of black sync, went on-camera for the third part of the sequence. The sections of black, after the first sequence and before the third sequence, were then spliced together, so that black, intervening between "before" and "after" was exactly the length desired for the sequence **"during"** the cosmetic application. The tape was now threaded on one machine, while the model stood by with the live camera in the studio; the tape was rolled, while a copy was made on a second machine. Toward the end of the first sequence, with the camera locked to sync from the tape recorder, the feed to the second recorder was lap-dissolved from tape-playback to live camera, and the "during" sequence recorded as the model applied the makeup. Toward the end of the second sequence, a second lap-dissolve was executed from live camera to tape. On the second recorder, the whole sequence appeared, "before" lap-dissolving into "during", lap-dissolving in turn into "after". Copies of this tape were then made and distributed. In the tapes which were distributed, sequences "1" and "3" were copies of copies, while the second sequence was a copy from an original tape. Through careful control over the quality of the recording, release tapes were obtained which were so free of defect that critical observers were unable to detect which was the third-generation portion of the material. These tapes were, of course, intended for replay on Videotape recorders at many different times and places.



Improvements have been made in control-trackhead, center.

Standardization Essential to Interchangeability

Results of this kind can be obtained only through the most careful cooperation between the engineering laboratory and the manufacturing facility, and between the manufacturer and the users of the equipment. The broadcasting industry has clearly seen the necessity for establishing and maintaining standard methods of operating these new machines. Charles P. Ginsburg, in his address to the NAB Convention last year, explained in detail the mechanical and electrical adjustments which determine the degree of fidelity which is obtainable in tapes which are interchanged among Videotape recorders. Standardization, he demonstrated, is required in the degree of tip-projection which is employed in recording and reproducing tapes, in the height of the concave tape guide, and in the precision of the 90° angles among the four heads on the rotating head structure. Throughout the first year and a quarter of Videotape recorder production, standards have continually been tightened on factory adjustment of head height and head quadrature. In current production, where specification calls for quadrature errors to be limited to less than 0.1 microseconds, average measured error is at 0.05 microseconds. Preservation of this standard, we believe, is essential to the continued free interchangeability of television tape recordings. Early in the development of the Videotape recorder, Ampex engineers invented an electronic method of correcting quadrature misalignment by means of adjustable delay-lines in the record and playback circuits. While the method certainly proved to be one possible solution of the problem, it was rejected because of the urgency of standardization. During these first years of television tape recording, it was felt, broadcasters would have quite enough new maintenance procedures to follow, without adding that of maintaining quadrature adjustment, particularly if a hidden trap existed in the adjustment method.

Where the delay-line adjustment method was used, experimentally, it was found that considerable misalignment could be compensated without the operator's knowledge that misalignment was present. The hazard to standardization thus presented is not easily seen. It may be understood by following through the reasons for our rejection of the variable delay-line method of adjusting quadrature. For the sake of interchangeability it is desired that all tapes be *recorded* as if their heads *were* in perfect quadrature alignment. Therefore, if loose quality-control methods are to be tolerated, with wide variations in actual quadrature alignment of the heads, it would be necessary to provide individual delay-line adjustment in each of the four *recording* circuits, so as to lay down a track *as if* the heads were actually in perfect physical alignment. If these same imperfect heads, or others of equally loose tolerances, were to be used in playback, then tapes which *were* recorded in perfect quadrature would reproduce improperly. Therefore, delay-lines would *also* have to be provided in the playback circuits. Now, suppose the delay-lines in the record-circuit were to be improperly adjusted, so that the resulting tape were recorded as if the heads were considerably out of proper quadrature; a relatively simple adjustment of the playback delay-lines would permit linear playback of the improperly-recorded tape, *and could easily give the impression that the machine were in proper operating condition.* Such a situation might easily develop, we felt, when-ever the recorders were especially busy, as we certainly hoped that they would be. Such tapes, while playable after individual adjustment, would be entirely unsuitable for splicing. This is the point where danger occurs to standardization. If television tapes were to become widely and commonly interchanged, we felt that this danger must be avoided, even though the cost of correct mechanical precision manufacture might be higher. Thus, the more difficult solution was chosen, and correction of the potential error at its source was undertaken. The hazard of unintentional dilution of interchangeability standards in this new and promising television medium was thus avoided. We urge again, during this critical year of the growth of tape syndication, that there be no toleration of loosening standards, and that the capability of tapes to be interchanged and inter-spliced should not be endangered by the adoption now of electrical compensation methods for adjustments which ought, rightly, to be accomplished with the necessary precision as a responsibility of the manufacturer, not the user.

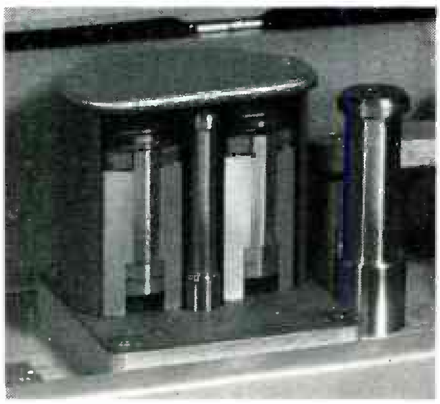
Recorded Tape As Alignment Standard

Preservation of the ability to interchange tapes depends also upon the industry's agreement on a standard way of adjusting such dimensions as tape-guide height and projection of head tips. These dimensions can, of course, be set by independent means to predetermined and agreed-upon positions. But the easiest way to check a machine quickly, and to arrive rapidly at the desired settings, is to use a standard recorded tape. Instrumentation and labor are reduced greatly. The tapes, of course, must be precisely uniform, and their production is therefore centralized in a single laboratory. Each is checked against a single standard, before release. Every new Videotape recorder is accomplished by an alignment tape.

Stereophonic sound has now also come of age. With stereophonic tapes, both home users and broadcasters have explored the possibilities in stereo. With the advent of stereophonic discs, a little over a year ago, stereo became a mass market item. More and more broadcasters began to schedule FM/AM stereo broadcasts and, last Fall, the National Broadcasting Co., began to experiment with TV/AM stereo. The results have justified further use of this medium, while proposals are now taking form not only for FM multiplex stereo, but also for a form of TV multiplex stereo sound. The equipment necessary for Videotape recording with stereophonic sound is already in existence. One such machine is in commercial use today, and others can be made available as needed. The stereo-modified Videotape recorder places two stereophonic sound-tracks in precisely the same area which has heretofore been used for the single sound channel which is normal to television broadcasting. The gaps of the separated record-playback heads are held precisely in line, so that tapes thus recorded are compatible for playback on normal single-channel machines. The precision of this alignment is such that when both channels are tracked by a normal single wide head, a precise A + B signal emerges from the sound playback system. Thus, insofar as stereo is in the future of TV, the Videotape recorder is already adapted for it.

Tele-Productions on Tape

It is obvious that the next big step for television tape recording is in the direction of syndicated programming. The first steps in this direction have already been taken. "Divorce Court", a highly successful local production of KTTV, Los Angeles, has been syndicated on tape to more than 15 stations, with live local quality, yet in syndicated form. There is good reason to believe that several programs, now regularly produced on photographic film, will appear this Fall on tape. While the reasons for the change will be largely economic, yet many of the reasons will be purely technical. The immediacy and liveness of tape reproduction is the first and most obvious of its technical advantages; in this, tape reproduction unlike film, is uniquely identified with television. But, unlike television, taped television is free of the danger of fluffs and unexpected disruptions. Tape shares the advantage which film has, in being spliceable.



Changes in VR-1000 audio head assembly reduce oxide accumulation. New cue track erase and record-playback heads trace track on lower edge of 2-inch tape.

Mobility in TV Tape

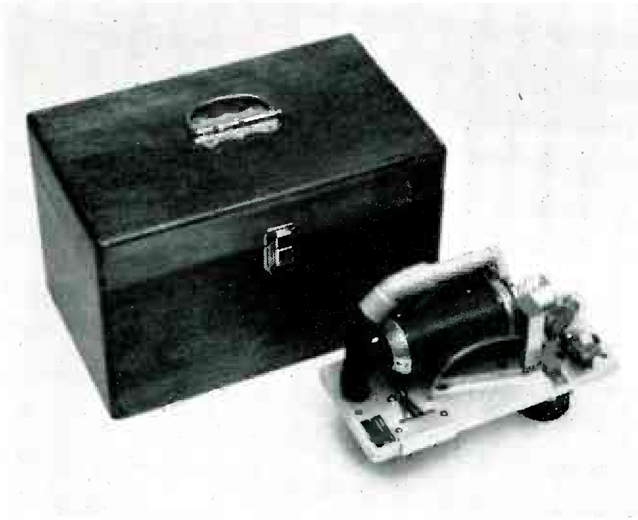
But if it is to be widely used, in syndicated production service, tape must acquire more of the advantages of film. Among these is mobility. A beginning has already been made in this direction. Two or three cameras, full control facilities, and television tape recording apparatus, complete with local AC power supply, can all be contained in a bus of the size and type which is found frequently in airport service. One of these, constructed for demonstration purposes, has already displayed its ability to "bring back alive" television recordings taken on-location, even tapes made with the Videotape Cruiser in motion.

Synchronizing Tape Picture

Still more special facilities, however, will be required, as tape moves more and more into syndicated television program production. Primary among these new devices will be means of inter-synchronizing two or more Videotape recorders, so that lap-dissolves and other special effects may be accomplished among their several outputs. Inter-syching of two or more Videotape recorders, with the precision required for split-screen, lap-dissolve, wipes, and other effects, will require precision line-by-line synchronization of the rotary heads of the several recorders. This development is well along, already, and successful demonstration has been made of breadboard system for its accomplishment. The outlook is bright, indeed, for the eventual adoption of magnetic tape as the preferred and commonest means of producing high-quality low-cost television entertainment.

A pattern can be clearly seen emerging, which no one may ignore if his engineering future is to lie in

Associated equipment for the VR-1000 includes 2-inch automatic erase head. Electronics chassis mounts in front of console, provides current and amplification both for cue track and erasing function.



More than 2500 of these VR-1000 plug-in head assemblies have been manufactured.

the creation of television programming.

Tape's ability to be spliced was exploited to great effect when CBS presented "The Old Man" on "Playhouse 90" last Fall. For this program more than 112 takes were tape recorded in separate shots. 55 of these were then smoothly spliced together to form a fast-paced, technically flawless dramatic program, of ninety minutes' length, produced, edited and distributed in five days. The creation of this program did *not* involve the use of some of the familiar film aids to production, such as frame by frame viewing and cutting, or double-film sound. It did use the usual television arts, extending upon them with creative ingenuity, and adding the new facilities of the magnetic tape process. Where the arts of the film craft contribute, television programmers have shown no hesitance to adapt them. Where electronic television production has needed such typically film aids as double-film sound, these are being reconstituted in television form. The National Broadcasting Company, during the past program season, announced it has successfully synchronized several sound tracks on separate magnetic sound playback machines, with a tape-recorded TV picture, for its "Bob Hope Show."

Magnetic tape has given memory to live television, without imposing any limitation on the facilities live television already had. The special facilities possessed only by live television are of course, shared by live television on tape: one of these is the extraordinarily effective "emulsion speed" of the image orthicon television camera. When we attach a magnetic tape recorder to a television camera, we have in effect a faithful live-TV memory with an A.S.A. speed of 2500 or more. This by itself, gives the director the opportunity to shoot pictures under lighting conditions which would not be acceptable for photography, and gives him also the familiar advantages of high-speed emulsions in control over depth-of-focus.

The bag of tricks which is familiar to the live television producer is now open wide for the use of the syndicated TV program producer. A television special-effects generator, like the one recently shown by Telechrome, is not only capable of a wide variety of montage and split-screen effects, wipes and fades and lap-dissolves, but is also capable of instantaneous electronic matting and superimposition, both moving and still. The special effects generator can distinguish, either on the basis of brightness or, in special applications, on the basis of color, between sections of picture. Thus, a brightly-lighted actor on one set can be electronically matted into a completely different background; titles of any degree of movement or complexity, can be electronically matted into previously-shot sequences; puppets or other moving models can be superimposed into live scenes, without laborious artwork. And, through the use of magnetic television tape recorder, all these effects can be performed in a series of steps, separated by any time-period which may be desired. New *electronic* skills are being developed, which exploit the capabilities of live television, and which will make possible increased output of high-quality taped live-looking television programs in an ever-increasing quantity, to keep up with television's ever-expanding demand for timely programming in syndicated packages, capable of scheduling to meet local program needs.

In the past, live television was preferred by many sponsors for its timeliness, spontaneity, immediacy, and live appearance. Film was preferred by others, because of its freedom from unexpected and sometimes embarrassing flaws, because of its unlimited mobility, and because of its ability to make available artists of the sponsors' choice for broadcast at times and places also of his choice. In the past, film was often the artist's choice because it assured him of error-free appearance on the air, and because it allowed him to schedule his performance at his own convenience.

If we may be forgiven the pun we might say that magnetic tape is now the happy medium—perhaps even the happiest medium, with live television's immediacy, timeliness, liveness and special electronic effects, but with a memory, so as to confer upon artists and sponsors alike the advantages of both live television and film.

In its short history, tape has acquired spliceability, interchangeability, separate sound facilities, special effects capabilities, mobility and accuracy of time-registration. We cannot doubt that these facilities will be refined and extended in the future, whether by the manufacturers of tape equipment and accessories or by tape users. Television tape recording offers an opportunity to fill the void in television programming which we all see ahead. The number and variety of TV stations is increasing, while the store of theater films for television is becoming obsolete, or non-competitive by reason of cost, or inadequate in volume.

