MAY, 1961

BROADCAST ENGINEERING®

THE TECHNICAL JOURNAL OF THE BROADCAST INDUSTRY

In this issue . . .

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All Modular
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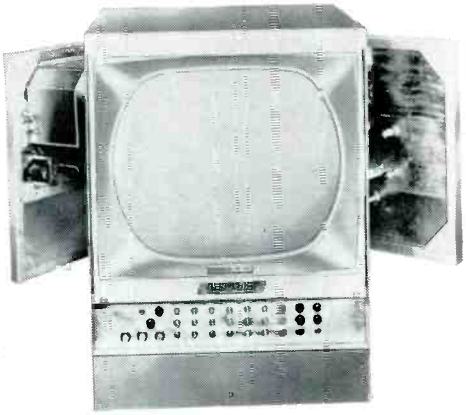
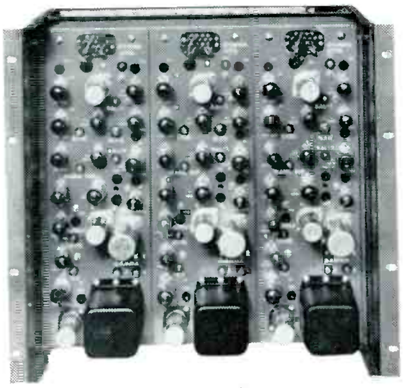
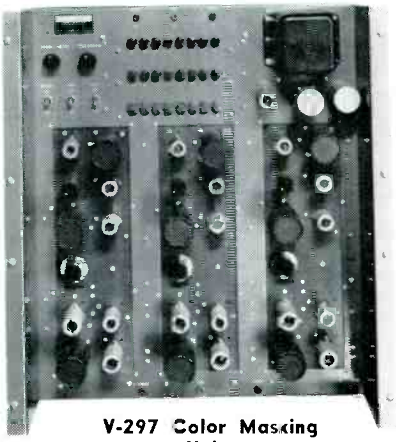




V-225 Color Gamma Correctors

V-229 Color Matrix Delay



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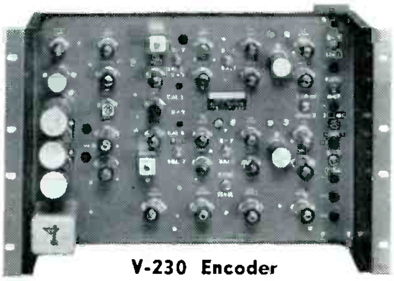

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V-8 Color Sub-Carrier Generator

V-516 Automatic Level Control

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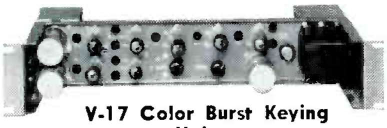

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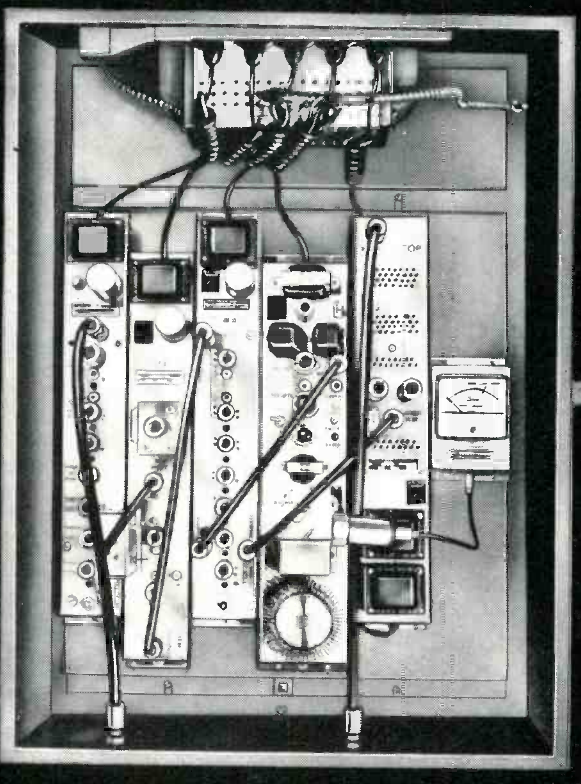
[VHF & UHF MODELS]



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MODEL T-1—VHF TRANSLATOR—FCC type accepted 1 Watt output. For United States use.

FOOLPROOF AUTOMATIC SHUT-OFF — When the master station goes off the air, this device turns off the translator transmitter. Ordinary shut-off systems work on the over all signal level. In weak signal areas, where a number of amplifiers must be used, noise generated in the amplifiers can be mistaken for the received signal. If this happens, the translator transmits noise, even though the master station is off the air.

The Benco Automatic Shut-Off can differentiate between noise and signal. It cuts off the transmitter any time the 4.5 MC beat between the sound and picture carriers is missing.

MINIMIZES "FALSE SHUT OFFS" DUE TO SIGNAL FADING —The T-1 will not shut off unless the received signal from the master station stays below 10 microvolts for longer than 4 seconds.

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QUICK EASY CODING OF INDENTIFICATION UNIT—The appropriate call letters for your area can be set up rapidly —no need to cut copper contacts.

SPECIFICATIONS FOR MODEL T-1

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Power Consumption	150W
Temperature Ambient	−30°C to +50°C
Max. Permissible Power	1 Watt
Overall Noise Figure:	
Low Band	4 db ±1 db
High Band	6 db ±1 db
Frequency Stability	.02%
Gain: (Maximum)	135 db
Dimensions of Housing	35" x 28" x 10½"
Weight	130 lbs.

MODEL T-5 VHF TRANSLATOR—8.9 Watts output. For use in Canada. Regulated power supply. Full size underrated output tube. Weatherproof housing. Type approval from Canadian Dept. of Transport.

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MODEL T-11 AND MODEL T-12 VHF TO UHF TRANSLATORS —3.5 Watts output. For Canadian use. Model T-11, VHF input, channels 7-13; Model T-12—VHF input, channels 2-6. *Features:* Automatic shut-off • remote 'on' and 'off' control facilities • weatherproof housing • type approval from Canadian Dept. of Transport.

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BROADCAST ENGINEERING

THE TECHNICAL JOURNAL OF THE BROADCAST INDUSTRY ®

VOLUME 3 MAY, 1961 NUMBER 5

Contents

Departments

Cover

The Engineering Achievement Award was presented to Raymond F. Guy, a retired NBC senior staff engineer, in recognition of his outstanding technical contributions to broadcasting for well over 40 years. The plaque was dedicated, as a highlight during the 15th Annual Engineering Conference, by A. Prose Walker, manager of NAB's engineering department, at a special luncheon in Washington, D. C., May 10.

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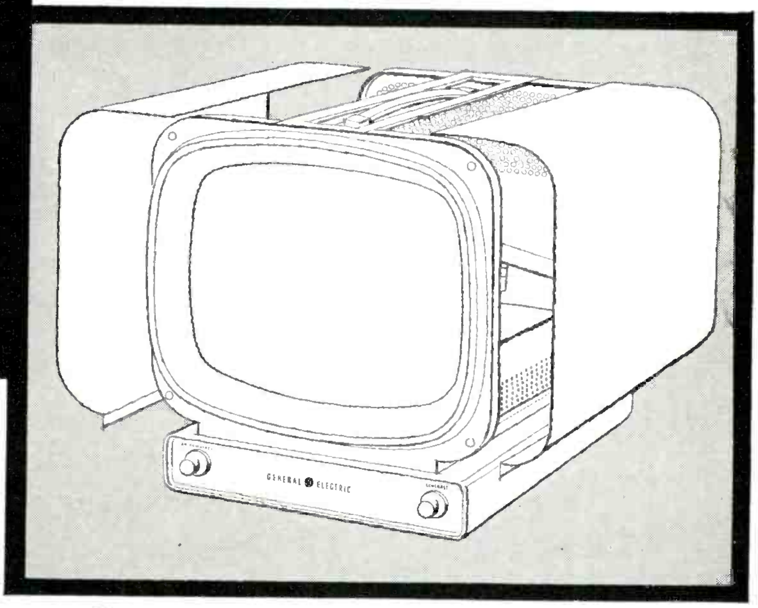
New General Electric Monitors

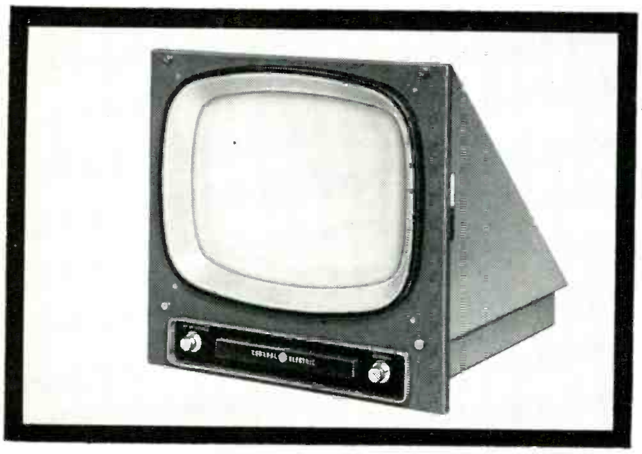
HIGH RESOLUTION AND BRIGHTNESS—STABLE —LOW MAINTENANCE

Cabinet Monitors available in 14, 17 and 21 inch screen sizes using the same chassis for each. Excellent low frequency response gives uniform picture backgrounds with no smear. There are no interactions between controls. Size, focus and linearity controls are operated individually and adjustment of one has no effect on the others.

High picture brightness is achieved without blooming. Picture tube voltage of 20 Kv combined with good regulation provides highest brightness while maintaining 800 line resolution. A polarized safety glass faceplate (optional) minimizes reflections in strongly lighted areas and improves picture contrast ratio.



Quick set up and servicing. No major disassembly is required for any normal servicing. Each side panel on cabinet models is held with just two screws, exposing the chassis. As a result, you can adjust the set and look squarely at the tube at the same time. The picture tube is inserted or removed from the front. Four screws release the faceplate for cleaning.



Rack mounted models are available in 14, 17 and 21 inch sizes. Image stability is excellent. Sharp focus with no focus drift is attained through the use of a low voltage electrostatic focus type picture tube. The wide band video amplifier (10 Mc ± 1 db) produces sharp, clear pictures. Picture interference from ground currents is eliminated.

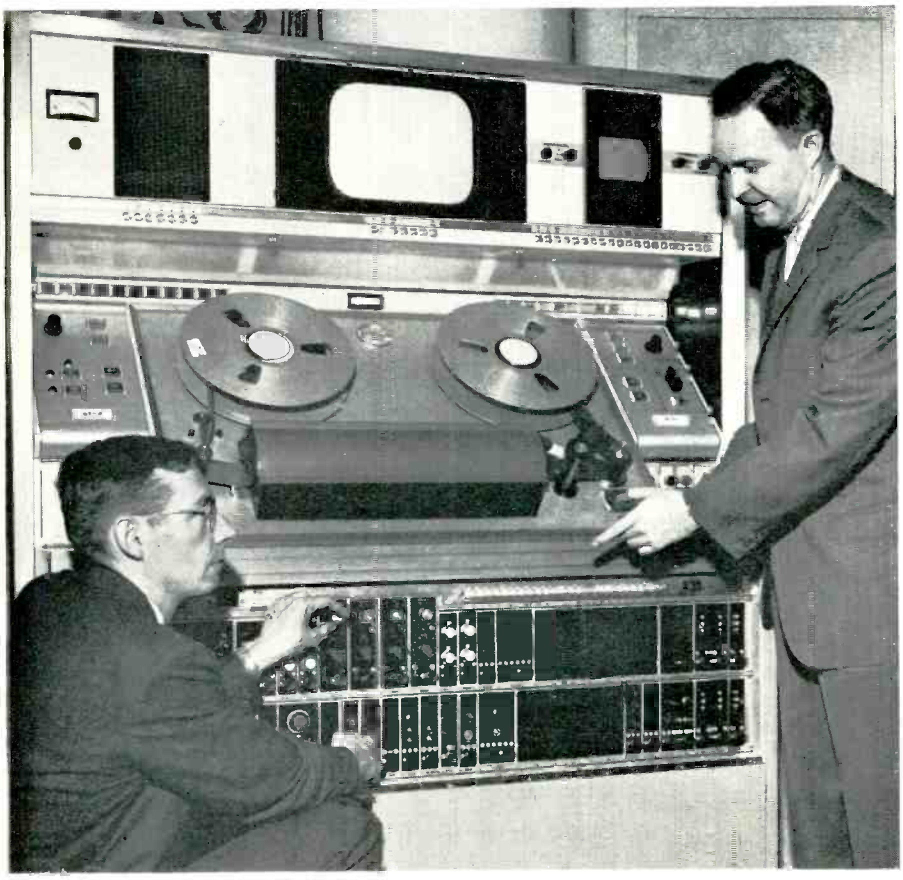
Differential gain of the video amplifier is less than 5 percent on a 50 percent white, 50 percent black picture. Geometric distortion is less than ± 2 percent.

For complete data on these new monitors — and the full line of G-E transistorized audio equipment and other broadcasting and telecasting equipment — write to Section 4951, Technical Products Operation, General Electric Company, Lynchburg, Va.

GENERAL ELECTRIC

focus

Stereo, Style and Transistors Highlight '61 NAB Show



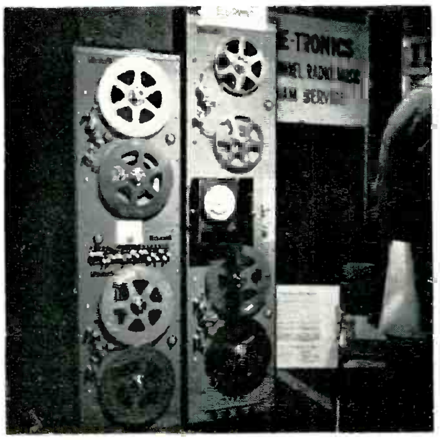
Recent style changes introduced by ITA Electronics, Collins Radio, in transmitter design, and RCA TV tape recorder.

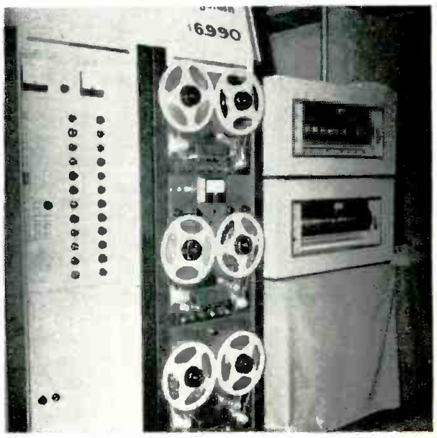
A GIANT display of the latest in equipment valued at more than $3 million was shown to broadcasters at the 39 annual convention of the National Assn. of Broadcasters held in the nation's capital May 7-10, 1961.

Sprinkled liberally throughout the Shoreham Hotel's main ballroom and exhibition hall, in an atmosphere of orderly chaos, were innovations in radio and television equipment from items as small as a phonograph needle to a 200-ton transmitting tower.

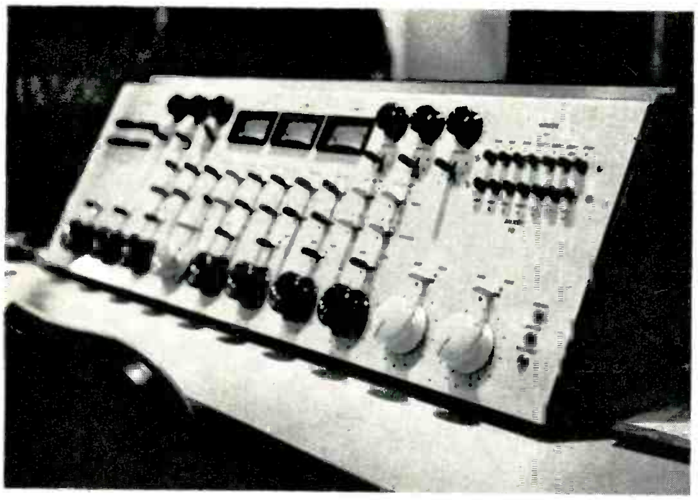
As expected, equipment is becoming more sophisticated in basic design and style. The new electronic design of component mounting is changing from the standard chassis, hand-wired units, to printed circuit or terminal board modules. The broadcast engineer is seeing the evolution of rack-mounted equipment to plug-in replaceable subassemblies.

Transistors are becoming a common word in new equipment. There is no discrimination—AM, FM, TV, and audio gear now employ these miniature units. Heat reduction, small size, less power requirements, and maintenance-free de-





Radio program syndication firms and associated automatic playing devices number many this year.



RCA (right), ITA (left) and Gates offered stereophonic audio consoles for the first time.

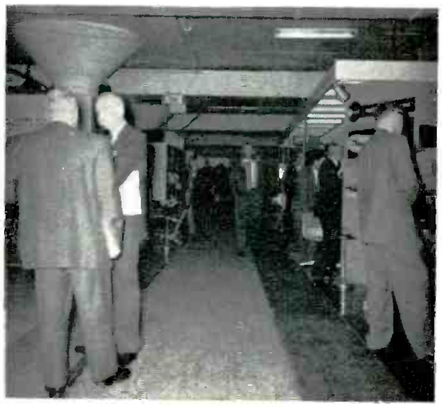
sign lend the use of the solid state devices to today's broadcast systems.

The long needed change in styling of outside covers, cabinets, and cases was definitely evident. What seems as radical thinking in new styling is just a fresh breath of air blowing over the past dingy, dreary designs. A few equipment firms unveiled their electronics wrapped in multicolored, futuristic-designed cloaks that would remind you of today's consumer appliances. Control meters, pilot indicator lamps, switches and dials are being blended together with a psychological intent to contrast the bright color enamel and aluminum panels. Most of this effect is being applied, at the moment, to AM-FM transmitters, video tape recorders, and a remote amplifier.

Automation and program suppliers impressed onlookers with many displays of rack-mounted tape machines, switches, cartridge tape decks and time clocks. Aiming to the FM and multi-station AM broadcaster these exhibitors were telling the virtues of lower operation costs and exclusive station franchise. Automatic billing and logging devices for TV operation calculated, sorted, correlated, and printed program logs right before your eyes.

Stereophonic FM broadcasting was on the lips of all at the convention. This big question mark hung in the air all through the convention: "Will it be or will it not be a success?" Many manufacturers kept the proto-type shops open late to introduce proposed stereo equipment. Major firms took orders on stereo generators even though, at the time of the convention, the FCC had not received a single application for type-number approval on stereo generating exciters.

