DECEMBER, 1959

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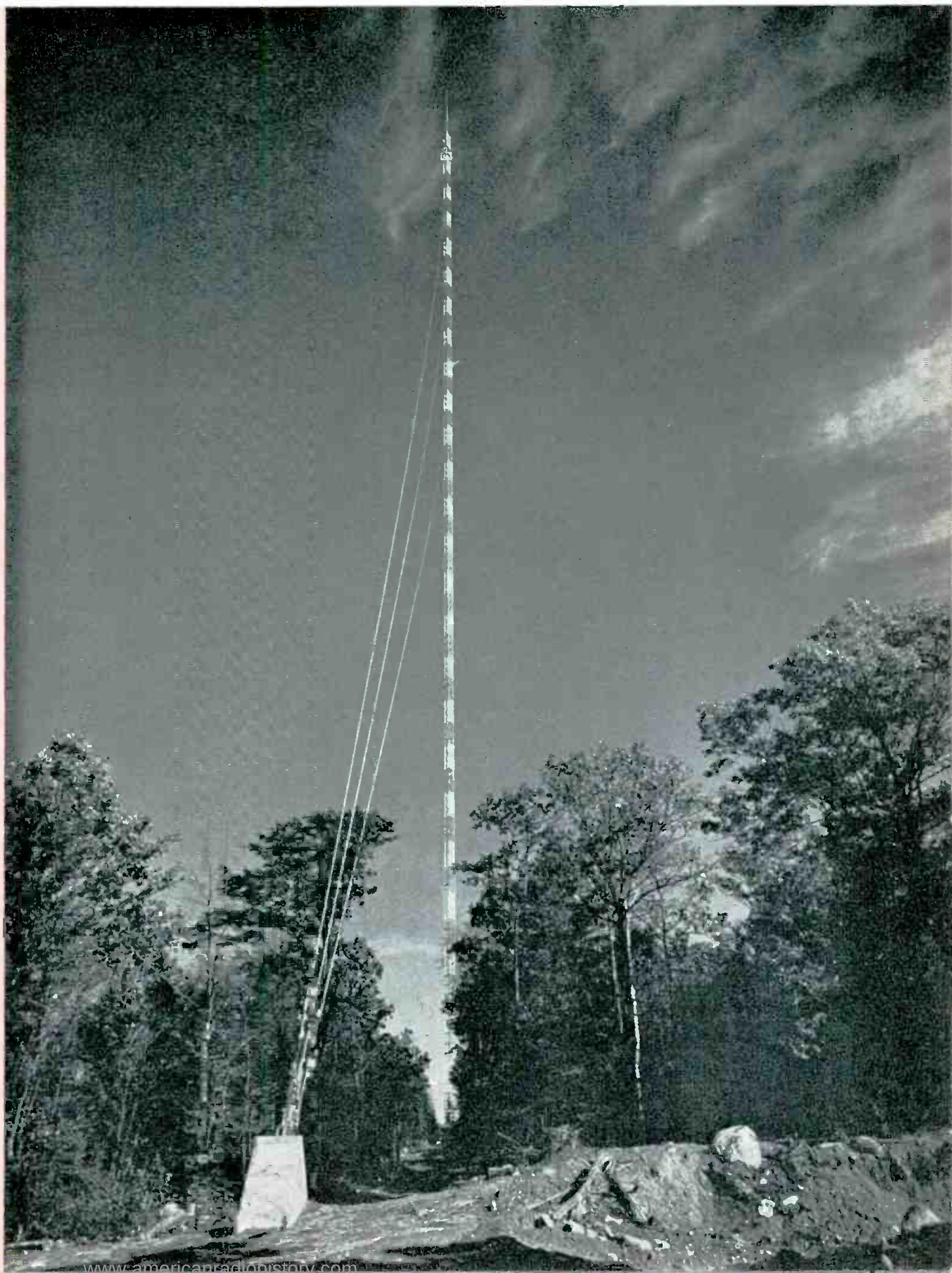
BROADCAST ENGINEERING

THE TECHNICAL JOURNAL OF THE BROADCAST INDUSTRY



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Pulse Amplitude Modulation System of Stereo Broadcasting for FM Stations

Methods of Sub-Carrier Generation for FM

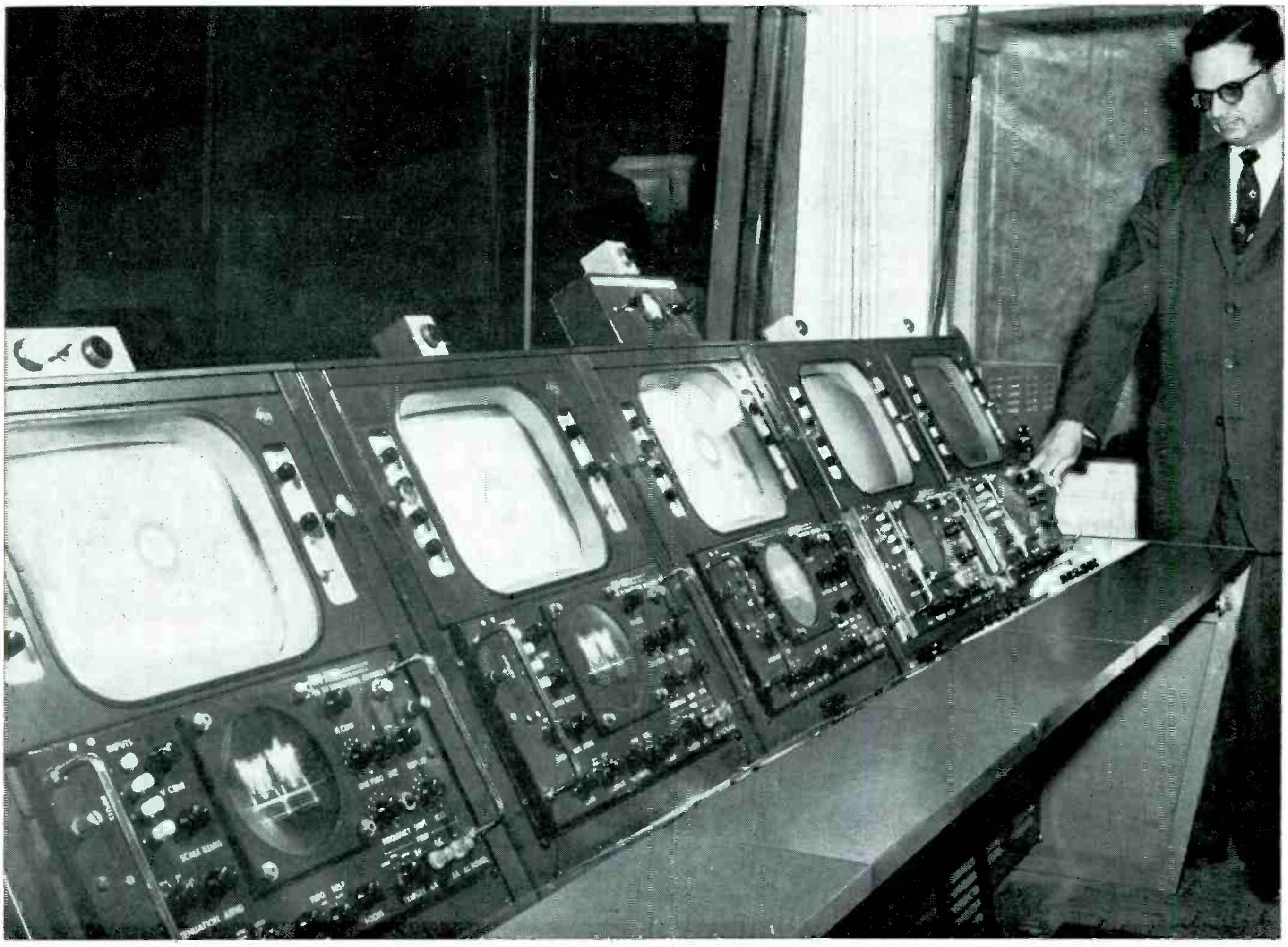
UHF Translators for Educational Television

An Experimental Study of Distortion

Cover picture shows the world's tallest tower at WGAN-TV, Portland, Maine.

FOTO-VIDEO® Waveform Monitor Faces Facts

— "THE FACTS OF CONTINUOUS OPERATION, DAY IN AND DAY OUT"
. . . says Charles Halle of WENH-TV, Durham, N. H. following a year's use of the new **FOTO-VIDEO** V-9B TV Waveform Monitor, the built-in features of which measure up to the precise requirements of this well-known consultant of educational TV stations.



Charles Halle is director of engineering at WENH-TV, the University of New Hampshire station, at Durham. Last December, after searching the field, he chose the rugged Foto-Video—an instrument of near perfection in this exacting phase of TV signal production —as most likely to meet the "operational FACTS of LIFE" in round the clock performance without deviation of characteristics. IT DID!

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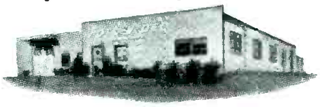
Foto-Video Laboratories, Inc.  Cedar Grove, N.J. CEnter 9-6100

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Cover

Shown on this month's cover is the world's tallest structure. The new 1,619-foot tower of WGAN-TV, Portland, Maine, is almost twice as high as the Eiffel Tower. Its two passenger elevator is the longest vertical lift elevator ever constructed. The total length of all guy cables is 4½ miles. The tower weighs 520,000 pounds and the concrete footings weigh 2,333,680 pounds. The tower was designed, fabricated, and erected by Kline Iron & Steel Co.

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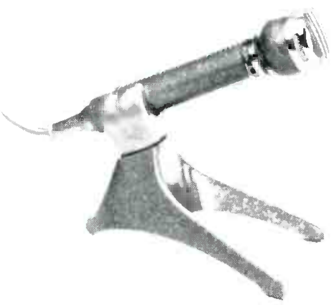

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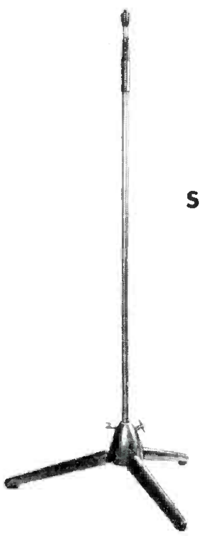
Impedance: 200 ohms (high impedance 50K ohms).

Directional characteristic: Cardioid.



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PAM/FM

A System of Stereo Broadcasting for

Translated from the German "Stereophoner Rundfunk Mittels Puls-Amplituden Modulation" by H. F. Mayer and F. Bath, of Siemens & Halske A. G., Munich. Original article appeared in Rundfunktechnische Mitteilungen, Hamburg, Aug., 1959. Translated by V. J. Skee, President, Electronic Applications, Inc., Stamford, Conn.

TRANSLATOR'S FOREWORD:

A few very minor liberties were taken in this translation in the interest of clarifying the text to U.S.A. engineers; these were in the form of enlargement on specific themes. The meaning, and the intent is that of the original document.

The European broadcaster has the same problem in adopting a system which is completely compatible for stereo-mono transmission as is faced here today. Siemens & Halske in Munich have tested the system proposed here with completely acceptable high quality results. The Siemens & Halske PAM/FM appears to be the outstanding proposal for high quality stereo transmission by the FM stations in Western Germany. FM quality is sustained. Both halves of the stereo signal are transmitted with full modulation, and balanced. A stereo-adapted receiver will hear monophonic broadcasts as transmitted; a monophonic receiver will hear a high grade, unchanged monophonic program when tuned to a PAM/FM transmitter. Full compatability is achieved. Transmitter service area is not perceptibly altered. The recovered stereo program is equal, for even critical listeners, to that originated in the studio control room. Where economic considerations require a subsidiary multiplex service, such can be accommodated so long as sub-carriers used are above 30 kc.

A simple "black box" is needed at the transmitter; this being under a cubic foot in volume. At the receiver, a small adapter under 2 inch by 3 by 6 inches in size (tube version) is needed. Transistorizing the receiver unit can reduce these dimensions. The receiver adapter is plugged into the average receiver without modification, and requires no tuning, balancing, etc.

Siemens & Halske AG in Munich have been most helpful in getting this translation available; they have also assisted in certain experiments, which were necessary.

The PAM/FM system of Siemens & Halske has been forwarded to the Federal Communications Commission for consideration.

1. Introduction

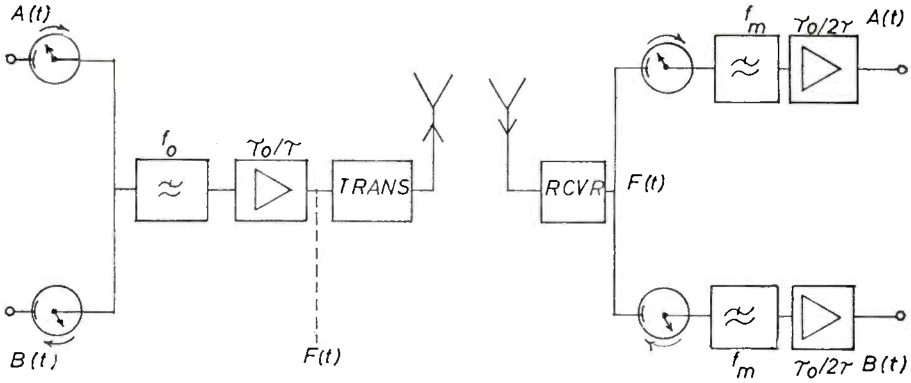
The appearance of stereophonic phonograph recordings and of stereophonic pre-recorded tapes in increasing numbers, which is tantamount to public acceptance, has raised the problem of stereo transmission in the public broadcasting channels. Several systems have been proposed for the reasonable adaptation of existing channels for such transmissions, particularly in the FM band of 88 to 100 (88 to 108) mc range. The systems proposed, and in fact tested, need not be discussed here, except to state that the current so-called multiplex techniques, in some variant or other, seem to be of interest.

Adoption of one standard system for stereo transmission and the modification of existing facilities to the standard, will be a decision of far-reaching importance. Such a decision will have to be most carefully made after searching investigation of the many proposals submitted.

It is considered of special importance that the present service area of FM transmitters is not diminished through the introduction of the stereo program. The following demands are considered reasonable for the stereo technique:

(a) It should permit the transmission of both halves of the stereo program within the channel width of 300 kc.

(b) It should be possible for present monophonic receivers to receive a monophonic program from the



FM Stations

SYSTEM FUNCTION

Fig. 1 pam/fm

stereo program offering. It should also be possible for a receiver adapted for stereo to receive monophonic programs without changes, switching, etc.

(c) The changeover to stereo transmission on the part of an existing FM system must not in any way reduce the strength and quality of the present monophonic signal, even in marginal areas.

(d) The effective service range of the stereo signal must be for all practical purposes equal or nearly equal to the service area of the monophonic signal.

(e) The transmitted stereo signal should not add interference to neighboring channel services (or be at a very low acceptable value).

(f) The economic factor of conversions or adaptation of present receivers, or of circuitry in new receivers, should be kept to an absolute minimum.

(g) The operational security of transmitters converted to stereo transmission must be in every way equal to that of present standards of performance.

(h) *Transmitted quality of both elements of the stereo signal must be identical, and must be at the highest standards obtainable in the present state of the art. (The premise is that FM broadcasting must provide a superior, highest fidelity program quality, plus the advantage of low noise, and wide dynamic range.)*

(i) At the consumer end, receivers adapted, or containing stereo circuitry, must be so designed that no manipulation, balancing, or critical adjustments have to be made by the consumer. He must merely tune in the signal.

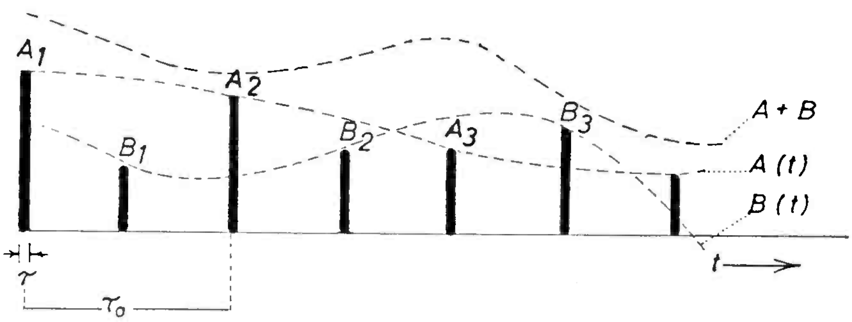
A stereo system will now be described which meets the reasonable specifications listed above; this system is based upon well known tried and tested principles, which have not been considered up to now for stereo transmission. This system after testing meets quality requirements through the techniques of Pulse-amplitude-modulation (PAM).

2. Mode of Transmission

In stereo pickup, one generally sets up a microphone "A" on the right, and a microphone "B" to the left of center related to the music directors position. Amplified signals right and left are sent via studio and lines to the transmitter. These separate signals make up the stereo signal "A" (t) and "B" (t).

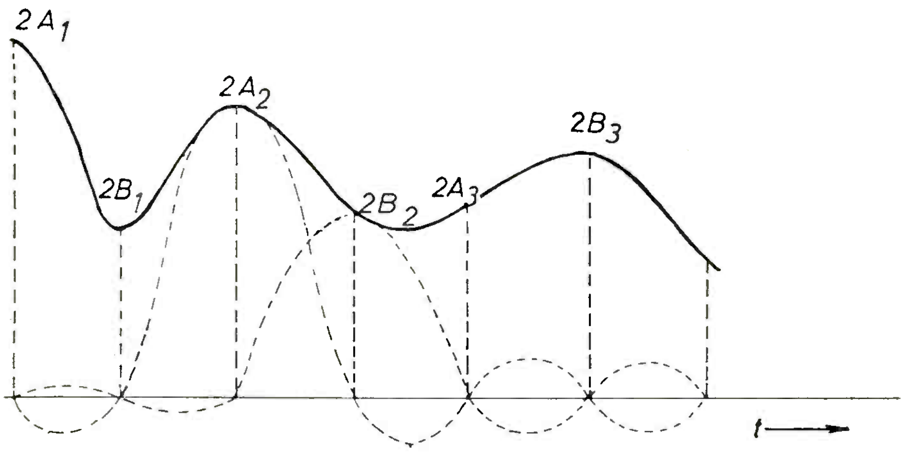
Figure 1 shows the method of transmission. Knowledge of the selective pulsing theorem is presupposed in the following discussion.

The two stereo signals are switched by two electronic switches at the rate designated *ro*, thus signal B appears opposite in the phase to signal A. The switching frequency f*o* is twice the maximum audio signal f*m* transmitted by A and B: *e.g.*, for 15 kc, f*o* is 30 kc. The signals are combined after switching. The sum signal (see Figure 2) consists of time



Pulsed Sequence after switching

Fig. 2. pam/fm



Sum Signal F(t)

Fig. 3. pam/fm

interval interlaced pulses of duration t and impulse amplitude A_1 B_1 A_2 B_2 etc. If these impulses are now passed through a low pass filter of a cutoff of 30 kc, these impulses are shaped into impulses of the nature of (sin x)/x, except that the single pulses do not interfere with each other. After an amplifier which makes up for the keying loss, one has a constant sum signal F (t) which has amplitudes at keying points of 2A, and 2B. The sum signal F (t) with its interlaced keyed modulation, contains all the information of stereo signal A and stereo signal B, and is transmitted as F (t) by the transmitter.

