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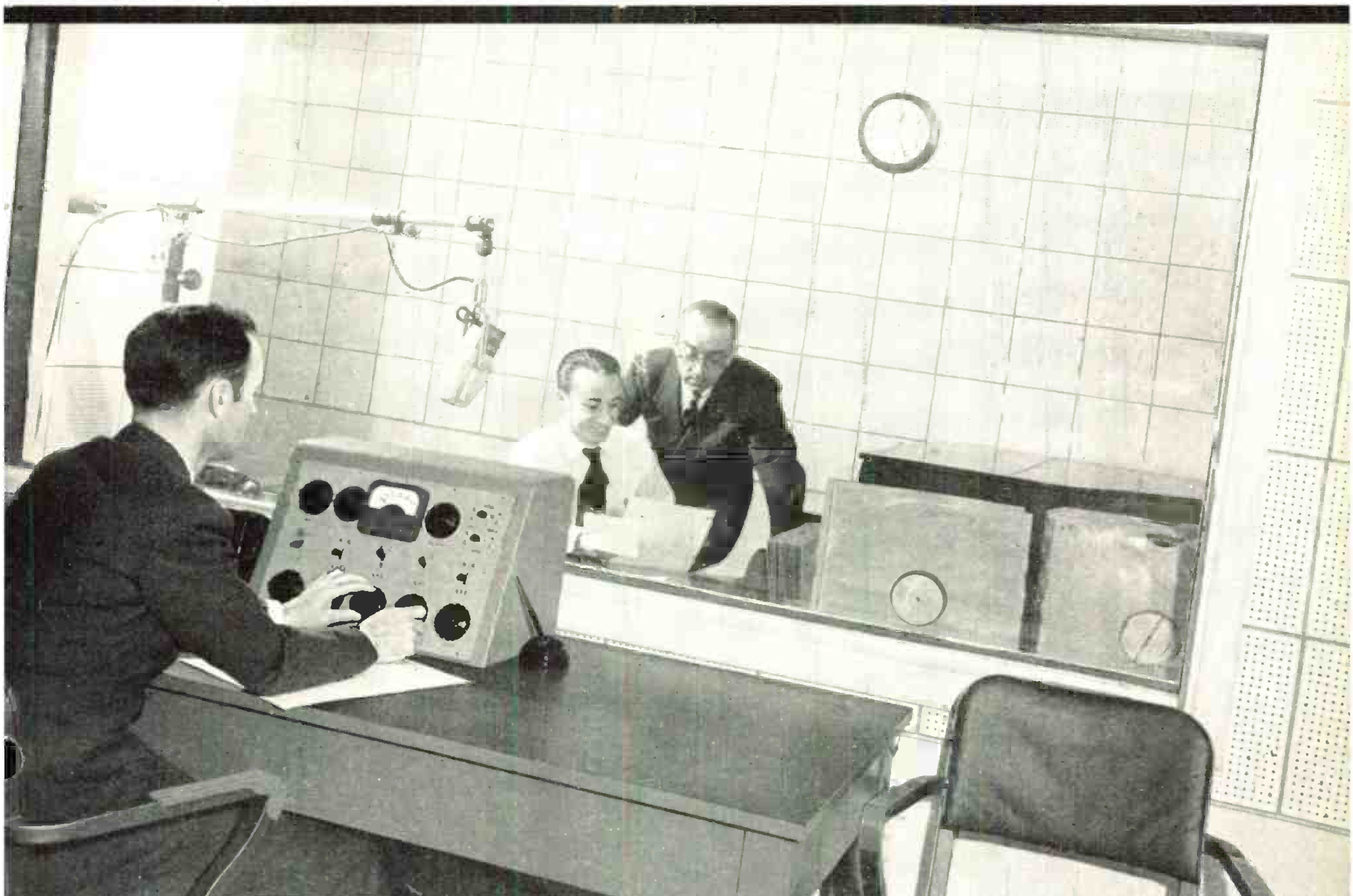

JULY

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1948

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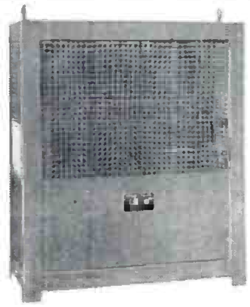
3P30,000	3000-30,000	0.5%
3P45,000	4500-45,000	0.5%

• Harmonic Distortion on above models 3%. Lower capacities also available.



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10,000+	1000-10,000	0.5%
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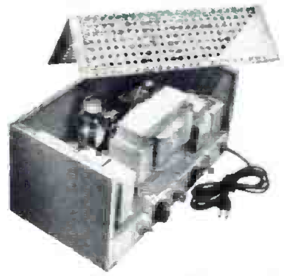

General Application

MODEL	LOAD RANGE VOLT-AMPERES	*REGULATION ACCURACY
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2000	200-2000	0.2%

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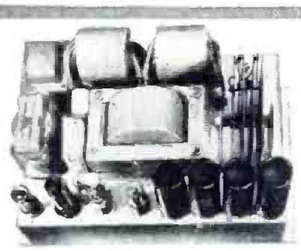

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COVER ILLUSTRATION

Control room setup at WMCP-FM, Baltimore, operating at 94.7 mc, with an effective radiated power of 20 kw. *(Courtesy Westinghouse)*

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COMMUNICATIONS

LEWIS WINNER, Editor

JULY, 1948

The TV Allocation Hearings

TELECAST ENGINEERING research and development activity was quite a featured topic during the recent tv allocation sessions in Washington. At this, the first comprehensive hearings on the channel problem, since the channels were set up two years ago, over 100 presented volumes of engineering data as testimony for and against the FCC plan which would nearly double the present channel setup. The acute problem of co-channel or adjacent interference served as a major point of most arguments. Exhibits disclosed that up to 180-mile separation may be required in some instances to avoid interference. Directionalized co-channel operation was offered as one solution.