The exhibit hall, an annual market for the review and purchase of the latest equipment by broadcasters attending the convention, certainly shown bright, complex, and expensive in 1961.



focus

The NAB '61 Convention

LOOKING AT THE ENGINEERING

A variety of topics was presented during the 15th

ALMOST 600 broadcast engineers had the opportunity to hear the presentation of 22 formal technical papers. The sessions covering all phases of AM, FM, TV and studio broadcasting technique were well planned and ran on schedule.

Beginning at 2:30 on the Monday afternoon of May 8th, George W. Bartlett, assistant manager of engineering for NAB, started the proceedings in the West Ballroom of the Shoreham Hotel.

The first paper was a review of the technical system of the Voice of America. The VOA, the international broadcasting service of the U. S. Information Agency, speaks for the United States in more than 36 different languages to a world-wide audience.

Henry Loomis, director of the Voice of America, said the VOA has less program hours and weaker signal than Communist radio stations, but that it has a bigger listening audience.

He told the Engineering Conference that the Voice now ranks fourth in broadcasting hours, with 620 hours per week. The Soviet Union ranks first, broadcasting more than 1000 hours weekly.

He said Communist China has achieved a surprising stature. Radio Peking now has 690 hours of propaganda programming each week, and has risen from sixth place to second place in the space of two years.

Mr. Loomis said that the Voice must maintain overseas relay stations, because its present system of international broadcasting will not reach into areas of international importance.

"In creating overseas relay stations," he said, "we run into a terrific stumbling block. The Federal Communications Commission will not allow any foreign broadcaster to transmit from this country, so when we ask for space in overseas nations, we are often asked for a reciprocal agreement. This, of course, is impossible."

Mr. Loomis also discussed problems encountered in transmitting Russian language programs behind the Iron Curtain. He said that the jamming of VOA schedules varies from week to week. At times it is 100 per cent of the VOA schedule and at other times, as low as 10 per cent.

The director said international broadcasting is constantly on the increase. The traffic is terrific in overseas broadcasting and it is now a question of who can shout the loudest, and force the little nation off the air.

The Voice of America is now building a new transmitting station in North Carolina. With this new facility, international broadcasts will be transmitted directly to overseas target areas without the requirement of a relay station.

The second paper reported information on semi-conductor high voltage power supplies for transmitters, prepared by Robert Morris of the American Broadcasting Co., but presented for the network's engineering department by Frank Marx.

Semi-conductors now are being used as rectifiers and promise to alleviate 35 to 40 per cent of breakdown time in broadcast stations. The company spokesman told delegates these high-voltage, solid state units offer a means of eliminating this old transmitter trouble, and at the same time reduce replacement cost of transmitter tubes.

Mr. Marx said more and more radio stations are being operated by remote control from studio locations, and this interest has brought about the need for trouble-free transmitter operation.

With the widespread use of conventional high-voltage rectifiers, the circuit which transforms ac to the desired dc is troubled by power irregularities or circuit malfunctions which cause the mercury vapor tubes to arc back and be destroyed. Use of silicon rectifiers eliminates the problem.

Although the initial cost of the silicon semi-conductor is three to ten times greater than mercury rectifiers, the improved reliability and reduced tube replacement cost make their use in existing transmitters, as well as new ones, quite advantageous. In many instances, the silicon units are directly interchangeable with the mercury tubes. In a few cases, only very slight modifications of the rectifier circuits are required.

"Communication of Engineering Information Between Operating

George S. Turner, chief of the FCC field engineering and monitoring bureau, told the Conference many stations were not covering the area called for in their license specifications.

CONFERENCE, MAY, '61

Annual Broadcast Engineering Conference

Technicians, Maintenance Technicians and Supervisors," was the title of the paper presented by George Hixenbaugh, chief engineer for the WMT stations.

A basic problem in communication between broadcast engineers employed on different shifts has been solved by information written on operation logs kept daily at each location where technicians are employed.

In case of a technical malfunction, or a deviation from normal operations, the engineer on duty logs the breakdown, and how it was corrected. A new man coming on duty reads the entire log for the previous shift, and notes all corrections and additions that have been made.

The supervisor also reads all log copies, and transfers the last one to the file. A full week's reports are always ready for reference, to all engineering personnel.

Mr. Hixenbaugh said this fast, efficient interdepartmental memorandum system is under constant operation, and everyone knows at all times what everyone else is doing.

George S. Turner, chief, Field Engineering and Monitoring Bureau of the Federal Communications Commission, provided valuable information in the text of FCC Broadcast Station Renewal Inspections.

From its inception, the inspection of broadcast stations has been a principal means of regulating and insuring the proficiency of operation. Mr. Turner said the recent "depth inspections" by the FCC teams were designed to aid broadcasters in their service to audiences, as well as to notify stations of FCC violations.

Mr. Turner added that, in many instances, stations were not covering the total area called for in their license specifications. In doing so, they were losing a potential audience that rightfully was theirs.

On the other hand, in many instances where a station's power is specified in certain areas by a directional antenna array, there was as much as a 200 per cent excess in a particular area.

In emphasizing benefits of an FCC inspection, Mr. Turner said, " . . . there are many occasions when the type of inspection we are now performing can be as beneficial to the licensee as a thorough going-over by a consulting engineer."

He told registrants that FCC monitoring stations in many instances record programs during the final 18 months of the license period. The operating logs then are checked against the recording to see if there are any discrepancies.

In summarizing his talk, Mr. Turner said: "Our prime purpose is to help the licensee help himself to provide the best possible service for the benefit of the public."

The last technical paper of the day was on the subject of the effect of transistorization on broadcast studio equipment design, presented by John Wentworth, manager of the educational electronics group, Broadcast & Television Division, RCA.

He told the delegates of the Conference that the transistor is making broadcast station control units smaller and more efficient. Interchangeability of transistorized circuits is the key to flexibility of the new semiconductors. Before, if a tube-controlled circuit developed trouble, the entire wiring would have to be traced to check on the fault. In the modular transistor circuits, the entire circuit is removed as a unit and replaced. Modularized, plug-in construction was described as a logical means of exploiting the small size and reduced heat dissipation of transistors. Examples of both etched-wiring and terminal-board mounting techniques were discussed in detail.

The Tuesday morning radio technical session of the Engineering Conference began with a report from William H. Beaubien, manager of advanced development engineering, radio receiver department of the General Electric Co. "The Newly-Adopted FM Stereo System—How It Works" was the title of his paper, describing the use of a sub-carrier and pilot, double side-band suppressed carrier with AM modulation technique to provide a stereo broadcasting system fully compatible with monophonic reception on existing receivers.

Mr Beaubien said the new system will open to listeners an entirely new world of sound and offers FM broadcasters many advantages, also.

An FM station can broadcast a stereo program to receivers equipped for this service, and also can provide on the frequency and at the same time a second program for background music in stores and restaurants.

For those listeners who are not equipped with stereophonic adapters, the new system will provide the stereo programs in full high fidelity monaural broadcasts. This dual-purpose broadcasting for home listeners in addition to the third facility for stereocasting or background music gives both audiences and commercial usage full service with no intermixture of different programs broadcast at the same time.

(Continued on page 8)

The new system will become effective June 1, as approved by the FCC. Mr. Beaubien expects receivers to be on the market for the stereophonic broadcasts at approximately the same time, and many FM receivers now on the market have a provision for stereo reception.

FM broadcasting was highlighted by a careful consideration of "The Effect of SWR on Cross Modulation of FM Multiplex Signals," presented by A. H. Bott, Radio Corp. of America. This paper described some recent work to determine the effect of the standing-wave ratio on cross-talk between FM multiplexed channels. He said the background music service provided by FM stations can be improved if transmission lines and antennas are closely observed for accurate impedance match.

Later, William A. Kennedy, of the engineering antenna research labs of the Collins Radio Co., discussed the various methods of FM antenna placement to side-mounted supporting towers.

Mr. Kennedy pointed out that more and more existing AM stations are adding an FM outlet to their services. The cost factor of constructing an additional tower for the mounting of an FM antenna is, at times, prohibitive.

Collins proved in experiments the feasibility of mounting the FM antenna directly on an existing tower. But this brought new problems, including the fact that the position changed the FM coverage pattern considerably. The angle of mounting, inside or outside, the proximity to the tower, all caused different areas of coverage.

A study on practical FM broadcast engineering followed, to complete the FM picture, presented by Bernard Wise, president of ITA Electronics Corp. This report brought out the fact that many broadcasters are unfamiliar with the unique technical characteristics associated with FM broadcasting. The paper discussed effective radiated powers, antenna gain, antenna patterns, FM antenna installation, FM multiplex, transmission lines problems, and finally, the evaluation of system performance on the regular program and subsidiary service channels.

Mr. Wise emphasized that new silicon rectifiers are by far the most important component of any transmitter. For that matter, he said, "purchasing a transmitter that does not incorporate these components is similar to selecting an automobile that does not have turn signals."

Power dividers for directional antenna systems for AM broadcast stations were discussed by R. C. Bush, from the engineering department of Gates Radio Co. The engineers of the Conference were told one of the integral functions of the antenna phasing unit is the power dividing circuit. Mr. Bush surveyed such matters as pertinent requirements, range of input impedance and its effect on power division and standing waves. Adjustability, efficiency, bandwidth and economy also were discussed, with the matching network considered in fine detail.

Rounding out the radio session was a revealing topic: "Interesting Aspects of Acoustical Design and Practical Improvements in Studio Characteristics," presented by Warren L. Braun, director of engineering, WSVA-AM-TV-FM, Harrisonburg, Va. The increased emphasis on high fidelity transmission has brought about a renewed interest in the design and construction of studio facilities. The paper reviewed the current knowledge and practice relating to acoustical treatment of studios, including practical examples of how to accomplish superior acoustical control.

On the television side of the 15th Annual Broadcast Engineering Conference for the Tuesday, May 9th, technical session, a wide range of subjects was covered.

"The Use of Color Field Redundancy for the Simplification of Color Television Transmission Systems," by Prof. William L. Hughes of Iowa State University, was presented in the morning. A new compatible color television pickup system was discussed. This system would reduce the cost of live cameras and film color cameras by allowing the standard black and white studio and film facilities to be simply and inexpensively adapted for color pickup. Mr. Hughes stated the proposed method would permit the use of present switching equipment with only slight changes.

Following was a timely "Progress Report on Automation at NBC," prepared by Richard H. Edmondson, automation program coordination, RCA. Automation of the program assembly function is one of the most promising approaches to cost reduction in the operation of a TV station. Developments along this line have reached a practical stage and have been installed in existing stations, according to Mr. Edmondson. The paper reviewed the progress of the automation program at the National Broadcasting Co.

Eight-millimeter motion picture film, long established as the home-movie film, has taken on a new dimension and importance for the television industry. A paper was presented on this topic by Kenneth LiDonnici of Fairchild Camera & Instrument Corp., titled "The Application of 8mm Magnetic Sound Equipment In Television."

Fairchild also outlined a new process which permits film to be exposed, developed and projected in a matter of minutes. The method is equally feasible for use in black and white or color photography.

The author said that by using electronic reversal of polarity, negative film can be used as well as direct positive prints.

Ben Wolfe, chief engineer, WJZ-TV, Baltimore, Md., spoke for the Westinghouse Group on the use of the 20 Millimicrosecond D. C. Pulser. Stated simply, the unit would feed a signal the length of the transmission line. The signal would appear on an oscilloscope screen which would be connected to the pulsing mechanism. If a fault developed in the line, it would show up on the oscilloscope as an abnormal bump. A short circuit would produce a positive bump; a broken line a negative bump. The Pulser described in this paper was accurate to within a few feet, very inexpensive, and simple to operate. This device can save hundreds of dollars in a rigger's time during a transmission line emergency, stated Mr. Wolfe.

In another paper, A. C. Angus of the General Electric Co. discussed the installation and design of a complete audio system at the Texas radio-television station, WFAA, Dallas, which recently moved into new studios that were completely

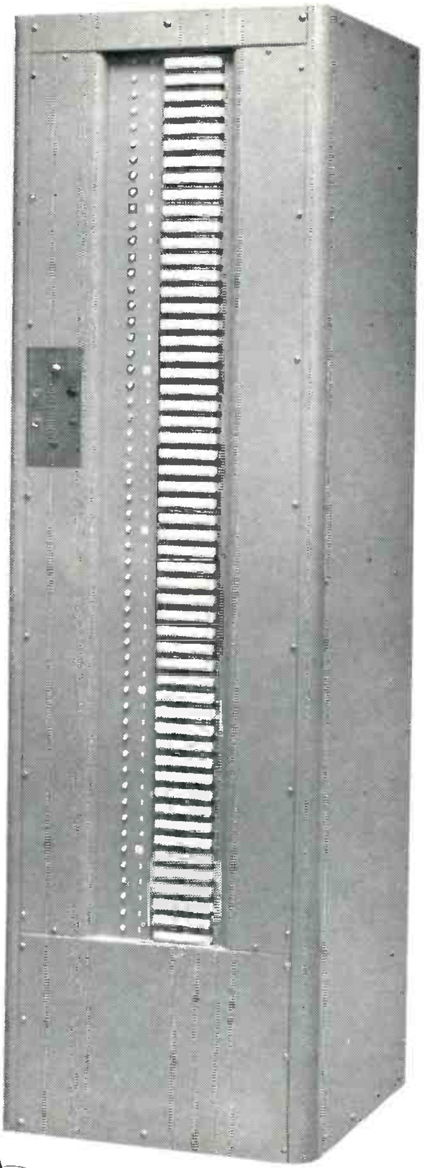
(Continued on page 12)

NEW ATC 55

a simple, low cost, versatile answer to full or part-time AUTOMATED BROADCASTING

- Allows automatic playback of 55 magazine-loaded tapes up to 10 minutes in length each. Models also available with up to 31-minute magazines.
- Outstanding flexibility and simplicity of operation.
- Far lower initial investment than other automated systems.
- Tape rewinds and recues automatically.
- Highest quality broadcast reproduction.

Automated broadcasting has proven to be desirable, but up to now, it has been an involved and costly proposition. The remarkable new ATC 55—from the originators and largest manufacturers of automatic tape control equipment—puts full or part-time automation within the reach of any size station. The ATC 55 plays up to 55 taped spots, themes, music and production aids in sequence without resetting or reloading. Tapes are contained in Standard Automatic Tape Control plastic magazines. The unit selects and positions the proper magazine for airing, broadcasts the material and then the tape rewinds itself ready for reuse or storage. The ATC 55 then disengages the magazine, moves to the next position and engages it for broadcast . . . *all automatically!* The playback element of the ATC 55 is the same popular, thoroughly-proven Standard Unit, except that a modification allows automatic starting of other functions through an auxiliary control tone. Frequency response at 7.5 inches per second is ±2 db from 70 to 12,000 cps and ±4 db from 50 to 15,000 cps. The signal-to-noise ratio is 55 db, and wow and flutter are under 0.2% RMS. Write, wire or phone for complete details.



ATC STANDARD UNITS NOW IN USE IN OVER 600 RADIO AND TV STATIONS

Thoroughly proven in many station operations, ATC Standard Recording-Playback units eliminate threading, recueing and rewinding—make it simple to use as much taped material as you wish. Write, wire or phone for complete details.

Recording Amplifier

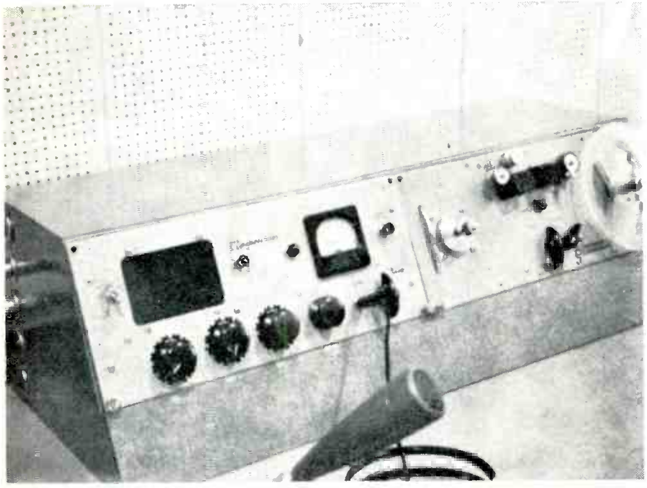
Playback Unit

made by broadcasters for broadcasters

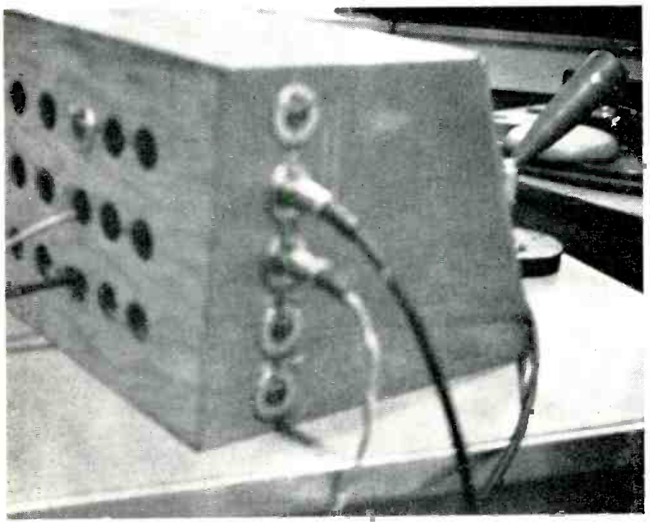
AUTOMATIC ATC TAPE CONTROL

209 E. Washington Street, Room 300
Bloomington, Illinois

Conversion of a single channel PT-6 Magnecorder amplifier into a three channel control console and two unused turntables gives WMGA a new auxiliary control room for recording. Seventy per cent of the station's spots and programs are now recorded here, thus freeing the main control room from this function.



The conversion of the recorder amplifier required the addition of three new attenuators to the input circuit. The console cabinet is made of wood and covered with formica. Receptacles mounted on the side and rear of the console and power switches for the recorder and amplifier completed the conversion.