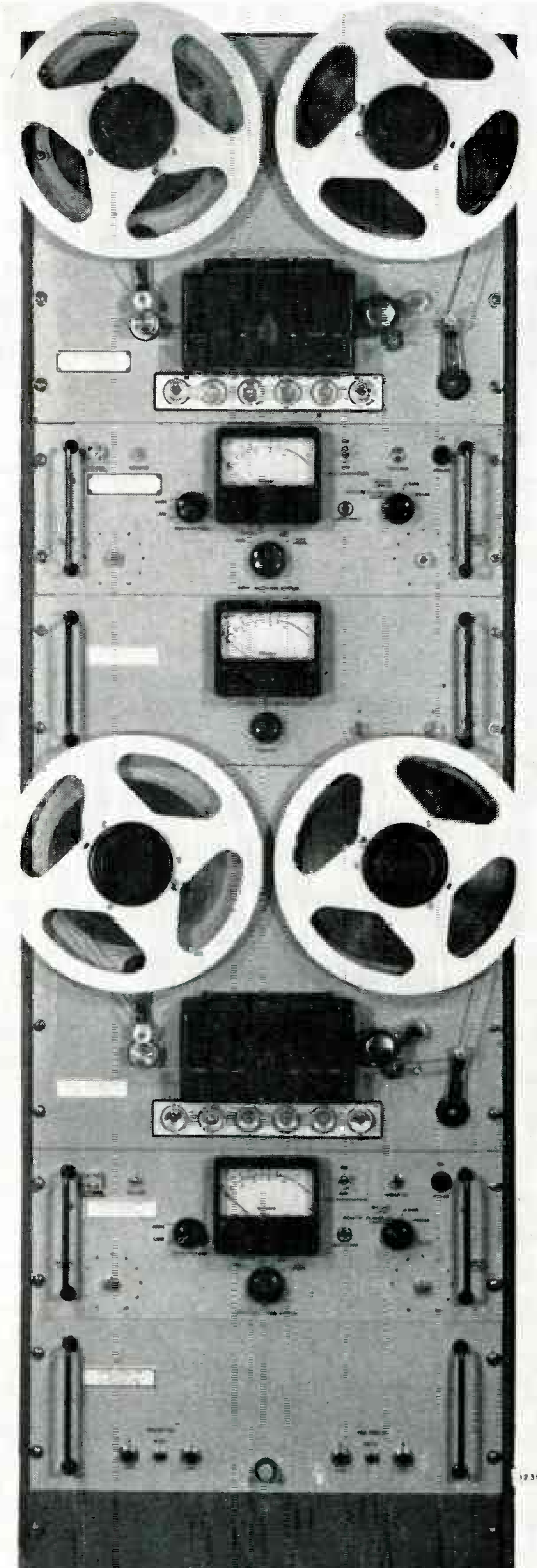
Tape Timer rapidly and accurately locates previously logged points inside reels of tape, gives precise indication of recorded program time.

The pattern we see is one of reduction in the use of photo-chemical techniques, and expansion in the use of electronic and magnetic techniques in television. It may well be that in three to five years photography will have little or no application in television broadcasting.

Color tape is of great importance in the future, in non-television broadcasting. The color television camera is the most accurate color-measuring instrument yet devised, and by suitable auxiliary instrumentation may be used with a color TV tape recorder to preserve indefinitely a precision record of events whose brightness, hue and chrome are of special scientific or military importance. It has been shown that the NTSC color system not only possesses greater accuracy in color metering, but also possesses a greater range of hue and chroma representation than does any photographic color process.

We may surely say safely that magnetic television tape will expand in use in the months and years ahead, supplementing photography, and to some extent supplanting it in entertainment television and in scientific, military and industrial uses.

Nowhere is this more evident than in the prospect of the wider use of color. The color TV tape recorder uses exactly the same tape as its monochrome counterpart—no special color tape is used. Color tape is also instantly replayable. It is capable of interchange, splicing and duplication. Color TV uses the same electronic special effects devices and electronic editing techniques as monochrome TV. Insofar as color is in the future of television, color tape will be the preferred medium, not only by reason of its superior broadcast quality but also because of its associated lower costs.



AUTOMATIC TAPE

An entirely new field of recorded programming has been opened by the development of an automatic delayed tape recording system for the National Broadcasting Co. by Telectro Industries Corp. of Long Island City. The purpose of the new system is to provide a signal delay of up to one hour from the time of the original recording. It was designed for the relaying of broadcast programs to a time zone one hour behind the area in which the "live" program originated. For instance, if a program is originating from New York at six o'clock and it is also scheduled to be heard in Chicago at six o'clock, the new system would record the original program and "hold" or delay the signal for one hour before it is released to Chicago.

The need for a really reliable and ruggedly built unit that would be foolproof in operation and automatic in all its aspects, as well as having the necessary high quality of per-

SYSTEM OF DELAYED BROADCAST RECORDING

By

GEORGE BROWN and MAX WEISSBACK

Engineering Department, Telectro Industries Corp.

formance required in broadcasting, has long been felt in the industry and resulted in the design of this unit for the National Broadcasting Co.

Features of the System

The system, which is completely automatic, is made up of two high quality tape recorders with a frequency response, at 7½ ips, of 25-10,000 c/s plus or minus 2 db: or 25-15,000 c/s plus or minus 2 db at 15 ips. The dual channel play-back pre-amplifier features a signal to noise ratio of better than 60 db below 1 per cent tape distortion. The master control unit has four primary functions and features: (1) it provides an operation sequence relay control circuit for each tape recorder; (2) it generates a stable 25 c/s low distortion signal used for an automatic fail-safe indication; (3) dual fail-safe amplifiers and transfer units; and, (4) notched rejection filters to remove the 25 c/s signal from the reproduced signals.

How It Operates

In actual operation, delayed broadcasting is achieved in the following manner. A four head assembly is used on each tape recorder with the heads positioned in a play-back, erase, record, and monitor sequence. Now, assuming that the tape has already been recorded during the first cycle, the previously recorded signal would be the delayed program, which, after being picked up on the first head (or the play-back head) is erased and immediately re-recorded with the "live" program. The latter may be monitored on the fourth (or monitor) head to check recording quality.

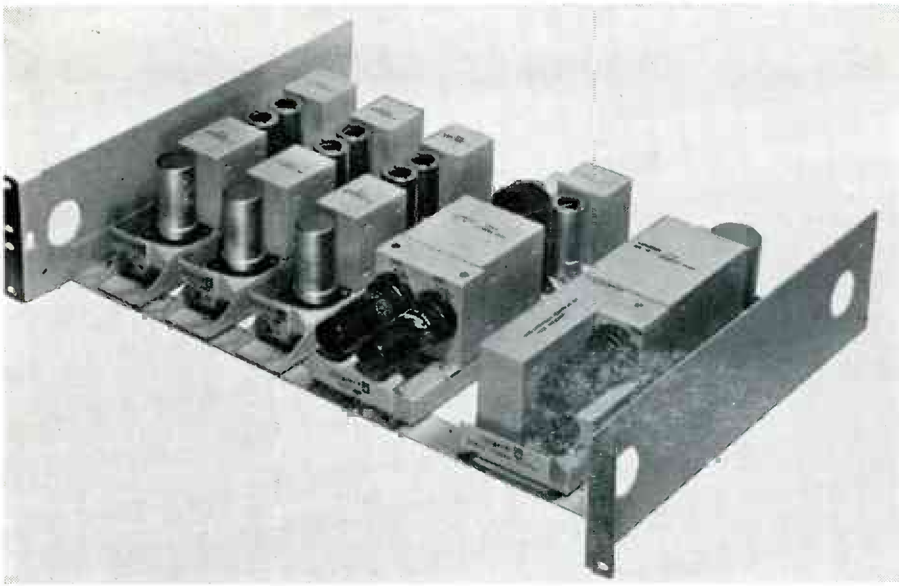
In order to achieve maximum reliability, two tape recorders are run simultaneously and a 25 c/s signal, about 20 db down, is mixed in the record amplifiers with the incoming signal. At the monitor output and the play-back amplifiers, the presence of this 25 c/s signal indicates proper functioning of the equipment. If this 25 c/s signal is absent from the play-back, the fail-safe amplifiers are activated and automatically switch the recording to the second unit which continues the operation without interruption. Before going out this 25 c/s safety signal is removed by notch filters.

The sequence of tape motions is completely automatic. A pulse signal is received from the Precision Time system at 05.00 after each hour of each beginning hourly program period. At this point the tape transports are automatically switched to the play-record position by the relay receiving the carrier pulse. The end of the recording period is indicated by a ½-inch length of clear tape placed at a point previously determined to give the correct recording time. As this strip of clear tape goes through the head assembly a light passes through the normally opaque tape and onto a photo cell. The photo cell is activated and a one-shot multi-vibrator sends a pulse signal to another relay which immediately switches the Record amplifiers off and sets the tape transports into the rewind position.

Close to the beginning of the tape reel is a 24-inch strip of clear tape which once again passes the light through and activates the photo cell. The transport then stops, pauses, and goes into the Play position until the end of the clear tape passes through the head assembly. It then stops and the system is ready to receive a new recording. The entire rewind-stop-wind cycle is achieved in less than two minutes. The high speeds attained during the rewind period cause a considerable overshoot before the tape stops; this accounts for the 24 inches of clear tape at the end of the cycle.

The entire system was created, designed and built by Telectro Industries' engineering staff at the request of the network. One of the many problems involved in the development of this system by Telectro was the need of building a machine which would be able to run continuously, 16 hours a day, with only routine maintenance for the entire period of daylight saving time, thus compensating the broadcasting schedules for the one hour time differential between various parts of the country. This necessitated that the finished recorder-reproducer be completely reliable, smooth running, and free of tape breakage for an indefinite length of time and, above all, be completely automatic in operation so that constant supervision is not required.

The engineering staff at Telectro completed the required research and design within a short time and went ahead with the building of the machine. The recorder-reproducer has already had a six-month, 16-hours-a-day running period with no serious breakdowns or repairs. The equipment is presently installed in the Network Operations Department of the National Broadcasting Co. and is in readiness for constant operation at the push of a button. Timing was always right "on the nose" and tape life was very good. No tape breakage has been experienced to date.



DESIGN CONSIDERATIONS FOR MINIATURE BROADCAST AMPLIFIERS

By
ALBERT SCHNEIDER*
Manager, Langevin Division

Years of experience have formulated in the minds of broadcasters and sound engineers exacting requirements necessary for quality amplifiers. In post-war years there has been a marked insistance on miniaturization of amplifiers since studio space is at a premium.

Up to this time seven or at the most eight pre-amplifiers in seven inches of standard rack space was considered maximum. With the latest advances it is now possible to get as many as 22 broadcast quality pre-amplifiers in the same standard rack space. Similar space savings result from the use of companion miniaturized amplifiers and power supplies.

Before detail design was started, the following general specifications were set up:

1 The amplifiers would have to be of the plug-in type. If a unit goes bad while on the air, the broadcast technician must be able to pull out the faulty amplifier and replace it with a spare in a matter of seconds. The unit can then be repaired under ideal conditions and without the paralyzing effect of extreme time limitations.

2. The trays housing the amplifiers must be designed to eliminate all alignment problems. The devices must hit home on the first try.

3. The trays must also be designed so that the socket accepting the amplifier is easily accessible to the cabler or the maintenance man.

4. Each amplifier should be equipped with miniature push button switches to facilitate plate current measurement. This would help immeasurably when trouble-shooting racks of amplifiers.

The Pre-Amplifier

(Langevin Mfg. Corp., Type No. 5116)

Choice of tube types in low noise pre-amplifiers is less of a problem now that two useful types of low-noise miniature tubes, the 5879 triode/pentode and the 12AY7 high-mu double triode, are available. In this design 5879's were used because they lend themselves to a simple single-ended circuit with ample gain from the pentode stage and adequate power output from the triode-connected stage. The 5879 has low hum, noise and microphonics and is less expensive than the 12AY7. The 5879 single-ended circuit is also very economical of filament and plate current.

The first component to be designed was the output transformer. This had to fit on a chassis 1⅜ inches wide, have a maximum overall height of 2½ inches, and still be capable of a substantially flat frequency response characteristic and a balanced output. It was evident that the transformer would require grain oriented steel to give the small size necessary and at the same time meet the exacting low frequency specifications of the pre-amplifier. The high frequency response characteristic of the output transformer, both in the audio band and in the much more extended band needed to insure feedback stability, required the investigation of many winding configurations before the transformer design was completed. The unit includes a tertiary feedback winding and provides a balanced output of either 150 or 600 ohms.

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It became evident that the input transformer would control the overall amplifier response since the rest of the circuit including the output transformer was within the feedback loop and would have practically flat response. Special mu-metal laminations together with extensive interleaving of windings gives the required band response. Hum-bucking coil construction plus mu-metal shielding reduces hum pickup to a negligible value.

With the complete circuit operation in prototype form the problem of noise reduction was tackled. It was found that much of the noise was hum due to filament to cathode leakage (mostly 60 with some 120 cycles). By careful by-passing of cathode circuits and control of ground returns to minimize induced hum the noise was reduced to below-120 dbm at the input. Then by arrangement of the cabling the hum was reduced even further, to within a few db of the DC filament readings of —125 to —127 db.

With miniaturization as the prime objective, the problem of heat dissipation proved to be a major one. Eleven pre-amplifiers packed across 17 inches of shelf space would make the temperature rise excessive unless adequate precautions were taken. The results of days of controlled heat run tests proved gratifying. An open rack in a warm 80° F. ambient allowed amplifier temperatures below 40° C., when stacked 22 per seven-inch rack space or almost 200 units per six-foot rack.

A few of the design efforts that helped are listed:

1. The electrolytic capacitor is kept as far away from the output tube as possible.

2. All capacitors used are capable of withstanding temperatures up to and including 65° C.

3. The amplifier supporting shelf is made shorter than the amplifier so that adequate air circulation in front and rear is allowed.

The following is a outline of production specifications of the Broadcast Quality Pre-Amplifier:

GAIN: 40 db.

INPUT SOURCE IMPEDANCE:
30/150/600 ohms center tap available when strapped for 150 or 600 ohms.

OUTPUT LOAD IMPEDANCE:
150/600 ohms with center tap on 600 ohm position.

OUTPUT NOISE:
equivalent to input signal of —120 dbm or less.

OUTPUT POWER:
plus 18 dbm (0.063 watts) with less than 0.5% RMS total distortion from 50—15,000 cps, less than 1% at 30 cps.

FREQUENCY CHARACTERISTIC:
±0.5 db from 30—15,000 cps.

POWER REQUIREMENTS:
7.5 ma D.C. at 275 V, 0.3 amp at 6.3 V.

SIZE: 9" long × 1 3/8" wide × 3 1/8" high.

The Program-Monitor Amplifier
(Langevin Mfg. Corp., Type No. 5117)

Concurrent with the design of the pre-amplifier, the program-monitor amplifier was being carefully examined. Here again, smallness and broadcast quality were prime objectives. The height of the 5116 established the overall height specification for the complete broadcast line. The question of how to design eight watts of amplifier in a package a little over three inches high presented itself. First the tubes, as in the case of the pre-amplifier, where low noise, sufficient gain and economy were all prime considerations, the 5879 was chosen for the input stage and the phase inverter stage. The question of the power stage was not easily answered. Two tube types were considered, the 6AQ5 and the 6V6. The 6AQ5 is small and the manufacturers maximum plate voltage is 250 volts D.C. If a program amplifier were to be unplugged from some installation the B plus voltage would rise (since the load on the power supply would be reduced) and it would be conceivable that the 6AQ5's would be working close to or above their rated maximum plate and screen dissipation because of this condition. 6V6's, however, can safely operate at voltages as high as 315 volts. Tube life is a very important consideration when choosing the proper tube for the Broadcast Quality Program Amplifier. At the design center ratings, it was found that the distortion of the 6V6's at full output (plus 39 dbm) was considerably lower than that of the 6AQ5. Because of these two factors, the 6V6's were chosen.