At the receiver end, the sum signal F (t) appears at the output of the discriminator or other detector. The sum signal is then divided into channel A and channel B (Figure 1). The two electronic switches performing this function in synchronism with the transmitter keying switch. Thus, the upper channel passes only the A pulse signal, and the lower channel passes only the B pulse signal (of Figure 3). Low pass filters with cutoffs of f*m*, and following amplifiers, restore the original stereo signals A (t) and B (t). Thus, microphone A and microphone B signal currents are restored.

By the process of interlace pulsing of the two signals, it is possible thereby to transmit both elements of the signal on one FM channel. It should be obvious that both elements of the stereo signal have identical quality, and are simultaneously affected by local noise, fade, and for all practical purposes, are equal in amplitude at the received point, and balanced. There can be no confusion about channel A and channel B at any time.

3. Compatibility

For a monophonic transmission the signals A (t) and B (t) are combined in one sum signal A plus B (Figure 2) and transmitted. In the stereo mode, the sum signal F (t) is transmitted, which differs in band width and shape from the A plus B signal. The question is, what kind of a signal would a normal monophonic FM receiver receive, when a sum signal (stereo) F (t) is transmitted instead of A plus B?

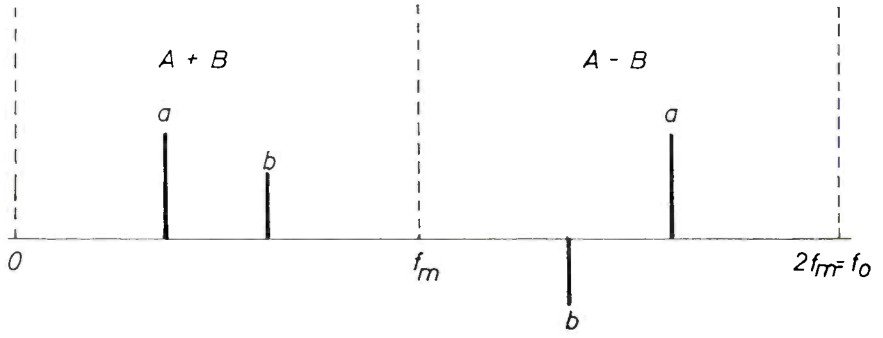
For this, the frequency spectrum of the sum signal F (t) is revealing. The two signals A and B each of bandwidth of 15 kc, when switched at a rate of 30 kc interlace, with all frequencies suppressed over 30 kc, is identical with the procedure by which a sum signal of the form A plus B in the range 0—15 kc, and a difference signal A minus B as a lower side band are recovered related to a suppressed carrier of 30 kc.

Figure 4 shows spectral distribution of stereo sum signal F (t). Spectral amplitudes a and b each represent non-specific components of the signals A and B. The *a* components are of the same polarity in the two wave elements, whereas the *b* components are polarized in opposition.

A monophonic receiver, which normally passes audio up to 15 kc, (A plus B) up to f*m*, passes only wave component up to f*m*. which is the same signal normally received.

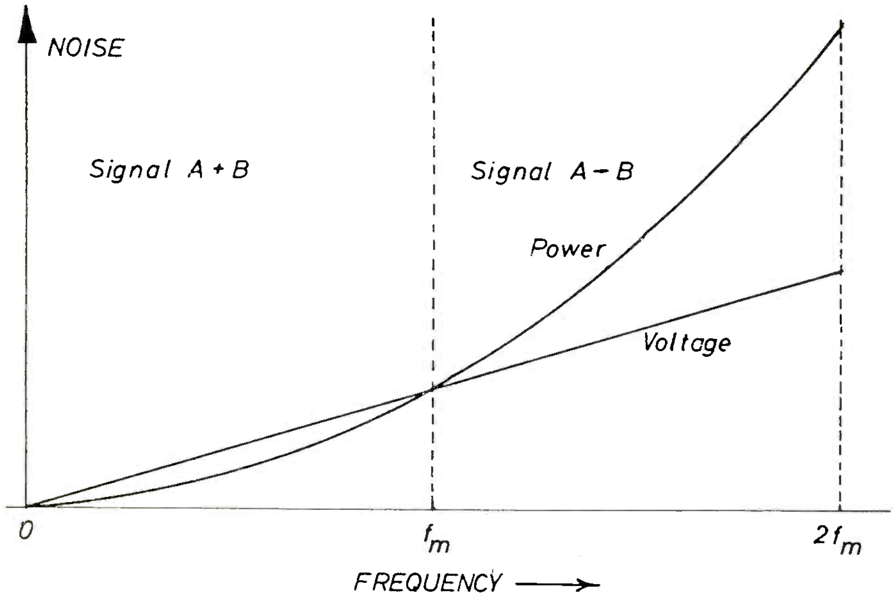
Therefore, the monophonic receiver will not show any differences between monophonic and stereo modes.

A stereo adapted receiver will also, of course, pass the monophonic f*m* signal; the discriminator will pass the combined A plus B signal instead of F (t). The two electronic switches in the circuit separate the signal into upper A and lower B elements, and feed these separated signals to the outputs right and left. There will be, of course, no stereo effect under these conditions because the original signal is monophonic and additive only. The pro-



Spectrum of Stereo Signal F(t)

Fig. 4. pam/fm



Noise Spectrum, F.M. Fig. 5. pam/fm

posed technique is, therefore, completely compatible.

4. Transmitter Carrier Swing

The question arises whether the proposed technique will require greater carrier swing as compared to normal monophonic procedure. (The question is based on the proportional distribution of A plus B versus F (t). Strictly stated, would sum signal F (t) demand greater maximum amplitudes than A plus B?

Figure 4 clearly shows that sum signal F (t) contains not only the power of A plus B, but also the difference between the power in A minus B. It is seen that there is more power in the stereo signal, and that greater maximum amplitudes can be expected.

If the signal A and B were completely independent, *i.e.*, two time functions without any correlation, the power of the stereo signal would be twice that of the monophonic signal, because in such cases, the power of both sum and difference signals would be equal; thus, in the uncorrelated condition of A plus B, there could be an amplitude difference averaging twice more in the stereo mode than in the mono mode.

However, in stereo programs, signals A and B are not independent of each other as they each derive from the same source. Large amplitudes (which affect frequency swing) occur for all practical purposes only at low audio frequencies, and gain controls can be set on the assumption that maximum amplitudes of both A and B channels are equal, and add in the sum signal, and are subtracted in the difference component. In the monophonic transmission, swing is limited to

$$f = 2\,Am \quad \text{or} = 2\,Bm$$

Larger amplitudes than 2 Am do not occur in the stereo mode, and one can therefore assume that the same swing occurs for both mono and stereo modes.

5. Bandwidth and Channel Width

Stereo signal F (t) has a width of 30 kc (2 fm) and sum signals A plus B have a bandwidth of 15 kc. If mixing or keying of A and B is undertaken in the studio, a single program line for such program would have to pass 30 kc; if signals A and B are independently fed to the transmitter, each program would, of course, be fed via the usual 15 kc pair.

First stages (audio) of the transmitter must pass, in this technique, 30 kc. High frequency (rf) circuits, and antennas must also be capable of linearity to 30 kc. Neither of these requirements are difficult of solution. Channel widths for FM are normally calculated as

$$B = 2(f + fm)$$

Deviations of 75 kc, and maximum audio of 15 kc produce a channel width of 180 kc. In the stereo technique proposed, channel width B maximum could be 210 kc. It is not expected that this slight increase in channel occupancy will adversely affect neighboring transmitters at 300 kc spacing. The equipment can be set up and monitored for 150 kc channel or ± 75 kc and maintained at that level.

6. Signal—Noise Ratio in The Receiver

(a) In FM, spectral noise amplitude rises linearly. The noise power per cycle of bandwidth rises quadratically. (See Figure 5.) At identical transmitter power, and identical carrier swing, Figure 5 holds for monophonic as well as for stereo reception, with the reservation that in mono reception the wave component 0 to fm only is received.

The signal to noise ratio in the lower wave part (0 to fm) remains

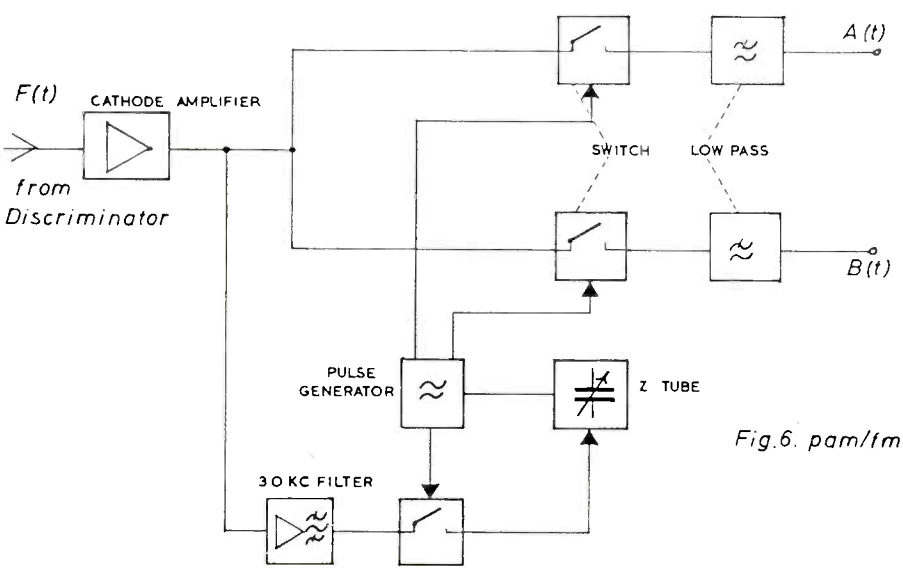
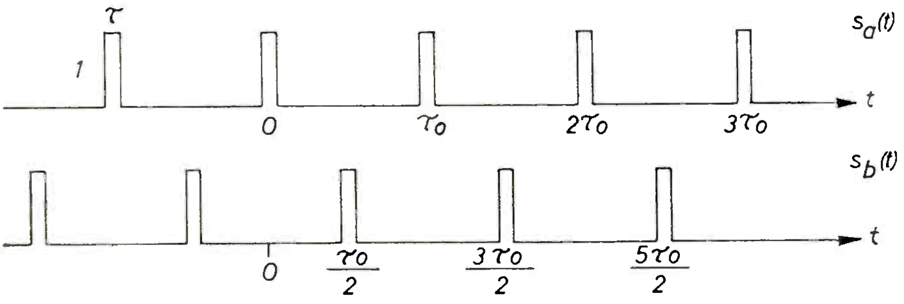


Fig. 6. pam/fm

Figure 6. Block diagram of stereo adapter for receiver.



Pulse Positioning *Fig. 7. pam/fm*

the same for both mono and stereo reception; *i.e.*, monophonic reception of the stereo signal is not different from monophonic transmission.

(b) In stereo reception with this technique, conditions are somewhat more complicated. Signal to noise in F (t) can be evaluated directly after the demodulator, or at the audio output terminals A and B. A further consideration is the subjective factor of loud-speaker orientation, spacing, distance, and other physiological factors operating in stereophonic or binaural hearing.

Assume noise conditions directly after the demodulator in the receiver: Signal power total (Figure 4) and noise power (Figure 5) (0 to 2 f*m*) must be considered simultaneously.

Noise power, as integrated over the total band, is eight times that of straight mono reception. If signals A and B were not correlated, received power in the stereo mode would be twice that of monophonic mode. Signal-noise in such a case would be reduced by a factor of 4.

If signals A and B are equal (never the case), the term A minus B disappears. The upper wave element contains, then, only noise less signal. Therefore, in such a case, there can be a reduction of S/N of about 8; this is the worst condition. In practice, the reduction in S/N is somewhere between factor 4 and 6.

7. Synchronization

In the transmitter equipment, the two electronic switches are operated by a stable pulse generator with a rate of 30 kc. Before switching, an additional dc voltage is added in opposition to the signal voltage, and therefore of opposite polarity in signals A and B. Thus, the sum signal F (t) contains, in addition to the signal information, a phase-correcting very small carrier of 30 kc.

Figure 6 shows the functional layout of the receiver. The carrier of 30 kc is selectively filtered, amplified, and used for synchronization of a local pulse generator. The local pulse generator performs selection in phase and frequency. The receiver adapter tested had the approximate physical dimensions 2 inches by 3½ inches by 6 inches. The adapter is connected to the discriminator of the receiver and produces stereo signal A and B at the output. The tested unit produced about 0.1 volts per channel across 100 kilo-ohms.

Figure 8 shows the experimental stereo receiver adapter using tubes.

8. Practical Tests Conducted

A comprehensive laboratory test has been conducted using the technique described above. An FM laboratory signal generator was used as transmitter source; receivers were several commercially available FM units. Stereo loudspeakers of high quality were set up in the test room.

Quality stereo tapes and stereo disc recordings were used. The test set-up was as shown in Figure 1. A switching arrangement was provided to "short-circuit" or bypass the rf system by means of direct connections between source audio and the monitor loudspeakers.

Qualified experts from Post Administration, from Radio Broadcasting, and the Manufacturing Industries were present for the demonstration and participated in it. *In no case were the experts able to tell when the program source was r.f. transmitted versus direct connected; many sources were tested, and the r.f. generator was set so as to duplicate normal FM broadcast service.*

During this demonstration, further, both the transmitter and the receiver were switched to monophonic modes, and vice versa, with complete compatibility shown.

In view of the foregoing, it is considered most desirable to conduct on the air testing of this system for selected observer/consumer reactions.

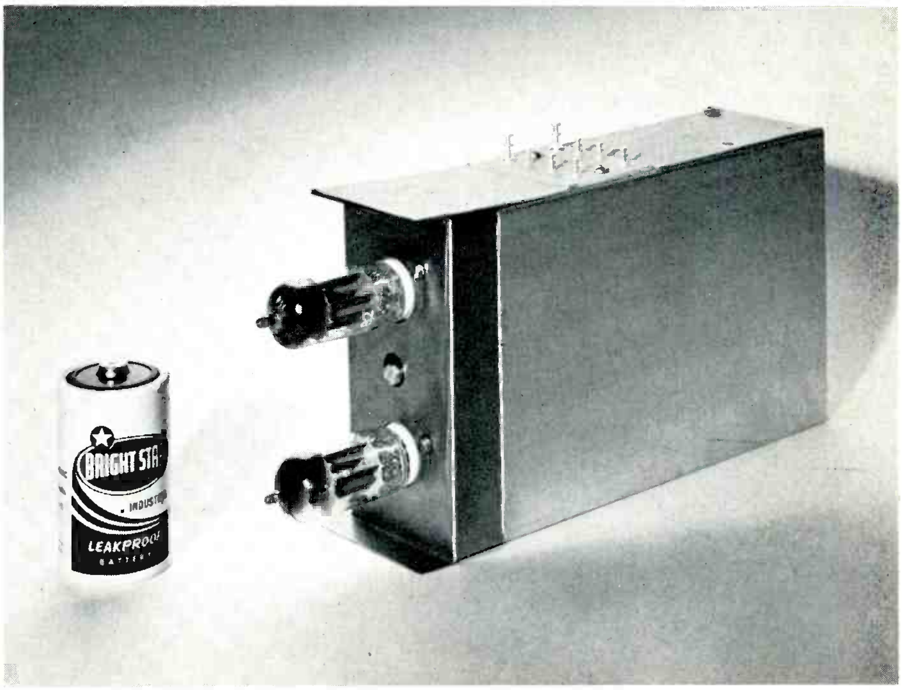


Figure 8. Stereo receiver adapter using tubes.

SUB-CARRIER GENERATION IN MULTIPLEX EXCITERS

An outline of the various systems used to generate frequency modulated sub-carriers for subsidiary communications services.

By DWIGHT "RED" HARKINS*

THERE are several methods that can be used for generating a frequency modulated carrier in the frequency range used for FM multiplex application.

In order to comply with F.C.C. regulations concerning applications for multiplex sub-carrier on an FM broadcast transmitter, the generated components must lie between 20 and 75 Kc. This ruling dictates, therefore, that the center frequency of the frequency modulated sub-carrier must be well within the 20-75 Kc. range in order to confine all the generated sidecarriers within that range.

This article will outline the various methods that are now being commercially used for generating these sub-carriers as well as the mention of several methods that have not been commercially developed as yet.

Supposing that we desire a sub-carrier of 65 Kc. center frequency with frequency modulation that will cause it to deviate plus or minus 10 Kc. There are two categories of methods being used to generate the frequency modulated sub-carriers. The first method which includes several sub-categories would be the heterodyne method. Using this method, two higher frequencies are heterodyned to produce a 65 Kc. beat note. If one of the two frequencies is frequency modulated the resulting beat note will have the same modulation characteristics.

The second general method is by use of an oscillator which is on the frequency of 65 Kc. and is modulated either by phase shift or reactance tube systems directly.

First we will outline the several methods used in the heterodyne group of sub-carrier generators. In the first system to be discussed, a reactance tube is used to modulate an oscillator in the 5 Mc. range. This produces an FM carrier which is then heterodyned with a fixed oscillator so that a 65 Kc. beat note results. The beat note or resulting product of heterodyne action contains all of the deviations that resulted from the reactance tube modulated oscillator and is then applied to the regular transmitter in the form of a sub-carrier. A block dia-

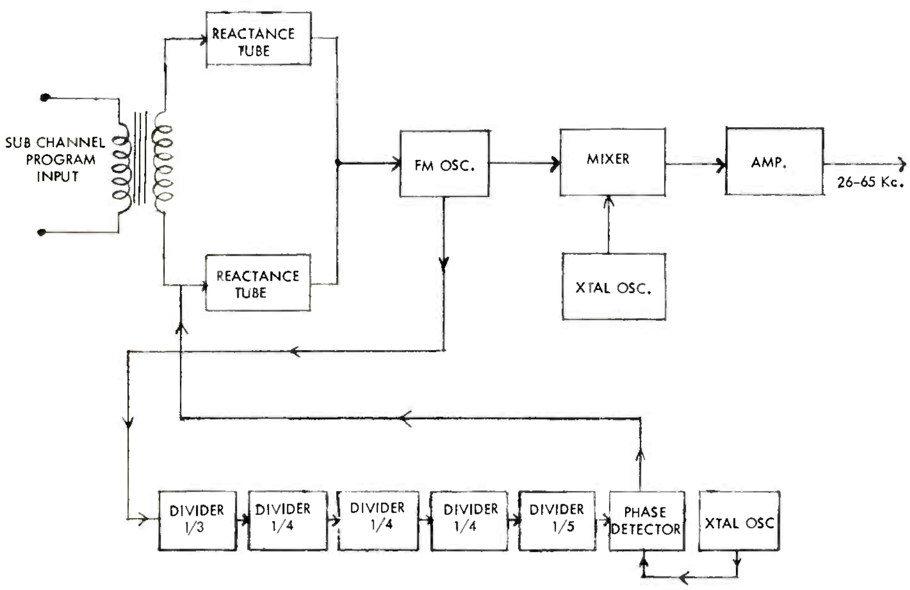


Figure 1. Block diagram of heterodyne method of generating a sub-carrier using a reactance-tube-controlled oscillator.