One exhibit, wherein the proposed use of channel *6* by WNHC-TV, New Haven, Conn., was described, showed that based on separation versus a 100:1 and 2:1 signal ratios for co-channel and adjacent channel clearances, the overlap of WNHC-TV, operating with a power of 20 kw at 500 feet elevation above surrounding terrain, as against 50 kw at 500 feet for WABD on channel *5* and likewise Worcester with 50 kw at 500 feet, was not greater than anticipated for the whole scheme of allocations for the New York and New England areas on channels *5* and *6*.

A plan offered by DuMont suggested an addition of 8 channels which are now in use by the Interdepartment Radio Advisory Committee (112-118, 132-138, 138-144, 162-168, 168-174, 216-222, 222-228, 228-234 mc or 162-168, 168-174, 221-227, 227-233, 233-239, 239-245, 251-257 mc). To justify this transfer, the government might be given an equal number of frequencies in the u-h-f band reserved for television.

Since on September 20, the u-h-f band allocations will be probed, this approach to the problem will, undoubtedly, be reviewed again with, perhaps, the entire 2 to 13 channel allocation testimony serving as an additional report for the basis of allocation judgment. Several witnesses at the 2 to 13 channel sessions indicated that no final decision could be made until both hearings were completed and studied carefully.

It appears as if this fall may see a revised allocation pattern which will bring new horizons to tv.

Intercarrier TV-Sound Reception

THE USE OF INTERCARRIER SOUND in tv receivers has been the subject of many investigations. For instance, the matter has been receiving careful study by the Television Transmitter Committee of the RMA Engineering Department.

At present and in the future, to make intercarrier reception feasible, at least three conditions must be met: (*1*)—The picture carrier must never disappear so that it is always available to provide the 4.5 mc beat upon which the system functions. Local generation of the 4.5 mc carrier is, of course, possible but brings with it unwanted complexity. (*2*)—The separation between the picture and sound carriers, nominally 4.5 mc, should be held with the minimum variation possible so that the bandwidth of the audio discriminator may be kept reasonably small, and to insure that a-m noise may be rejected with a minimum of limiting involved. (*3*)—Incidental f-m or phase modulation of the picture carrier, with respect to the audio carrier, must be minimized so as to avoid the introduction of hum or unwanted signal into the f-m sound channel.

Initial opinions indicated that some of these limitations would restrict the practicality of the system. However, recent surveys by S. W. Seeley indicated that these objections may not be too well founded. From stations in metropolitan New York currently surveyed, indications were that with no design or operational changes, the limiting performance of the intercarrier receivers was not found excessively wanting. To further safeguard performance, however, there is likely to be a concerted campaign by proponents of the intercarrier system for further safeguards with respect to transmitting equipment.

Commenting on the problem, Leonard Mautner, head of the television transmitter division of the Allen B. DuMont Labs. stated that although it may be argued that a substantial modification of the design or operation of the transmitting gear is warranted to further the production of low-cost tv receivers, an engineering compromise which will give the greatest freedom to both transmitter and set designers is indicated. He said: "Inevitably, further study of present transmitter capabilities and deficiencies must be made before a standards review is indicated for the transmitter gear. Likewise, a review of the intercarrier set requirements must be made before the minimum requirements of intercarrier set designers could be adequately defined.

"For the interim period during which the intercarrier system holds forth with no modification of the transmitter equipment, it would appear that broadcasters may expect most favorable comments of their programs on intercarrier sets if they will . . .

(*a*) Carefully monitor their video transmission to insure that maximum white transmitted corresponds to no less than 10% of maximum carrier.

(*b*) Monitor the frequencies of the audio and video carriers so as to maintain the 4.5-mc nominal separation to as much within the present FCC standard of .002% for the individual carriers as operations will permit.

"These conditions may be readily met by telecasters with careful attention to operating practice. The remaining condition of phase modulation appears at the moment to be less of a limiting factor to satisfactory performance of intercarrier receivers and one that can only be resolved when additional information is forthcoming from both transmitting and receiving groups

"The extent to which intercarrier receivers will approach the optimum performance that such a system will permit, assuming that the requisite transmitter deficiencies could be overcome, will rest primarily with the intercarrier set makers and the self-imposed economic conditions."—L. W.