Mounting the 6V6's was another problem. First, the broadcaster should be able to change the output tubes without disengaging the amplifier. The overall size of the 6V6 presented still another problem. Horizontal mounting of the power tubes was the answer. The overall height was a little over three inches and the power tubes were removable while the unit was still in operation. Located at the rear of the chassis, the tubes were also well situated for maximum heat dissipation.

A salient feature of the 5117 is its use as a program amplifier or a monitor amplifier. The strapping of two pins on the rack receptacle allows the full eight watt output requiring a drain of 75 Ma at 300 volts D.C. For program service the strap is omitted and the power requirements are reduced to 35 Ma at 300 volts. Rated output for program service is plus 26 dbm. Six of these versatile amplifiers will fit in 3½ inches of standard rack space.

The production specifications for the Broadcast Quality Program-Monitor Amplifier are here outlined.

GAIN: 55 db, fixed.

INPUT SOURCE IMPEDANCE:
150/600 ohms, center tapped.

OUTPUT LOAD IMPEDANCE:
150/600 ohms, with center tap on 600 ohm position.

OUTPUT NOISE:
equivalent to input signal of —110 dbm or less.

OUTPUT POWER:
plus 26 dbm as a program amplifier with less than 0.5% RMS total distortion from 50 to 15,000 cps; plus 39 dbm (8 watts) as a monitor amplifier with less than 1% RMS total distortion from 50 to 15,000 cps.

FREQUENCY CHARACTERISTIC:
±0.5 db from 30 to 15,000 cps.

POWER REQUIREMENTS:
75 ma D.C. at 300 V, 1.2 amps at 6.3 V, as monitor amplifier.
35 ma D.C. at 300 V, 1.2 amps at 6.3 V, as program amplifier.

TUBE COMPLEMENT:
two type 6V6's, two type 5879's.

Each amplifier plugs into a tray. The trays mount on a rack-mounting frame.

This mounting is designed for minimum vertical deflection, thus avoiding interference with equipment mounted immediately below. The front panel is made snap-in. The trays mount with their receptacle in the front of the rack near the panel, or at the rear. In either case very good accessibility for wiring is provided.

A larger, 210 MA power supply provides the convenience of B+ indicator light and separate fuses for filament and B+. Two mount on each frame.

The amplifier complement mounted on this one shelf only 19 inches wide by 3½ inches high is enough to fully equip a large size studio console with pre-amplifiers, booster amplifier, line and monitor amplifiers. This is truly a remarkable example of miniaturization.

SOLVING MICROPHONE LOADING PROBLEMS

By

ROBERT C. RAMSEY

Chief Engineer for Broadcast Equipment

Electro-Voice, Inc.

A MICROPHONE without a connected load will still have an output voltage across its terminals. This is the unloaded or open-circuit voltage output. It is this voltage the manufacturer refers to when output level and frequency response is specified.

In most applications, these open-circuit specifications accurately describe the microphone performance since the microphone is usually unloaded. In a typical audio console, the microphone is connected to a transformer that raises the microphone impedance (50 ohm, 150 ohm, 250 ohm) to approximately 50,000 ohms. The secondary of the transformer is connected to an open grid, which is virtually an open circuit; hence the microphone is not loaded.

In some applications, broadcast microphones are connected to impedances equal to the impedance of the microphone. When this occurs, the microphone is loaded and the performance of the microphone differs from that of the open circuit condition. One example of microphone loading is low-level mixing at the input of the console. In this type of installation, the microphone is connected to an impedance very nearly equal to that of the microphone, resulting in a load on the microphone. Another example is in transistor amplifiers, which are usually designed with an impedance match between the microphone and input stage.

To sum up: broadcast microphones are typically used unloaded and manufacturers specifications accurately describe the performance. However, in certain applications, broadcast microphones are used loaded and, when this occurs, the performance of the microphone changes. It is this change in performance that makes the subject of microphone loading important to both the manufacturer and user.

The simplest condition of loading is one where both the microphone impedance and load impedance are the same at all frequencies. This condition occurs when a microphone with essentially a constant impedance is connected to a purely resistive load. The impedance of a Model 655C, rated at 50 ohms, is shown in Figure 1. When this microphone is connected to a 50-ohm resistor, the voltage output changes, as shown in Figure 2. This change can be accurately described as simply a change in level. No change in frequency response is evident as the output has dropped by the same amount at all frequencies. Microphones with essentially constant impedance curves, which would include the E-V Models 655C, 654, 635, 646 and 649A, suffer only a loss in level when connected to a resistive load. This loss is significant only to the designer of the input circuit to be used with the microphone and is of little importance to the user.

One type of loading that is important to the user is the type where the load impedance varies with frequency and results in a change in frequency response of the microphone. An example of a load of this type is the capacitance of a standard microphone cable connecting the microphone to the input equipment. This capacitance has an impedance that decreases with increasing frequency. For long cable runs this im-

CHART I

Microphone Impedance (ohms)	Cable Length (feet) Causing 1 db Loss at 10 kc
50	920
150	310
250	190

pedance can be low enough in the range of 10 to 20 kc to affect the microphone output. The amount that the high frequencies are attenuated depends on the impedance of the microphone and the length of cable used. Chart 1 shows the cable lengths at various impedances that cause a 1-db loss at 10 kc. These cable lengths are the maximum lengths that can be used without introducing noticeable loss in high frequency response.

Another loading condition that is important to the user is that in which the microphones have an impedance that varies with frequency. Mass controlled bidirectional and cardioid microphones generally have impedance curves as in Figure 3. When microphones of this type are connected to a resistive load both a loss in level and a change in frequency response occurs, as shown in Figure 4. The significant change is the reduction in bass response. The reduction shown in Figure 4 is typical. This amount of change would not be heard as a severe degradation in bass, but rather as a coloring of the sound quality. Whether this coloring of the sound is good or bad is a question we have no room to discuss here; rather, it is sufficient to state that bidirectional and cardioid

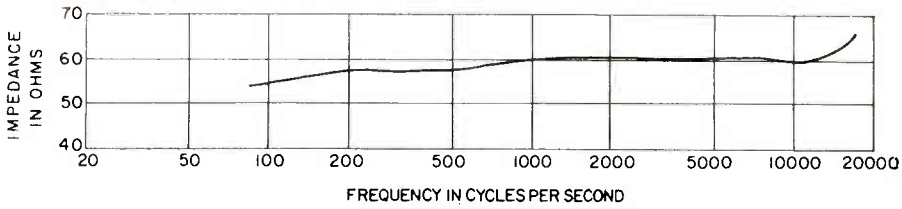


FIGURE 1 - IMPEDANCE OF 655C

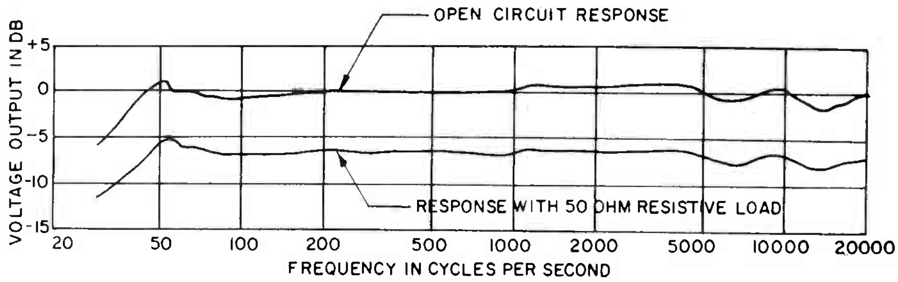


FIGURE 2 - RESPONSE OF 655C

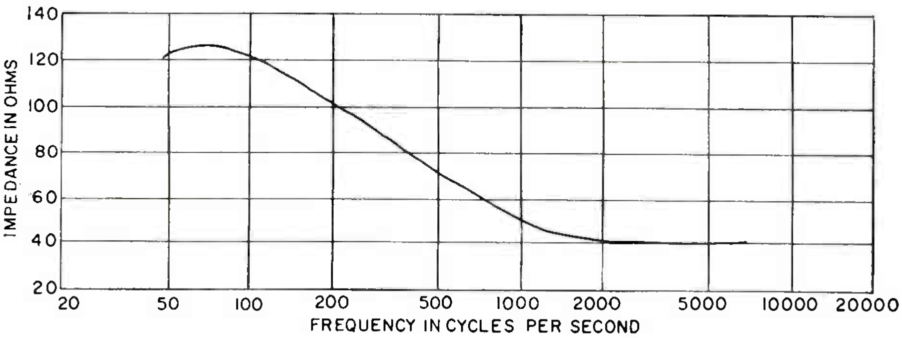


FIGURE 3

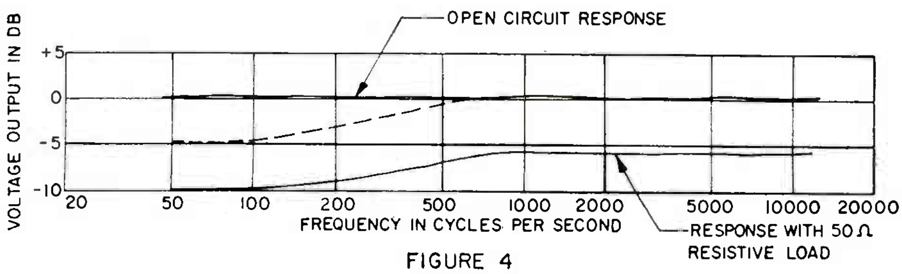


FIGURE 4

CHART II

RATED AMPLIFIER INPUT IMPEDANCE

	50-ohm input impedance			150-ohm input impedance			250-ohm input impedance		
Microphone Impedance in Ohms	effect on level	effect on 100 response	effect on 10,000 response	effect on level	effect on 100 response	effect on 10,000 response	effect on level	effect on 100 response	effect on 10,000 response
50	none	none	none	5 db loss	none	none	7 db loss	none	none
150	5 db gain	no noticeable loss	no noticeable loss	none	none	none	2 db loss	none	none
250	7 db gain	noticeable loss	noticeable loss	2 db gain	no noticeable loss	no noticeable loss	none	none	none

microphones will generally have reduced bass response when connected to a resistive load equal to its impedance.

As the information in this article indicates, loading broadcast microphones normally will not result in any severe degradation of sound quality. In most applications broadcast microphones are used open-circuited, and loading simply does not exist. With care, cable capacity need not be a problem. Bidirectional and cardioid microphones should be used open-circuited, or with the knowledge that some bass attenuation may be present.

Thus far, the normal conditions of microphone loading have been discussed. It has been assumed that the microphone impedance falls within the design limits of the input equipment. In broadcast work the input equipment is rated at 50, 150, or 250 ohms. Broadcast microphones also are rated at 50, 150, or 250 ohms. Obviously many combinations of microphone and input impedance are possible. Under certain extreme conditions of impedance mismatch, the input transformer can act as a load on the microphone.

Chart II shows the effect on frequency response and level of each of the possible combinations of microphone impedance and rated input impedance. In preparing the chart it has been assumed that the input transformer is well designed. An examination of this chart shows that, ignoring level variations, the only combination that causes a noticeable change in microphone performance is a 250 ohm microphone used with a 50 ohm input.

As an aid in solving special problems of loading, such as would occur with the use of electrical filters, a general solution of the problem of loading a microphone has been included below.

To calculate the effect of a load on microphone output consider the microphone to be an electrical generator. This is shown schematically below:

The generator voltage output, E, equals the open circuit voltage output of the microphone. The series impedance, Z, equals the impedance of the microphone. Z_L represents the load impedance. The microphone output voltage is designated E_0.

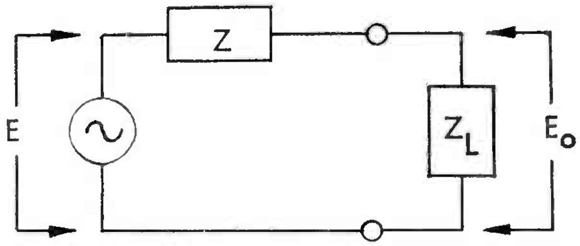
The impedance of the microphone is generally resistive, but not necessarily constant at all frequencies.

The load impedance can be a resistor, capacitor or inductor or a combination and in the general case:

$$Z_L = R_L + j\left(WL_L - \frac{1}{WC_L}\right)$$

With this in mind, the microphone voltage output is given by the equation:

$$E_0 = E\left(\frac{Z_L}{Z_L + Z}\right)$$



F.C.C. REGULATIONS

ON THE FOLLOWING PAGES ARE PRINTED THE FM TECHNICAL STANDARDS FROM THE F.C.C. REGULATIONS PERTAINING TO BROADCAST SERVICES. THESE ARE REVISED UP TO PUBLISHING TIME.

AMENDMENTS AND PROPOSED CHANGES FOLLOWS THE REGULATIONS.

FM TECHNICAL STANDARDS

§ 3.301 **Introduction.** (a) There are presented herein the Commission's engineering standards relating to the allocation and operation of FM broadcast stations. These standards also apply to noncommercial educational FM broadcast stations, except as noted herein. The Commission's rules and regulations contain references to these standards. which have been approved by the Commission and thus are considered as reflecting its opinion in all matters involved.

(b) The standards set forth herein are those deemed necessary for the construction and operation of FM broadcast stations to meet the requirements of technical regulations and for operation in the public interest along technical lines not otherwise enunciated. These standards are based upon the best engineering data available, including evidence at hearings, conferences with radio engineers, and data supplied by manufacturers of radio equipment and by licensees of FM broadcast stations. These standards are complete in themselves and supersede previous engineering standards or policies of the Commission concerning FM broadcast stations. While these standards provide for flexibility and indicate the conditions under which they are applicable, it is not expected that material deviation from the fundamental principles will be recognized unless full information is submitted as to the need and reasons therefor.

(c) These standards will necessarily be revised from time to time as progress is made in the art. The Commission will accumulate and analyze engineering data available as to the progress of the art so that these standards may be kept current with technical developments.

§ 3.310 **Definitions** — (a) **FM broadcast station.** The term "FM broadcast station" means a station employing frequency modulation in the FM broadcast band and licensed primarily for the transmission of radiotelephone emissions intended to be received by the general public.

(b) **Frequency modulation.** The term "frequency modulation" means a system of modulation where the instantaneous radio frequency varies in proportion to the instantaneous amplitude of the modulating signal (amplitude of modulating signal to be measured after pre-emphasis, if used) and the instantaneous radio frequency is independent of the frequency of the modulating signal.

(c) **FM broadcast band.** The term "FM broadcast band" means the band of frequencies extending from 88 to 103 megacycles, which includes those assigned to noncommercial educational broadcasting.

(d) **Center frequency.** The term "center frequency" means:

(1) The average frequency of the emitted wave when modulated by a sinusoidal signal.

(2) The frequency of the emitted wave without modulation.

(e) **Frequency swing.** The term "frequency swing" means the instantaneous departure of the frequency of the emitted wave from the center frequency resulting from modulation.