*Harkins Radio, Inc.
4444 East Washington
Phoenix, Arizona

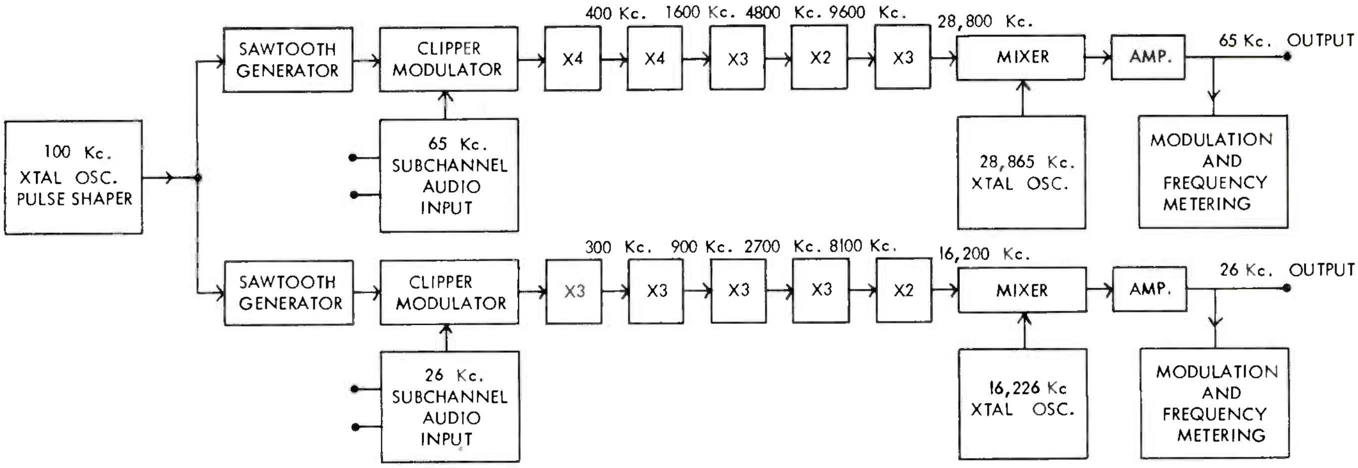


Figure 2. Block diagram of indirect FM method of heterodyne sub-carrier generation.

gram of this method appears in Figure 1.

This system uses a reactance-tube-controlled oscillator together with its center frequency controlling circuits exactly the same as it is used in the exciter portions of a regular FM transmitter with the exception that there are no multiplication stages used. The total amount of deviation required does not require the use of multipliers. In the regular broadcast application the signal is multiplied sufficiently to reach the operating frequency level in the neighborhood of 100 Mc. with deviation capability of plus or minus 75 Kc. In this arrangement considerable attention has been given to the frequency controlling circuits associated with the reactance-tube-controlled oscillator.

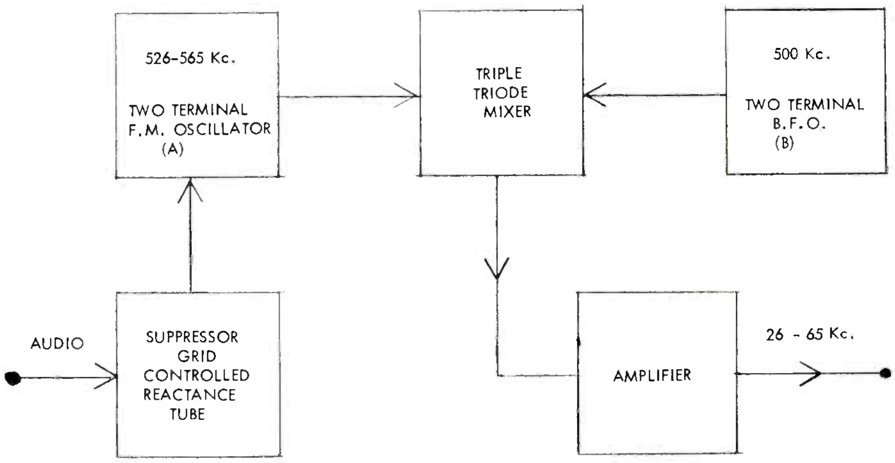


Figure 3. Direct FM heterodyne sub-carrier generation system without using frequency multipliers or center frequency control.

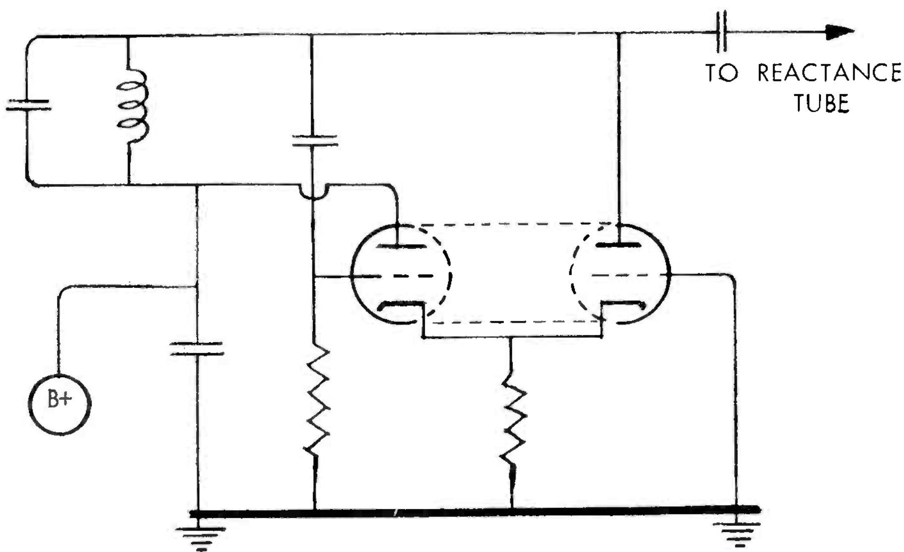


Figure 4. Circuit diagram of two-terminal oscillator which is used in sub-carrier generation circuits because of its stability and characteristics as a reactance tube modulated oscillator.

The second of the heterodyne methods consists of using the pulse modulation techniques to generate the frequency modulation signal by what is known as indirect FM. In this case the advantages of direct crystal control are realized but the disadvantage of additional multiplier stages is added. In the block diagram of Figure 2 is shown the method whereby one master crystal oscillator can be used to drive two pulse modulators which in turn drive two separate multiplier chains. The output of each multiplier chain is heterodyned with an appropriate frequency to form the desired sub-carrier.

Channel A is multiplied 288 times before mixing with the heterodyne oscillator to form a 65 Kc. sub-carrier and Channel B is multiplied 162 times before mixing to form the sub-carrier of 26 Kc.

All of the desirable characteristics of the pulse modulation system are found in this method. Low noise, low distortion, and excellent frequency response are obtainable with full crystal control.

Also included in the heterodyne method of producing sub-carrier methods is a system which uses recent improvements in the design of reactance-tube-modulated oscilla-

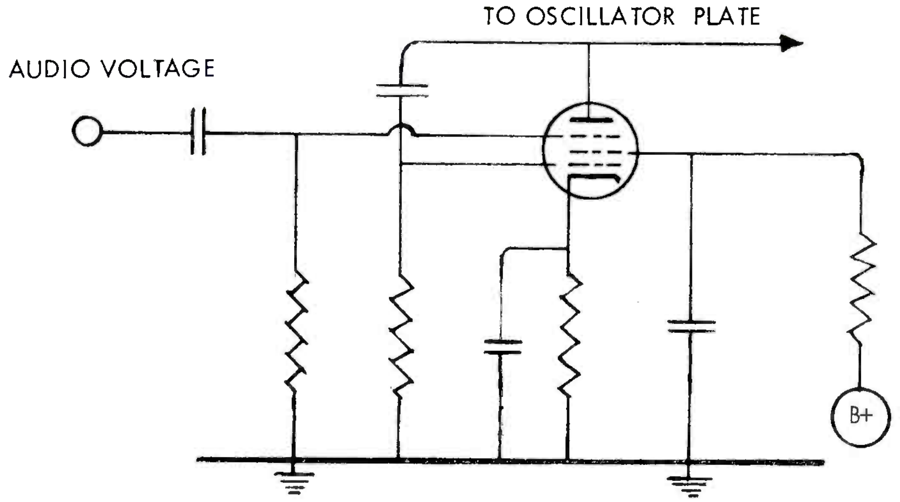


Figure 5. Reactance tube circuit using suppressor grid injection of the audio voltage.

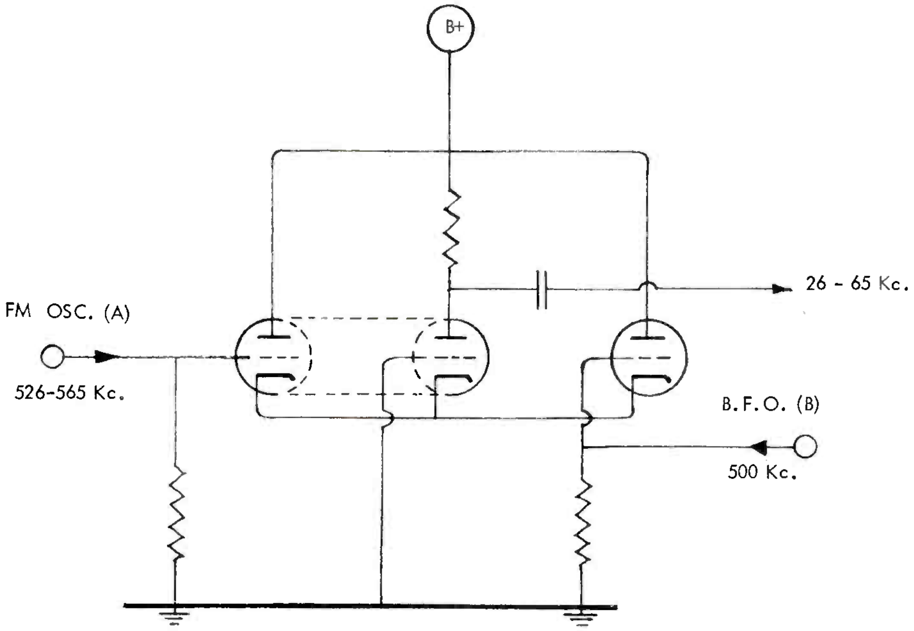


Figure 6. Triple triode mixer which combines outputs of fixed and modulated oscillators to form sub-carrier.

tors. This system does away with the disadvantages of both of the first two mentioned. First, no multipliers are used, and secondly no center frequency control is necessary as oscillators are stabilized at a lower frequency near 500 Kc.

This system as shown in the block diagram of Figure 3 consists of an oscillator which is reactance-tube-modulated and caused to heterodyne with another oscillator spaced 65 Kc. away. For example, oscillator A could be at 565 Kc. and oscillator B at 500 Kc. which when mixed will produce a 65 Kc. beat note which is frequency modulated.

Using several techniques that were developed by Murray G. Crosby, it is possible to obtain a relatively high deviation of plus or minus 25 Kc. with low distortion and low noise as well as center carrier stability on the order of 0.1 per cent. This has been found to be more than adequate for multiplex application.

The first secret of success in the technique developed by Crosby is the use of a two-terminal oscillator. This oscillator consists of a dual triode arrangement, as shown in Figure 4, and is called a two-terminal oscillator because of the fact that the portion of the circuit which determines the frequency is not involved with a third connection at any point or by any method such as the classic Hartley, Colpitts and other well known oscillators which require three terminals. This oscillator has certain characteristics beyond the scope of this paper which lend it to the application of being reactance-tube-modulated. It also has a high degree of stability.

In order to enable wide frequency deviation without resorting to the complex frequency multiplication processes that are used in other systems, a special reactance tube circuit is used which utilizes suppressor injection of the audio voltage to produce the change in the reactance across the tank circuit of the oscillator. This is shown in Figure 5.

In addition to these two elements a unique form of mixing is used that enables a sub-carrier to be produced that is absolutely free of amplitude modulation. The mixing circuit could be called a triple triode mixer. As shown in Figure 6, the voltage from the fixed oscillator enters triode A and is combined with the voltage from the reactance-tube-modulated oscillator at triode B to mix in triode C where the sub-carrier is formed.

These new developments make it possible to form a sub-carrier of very desirable characteristics with the minimum amount of circuitry. The necessity for the multiplication stages or the bulky frequency control section is eliminated.

(Continued on page 19)

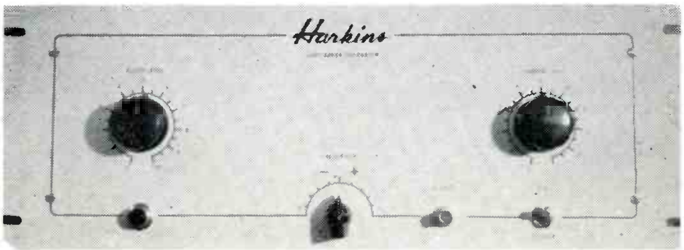


Figure 7. Sub-carrier generator which produces 25 KC deviation with high stability and low distortion using circuits described in this article.

THE USE OF UHF-TV TRANSLATORS FOR EDUCATIONAL TELEVISION

By BEN ADLER*

A description of the techniques used in planning UHF Translator installations.

WHEN the FCC issued their Sixth Report and Order ending the three and one-half year freeze on TV broadcast grants, and authorized the issuance of new permits starting July 1, 1952, the industry was quite enthusiastic over the fact that 70 additional channels had become available for TV broadcast use. It was not until late that fall, when KPTV went on the air in Portland, Ore., using channel 27, that some of the shortcomings of UHF broadcasting were brought to the surface. The problems presented by receivers and the results of shadow effects are well known, and have continued to plague us to this day.

Those of us who were involved with some of the data and information which helped to make up the Sixth Report and Order of the Commission were very apprehensive about some of the problems connected with UHF—even before the report was issued. This apprehension is clearly evidenced by the extreme precautions taken in the introduction of the so-called Taboo Table of Mileage Separations. These were all based on expected discrepancies in UHF-TV receivers and stemmed largely from the experimental work carried out by RCA at its Bridgeport, Conn., experimental UHF-TV broadcast station.

The early difficulties at the first commercial UHF-TV station rapidly diminished as new receiver and antenna installation techniques evolved. Within one or two months after KPTV went on the air acceptable results were achieved—and the people of Portland were able to enjoy their first television. The station became a tremendous success and remained so until the first VHF station was granted to the city and placed on the air. UHF could not possibly compete with the VHF station. It did not take very long for the UHF station to be pushed into the background. It ultimately went dark, as did over one-half of the UHF-TV stations authorized since 1952. Our company was close enough to the entire activity at Portland, as consulting engineers for the owners of the station, to have been very much involved in the UHF coverage problems. It was during this work that we originally conceived the need for a means to fill the shadows in UHF station coverage. The original work was with "on channel" devices, but results were so much more acceptable with the heterodyne converter or Translator approach that this system was finally adopted, and the FCC issued a set of rules covering Translator operation.

As a result of the Portland, Ore., experience, and Translator experimental work carried on at New Rochelle and at Manson, Wash., we were fully cognizant of the seriousness of the problems of poor receivers and shadow effects before the first regularly licensed UHF-TV Translator went on the air at Hawthorne, Nev., in 1956.

Since Translators were intended to operate in areas otherwise unserved, we had no concern over the consequences of competition with VHF. Our hard look at the dual problem of poor receivers and shadows was based on a desire to make certain that UHF Translator service would be more than just acceptable, because nothing else is available for comparison. We wanted Translators to become a real public service.

We were faced with a long list of UHF receiver complaints including poor reliability, oscillator drift, short tube life, high noise level and low sensitivity. We attempted—with the tremendous amount of data available to us from our UHF station clients and with field checks—to separate these complaints into rumors, prejudices and actual inherent design deficiencies. It did not take very long before we were convinced that average UHF receiver performance was fully acceptable with properly installed antennas, and signal levels of

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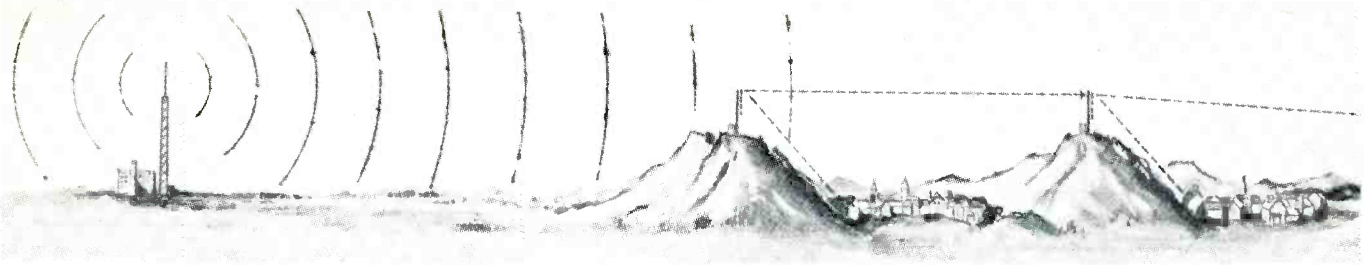

Figure 1. Above drawing shows typical UHF Translator installation illustrating how communities can be served.

500 microvolts per meter or more. In such signal areas the complaints vanished into thin air. We concluded that UHF receivers (all channel, strip and VHF with converters) were perfectly acceptable for clean picture and reliable performance provided they were operated within their capabilities. We also found that with sufficient signal strength such problems as multipath ghosts, ignition and other external noise interference, and flutter from low flying aircraft were non-existent on UHF. This was more than three years ago before the first UHF Translator was placed into regular service.

We were determined to get started with Translator activities, with our best foot forward, by making our service range predictions extremely conservative. We were opposed to the idea of claiming long ranges of coverage and then being faced with receiver complaints. Field strength measurements, made under controlled conditions at our laboratory in New Rochelle, revealed the fact that free space propagation formulas, such as those used for microwave relay systems planning, could be used for Translator planning in predicting coverage and signal range in the 800 to 1000 megacycle part of the spectrum. We decided in our planning for Translator installations to use 1000 microvolts per meter as the low limit of usable coverage to avoid receiver complaints.

It also was decided to make certain that free space conditions would be simulated within the population area to be covered as long as no obstruction existed. In order to simulate free space transmission, it is necessary to have both line-of-sight and first fresnel zone clearance. This is a technique well known to microwave system planners. The requirements are to carefully select the transmitting site and the transmitting anenna tower height, together with a directional antenna having suitable pattern and gain. In addition, receiver antennas must be carefully probed both vertically and horizontally before they are secured in place. It has been found, in many instances, where trees obstruct the direct path, free space transmission may be obtained by lowering the receiving antenna to reach on opening beneath the trees. No attempt is made to serve population beyond obstructions unless a second Translator is used as a repeater. There are many installations now operating successfully with a number of Translators repeating in a multihop string.