Frequency Stabilization In

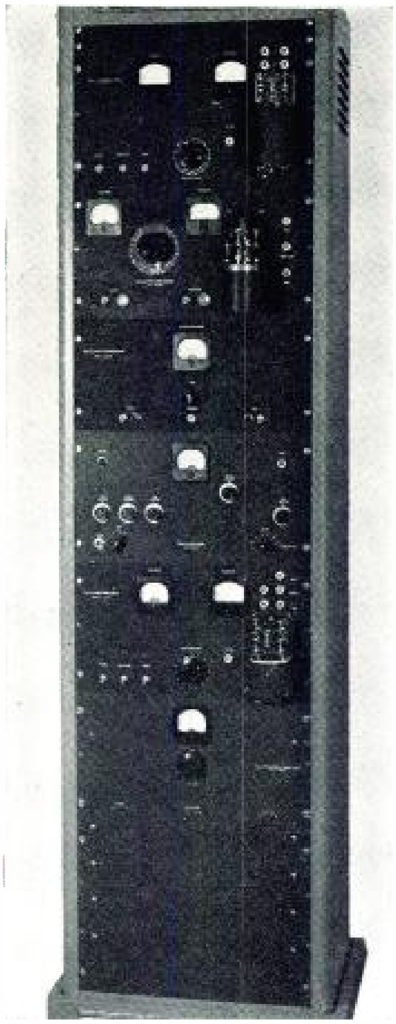


Figure 1
Frequency multiplier unit.

Frequency Stabilization Procedure, Using Feedback Technique, Permits Construction of Compact Easy-To-Tune Equipment. Uses Microwave Oscillator, Reflex Klystron, H-F Discriminator and Direct Coupled (D-C) Amplifier Setup.

by A. V. DONNELLY**
Assistant Professor
Department of Electrical Engineering
The State University of Iowa

There are two basic methods of obtaining a stabilized oscillator at microwave frequencies. The first is frequency multiplication. This is the practice of employing a quartz crystal vibrating at a relatively low radio frequency, whose output is multiplied the number of times necessary to give the desired frequency. The second method involves feedback techniques. In this scheme some type of frequency-sensitive control circuit is used which is capable of changing the oscillator frequency in a manner which will maintain the frequency within specified limits.

Frequency Multiplication

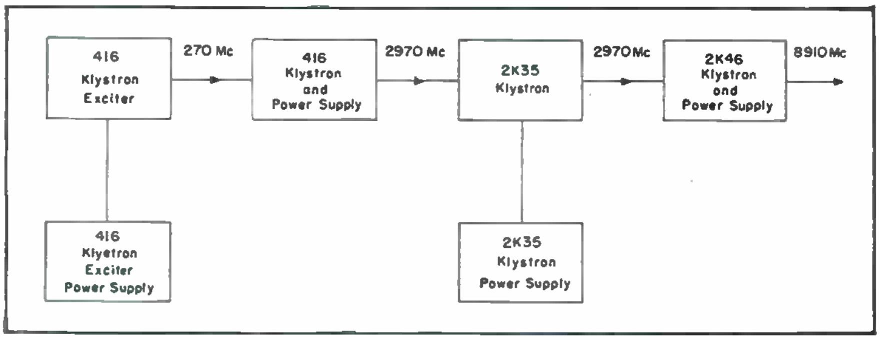
A frequency multiplier unit used by the author is shown in Figure 1. The general plan of its construction appears in the block diagram of Figure 2. A crystal whose frequency is approximately 7.5 mc is used as the basic element in a 416-klystron exciter. Employing conventional doubler and tripler circuits, this frequency is multiplied 36 times providing an output frequency of approximately 270 mc with a power of about 10 watts. This feeds the input of a 416-klystron multiplier tube where an eleven-fold multiplication takes place. (This multiplication may be ten, eleven, or twelve times depending on the tuning adjustment.) This multiplier tube is not very efficient, and at 2,970 mc the output is about 10 milliwatts. The output is then fed to a 2K35, a klystron cascade amplifier, with a power gain of 1,000. This provides a 1-watt (approximately) input to a 2K46 klystron, a multiplier tube, the output frequency of which is three times the input frequency, or 8,910 mc at a power of approximately 10 milliwatts.

The output of such a unit will have the same degree of stability as the l-f quartz crystal used in the exciter unit. By employing temperature-regulated crystal units, the frequency deviation can be kept to a minimum.

Two commercial applications*** of this system have been made: a microwave blind landing system[1] and a two-way microwave f-m system for use in a railroad installation.[2] Both of these systems, however, operate on a frequency in the region of 3,000 mc, and do not use the 2K46 multiplier stage.

One of the greatest disadvantages of the aforementioned system has been the difficulty in *tuning up*. There are

Figure 2
Block diagram of the frequency multiplier unit.



*Based in part on a dissertation submitted for Ph.D. requirements at the State University of Iowa.
**Formerly with Collins Radio Company.
***Systems installed by Sperry Gyroscope Co.

The Region of 10,000 Mc*

nine cavities in the system, three on each of three klystron tubes, which require delicate adjustment. The problem was recently solved by the National Bureau of Standards who now employ the modified setup as its *microwave frequency standard* at the Central Radio Propagation Laboratory.[3] No klystron generators are used in this system. Instead, harmonics of the output frequencies from the conventional multipliers are generated by silicon-crystal multipliers. Thus there is no need for the tedious cavity adjustments required with the klystrons.