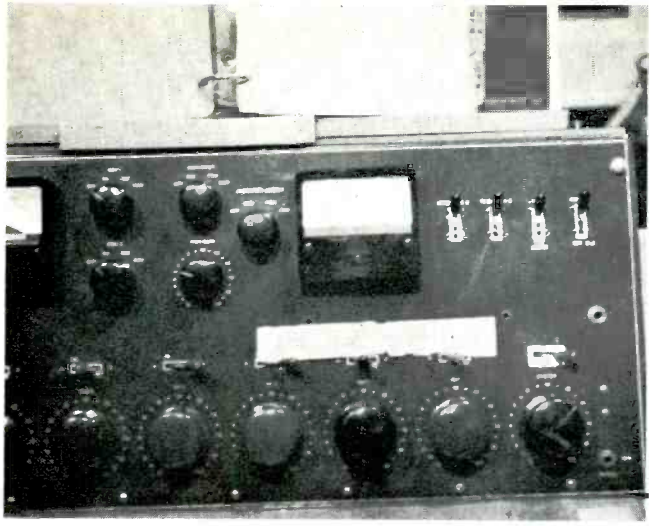


The five receptacles on the side provide the input circuits. Three of the receptacles are for the three input attenuators and the other two are the regular recorder input and output connections.

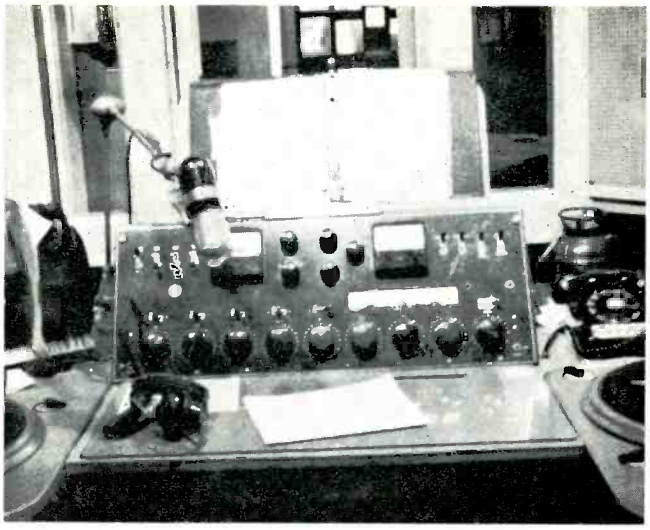
IMPROVING A CONTROL ROOM

Imagination, ingenuity, and work can often improve operating convenience and versatility by making use of equipment on hand. Here is how WMGA in Moultrie, Ga., did it.

By Sam Dudas*



More flexibility is obtained in the main control room by the addition of a recording selector switch and five lever type switches on the control console. The recording selector switch is to the left and center from the modulation meter. It bridges the monitor selector switch and feeds a recording amplifier. The key switch above the master potentiometer is used to substitute the audition amplifier for the program amplifier in the event of failure. The four switches on the upper right are used to switch inputs to four potentiometers and doubles the inputs available for these controls.



An overall view of the modified console. The meter on the right reads the level of modulation of the transmitter and is identical in appearance to the console meter. The changes simplify the amount of patching required of the operators for recording and on-the-air mixing.

Previously two Ampex 601 recorders were placed on either side of the controls console in the portable cases. To improve this arrangement a special recording cabinet was constructed which now contains the recorders and tape reels. Two shelves at the top hold 74 five-inch reels of tape. Beneath the tape bins are mounted the two Ampex recorders on steel rails. At the bottom of the case are 37 slots for seven-inch tape reels and 31 slots for records and transcriptions. Provision is made for record sizes from 10 to 16 inches and the smaller records will not go all the way back in the cabinet. All tape reel and record compartments are tilted to prevent them from rolling out. The separating sections are made of masonite and the back is made of pegboard to allow ventilation for the machines.

The operating convenience of the control room is shown in this picture. The recorders and the tape and records are now within reach of the operator and the operating desk is clear.

*Chief Engineer, WMGA,
Moultrie, Georgia

Engineering Conference

(Continued from page 8)

equipped for stereophonic broadcasting and recording. The paper dealt with the objectives and results obtained in the design and installation of the new facilities.

"Time Base Stability in Video Magnetic Recording" was presented by L. W. Weiland, Ampex Corp. The Conference was told there are bound to be some discrepancies in video tape recording equipment because of the myriad of mechanical devices employed. His firm manufactures a Television Signal Synchronizer (Intersync), a Time Element Compensator (Amtec) and other devices that preview the video signal before it is played back. If any of the lines making up the total TV picture are out of alignment, corrective devices put them in place during the playback sequence.

The end result, he said, is sharply defined and improved programs for the viewer at home.

The Wednesday sessions of the Conference pertained to television.

Adrian Ettlinger, project engineer for the CBS Television Network, presented information on "A Computer Control System for Program Switching" at the first meeting of the day. Working with TRW Computers Co., a special-purpose digital computer is used to control the sequential switching among the various program components at KNXT. Automation of the switching functions during the "panic periods" allows the operator to devote full time and attention to quality.

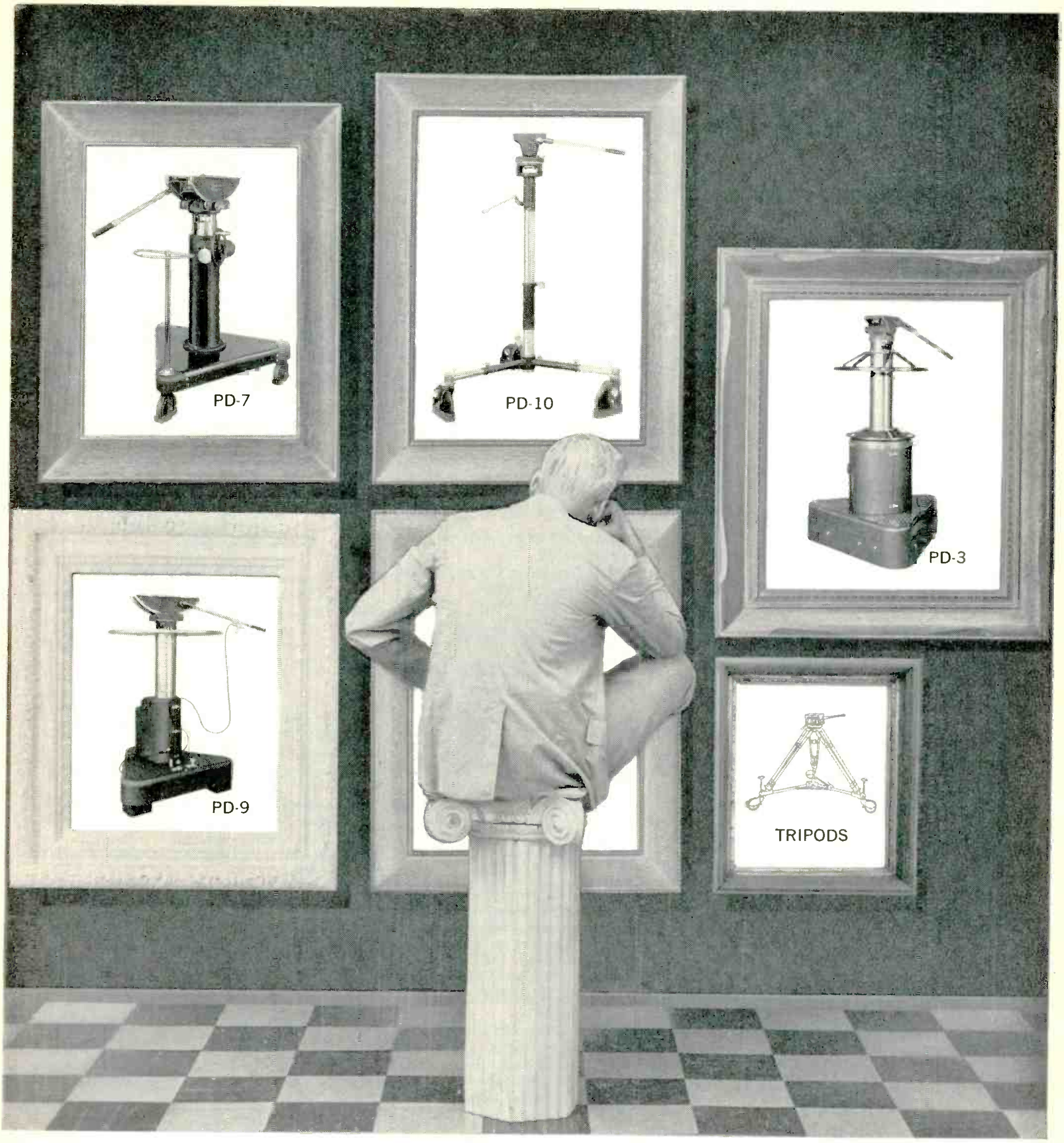
Later, Gene Ellerman, vice-president and general manager of Station WWTV, Cadillac-Traverse City, Mich., discussed TV station fires in an interesting paper entitled: "'Fireproof' Buildings Do Burn: Tips on Guarding Against Fire Losses In Broadcast Operations." Mr. Ellerman said his station was built to be completely fireproof, but secondary causes from a blaze touched off by an overheated motor last January wrecked the installation. Most of the damage was caused when roof supports buckled and collapsed under the intense heat, and allowed the entire structure to cave in.

Fire equipment responded at the first report of smoke, but water pumps were frozen and inoperative in the 12-degree-below-zero weather. Firemen and station employees watched helplessly as the flames destroyed everything.

Replacement equipment for the entire station was ordered from manufacturers before the embers were cool. WWTV returned to the air two weeks later, but problems created are far from solved.

Because of the uniqueness of a total-loss blaze of the TV station, insurance adjusters have not been able to agree on replacement costs. Many items of equipment have gone up in price since the original equipment was installed; a few have been reduced. Mr. Ellerman advised TV stations to keep insurance policies revised up-to-the-minute, making certain coverage properly reflects their investment.

A great variety of information and a wealth of ideas were for the asking for those who attended the 15th Annual Broadcast Engineering Conference concurrently with the 39th Annual NAB Convention in Washington, D. C.



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May, 1959, through April, 1960

A complete listing of technical subjects reviewing the first two years of this Journal.

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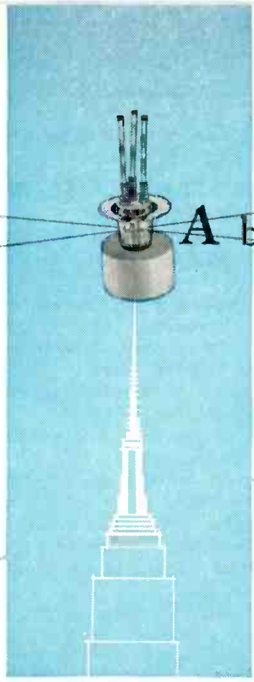

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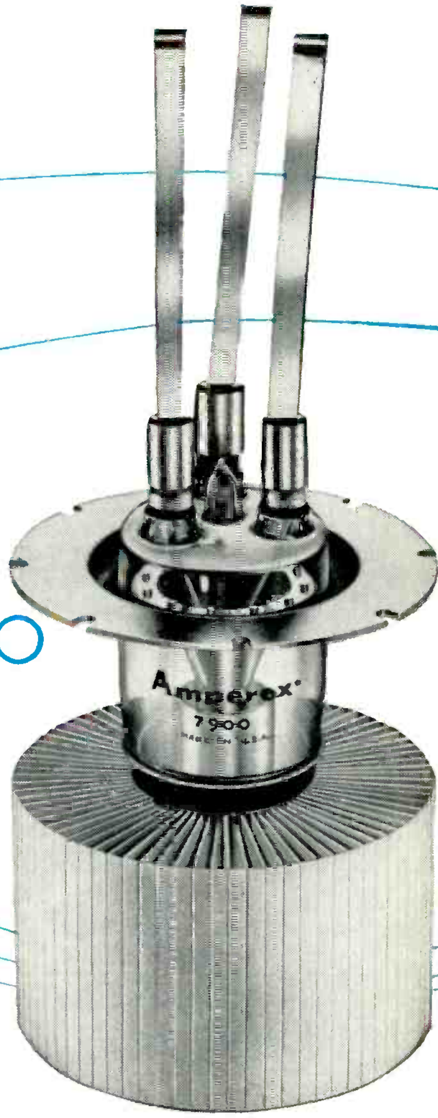

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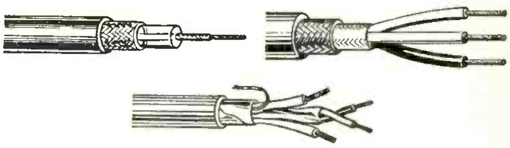

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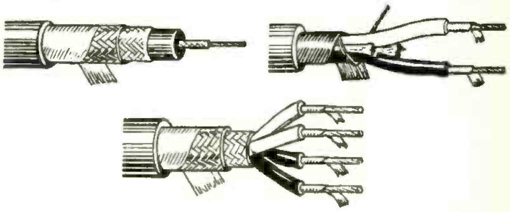

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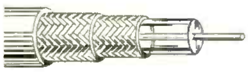

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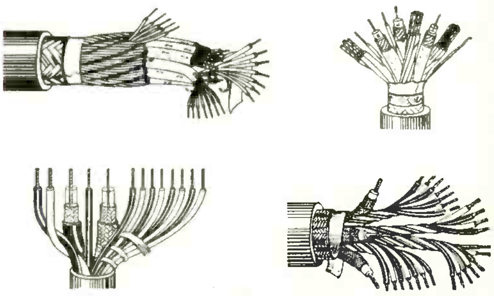


TELEVISION SYSTEM MAINTENANCE

By HAROLD E. ENNES
Maintenance Supervisor,
Television City, Inc. (WTAE)
Pittsburgh, Pa.

EDITOR'S NOTE:

This article is the second in a series of general and specific reports on Broadcast Television Maintenance.

THE SYNC generator consists of two basic sections: (a) timing and (b) pulse shaping.

The simplest timing relationship which could be used is a 15,750 cps oscillator for the "line" frequency, and a 60-cycle pulse derived directly from the power line for the field frequency. This form of "timing generator" is employed in a number of closed-circuit industrial systems since the signal is not intended for broadcast. However, in order to produce field interlace required for standard broadcast transmission, it is necessary that the field frequency be derived from the master oscillator frequency. When two independent frequency generators are used, as in the industrial system, a form of "random interlace" results, since the frequency relationships are not locked. Also the actual number of lines constituting a single frame will vary with the magnitude of drift between the line and field frequencies.

Fig. 1 serves as a "capsule" review of what the sync generator must do, and should be observed during the following discussion.

From the familiar waveforms of (N) and (P) note field 1 has a full line (H) to the first equalizer pulse while field 2 has a half line interval. This is the requirement for odd line interlaced (two-to-one) scanning. The master oscillator must therefore be twice the line frequency so that either H or ½H pulses are available. (Note: field 1 and field 2 are arbitrarily numbered. In this article, field 1 refers to the full line interval before the 9H vertical time, and field 2 refers to the ½ line as shown. Also remember field 1, therefore, has ½H spacing from the last equalizer pulse to the first H sync pulse (which is now field 2), while field 2 has H spacing from the same point in time (now field 1). This characteristic is useful in setting the vertical blanking duration (as described later).

Waveform (A) represents the 31.5 kc triggers from the master oscillator, initiating the leading edge for (B), (C), (D) and (F). The width of pulse (B) determines the front porch interval since the trailing edge of this pulse times the H sync information (waveform E). Some generators use a tapped delay line for this purpose.

Although a considerable difference exists in methods used by various manufacturers of sync generators, the timing will be as shown by Fig. 1. The master oscillator frequency is divided by 525 and triggers the leading edge of vertical blanking, vertical drive, and the various gates shown. Delayed triggers (B-prime) still provide the coincidence timing of H sync during the long (9H) vertical interval.

The importance of timing accuracy and allowable tolerance may be realized from the following examples. Consider the observation of a thin vertical line representing a frequency of 4 mc in the picture. If the timing on alternate lines of the raster is shifted by as much as ½ cycle, fine detail is lost. Since a complete cycle of 4 mc occurs in 0.25 u/s, a half-cycle occurs in 0.125 u/s. This means that the *overall* tolerance (sync generator and monitor or home receiver) in variation of timing between successive horizontal pulses is 0.125 u/s for a 4 mc detail. This is roughly an accuracy of 1 part in 600 for overall H timing. For the sync generator alone, EIA Standards allow approximately 0.0008H in an averaging process of 20 to 100 lines, or about 0.05 u/s (less than ½ of 0.125 u/s).

The tolerance of vertical timing is even more severe. Since only ½ line difference exists for alternate fields, complete loss of interlace occurs with a vertical timing error of ½H (32 u/s). In practice, the overall vertical difference in line spacing must be less than 10 per cent to preserve the illusion of perfect interlace. This is approximately 3 u/s out of the vertical interval of 16,667 u/s, or less than 1 part in 5,000.

Before leaving the basics of interlace, it is pertinent to review very briefly the real function of equalizing pulses. They do not, as the name implies, equalize the charge on the vertical sync integrating capacitor between the H and ½H fields. Fig. 2 will make this clear. Time t_1 to t_3 represents H (field 1), and t_2 to t_3 represents ½H or field 2. If the first V sync pulse occurred at t_3 the integrating capacitor would start charging with a 2/1 voltage difference between fields, resulting in a much earlier firing of the oscillator for field 2 than for field 1. However, if a 3H "waiting" or "equalizing" interval is allowed (t_4) the following condition prevails:

II. Sync Generator—Adjustments and Maintenance

An examination of the heart of the telecast system, including waveform definition, pulse shaping-distribution, and timing data.

Field 1: H + 3H = 4H
Field 2: 0.5H + 3H = 3.5H
Ratio: 4H/3.5H = 1.14/1

Thus by the time the first V sync pulse occurs at t_4 the integrating capacitor charge is sufficiently equalized between even and odd fields to fall within the requirements of interlace. (Assuming proper adjustment of the receiver Vertical hold Control.)

Obviously pulses must be present during this interval to maintain H sync. These pulses must be twice H frequency so that equalizers 1-3-5 supply triggers for field 1, and 2-4-6 for field 2. The trailing edge of alternate V sync pulses (serrations) then step the H sync oscillator during that interval. Equalizing pulses are made one-half the width of H sync pulses so that no shift in the ac axis will occur at the transition between the line frequency and the double-frequency equalizers. Preventing this shift in axis is important to attenuate the inherent 30-cycle component of horizontal sync introduced from the fact that alternate fields are displaced by ½ line (30-cps).