(f) **FM broadcast channel.** The term "FM broadcast channel" means a band of frequencies 200 kilocycles wide and is designated by its center frequency. Channels for FM broadcast stations begin at 88.1 megacycles and continue in successive steps of 200 kilocycles to and including 107.9 megacycles.

(g) **Antenna field gain.** The term "antenna field gain" of an FM broadcast antenna means the ratio of the effective free space field intensity produced at one mile in the horizontal plane expressed in millivolts per meter for 1 kilowatt antenna input power to 137.6 mv/m.

(h) **Free space field intensity.** The term "free space field intensity" means the field intensity that would exist at a point in the absence of waves reflected from the earth or other reflecting objects.

(i) **Multiplex transmission.** The term "multiplex transmission" means the simultaneous transmission of two or more signals within a single channel. Multiplex transmission as applied to FM broadcast stations means the transmission of facsimile or other signals in addition to the regular broadcast signals.

(j) **Percentage modulation.** The term "percentage modulation" as applied to frequency modulation means the ratio of the actual frequency swing to the frequency swing defined as 100 per cent modulation, expressed in percentage. For FM broadcast stations a frequency swing of ±75 kilocycles is defined as 100 per cent modulation.

(k) **Effective radiated power.** The term "effective radiated power" means the product of the antenna power (transmitter output power less transmission line loss) times (1) the antenna power gain, or (2) the antenna field gain squared. Where circular or elliptical polarization is employed the term effective radiated power is applied separately to the horizontal and vertical components of radiation. For allocation purposes, the effective radiated power authorized is the horizontally polarized component of radiation only.

(l) **Service area.** The term "service area" as applied to FM broadcasting means the service resulting from an assigned effective radiated power and antenna height above average terrain.

(m) **Antenna height above average terrain.** (1) The term "antenna height above average terrain" means the height of the radiation center of the antenna above the terrain 2 to 10 miles from the antenna. (In general a different antenna height will be determined for each direction from the antenna. The average of these various heights is considered as the antenna height above average terrain.)

(2) Where circular or elliptical polarization is employed the antenna height above average terrain shall be based upon the height of the radiation center of the antenna which transmits the horizontal component of radiation.

(n) **Field intensity.** The term "field intensity" as used in these standards shall mean the electric field intensity in the horizontal direction.

(o) **Index of cooperation.** The index of cooperation as applied to facsimile broadcasting is the product of the number of lines per inch, the available line length in inches, and the reciprocal of the line-use ratio (e.g., 105×8.2×8/7=984).

(p) **Line-use ratio.** The term "line-use ratio" as applied to facsimile broadcasting is the ratio of the available line to the total length of scanning line.

(q) **Available line.** The term "available line" means the portion of the total length of scanning line that can be used specifically for picture signals.

(r) **Rectilinear scanning.** The term "rectilinear scanning" means the process of scanning an area in a predetermined sequence of narrow straight parallel strips.

(s) **Optical density.** The term "optical density" means the logarithm (to the base 10) of the ratio of incident to transmitted or reflected light.

§ 3.311 **Engineering standards of allocation.** (a) Sections 3.202 to 3.205 inclusive of the rules and regulations describe the basis for allocation of FM broadcast stations, including the division of the United States into Areas I and II.

(b) FM broadcast stations shall determine the extent of their 1 mv/m and 50 uv/m contours in accordance with the methods prescribed in these Standards.

(c) Although some service is provided by tropospheric waves, the service area is considered to be only that served by the ground wave. The extent of service is determined by the point at which the ground wave is no longer of sufficient intensity to provide satisfactory broadcast service. The field intensity considered necessary for service is as follows:

Area:	Median field intensity
City business or factory areas	1 mv/m
Rural areas	50 uv/m

A median field intensity of 3 to 5 mv/m should be placed over the principal city to be served and for class B stations, a median field intensity of 1 mv/m should be placed over the business district of cities of 10,000 or greater within the metropolitan district served. A field intensity of 5 mv/m should be provided over the main studio of a class B station except as otherwise provided in § 3.205. These figures are based upon the usual noise levels encountered in the several areas and upon the absence of interference from other FM stations.

(d) A basis for allocation of satellite stations has not yet been determined. For the present, applications will be considered on their individual merits.

(e) The service area is predicted as follows: Profile graphs must be drawn for at least eight radials from the proposed antenna site. These profiles should be prepared for each radial beginning at the antenna site and extending to 10 miles therefrom. Normally the radials are drawn for each 45° of azimuth; however, where feasible the radials should be drawn for angles along which roads tend to follow. (The latter method may be helpful in obtaining topographical data where otherwise unavailable, and is particularly useful in connection with mobile field intensity measurements of the station and the correlation of such measurements with predicted field intensities.) In each case one or more radials must include the principal city or cities to be served, particularly in cases of rugged terrain, even though the city may be more than 10 miles from the antenna site. The profile graph for each radial should be plotted by contour intervals of from 40 to 100 feet and, where the data permits, at least 50 points of elevation (generally uniformly spaced) should be used for each radial. In instances of very rugged terrian where the use of contour intervals of 100 feet would result in several points in a short distance, 200- or 400-foot contour intervals may be used for such distances. On the other hand, where the terrain is uniform or gently sloping the smallest contour interval indicated on the topographic map (see below) should be used, although only a relatively few points may be available. The profile graph should accurately indicate the topography for each radial, and the graphs should be plotted with the distance in miles as the abscissa and the elevation in feet above mean sea level as the ordinate. The profile graphs should indicate the source of the topographical data employed. The graph should also show the elevation of the center of the radiating system. The graph may be plotted either on rectangular coordinate paper or on special paper which shows the curvature of the earth. It is not necessary to take the curvature of the earth into consideration in this procedure, as this factor is taken care of in the chart showing signal intensities (Fig. 1 of § 3.333).

(f) The average elevation of the 8-mile distance between 2 and 10 miles from the antenna site should then be determined from the profile graph for each radial. This may be obtained by averaging a large number of equally spaced points, by using a planimeter, or by obtaining the median elevation (that exceeded for 50 per cent of the distance) in sectors and averaging these values.

(g) To determine the distance to a particular contour, Figure 1 of § 3.333 concerning the range of FM broadcast stations should be used. This chart has been prepared for a frequency in the center of the band and is to be used for all FM broadcast channels, since little change results over this frequency range. The distance to a contour is determined by the effective radiated power and the antenna height. The height of the antenna used in connection with Figure 1 of § 3.333 should be the height of the center of the proposed antenna radiator above the average elevation obtained by the preceding method. The distances shown by Figure 1 of § 3.333 are based upon an effective radiated power of 1 kilowatt: to use the chart for other powers, the sliding scale associated with the chart should be trimmed and used as the ordinate scale. This sliding scale is placed on the chart with the appropriate graduation for power in line with the lower line of the top edge of the chart. The right edge of the scale is placed in line with the appropriate antenna height graduations and the chart then becomes direct reading for this power and antenna height. Where the antenna height is not one of those for which a scale is provided, the signal strength or distance is determined by interpolation between the curves connecting the equidistant points.

(h) The foregoing process of determining the extent of the required contours shall be followed in determining the boundary of the proposed service area. The areas within the required contours must be determined and submitted with each application for an FM broadcast station. Each application shall include a map showing these contours, and for this purpose sectional aeronautical charts or other maps having a convenient scale may be used. The map shall show the radials along which the profile charts and expected field strengths have been determined. The area within each contour should then be measured (by planimeter or other approximate means) to determine the number of square miles therein. In computing the area within the contours, exclude (1) areas beyond the borders of the United States, and (2) large bodies of water, such as ocean areas, gulfs, sounds, bays, large lakes, etc., but not rivers.

(i) In cases where the terrain in one or more directions from the antenna site departs widely from the average elevation of the 2 to 10 mile sector, the application of this prediction method may indicate contour distances that are different from those which may be expected in practice. In such cases the prediction method should be followed, but a showing may be made if desired concerning the distance to the contour as determined by other means. Such showing should include data concerning the procedure employed and sample calculations. For example, a mountain ridge may indicate the practical limit of service although the prediction method may indicate the contour elsewhere. In cases of such limitation, the map of prediction coverage should show both the regular predicted area and the area as limited or extended by terrain. Both areas should be measured as previously described; the area obtained by the regular prediction method should be given in the application form, with a supplementary note giving the limited or extended area. In special cases the Commission may require additional information as to the terrain in the proposed service area.

(j) In determining the population served by FM broadcast stations, it is considered that the built-up city areas and business districts in cities having over 10,000 population and located beyond the 1 mv/m contour do not receive adequate service. Minor civil division maps (1950 census) should be used in making population counts, excluding cities not receiving adequate service. Where a contour divides a minor division, uniform distribution of population within the division should be assumed in order to determine the population included within the contour unless a more accurate count is available.

§ 3.312. **Topographic data.** (a) In the preparation of the profile graphs previously described, and in determining the location and height above mean sea level of the antenna site, the elevation or contour intervals shall be taken from United States Geological Survey Topographic Quadrangle Maps, United States Army Corps of Engineers Maps or Tennessee Valley Authority maps, whichever is the latest, for all areas for which such maps are available. If such maps are not published for the area in question, the next best topographic information should be used. Topographic data may sometimes be obtained from state and municipal agencies. The data from the Sectional Aeronautical Charts (including bench marks) or railroad depot elevations and highway elevations from road maps may be used where no better information is available. In cases where limited topographic data can be obtained, use may be made of an altimeter in a car driven along roads extending generally radially from the transmitter site.

(b) The Commission will not ordinarily require the submission of topographical maps for areas beyond 15 miles from the antenna site, but the maps must include the principal city or cities to be served. If it appears necessary, additional data may be requested.

(c) The United States Geological Survey Topography Quadrangle Sheets may be obtained from the United States Geological Survey Department of the Interior, Washington, D. C., for 20 cents each. The Sectional Aeronautical Charts are available from the United States Coast and Geodetic Survey, Department of Commerce, Washington, D. C., for 25 cents each. These maps may also be secured from branch offices and from authorized agents or dealers in most principal cities.

§ 3.313. **Interference standard.** (a) Field intensity measurements are preferable in predicting interference between FM broadcast stations and should be used, when available, in determining the extent of interference. (For methods and procedure, see § 3.314.) In lieu of measurements, the interference should be predicted in accordance with the method described herein.

(b) Objectionable interference is considered to exist when the interference signal exceeds that given by the following ratios. (The desired signal is median field and the undesired signal is the tropospheric signal intensity exceeded for 1 per cent of the time.)

Channel separation:	Ratio of desired to undesired signals
Same channel	10:1.
200 kc	2:1.
400 kc	1:10.
600 kc	1:100.
800 kc and above	No restriction.[1]

[1]Intermediate frequency amplifiers of most FM broadcast receivers are designed to operate on 10.7 megacycles. For this reason the assignment of two stations in the same area, one with a frequency 10.6 or 10.8 megacycles removed from that of the the other, should be avoided if possible.

(c) Stations normally will not be authorized to operated in the same city or in nearby cities with a frequency separation of less than 800 kc.: *Provided*, That stations may be authorized to operate in nearby cities with a frequency separation of not less than 400 kc. where necessary in order to provide an equitable and efficient distribution of facilities: *And provided further*, That class B stations will not be authorized in the same metropolitan district with a frequency separation of less than 800 kc. In the assignment of FM broadcast facilities the Commission will endeavor to provide the optimum use of the channels in the band, and accordingly may assign a channel different from that requested in an application.

(d) In predicting the extent of interference within the ground wave service area of a station, use should be made of the groundwave chart. (Figure 1 of § 3.333.)

(e) In determining the points at which the interference ratio is equal to the values shown in paragraph (b) of this section, the field intensities for the two interfering signals under consideration should be computed for a considerable number of points along the line between the two stations. Using this data, field intensity versus distance curves should be plotted (e. g., cross-curves on graph paper) in order to determine the points on this path where the interference ratios exist. The points established by this method together with the points along the contours where the same ratios are determined, are considered to be generally sufficient to predict the area of interference. Additional points may be required in the case of irregular terrain or the use of directional antenna systems.

(f) The area of interference, if any shall be shown in connection with the map of predicted coverage required by the application form, together with the basic data employed in computing such interference. The map shall show the interference within the 50 uv/m contour.

§ 3.314. **Field intensity measurements in allocation.** (a) When field intensity measurements are required by the Commission's rules or when employed in determining the extent of service or interference of existing stations, such measurements should be made in accordance with the procedure outlined herein.

(b) Measurements made to determine the service and interference areas of FM broadcast stations should be made with mobile equipment along roads which are as close and similar as possible to the radials showing topography which were submitted with the application for construction permit. Suitable measuring equipment and a continuous recording device must be employed, the chart of which is either directly driven from the speedometer of the automobile in which the equipment is mounted or so arranged that distances and identifying landmarks may be readily noted. The measuring equipment must be calibrated against recognized standards of field intensity and so constructed that it will maintain an acceptable accuracy of measurement while in motion or when stationary. The equipment should be so operated that the recorder chart can be calibrated directly in field intensity in order to facilitate analysis of the chart. The receiving antenna shall be primarily responsive to the horizontal electric field and should be nondirectional unless otherwise authorized. Authorization to use a halfwave dipole may be requested by filing application with the Commission prior to the making of measurements. The application may be filed by letter describing the proposed antenna, the method of installation and operation, and calibration procedures. Such authorization will remain in effect throughout the series of measurements for which granted.

(c) Mobile measurements should be made with a minimum chart speed of 3 inches per mile and preferably 5 or 6 inches per mile. Locations shall be noted on the recorder chart as frequently as necessary to definitely fix the relation between the measured field intensity and the location. The time constant of the equipment should be such to permit adequate analysis of the charts, and the time constant employed shall be shown. Measurements should be made to a point on each radial well beyond the particular contour under investigation. The transmitter power shall be maintained as close as possible to the authorized power throughout the survey.

(d) After the measurements are completed, the recorder chart shall be divided into not less than 15 sections on each equivalent radial from the station. The field intensity in each section of the chart shall be analyzed to determined the field intensity received 50 per cent of the distance (median field) throughout the section, and this median field intensity associated with the corresponding sector of the radial. The field intensity figures must be corrected for a receiving antenna elevation of 30 feet and for any directional effects of the automobile not otherwise compensated. This data should be plotted for each radial, using log-log coordinate paper with distance as the abscissa and field intensity as the ordinate. A smooth curve should be drawn through these points (of median fields for all sectors), and this curve used to determine the distance to the desired contour. The distance obtained for each radial may then be plotted on the map of predicted coverage or on polar coordinate paper (excluding water areas, etc.) to determine the service and interference areas of a station.

(e) In making measurements to establish the field intensity contours of a station, mobile recordings should be made along each of the radials drawn in § 3.311 (e). Measurements should extend from the vicinity of the station out to the 1 mv/m measurement contour and somewhat beyond (at the present time it is not considered practical to conduct mobile measurements far beyond this contour due to the fading ratio at weak fields, which complicates analysis of the charts). These measurements would be made for the purpose of determining the variation of the measured contours from those predicted, and it is expected that initially the correlation of the measured 1 mv/m with the predicted 1 mv/m contour will be used as a basis in determining adherence to authorized service areas within the 50 uv/m contour.