Feedback Stabilization

In this type of stabilization, the frequency of oscillation is generated at the value at which it is to be used and not derived from multiplication of a lower frequency. The frequency of the oscillator tube is controlled by a correction voltage obtained from a frequency discriminator circuit. This discriminator circuit converts any change of frequency to a corresponding change in voltage. This correction voltage, in turn, is applied to the oscillator tube so that the frequency is maintained at a desired value.

The discriminating action can take place at one of two different levels in the system; either at (*1*) a low frequency, usually the intermediate frequency in a superheterodyne receiver or at (*2*), a high frequency, such as the microwave frequency of the oscillator to be stabilized.

Low-Frequency (I-F) Discrimination

In the low-frequency discriminating system, the discriminator circuit is of conventional design and operates from the intermediate frequency. The output from this circuit is allowed to control the frequency of the oscillator by changing one of the electrode voltages. This system was used considerably in radar systems in which the magnetron source was fairly unstable. To keep the receiver tuned so that the i-f was confined within the bandwidth of the i-f amplifier the frequency of the local oscillator was changed so that it could follow the variations of the signal source. (Actually this is opposite to frequency stabilization but it is included so that the theory presented will be complete.) Three of the many radar systems that used this method were the MPG-1 Fire Control Radar,[4] the APS-15 and the APQ-13[5] Radars for Blind Bombing. In these cases the i-f was 30 mc.

High-Frequency (R-F) Discrimination

As a contrast to the l-f discriminating system, h-f discrimination involves the use of a discriminator circuit which is capable of converting deviations at the microwave frequency into voltage variations. Suitable combinations of wave-guide components can provide an appropriate discriminator circuit, the output of which can be made to control the voltage of an electrode of the oscillator. The electrode used in the case of the reflex klystron is the reflector.

A Feedback Stabilization System

This type of stabilization system consists chiefly of a microwave oscillator (a reflex klystron such as the 723 A/B of the 2K39), a h-f discriminator circuit, a direct-coupled (d-c) amplifier and a power supply. Figure 3 shows the relationship of these units. One of the simplest h-f discriminator circuits may be formed by a combination of a hybrid tee, a shorting plunger, a resonant cavity and a crystal termination, as shown in Figure 4. With proper adjustment, an amplitude variation in the output can be obtained with a variation in frequency of the input. To minimize variations due to temperature changes, the resonant cavity used as a reference standard was enclosed in a temperature-regulated oven (not shown in the photograph). The output of the discriminator is fed to a direct-coupled amplifier where the minute fluctuations are amplified to larger fluctuations. The output of the d-c amplifier is connected in series with the reflector power supply of the oscillator tube. The variations from the d-c amplifier then can vary the voltage of the reflector which

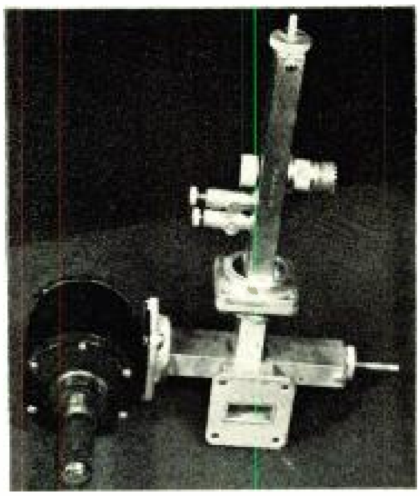
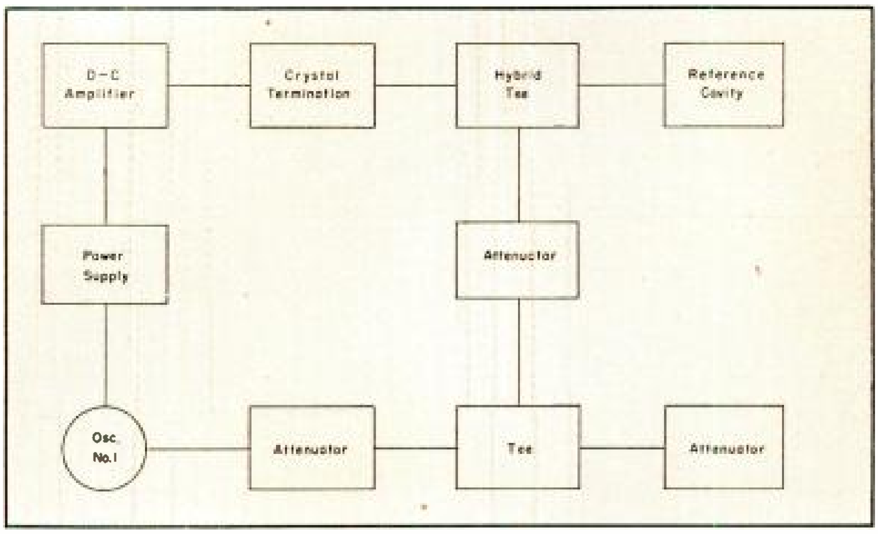


Figure 4
High frequency discriminator.

Figure 3
Setup of a feedback stabilization system.