Using free space propagation calculations at 850 mc, typical distance to the 1000 microvolt per meter contour from a 10-watt Translator-transmitter using a transmitting antenna with a gain of 15 db, which produces 200 watts of effective radiated power, is 13½ miles. Such free space calculations have been checked in practice within the accuracy of measurement.

The careful pains taken in planning, well in advance, to operate UHF Translator systems well within the then existing UHF receiver capabilities has proven to be extremely worth while. The TASO Report of a Survey of Translator Stations which included about a half-million receivers, revealed that there are no receiver complaints in the form of poor performance or the need for excessive service. Those of us who have been close to UHF Translator operations for the past three years realize that there is no UHF-TV receiver performance problem.

When additional coverage was required we requested the FCC to authorize an increase of maximum transmitter power from 10 watts to 100 watts which has, in effect, resulted in approximately three times the distance we had before, to the 1000 microvolt per meter contour. There is no need to bemoan our fate with poor UHF-TV receivers. We plan to continue operating the existing sets well within their capabilities by making certain that all points of a population area to be served are covered with at least 1000 microvolts per meter. It is my understanding that the receiver manufacturers agree that a 10 db improvement in receiver noise figure is within the present state of the art, but probably would increase the cost of UHF receivers prohibitively. Hence, we are not counting on any improvement at this time.

The other basic problem with UHF as a TV broadcasting medium was the one of deep and dark shadows behind propagation path obstructions. Our technique for overcoming this difficulty, as already mentioned, has been to use multihop repeaters to extend the 1000 microvolt per meter contour beyond an obstruction.

Another part of our Translator system planning technique is to make certain that no more effective radiated power is used than is needed to provide the necessary signal levels. Power, antenna gain and horizontal pattern are selected as a result of calculations to determine the minimum ERP required to place a 1000 microvolt per meter signal either at the nearest obstruction or at the far edge of the population to be served, whichever is greater. Our desire to keep the power down to a minimum ties in with the need for reassigning the same channel at a nearby translator setup, especially where multihop systems are used.

With only 14 channels available for this type of service, we felt that it would be necessary to go even

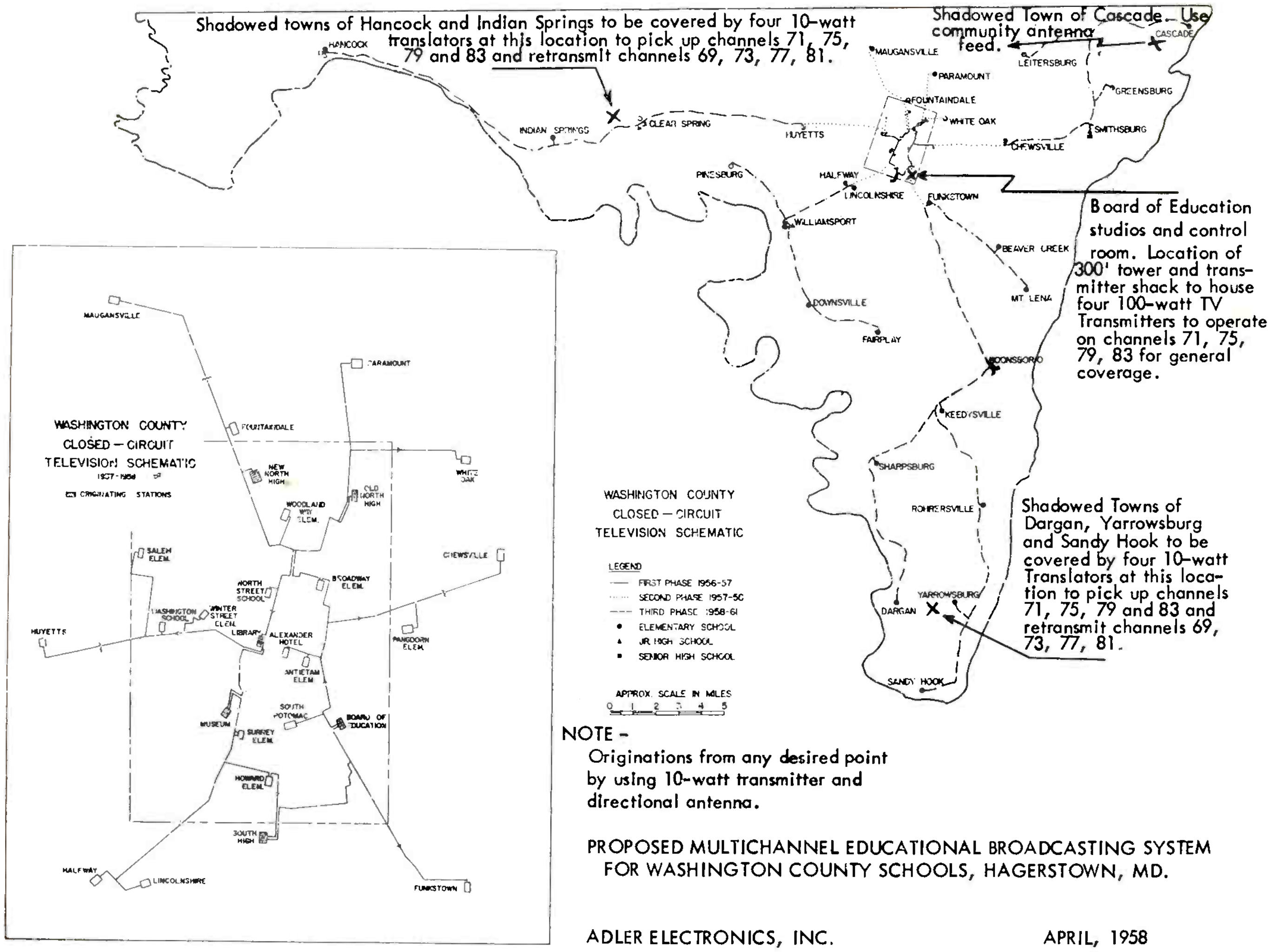

Figure 2.

further by investigating the possibility of operating on alternate channels, as is used in VHF allocations. The existing taboo table of mileage separations applicable to standard UHF-TV stations, but not to Translator stations among themselves, requires six channel spacing at any one location. We started out by following this procedure, as a precautionary measure, even though Part 4 of the rules does not require such separation. We soon ran out of channels. We then conducted tests at our laboratories to determine the degree of interference if alternate channels were used. We found that with proper precautions the alternate channels could be used without interference. A report of these tests made in collaboration with four TV receiver manufacturers was submitted to the FCC and we are looking forward to its having some effect on the removal of certain taboos now applicable to standard UHF-TV broadcast stations. No rules changes were required to permit using alternate channel assignments for Translators. Encouraged by the results of our tests, we started setting up clusters of stations separated by only one blank channel. The results have been most gratifying and channel crowding ceased to be a problem.

UHF-TV Translator service is increasing at a rate of about 12 new stations per month. There is never a word about poor performance, nor do any of the stations cease to operate. At the present rate of growth, saturation would be reached quickly under the existing rules. The FCC recognizes this problem and is considering the adoption of amendments to authorize Translator service on additional channels.

Considerable interest has developed along the lines of employing UHF-TV Translator facilities and techniques for ETV purposes. This can be done under the existing FCC rules and regulations by using Translators to repeat standard ETV stations' signals into areas beyond their range of coverage. One of the best examples of this application of Translators to ETV is now in operation at Burlington, Washington. The Burlington Edison School District No. 100, located about 61 miles north of ETC station KCTS in Seattle, installed a 10-watt UHF-TV Translator to repeat the channel 9 signals. School District No. 100 together with four other surrounding school districts in the Burlington area lie in a hollow and are unable to receive direct signals. The channel 9 signals are picked up on a hill within the hollow and translated to channel 79. The 10-watt power output of the Translator is split two ways, each half feeding separate antenna systems pointing in opposite directions. The single Translator system covers a radius of about fourteen miles, serves thirty schools housing 11,000 pupils, and in addition covers homes in the area with a population of 30,000. Performance is excellent and everyone is extremely pleased with the results.

A similar system is set up at Truth or Consequences, N. M. This town has, in addition to the UHF-TV Translator repeating Albuquerque ETV programs, two other UHF-TV Translators each repeating the signals of a distant commercial station. The entire area around Truth or Consequences is well equipped with UHF receivers and the results in schools and in homes are extremely successful—no receiver complaint, no shadowed areas.

A number of other single Translator installations are already in effective operation extending the range of standard ETV stations. Many more are being planned with several of them proposing to use multihop translators to serve a sequence of school areas well beyond the normal range of the ETV stations which are being repeated.

The artist's sketch shown in Figure 1 will give a general idea of the operation of a multihop system using Translators. By using the heterodyne converter principle in these Translators a large number of hops may be used without degradation of picture or sound signals.

The work which we performed for the Washington County Board of Education on a proposed system for "on-air" multichannel distribution system is shown on the map in Figure 2. We were able to determine that, by using the upper UHF-TV broadcast channels, and TV Translator techniques and equipment, including local origination, a complete four-channel open-circuit system could be established in Washington County for something less than 20 per cent of the cost of building the six-channel cable system. Estimates also show that maintenance charges would be a small fraction of the cost of maintaining the cable system. Our study revealed that the four-channel system, which we proposed, easily could be extended to six or more channels if required at a proportional increase in cost.

This "on-air" multichannel distribution system was not implemented because of a lack of FCC rules to cover this class of operation. The work carried out for the Washington County Board of Education resulted in a study, which we conducted, to determine what rules changes would be required in order to permit the operation of a system such as that proposed for Hagerstown. This work resulted in the preparation and filing of a petition to the FCC requesting, in essence, a modification of the UHF-TV Translator Rules to permit operation with local origination as well as with off-air pickup.

In addition to the Hagerstown study, we have prepared studies on a number of local, regional and statewide ETV systems for multichannel distribution, and for local origination of programs at a number of key points throughout the area to be covered. An example of one such system is shown in Figure 3.

This distribution system plan was prepared for Central Michigan College and has been worked out to achieve widespread coverage of schools and communities. Programs can be originated at any one of five points throughout the area. The entire network is made up of a combination of 10-watt and 100-watt Translators. The local origination stations as well as the other stations can be used as straight-through heterodyne repeaters. A system such as this can only be implemented if the rules are amended as proposed.

In conclusion I want to emphasize the extremely successful operation of Translators on UHF channels, and by pointing out that a large number of perfectly good and usable UHF-TV channels are lying dormant while everyone, commercial broadcasters and educators alike, is holding out for the impossible — additional VHF channels. The existing VHF assignments to educators should be developed to their fullest extent—but don't overlook the fact that through the proper application of Translator techniques, suitable amendments to FCC rules, and the operation of UHF-TV receivers within their existing capabilities, UHF can easily do as good a job as VHF for the educators — and probably a better one because of the repeater capabilities.

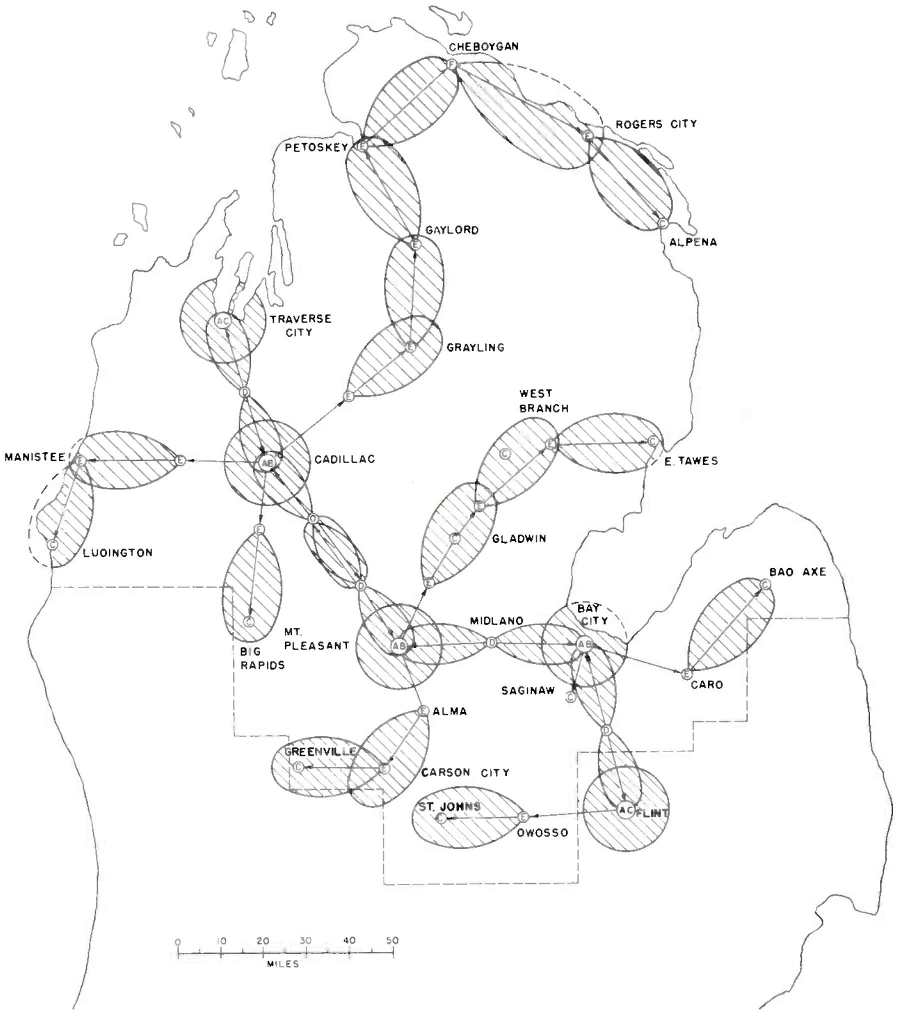

Figure 3. Proposed educational television system for the state of Michigan.

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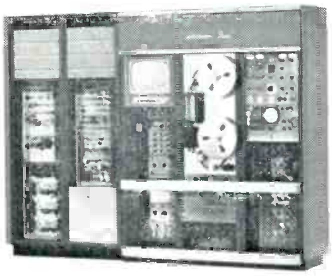

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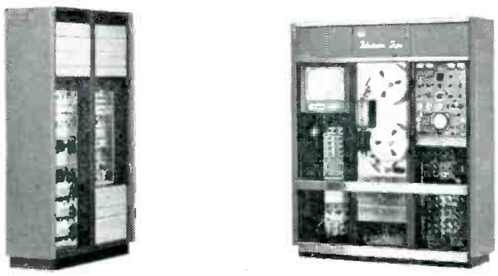

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NEGATIVE DISTORTION—
The Dibber's Panacea

The professor reports on experiments with a system which simulates over-all negative feedback from receiver to transmitter causing almost complete cancellation of distortion.

By PROFESSOR OSCAR VON DER SNIKRAH

THIS paper is actually a report of the recent fall conference of the Cactus County *"Society of Dibbers"* held in conjunction with the *"Society of Broadcasters."*

Great new things came into light and the general progress of the industry was seriously discussed.

In keeping with the standard working hours of all the Dibbers, the main session didn't get going good until about 4:00 a.m. when the amateur Dibbers and the associate members began to leave. With only the professionals in attendance, the delegate from lower Cactus County presented before the group the results of his recent experiments with negative distortion.

Unfortunately, he does not wish his name released as the company for whom he works prohibits experimenting.

Although the Broadcast Engineers have had to put up with such things as negative resistance and terms like MHOS, (which is really ohms spelled backwards), for many years, it is hoped that the principles which make possible negative distortion are more understandable. During the course of the meeting, not only were schematics discussed but the actual field tests measurements were exhibited as notarized by the local notary public. To give you some idea of the importance of these discoveries, it can be recorded here that those who were at the meeting were so enthused over the news when they first heard of it that they immediately demanded that the whole system be put into use immediately.

As the principles of negative distortion were unfolded to the professional group, the thought in everyone's mind was, "Why didn't I think of this?"

As detailed to the group, the system consists basically of first surveying all of the existing receivers in the coverage area to determine their inherent distortion characteristics and then applying the sum root difference of the receiver distortion characteristics to the transmitted signals in an out of phase manner. Obviously, the result is going to be a complete cancellation of the inherent distortion in the system.

What it then amounts to is inverse feedback without the output being connected to the input. Or to put it another way, an ersatz signal is introduced which is the equivalent to an inverse feedback of the unwanted components. Physical connection is not available from the receivers listening to the station; obviously a synthetic distortion must be introduced at the transmitter which is the negative of the distortion present at the receiver output.

The only difficulty of applying these principles in actual practice arises when the receiver is distortionless. Since only 0.7436 per cent of the receivers in existance are capable of low distortion demodulation of the broadcasted signal, it is obvious that the majority of the public will benefit greatly by the application of the negative distortion at the transmitter.

One of the first questions brought up by one of the members of the professional group was in regard to what happens when the distortion is in the transmitter and not in the receiver as he blushingly admitted was the case at his station. (Name not revealed for obvious reasons.)

The important thing, though, to be brought out here is that regardless of whether the distortion is at the transmitter or the receiver, the application of the negative distortion components cleans up the whole mess.

Although, the inventor of the new system admitted he didn't have a schematic of the negative distortion generator as yet, he faithfully promised the group that immediately upon recovering from the meeting he would trace out the connections and draw a diagram so that the important discovery could be used by the rest of the group.

He claimed that under actual use, the application of 7.5 per cent negative distortion actually cancelled out the normal characteristics of his transmitter which was in the neighborhood of 7.7 per cent. This meant that the listener received the signal with only 0.2 per cent distortion. This revelation brought a lusty cheer from the crowd which by this time was in a mellow mood.

Then a very serious note cropped up in the meeting when one of the older professional members brought up the subject of rules and regulations of the usage of the newly proposed negative distortion component. It was stated that this revolutionary method must be controlled, otherwise, the whole AM band would become better than the FM band thus defeating one of the major advantages of frequency modulation. (It was noted that the injection of negative static was also possible during local thunderstorms.)

The corresponding secretary was instructed by the group to notify the commission that rule making procedure should be instigated immediately to limit the use of "negative distortion" component to stations that could prove a long period of operation of at least a year with consistently high distortion before they would be allowed to use the new method.

A sad note temporarily took over the meeting when it was pointed out that it would no longer be necessary to use the beloved "Kentucky Windage" system for making distortion measurements when the negative distortion component was added to the system. Like all true dyed-in-the-wool engineers, however, the great advantages of the progress of the science of broadcasting far overshadowed the loss of the beloved techniques and occasional proof of performance measurements.

The illustrious group, just before adjourning, voted that the meeting was the most successful conference held since the last one.

". . . amplitude component is less than one per cent . . ."

SUB-CARRIERS starts on page 9

A unit incorporating this system, as developed in collaboration with Murray Crosby is shown in Figure 7. This enables a sub-carrier to be generated with the minimum amount of parts that will deviate it up to a peak of plus or minus 25 Kc. and have frequency response and noise figures that are equal to those required for main channel operation of FM stations.

This generator can be used for multiplex applications such as used with the subsidiary communications purposes or by modifying the frequency response characteristics of the input filter can be modified to accommodate the Crosby sum and difference stereo system which is pending before the Federal Communications Commission. In this case, plus or minus 25 Kc. deviation is available.