(f) In addition to the 1 mv/m contour, the map of measured coverage shall show the 50 uv/m contour as determined by employing Figure 1 of § 3.333 and the distance to the 1 mv/m contour along each radial. The sliding scale shall be placed on the figure at the appropriate antenna height for the radial in question and then moved so the distance to the 1 mv/m contour (as measured) and the 1 mv/m mark are opposite. The distance to the 50 uv/m mark contour is then given opposite the 50 uv/m mark on the scale.

(g) In certain cases the Commission may desire more information or recordings and in these instances special instructions will be issued. This may include fixed location measurements to determine tropospheric propagation and fading ratios.

(h) Complete data taken in conjunction with field intensity measurements shall be submitted to the Commission in affidavit form including the following:

(1) Map or maps showing the roads or points where measurements were made, the service and/or interference areas determined by the prediction method and by the measurements, and any unusual terrain characteristics existing in these areas. (This map may preferably be of a type showing topography in the area.)

(2) If a directional transmitting antenna is employed, a diagram on polar coordinate paper showing the predicted free space field intensity in millivolts per meter at one mile in all directions. (See § 3.316.)

(3) A full description of the procedures and methods employed including the type of equipment, the method of installation and operation, and calibration procedures.

(4) A representative sample of the recording tape, including calibration.

(5) Antenna system and power employed during the survey.

(6) Name, address, and qualifications of the engineer or engineers making the measurements.

(i) All data shall be submitted to the Commission in triplicate.

§ 3.315. **Transmitter location.** (a) The transmitter location should be as near the center of the proposed service area as possible consistent with the applicant's ability to find a site with sufficient elevation to provide service throughout the area. Location of the antenna at a point of high elevation is necessary to reduce to a minimum the shadow effect on propagation due to hills and buildings which may reduce materially the intensity of the station's signals in a particular direction. The transmitting site should be selected consistent with the purpose of the station, i.e., whether it is intended to serve a small city, a metropolitan area, or a large region. Inasmuch as service may be provided by signals of 1 mv/m or greater field intensities in metropolitan areas, and inasmuch as signals as low as 20 uv/m may provide service in rural areas, considerable latitude in the geographical location of the transmitter is permitted; however, the necessity for a high elevation for the antenna may render this problem difficult. In general, the transmitting antenna of a station should be located at the most central point at the highest elevation available. In providing the best degree of service to an area, it is usually preferable to use a high antenna rather than a lower antenna with increased transmitter power. The location should be so chosen that line-of-sight can be obtained from the antenna over the principal city or cities to be served; in no event should there be a major obstruction in this path.

(b) The transmitting location should be selected so that the 1 mv/m contour encompasses the urban population within the area to be served and the 50 uv/m or the interference free contour coincides generally with the limits of the area to be served. It is recognized that topography, shape of the desired service area, and population distribution may make the choice of a transmitter location difficult. In such cases consideration may be given to the use of a directional antenna system, although it is generally preferable to choose a site where a nondirectional antenna may be employed.

(c) In cases of questionable antenna locations it is desirable to conduct propagation tests to indicate the field intensity expected in the principal city or cities to be served and in other areas, particularly where severe shadow problems may be expected. In considering applications proposing the use of such locations, the Commission may require site tests to be made. Such tests should be made in accordance with the measurement procedure previously described, and full data thereon must be supplied to the Commission. Test transmitters should employ an antenna having a height as close as possible to the proposed antenna height, using a balloon or other support if necessary and feasible. Information concerning the authorization of site tests may be obtained from the Commission upon request.

(d) Present information is not sufficiently complete to establish "blanket areas" of FM broadcast stations, which are defined as those areas adjacent to the transmitters in which the reception of other stations is subject to interference due to the strong signal from the stations. Where it is found necessary to locate the transmitter in a residential area where blanketing problems may appear to be excessive, the application must include a showing concerning the availability of other sites. The authorization of station construction in areas where blanketing problems appear to be excessive will be on the basis that the applicant will assume full responsibility for the adjustment of reasonable complaints arising from excessively strong signals of the applicant's station. As a means of minimizing interference problems it is expected that stations adjacent in location will generally be assigned frequencies that are generally adjacent. Insofar as is feasible, frequency assignments for stations at separated locations will also be separated.

(e) Cognizance must of course be taken regarding the possible hazard of the proposed antenna structure to aviation and the proximity of the proposed site to airports and airways. Procedures and standards with respect to the Commission's consideration of proposed antenna structures which will serve as a guide to persons intending to apply for radio station licenses are contained in Part 17 of this chapter (Rules Concerning the Construction, Marking and Lighting of Antenna Structures).

§ 3.316 **Antenna systems.** (a) It shall be standard to employ horizontal polarization; however, circular or elliptical polarization may be employed if desired. Clockwise or counter-clockwise rotation may be used. The supplemental vertically polarized effective radiated power required for circular or elliptical polarization shall in no event exceed the effective radiated power authorized.

(b) The antenna must be constructed so that it is as clear as possible of surrounding buildings or objects that would cause shadow problems.

(c) Applications proposing the use of directional antenna systems must be accompanied by the following:

(1) Complete description of the proposed antenna system.

(2) Orientation of array with respect to true north; time phasing of fields from elements (degrees leading or lagging); space phasing of elements (in feet and in degrees); ratio of fields from elements.

(3) Calculated field intensity pattern (on letter-size polar coordinate paper) giving the free space field intensity in millivolts per meter at one mile in the horizontal plane, together with the formula used, constants employed, sample calculations and tabulation of calculation data.

(4) Name, address, and qualifications of the engineer making the calculations.

(d) Applications proposing the use of FM broadcast antennas in the immediate vicinity (i. e., 200 feet or less) of (1) other FM broadcast antennas, or (2) television broadcast antennas for frequencies adjacent to the FM broadcast band, must include a showing as to the expected effect, if any, of such proximate operation.

(e) In cases where it is proposed to use a tower of a standard broadcast station as a supporting structure for an FM broadcast antenna, an application for construction permit (or modification of construction permit) for such station must be filed for consideration with the FM application. Applications may be required for other classes of stations when their towers are to be used in connection with FM broadcast stations.

(f) When an FM broadcast antenna is mounted on a nondirectional standard broadcast antenna, new resistance measurements must be made of the standard broadcast antenna after installation and testing of the FM broadcast antenna. During the installation and until the new resistance determination is approved, the standard broadcast station licensee should apply for authority (informal application) to operate by the indirect method of power determination. The FM broadcast license application will not be considered until the application form concerning resistance measurements is filed for the standard broadcast station.

(g) When an FM broadcast antenna is mounted on an element of a standard broadcast directional antenna, a full engineering study concerning the effect of the FM broadcast antenna on the directional pattern must be filed with the application concerning the standard broadcast station. Depending upon the individual case, the Commission may require readjustment and certain field intensity measurements of the standard broadcast station following the completion of the FM broadcast antenna system.

(h) When the proposed FM broadcast antenna is to be mounted on a tower in the vicinity of a standard broadcast directional array and it appears that the operation of the directional antenna system may be affected, an engineering study must be filed with the FM broadcast application concerning the effect of the FM broadcast antenna on the directional pattern. Readjustment and field intensity measurements of the standard broadcast station may be required following construction of the FM broadcast antenna.

(i) Information regarding data required in connection with standard broadcast directional antenna systems may be found in § 3.150 of this chapter. (See also Standard Broadcast Technical Standards.)

(j) In the event a common tower is used by two or more licensees for antenna and/or antenna supporting purposes, the licensee who is owner of the tower shall assume full responsibility for the installation and maintenance of any painting or lighting requirements. In the event of shared ownership, one licensee shall assume such responsibility and advise the Commission accordingly.

(k) It is recommended that an emergency FM broadcast antenna be installed, or, alternately, an auxiliary transmission line or lines if feasible in the particular circumstances. Data thereon should be supplied with the application for construction permit; if proposed after station construction, an informal application should be submitted to the Commission.

(l) When necessary for the protection of air navigation, the antenna and supporting structure shall be painted and illuminated in accordance with the specifications supplied by the Commission pursuant to section 303 (q) of the Communications Act of 1934, as amended.

§ 3.317 **Transmitters and associated equipment — (a) Electrical performance standards.** The general design of the FM broadcast transmitting system (from input terminals of microphone preamplifier, through audio facilities at the studio, through lines or other circuits between studio and transmitter, through audio facilities at the transmitter, and through the transmitter, but excluding equalizers for the correction of deficiencies in microphone response) shall be in accordance with the following principles and specifications:

(1) Standard power ratings and operating power range of FM broadcast transmitters shall be in accordance with the following table:

Standard power rating:	Operating power range
10 watts[1]	100 watts or less.
250 watts	250 watts or less.
1 kw	250 watts-1 kw.
3 kw	1-3 kw.
5 kw	1-5 kw.
10 kw	3-10 kw.
25 kw	10-25 kw.
50 kw	10-50 kw.
100 kw	50-100 kw.

[1]For noncommercial education FM stations.

(i) Composite transmitters may be authorized with a power rating different from the above table; provided full data is supplied in the application concerning the basis employed in establishing the rating and the need therefor. The operating range of such transmitters shall be from one-third of the power rating to the power rating.

(ii) The transmitter shall operate satisfactorily in the operating power range with a frequency swing of ±75 kilocycles, which is defined as 100 percent modulation.

(2) The transmitting system shall be capable of transmitting a band of frequencies from 50 to 15,000 cycles. Preemphasis shall be employed in accordance with the impedance-frequency characteristic of a series inductance-resistance network having a time constant of 75 microseconds. (See Fig. 2 of § 3.333). The deviation of the system response from the standard preemphasis curve shall lie between two limits as shown in Figure 2 of § 3.333. The upper of these limits shall be uniform (no deviation) from 50 to 15,000 cycles. The lower limit shall be uniform from 100 to 7,500 cycles, and 3 db. below the upper limit; from 100 to 50 cycles the lower limit shall fall from the 3 db. limit at a uniform rate of 1 db. per octave (d 4b. at 50 cycles); from 7,500 to 15,000 cycles the lower limit shall fall from the 3 db. limit at a uniform rate of 2 db. per octave (5 db. at 15,000 cycles).

(3) At any modulation frequency between 50 and 15,000 cycles and at modulation percentages of 25, 50, and 100 per cent, the combined audio frequency harmonics measured in the output of the system shall not exceed the root-mean-square values given in the following table:

Modulating frequency:	Distortion per cent
50 to 100 cycles	3.5
100 to 7,500 cycles	2.5
7,500 to 15,000 cycles	3.0

(i) Measurements shall be made employing 75 microsecond deemphasis in the measuring equipment and 75 microsecond preemphasis in the transmitting equipment, and without compression if a compression amplifier is employed. Harmonics shall be included to 30 kc.

(ii) It is recommended that none of the three main divisions of the system (transmitter, studio to transmitter circuit, and audio facilities) contribute over one-half of these percentages since at some frequencies the total distortion may become the arithmetic sum of the distortions of the divisions.

(4) The transmitting system output noise level (frequency modulation) in the band of 50 to 15,000 cycles shall be at least 60 decibels below 100 per cent modulation (frequency swing of ±75 kilocycles). The measurement shall be made using 400 cycle modulation as a reference. The noise-measuring equipment shall be provided with standard 75 microsecond deemphasis; the ballistic characteristics of the instrument shall be similar to those of the standard VU meter.

(5) The transmitting system output noise level (amplitude modulation) in the band of 50 to 15,000 cycles shall be at least 50 decibels below the level representing 100 per cent amplitude modulation. The noise-measuring equipment shall be provided with standard 75-microsecond deemphasis; the ballistic characteristics of the instrument shall be similar to those of the standard UV meter.

(6) Automatic means shall be provided in the transmitter to maintain the assigned center frequency within the allowable tolerance (±2000 cycles).

(7) The transmitter shall be equipped with suitable indicating instruments for the determination of operating power and with other instruments as are necessary for proper adjustment, operation, and maintenance of the equipment (see § 3.320).

(8) Adequate provision shall be made for varying the transmitter output power to compensate for excessive variations in line voltage or for other factors affecting the output power.

(9) Adequate provision shall be provided in all component parts to avoid overheating at the rated maximum output power.

(10) Means should be provided for connection and continuous operation of approved frequency and modulation monitors.

(11) If a limiting or compression amplifier is employed, precaution should be maintained in its connection in the circuit due to the use of preemphasis in the transmitting system.

(b) **Construction.** In general, the transmitter shall be constructed either on racks and panels or in totally enclosed frames protected as required by article 810 of the National Electrical Code and set forth below:

Note: The pertinent sections of article 810 of the National Electrical Code read as follows:

"8191. **General.** Transmitters shall comply with the following:

"a. **Enclosing.** The transmitter shall be enclosed in a metal frame or grille, or separated from the operating space by a barrier or other equivalent means, all metallic parts of which are effectually connected to ground.

"b. **Ground of controls.** All external metallic handles and controls accessible to the operating personnel shall be effectually grounded. No circuit in excess of 150 volts shall have any parts exposed to direct contact. A complete dead-front type of switchboard is preferred.

"c. **Interlocks on doors.** All access doors shall be provided with interlocks which will disconnect all voltages in excess of 350 volts when any access door is opened."

(1) Means shall be provided for making all tuning adjustments, requiring voltages in excess of 350 volts to be applied to the circuit, from the front of the panels with all access doors closed.

(2) Proper bleeder resistors or other automatic means shall be installed across all capacitor banks to lower any voltage which may remain accessible with access door open to less than 350 volts within 2 seconds after the access door is opened.

(3) All plate supply and other high voltage equipment, including transformers, filters, rectifiers and motor generators, shall be protected so as to prevent injury to operating personnel.

(i) Commutator guards shall be provided on all high voltage rotating machinery. Coupling guards should be provided on motor generators.

(ii) Power equipment and control panels of the transmitter shall meet the above requirements (exposed 220 volt AC switching equipment on the front of the power control panels is not recommended but is not prohibited).

(iii) Power equipment located at a broadcast station but not directly associated with the transmitter (not purchased as part of same), such as power distribution panels, are not under the jurisdiction of the Commission; therefore § 3.254 does not apply.

(4) Metering equipment:

(i) All instruments having more than 1,000 volts potential to ground on the movement shall be protected by a cage or cover in addition to the regular case. (Some instruments are designed by the manufacturer to operate safely with voltages in excess of 1,000 volts on the movement. If it can be shown by the manufacturer's rating that the instrument will operate safely at the applied potential, additional protection is not necessary.)

(ii) In case the plate voltmeter is located on the low potential side of the multiplier resistor with the potential of the high potential terminal of the instrument at or less than 1,000 volts above ground, no protective case is required. However, it is good practice to protect voltmeters subject to more than 5,000 volts with suitable overvoltage protective devices across the instrument terminals in case the winding opens.