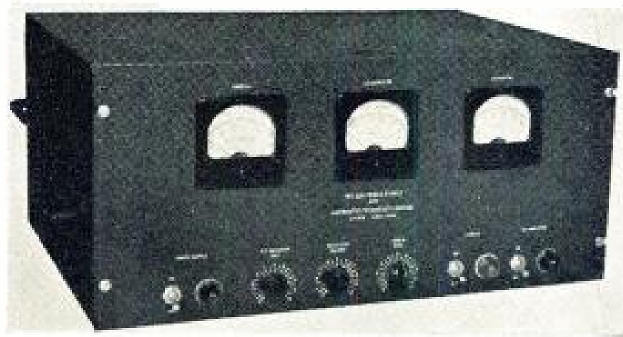


Figure 5

Feedback stabilization system power supply.

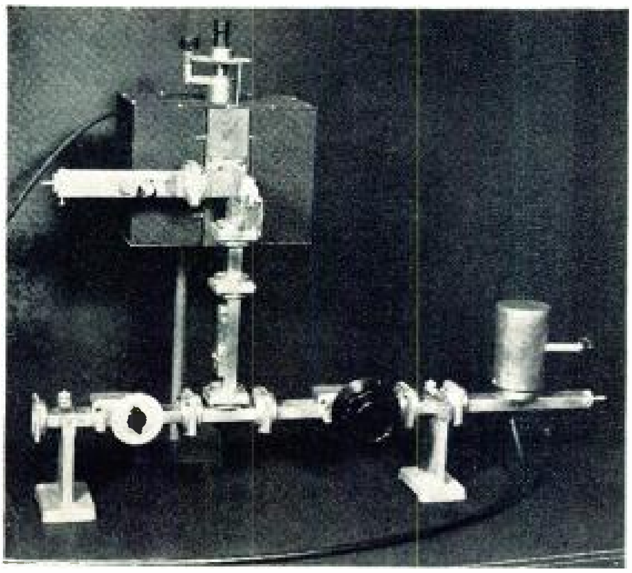


Figure 6

Feedback stabilization system waveguide plumbing.

will cause the frequency of the system to return to its original value. Figure 5 shows a complete laboratory unit incorporating the power supply and the d-c amplifier, and Figure 6 shows a representative arrangement of waveguide plumbing.

Numerous modifications and refinements are possible but the simplest type is presented so that complications of apparatus and involved theory of waveguide components would not overshadow the basic operation of the system.

Determination of Stability

An engineer or a laboratory technician working with a stabilized oscillator always demands that the value of the stability be given. In the case of the frequency multiplier units, this value can be easily determined. The output of the frequency multiplier unit will have the same percentage deviation as the original crystal oscillator. Hence, all that is necessary is to determine the percentage deviation of the l-f crystal. This procedure presents no problem. The output of the crystal oscillator can be compared with that of a secondary frequency standard previously calibrated from the signals received from WWV of the National Bureau of Standards.

The determination of the stability of a feedback stabilization system is, however, an entirely different problem. To determine the stability of a feedback stabilization system, one could compare the output with the output of a frequency multiplier unit whose deviation was known. This method could not be universally adopted because of the few microwave frequency multiplier units available. In addition, it is assumed that the percentage deviation of the frequency multiplier unit is of a comparable value with that of the feedback stabilization unit to be measured. This restriction further reduces the number of frequency multiplier units that would be suitable for this purpose. Because of this difficulty, other methods of determining frequency deviation must be conceived.

One method which could be utilized would be that involving a frequency comparison similar to that encountered at the lower frequencies. In this method, however, the two frequencies being compared would both have to be unknown. To be more explicit, two identical oscillating systems of unknown frequency deviations could be beat together giving some intermediate frequency. The frequency deviation of this intermediate frequency could then be determined by conventional methods. This procedure will not give an absolute value because one unknown is being compared with another. Instead, a relative figure of merit is obtained indicating the maximum deviation of either of the two units.

During an investigation, an attempt was made to utilize the above method. Difficulty was encountered with noise modulation on the two oscillators which did not permit a satisfactory beat frequency to be obtained. As a consequence, a modification of the above method was used.

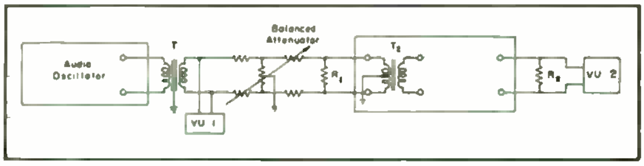
The two unknown oscillator systems were allowed to beat together at a frequency of approximately two megacycles per second. This intermediate frequency was passed through an r-f amplifier whose bandwidth could be varied over a known range. A cathode-ray tube indicated the output from the r-f amplifier. The operation of this method was based on the fact that as long as the cathode-ray tube indicated that an output was being obtained, the frequency deviation was less than the bandwidth of the r-f amplifier. By varying the width of the tuned circuits of the amplifier, the limiting value of the frequency deviation could be determined. Satisfactory results have been obtained with a limiting value of stability of the order of one part in 25,000,000 being measured when employing an oscillator frequency in the region of 10,000 mc.