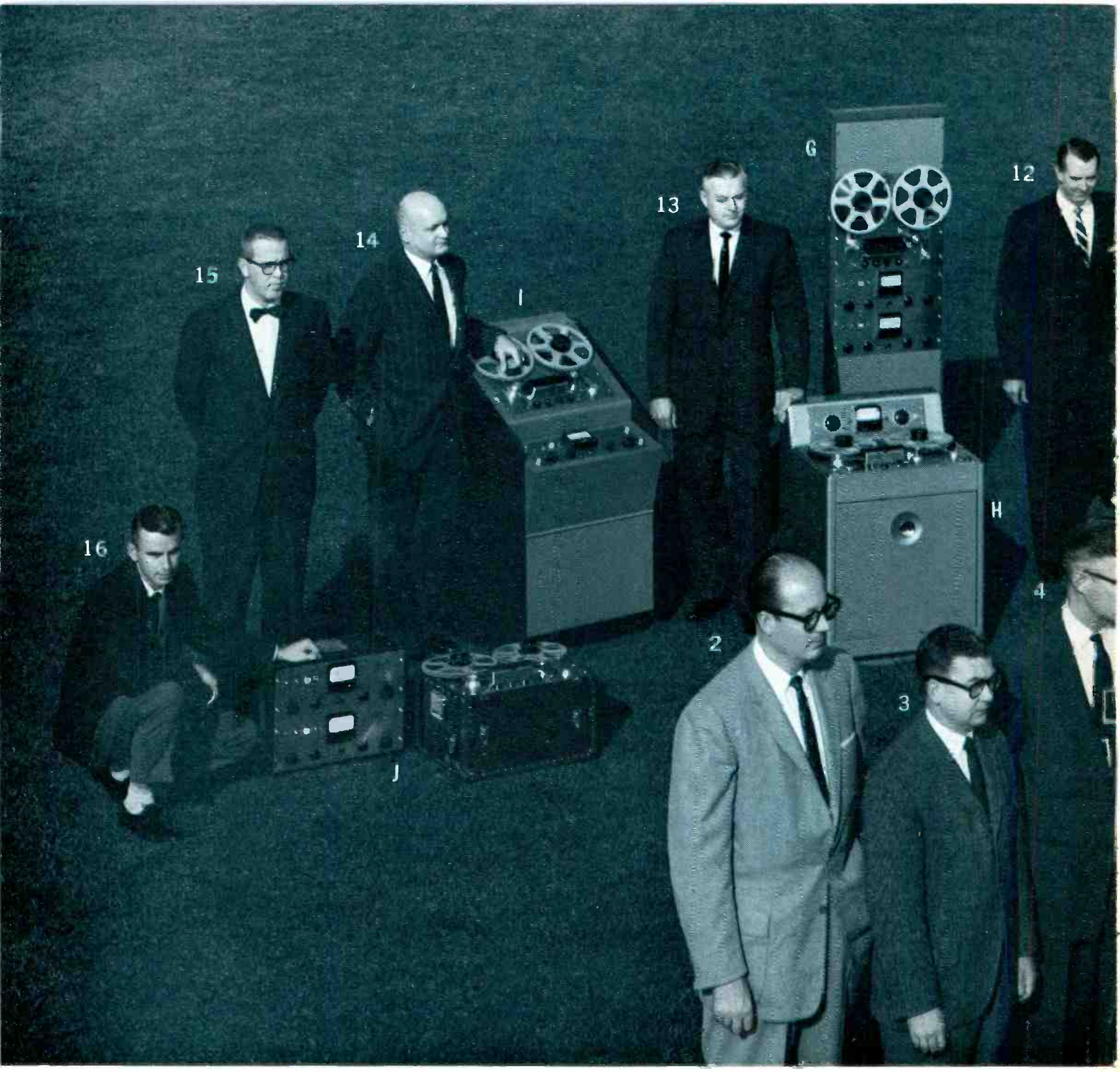
When used for the Subsidiary Communications Applications a plug in pre-emphasis filter causes the audio to be equalized according to the curve that gives a rapid rise up to 5,000 cycles and is then cut off. When used for the compatible stereo system a different filter is used, which gives the standard 75 microsecond curve up to 15,000 cycles.

The amplitude component present in the output is less than 1 per cent. This insures maximum signal to noise ratio from the multiplex receivers which could produce severe distortion if any amplitude modulation was present in addition to the frequency modulation.

Since many stations serve background music customers with the operating procedure of periods of silence at regular intervals, it is considered good practice to turn off the sub-carrier when the music is not present.

In order to accommodate this procedure, the unit of Figure 7 includes provisions for automatic muting. At the end of each musical selection it automatically turns off the sub-carrier which in turn causes the receivers to mute.

(Next month the direct methods of producing a frequency modulated sub-carrier will be described.)



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The company reflects the rapidly growing importance of magnetic tape technology, an importance which acquired enormous significance when Ampex developed and introduced the *Videotape** Television Recorder in 1956. This milestone in television, which came only nine years after Ampex introduced the first professional quality audio tape recorder, was only the beginning. To realize the promise of the future in this rapidly maturing technology, Ampex has formed this company to specialize in the needs of the broadcasters, business men, scientists, educators, and the government.

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VIDEO PRODUCTS DIVISION

3. **Thomas E. Davis,** Division Manager
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H. Model 300-C Single-Channel Console Recorder
I. Model 351-C Console Recorder with Single-Channel Electronics
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AN EXPERIMENTAL STUDY OF DISTORTION

By C. J. LeBEL*

There has been an unfortunate tendency to accept mathematical theories without adequate laboratory test of their practical applicability. This prompted an experimental study of the relation between intermodulation and harmonic distortion in various single amplifier stages and in a complete push-pull amplifier. The results indicate that the ratio of percentage intermodulation distortion to percentage harmonic distortion may vary between less than 0.2 and over 10. Accordingly, the widely published predictions of a ratio between 3.2 and 3.8 are shown to be often incorrect, probably because of the inadequate scope of the mathematical treatment.

Engineers have an unfortunate tendency to revere the mathematician. Thus, highly idealized theories are not subjected to a laboratory test of their validity. The mathematician is often the first to admit that he has used a grossly oversimplified treatment, simply because the problem would become more difficult if rigorously treated. Nevertheless, the most elegant mathematical development is valueless to the engineer if it is not in accord with physical reality.

An equally serious fault, fortunately limited to a few organizations, is to perform an experiment in similarly elegant fashion—so far removed from reality, so idealized, that it has no engineering applicability. A good example of this may be found in a number of experiments which purported to prove that the public had no interest in high-quality sound reproduction.

The subject of distortion measurement has suffered both from inadequately tested mathematics and from the overidealized experiment. It was therefore felt desirable to make an experimental study (conforming as closely as possible to actual use conditions) of distortion characteristics of typical amplifiers. The results show that the relation between harmonic and intermodulation distortion is highly elastic and very uncertain as applied to a specific amplifier. It is not possible to compute intermodulation distortion from harmonic distortion values, unless an error of up to fifteenfold is permissible.

Prior Work

There was considerable work in Europe on the subject of intermodulation measurement from 1929 on, but the first and most definitive American publication was that of Frayne and Scoville[1] in 1939. They discussed a type of intermodulation meter especially suited for motion picture film and equipment work. They compared intermodulation and harmonic methods of measuring distortion, to the favor of the former. They made a simple mathematical study, concluding that with second-order distortion only the relation is

% Intermodulation distortion/% Harmonic distortion = 3.2

With the only distortion being third-order, the ratio changes to 3.84 at low distortion, and to 3.6 at intermodulations of the order of 20 per cent.

All their tests were made with a ratio of low-frequency voltage to high-frequency voltage of 4:1 and on unspecified models of the following motion picture recording equipment: amplifiers, light valves, and film. Tests were made with the same peak output voltage in both cases, and an average-reading meter was used (as has been the case ever since in the industry).

Warren and Hewlett,[2] in 1948, introduced more mathematics into the discussion but came to essentially the same conclusion with one exception. Under certain conditions the ratio of intermodulation to harmonic distortion might be as low as 1, since it varied with the distortion law.

Roddam,[3] in 1950, calculated a ratio of 2.8 for second-order distortion and indicated that higher-order distortions produced an increased ratio. Like others before him, he used a power series of few terms in the calculation.

Callendar,[4] in 1950, pointed out that, judging by the results of measurements on tube performance, tube characteristics could not be accurately represented by a power series with strongly convergent coefficients. Conventionally calculated ratios were therefore in error.

Finally, Bloch,[5] in 1953, made a more extended mathematical study, predicting a ratio of 2.82 if the output voltage used in the harmonic test were 1.41 times the low-frequency voltage used in the intermodulation test.

None of the references cited shows any evidence of an extended and systematic experimental check on the mathematical interrelations, so the writer felt it about time to study the matter under as many practical conditions as possible.

Method of Test

Everyone has conceded that the harmonic method of distortion measurement is fatally misleading in a system of such limited frequency range that harmonics are seriously attenuated, so all tests were done on a broad-band basis. Tests were made of both single stages and complete amplifiers, and a variety of tubes and components was used.

In tests of single-amplifier stages, the tube was relieved of the load of the distortion meter by interposing a Bridger (an instrument bridging amplifier with 70 megohms input impedance and negligible distortion in the voltage range used) between tube and meter. This was essential in the case of the harmonic distortion meter, whose input impedance was only 100,000 ohms, but the Bridger was also used with the intermodulation meter to keep the tests on a uniform basis.

The complete amplifier was rated at 5 watts output into a 500-ohm load, and the meter load was unimportant by comparison; no Bridger was used.

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The harmonic distortion meter chosen for the tests was of the high-pass filter type; a calibration check indicated a probable error of the order of 5 per cent. The meter circuit showed the erratic drift which has always been so common in vacuum-tube voltmeters of the rms-reading type, so there undoubtedly were errors in reading as well.

The intermodulation distortion meter employed filters for use with 40 to 400 cps and 2- to 20-kc tones. A calibration check showed a probable error of the order of 2 per cent. The vacuum-tube voltmeter was completely stable, being of the average-reading type which has been used in all intermodulation meters and virtually all amplifier voltmeters since their inception.

TABLE I

Comparison of Intermodulation and Harmonic Distortion of Single-Ended Triode

TUBE: 12AU7 (half). Plate-feed resistor: 100,000 ohms. E_B = 90 v.

BIAS: 4500 ohms self-bias resistor, bypassed by 25 mf.

		At 1.25E_{LF}		At 1.41E_{LF}	
E_o	% IM	% Harmonic	IM/Harmonic	% Harmonic	IM/Harmonic
1.75	1.90	0.64	2.97	0.65	2.92
2.00	2.12	0.77	2.75	0.77	2.76
3.25	3.55	1.05	3.38	1.27	2.80
4.50	4.85	1.45	3.35	1.81	2.68
5.45	5.9	1.74	3.39	2.18	2.71
6.55	7.1	2.07	3.43	2.64	2.68
7.70	8.4	2.48	3.4	3.50	2.41
8.70	9.6	2.84	3.38	3.90	2.46
9.55	10.0	3.00	3.33	4.30	2.32
10.0	11.2	3.40	3.29	4.40	2.54
11.1	12.8	3.75	3.42	5.00	2.56
12.3	14.2	4.20	3.38	5.6	2.53
15.5	18.0	5.50	3.28	7.7	2.33
AVERAGE RATIOS:			3.3		2.6

Because of the difference in voltmeter law, it should be pointed out that the two are essentially equivalent for practical purposes. The occasionally touted differences usually prove on practical analysis to be insignificant when compared to other components of experimental error.

Intermodulation readings were taken with frequencies of 100 and 2000 cps, mixed with a low frequency/high-frequency voltage ratio of 4:1, and an output voltage of E_o (composed of components E and $E/4$ of low and high frequency, respectively).

Harmonic distortion readings were taken at 100 cps.

One set of harmonic readings was taken to check the previously referenced Bloch proposal, at an output voltage of 1.41E. Another set of harmonic readings were taken at 1.25E (the same peak voltage as E_o) as a check on Frayne and Scoville.

Single-Stage Tests

The first test was run on half of a 12AU7, with self-bias and a plate load of 100,000 ohms. Table I shows the results in detail. They may be summarized by saying that the ratio of percentage intermodulation distortion to percentage harmonic distortion on the Frayne and Scoville basis averaged 3.3, which is within the predicted range of 3.2 to 3.84. The corresponding ratio for the Bloch condition averaged 2.6, as against his suggestion of 2.82, which is within the margin of experimental error.

The next test was run with a self-biased 6AU6, again with a plate load of 100,000 ohms. Table II shows the results. The ratio on a Frayne and Scoville basis averaged 3.4, again within limits. On a Bloch basis, the ratio was 2.6, an error of 8 per cent, likewise within experimental limits.

TABLE II

Comparison of Intermodulation and Harmonic Distortion of Single-Ended Pentode

TUBE: 6AU6. Plate-feed resistor: 100,000 ohms. Screen-feed resistor: 96,000 ohms.

BIAS: 2100 ohms self-bias resistor, bypassed by 25 mf. E_B = 90 v.

		At 1.25E_{LF}		At 1.41E_{LF}	
E_o	% IM	% Harmonic	IM/Harmonic	% Harmonic	IM/Harmonic
8.30	4.00	1.28	3.14	1.76	2.27
9.22	5.00	1.63	3.06	2.04	2.46
10.0	6.00	1.93	3.12	2.48	2.42
10.5	7.05	2.05	3.43	2.60	2.72
11.4	8.15	2.38	3.43	3.00	2.72
11.9	9.0	2.45	3.68	3.20	2.82
12.7	9.95	2.77	3.60	3.70	2.68
14.5	12.0	3.50	3.43	4.30	2.79
17.2	15.6	4.50	3.47	5.80	2.69
19.0	18.0	5.20	3.46	7.15	2.52
20.8	21.5	6.00	3.58	8.80	2.44
22.2	25.0	7.25	3.46	11.4	2.19
AVERAGE RATIOS:			3.4		2.6

TABLE III

Comparison of Intermodulation and Harmonic Distortion of Single-Ended Pentode

TUBE: 5672. Plate-feed resistor: 50,000 ohms shunted by 700 henries. Screen-feed resistor: 33,000 ohms.

BIAS: 1800 ohms self-bias resistor, not bypassed. E_B = 90 v.

		At 1.25E_{LF}		At 1.41E_{LF}	
E_o	% IM	% Harmonic	IM/Harmonic	% Harmonic	IM/Harmonic
9.25	2.0	1.49	1.35	1.79	1.12
11.5	3.15	2.08	1.52	2.65	1.19
12.2	4.0	2.48	1.61	3.09	1.30
13.3	4.9	2.70	1.81	3.70	1.33
14.0	6.1	3.10	1.97	4.20	1.46
14.4	6.9	3.60	1.92	4.40	1.57
15.0	7.8	3.90	2.00	4.60	1.70
15.6	9.0	4.00	2.26	5.00	1.80
16.5	10.2	4.55	2.23	6.30	1.63
17.8	12.3	5.10	2.42	6.5	1.89
20.0	16.5	6.60	2.50	8.2	2.01
AVERAGE RATIOS:			2.0		1.5

Failure to Check

The third test was run with a 5672 (a subminiature pentode) feeding a 50,000-ohm load. Table III shows that on a Frayne and Scoville basis the ratio averages 2.0; on a Bloch basis it averages 1.5. These are about two-thirds of the predicted values, so that simple theory has proved inadequate.

Complete Amplifier

The fourth test was made with a complete high-quality 5-watt amplifier, with triode input and triode split-load phase inverter using a 6SN7 and push-pull 6W6GT output tubes. Three-stage negative feedback of 9 db was used. As shown by Table IV, the ratio averages 1.13 (ranging from 0.4 to 1.90) for the higher distortion portion of the data on a Frayne and Scoville basis, and 0.46 (ranging from 0.36 to 0.55) on a Bloch basis. At very low distortion values the ratios drop as low as 0.2.

Whereas both bases were in error by the same proportion with the 5672, the bases are, in this case, quite different in their deviations, being fivefold and eightfold errors, respectively. Bearing in mind that both are far smaller than theory predicts, there is nothing in the literature to explain either this case or that of the 5672.

Effect of High-Order Distortion

In an attempt to analyze the rather puzzling results with the push-pull amplifier, it was decided to introduce high-order distortion by producing a discontinuity near the origin, i.e., by going to overbiased class B operation. The bias resistor was increased from 100 to 2100 ohms.

TABLE IV
Comparison of Intermodulation and Harmonic Distortion of Push-Pull Power Amplifier
TUBES: 6SN7 amplifier, split-load phase inverter. 6W6GT push-pull power stage.

		At 1.25*ELF*		At 1.41*ELF*	
Eo	% IM	% Harmonic	IM/Harmonic	% Harmonic	IM/Harmonic
5.0	0.14	0.68	0.21	0.72	0.195
7.5	0.16	0.80	0.20	0.90	0.178
10.0	0.25	1.05	0.24	1.16	0.216
15.0	0.44	1.45	0.30	1.56	0.282
30.0	0.92	2.33	0.40	2.90	0.316
35.0	1.15	2.88	0.40	2.08	0.553
37.5	1.40	2.53	0.55	2.88	0.486
40.0	2.65	2.60	1.02	5.2	0.510
42.5	5.50	2.90	1.90	15.2	0.362
44.0	8.40	4.70	1.79	22.0	0.382
AVERAGE RATIOS:			1.13		0.46

Note: Only figures below the dash line are included in averages.

TABLE V
Comparison of Intermodulation and Harmonic Distortion of Class B Push-Pull Power Amplifier
(Same conditions as in Table IV, except that power-stage bias resistor is increased from 100 to 2100 ohms)

		At 1.25*ELF*		At 1.41*ELF*	
Eo	% IM	% Harmonic	IM/Harmonic	% Harmonic	IM/Harmonic
2.5	1.55	3.05	0.51	2.74	0.57
4.0	3.0	5.08	0.59	4.38	0.68
5.0	4.7	6.8	0.69	5.90	0.80
5.5	6.2	8.1	0.77	6.80	0.91
6.0	7.7	9.45	0.81	7.60	1.01
6.3	9.2	11.5	0.80	8.20	1.12
7.0	11.4	16.0	0.71	11.3	1.01
AVERAGE RATIOS:			0.70		0.87

TABLE VI
Comparison of Intermodulation and Harmonic Distortion of Push-Pull Power Amplifier with Overload Transformer
(Same conditions as in Table IV, except that the output passes through a transformer whose core approaches saturation)

		At 1.25*ELF*		At 1.41*ELF*	
Eo	% IM	% Harmonic	IM/Harmonic	% Harmonic	IM/Harmonic
5.0	0.67	0.77	0.87	0.85	0.79
7.5	1.02	1.06	0.96	1.16	0.88
10.0	1.32	1.29	1.03	1.41	0.94
12.5	1.80	1.58	1.07	1.88	0.96
15.0	4.40	2.03	2.16	2.58	1.70
17.5	9.25	2.70	3.43	8.00	1.15
19.0	11.8	5.50	2.15	27.8	0.43
AVERAGE RATIOS:			1.67		0.98

A glance at Table V shows that this bias makes matters no less puzzling. The average ratio for the Frayne condition has dropped. The average in the Bloch condition has doubled. Both ratios are still only a fraction of what the literature predicts.