(iii) Transmission line meters and any other radio frequency instrument which may be necessary for the operator to read shall be so installed as to be easily and accurately read without the operator having to risk contact with circuits carrying high potential radio frequency energy.

(5) It is recommended that component parts comply as much as possible with the component specifications designated by the Army-Navy Electronics Standards Agency.

(c) **Wiring and shielding.** (1) The transmitter panels or units shall be wired in accordance with standard switchboard practice, either with insulated leads properly cabled and supported or with rigid bus bar properly insulated and protected.

(2) Wiring between units of the transmitter, with the exception of circuits carrying radio frequency energy, shall be installed in conduits or approved fiber or metal raceways for protection from mechanical injury.

(3) Circuits carrying radio frequency energy between units shall be coaxial, two wire balanced lines, or properly shielded.

(4) All stages or units shall be adequately shielded and filtered to prevent interaction and radiation.

(5) The frequency and modulation monitors and associated radio frequency lines to the transmitter shall be thoroughly shielded.

(d) **Installation.** (1) The installation shall be made in suitable quarters.

(2) Since an operator must be on duty at the transmitter control point during operation, suitable facilities for his welfare and comfort shall be provided at the control point.

(e) **Spare tubes.** A spare tube of every type employed in the transmitter and frequency and modulation monitors shall be kept on hand at the equipment location. When more than one tube of any type are employed, the following table determines the number of spares of that type required:

Number of each type employed:	Spares required
1 or 2	1
3 to 5	2
6 to 8	3
9 or more	4

An accurate circuit diagram and list of required space tubes, as furnished by the manufacturer of the equipment, shall be retained at the transmitter location.

(f) **Operation.** In addition to specific requirements of the rules governing FM broadcast stations, the following operating requirements are specified:

(1) The maximum percentage of modulation shall be maintained in accordance with § 3.268. However, precautions shall be taken so as not to substantially alter the dynamic characteristics of musical programs.

(2) Spurious emissions, including radio frequency harmonics, shall be maintained at as low a level as practicable at all times in accordance with good engineering practice.

(3) If a limiting or compression amplifier is employed, care should be maintained in its use due to preemphasis in the transmitting system.

(g) **Studio equipment.** (1) Studio equipment shall be subject to all the above requirements where applicable except as follows:

(i) If properly covered by an underwriter's certificate, it will be considered as satisfying safety requirements.

(ii) Section 8191 of article 810 of the National Electrical Code shall apply for voltages only in excess of 500 volts.

(2) No specific requirements are made with regard to the microphones to be employed. However, microphone performance (including compensating networks, if employed) shall be compatible with the required performance of the transmitting system.

(3) No specific requirements are made relative to the design and acoustical treatment of studios. However, the design of studios, particularly the main studio, shall be compatible with the required performance characteristics of FM broadcast stations.

§ 3.318 **Facsimile: engineering standards.** The following standards apply to facsimile broadcasting under § 3.226:

(a) Rectilinear scanning shall be employed with scanning spot progressing from left to right and scanned lines progressing from top to bottom of subject copy.

(b) The standard index of cooperation shall be 984.

(c) The number of scanning lines per minute shall be 360.

(d) The line-use ratio shall be ⅞, or 315° of the full scanning cycle.

(e) The ⅛ cycle or 45° not included in

the available scanning line shall be divided into 3 equal parts, the first 15° being used for transmission at approximately white level, the second 15° for transmission at approximately black level, and the third 15° for transmission at approximately white level.

(f) An interval of not more than 12 seconds shall be available between two pages of subject copy, for the transmission of a page-separation signal and/or other services.

(g) Amplitude or frequency (frequency-shift) modulation of the subcarrier shall be used.

(h) Subcarrier modulation shall normally vary approximately linearly with the optical density of the subject copy.

(i) Negative modulation shall be used, i.e., for amplitude modulation of subcarrier, maximum subcarrier amplitude and maximum radio frequency swing on black; for frequency modulation of subcarrier, highest instantaneous frequency of subcarrier on black.

(j) Subcarrier noise level shall be maintained at least 30 db. below maximum (black) picture modulation level, at the radio transmitter input.

(k) The facsimile subcarrier transmission shall be conducted in the frequency range between 22 and 28 kilocycles. Should amplitude modulation of the subcarrier be employed the subcarrier frequency shall be 25 kilocycles with sidebands extending not more than 3 kilocycles in either direction from the subcarrier frequency. Should frequency modulation of the subcarrier be employed the total swing of the subcarrier shall be within the range from 22 to 28 kilocycles, with 22 kilocycles corresponding to white and 28 kilocycles corresponding to black on the transmitted copy. In multiplex operation the modulation of the FM carrier by the modulated subcarrier shall not exceed 5 per cent. In simplex operation the modulation of the FM carrier by the modulated subcarrier shall not exceed 30 per cent.

(l) During periods of multiplex facsimile transmission, frequency modulation of the FM carrier caused by the aural signals shall, in the frequency range from 20 to 30 kilocycles, be at least 60 db. below 100 per cent modulation. Frequency modulation of the FM carrier caused by the facsimile signals shall, in the frequency range from 50 to 15,000 cycles, be at least 60 db. below 100 per cent modulation.

§ 3.319 **Subsidiary communications multiplex operations: engineering standards.** The following standards apply to subsidiary communications multiplex operations under § § 3.293 to 3.295.

(a) Frequency modulation of subcarrier shall be used.

(b) The instantaneous frequency of the subcarriers shall at all times lie within the range 20 to 75 kilocycles.

(c) The arithmetic sum of the modulation of the main carrier by the subcarriers shall not exceed 30 per cent.

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

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

(e) Frequency modulation of the main carrier caused by the subcarrier operation shall, in the frequency range 50 to 15,000 cycles, be at least 60 db. below 100 per cent modulation.

§ 3.320 **Indicating instruments—specifications.** The following requirements and specifications shall apply to indicating instruments used by FM broadcast stations:

(a) Instruments indicating the plate current or plate voltage of the last radio stage (linear scale instruments) shall meet the following specifications:

(1) Length of scale shall be not less than 2 3/10 inches.

(2) Accuracy shall be at least 2 per cent of the full scale reading.

(3) Scale shall have at least 40 divisions.

(4) Full scale reading shall not be greater than five times the minimum normal indication.

(b) Instruments indicating transmission line current or voltage shall meet the following specifications:

(1) Instruments having linear scales shall meet the requirements of paragraph (a) (1), (2), (3), and (4) of this section.

(2) Instruments having logarithmic or square law scales:

(i) Shall meet the requirements of paragraph (a) (1) and (2) of this section for linear scale instruments.

(ii) Full scale reading shall not be greater than three times the minimum normal indication.

(iii) No scale division above one-third full scale reading shall be greater than one-thirtieth of the full scale reading.

(c) Radio frequency instruments having expanded scales:

(1) Shall meet the requirements of paragraph (a) (1), (2), and (4) of this section for linear scale instruments.

(2) No scale division above one-fifth full scale reading shall be greater than one-fiftieth of the full scale reading.

(3) The meter face shall be marked with the words "Expanded scale" or the abbreviation thereof (E. S.).

(d) No required instrument, the accuracy of which is questionable, shall be employed. Repairs and recalibration of instruments shall be made by the manufacturer, or by an authorized instrument repair service of the manufacturer, or by some other properly qualified and equipped instrument repair service. In any event the repaired instrument must be supplied with a certificate of calibration.

(e) Recording instruments may be employed in addition to the indicating instruments to record the transmission line current or voltage and the direct plate current and/or direct plate voltage of the last radio stage, provided that they do not affect the operation of the circuits or accuracy of the indicating instruments. If the records are to be used in any proceeding before the Commission as representative of operation, the accuracy must be the equivalent of the indicating instruments and the calibration shall be checked at such intervals as to insure the retention of the accuracy.

(f) The function of each instrument used in the equipment shall be clearly and permanently shown on the instrument itself or on the panel immediately adjacent thereto.

§ 3.321 **Auxiliary transmitters.** Auxiliary transmitters may not exceed the power rating or operating power range of the main transmitter, but need not conform to the performance characteristics specified by § 3.317 (a) (2) to (a) (5) inclusive. The subsequent portions of § 3.317 apply to auxiliary transmitters.

§ 3.330 **Frequency and modulation monitors at auxiliary transmitters.** (a) The following shall govern the installation of approved frequency and modulation monitors at auxiliary transmitters of FM broadcast stations in compliance with these rules:

(1) In case the auxiliary transmitter location is at a site different from that of the main transmitter, an approved frequency monitor shall be installed at the auxiliary transmitter except when the frequency of the auxiliary transmitter can be monitored by means of the frequency monitor at the main transmitter. When the auxiliary transmitter is operated without a frequency monitor under this exemption, it shall be monitored by means of the frequency monitor at the main transmitter.

(2) The licensee will be held strictly responsible for any center frequency deviation of the auxiliary transmitter in excess of 2,000 cycles from the assigned frequency, even though exempted by the above from installing an approved frequency monitor.

(3) Installation of an approved modulation monitor at the location of the auxiliary transmitter, when different from that of the main transmitter, is optional with the licensee. However, when it is necessary to operate the auxiliary transmitter beyond two calendar days, a modulation monitor shall be installed and operated at the auxiliary transmitter. The monitor (if taken from the main transmitter) shall be reinstalled at the main transmitter immediately upon resumption of operation of the main transmitter.

(4) In all cases where the auxiliary transmitter and the main transmitter have the same location, the same frequency and modulation monitors may be used for monitoring both transmitters, provided they are so arranged as to be readily switched from one transmitter to the other.

§ 3.331 **Requirements for type approval of frequency monitors — (a) General requirements.** (1) Any manufacturer desiring to submit a monitor for type approval shall supply the Commission with full specification details (two sworn copies) as well as the test data specified in paragraph (c) of this section. If this information appears to meet the requirements of the rules, shipping instructions will be issued to the manufacturer. The shipping charges to and from the Laboratory at Laurel, Maryland, shall be paid for by the manufacturer. Approval of a monitor will only be given on the basis of the data obtained from the sample monitor submitted to the Commission for test.

(2) In approving a monitor upon the basis of the tests conducted by the Laboratory, the Commission merely recognizes that the type of monitor has the inherent capability of functioning in compliance with the rules, if properly constructed, maintained, and operated. The Commission realizes that the frequency monitor may have limited range over which the visual indicator will determine deviations. Accordingly, it may be necessary that adjunct equipment be used to determine major deviations.

(3) Additional rules with respect to withdrawal of type approval, modification of type approval equipment and limitations of the findings upon which type approval is based are set forth in Part 2, Subpart F, of this chapter.

(b) **General specifications.** The general specifications that frequency monitors shall meet before they will be approved by the Commission are as follows:

(1) The unit shall have an accuracy of at least ±1000 cycles under ordinary conditions (temperature, humidity, power supply variations and other conditions which may affect its accuracy) encountered in FM broadcast stations throughout the United States, for any channel within the FM broadcast band.

(2) The range of the indicating device shall be at least from 2000 cycles below to 2000 cycles above the assigned center frequency.

(3) The scale of the indicating device shall be so calibrated as to be accurately read within at least 100 cycles.

(4) Means shall be provided for adjustment of the monitor indication to agree with an external standard.

(5) The monitor shall be capable of continuous operation and its circuit shall be such as to permit continuous monitoring of the transmitter center frequency.

(6) Operation of the monitor shall have no deleterious effect on the operation of the transmitter of the signal emitted therefrom.

(c) **Tests to be made for approval of FM broadcast frequency monitors.** The manufacturer of a monitor shall submit data on the following at the time of requesting approval:

(1) Constancy of oscillator frequency as measured several times in 1 month.

(2) Constancy of oscillator frequency when subjected to vibration tests which would correspond to the treatment received in shipping, handling and installing the instrument.

(3) Accuracy of readings of the frequency deviation instrument.

(4) Functioning of frequency adjustment device.

(5) Effects on frequency and readings, of the changing of tubes of voltage variations, and of variations of room temperature through a range not to exceed 10° to 40° C.

(6) Response of indicating instrument to small changes of frequency.

(7) General information on the effect of tilting or tipping or other tests to deter-

mine ability of equipment to withstand shipment.

(d) Various other tests may be made or required, such as effects of variation of input from the transmitter depending upon the character of the apparatus.

(e) Tests shall be conducted in such a manner as to approximate actual operating conditions as nearly as possible. The equipment under test shall be operated on any channel in the FM broadcast band.

§ 3.332 **Requirements for type approval of modulation monitors.** (a) Any manufacturer desiring to submit a monitor for type approval shall supply the Commission with full specification detail (two sworn copies) specified in paragraph (b) of this section. If this information appears to meet the requirements of the rules, shipping instructions will be issued to the manufacturer. The shipping charges to and from the Laboratory at Laurel, Maryland, shall be paid for by the manufacturer. Approval of a monitor will only be given on the basis of the data obtained from the sample monitor submitted to the Commission for test.

(1) In approving a monitor upon the basis of the tests conducted by the Laboratory, the Commission merely recognizes that the type of monitor has the inherent capability of functioning in compliance with the rules, if properly constructed, maintained and operated.

(2) Additional rules with respect to withdrawal of type approval, modification of type approval equipment and limitations on the findings upon which type approval is based are set forth in Part 2, Subpart F, of this chapter.

(b) The specifications that the modulation monitor shall meet before it will be approved by the Commission are as follows:

(1) A means for insuring that the transmitter input to the modulation monitor is proper.

(2) A modulation peak indicating device that can be set at any predetermined value from 50 to 120 per cent modulation (±75 kc swing is defined as 100 per cent modulation) and for either positive or negative swings (i.e., either above or below transmitter center frequency).

(3) A semi-peak indicator with a meter having the characteristics given below shall be used with a circuit such that peaks of modulation of duration between 40 and 90 milliseconds are indicated to 90 per cent of full value and the discharge rate adjusted so that the pointer returns from full reading to 10 per cent of zero within 500 to 800 milliseconds. A switch shall be provided so that this meter will read either positive or negative swings.

(i) The characteristics of the indicating meter are: **(a) Speed.** The time for one complete oscillation of the pointer shall be 290 to 350 milliseconds. The damping factor shall be between 16 and 200. **(b) Scale.** The meter scale shall be similar in appearance to that of a standard VU meter. The scale length between 0 and 100 per cent modulation markings should be at least 2.3 inches. In addition to other markings a small mark for 133 per cent modulation and designated as such should be included for the purpose of testing transmitters with 100 kc swing.

(4) The accuracy of reading of percentage of modulation shall be within ±5 per cent modulation percentage at any percentage of modulation up to 100 per cent modulation.

(5) The frequency characteristic curve shall not depart from a straight line more than ±½ db. from 50 to 15,000 cycles. Distortion shall be kept to a minimum.