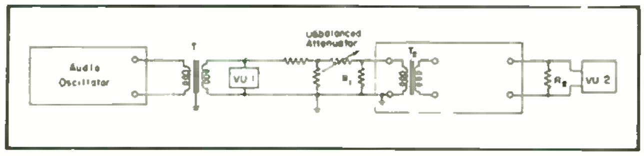
Summary

The frequency multiplier unit employing klystron multiplier tubes is not satisfactory since tedious adjustment of the various cavities are involved. In addition, the use of the multiplier tubes requires a number of high-voltage power supplies which should be well regulated; items which are costly and space consuming. These disadvantages have been more or less overcome by the substitution of silicon-crystal multipliers for the klystrons. With super refinement in the driving oscillator, it is possible to obtain a frequency standard with a variation of less than one part in 100 million.

As a contrast with the frequency multiplier units, a feedback stabilization system can provide the same degree of stabilization with much less equipment resulting in a much lower cost and a lower space factor. This

(*Continued on page* 31)





Figures 1 (left) and 2 (right)

Figure 1: Recommended method of determining frequency and linearity characteristics of a preamp containing a balanced input transformer. If the preamp has a bridging impedance or is to be fed from a source impedance of R_1 ohms, then R_1 should be made equal to the required impedance. This can be a pure resistance, either carbon or non-inductive wire wound, with a value of about 250 ohms. If the preamp has an input impedance, then R_1 is not necessary since the amplifier will terminate the attenuator. The ground in the balanced attenuator circuit need not necessarily be used for low and medium gain amplifiers. It is, however, required for high gain amplifiers.

The T transformer is desirable to isolate from the unbalanced ground effects which may be present within the audio oscillator. It should be a 1:1 ratio and have an electrostatic shield. Typical impedance ratios are from 200/200 to 600/600 ohms.

Figure 2. Circuit recommended for measuring a preamp containing an *unbalanced-to-ground input transformer.*

Maintenance of Preamp Equipment

In Broadcast Transcription-Reproducing Systems

Maintenance Progam, Developed by NBC Radio-Recording Division, Features Tests Which Determine Frequency Response, Distortion and Operating Levels of Preamp Units.

by RALPH G. PETERS

The preamp is a particularly vital link in the broadcast transcription-reproducing system and accordingly must be carefully checked, at least once a month, for its frequency response, distortion and operating level.

To determine the frequency response of the preamp, the Figure 1 circuit can be used. The audio oscillator used in this setup should cover the 30- to 15,000-cps range. The output of the oscillator should not contain more than 1% total harmonic distortion at the normal operating level used for the proposed tests (approximately +4 vu).

The use of an isolation transformer between the oscillator and the preamp input is indicated in this circuit. Experience has indicated that the use of proper isolation will greatly minimize errors, particularly when measurements are made at the higher frequencies with circuits which are balanced to ground. The isolation transformer should provide the correct impedance matching between the oscillator output and the preamp input; it should also include an electrostatic shield, which should be connected to a good ground.

Measurement Technique

The frequency response characteristic of the preamp can be determined by a direct comparison between the volume indicator connected to the audio oscillator, and the volume indicator connected to the output of the preamp. To eliminate any possibility of error due to inaccuracies in the volume indicators, the tracking of the volume indicators should be compared by connecting them in parallel across the output of the audio oscillator and sweeping over the frequency range to be used. The two volume indicators should agree with ±.3 db to be considered satisfactory for use. If the departure should be greater than this limit one volume indicator should be considered as a standard (usually the volume indicator associated with the oscillator output), and a correction curve used to correct the final reading.

Many preamps have relatively high input impedance. If such a type is to

(*Continued on page 30*)

[1]From maintenance manual, *Maintenance Procedure For the Broadcast Transcription System*, prepared by research engineers of NBC Radio-Recording Division.

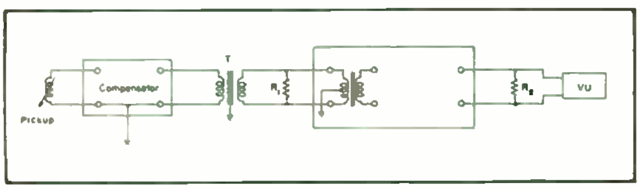
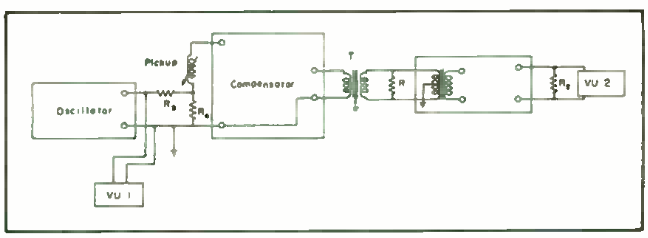