Effect of Transformer Overload

In a continuation of this analysis, the output of the push-pull power amplifier was passed through a transformer which would overload readily. As Table VI shows, the ratio was greatly increased under both test conditions but varied greatly with level. Under the Frayne and Scoville condition the ratio averaged 1.67 instead of the previous 1.13; under the Bloch condition the ratio averaged 0.98 instead of 0.46. Nevertheless, most of the readings fail to agree with simple theory.

The first foreshadowing of these results may be found in the data presented by Pickering,[6] where ratios of 1:1 to 2:1 may be computed from his curves.

Even more extreme variations in ratios may be found in an article by LeBel,[7] and the disparity is pointed out for a push-pull amplifier, where a ratio of 0.16 at low levels changes to 4 at high levels.

The averages given in the various tables of this paper are illustrative only and are not intended for comparison with each other, since they are taken over somewhat different ranges.

Transistors

Purely to satisfy curiosity, some tests were run on a single-ended power transistor, with the results shown in Table VII. It is evident that the intermodulation distortion produced by a power transistor is very high, and the ratio is correspondingly great (a range of 6.3 to 10.2 times).

TABLE VII
Comparison of Intermodulation and Harmonic Distortion of Single-Ended Power Transistor Stage
TRANSISTOR: H-2. CIRCUIT: Common emitter.

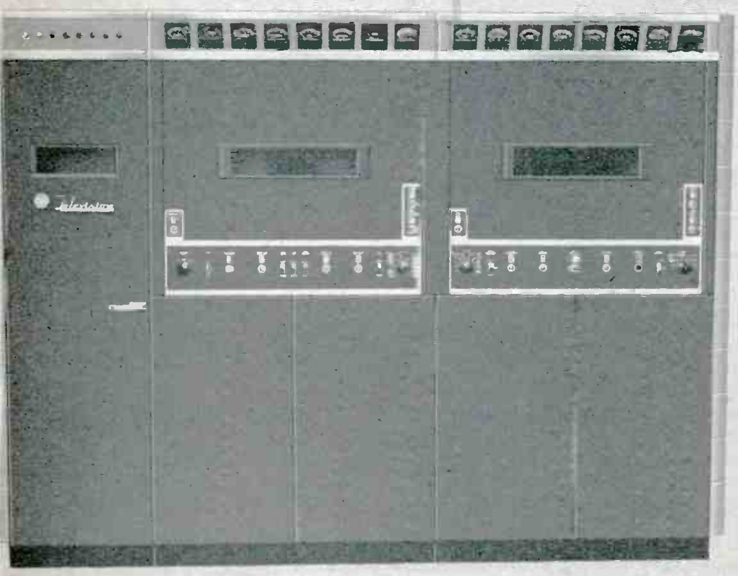
		At 1.25*ELF*	
Eo	% IM	% Harmonic	IM/Harmonic
2.5	10.0	0.98	10.2
4.0	15.5	2.96	5.2
6.3	23.0	3.12	7.4
7.5	28.0	4.48	6.3
AVERAGE RATIO:			7.3

Conclusion

The relation between intermodulation distortion and harmonic distortion is much more elastic than the usually cited literature would lead us to believe. There is need for a far more rigorous mathematical study of the question. Push-pull operation is in special need of attention. It appears that push-pull operation is unusually effective in reducing intermodulation distortion. In the meantime, the only effective way to determine intermodulation distortion is to measure it directly.

1. J. G. Frayne and R. R. Scoville, "Analysis of Measurement of Distortion in Variable Density Recording," J. Soc. Motion Picture Engrs., 32, 648-673 (June, 1939).
2. W. J. Warren and W. R. Hewlett, "An Analysis of the Intermodulation Method of Distortion Measurement," Proc. I.R.E., 36, No. 4, p. 457 (April, 1948).
3. Thomas Roddam, "Intermodulation Distortion," Wireless World, 46, No. 4, pp. 122-125 (April, 1950).
4. M. V. Callendar, "The Influence of High-Order Products in Nonlinear Distortion," Electronic Eng., 22, No. 272, p. 443 (Oct., 1950).
5. Alan Bloch, "Measurement of Nonlinear Distortion," J. Audio Eng. Soc., 1, No. 1, pp. 62-67 (January, 1953).
6. Norman C. Pickering, "Measuring Audio Intermodulation," Electronic Ind., 5, No. 6, pp. 56-58, 124, 125 (June, 1946).
7. C. J. LeBel, "A New Method of Measuring and Analyzing Intermodulation," Audio Eng., 35, No. 7, pp. 18-21, 131 (July, 1951).

TT-25CL, 25-Kw Low-Band Transmitter



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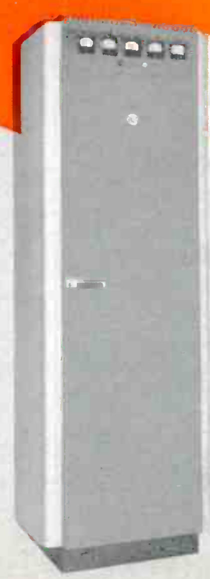

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AMENDMENTS AND PROPOSED CHANGES OF F.C.C. REGULATIONS

CLEAR CHANNEL BROADCASTING IN THE STANDARD BROADCAST BAND

Supplement to Third Notice of Further Proposed Rule Making

1. Attached to the Third Notice of Further Proposed Rule Making (FCC 59-972), issued by the Commission on September 22, 1959, are ten maps and a sample directional antenna pattern collectively identified as "Exhibit C" (24 F.R. 7737).

2. This exhibit is referred to in paragraph 16 of the text of the Notice as follows: "There are indicated in the maps attached as Exhibit C examples of the general impact upon the present capacity of the channels for skywave service resulting from 10 kilowatt directional antenna operation of new Class II stations at centralized geographic locations under Table I. These are included in the Notice for illustrative purposes only, to show the general effect of the assignments listed therein. They should not be considered to constitute a determination that the capacity of these channels should be so delimited."

3. Inquiries addressed to the Commission have indicated that, despite the aforenoted portion of the text, an undue and misleading significance is being attached to Exhibit C. The correlation therein, in map form, of a series of existing Class I stations with a series of non-existent Class II stations, each shown at a definite location, appears to have created the erroneous impression that Exhibit C comprises detailed Commission plans for ten of the clear channels. This misinterpretation has led to: (a) Consideration of the over-all proposal of Class II assignments on clear channels in terms of the limited data of Exhibit C only; (b) limitation of the method of formulating and presenting engineering data to the method employed in Exhibit C only, although no such limitation was intended by the Commission; (c) concern on the part of certain interested parties as to corresponding Commission plans for several channels not included in Exhibit C.

4. Exhibit C does not constitute an integral part of the proposal with which it is associated. As was indicated in the aforenoted portion of the text of the Notice, Exhibit C was attached thereto for the sole purpose of illustrating the general type of situation to be anticipated as a consequence of the implementation of this or a similar proposal. Exhibit C should therefore not be understood as placing any kind of limitation on data or showings which interested parties may wish to submit in response to the Third Notice.

SPARE TUBE REQUIREMENT DELETED

1. At a session of the Federal Communications Commission held at its offices in Washington, D.C., on the 21st day of October, 1959;

2. The Commission has before it for consideration the provisions of the rules which require that each broadcast station keep on hand a prescribed number of spare vacuum tubes. A spare tube is required for every type used in the equipment and, if several of the same type are used, additional spares are necessary; as determined by the tables in §§ 3.40 (e), 3.317 (e) and 3.697 (h) of the rules.

3. These detailed requirements were adopted into the rules a number of years ago, first for standard broadcast (AM) stations and then extended to FM and TV stations. They were bottomed upon the desirability of avoiding or shortening broadcast service interruptions resulting from the tube failures.

4. Upon reexamination, we believe these provisions carry with them an administrative burden, affecting the commission and the station licensees, which is no longer warranted. The high reliability now realized in broadcast station operations results from various factors. While recognizing the importance of spare tubes to equipment reliability, we believe their availability, as with many other equipment components, can now more appropriately be left with the responsibility and initiative of the station licensees than with the requirements of the rules. Thus, we are deleting these provisions from our rules. The amendment is of minor nature for which a rule making notice and public procedure are unnecessary.

5. Authority for the adoption of the amendment is contained in §§ 4 (i), 301, and 303 (r) of the Communications Act of 1934, as amended.

6. *Accordingly, it is ordered,* That effective November 30, 1959, §§ 3.40, 3.317, and 3.687 of the Commission's rules are amended as set forth below.

§ 3.40 [Amendment]

1. Section 3.40 is amended by deleting the text of paragraph (e) and inserting in lieu thereof the word (Reserved).

2. Section 3.317 (e) is amended to read as follows:

§ 3.317 Transmitters and associated equipment.

* * *

(e) An accurate circuit diagram, as furnished by the manufacturer of the equipment, shall be retained at the transmitter location.

3. Section 3.687 (h) is amended to read as follows:

§ 3.687 Transmitters and associated equipment.

* * *

(h) An accurate circuit diagram, as furnished by the manufacturer of the equipment, shall be retained at the transmitter location.

DAYTIME SKYWAVE TRANSMISSIONS

1. The Commission has under consideration its Report and Order adopted herein on September 18, 1959, in which we adopted certain amendments to §§ 3.23 (b) and 3.24 of the Commission's rules, added new §§ 3.38 and 3.187 to the rules, added new material to § 3.190, and ordered that this proceeding is terminated. The changes in the rules were all made effective October 30, 1959.

2. Upon further consideration of the Daytime Skywave proceeding and our decision therein, we are of the view that certain additional changes in our rules are necessary and appropriate in order to achieve proper and complete resolution of this matter. These are: (1) clarification of the language of the new § 3.187 (a) so as to define the pertinent vertical angles of radiation which are to be considered in applying the restrictions on operation during the two hours after sunrise and the two hours before sunset; (2) modification of the same section so as to permit changes in existing Class II facilities which, while not conforming to the new restrictions, would not result in daytime skywave interference greater than that from the present facilities; (3) similar modification of the restriction on changes in existing Class II Limited Time facilities (§ 3.38); and (4) a clarifying amendment to § 3.87 relating to pre-sunrise operation by Class II stations. Accordingly, on our own motion, pursuant to § 1.16 of our rules, we set aside those portions of Paragraph 27 of our September 18 Report and Order, and of the Appendix thereto, which: (1) make all of the changes in the rules effective October 30, 1959; (2) set forth the text of new §§ 3.38 and 3.187; (3) order the proceeding terminated. The present Supple-

mental Report and Order covers these matters; in all other respects our September 18 Report and Order is affirmed.

3. *The pertinent vertical angles involved.* In our March, 1954, Proposed Report and Order herein (FCC 54-333, 10 Pike & Fischer R.R. 1541) we stated (Paragraph 30) that the proposed permissible-radiation curves would permit radiation "at or below the values given by these curves in the vertical angles below the pertinent angles" during the four transitional hours. In Footnote 17 of the same document we indicated that the "pertinent angles" mentioned were those obtained by application of Curve 4 of Figure 6a of the Standards of Good Engineering Practice (now Figure 6a of § 3.190 of the rules). Our Report and Order issued herein on September 18 did not contain any specific reference to the vertical angles to be considered in applying the permissible-radiation curves.

4. Upon further consideration, we are of the view that the determination reached in 1954 concerning this matter is correct, and that in each case the portion of the vertical radiation pattern to which the daytime skywave restrictions should be applied is that up to and including the pertinent angle as indicated by Curve 4 of Figure 6a. It appears that this will afford an adequate degree of protection against daytime skywave interference. It might be argued that portions of the vertical angle higher than the "pertinent angle" indicated by Figure 6a should also be considered, and applicants be required to show compliance with the daytime skywave restrictions at such higher angles. But such a rigid requirement we believe to be undesirable, especially because if it should be adopted our rules would present the anomaly of requiring a more complete showing of protection with respect to daytime skywave radiation than with respect to nighttime skywave radiation (which is of course much greater), since the latter is evaluated over the portion of the vertical angle up to the pertinent angle as indicated by Figures 6 or 6a (See § 3.185 of the rules). Therefore, we adopt herein the decision on this matter announced in our 1954 Proposed Report and Order. Accordingly, we are amending § 3.187 (a) by the addition of the words "at or below the pertinent vertical angle determined from Curve 4 of Figure 6a of § 3.190" immediately after the words "Class I station" in subparagraph (1) of that paragraph.

5. *Changes in facilities not resulting in increased daytime skywave interference.* As set forth in the Appendix to our September Report and Order, § 3.187 (a) precludes the authorization of any new Class II facilities and of any changes in facilities, unless the proposed operation would comply with the new daytime skywave restrictions. Upon further consideration, we conclude that this rule is un-

duly restrictive as to changes in facilities, in that it would preclude authorizations for changes in Class II operations which, while not meeting the new restrictions, would in fact cause daytime skywave interference less than, or no more than, the present mode of the Class II station's operation. Therefore we are revising § 3.187 (a) so as to preclude grants of changed facilities where there would be no increase in daytime radiation toward the co-channel Class I station, or material decrease in the distance to that station's normally protected contour, even though such changes would not conform to the new daytime radiation restrictions. The rule as amended also provided that where an existing Class II station is authorized to make changes which increase daytime radiation toward the co-channel Class I station (but do not involve changes in frequency or material reduction in distance to that station), the radiation during the transitional hours may remain the same as that now radiated in such directions, even though higher than the level otherwise permitted under the daytime skywave restrictions.

6. *Restrictions on changes in existing Limited Time Class II facilities.* As set forth in the Appendix to our September 18 Report and Order, new § 3.38 of our rules states in substance that no substantial changes in the facilities of existing Class II Limited Time stations will be authorized. Upon further consideration, the rule as set forth appears unduly restrictive, for reasons similar to those just set out with respect to new § 3.187. Accordingly, we are revising new § 3.38 to permit future changes in the facilities of existing Limited Time stations which do not involve changes in frequency or a material reduction in distance to the co-channel U. S. Class I station, or increases in radiation toward such Class I station during the "bonus hours" after local sunset.

7. *Restrictions on pre-sunrise operation by Class II stations.* Under § 3.87 of the rules Class II stations complying with conditions set out therein may operate prior to local sunrise with "their authorized daytime facilities". The amendment to § 3.87 adopted herein merely makes it clear that restrictions applicable under § 3.187 to post-sunrise operations apply to pre-sunrise operations under § 3.87.

8. Section 3.23 (b) is also amended so as to change the date specified therein.

9. *In view of the foregoing, it is ordered,* (1) That Paragraph 27 of the Report and Order adopted herein on September 18, 1959 (FCC 59-970) is set aside, insofar as it makes the changes in the Commission's rules effective October 30, 1959, insofar as it orders new §§ 3.38 and 3.187 added to the rules as set forth in the Appendix thereto and amends § 3.23 (b), and insofar as it orders this proceeding terminated; and the Appendix to said Report and Order is set aside insofar as it sets forth the text of amended § 3.23 (b) and new §§ 3.38 and 3.187;

(2) That §§ 3.23 (b) and 3.87 of the Commission's rules are amended as set forth below;

(3) That new §§ 3.38 and 3.187 are added to the Commission's Rules as set forth below;

(4) That those changes in the Commission's rules set forth in the Appendix to the September 19, 1959, Report and Order herein which have not been set aside in the present Supplemental Report and Order, and the changes in the rules set forth below, are effective November 30, 1959;

(5) That in all other respects the Report and Order adopted herein on September 18, 1959 (FCC 59-970) is affirmed; and

(6) That this proceeding is terminated.

1. Section 3.23 (b) is amended to read as follows:

§ 3.23 Time of operation of the several classes of stations.

* * *

(b) Limited time is applicable to Class II (secondary) stations operating on a clear channel with facilities authorized before November 30, 1959. It permits operation of the secondary station during daytime, and until local sunset if located west of the dominant station on the channel, or if located east thereof, until sunset at the dominant station, and in addition during night hours, if any, not used by the dominant station or stations on the channel.

2. The following new § 3.38 is added:

§ 3.38 Limited time operation.

(a) Starting November 30, 1959, no authorization will be granted for:

(1) A new Limited Time station;

(2) A Limited Time station operating on a changed frequency;

(3) A Limited Time station with a new transmitter site materially closer to the 0.1 mv/m contour of a co-channel U. S. Class I station; or

(4) Modification of the operating facilities of a Limited Time station resulting in increased radiation toward any point on the 0.1 mv/m contour of a co-channel U. S. Class I station, during the hours after local sunset in which the Limited Time station is permitted to operate by reason of location east of the Class I station.

3. Section 3.87 is amended by the addition of the following paragraph (e):

§ 3.87 Program transmissions prior to local sunrise.

* * *

(e) Restrictions imposed by § 3.187 on daytime operations shall apply to pre-sunrise operation under this section.

4. The following new § 3.187 is added:

§ 3.187 Limitation on daytime radiation.

(a) (1) Except as otherwise provided in subparagraphs (2) and (3) of this paragraph, no authorization will be granted for Class II facilities if the proposed facilities would radiate, during the two hours after local sunrise and the two hours before local sunset, toward any point on the 0.1 mv/m contour of a co-channel U. S. Class I station, at or below the pertinent vertical angle determined from Curve 4 of Figure 6a of § 3.190, values in excess of those obtained as provided in paragraph (b) of this section.

(2) The limitation set forth in subparagraph (1) of this paragraph shall not apply in the following cases:

(i) Any Class II facilities authorized before November 30, 1959; or

(ii) For Class II stations authorized before November 30, 1959, subsequent changes of facilities which do not involve a change in frequency, an increase in radiation toward any point on the 0.1 mv/m contour of a co-channel U. S. Class I station, or the move of transmitter site materially closer to the 0.1 mv/m contour of such Class I stations.

(3) If a Class II station authorized before November 30, 1959, is authorized to increase its daytime radiation in any direction toward the 0.1 mv/m contour of a co-channel U. S. Class I station (without a change in frequency or a move of transmitter site materially closer to such contour), it may not, during the two hours after local sunrise or the two hours before local sunset, radiate in such directions a value exceeding the higher of:

(i) The value radiated in such directions with facilities last authorized before November 30, 1959, or

(ii) The limitation specified in subparagraph (1) of this paragraph.

(b) To obtain the maximum permissible radiation for a Class II station on a given frequency (fkc) from 640 kc through 990 kc, multiply the radiation value obtained for the given distance and azimuth from the 500 kc chart (Figure 9 of § 3.190) by the appropriate interpolation factor shown in the *K500* column of paragraph (c) of this section; and multiply the radiation value obtained for the given distance and azimuth from the 1000 kc chart (Figure 10 of § 3.190) by the appropriate interpolation factor shown in the *K1000* column of paragraph (c) of this section. Add the two products thus obtained; the result is the maximum radiation value applicable to the Class II station in the pertinent directions. For frequencies from 1010 kc to 1580 kc, obtain in a similar manner the proper radiation values from the 1000 kc and 1600 kc charts (Figures 10 and 11 of § 3.190), multiply each of these values by the appropriate interpolation factor in the

K'1000 and K'1600 columns in paragraph (c) of this section, and add the products.