Frequency Adjustment

Proper operation of the counters and pulse gating circuits will usually result if the master oscillator is within 5 per cent of 31.5 kc nominal

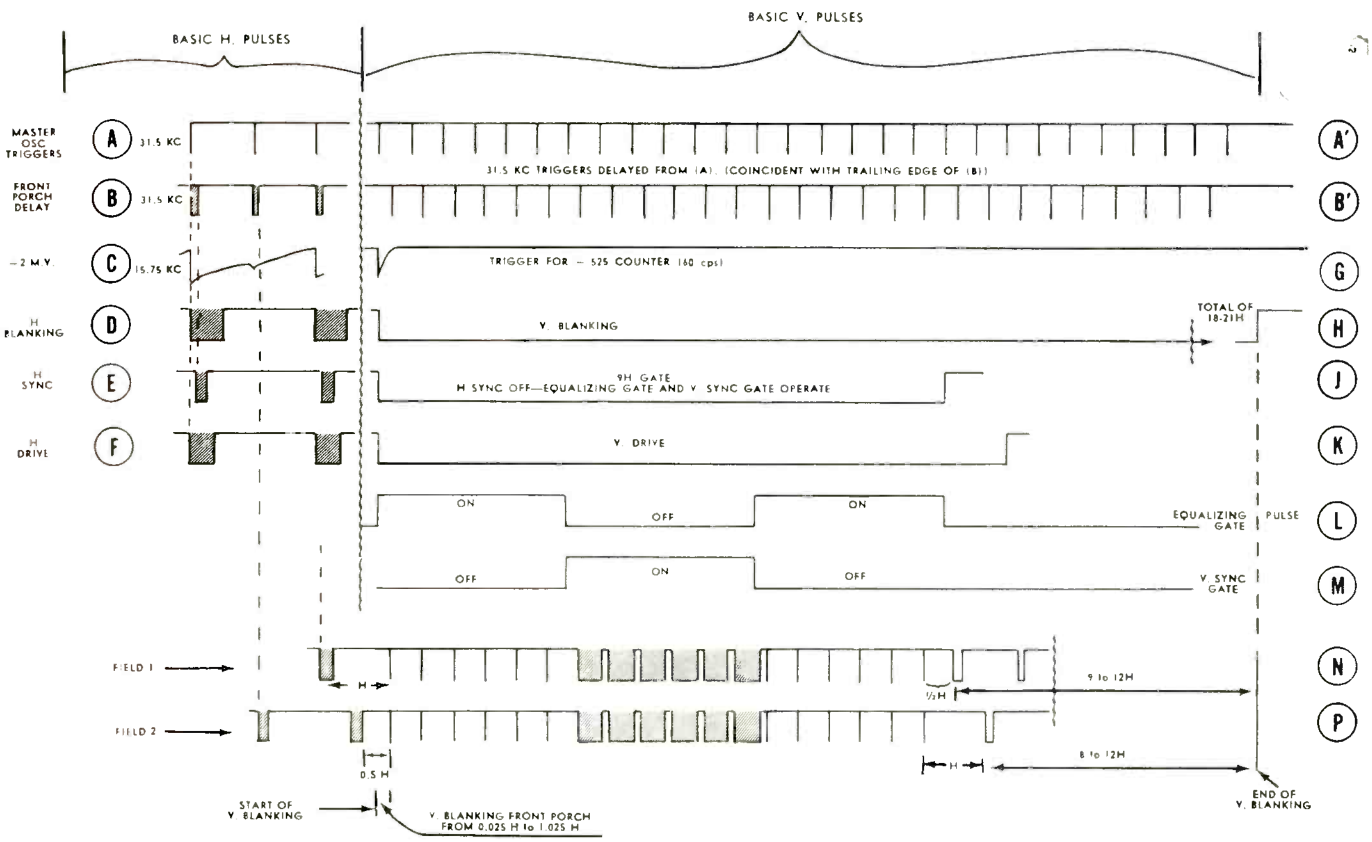


Fig. 1: Basic pulse timing of the sync generator. Due to space limitations the horizontal time scale of the vertical interval is shortened compared to the horizontal pulse scale.

TABLE 1

TIME BASE OF COUNTER CIRCUITS

STAGE	TOTAL DIVISION	FREQ	TERMS OF H	WIDTH OF PULSE* IN U/S
MO	1	31,500	½	31.75
÷ 7	7	4,500	3.5	222.0
÷ 5	35	900	17.5	1111.0
÷ 5	175	180	87.5	5556.0
÷ 3	525	60	262.5	16,668

*From leading edge of pulse to leading edge of following pulse

frequency. It is entirely practical to adjust this frequency within 1 per cent or less which greatly extends the stability factor over a period of time with changing tube and component characteristics.

Most sync generators provide some means of controlling the master oscillator frequency in any one of the following conditions:

(A) Free running for test or emergency use.

(B) Crystal control. Usually used for test setup. May also be used when power line frequency is unreliable as in some remote locations, or when using standby power sources such as emergency power generators.

(C) Line-lock to local 60-cycle power line. This is the most common operating condition.

(D) Genlock. Uses stripped-off sync pulses from network or remote signals to control local oscillator (and field counters) allowing superimposition of local signals over the net or remote signal.

(E) Any selected external signal such as "color-lock" for color programs.

When a crystal circuit is employed, the crystal frequency is usually 94.5 kc or three times the master oscillator (hereafter termed MO) frequency. The oscillator acts as a 3/1 divider when placed under crystal control. The crystal provides an accurate means of adjusting the MO frequency even though the remaining circuits may not be functioning, therefore is a convenient servicing aid.

The best way to adjust the free-running frequency of the MO when a crystal circuit is included is outlined as follows:

Function 1—Place the scope probe (low-capacity type) at the 31.5 kc test point. With the switch in "XTAL" position, the waveform of Fig. 3(a) should be displayed. Since the crystal is 94.5 kc, a division of three is 31.5 kc and is indicated by the three sine-wave cycles between pulses as shown. If a different indication occurs, the MO frequency adjust control should be rotated for proper frequency. In the RCA type TG-2A generator, a capacitor is used as a course adjustment and a time-constant potentiometer as a "fine" (about 3 per cent) adjustment. Use the capacitor for setting the exact frequency with the time-constant control in mid-position. This same procedure is followed on similar types of MO circuitry in other manufactured generators.

The foregoing function assures proper frequency under crystal control. This step sets the free running frequency to 31.5 kc within close limits. (Procedure 1 assumes use of a triggered scope such as the Tektronix 524. Step 3 is an alternate method when triggered sweep is not available.) Step 4 describes a "vernier" adjustment for precise setting providing counters are properly functioning.

Function 2 — Expand the scope sweep to obtain one cycle of the 31.5 kc in crystal control (Fig. 3a) and position the leading edge of the pulse on a vertical graticule line. Switch MO control from "XTAL" to "OFF" condition (free-running), observed in Fig. 3b. If the pulse shifts from the reference position, adjust the MO frequency until no shift occurs between the crystal control and free-running modes.

Function 3—Fig 4. illustrates the basis for a method of setting the MO frequency when a scope with triggered sweep is not available. Fig. 4(a) is the waveform of the 31.5 kc MO and Fig. 4(b) is the output of the divide-by-two (15.75 kc) circuit showing the characteristic "division pip" of the alternate pulse. Expand the waveform shown by (b) so that the distance between the tip of this "pip" and the steep side of the pulse immediately to the right occupies a given number of graticule lines horizontally (Fig. 4c). If this width changes when on "free-run" position compared to the width when on crystal control, adjust the MO frequency so that no change occurs between crystal and free-run modes.

Function 4 — With the MO in free-running mode, observe any 60-cycle signal (such as at the counter output, vertical drive or blanking) with the scope trigger selector on LINE position. This shows any "slip" with the line frequency. Adjust the MO frequency so that the trace becomes stable. A slight drift back and forth may occur but no sudden changes should exist. The MO frequency is now within a small fraction of 1 per cent and placing the oscillator in "line-lock" control should immediately stabilize the trace. If this does not occur, or if the trace becomes noticeably unstable on line-lock, the AFC circuitry needs service.

Step 4 is normally only necessary for routine checks of MO frequency. However, the previous steps should be exercised occasionally to check the crystal control and, of course, are necessary if trouble is experienced in counter stages.

Some generators that do not include a crystal for test have a 94.5 kc ringing circuit in the MO to sharpen wavefronts and provide a reasonable degree of short term stability. (Long term stability is provided by the AFC circuit.) Function 4 above is normally used to adjust the frequency for this type of MO. But, any indication of faulty 60-cycle pulses always poses the question as to whether the trouble is in the counters or master oscillator. By use of the low-capacity scope probe, the waveform across the ringing circuit may be observed. The MO frequency should be adjusted so that the "firing pulse" occurs at approximately the 45-degree point of the third cycle of sine waves.

An alternate method is the old standby of employing a 31.5 kc frequency standard and some form of comparison. The "beat" method is subject to error in pulse circuits due to the rich harmonic content. The frequency standard signal may be displayed on the scope, triggered externally by the same signal. Without disturbing the external trigger, the MO may be observed and circuit adjusted for the same frequency and maximum stability of trace.

Whenever a sync generator becomes erratic, the first procedure is to change the MO control from the usual line-lock position to the free-run or crystal control. If the pulses stabilize, the MO frequency may be out of range of AFC control.

Checking the Countdown

Some of the older type sync generators employing "step-by-step" counters featured continuous display of counter circuit action by means of a small scope on the front panel. More recent generators have deleted this feature in the interest of overall simplification. Several types use binary counters with plug-in modules or replaceable strips which are not serviced by station personnel. In the RCA TG-2A, the first counter (7/1) contains a variable adjustment while the remaining counters use fixed constants with no adjustable controls. Test points are usually provided at the various counter outputs on all generators, for the purpose of testing and servicing.

Due to the nature of binary counters employing feedback pulses to obtain the odd-number countdown (525-1), a direct counting check is usually not practical. Trouble in the preceding binary stage is indicated by the first grid check point where random or unstable pulses exist.

Generators using multivibrator type counters (such as the RCA-TG2) normally employ four stages as follows:

Stage No.	Input Frequency	Division	Output Frequency
1	31,500	7	4500
2	4,500	5	900
3	900	5	180
4	180	3	60

The total division is thus $7 \times 5 \times 5 \times 3 = 525$.

The most convenient method of checking such a counter chain is as follows:

1. Observe the waveform of the first 7/1 divider circuit by adjusting the sweep to obtain 1 cycle of the waveform shown by Fig. 5(a). The counter should show a division of 7.

2. Apply the same signal to the external sync input of the scope and adjust the sweep for 5 complete cycles as shown by Fig. 5(a).

3. Without changing the external sync connection or the sweep, place the scope vertical amplifier probe in the following (5/1) counter. Exactly 1 cycle should now occur in the same interval as shown by Fig. 5(b).

Repeat the same procedure for the remaining stages by triggering the sweep with the counter *preceding* the one to be checked, and adjusting the sweep for the number of cycles that equals the division of the counter to be checked.

An alternate method (less accurate) shown by Table 1 is to measure the frequency of the pulse by using the time base of the scope in microseconds. In this case the engineer must assure himself that the time base is both accurate and linear as discussed in the first article of this series.

Setting Pulse Widths

Pulse widths are set by either of two general methods: (A) Variable time constant of triggered multivibrators. (B) Multivibrators (driven type) which receive "on" and "off" triggers from adjustable delay lines.

The methods of measuring pulse widths are applicable to any type

TABLE 2 — PULSE TABLE

PULSE	MINIMUM H	MINIMUM uS	NOMINAL H	NOMINAL uS	MAXIMUM H	MAXIMUM uS
H Blanking	0.165	10.5*	0.175	11.1*	0.178	11.3*
H Sync	0.07	4.445	0.075	4.8	0.08	5.08
Equalizing	0.45 of H. Sync	2.0	0.5 of H. Sync	2.4	0.04	2.54
V. Serration	0.06	3.8	0.07	4.5	0.08	5.08
V. Blanking	18.375	1167*	19.7	1250*	21	1333*

*H and V blanking must be of proper ratio to establish 4/3 aspect ratio

NOTE: EIA resolution and ball charts are based on following values:
H. Blanking = 11.1 u/S
V. Blanking = 1250 u/S

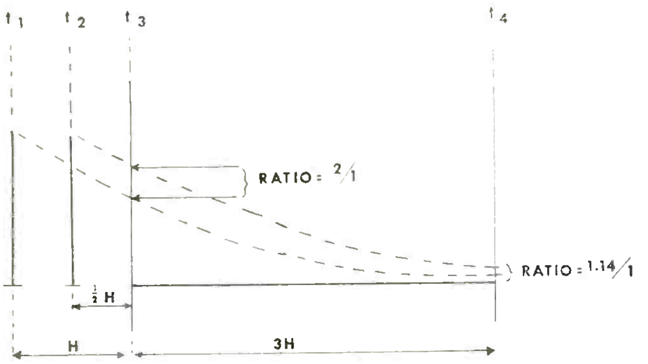


Fig. 2: Purpose of the 3H "equalizing interval" before vertical sync.

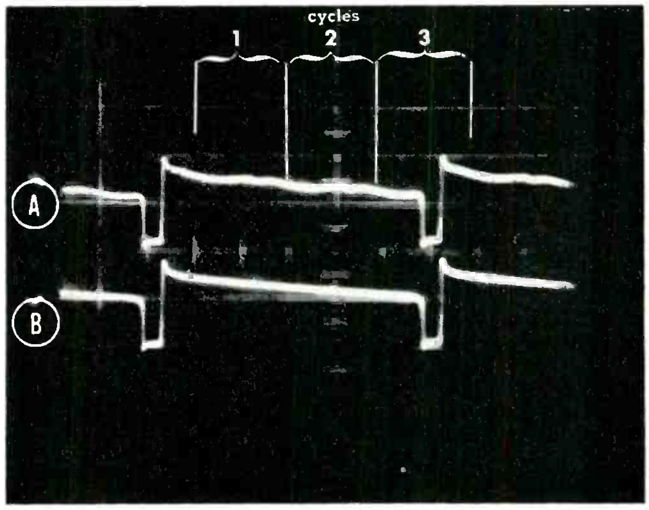


Fig. 3: (a) 31.5 kc waveform with MO on crystal control (b) Same waveform with MO free-running

of generator, but the adjustment procedures differ radically between various manufacturers. It is usually quite important to follow the recommended sequence of adjustments in the instruction manual for the particular generator involved.

For convenience, pulse widths in terms of both H and u/s are listed in Table 2. Fig. 6 is an exaggerated drawing illustrating the standards of pulse measurements. The width is normally measured at 0.9 peak amplitude where "peak" is taken as the positive-going direction. (Horizontal blanking is an exception where, for the purpose of setting aspect ratio, width is measured at the 50 per cent amplitude point). Note also that pulse rise and decay times are measured as the time interval between the 10 per cent and 90 per cent amplitude points.

By cross-mixing sync and blanking outputs and adjusting the scope time base to obtain the waveform shown by Fig. 7, horizontal sync, equalizing, horizontal blanking and vertical serration widths may be adjusted from this one display. The markers are 0.005H (½ of 1 per cent of H) for maximum accuracy.

From Table 2, H sync should be adjusted to 4.8 u/s, or 0.075H. For a width of 7.5 per cent of H there will be 15 of the 0.005H markers present as shown. The 1 u/s markers could be used here if desired, as well as for setting total width of H blanking to 11.1 u/s, with slightly less accuracy. The vertical sync serration should be 4.5 u/s or 7 per cent H which is indicated by 14 of the 0.005H markers. Where the time base and sweep linearity are known to be accurate, the graticule lines only may be used. For example, the vertical serration could be set by adjusting the scope for 2.25 u/s per cm, and the serration adjusted to cover exactly 2 cm.

Vertical blanking can be accurately set by using horizontal drive pulses as markers. By using a 1000-ohm resistor from the H Drive test point to the Blanking test point, the horizontal signal is attenuated to a convenient marker amplitude superimposed on blanking viewed at vertical rate on the scope. From Table 2, vertical blanking (nominal value) is 19.7H, thus 19 markers plus 0.7 indicates the proper width. The 0.7 value can be interpolated quite accurately provided the operator is familiar with the linearity of the scope sweep.

Actually the use of markers as described above is not necessary if the scope incorporates variable delayed sweep as provided in the Tektronix 524-AD. In this method simply leave sync and blanking cross-mixed as in H pulse measurements, use the 200 u/s time base and delayed sweep, and select the field with the full line (H) interval following the last equalizing pulse.

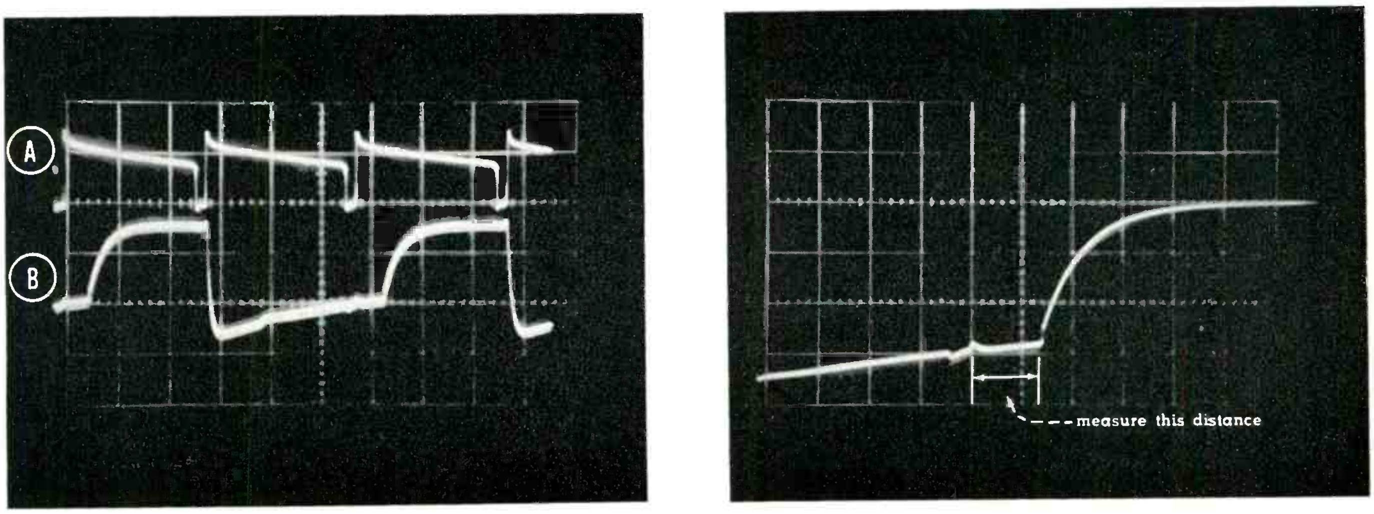


Fig. 4: (a) 31.5 kc MO waveform. (b) 15.75 kc (÷ 2 stage) showing "division pip." (c) Same as (b) on expanded scale.