(6) The monitor shall not absorb appreciable power from the transmitter.

(7) Operation of the monitor shall have no deleterious effect on the operation of the transmitter.

(8) General design, construction, and operation shall be in accordance with good engineering practice.

(c) The modulation monitor may be a part of the frequency monitor.

AMENDMENTS AND PROPOSED CHANGES OF REGULATIONS

Authorization of Class IV Stations For Power Increase

The Commission had not taken final action on applications proposing the use of a daytime power in excess of 250 watts by a Class IV station on a local channel until appropriate coordination of the rules providing for the use of such power had been effected with other North American countries. These countries have now agreed to the daytime operation of Class IV stations with several exceptions which are listed in the following amendment to Part 3 of the Regulations covering Radio Broadcast Services.

1. *Amend the text of the note following § 3.21(c) to read as follows:*

NOTE: The power ceiling for Class IV stations under the North American Regional Broadcasting Agreement (NARBA) is 250 watts. The Agreement between the United States of America and the United Mexican States Concerning Radio Broadcasting in the Standard Broadcast Band would permit daytime operation of Class IV stations with a maximum power of 1 kilowatt in all areas of the United States more than 100 kilometers (62 miles) from the United States/Mexican border. Pursuant to the U.S./Mexican Agreement and informal coordination with the other NARBA signatories, the Commission will consider applications proposing the use of daytime power in excess of 250 watts by a Class IV station providing such station is located more than 100 kilometers (62 miles) from the U.S./Mexican border, or, if located in the State of Florida, providing that such station is not located south of 28 degrees north latitude and between 80 and 82 degrees west longitude.

2. *Amend the text of the first paragraph of the note following § 3.28(b) to read as follows:*

NOTE: Pending action with respect to ratification and entry into force of the North American Regional Broadcasting Agreement, Washington, 1950 (referred to herein as NARBA), and the Agreement between the United States of America and the United Mexican States Concerning Radio Broadcasting in the Standard Broadcasting Band (referred to herein as the U.S./Mexican Agreement) no assignment for a standard broadcast station will be made which would be inconsistent with the terms of these agreements, except for the power ceiling permitted for Class IV stations on local channels, pursuant to § 3.21 (c).

Use of Television Test Signals

A rule making proceeding is outstanding for the purpose of considering the adoption of a standard test signal to be transmitted by television broadcast stations. The time for filing comments in this proceeding has expired.

When the Commission released its Notice of Proposed Rule Making in the proceeding referred to above, it issued a Public Notice on April 4, 1957, pointing out that it would be helpful if during the course of the proceeding television stations were authorized, without further specific authority, to transmit test signals during programming. The Commission noted that such test transmissions could be employed for the purpose of developing and testing the feasibility of the particular method used and would be helpful in the preparation of comments and data in the rule making proceeding.

Station licensees were cautioned, however, that the specifications of any test signal which may be adopted would be determined after the completion of the rule making proceeding, and that equipment employed under the test authorization may become obsolete as a result of the specifications finally adopted. The Commission provided, further, that the transmission of test signals during program transmissions shall not interfere with synchronization nor significantly degrade the picture reception.

Pending a final decision, television broadcast stations are authorized to continue to conduct test transmissions in accordance with the Public Notice of April 4, 1957, for the period ending October 3, 1959. Stations originating test signals pursuant to this authorization are requested to notify the Commission.

TV Repeater Operation In VHF Band

Recommendation of Amendment to Communications Act to Permit Licensing Use of Television Test Signals

The Federal Communications Commission is recommending that Congress amend the Communications Act to permit it to license qualifying TV "repeater" stations in the VHF band under certain conditions and, if that is done, to allow up to one year of time for existing "booster" and "repeater" operations to conform with certain requirements necessary to prevent interference to other broadcast and nonbroadcast services.

Pending Congress's consideration of this recommendation, the Commission is extending from June 20 to September 30 the general period of grace for such operations.

Specifically, the Commission seeks amendment of section 319 (d) to enable it to consider licensing such stations engaged solely in rebroadcasting TV programs if they were constructed on or before January 1, 1959; also amendment of section 318 to clarify the statutory requirements concerning radio operators of equipment used for this purpose.

The Commission's study of the interference problem posed by the use of repeaters in the VHF band indicates potential interference to other VHF repeaters, to the reception of programs of regular VHF television stations, to FM broadcast, and to nonbroadcast services, such as public safety (police and forestry) services using frequencies between TV Channels 4 and 5, and to the operation of the aerial navigation services employing radio fan markers on 75 Mc, also between Channels 4 and 5.

Taking all of these considerations into account, the Commission believes that the following minimum requirements should be imposed upon the operation of VHF repeaters:

Transmission of the rebroadcasting signals on a channel other than the channel on which the signal is received.

Maximum power output limited to no more than 1 watt.

Facilities for on and off remote control.

The designation of a person responsible for required periodic checks and other related functions.

The selection of transmitting frequency, appropriate minimum mileage separation from co-channel transmitters of regular television broadcast stations (still to be determined) and such other operating conditions as may be needed to insure reasonable protection to regular broadcast and nonbroadcast services.

Require repeaters to obtain consent of stations whose signals they rebroadcast, pursuant to Section 325 (a) of the Act.

Further, the Commission feels that in order to minimize any possible hazard to aerial navigation it is desirable to take early steps toward the elimination of the operations on Channels 4 and 5 of VHF repeaters or boosters which retransmit on the same channel as the incoming signal. The object would be to eliminate the possibility of such a VHF repeater receiving, amplifying and transmitting signals of aerial fan markers operating on 75 Mc, with the possible result that an aircraft pilot might be misled as to his true position. While the possibilities of this occurring appear relatively remote, and while it would require a combination of circumstances in addition to the retransmission of the fan marker signal to create a serious hazard, the Commission believes that the earliest possible elimination from Channels 4 and 5 of VHF repeaters which transmit on the incoming frequency is highly desirable.

In numerous small communities and outlying areas beyond the direct range of TV broadcast stations, TV programs are made available to local residents by means of small low-powered repeating devices. Located at favorable reception points on hills and mountains, they pick up TV signals from distant stations, amplify and retransmit them to nearby home receivers which are unable to obtain satisfactory direct reception.

Hitherto, cognizant of the potential interference of such operation, the Commission has confined the authorization of repeater devices to "translators" operating in the UHF band. UHF translators offer several distinct advantages, both as to the limitation of interference and as to the range of useful service of good grade.

Prior to and during lengthy Commission proceedings devoted to a study of conditions under which it might be desirable to authorize repeaters in the VHF band, numerous VHF boosters and repeaters have been installed, without FCC authorization. The Commission has direct knowledge of over 300, and it has been estimated that the total number is substantially greater. In December 1958 the Commission announced the conclusion, to which it had come at that time, that the advantages of UHF translators so outweighed the considerations favoring the authorization of VHF repeaters that it would be in the public interest to confine repeaters to the UHF band.

Since that time, however, the Commission has had the matter under continuing review, and has received additional field data which indicate that, under certain conditions, VHF repeater operation may be conducted with less actual interference than had previously been calculated. Aware of the useful purpose served by these devices, and taking into account the investments made in those which have been installed, the Commission is now of the opinion that, if the Communications Act is appropriately amended, VHF repeaters could be licensed under conditions which will insure due protection to other users of the radio spectrum including aerial navigation services.

The present language of section 319 prohibits the Commission from licensing broadcast facilities which were constructed without a prior permit from the Commission. Section 318 now requires practically all radio transmitters to be operated by licensed operators.

MOBILE VIDEOTAPE

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3. Audio chain controls and remote control for the recorder are on a recessed panel directly in front of the operator. At his left is the power panel with circuit breakers and the metering for voltage, current and frequency of the power source, either internal or external.

4. Audio, video and video waveform monitors are directly above the camera chains. Off-the-air facilities are at the operator's lower left, with a mobile telephone near at hand on the right.

The cruiser has a door amply wide for equipment, cameras and perhaps scenery. It opens toward the rear of the right side, located between the Videotape television recorder and the camera control.

Cable storage is under the floor in compartments which are both water and dust-proof.

The roof area is covered with "diamond plate," enabling two complete camera crews to operate at one time. Camera tripod holddown rings, cable and lighting power outlets, a guard rail and ladders are all integral with the rooftop installation. A hydraulic camera hoist is located at the rear of the top deck.

The 10 kw, auxiliary power supply has special muffling to prevent noise interference. In several months of operation, there has been no trace of ignition interference with the recorder, the two engineers reported.

The bus, they said, can serve as a small on-the-spot studio. Of the more than 400 recording hours chalked up by the unit to date, more than 70 per cent was on auxiliary power and about 40 per cent of that time was logged while the vehicle was in motion.

TECHNICAL HINTS

SEND US YOUR CONTRIBUTIONS. FIVE DOLLARS WILL BE PAID FOR ALL SUGGESTIONS WHICH ARE PUBLISHED

Rotate Pickup Heads To Prolong Life

Stations using the higher priced transcription pickup heads might want to consider rotating them rather than keeping new, or factory repaired heads on a "spare" basis. Keeping the heads on a spare status has a deteriorating effect upon the rubber dampers support, causing them to dry out. When this happens, the stylus will wobble during operation and either fracture the solder joint or etch the record. Factory tests show that utilizing all of the pickup heads on a rotating basis will increase their life considerably.

I. A. Elliot,
Manager
KATL,
Miles City, Mont.

Modification Simplifies Monitoring of Remote Lines

Monitoring remote lines with the Collins 212-B Broadcast Console can be made more convenient by connecting the jack J-801 across the input to T-801. Thus, any line can be monitored on headphones in the program monitor jack without cutting out the monitor speakers by simply pushing the desired remote line button.

George W. Morrison,
Chief Engineer
KPLK,
Dallas, Ore.

How to Locate Temperature Sensitive Components

In the design and fabrication of equipment I have often come across the problem of locating temperature sensitive components which are particularly critical in such circuits as oscillators, multivibrators, etc. To assist in locating these components, determining the effect of temperature and arriving at compensation, I find that by wrapping a length of 3/16-inch diameter copper tubing around the barrel of a soldering iron and forcing air through the tubing, a jet of hot air results which can be directed toward a given area. This hot air blast can be applied to a single component or group of components to permit temperature compensation adjustments. Copper nozzles also can be fitted to the end of the tubing to shape the jet stream.

John W. Doering,
President
Telecontrol Corp.,
Hawthorne, Calif.

Servicing Tips for Turntable

The Gates CB-11 turntable was originally designed for two-speed operation. With the advent of 45 RPM records, the manufacturer offered a simple modification kit for these tables to convert them to three-speed operation. Here are some tips in servicing the turntables. In adjusting the yoke assembly, it is important that the microswitch which turns on the motor is actuated before the idler engages the motor shaft. If bearing trouble develops, they may be replaced for a fraction of the cost of a new motor. A small-motor shop can insert new bearings. If the motor does not have a thrust bearing on the dead end of the armature, a thrust bearing assembly may be obtained from a small motor repair shop such as the ones maintained by the Apparatus Division of the General Electric Co. In installing this assembly it is necessary to drill a hole in the base mounting plate in order to allow the thrust adjusting screw to extend about an inch below the motor. This hole must be large enough to allow freedom of movement. My experience indicates that oiling the motor several times a month instead of the recommended three-month schedule may prolong the life of the motor bearings. If the motor mounts deteriorate, new ones can often be obtained inexpensively from government surplus dealers.

Stu Underwood,
Chief Engineer
KDKD,
Clinton, Mo.

INDUSTRY NEWS

Governor Mark Hatfield of Oregon throws the switch at KPLK in Dallas, Ore., changing over from 500 watts to 1,000 watts on KPLK's 4th Anniversary. The Collins 550 A- Transmitter had been previously converted to a 20V-2 and operated at half power. The Governor is turning power switch to full power. (L. to R. are Gov. Mark Hatfield, Station Manager Ray Kozak, Gerry Frank, manager of Meier & Franks Store in Salem and seated is the chief engineer, George W. Morrison.)

Visual Electronics' Contest Winner: $pot $aver

$POT SAVER was the winning name in the contest held recently by Visual Electronics Corp. to choose a name for their new program automation system, James B. Tharpe, president, has announced.

$POT $AVER was selected on the basis that it seemed the best descriptive name highlighting one of the most important features of the Program Automation System.

The contest prize, a Conrac Fleetwood Model 900 Remote Receiver, featuring a very thin design for custom installation where space is at a premium, was awarded to Morris C. Barton, Jr., chief engineer, at KSLA-TV, Shreveport, La.

EMIL KOHLER

The Daven Co., Livingston, N. J., announces the appointment of Emil Kohler, electronics engineer, to its design and development staff. Mr. Kohler will be project engineer, in charge of development on transistorized power supplies and various other transistorized power equipment.

Lee Named President of General Precision Laboratory

Tull and Hilliard in New Posts

Richard W. Lee has been elected president of General Precision Laboratory Inc., Pleasantville, N. Y., it was announced by James W. Murray, chairman and chief executive officer of GPL's parent company, General Precision Equipment Corp. Mr. Lee, who succeeds Mr. Murray as GPL president, was also named to the subsidiary's board of directors.

In other GPL management changes announced at the same time, William P. Hilliard becomes vice-president and general manager, and William J. Tull becomes vice-president, avionic engineering and sales.

In connection with their new duties, Messrs. Tull and Hilliard were also elected to the GPL board.

WILLIAM A. FINK

ORRadio Industries, Inc. has named William A. Fink as sales manager, professional products. The announcement was made by Nat Welch, vice-president for sales. Mr. Fink was formerly associated with the Ampex Corp. as district sales manager, Professional Products Division.

His affiliation with professional societies includes membership in the Sales Research Institute, Audio Engineering Society, American Institute of Electrical Engineers, Society of Motion Picture and Television Engineers.

UHF Translator Installation

Three Adler translators installed by Industrial Television Co., bring ABC, CBS and NBC programming to the Navajo Tribe at Window Rock, Ariz.

Voice of America Orders Six 50 KW Transmitters

Six 50 KW short wave broadcast transmitters, manufactured by the Gates Radio Corp., have been ordered by the United States Information Agency for use by the Voice of America. These transmitters will be installed at the new high-powered East Coast facilities of the Voice of America which will be constructed in North Carolina during the next two years. When completed, these facilities will increase VOA's broadcast signals beamed behind the Iron Curtain and improve reception at its overseas relay point.

Gates, a subsidiary of the Harris-Intertype Corp., reports that the 50 KW transmitters are capable of quick change frequency over the range of from 4 to 30 MC.

The USIA has called on Gates in recent years to construct the special broadcast and recording equipment for the Washington studios of the Voice of America. This included 16 studio control consoles, 60 wall mounted control cabinets, 71 equipment racks, 74 switching racks, two large switching consoles and a sizeable amount of accessory equipment.