(c) Interpolation factors. (1) Frequencies below 1000 kc.

f kc	K500	K1000	f kc	K500	K1000
640	0.720	0.280	780	0.440	0.560
650	0.700	0.300	800	0.400	0.600
660	0.680	0.320	810	0.380	0.620
670	0.660	0.340	820	0.360	0.640
680	0.640	0.360	830	0.340	0.660
690	0.620	0.380	840	0.320	0.680
700	0.600	0.400	850	0.300	0.700
710	0.580	0.420	860	0.280	0.720
720	0.560	0.440	870	0.260	0.740
730	0.540	0.460	880	0.240	0.760
740	0.520	0.480	890	0.220	0.780
750	0.500	0.500	900	0.200	0.800
760	0.480	0.520	940	0.120	0.880
770	0.460	0.540	990	0.020	0.980

(2) Frequencies above 1000 kc.

f'kc	K'1000	K'1600	f'kc	K'1000	K'1600
1010	0.983	0.017	1170	0.717	0.283
1020	0.967	0.033	1180	0.700	0.300
1030	0.950	0.050	1190	0.683	0.317
1040	0.933	0.067	1200	0.667	0.333
1050	0.917	0.083	1210	0.650	0.350
1060	0.900	0.100	1220	0.633	0.367
1070	0.883	0.117	1500	0.167	0.833
1080	0.867	0.133	1510	0.150	0.850
1090	0.850	0.150	1520	0.133	0.867
1100	0.833	0.167	1530	0.117	0.883
1110	0.817	0.183	1540	0.100	0.900
1120	0.800	0.200	1550	0.083	0.917
1130	0.783	0.217	1560	0.067	0.933
1140	0.767	0.233	1570	0.050	0.950
1160	0.733	0.267	1580	0.033	0.967

STANDARD BROADCAST APPLICATIONS; POSTPONEMENT OF EFFECTIVE DATE

In re Amendment of § 1.351 of the Commission's rules and regulations.

At a session of the Federal Communications Commission held at its offices in Washington, D. C., on the 28th day of October, 1959;

The Commission has under consideration (1) the Order and Appendix thereto adopted herein on September 18, 1959 (FCC 59-971, released September 22, 1959), amending, effective October 30, 1959, § 1.351 of the Commission's rules, relating to the withholding of action on certain types of standard broadcast applications proposing operation on frequencies specified in § 3.25 of the rules, and (2) the Supplemental Report and Order in Docket 8333 (the Daytime Skywave proceeding), adopted October 21, 1959 (FCC 59-1072, released October 28, 1959), which, inter alia, postponed the effective date of various changes in the Commission's rules concerning standard broadcast operations from October 30, 1959, to November 30, 1959;

It appears that there would be no useful purpose in beginning the processing of applications removed from the "freeze" by the amendment to § 1.351 until criteria to be used in that connection become effective on November 30, that the change in § 1.351 should become effective at the same time as the changes adopted in Docket 8333, and that therefore the public interest would be served by postponing the effective date of the amendments to § 1.351 until November 30, 1959.

In view of the foregoing: *It is ordered*, That the effective date of the amendments to § 1.351 of the Commission's rules contained in the order adopted herein on September 18, 1959 (FCC 59-

971) is postponed from October 30 until November 30, 1959.

ANTENNA AMMETERS

In the matter of Amendment of § 3.39 of the Commission's rules and regulations to permit the use of plug-in type antenna ammeters by standard broadcast stations.

At a session of the Federal Communications Commission held at its offices in Washington, D. C., on the 28th day of October, 1959;

The Commission has before it a proposal to amend § 3.39 of its rules to permit the use of plug-in type antenna ammeters at standard broadcast stations.

On February 8, 1951, the Commission received a petition from the Florida Association of Broadcasters requesting that section 13B (3) (b) of the Standards of Good Engineering Practice concerning standard broadcast stations be amended so as to permit the use of plug-in type antenna ammeters in lieu of permanently wired-in meters. In support of its petition, the Association stated that antenna ammeters which are permanently wired into the antenna circuit are subjected to the hazard of lightning induced current surges and are frequently damaged or destroyed by such surges. The problem is said to be particularly acute in Florida and other southeastern states where severe thunderstorms occur frequently during certain seasons of the year. The petition cites the results of a survey in which member stations reported that everyone of them had found it necessary to repair or replace antenna ammeters which had been damaged by lightning, one or more times during the preceding 5 years. The cost of such repairs and replacements was said to amount to several thousands of dollars.

At the time the petition was submitted, the Commission was occupied with the problem of lifting the "freeze" on television construction and decided that as an interim measure, plug-in meters, if properly installed and arranged so that they could be inserted and removed from the circuit without interrupting transmissions, would be considered to comply with section 13B (3) (b) of the Standards of Good Engineering Practice. The petition was laid aside with a view toward revising the language of the Standard to make it clear that such use was permissive. The complex television proceedings extended into 1952 and, in view of the interim action taken, the petitioner did not press for further action on its petition. The Standards of Good Engineering Practice were subsequently recodified and made a part of the rules governing standard broadcast stations and section 13B (3) (b) became a part of § 3.39 of the rules.

In a recent review of its rules, it was found that § 3.93 of the rules had not been revised to conform to the practice of the Commission with respect to this requirement.

Authority for the adoption of this amendment is contained in sections 4 (i), 303 (e), and 303 (r) of the Communications Act of 1943, as amended.

Since the amendment adopted herein represents a relaxation of a requirement of the rules by making it permissive to use plug-in type antenna ammeters and its purpose is to conform the rules with present practice, prior notice of rule making is unnecessary and the amendment may be made effective immediately.

Accordingly: *It is ordered*, That paragraph (c) of § 3.39 of the Commission's rules and regulations is hereby amended to read as follows, effective December 7, 1959:

§ 3.39 Indicating instruments—specifications.

(c) A thermocouple type ammeter meeting the requirements of paragraph (b) of this section shall be permanently installed in the antenna circuit or a suitable jack and plug arrangement may be made to permit removal of the meter from the antenna circuit so as to protect it from damage by lightning. Where a jack and plug arrangement is used, contacts shall be made of silver and capable of operating without arcing or heating, and shall be protected against corrosion. Insertion and removal of the meter shall not interrupt the transmissions of the station. When removed from the antenna circuit, the meter shall be stored in a suitable housing at the base of the tower in which it is used. Care shall be exercised in handling the meter to prevent damage which would impair its accuracy. Where the meter is permanently connected in the antenna circuit, provision may be made to short or open the meter circuit when it is not being used to measure antenna current. Such switching shall be accomplished without interrupting the transmissions of the station.

Industry News

Du Pont Forms New District For Industrial Film Sales

Headquarters of a new industrial sales district for the film department of the Du Pont Co. have been established in Cleveland with Lockhart T. Hicks as manager.

Formation of the new district reflects the expanding use of films as components in a variety of industrial products, according to Mr. Hicks. Cleveland was chosen for the headquarters because it is near major markets for films, he said.

Du Pont films to be handled through the new district are Mylar polyester film, polyethylene film, Teflon FEP-fluorocarbon film, cellophane, and acetate film. Other industrial sales district headquarters are in New York and Chicago.

Langevin Division Moves To Old Forge, Pa.

The W. L. Maxson Corp. announces that the manufacturing activities of the Langevin Division are being moved to its modern manufacturing plant at Old Forge, Pa.

The administrative, sales and engineering departments will be located at corporation headquarters, 475 Tenth Ave., New York 18, N. Y.

RCA Engineer Heads IRE Group

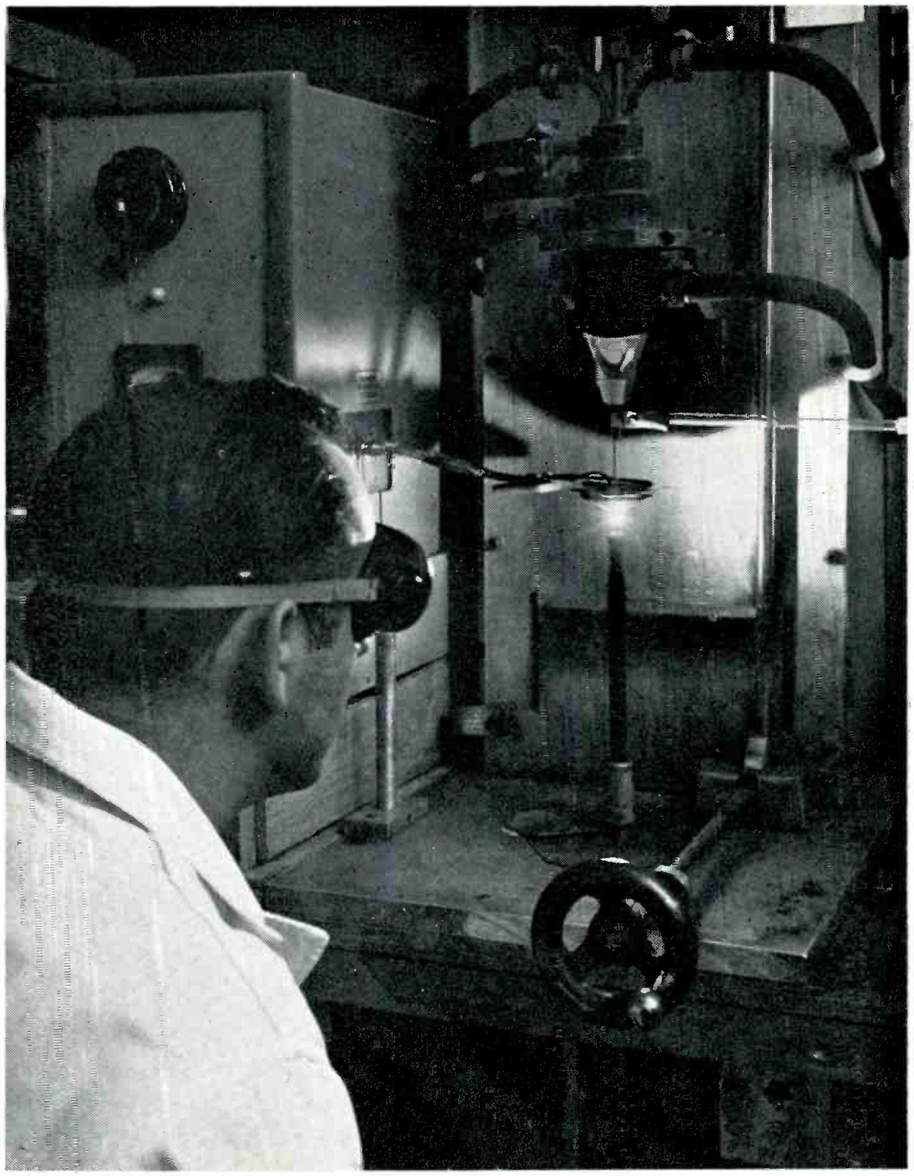
T. T. Patterson of the Radio Corp. of America has been named Administrative Committee Chairman for the Professional Group on Engineering Writing and Speech, Institute of Radio Engineers.

Mr. Patterson, who is in charge of the preparation of technical publications for RCA's Electronic Data Processing Engineering Department at Camden, N. J., also heads up an annual IRE symposia which offers information on professional writing and speaking techniques for engineers.

Audio Devices Adds to Staff

Donald J. Moore and David W. Murphy have joined Audio Devices, Inc., manufacturer of magnetic recording tape, as production control manager and plant comptroller respectively of Audio's expanding Stamford, Conn., plant.

Mr. Moore comes to Audio Devices from Sikorsky Aircraft, Stratford, Conn., where he was production coordinator. Mr. Murphy was formerly with Armstrong Rubber Co., West Haven, Conn.



CRYSTALS FROM RUST—"Flameless Fusion," a method of transforming a few cents worth of rust-like substance into a nearly perfect crystal worth hundreds of dollars to the electronics industry, has been disclosed by International Telephone & Telegraph Corp. The method produces a substance, rarely found in nature, called a monocrystalline ferrite. Scientists hope it will be a new electronic workhouse like the transistor. To produce it, radio energy charges a metal loop (center) and heats a powdered mixture of ferric oxide, a form of common rust, and other oxides. This sifts by tube through the loop and becomes a crystal upon cooling. Previous unsatisfactory methods used flames from gas torches for heat. An enclosure, to surround the loop and permit the crystal to be "grown" in a controlled atmosphere for greater purity, is not shown in this photograph.

Industry News

Blonder-Tongue Appoints Walker Chief Engineer

Ben H. Tongue, president of Blonder-Tongue Laboratories, Inc., announces the appointment of former U. S. Navy Lt. Commander Harold R. Walker to the post of chief engineer of the Special Products Division of Blonder-Tongue Laboratories, Inc.

As a United States Naval Officer for 16 years, LCDR. Walker held various technical positions. Among these were: Staff Electronics Officer to Chief of Naval Air Technical Training, Commanding Officer at the Naval Aviation Electronics Service Unit, and Head of the Infra-Red Section, Control and Guidance Division of the Naval Air Development Center.

LCDR. Walker received his B.S. in engineering from the U. S. Naval Academy, and B.S. and M.S. in electronic engineering from the U. S. Naval post-graduate school.

As head of the Infra-Red Section, he invented a new missile test set for the Bull Pup and Sparrow I missiles, conducted basic research resulting in over 40 patent disclosures, designed many new infra-red and television systems, test-piloted Bull Pup control links, Sidewinder, and inertial navigation systems.

As chief engineer of Blonder-Tongue's Special Products Division, his duties consist of directing performance on government and military contracts, and advanced research and development on company-sponsored projects having military applications.

Mr. Walker is a member of the IRE and has many articles published in leading electronic publications.

Initial group of educational TV station engineering supervisors to complete the training course in operation and maintenance of the Ampex Videotape television recorder is pictured receiving instructions from Eldon Brown (fourth from left), video service engineering supervisor of Ampex Corp.'s Professional Products Division. The week-long course was held at the firm's plant in Redwood City, Calif. Left to right are: Edward W. Reed, Jr., KTCA-TV, St. Paul-Minneapolis; O. C. Crossland, KUHT-TV, Houston; Harold D. Gorsuch, WOSU-TV, Columbus, Ohio; Brown; William Boehma, WUFT, Gainesville, Fla.; Joseph Jankowski, Jr., WTVS, Detroit; Frank Stuckman, WGED, Pittsburgh; and James C. Wulliman, WMVS-TV, Milwaukee. They represent stations heading the list of 43 educational TV stations which will receive the Ampex recorders under terms of a sales contract with National Educational Television & Radio Center.

Collins Names Hoisington

John A. Haerle, manager of southern regional sales, Collins Radio Co., Dallas, Texas, has announced the appointment of Duane W. Hoisington as broadcast sales representative for Arkansas, Mississippi, Louisiana and Alabama with offices in Jackson, Miss. Mr. Hoisington has recently completed 22 years as chief engineer and manager of stations in the Midwest.

New Catalog Available From Rohn

The Communication Tower Catalog of Rohn Mfg. Co. has been greatly expanded to include complete engineering details and structural data on Rohn Communication Towers.

Purchasers, engineers and staff members using towers and needing such information may obtain a copy of this complete engineering data catalog together with the tower specifications. Contact any Rohn coast-to-coast representative or write to Rohn Mfg. Co., 116 Limestone Bellevue, Peoria, Ill.

Kahn Research Expands Facilities

Kahn Research Laboratories, Inc., recently moved to new, larger office and plant facilities at 81 South Bergen Place, Freeport, N. Y.

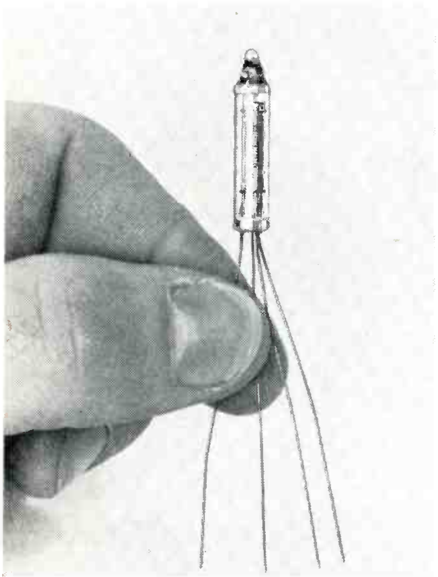
For the past eight years, Kahn Research has specialized in the development and manufacture of completely new and improved communications systems widely used by government and commercial organizations throughout the world. The move will provide much needed engineering and manufacturing space for the production of single-sideband and compatible single-sideband adapters for high frequency and broadcast type AM transmitters. Expanded production will also include the new all-AM twin sideband stereophonic transmitter adapter, voiceplex, Symmetra-peak, and SSB adapters with a unique all-electronic AFC system for AM communications receivers.

New Plant Manager At Audio Devices

Edwin J. Deadrick has been appointed plant manager of Audio Devices, Inc., manufacturer of magnetic recording tape and discs. Mr. Deadrick will be responsible for the operation of Audio Devices' two subsidiaries in Stamford, Conn, the Audiotape Corp. and the Audio Mfg. Corp. He will supervise all manufacturing, maintenance and cost accounting. Mr. Deadrick brings to Audio much administrative and manufacturing experience in the field of plastics. He was formerly with Howard Plastics and Cryovac Co.

Greater Transistor Use Boosts Use of Vacuum Tubes

"There is much talk and speculation on how transistors will eventually replace vacuum tubes in all electronic equipment. A paradoxical development in this controversy is to be found in the history of the Amperex type 6977 subminiature in-



dicator tube. Here we have a case where the increased use of transistors has actually resulted in an increased use of vacuum tubes. For the larger the computer the more indicator tubes it uses. One transistorized computer of average size may use as many as 2,500 type 6977 tubes," according to Mr. Frank Randall, president of Amperex Electronic Corp. of Hicksville, Long Island, N. Y.

Industry News

Robinson Named New Director of Collins

The election of Frederick F. Robinson as a director of Collins Radio Co. has been announced by Arthur A. Collins, president. Robinson is president and director of National Aviation Corp. He is a director also of Giannini Controls Corp., Datex Corp., the Flight Safety Foundation, Toledo Scale Corp., and is a member of the Transportation Assn. of America and the Institute of the Aeronautical sciences.

Balchen Joins GPL Staff

Col. Bernt Balchen, USAF (Ret.), has joined the planning and requirements staff of General Precision Laboratory, Inc., as an aviation consultant. Col. Balchen, internationally known as an aviation pioneer, flyer, polar explorer, and author, served with distinction in World War II and has been widely honored for his achievements. He has received the Congressional Medal of Honor.

CBS Electronics Names Sales Manager

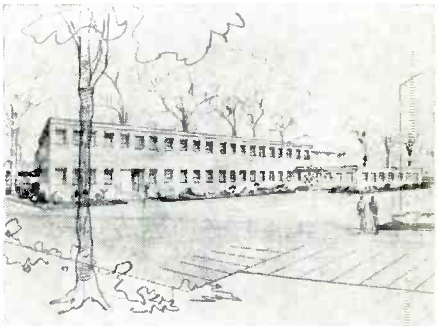
Edmund J. Nendick has been named district manager, equipment sales, for CBS Electronics, the electronic manufacturing division of Columbia Broadcasting System, Inc., in an announcement by O. Lee Ballengee, equipment sales manager. Mr. Nendick was previously an equipment salesman. His headquarters will be at the Chicago office of CBS Electronics.