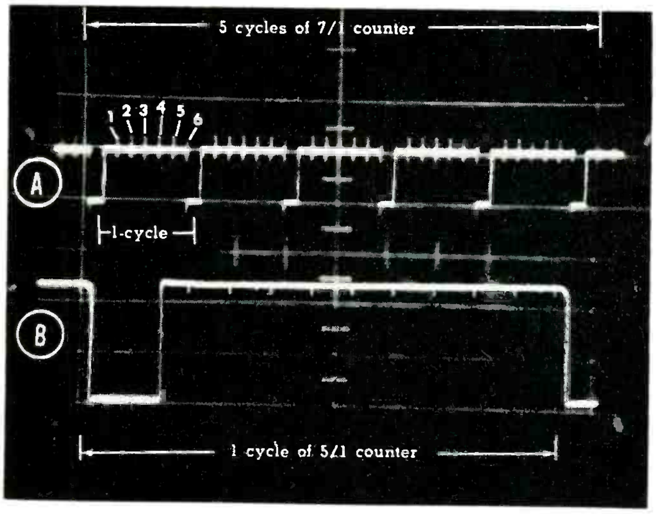
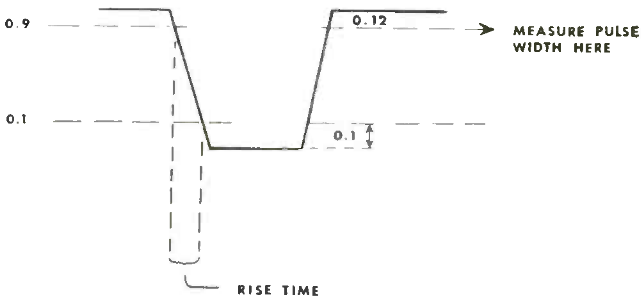


Fig. 5: (a) Five cycles of 7/1 counter
(b) One cycle of 5/1 counter

Fig. 6: Standard for measuring pulse width and rise time.



(See Fig. 8.) The last equalizing pulse is the end of the first 9H interval of vertical blanking, plus the 0.025H to 1.025H vertical front porch which should be counted. The remaining H sync pulses may then be counted to arrive at the total vertical blanking interval as shown.

The Pulse Cross Monitor

Two basic types of pulse-cross monitors are used: the interlaced and the non-interlaced. In both types, the horizontal sweep is delayed sufficiently that the H blanking and sync pulses appear near the center of the raster. To display the entire frame (interlaced presentation) it is also necessary that the vertical sweep be delayed to place V blanking and sync in the normal active line area of the monitor. This displays both fields (interlaced) so that the entire 37 to 42 line vertical blanking interval is visible. If the monitor vertical deflection rate is changed to half-rate (30 cps), a single field is displayed with ½ the number of pulses (non-interlaced presentation). In either case, expansion of the vertical sweep is normally used to allow more critical observation of the pulses.

Fig. 9 is the pulse-cross presentation of a line-output signal with an interlaced monitor. In this case the video polarity is inverted so that sync is in the white-going direction. Note the convenience as a quick reference check for horizontal front-porch, sync, blanking, equalizing and V sync widths. Vertical blanking is conveniently checked by counting the number of blanking lines. Some stations construct graticules with normal pulse widths indicated after an accurate check of the generator with the oscilloscope.

The pulse-cross is extremely useful both as a continuous monitor and as a servicing tool. A 9 x 1 switch panel is used at WTAE to allow selection of signal from a number of points to feed the monitor, but is normally left on the "stand-by generator" position. This enables continuous monitoring of whichever generator is in "stand-by" position (composite sync only) as shown by Fig. 10. Fig. 11 is an exploded view of the presentation with identification of pulses.

The "cross" is formed at the in-line-with H sync period. The reader can readily understand the sequential presentation of the monitor (Fig. 11) if he will visually move field 2 (waveform P of Fig. 1) to the right one-half line so that H sync pulses of both fields are in vertical alignment and the last H pulse of field 2 is in line with the first equalizer of field 1. Now observing Fig. 11, note that the in-line pulses (those occurring at H intervals) are equalizers 1-3-5 of field 1, and 2-4-6 of field 2, spaced on alternate lines due to interlace of fields. The

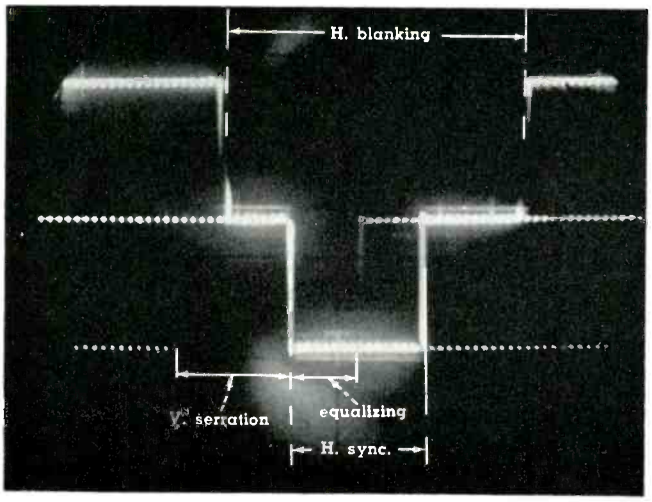


Fig. 7: Cross-mixed sync and blanking with 0.005H markers.

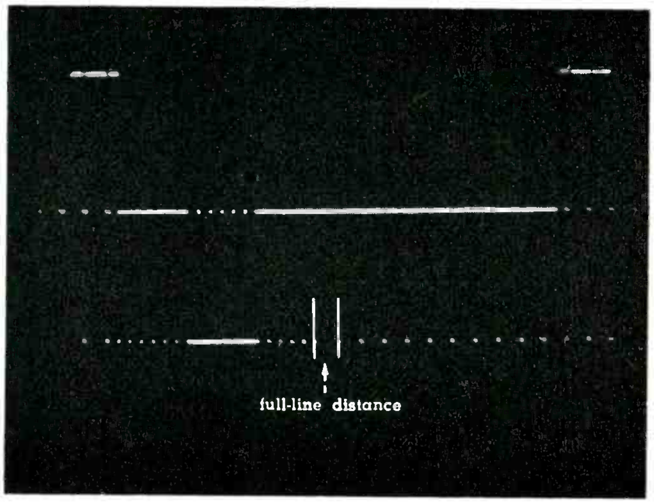


Fig. 8: Vertical blanking interval (waveform P of Fig. 1) adusted to 19.7H.

half-line intervals and the remainder of the presentation is obvious in pulse identification by following the above reasoning.

With an interlaced type of pulse-cross monitor, loss of interlace as could be caused by a vertical count-down error of 0.5H is readily apparent as illustrated by Fig. 12. Brightness of the display will be greater than normal for a given adjustment due to the double tracing of identical raster lines.

Suggested Maintenance Procedures

An adequate preventive maintenance schedule can be outlined as follows:

30-*Days*: Stability, pulse widths and EIA Standards check. This includes an overall stability check where possible, a check (and adjustment if necessary) of MO frequency, counter chain and all pulse widths, and measurement of pulse amplitude, overshoot and rise times both at the generator output and all pulse distribution amplifier outputs with cables connected as in normal operations.

90-*Days*: Tube check and a repeat of the 30-day schedule. All tubes should be checked for transconductance, shorts and gas. Normally the "good-bad" scale which allows manufacturers tolerance of performance is sufficient for the transconductance check. When tubes are replaced, it is always important to re-check pulse widths in about four days, and again after seven days.

When experience dictates that pulse widths do not hold within minimum to maximum tolerances for 30 days, this schedule should be shortened accordingly.

The overall stability test is a good indication of any deterioration of tubes and/or components. The test is possible if the MO has a vernier frequency adjustment which will allow a 3 to 5 per cent frequency variation from exact operating frequency (such as the RCA TG-2A generator). In this test it is assumed that the MO has been adjusted to 31.5 kc in the free-running mode with the vernier control at midrange, by one of the methods previously described.

Cross-mix sync and blanking at the test points and observe this on the scope or pulse-cross monitor. When using the Tektronix 524 scope, the best display is obtained by using delayed sweep on a 200 u/s time base and rotating the delay control to observe an entire vertical blanking field plus several lines. The field-shift key should then be used to observe the opposite field. This procedure is unnecessary if an interlaced pulse-cross is available.

Rotate the vernier frequency control through extremes of rotation. Maximum stability is indicated if no erratic behavior of pulses exists between extremes. If H pulses become erratic or change frequency, check the divide-by-two circuit (15.75 kc) with the scope. If this output remains stable, check each following H circuit until the instability becomes evident. If only equalizing pulses become erratic, check the equalizing pulse gate and any gate amplifiers. If only vertical sync instability occurs, check the vertical sync gate. If both equalizing and V sync instability occur, check any 9H gating circuit and/or 3H stop or delay circuits, and particularly the counter chain.

Keeping tabs on the rise and decay times of pulses is also a good procedure from the standpoint of troubles casting their shadows before them. The time interval of leading and trailing edges of H and V sync, equalizing pulses, H blanking and H drive should not exceed 0.003H (0.19 u/s). Using expanded scale on the scope, measure the slopes between the 0.1 and 0.9 amplitude points as shown by Fig. 6.

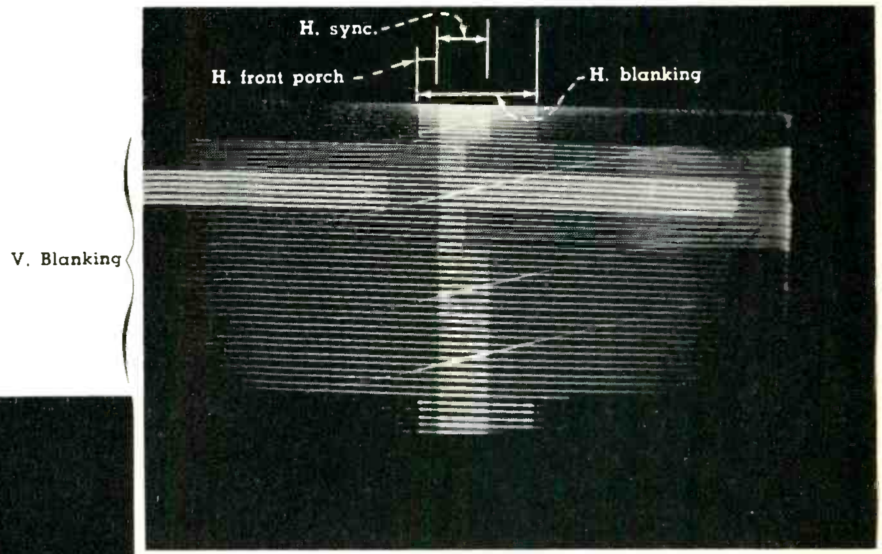


Fig. 9: Interlaced pulse-cross display on composite signal.

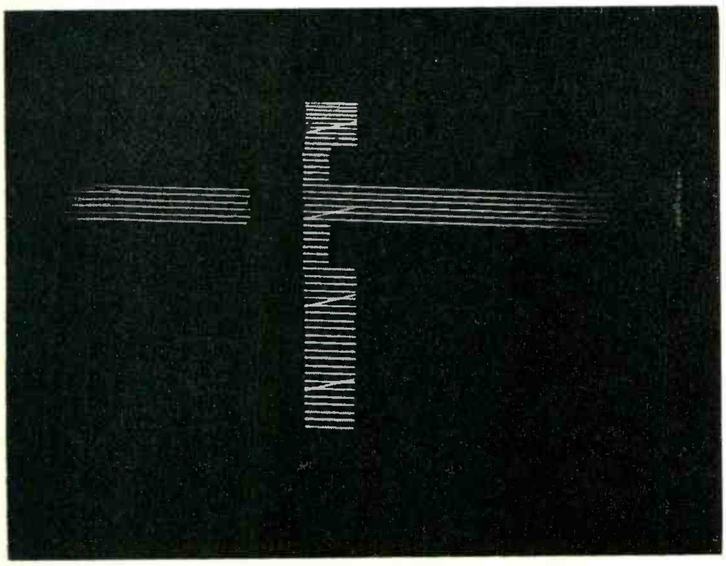


Fig. 10: Pulse-cross display, sync only.

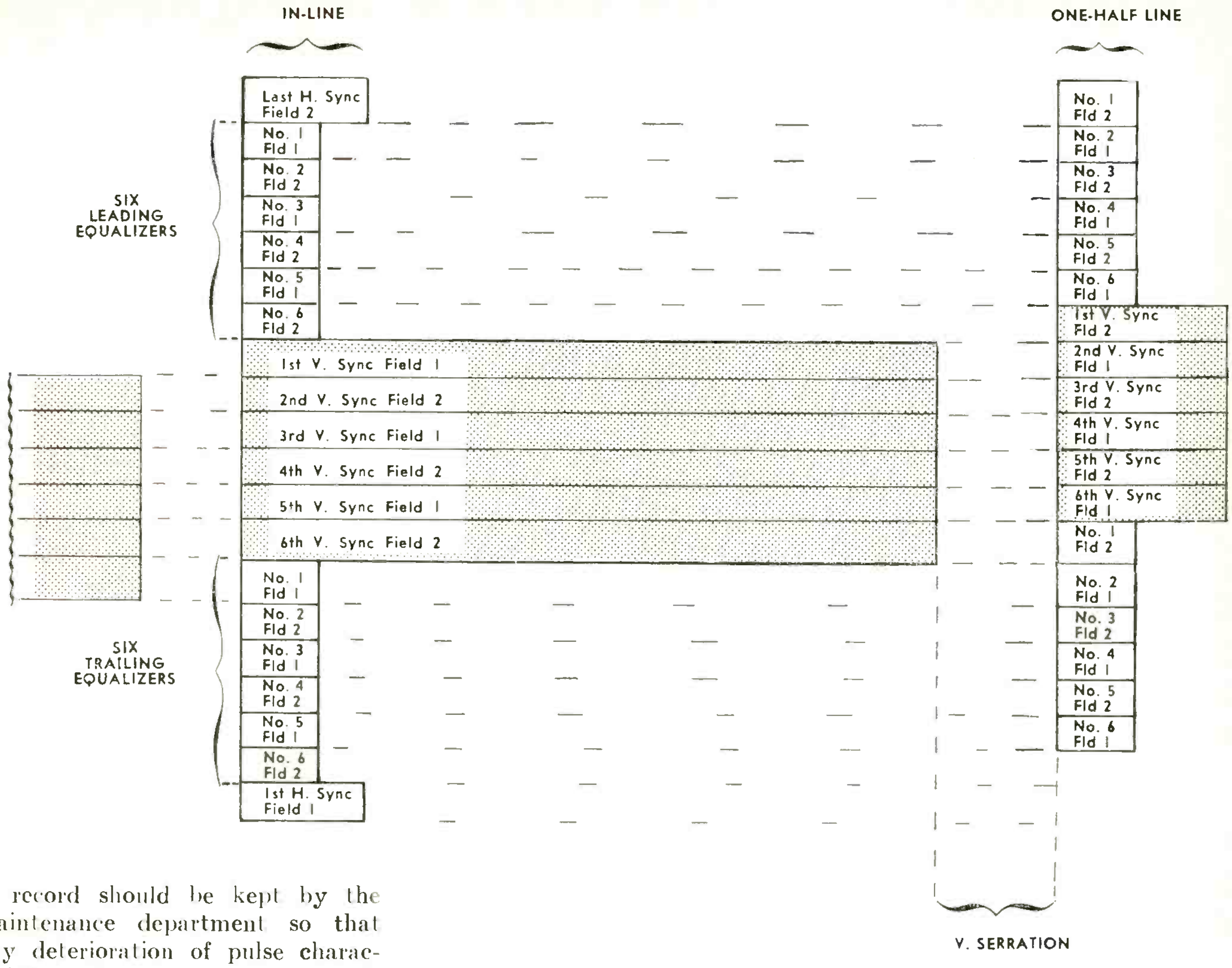


Fig. 11: Exploded view of pulse-cross with pulse identification.

A record should be kept by the maintenance department so that any deterioration of pulse characteristics will be evident from month to month.

Leading edge overshoots should be no greater than 5 per cent as measured by a scope with good transient response (Normal position on the Tektronix 524-AD) and with interconnecting cables in place. When long coax runs are involved, an overshoot with "ringing" sometimes occurs. If the pulse waveshape is important (not used simply as "triggers"), the termination should be varied slightly around the nominal value for best transmission. It is sometimes necessary to provide complex terminations on extremely long cable runs.

Sync Crosstalk

This term can be applied either to crosstalk within the sync generator itself, or to the so-called "windshield wiper" effect similar to the horizontal motion of co-channel interference on a home receiver.