BOB LAKIN

MAYOR ED JOCHUMSEN

Tape Storage For One Hundred Years

On March 21 the city of Waterloo dedicated its new $800,000 city hall, which is under construction at East 5th and Mulberry streets. As part of the cornerstone-laying ceremony, Mayor Ed Jochumsen placed a number of items representative of 1959 in a copper box designed to be opened by future city administrators at the centennial anniversary of the building.

Radio station KXEL—in addition to contributing technical data—included a tape recording of excerpts from present programming.

The location of the "time box" just inside the outer wall of the building was their main concern in selecting a tape for this recording purpose. "It was essential to use the most weather-resistant tape available, one that would withstand Iowa's 110-degree summers and 20-below winters," according to Bob Lakin of KXEL. The recording was made at 7½ ips full track on KXEL's professional recording equipment, using "Scotch" brand 150 magnetic recording tape.

"We didn't need the extra-long feature of the tape, since the recording plays only half-an-hour," Lakin points out. "But it was necessary to use a tape that would resist extreme changes in temperature and humidity."

The recording features a narrative outlining the station's program policies, with radio personalities introducing each excerpt from current radio shows. The six announcers recorded typical news items occurring that day, a resume of the current hit parade, and a roundup of the most important farm news of 1959.

After the recording session at the studio, the tape was sealed in a plastic bag and encased in an aluminum tape storage can. The can was tightly sealed with "Scotch" brand masking tape to prevent dust or moisture from reaching the recording.

Elaborate instructions also were included in the can to assure the tape is handled properly when—a century from now—it is replayed. Some of the instructions, designed for persons who might never have played tape before:

- This tape has been stored for 100 years. Don't try to play it without reading these instructions carefully.
- Keep tape away from anything magnetic.
- In 100 years of storage, the tape may have a tendency to stick together. To loosen, wind the tape forward onto another reel, then wind it back.
- On second rewind, be sure to wind tape tightly so it will play back satisfactorily. (This tape has been wound loosely on the reel to keep down "print through" characteristics).
- Tape must be played with the oxide coating in to the playback head.

The reason for including these basic, detailed instructions, Lakin explains, is that 100 years may make such a technological change in our way of living that tape recording might be a thing of the past.

"We even considered including a tape recorder with our contribution to the cornerstone time box to make sure 21st Century Iowans know what the magnetic tape is for," Lakin adds, "Who knows what recording methods they'll have in 2059?"

PRODUCT NEWS

MODELS 652 and 653 MICROPHONES
Electro-Voice, Inc.
Buchanan, Mich.

A unique new design microphone which is mounted on the end of a semi-rigid tube, bringing the moving coil element closer to the user. Breath and wind filter is an integral part of the microphone. Two clear plastic baffles are provided to give either a 6 db or 3 db boost in the brilliance range of 600 cycles. Without the baffles the response is 50 to 12,000 cycles. The Model 653 includes an adjustable desk stand as an integral part of the microphone. The Model 652 weighs 11 oz. The Model 653 is 1 lb. 6 oz.

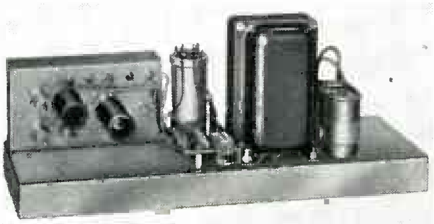
RAPID SPRAY FILM PROCESSOR
Houston-Fearless Corp.
11851 W. Olympic Blvd.,
Los Angeles 64, Calif.

16mm. or 35mm. black and white positive motion picture film can be processed at speeds up to 150 feet per minute by a new automatic Rapid Spray Film Processor. Negative film is processed up to 100 f.p.m. Complete processing time for positive film is as short as five minutes from dry to dry.

The fast processing time is made possible by high impingement spray application of the developing solution, fix and wash, utilizing new, improved spray bars which assure uniform results. Impingement drying is also employed.

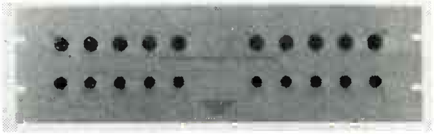
SP 58-1A SYMMETRA-PEAK
Kahn Research Laboratories, Inc.
22 Pine St., Freeport, L. I., N. Y.

The Model SP 58-1A Symmetra-peak is being widely used by AM, FM and TV stations to increase their voice coverage range because it equally distributes unequal positive or negative peak energy contained in voice waves. Thus, non-symmetry resulting from certain voice characteristics, improperly phased microphones or switching between local and network voice program sources is eliminated. With peak energy lowered, average audio level can be increased, permitting modulation to be raised by as much as 4 db. A symmetrical input also provides better over-all performance of limiters and AGC amplifiers. No power source is needed and there is nothing to wear out or replace in normal service.



VHF LOW NOISE AMPLIFIER
Adler Electronics, Inc.
One LeFevre Lane, New Rochelle, N. Y.

The Type VCA-1 Amplifier provides a minimum gain of 40 db on any VHF TV channel in the 54-88 mc frequency range. At channel 6, the noise figure is 3 db. The amplifier also features 10,000 hour tubes for reliability and remote crystal-control monitoring. Housed in a waterproof enclosure, this compact 12-lb. unit may be either pole, rack or chassis mounted. Complete descriptive literature is available from Adler Electronics.



RF 540-550 PUSH BUTTON ATTENUATOR
Daven Co.
Livingston, N. J.

A new variation of the RF 540 and 550 Push Button Attenuator. As a Spec 7130 Network, dial lights are installed which indicate the total attenuation in decibels when one or more of the dial buttons are depressed.

Any of the standard Daven RF 540 or 550 series can be modified to incorporate this dial light arrangement.

The dial lights will operate from an external six volt source. The unit is mounted on a standard 19-inch rack panel.

All these units have a flat frequency response from DC to 225 megacycles. All are available for a total of either 120 DB in steps of 2 DB or 100 DB in steps of 1 DB, using standard Daven RF 540 and RF 550 attenuators.

STELLAVOX TYPE SM 4
Electronic Applications, Inc.
194 Richmond Hill Ave., Stamford, Conn.

A $3\frac{1}{2}$-lb. transistorized professional pocket tape recorder. The recorder operates at $7\frac{1}{2}$ ips and includes a volume level indicator. Battery power supply consists of four rechargeable miniature cells. The unit meets NAB specifications. A low impedance microphone input and monitor loudspeaker are included. The size is $2\frac{3}{8}$ X $4\frac{7}{8}$ X $10\frac{1}{4}$ inches. Recording time is 20 minutes.

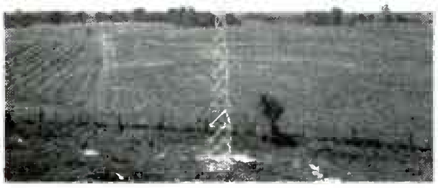
L59B/8-INCH PORTABLE MONITOR
Miratel, Inc.
1080 Dionne St., St. Paul, Minn.

A new portable professional television monitor, giving 600 line resolution and stable sync circuitry. The video input is high impedance looping for signal levels of .3 to 1.5 volts for full contrast. The unit is enclosed is a gray hammer-tone metal cabinet. The unit is $9\frac{3}{4}$ inches high, $12\frac{3}{4}$ inches wide and 16 inches deep and weighs 32 lb.

WRITE

Manufacturers for further Information

Please Mention
BROADCAST ENGINEERING

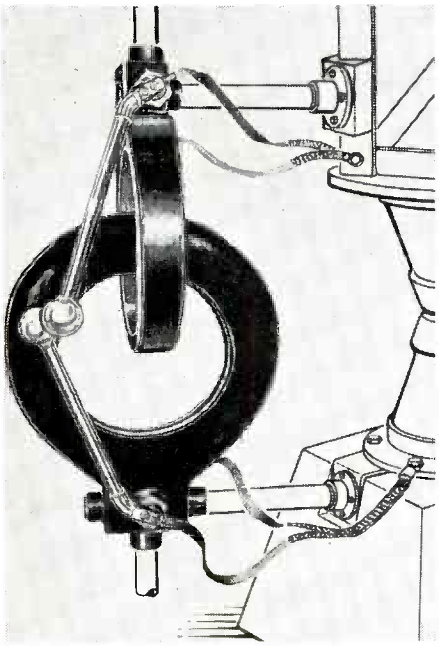


NO. 50 HEAVY-DUTY COMMUNICATION TOWER

Rohn Mfg. Co.

116 Limestone, Bellevue, Peoria, Ill.

An extremely heavy-duty communications tower utilizes the No. 5 section of the Rohn "Self-Supporting" tower and can provide outstanding rigidity and strength in heights up to 450 feet when properly guyed. Its rugged strength lends the No. 50 Tower to a wide range of communication uses including the mounting of antennas for micro-wave, radio communications, broadcasting, and amateur uses.

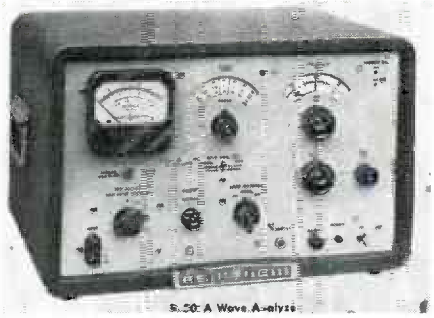


TOWER LIGHTING ISOLATION TRANSFORMER

Hughey & Phillips, Inc.

3200 N. San Fernando Rd., Burbank, Calif.

A new isolation transformer is available in three load capacities: 750, 1,750 and 3,500 watts. The transformers provide higher efficiency, improved regulation, additional tapes and epoxy encasement. Write for bulletin HPS-152.



302A WAVE ANALYZER

Hewlett-Packard Co.

275 Page Mill Road, Palo Alto, Calif.

A new, completely transistorized wave analyzer operating from 20 cps to 50 kc. The instrument separates an input signal into its individual components so that the fundamental, harmonics and intermodulation products may be separately measured and evaluated. It may also be used as a narrow-band tuned voltmeter which will read absolute or relative levels.

TYPE 1650-A IMPEDANCE BRIDGE

General Radio Co.

West Concord, Massachusetts

A new design replaces the 650A Bridge and improves on most of the electrical specifications as well as providing new mechanical features.

TRANS MAGNEMITE

Amplifier Corp. of America

398 Broadway, New York 13, N. Y.

A professional transistorized battery-operated, spring-motor portable tape recorder. Rewinds 900 feet of tape in approximately one and three quarter minutes. Exceeds NARTB standards.

NEW AMPEX 1000B VIDEOTAPE

The developments incorporated in the new videotape model include improved picture quality, three innovations for simplified production of recorded tapes and seven innovations for simplified maintenance.

The new model is completely compatible with the present VR-1000 recorder. Tapes will be interchangeable between the VR-1000 and the VR-1000B.

Improved picture quality has been accomplished through new developments and the process of tightening production quality control of both mechanical and electronic components. The VR-1000B has a guaranteed signal-to-noise ratio of 36 db. The present guarantee on the VR-1000 is 30 db. The higher signal-to-noise ratio means better picture definition and the elimination of graininess or "snow" visible to the eye at lower signal-to-noise ratios.

The Model VR-1000B's three completely new features for efficient and simplified production of recorded tapes are as follows:

1. Faster tape start, which brings the tape to full operating speed in two seconds as compared with five seconds in the current model. This is a valuable aid to better "on-air" program cueing as well as in production work.

2. Automatic brake release, a feature permitting the operator to pull the tape easily from the supply and take-up reels for quick threading and splicing operations.

3. Tape playback speed control, which provides smooth momentary speedup or slow-down of tape speed to permit two Ampex recorders to be lip-synchronized or to synchronize a VR-1000B with an external audio recorder.

Seven innovations in design of the VR-1000B simplify maintenance and set-up procedures by relocating controls and providing quick-check metering and monitoring of all functions. These design features were listed as follows:

1. *Head life indicator.* A calibrated ring around the "Tip Projection" control knob on the left control panel indicates the remaining operating life of the video head assembly.

2. *High power tube metering.* Operator can check condition of all high power tubes by means of direct metering to 38 points. This is an important safeguard against abrupt interruption of service because he can immediately detect any deterioration in any of these critical tubes.

3. *Accessible controls.* Controls used by operator in routine operating adjustments are easily reached through the front panels of the console itself.

4. *Improved switcher and demodulator design.* Controls on the switcher have been minimized. Demodulator design improvement has eliminated need for low-pass filter with its associated controls. It is now far easier to set up recorder to standard operating performance. Improved transient response on playback of tapes is provided.

5. *Protective circuits.* Each electronics chassis is equipped with its own protective circuit. A white light indicates to operator the location of any trouble.

6. *Adjustment "memory."* A special pointer behind each control knob provides a fixed indication of the original dial setting during subsequent adjustment.

7. **Component accessibility.** Swing-out harness provides instant access to all components in the racks without interruption of service. The console, mounted on wheels, rolls out from the wall to provide access to all components through the rear door.

Basic appearance of the VR-1000B is unchanged from the current model.

CLASSIFIED

Advertising rates in the Classified Section are ten cents per word. Minimum charge is $2.00. Blind box number is 50 cents extra. Check or money order must be enclosed with ad.

EQUIPMENT WANTED

500 Watt AM Transmitter wanted for auxiliary rig. Must be in good shape. Contact Joseph Brandt, KRUX, Sahara Hotel, Phoenix, Ariz.

Two or three RCA 44BX microphones. Please give condition and price first letter. D. H. Elliott, Chief Engineer, KINS, Box 1015, Eureka, Calif.

Used AM modulation monitor. Don M. Lidenton, 701 Popular Street, Poplar Bluff, Mo.

Robinson turntables, Western Electric consoles, Pentron tape recorders, WE 639 microphones, modulation monitor, frequency monitor, other equipment. WCCM, 9 Valley Street, Lawrence, Mass.

EQUIPMENT FOR SALE

Two Magnemite battery-operated spring wound tape recorders at 50% of original cost. Excellent condition. Keith LeMay, KSEW, Sitka, Alaska.

Going 5 Kw Gates BC-1J XMTR, No. 44 ant. coupler. Best offer over $3,500. Contact Mel Stone, WLOB, Portland, Maine.

Transformers, condensers, chokes, coils, resistors, meters, etc. State your needs. Chief Engineer, WFRL, Freeport, Ill.

WE9A pickups and arms with equalizers, also RME pickups, arms and equalizers. What will you offer? Phil Whitney, 200 Shawnee Avenue, Winchester, Va.

One new Bailey Type B C 46 T crystal oven with thermometer and Xtal for trade or sale. WNCA, Silver City, N. C.

Two tape recorders. Robert Model 90, $150, and Bell Cubcorder (battery operated), $125. Both like new. WCMC, Wildwood, N. J.

PERSONNEL

Wise station managers and chief engineers insist on RERB registration of all new personnel. RERB investigation before hiring reduces hiring hazards. Radio-TV Employee Reference Bureau, P. O. Box 333, Tacoma, Wash.