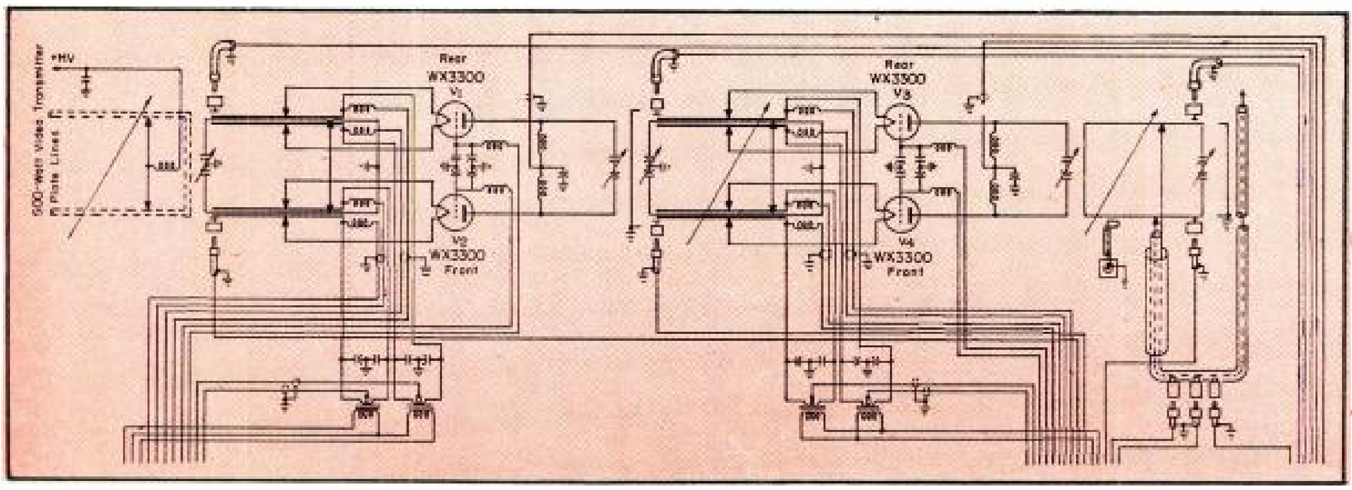
Figure 3

Another preamp setup where the isolation transformer must be used since the preamp input is balanced to ground, while the compensator has a ground on one leg. Should the preamp have a ground on one side of its input, then the isolation transformer can be deleted.

Figure 4

Circuit used to measure the transmission of a compensator. R_4 can be a 1 to 10-ohm resistor, providing the pickup impedance is in the vicinity of from 200 to 500 ohms (a-c impedance). R_3 can be approximately 500 ohms. R_3 and R_4 constitute a voltage divider with R_4 low enough in value to permit the signal to be injected in series with the pickup and still not disturb the compensator circuit by introducing an appreciable resistance.





TV Transmitter Design

In our analysis of class *B* linear amplifiers last month, the four primary conditions which linear amplifiers must meet were detailed as satisfactory bandwidth, adequate power output, linear output between the limits of 100% and 15% modulation, and suppression of lower sideband. Circuitry evolved to achieve these results were reviewed.

In this installment, linear amplifier design features are probed further.

Figure 1 shows the circuit breakdown of the two class *B* linear amplifier stages in which coupling and loading may be varied to produce a response characteristic satisfactory for the wide band of frequencies required for tv service. Secondary loading is increased by moving the cathode leads (filament) toward the open end of the resonant line. A fine adjustment of this variable is provided by a shorting bar near the shorted end of the line.

Variable coupling is provided by changing the physical position of the secondary with respect to the primary by means of a worm drive gearing system. This design, showing this physical positioning of the various elements, is illustrated in the six views shown in Figure 2. It will be noted that half wave lines are used. This allows for greater line length outside the tube to the quarter wave point, and in addition provides greater coupling efficiency between the stages. It is desirable to make the tuned circuits *only* broad enough to deliver high-definition television picture elements to realize a satisfactory plate circuit efficiency, since circuit efficiency is a function of bandwidth. A further criteria for plate-circuit efficiency is that the tube output circuit be designed around a tube with relative low plate resistance, with respect to the plate-load resistance, in order that maximum voltage will be developed across the load impedance.

The modulated amplifier and class *B* linear stages are so tuned that the upper sideband of the television information is included in the passband characteristic of the tuned circuits, i.e., the carrier is positioned on the edge of the low-frequency end of the passband, and the circuits are adjusted to give a smooth frequency response characteristic over approximately F_c to $(F_c + 4)$ mc. This adjustment produces a single-sideband transmission system, since the tuned circuits reject the lower sideband—each tuned circuit contributing to the overall attenuation. In addition to the inherent selectivity of the tuned circuit, a notching filter is coupled to the cathode input circuit of the intermediate power amplifier. This filter is adjusted to 1.25 mc lower than the carrier frequency and results in narrowing the low frequency *skirt* of the passband characteristic.

Figure 1 (above)
Intermediate and power amplifier single sideband class *B* linear amplifier section of transmitter.

Operation Setup of Amplifiers

Initial *operation setup* of the class *B* linear amplifiers is essentially the same as previously described for the modulated amplifier, except that in this case the video signal and r-f drive parameters are fixed. Bias should be maintained such that approximately 10% normal plate current flows with no excitation. This condition assumes that the grid plate transfer characteristic will be linear from this value up to the maximum excitation required to produce full rated output. For a *driving condition* as described for the modulated amplifier, the output voltage will be directly proportional to the exciting voltage, and the modulation percentages will be maintained. Should the bias be kept at too highly negative a value, and the modulated amplifier be adjusted for proper modulation percentages, the video information will saturate in the white direction. This is due to operation about the lower knee of the transfer characteristic. Obviously should the bias be too positive, the sync output will swing into the upper knee of the transfer characteristic resulting in sync compression, excessive plate dissipation, and poor efficiency. The condition of excessive negative bias may be *masked* by reducing the modulation percentages in the modulated amplifier. This setup will allow the class *B* linear amplifiers to saturate toward the zero modulation direction, which *may* result in the proper ratio of modulation envelope percentages. However, this condition should be avoided, since the angle of flow of plate current with respect to the r-f grid drive will be reduced, resulting in lower efficiency and poor utilization of the transfer characteristic.