Crosstalk within the generator itself is usually caused by a very small amount of any one of the counter frequencies "leaking" to the MO waveform. This type of cross-

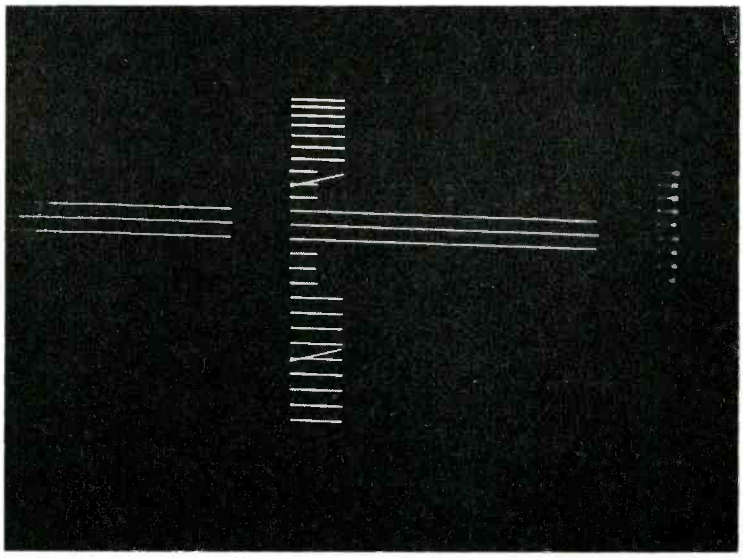


Fig. 12: Interlaced pulse-cross display when sync generator has lost interlace. Note the apparent loss of one field.

talk is evident on driven monitors as a slight horizontal line displacement at the vertical raster edges and on vertical lines in the picture. The frequency of the crosstalk can be determined by considering the number of such horizontal line displacements occurring from top to bottom of the raster as follows:

Crosstalk Frequency	Number of Displacements Top to Bottom
4500	70
900	14
180	3

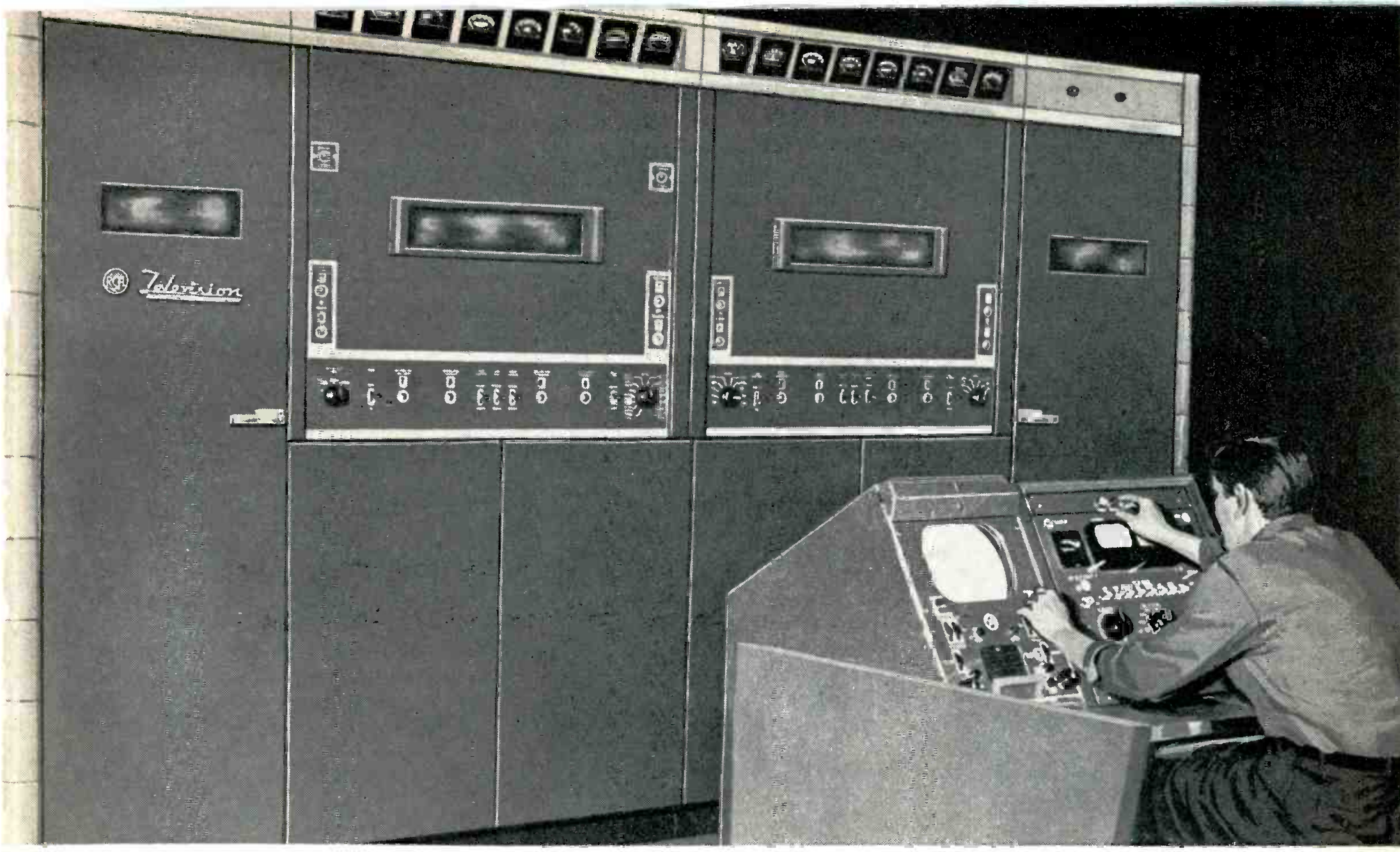
If this effect should be evident on all driven monitors, the counter indicated should be additionally shielded or wiring re-routed until the interference is eliminated.

A much more prevalent type of sync crosstalk is that which occurs between two non-synchronous sources such as local and network or local and video tape signal. This trouble is evident as a vertical bar or line moving back-and-forth horizontally through the signal when a remote source not tied to the local sync generator is observed. When this condition exists, local sync will also crosstalk with the signal from the video tape recorder in playblack mode. Also in many cases, the system is subject to pickup of strong fields of a transient nature such as radiation from inadequately shielded rotating machinery.

Trouble of this nature is usually the result of "ground-loops." A ground loop in an otherwise well designed installation is most often caused by an open or intermittent ground at one end of a coax cable. The signal at the open shield end must pick up its ground return through a number of racks depending upon the cable length and routing.

Each cable should be disconnected from the sending end and checked with an ohmmeter from center conductor to shield to determine if the termination resistance is obtained. If the shield is open, no continuity will exist. Always twist both sending and receiving connectors while making this check so that loose or intermittent (or high-resistance) connections will be evident.

(This has been the second article in a series of general and specific considerations in telecast system maintenance. Next month, the third editorial will deal with "Amplitude Calibration and Level Interpretation"—Editor.)



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FCC Approves FM Stereophonic Broadcasting

A composite GE-Zenith multiplex transmission system standard is adopted

1. The Commission on March 22, 1955, released a Report and Order in Docket No. 10832 (FCC 55-340) which adopted rules providing for the issuance of Subsidiary Communications Authorizations (SCA's) to FM broadcasters — Section 3.293, et seq. After a few years of operation under these rules, it became evident that multiplex techniques could be employed for additional uses beyond the limited "news, music, time and weather" format prescribed therein. Accordingly, a Notice of Inquiry was released on July 8, 1958 (Docket No. 12517; FCC 58-636), for the purpose of exploring possible additional uses of FM multiplexing.

2. A preliminary examination of the comments submitted in response to the Notice of Inquiry in Docket No. 12517 demonstrated a widespread interest in the subject of FM stereophonic broadcasting by means of subcarrier multiplex transmission in conjunction with main channel operation. Accordingly, the Commission on March 12, 1959, released a Further Notice of Inquiry (FCC 59-211) which enlarged the scope of the proceedings under Docket No. 12517 to afford interested persons an opportunity to subbmit data and opinions directed specifically to the matter of FM stereophonic broadcasting.

3. During the pendency of the Notice of Inquiry, the Electronic Industries Association organized the National Stereophonic Radio Committee (NSRC) for the purpose of developing and recommending national standards for FM stereophonic radio. As a result of its studies, the NSRC submitted for consideration in Docket No. 12517 seven FM stereophonic broadcasting systems. Supplemental comments were submitted by the Radio Corporation of America, H. M. Davison, National Broadcasting Company, Zenith Radio Corporation, Philco Corporation, Multiplex Development Corporation, Crosby Laboratories, Inc., General Electric Company, FM Station WJBR, Audio Engineering Society, J. David Dykstra and others. This material formed the basis for the instant Notice of Proposed Rule Making (FCC 60-498; 25 F.R. 4257) released May 9, 1960, wherein the engineering characteristics of the seven systems submitted by the NSRC and an additional system submitted by the Philco Corporation were described and comments requested thereon.

4. The notice of proposed rule making in this proceeding emphasized that comments expressing preferences unsupported by engineering analyses were not desired, since adequate provision was made for the submission of general comments in Docket No. 12517. Nonetheless, more than 2500 such comments were received, most of which resulted from a series of articles in the trade press which reflected adversely on certain of the systems under consideration and concluded by urging readers to write to the Chairman of this agency on behalf of one particular system. Even though these "votes" cannot form the basis of our decision, they are nonetheless indicative of an intense interest in FM stereophonic broadcasting by a segment of the listening public.

5. Comments of an engineering nature were submitted by the Philco Corporation, Radio Corporation of America, Electric and Musical Industries, Ltd., Concert Network, Moseley Associates, Multiplex Development Corporation, Charles River Broadcasting Co. (WCRB), J. D. Dykstra, H. M. Davison, Zenith Corporation, Channel Broadcasting Company, Inc. (KRCW), General Electric Company, Crosby-Teletronics Corporation, H. H. Scott Company, Inc., Pacific FM, Inc. (KPEN) and others. Additionally, six of the eight systems outlined in the Notice of Proposed Rule Making were thoroughly field tested by the NSRC under FCC observation. Our analysis of the comments together with data empirically derived from the field test program form the basis of our decision in this proceeding. In this connection, we wish to express our gratitude to the National Stereophonic Radio Committee and to its members who devoted their time and talents to the end that we might be fully informed in the matters extant in this proceeding.

6. We feel that FM stereophonic transmission is properly an adjunct to existing aural broadcast service, to be permitted on a voluntary basis as part of the FM broadcast service. Moreover, on the basis of the information developed in this proceeding, we affirm at the threshold our conviction that there must be a single set of national standards governing FM stereophonic broadcasting.

7. Of the eight stereophonic broadcasting systems contained in the notice of proposed rule making, Systems 5 and 6 were withdrawn by their proponents.[1] In order to narrow further the range of choices leading to our ultimate selection of a stereophonic system we turn briefly to the requirements of frequency response and stereo separation as applied to FM stereophonic broadcasting. Respondents disagree as to the desirability of and the need for maintaining suitable frequency response and electrical separation to 15,000 cycles. Each of the proposed systems transmits audio frequencies up to 15,000 cycles as main channel modulation, but Systems 2A and 2B have stereo subcarrier upper limitations at 7,000 and 8,000 cycles respectively. An upper limit of 9,500 cycles has also been suggested.[2] These two systems are characterized by a cross-feed-

EDITOR'S NOTE

This is a report and actions from the proceedings of the FCC released April 20, 1961. The text is a technical evaluation of the various proposed stereophonic systems and the conclusions of the recent broadcast tests supported by the N.S.R.C., held in Pittsburgh and Uniontown, Pa.

Reference to a back article, "Stereophonic Broadcast Tests by the National Stereophonic Radio Committee," as featured in the February, 1961, issue of BROADCAST ENGINEERING, *may be helpful in understanding the conditions and data outlined in this information.*

The new rules and definitions covering these latest developments pertaining to stereophonic broadcasting and SCA operations may be found in BROADCAST ENGINEERING'S *regular FCC department, "Amendments and Proposed Changes of F.C.C. Regulations."*

[1]See comments of Philco Corporation received July 27, 1960; also report on developmental operation of WGFM received May 23, 1960.

[2]The Radio Corporation of America's comments of August 8, 1960 recommended the adoption of a system with a stereophonic subchannel modulation band from 30 to 9,500 cycles. For the reasons indicated elsewhere, we cannot accept this recommendation.

ing technique in the receiver[3] which injects main channel audio components above the stereo subchannel cut-off frequency into the demodulated subcarrier audio. Hence, the systems lack stereo separation above the stereo subcarrier cut-off frequency. There is considerable evidence that frequency response and stereo separation above 8,000 cycles make a significant contribution to stereophonic quality.[4,5] On the basis of this evidence and our analysis of the systems remaining, we find that Systems 1, 4, and 4A provide frequency response and stereo separation markedly superior to Systems 2A and 2B—up to 15,000 cycles. Since a prime objective is good stereophonic quality, we are not favorably impressed by Systems 2A and 2B.[6]

8. Turning to System 3, we note that it is theoretically superior to all other systems in most respects. We find, howevevr, that in actual operation its capability for producing a subjective stereophonic effect is handicapped by orchestral dynamics in that the separation of left and right microphone signals is not accurately preserved for reproduction at the respective loudspeakers. On sustained tones, for example, the output for the stereo receiver becomes monophonic. On the other hand, program material consisting of a number of sound sources produces a very rapid shifting of gain between receiver output channels which is a source of annoyance to a listener near one loudspeaker. The tape recordings made during the field test program confirm these limitations, which we find to outweigh the virtues of this system. We are keenly aware of the difficulties under which Electric and Musical Industries has labored both as to unfamiliarity with our procedures and to the mileage which separated the "home office" from the sites of the NSRC meetings and field tests. We extend our appreciation to our British friends for their helpfulness in this common endeavor.

9. By the process of elimination there remain for consideration only Systems 1, 4, and 4A. Shortly prior to the issuance of the notice of proposed rule making, System 4 was modified to the extent that, except for minor parameter differences, Systems 4 and 4A are now theoretically identical and we shall treat them as such.[7] Accordingly, we proceed with a more detailed examination of System 1 and System 4-4A.

10. For System 1, the main channel modulation, which consists of the addition of the left and right microphone signals (L+R), frequency modulates the main carrier to a maximum deviation of plus or minus 37.5 kilocycles. A subcarrier, which is centered at 50 kilocycles and which is modulated by the difference of the left and right microphone signals (L—R) to a maximum of plus or minus 25 kilocycles, also modulates the main carrier plus or minus 37.5 kilocycles. System 4-4A also provides for modulation of the main carrier by the main channel modulation (L+R) but the maximum deviation of the main carrier by this modulation is 67.5 kilocycles. The subcarrier is at 38 kilocycles but is suppressed and amplitude modulated by the difference signal L—R. The suppressed subcarrier sidebands, which exist in the range 23 to 53 kilocycles, also frequency modulate the main carrier to a maximum of plus or minus 67.5 kilocycles. As previously noted, the record before us demonstrates that both System 1 and System 4-4A are adequate in terms of frequency response and stereo separation up to 15,000 cycles. We believe that these systems as proposed are capable, under properly controlled conditions,[8] of performance superior to that demonstrated thus far, and our rules, as amended herein, anticipate this improvement.

11. In the field test program, System 4A exhibited low values of distortion[9] (well below 2 percent) under all test conditions for frequencies below 7,500 cycles. System 1 produced low distortion for frequencies below 7,500 cycles, except when the transmitted left and right signals are equal and of opposite polarity (L = —R). Then the distortion reached higher values pointing up a transmitter and receiver design problem which is more critical in System 1 than

[3]System 2B is intended to provide channel separation without a de-matrix circuit at the receiver, utilizing acoustic cancellation of components of the loudspeaker signals. Optionally, an electrical de-matrix circuit and high frequency cross-over are included. Unless this is done, however, maximum frequency response of the right loudspeaker signal will be limited to 8,000 cycles and its noise output will be approximately 6 db higher than the left speaker.

[4]"Subjective Evaluation of Factors Affecting Two Channel Stereophony" by F. K. Harvey and M. R. Schroeder, presented at the 12th Annual Meeting, Audio Engineering Society, October, 1960.

[5]"Perception of the Stereophonic Effect as a Function of Frequency" by Beaubien and Moore presented at the 11th Annual Meeting, Audio Engineering Society, October, 1959.

[6]Limited frequency response and stereo separation are not the only faults of these systems for, as the field test measurements indicate, Systems 2A and 2B also demonstrate high stereo subchannel noise characteristics and excessive cross-talk.

[7]Examination of the field test data reveals, in some instances, marked differences. These we attribute to variables in receiver design and measuring techniques.

[8]The Comments of the General Electric Company dated October 28, 1960, indicate the importance of maintaining equal transfer characteristics in the L+R channel and the L—R channel with respect to stereo separation. The curves supplied show, for example, that a gain difference of only 1 db between the L+R and L—R channels will result in a stereo separation of 25 db. Additionally, a phase shift difference between the L+R and L—R channels of only 3 degrees will, by itself, result in a stereo separation of 30 db. A combination of these factors would, of course, produce a greater degradation in performance.

[9]The term "distortion" as used here includes harmonic distortion, cross-talk and intermodulation products due to system non-linearity either in transmission or reception.

in any other system. Under this condition of L=−R, the instantaneous frequency of the subcarrier varies from 25 kilocycles to 75 kilocycles when the subcarrier is being modulated fully. Hence, the subcarrier portion of the receiver must contain a filter which will accept all frequencies from 25 to 75 kilocycles with as nearly "flat" response as possible, but must attentuate all frequencies below aproximately 25 kilocycles. While it is theoretically possible to design and manufacture a satisfactory subcarrier separation filter for System 1 receivers, there is no evidence that this has been done or that it could be done at moderate cost.

12. The field test program provided for the measurement of harmonic distortion and required the insertion of a 15-kilocycle low-pass filter in the receiver output. In view of the presence of this filter it was not possible to measure harmonic distortion at frequencies above 7,500 cycles. System 4 was measured for "distortion" up to 15,000 cycles, and the distortion analyzer indicated the presence of undesired signal components in the receiver output of this system. The numerical values are not necessarily accurate, because of limitations of the test instruments used and it is reasonable to expect that similar results would have been obtained had the other systems been so tested. In analyzing the measurements to determine the "distortion" characteristics of System 4-4A, we note that measurements at the transmitter failed to exhibit correspondingly high "distortion" figures. While to some degree the inaccuracies may be attributed to measuring techniques and to the limitations of test instruments used, there does exist a degree of distortion which originates in the receiver and which is caused by non-linearity in the detector circuits and by certain phase shift characteristics of the receiver intermediate frequency (IF) stages near the extremity of the IF pass-band. On the basis of certain liberal assumptions, the degree of distortion of AM subcarrier systems (such as System 4-4A) has been calculated.[10] Re-alignment or modification of existing receivers for a broader, less "peaked" frequency response of IF stages is a remedy although this would reduce selectivity, sensitivity and signal-to-noise performance of the receiver. Our analysis of the problem leads us to the conclusion that the expense involved in overcoming the receiver distortion present in System 4-4A will not be nearly so great as the expense involved in overcoming the receiver dis-

[10] See Zenith Radio Corporation comments dated October 28, 1960, in Docket No. 13506 and comments of the Radio Corporation of America dated March 14, 1960 in Docket No. 12517.

tortion problem of System 1.[11] It is reasonable to assume that this cost differential would be reflected in the pricing of stereophonic receivers.

13. With respect to the question of monophonic distortion, i.e., the distortion that would appear at the output of a monophonic receiver while a station is engaged in stereophonic broadcasting, we find that both System 1 and System 4-4A produce very low distortion values and, accordingly, the monophonic listener would not be affected thereby.

14. The relative absence of noise in the output of receivers is of great importance in any broadcast transmission system. Signal-to-noise ratio, which is the term commonly used to describe this quality, is ordinarily expressed in decibels and is based upon the ratio, at the output of the receiver, of the power of the desired audio to the total noise power in the frequency band under consideration. The total noise is principally composed of (1) ambient noise or "static" radio fields, (2) thermal agitation noise in the resistance that the antenna system presents to the input terminals of the receiver and (3) noise generated within the receiver as a result of thermal agitation effects.