New Edition of F. C. C. Regulations Available

A new edition of Part 3 of the Federal Communications Commission's Rules and Regulations is now available from the Superintendent of Documents, Government Printing Office, Washington 25, D. C. The price of the new style looseleaf edition is $4.50.

New Building for Adler Electronics

A new $250,000 engineering building which will house research and development laboratories, drafting



offices and a technical library is being built by Adler Electronics, Inc., New Rochelle, N. Y. The fully air-conditioned 14,000 square foot structure will be ready for occupancy this month.

CBS Electronics Appoints Personnel Supervisor

Howard P. Munday has been named supervisor of personnel for the Danvers headquarters plant of CBS Electronics, in an announcement by A. S. Nelson, director of personnel. Mr. Munday was previously personnel manager for CBS Laboratories in Stamford, Conn. Prior to that, he was placement co-ordinator for CBS Electronics.

Mr. Munday joined CBS Electronics in 1951. He established and edited the division magazine, the "Microphone," and subsequently held numerous supervisory posts in the personnel department.

RCA Color TV Tape Recorder Flown to Tokyo

A color television tape recorder has been flown from New York to Tokyo for service in the Nippon TV Network Corp. (NTV).

Produced by the Radio Corp. of America, it is the first such recorder to be shipped to Japan and will be used to increase substantially the color programming already being broadcast in considerable quantity there. One of its initial services will be to broadcast color tape recordings of the weekly Perry Como show under an agreement with the National Broadcasting Co.

The recorder, stripped into eight crates and boxes, weighing a total of 3,000 pounds, was trucked from the RCA factory in Camden, N. J., to Idlewild Airport.

The Japanese have shown strong interest in color television since NTV began broadcasting it last year. An average of two hours each evening is broadcast in the Greater Tokyo area. As a public service, NTV has placed 50 color receivers at strategic spots along Tokyo's main shopping street, the Ginza, and in other places including the Tokyo railroad station. During color broadcasts, these draw overflow crowds.

A majority of the programs to be taped with the RCA recorder will be dramatic presentations, but sports also will figure in the over-all schedule. Because virtually all the professional baseball games played in Tokyo are nighttime contests, NTV has broadcast these in color by "live" pickup during the regular evening color period.

Other popular sports in Japan, however, are staged during the day and a number of these will be tape recorded in color for playback in the evening. The tentative schedule calls for such coverage of ice skating events, skiing and soccer.

According the NTV officials, the RCA TV tape recorder will help the broadcasting company trim color production costs. Using the same production crews and equipment—and in some instances the same talent—several shows can be taped, one after another, during a single recording session.

The recorder, which is capable of preparing black-and-white tapes as well as color, also will be used to tape monochrome material for use on the NTV network, extending to stations beyond the area of color receiver concentration.

Andre Joins Gates

Gates Radio Co., a subsidiary of Harris-Intertype Corp., announces the appointment of John Andre as

broadcast sales engineer covering Florida. Mr. Andre has previously been associated with a number of stations in Florida in the capacity of chief engineer.

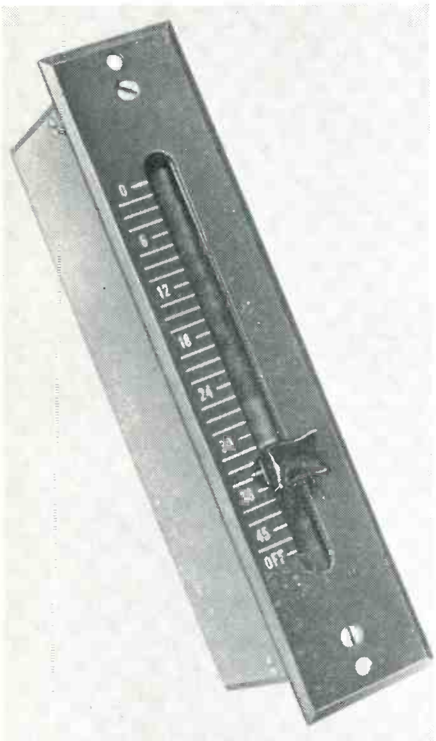
Television Recorder In Operation Quickly

One hour and 45 minutes after a truck delivered a Radio Corp. of America television tape recorder to the Baltimore studios of station WBAL-TV, the machine was in use on a regularly scheduled program. Taped material was broadcast four minutes after power was turned on.

Wilde Named Sales Engineer For CBS Electronics

George A. Wilde has been named semiconductor sales engineer for the East Coast for CBS Electronics. Mr. Wilde previously held sales engineering positions with Bendix Aviation and Russell Associates. His headquarters will be in the Newark office of CBS Electronics.

Product News



SERIES 825 AND 835 SLIDE ATTENUATORS

The Daven Co.

Livingston, N. J.

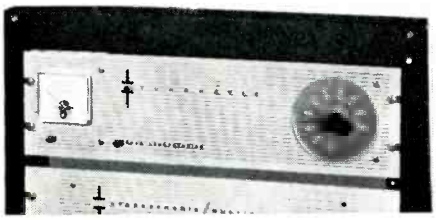
These new slide attenuators are supplied with a finger-fitting knob that moves in a straight line and can be operated with a maximum pressure of 4 ounces. The units are protected against dirt and foreign objects and supplied with slider-type terminals on rear. A removable side plate permits access to contacts. Standard on these units are quiet, long-lasting silver alloy contacts and wiper arms. They are available in balanced and unbalanced ladders and in T-type attenuators; in any standard input and output impedance; with or without tapers; in 20 and 30 steps; and with cue position. Panel space required is 1½ inches wide, 6 inches long and 2 inches deep.

505 STEREO RECORDER

American Concertone

1025 West Seventh St.
Los Angeles 17, Calif.

The new Concertone 505 plays both two-track and four-track tapes. For two-channel stereo and half-track monaural playback, a two-track stereo playback head is used. For four-track stereo, at either 7½ ips or 3¾ ips, a second head designed for slow speed, quarter-track tapes is used. Separate record and playback heads permit instant monitoring of the taped signal. Features include push-button relay operation, three motors, including hysteresis drive; mechanical flutter filter and dynamic balanced flywheel; separate record/playback amplifiers; instant start/stop; automatic cut-off switch; automatic tape lifters; tape location indicators; separate microphone and line inputs for each channel.



CRYSTAL-CONTROLLED MULTI-CHANNEL FM TUNER

Karg Laboratories, Inc.

30 Meadow St.
South Norwalk, Conn.

A crystal-controlled multi-channel FM tuner for monitoring and relaying FM broadcasts requires 5¼ inches of rack space. It can be switched instantly between groups of up to 12 pre-determined FM channels, permitting a single tuner to be used for monitoring, network pickup for rebroadcasting, off-the-air recording, or field strength surveying. It features high sensitivity, low distortion, calibrated field strength meter, and 600 ohm output. Remote control channel switching is also available.

26U-1 PEAK LIMITING AMPLIFIER

Collins Radio Co.

Cedar Rapids, Iowa

The 26U-1 is designed to achieve maximum modulation with minimum distortion. Audio passages are limited to prevent over-modulation, distortion and adjacent channel interference while permitting low level passages to be broadcast in their true range. A higher average level of modulation can be obtained with the peak limiter. In recording a higher signal to noise ratio can be obtained. A self-balancing circuit eliminates the need of tube selection or delicate balancing procedures. It is capable of 30 db compression.

PORTABLE TRANSISTORIZED OPTICAL SOUND CAMERA

Television Specialty Co., Inc.

350 West 31st St.
New York 1, N. Y.

The new lightweight camera has a built-in transistor amplifier, VU meter, monitoring jack, and microphone input. It weighs less than 16 pounds. The amplifier is essentially flat from 100 to 20,000 cycles. A thumb actuated push button starts and stops the camera without danger of jarring. A separate shoulder strap gadget bag contains the rechargeable power pack, as well as storage for the microphone and headset. The magazine capacity ranges from 100 ft. to 400 ft.

CONAX

Fairchild Recording Equipment Corp.
10-40 45th Ave.
Long Island City 1, N. Y.

This new device which has been named the Conaccelerator (Conax for short) was designed specifically to remove or reduce high frequency overload (overmodulation) in FM broadcasting or disk and tape recording. The Conax is an automatic filter, which under normal operating conditions is entirely out of the circuit passing the full frequency range. It monitors high frequency sounds, reducing the bandwidth if and when required, thus eliminating overload problems. It acts faster than one microsecond to reduce the bandwidth for the duration of the disturbance only. It is claimed the device can increase the average level of either discs or FM broadcasting by more than 50 per cent.

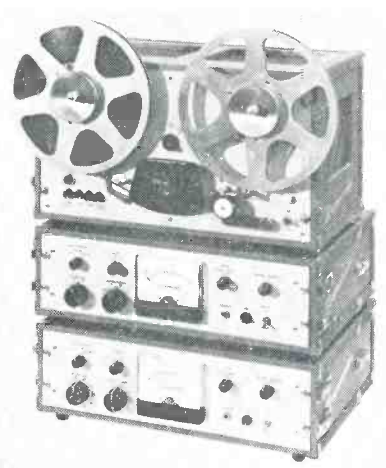
MODEL 196A OSCILLOSCOPE CAMERA

Hewlett-Packard Co.
275 Page Mill Road, Palo Alto, Calif.

This new oscilloscope camera records full-sized oscilloscope patterns without distortion on Polaroid Land film. It uses a standard camera bellows to eliminate light leakage. Its object to image size ratio is 1 to 0.9 to show a full 10 cm graticule width. Lens adjustments may be made without removing the camera from the scope. The 196A simplifies multiple exposure procedures since a convenient knob moves the lens through 11 detented positions while the camera back remains fixed. The stationary camera back simplifies tab pulling. The camera weighs 9 pounds and is equipped with a special lock tab for one-hand mounting on the scope. While making an exposure, the operator can observe the pattern with both eyes.

THREE COLOR MAGNETIC TAPE

Audio Devices, Inc., is now supplying magnetic tape in three different colors, blue and green, as well as the traditional oxide brown. The three colors may be used by studios to distinguish between categories of recorded material, between master and non-master tapes, or between material recorded at different levels or equalizations. They can serve an important function in studios now using both the new Ampex Master Equalization Curve and the standard NAB curve. The AME curve is considered to allow a substantial increase in signal-to-noise ratio resulting in a reduction in the audibility of tape noise, especially apparent in the 2000-6000 cycle range. The new curve is being used increasingly in stereo recorders for pre-recorded tape and disc mastering for quantity duplication. The NAB curve is still used for master tapes distributed to broadcasters and others for direct reproduction. The tape in either blue or green has the same characteristics and sells at the same price as standard brown.



P75 STEREO RECORDER

Magnecord Division
Box 7186, Tulsa, Okla.

A stereo version of the Magnecord P75 "Editor" tape recorder/reproducer, the P75 "Stereo," is now being offered. The recorder's specifications meet professional requirements. It has stacked stereophonic heads and matched twin record/playback amplifiers. It is powered by a direct-drive dual-speed hysteresis synchronous motor and individual reel drive motors. Features include instant starting, automatic tape lifter for fast-forward and rewind, solenoid-operated, fail-safe brake control to prevent tape spillage, automatic shut-off at the end of the reel and manual cueing. Separate erase, low-impedance record and playback heads allow simultaneous record and playback. A phone jack provides for monitoring the output from the record or playback amplifier.

KENSOL HOT PRESS

Camera Equipment Co., Inc.
315 West 43rd St.
New York 36, N. Y.

Camera Equipment Co., Inc., has recently introduced a Hot Press designed to produce quality opaque titles on posterboard, paper, cellulose acetate, photographs, or cloth. The unit prints letters in any size and in all popular colors without the use of chemicals or ink. The press letters several lines in one operation and can produce third dimensional and drop shadow effects as well as normal lettering. The stamping head is designed to swivel up to a 90-degree angle to permit the use of the press for "Crawl" work and to get special angular effects. The preheating hot plate is thermostatically controlled for consistent stampings. The stamping foil comes in a variety of 17 different colors and comes in 200-ft. rolls. A type kit with all the popular sizes and faces necessary for TV and Film Titling is also available.

Product News

"AUTO-LEVEL" LIMITING AMPLIFIER

Harkins Radio Co.
4444 East Washington
Phoenix, Ariz.

The new Harkins Radio design of an automatic constant level controlling amplifier features high performance at an economy price. Over-all gain is 60 db. continuous variable input control and continuous variable output control up to plus 30 dbm. output. Input and output impedances are both 600 ohms balanced.

The "Auto-Level" produces harmonic distortion of less than 1.5% RMS at 20 dbm. output 30 to 15,000 cps. Maximum gain at threshold of compression is 60 db. Frequency response is plus or minus 1 db., 30-15,000 cps. Noise is better than minus 70 db. below rated maximum output at 60 db. gain. Compression ratio up to 6:1 at 20 dbm. output.

The "Auto-Level" has an attack time constant of 25 milliseconds and using a dual time constant has a recovery time of 2½ seconds for 63 per cent recovery and 9 seconds for 90 per cent recovery. Fully self-contained, the compact unit is 5¼ inches high by 5½ inches deep with a standard rack panel width of 19 inches.

NEW COLLAPSIBLE MICROPHONE BOOM

Atlas Sound Corp.
1449—39th St.
Brooklyn 18, N. Y.

The new Atlas "Porto Boom" Model 37 can be knocked down and reassembled quickly without tools. It has a large brake shoe type clutch assembly that securely locks the telescopic upright in position. A piston type air check mechanism prevents accidental collapse of the upright, and an adjustable pneumatic orifice valve in the base permits rapid height adjustment while preventing sudden downward motion. A two-position dual control microphone gunning device, with an internal telescoping linkage that continuously functions at any boom extension, rotates the microphone through a 360 degree arc. One control is located at the operating end of the boom and an additional pendant type control hangs on a universal joint. The upright is 5¼ ft. retracted; 9 ft. extended. The boom, when retracted, is 7 ft., when extended it is 18 ft.

THE ANNOUNCER

Collins Radio Co.
Cedar Rapids, Iowa

This 68-pound, all transistorized portable unit designed for hi-fidelity program origination in remote broadcasting is being marketed by Collins Radio Co. For use at fairs, supermarket openings, disc jockey hops, and other events, the portable Collins Announcer is small enough to slide into the rear seat of a standard automobile. Self-storing legs detach and fit into the cabinet. The unit eliminates the need for multiple equipment in remote broadcasting situations.

Technical Hints

Transmitter Space Heaters

Users of transmitters that have space heaters probably have found out that they aren't as inexpensive as they look when they have to be replaced. An easy way to solve the cost outlay is to install regular bulb sockets and use your old tower light 111-watt bulbs. These 130-volt bulbs also last much longer and give off plenty of heat.

Our GE XT-1-A transmitter used two space heaters and the installation of three bulbs did the trick. This heat is needed when the transmitter building is not heated in winter due to the use of remote control. In over five years' time this has amounted to a considerable saving plus added reliability. Incidentally, if your station uses regular bulbs anywhere in its operation, always buy them at 130 volts. They last much longer and save work and cost no more than the regular 115-volt bulb.

Norman F. Round
WCCM
Lawrence, Mass.

Classified

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

EQUIPMENT FOR SALE

Field Intensity Meter, Federal 101-C, with 530 to 1600 kc loop antenna, in excellent condition, 250. WCAE, Inc., Pittsburgh 30, Pa. 12-59 1t

F. M. Antenna, Western Electric 54-A 8-bay Cloverleaf, for any frequency from 88 to 108 mc. On ground in five sections. Make offer. WCAE, Inc., Pittsburgh 30, Pa. 12-59 1t

MIRATEL TV MONITORS — Demonstration units, new warranty. 15-17" metal cabinet, $215 each. 8-17" veneer cabinet $185 each. Complete line of new units available in 8", 14", 17", 21" and 24". Write: Miratel, Inc., 1082 Dionne St., St. Paul 13, Minn. 12-59 3t

Motorola Base Station Receiver—New, used 8 days, Model LA3AB-1A, 153.29 MCS. Cost $339, best offer. George Jowdy, CE. WEZE, Boston, Mass. 12-59 1t

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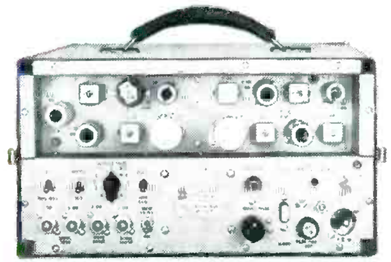
1003-C VIDEO TRANSMISSION TEST SIGNAL GENERATOR

Produces multi-frequency burst, stairstep, modulated stairstep, white window, composite sync. Variable duty cycle. Regulated power supply.



1004-B VIDEO TRANSMISSION TEST SIGNAL RECEIVER

Very rapid and accurate measurements of differential phase and differential gain characteristics of video facilities. Responds to standard stairstep test signal modulated with 3.58mc, or any differential phase or gain test signal.

VIDEO TRANSMISSION TEST EQUIPMENT

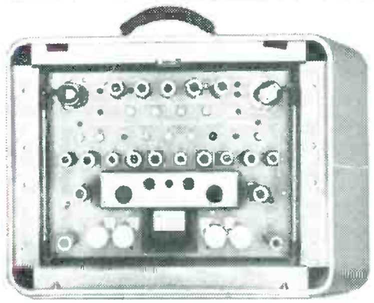
In Daily Use by All Major Networks, Stations and Telephone Co. Coaxial Cable, Microwave, and Intercity Facilities.

ALL CARRYING CASE UNITS IMMEDIATELY ADAPTABLE TO STANDARD RACK MOUNTING

1005-A VIDEO TRANSMISSION TEST SET

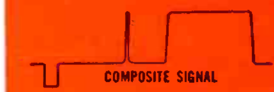
1005-A1 — Produces composite television waveforms suitable for measuring amplitude vs. frequency; differential gain vs. amplitude; dynamic linearity; differential phase vs. amplitude; high frequency transient response; low frequency transient response; low frequency phase or streaking, smears, mismatches; and other video characteristics.

1005-A2 — Supplies composite EIA Sync, blanking, horizontal and vertical drive signals and regulated B + power for itself and 1005-A1. Features magnetic core binary counters.



1008-A VERTICAL INTERVAL KEYER

Permits test and control signals to be transmitted simultaneously with program material, between frames of TV picture. Any test signal (multiburst, stairstep, color bar, etc.) may be added to the composite program signal. Test signals are always present for checking transmission conditions without impairing picture quality. The home viewer is not aware of their presence.



1073-CR SINE SQUARED (SIN^2)—SQUARE WAVE GENERATOR

Produces new waveform for testing TV or other pulse unit or system for amplitude and phase characteristics. Sin^2—Square Wave pulse is equivalent to TV camera signal and is more sensitive than a Square Wave in indicating ringing. Video test signal adjustable for 1.0 volts or 1.4 volts peak to peak. Now in use by major TV networks and telephone companies.

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