15. In comparing FM stereophonic systems, it is customary to use as the standard of comparison the signal-to-noise ratio obtained with monophonic transmission and reception for a given amount of transmitted power and other specified conditions, including height of antenna, transmission path and receiver sensitivity. When stereophonic transmission is substituted under the same set of conditions, the main carrier output and subcarrier output at the receiver will have reduced signal-to-noise ratios. The amount of reduction depends upon a number of transmission parameters, including the subcarrier frequency, the frequency swing of the main and subcarriers and the deviation of the main carrier caused by the subcarrier or subcarriers. The calculated loss of signal-to-noise ratio, compared to monophonic transmission and reception for each System is:

	System 1	System 4-4A Less than
Monophonic receiver output	6 db	1 db
Subcarrier output	15 db	23 db
Left signal output	13 db	20 db
Right signal output	13 db	20 db

16. It will be observed that System 1 has the greater loss in signal to noise ratio for monophonic reception and the lesser loss for stereo; conversely, System 4-4A has a smaller loss for monophonic reception and a greater loss for stereo. Both the monophonic and stereo losses for System 4-4A would be greater if SCA subcarrier frequencies were also used.[12]

17. The table below affords some comparison between Systems 1 and 4-4A for expected service range for a given level of signal-to-noise performance. It is based upon the figures in Paragraph 15, *supra*, the measured performance of two FM tuners (used in the field test program) which differ widely in price, and the curves in § 3.333 of the Commission rules.

	System 1 Tuner No. 1	System 1 Tuner No. 2	System 4-4A Tuner No. 1	System 4-4A Tuner No. 2
Distance in miles:				
MM[1]	90	46	90	46
SM[2]	81	37	88	44
SS[3]	71	30	61	23
Coverage in square miles:				
MM	25,400	6,650	25,400	6,650
SM	20,650	4,300	24,400	6,100
SS	15,850	2,830	11,700	1,660
Coverage in square miles lost (from MM):				
SM	4,750	2,350	1,000	550
SS	9,550	3,820	13,700	4,990

[1] MM: Monophonic transmission and monophonic reception.

[2] SM: Stereophonic transmission and monophonic reception.

[3] SS: Stereophonic transmission and stereophonic reception.

Assumptions: Effective radiated power 20 kilowatts; transmitting antenna 500 feet in height; receiving antenna: half-wave dipole, 30 feet in height; service areas not subject to co-channel or adjacent channel interference; frequency: 97 megacycles; signal-to-noise ratio 60 db at output of FM tuner.

18. The most distinct advantage for System 1 would occur under conditions in which stereo listeners would be unable to use outside antennas or otherwise unable to receive anything but low voltages at the receiver antenna input terminals. Under these circumstances, more listeners would receive a usable stereo signal under System 1 than under System 4-4A. With respect to signal-to-noise performance for main channel monophonic reception, listeners in fringe areas or otherwise under low signal conditions would fare better with System 4-4A than under System 1.

19. In anticipation of the noted impairment of main channel coverage associated with System 1, comments were requested in the Notice of Proposed Rule Making on "the need for or desirability of increases in transmitter power output to offset reductions in main channel modulation." After examining the comments we do not consider power increase to be a satisfactory solution. Many FM stations are now operating with a maximum transmitter power output and a requirement to increase transmitter power during hours of stereophonic programming would require the installation of a new transmitter. A more serious consequence, however, is the definite probability that raising transmitter power would increase co-channel and adjacent channel interference during periods of subchannel activity.

20. On May 9, 1960, we released a Report and Order in Docket No. 12517 (FCC 60-497) which modified our rules to extend the uses to which SCA multiplex subchannels may be put. Permissible uses must now fall within one or both of the following categories:

(1) Transmission of programs which are of a broadcast nature, but which are of interest primarily to limited segments of the public wishing to subscribe thereto. Illustrative services include: background music; storecasting; detailed weather forecasting; special time signals; and other material of a broadcast nature expressly designed and intended for business, professional, educational, religious, trade, labor, agricultural or other groups engaged in any lawful activity.

(2) Transmission of signals which are directly related to the operation of FM broadcast stations; for example: relaying of broadcast material to other FM and standard broadcast stations; remote cueing and order circuits; remote control telemetering functions associated with authorized STL operation, and similar uses.

21. As of January 31, 1961, more than 250 stations held SCA multiplex authorizations. It is estimated that over 200 stations are actually providing background music and other services on authorized subcarrier frequencies. Because its wide band characteristics make it mutually exclusive with SCA multiplex operation, adoption of System 1 would require each of these stations to choose between SCA operation and stereophonic programming. Some stations, unsupported by companion AM or TV operations, would find it difficult if not financially impossible to forego subscription revenues. Other stations utilizing SCA subcarrier frequencies for relaying broadcast material to other FM and standard broadcast stations and for various telemetering functions would also be foreclosed from engaging in stereophonic broadcasting with System 1. While an exact assessment of the future of SCA operations is impossible, the extended uses recently sanctioned under Docket No. 12517 have focused increased interest on the potentialities of SCA operation and it is possible that the next few years will find the majority of FM broadcast stations engaging in such operation.

22. The necessity, inherent in the adoption of System 1, of choosing between stereophonic broadcasting and SCA operation is of no decisional significance insofar as the major markets

[11] We also note the comments of the General Electric Company dated October 28, 1960, to the effect that adoption of System A would permit the transmitter distortion specifications presently contained in our rules to be extended to stereophonic broadcasting without change.

[12] This further loss may be controlled by limiting the amount of main carrier modulation permitted by SCA subcarriers.

Photo courtesy American Broadcasting Co.

"Thanks, Al Powley"

Your telegram tells more effectively than any advertisement, the performance you can expect — and get — from the GL-7629 General Electric image orthicon. The results are all the more gratifying because this was the first time the President's press conference was taped for release through the three major networks (by WMAL-TV, ABC, Washington, D. C.). Meeting the quality requirements of critical video tape recording under these conditions was a real challenge to your staff and your equipment.

The GL-7629 is especially designed for both black-and-white and color telecasting where normal lighting is either unavailable or undesirable. It requires less than one-tenth the light of standard camera tubes. A thin-film magnesium oxide target improves depth of focus, eliminates "stickiness" and burn-in. Use the GL-7629 to broaden the scope of your color and monochrome camera work — in the studio and for remotes. General Electric Company, Distributor Sales, Owensboro, Kentucky.

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are concerned, for in larger cities where numerous FM assignments have been made only a small portion of FM licensees presently engage in SCA operation. However, our records indicate that of the approximately 250 stations holding SCA's, 81 have been granted to stations in cities which have only one FM station. Here, the necessity of choice assumes greater importance, for a decision by station management to continue with SCA operation would deprive the community of local stereophonic broadcast service for an indeterminate period of time. We also recognize that stations now operating with SCA's have already installed the basic multiplex equipment for stereophonic broadcasting, which equipment could be used for simultaneous SCA/stereophonic operation only if a narrow band system of stereophonic transmission (such as System 4-4A) is adopted.

23. Another factor to be weighed with respect to SCA operations is that a stereophonic receiver designed for System 4-4A would be incapable of receiving SCA transmissions because the latter are FM emissions, whereas the subcarrier detector in the System 4-4A stereo receiver is designed for the reception of AM multiplex signals.

24. Inasmuch as System 1 rules out the use of additional subchannels, the problem of cross-talk between the stereophonic subchannel and other channels need not be considered in relation to that system. However, this question must be considered with respect to System 4-4A. We are not vitally concerned with cross-talk from the main channel or stereophonic subchannel into SCA subchannels, for the latter do not carry programming which is intended for the general public. We do find from the record before us, however, that for System 4-4A the cross-talk into SCA channels is not sufficient to destroy the usefulness of SCA services. With respect to cross-talk from SCA subchannels into the main channel and stereophonic subchannel, the field test program did not yield values for System 4-4A which are completely acceptable. In this connection, adoption of System 4-4A would require that we carry forward the protection values already applicable to SCA operation—§ 3.319 (e) of the rules.

25. With the exception of System 2B, the systems described in the Notice of Proposed Rule Making would all transmit the sum of the Left and Right microphone signals (L+R) as the signal heard by the main channel monophonic listener. It appears that, for the monophonic listener, this is preferable to the alternatives of single Left (L) or Right (R) microphone signals or the two Left minus Right (2L—R) combination advocated in System 2B. It is recognized that, because of acoustical effects, some stereophonic recordings fail to provide good monophonic presentation upon straight addition of the L and R channels. This same problem has been encountered by the recording industry in the preparation of monophonic records from stereophonic recordings.[13] In all probability, most of the stereophonic programming by the broadcasting industry will be from available sterephonic tapes and discs. Hence, FM stations engaging in stereophonic broadcasting will be expected to exercise appropriate discretion in the selection of program material.

26. We call attention to existing arrangements among standard, FM and TV broadcast stations whereby Left and Right signals are separately transmitted in order to achieve stereophonic effects. While recognizing that many stations engaging in this type of operation have screened the records and tapes used in stereophonic transmission in order to assure some semblance of aural balance, we feel that dual station stereophonic programming violates good engineering practice insofar as the monophonic listener is concerned. Accordingly, we contemplate the discontinuance of dual station stereophonic programming at such time as equipment to conduct FM stereophonic broadcasting under the rules herein adopted becomes generally available.

27. In Paragraph 7 of the Notice of Proposed Rule Making comments were requested, among other things, on: (1) The need for or desirability of suitable frequency and modulation monitors for use with the respective systems and the technical specifications for such monitors; (2) the approximate cost and practicability of transmitter modifications; and (3) the cost and relative simplicity of stereophonic receivers or adaptations of existing receivers for the respective systems.

28. With respect to the necessity for frequency and modulation monitors, we find that since stereophonic broadcasting is intended to be received by the general public, it should be conducted only under suitable controls to assure not only the proper operation of the main channel as presently required by our Rules, but of the stereophonic subchannel as well. Accordingly, our Rules will be amended in the near future to require the use of frequency and modulation monitors capable of monitoring the operation of the stereophonic subchannel.

29. As stated in Paragraph 22, *supra*, stations engaged in SCA operations have already installed the basic multiplex equipment for stereophonic broadcasting. While none of the proponents submitted information specifically related to the cost of transmitter modifications, the General Electric Company indicated that a survey conducted in October of 1960 demonstrated that the cost of suitable stereophonic subcarrier signal generators would be acceptable to the majority of FM broadcasters.

30. With respect to the cost and relative simplicity of stereophonic receivers and adoptations of existing receivers, we have indicated our concern with the cost of a receiver for System 1 providing acceptably low distortion. We are mindful of the fact that a limited number of adapters were built and sold during the relatively short time that System 1 was being tested by various FM broadcast stations under developmental authorizations issued by this agency. It is understood that these adapters were sold for prices ranging from approximately fifty to one hundred dollars, depending on the manufacturer.

31. Since adapters have never been made available to the listening public in connection with the developmental testing of Systems 4—4A, we have no information as to the probable retail cost of such adapters. We do note, however, that the adapter for System 4—4A recommended by the proponent of System 4A would be a relatively small device which could be manufactured for a parts cost of less than eight dollars. However, the cost of the adapter to the ultimate consumer will represent only a fractional part of the cost of conversion to stereophonic reception; the necessity for an additional amplifier and speaker must also be taken into account. And, if the field test results are indicative of the true performance capabilities of present stereo receivers and adapters, we must conclude that receiver development to date has been inadequate for stereo reception of optimum quality. It is therefore to be expected that good stereo receivers will be considerably more costly than monophonic receivers, irrespective of the system adopted.

32. The closing date, as extended, for the submission of original comments in this proceeding was November 8, 1960 with reply comments due November 21, 1960. However, a number of respondents submitted original and rebuttal comments after the dates indicated, a few of which were accompanied by petitions for acceptance of late filing. Inasmuch as this material has been of assistance in our deliberations and in view of the non-adjudicatory nature of this proceeding, we take official notice of all comments received through March 1, 1961. The necessity for our acting on petitions for acceptance of late filing

[13]See comment of NSRC dated October 24, 1960, Docket No. 13506.

in this proceeding has therefore been rendered moot.

33. In our recent Report and Order in Docket No. 13755 (FCC 61-116, released January 30, 1961) amending the Rules to permit noncommercial educational FM broadcast stations to engage in specified nonbroadcast activities on a multiplex basis, we noted that "to the extent that (such) licensees can demonstrate a need for FM stereophonic broadcasting, such need will be considered by the Commission" in connection with the instant proceeding. In view of the limited response to this issue, we cannot conclude on the existing record that amendment of the Rules governing noncommercial educational FM broadcast stations to provide for stereophonic broadcasting would be warranted at this time. However, in recognition of the comments filed by WGBH Educational Foundation, we intend to institute a separate rule making proceeding in the near future to ascertain whether a requirement for stereophonic broadcasting can be established by educational FM interests.

34. The proponents of Systems 1, 4, and 4A have, as requested in the Notice of Proposed Rule Making, submitted statements which indicate in substance that each is prepared to grant non-exclusive licenses under any one or more of its patent applications and the patents issuing thereon to any responsible party at reasonable royalties for the manufacture, use and sale of the apparatus covered thereby. We find these representations consistent with the patent policies of the Commission which are designed to obviate any restraint of trade or monopolistic practices in matters coming within its cognizance.

35. In summary, we find that Systems 2A and 2B must be rejected because of inferior frequency response and stereo separation together with excessive cross-talk and high stereo subchannel noise characteristics. System 3, despite impressive theoretical advantages, must be rejected because of its inability to handle orchestral dynamics in a manner that will produce an acceptable subjective stereophonic effect. Systems 5 and 6 were withdrawn by their proponents from further considerations. The adoption of national FM stereophonic broadcast standards therefore reduces to a selection of either System 1 or System 4—4A. With respect to the technical criteria of frequency response and stereophonic separation these two systems compare favorably on a theoretical as well as a practical basis. However, we find that System 4—4A has the clearly decisive advantage of being able to provide stereophonic broadcast service with negligible effect on the monophonic listener and that the correlative

disadvantage of System 1 is its detrimental effect on the monophonic listener[14]. As stated in the Notice of Proposed Rule Making, we feel that "* * * any stereophonic system adopted should be based upon standards capable of rendering as high a quality of service as the art can provide, consistent with economic and other factors involved, without significant degradation of the service now provided under existing FM rules" (emphasis supplied). We find, therefore, that the public interest would best be served by the adoption of System 4—4A.[15]

36. It should be observed that System 4—4A, like any multiplex transmission system, will increase energy transmission at the edges of the FM channel involved. Accordingly, for optimum stereophonic reception, the bandwidth of stereophonic receivers must be considerably greater than that of monophonic receivers. Stereophonic receivers will thus be inherently more susceptible to adjacent channel interference. Also System 4—4A, in common with other multiplex systems, will not provide an FM stereophonic service area which is co-extensive with the service area available to monophonic listeners. Accordingly, acceptable monophonic reception of a given station will not, per se, insure acceptable stereophonic reception.

37. Upon the effectiveness of the amendments herein ordered, FM broadcast licensees desiring to undertake stereophonic broadcasting may, without further authority from the Commission, transmit stereophonic programs in accordance with the technical standards and notification procedures herein adopted.

38. Authority for the adoption of this Report and Order and associated rule amendments is contained in sections 303 (b), 303 (c), 303 (e), 303 (g), 303 (j), and 303 (r) of the Communications Act of 1934, as amended.

39. *It is ordered*, This 19th day of April 1961, that effective June 1, 1961, the Commission's rules be amended as set forth below: and

40. *It is furthered ordered*, That proceedings under Docket No. 13506 are hereby terminated.

Released: April 20, 1961.

FEDERAL COMMUNICATIONS COMMISSION,
BEN F. WAPLE,
Acting Secretary.

[14]We are also impressed by the apparent lower cost of System 4-4A, its comparative freedom from distortion, and the fact that its use does not ipso facto displace SCA operation.

[15]System 4-4A is a composite of stereophonic transmission standards proposed by the Zenith Radio Corporation and General Electric Company, respectively. The proponents of the other systems were: System 1, Crosby-Teletronics Corporation; System 2A, Calbest Electronics; System 2B, Multiplex Development Corp.; System 3, Electric and Musical Industries, Ltd.; System 5, General Electric Company's alternate proposal; System 6, Philco Corporation.

Industry News

George Houlroyd Named Foto-Video Vice-President

Albert J. Baracket, president, Foto-Video Electronics, Inc., has announced the election of George F. Houlroyd as vice - president, manufacturing.

From 1949, until he joined the staff of Foto-Video in 1959, Houlroyd served as plant manager for Boonton Radio Corp., where he advanced techniques for the manufacture of electronic instruments. During this period he also instituted safety procedures that won recognition for the company through awards by Liberty Mutual Insurance Co. and the New Jersey Dept. of Labor and Industry.

Prodelin, Inc., Appoints General Sales Manager

The appointment of George B. Voorhis, Jr. as general sales manager has been announced by Prodelin, Inc., Kearny, N. J., designer and manufacturer of antennas and transmission line systems.

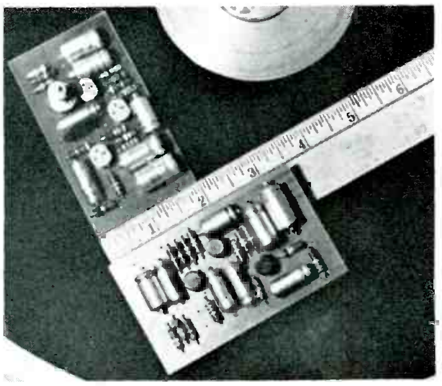
Voorhis was promoted to his new position from that of district sales manager for the company in the New York-New England area. In his new post, he will be responsible for the management and direction of the corporation's newly integrated, nation-wide sales organization.

General Electronic Acquires Rust Remote Control Line

General Electronic Laboratories, Inc., has announced the acquisition of the complete line of Rust remote control systems for broadcasting from Rust Industrial Co., Inc., Manchester, N. H.

The Rust remote control line will be added to GEL's current broadcast equipment lines, the 1 KW and 15 KW FM broadcast transmitters and FM multiplex systems.

Product News



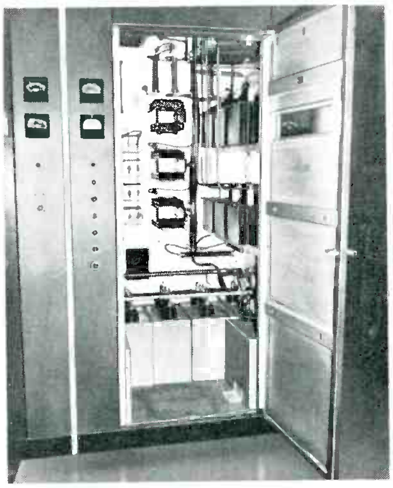
PACKAGED TRANSISTOR AUDIO MODULES CIRCUITS

Packaged or unmounted transister audio modules circuits are available to the broadcasting and recording industry, according to Telesound Electronic Associates, 5715 McGee, Kansas City, Mo. A complete line of military type modules is designed for lower cost of custom installations, additional amplifier stages, and stereophonic broadcasting expansions.

The new series includes microphone preamplifier; tape-transcription pre-amp with variable equalizer; booster amplifier stage; line amplifier, and two sizes of dc power supplies. Each miniature unit exceeds broadcast standards.

DIRECTIONAL ANTENNA GUIDE

Collins Radio Co., Cedar Rapids, Iowa, is offering a booklet describing the factors which should be considered in planning a directional antenna system for AM broadcasting. The publication may be obtained by writing Collins at Cedar Rapids.

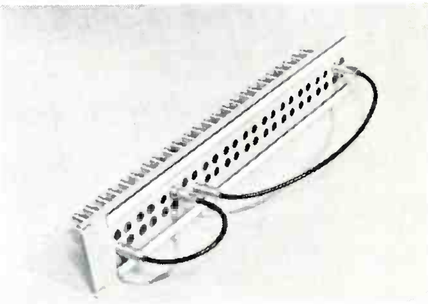


NEW AMPLIPHASE TRANSMITTER FOR AM BROADCASTERS

A new 50-kilowatt ampliphase transmitter for AM broadcasting, featuring all-siliconized power supplies and other improvements, has been announced by RCA Broadcast & Television Equipment Div., 30 Rockefeller Plaza, New York 20, N. Y.

The new transmitter, designated type BTA-50H, supersedes type BTA-50G, developed by RCA in 1950. While incorporating numerous new features, the model retains the basic design, floor space requirements and ease of installation of the original transmitter, it is stated.

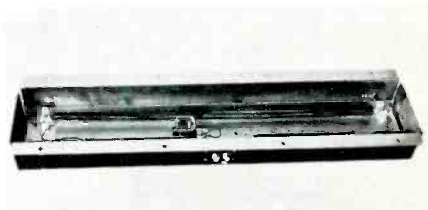
Use of all-siliconized power supplies is said to reduce tube costs and to result in improved reliability for remote control installations where temperatures are subject to wide variations. In addition, the power amplifier and driver of the new transmitter are equipped with new-type tubes which are used in an ampliphase circuit to provide greater peak power capabilities.



RF AND VIDEO PATCHING EQUIPMENT

Trompeter Electronics, 7713 Oakdale Ave., Canoga Park, Calif., has introduced a new line of 52 and 72 ohm coaxial jack strips and patch cords used for the routing of RF in receiver and low power transmitter installations, and the distribution of audio and video signals in data, computer, telemetry, communication and TV installations.

The rack mounted panels are usable for patching in coaxial systems of RG-8, 9, 11, 55, 58, 59, 62, and miniature coaxial cables. Each jack has a BNC fitting on the back for easy installation of the original cable and making any subsequent changes. The jacks and plugs have large wiping and contact surfaces, and are said to be heavily gold plated to insure perfect contact in the worst climatic and salt atmosphere conditions. Panels are available with 12, 20 and 48 jacks.



CBS ELECTRONICS TO MANUFACTURE REVERBERATION UNIT

A new reverberation unit designed to add the "concert hall echo effect" to any audio system or broadcast station has been announced by CBS Electronics, manufacturing division of Columbia Broadcasting System, Inc. A development of CBS laboratories, Stamford, Conn., the new audio component will be manufactured by CBS Electronics at Danvers, Mass.

Incorporating a magnetic driver and two ceramic transducers, the model 3-1-C reverberation unit produces a short delay in the audio signal by causing it to traverse mechanically two unequal lengths of a coiled spring. A ceramic transducer at each end of the spring converts this mechanical wave motion back to electrical energy again. Differential interference between the two reflected sound waves caused by driving the spring off-center produces a pleasing and natural spatial effect upon the reproduced signal. The unit requires external amplifiers.

For further information request bulletin E-438 from CBS Electronics, Information Services, 100 Endicott St., Danvers, Mass.

AMENDMENTS AND PROPOSED CHANGES OF F.C.C. REGULATIONS

Notice of new rulings pertaining to Part 3, Radio Broadcast Services: Permission of FM Broadcast Stations to Transmit Stereophonic Programs on a Multiplex Basis.

1. New § 3.297 is added to read as follows:

§ 3.297 Stereophonic broadcasting.

FM broadcast stations may, without further authority, transmit stereophonic programs in accordance with the technical standards set forth in § 3.322: *Provided, however,* That the Commission and the Engineer in Charge of the radio district in which the station is located shall be notified within 10 days from the installation of type-accepted stereophonic transmission equipment or any change therein, and: *Provided further,* That the Commission and the Engineer in Charge shall be notified within 10 days from the commencement of stereophonic operation, scheduled hours of such operation or any change therein.

2. Section 3.310 is amended by adding the following paragraphs:

§ 3.310 Definitions.

* * * * *

(t) *Cross-talk.* An undesired signal occurring in one channel caused by an electrical signal in another channel.

(u) *FM stereophonic broadcast.* The transmission of a stereophonic program by a single FM broadcast station utilizing the main channel and a stereophonic subchannel.

(v) *Left (or right) signal.* The electrical output of a microphone or combination of microphones placed so as to convey the intensity, time and location of sounds originating predominately to the listener's left (or right) of the center of the performing area.

(w) *Left (or right) stereophonic channel.* The left (or right) signal as electrically reproduced in reception of FM stereophonic broadcasts.

(x) *Main channel.* The band of frequencies from 50 to 15,000 cycles which frequency modulate the main carrier.

(y) *Pilot subcarrier.* A subcarrier serving as a control signal for use in the reception of FM stereophonic broadcasts.

(z) *Stereophonic separation.* The ratio of the electrical signal caused in the right (or left) stereophonic channel to the electrical signal caused in the left (or right) stereophonic channel by the transmission of only a right (or left) signal.

(aa) *Stereophonic subcarrier.* A subcarrier having a frequency which is the second harmonic of the pilot subcarrier frequency and which is employed in FM stereophonic broadcasting.

(bb) *Stereophonic subchannel.* The band of frequencies from 23 to 53 kilocycles containing the stereophonic subcarrier and its associated sidebands.

3. Section 3.319 is amended to read as follows:

§ 3.319 Subsidiary communications multiplex operations: engineering standards.

(a) Frequency modulation of SCA subcarriers shall be used.

(b) The instantaneous frequency of SCA subcarriers shall at all times be within the range 20 to 75 kilocycles: *Provided, however,* That when the station is engaged in stereophonic broadcasting pursuant to § 3.297, the instantaneous frequency of SCA subcarriers shall at all times be within the range 53 to 75 kilocycles.

(c) The arithmetic sum of the modulation of the main carrier by SCA subcarriers shall not exceed 30 percent: *Provided, however,* That when the station is engaged in stereophonic broadcasting pursuant to § 3.297, the arithmetic sum of the modulation of the main carrier by the SCA subcarriers shall not exceed 10 percent.

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 SCA multiplex operation may not be appropriate since the subcarriers utilized are above 20,000 cycles.

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

(e) Frequency modulation of the main carrier caused by the SCA subcarrier operation shall, in the frequency range 50 to 15,000 cycles, be at least 60 db below 100 percent modulation: *Provided, however,* That when the station is engaged in stereophonic broadcasting pursuant to § 3.297, frequency modulation of the main carrier by the SCA subcarrier operation shall, in the frequency range 50 to 53,000 cycles, be at least 60 db below 100 per cent modulation.

4. New § 3.322 is added to read as follows:

§ 3.322 Stereophonic transmission standards.

(a) The modulating signal for the main channel shall consist of the sum of the left and right signals.

(b) A pilot subcarrier at 19,000 cycles plus or minus 2 cycles shall be transmitted that shall frequency modulate the main carrier between the limits of 8 and 10 per cent.

(c) The stereophonic subcarrier shall be the second harmonic of the pilot subcarrier and shall cross the time axis with a positive slope simultaneously with each crossing of the time axis by the pilot subcarrier.

(d) Amplitude modulation of the stereophonic subcarrier shall be used.

(e) The stereophonic subcarrier shall be suppressed to a level less than one percent modulation of the main carrier.

(f) The stereophonic subcarrier shall be capable of accepting audio frequencies from 50 to 15,000 cycles.

(g) The modulating signal for the stereophonic subcarrier shall be equal to the difference of the left and right signals.

(h) The pre-emphasis characteristics of the stereophonic subchannel shall be identical with those of the main channel with respect to phase and amplitude at all frequencies.

(i) The sum of the side bands resulting from amplitude modulation of the stereophonic subcarrier shall not cause a peak deviation of the main carrier in excess of 45 percent of total modulation (excluding SCA subcarriers) when only a left (or right) signal exists; simultaneously in the main channel, the devi-

EDITOR'S NOTE:

For complete details of the decision concerning the new Stereophonic Broadcasting by FM Radio Standards, see "FCC Approves FM Stereophonic Broadcasting," page 28.

ation when only a left (or right) signal exists shall not exceed 45 percent of total modulation (excluding SCA subcarriers).

(j) Total modulation of the main carrier including pilot subcarrier and SCA subcarriers shall meet the requirements of Section 3.268 with maximum modulation of the main carrier by all SCA subcarriers limited to 10 percent.

(k) At the instant when only a positive left signal is applied, the main channel modulation shall cause an upward deviation of the main carrier frequency; and the stereophonic subcarrier and its sidebands signal shall cross the time axis simultaneously and in the same direction.

(l) The ratio of peak main channel deviation to peak stereophonic subchannel deviation when only a steady state left (or right) signal exists shall be within plus or minus 3.5 percent of unity for all levels of this signal and all frequencies from 50 to 15,000 cycles.

(m) The phase difference between the zero points of the main channel signal and the stereophonic subcarrier sidebands envelope, when only a steady state left (or right) signal exists, shall not exceed plus or minus 3 degrees for audio modulating frequencies from 50 to 15,000 cycles.

Note: If the stereophonic separation between left and right stereophonic channels is better than 29.7 decibels at audio modulating frequencies between 50 and 15,000 cycles, it will be assumed that paragraphs (l) and (m) of this section have been complied with.

(n) Cross-talk into the main channel caused by a signal in the stereophonic subchannel shall be attenuated at least 40 decibels below 90 percent modulation.

(o) Cross-talk into the stereophonic subchannel caused by a signal in the main channel shall be attenuated at least 40 decibels below 90 percent modulation.

(p) For required transmitter performance, all of the requirements of § 3.254 shall apply with the exception that the maximum modulation to be employed is 90 percent (excluding pilot subcarrier) rather than 100 percent.

(q) For electrical performance standards of the transmitter and associated equipment, the requirements of § 3.317 (a) (2), (3), (4), and (5) shall apply to the main channel and the stereophonic subchannel alike, except that where 100 percent modulation is referred to, this figure shall include the pilot subcarrier.

Filed April 24, 1961.

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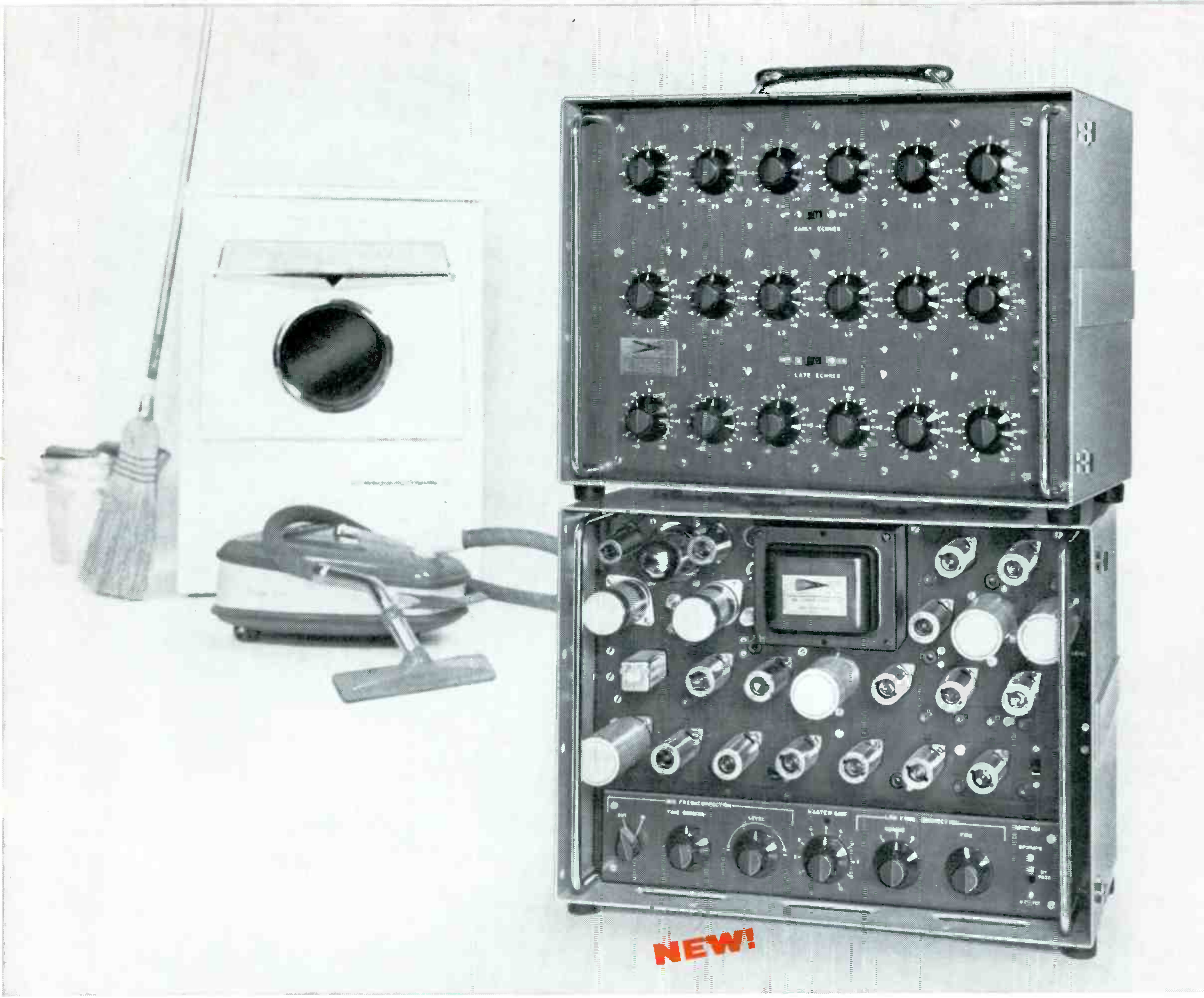
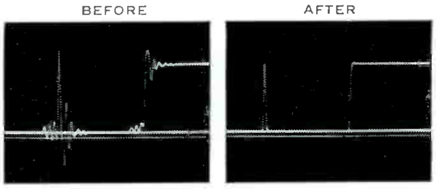


...but only the "Twenty/Twenty" cleans up video transmission distortion

BEFORE AFTER

Photos, taken a few seconds apart, show how the Model 20/20 cleans up smears, overshoots, ringing and other waveform defects.

BEFORE AFTER



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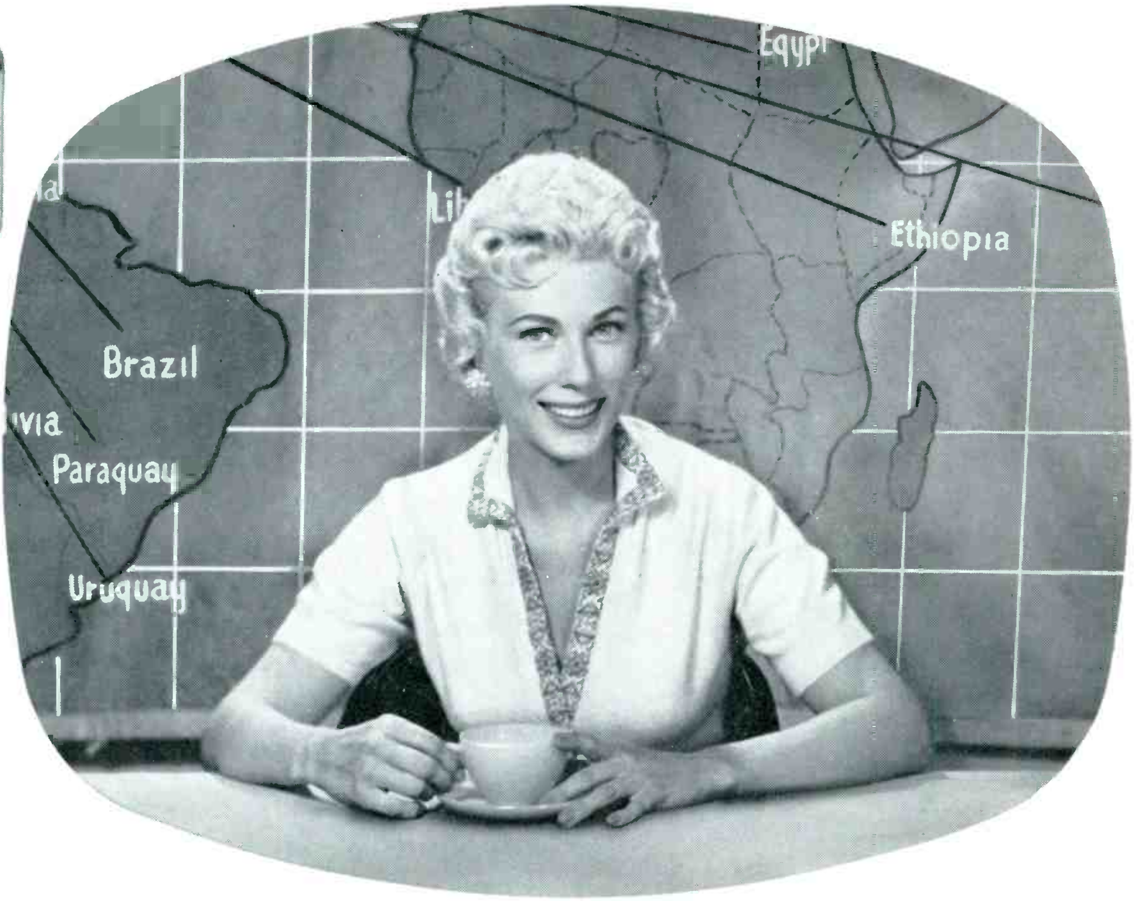

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