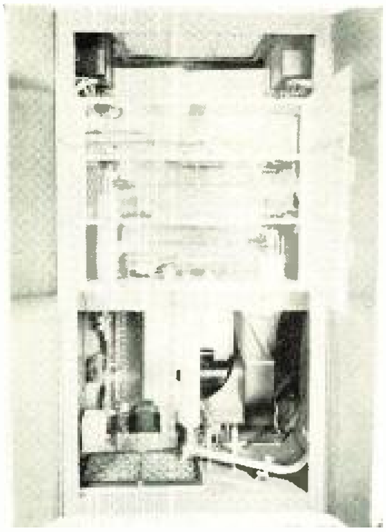
Output Load Considerations

The transmitter output is essentially a balanced system since the power am-

Part III . . . Linear Amplifier Design Features . . . Output Load Considerations . . . Testing the TV Transmitter (Video Amplifier Modulator Frequency Response) . . . Testing D-C Restorer . . . R-F Pass-Band Characteristics.

by G. EDWARD HAMILTON

Head, Television R-F Development Section
Television Transmitter Department
Allen B. Du Mont Laboratories, Inc.



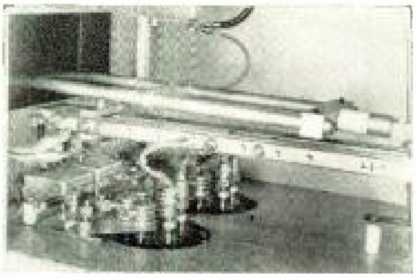


Figure 2

Top (*a*): Layout of final class *B* linear amplifier stages. Below (*b*): View showing manner in which the modulated amplifier drives the cathode to the intermediate power amplifier.

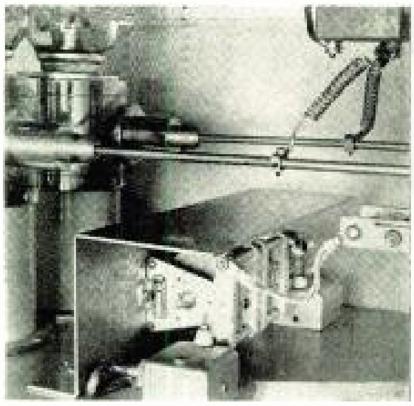
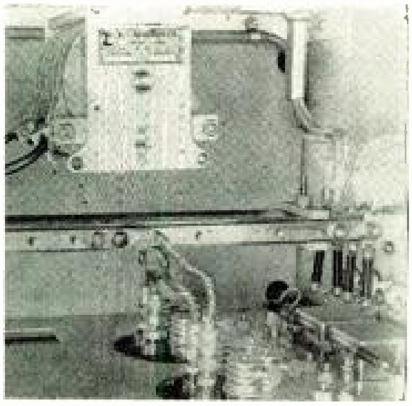


Figure 2

Above: Tuning and coupling system between intermediate power amplifier and power amplifier. Below: Another view of the tuning and coupling system between the intermediate power amplifier and power amplifier.



plifier is push pull. Provision may be made for either balanced or unbalanced output connection, depending upon the antenna system to be used. Balanced output may be accomplished by connecting two transmission lines to the output coupling network. The two inner conductors connect to the coupling line at a position that produces satisfactory loading and match to the plate tank circuit, and the two outer conductors are bonded to chassis thereby producing a balanced output. To proceed from a balanced output circuit to an unbalanced transmission line, it is necessary to insert a balance to unbalance converter unit. This consists of a so-called *bazooka* system, i.e., a quarter-wave isolation transformer which places the outer conductor of the output transmission line at a high impedance with respect to the chassis. Figure 1 shows the manner in which the unit is installed in the transmitter. The electrical length of the *bazooka* is made adjustable by means of capacitive end loading for channels *2* and *3*, and stub shortening for channels *4*, *5* and *6*.

The antenna is of prime importance in any installation since it must present a constant resistive load, at the end of the transmission line, over the entire passband (at least 4 mc above the video carrier frequency). A standing-wave ratio of better than 1:1 must be maintained for satisfactory picture resolution. Every effort must be made to keep the characteristic impedance of the transmission line constant since irregularities reflect back into the output circuit resulting in such effects as multiple reflections. These mismatches may be observed by the following method: (*1*) The transmitter output line is connected to a resistive impedance equal to its characteristic impedance and the output characteristic noted as traced on the wobbulator scope with the transmitter operating under conditions of wobbulation and (*2*), the terminating resistor is replaced with the transmission line and compared with step *1*. It has been noted that long transmission line installations show considerable variation across the passband especially where irregularities exist along the transmission line. It is, therefore, desirable for the antenna and transmitter to be located as close together as building layout permits to reduce the foregoing conditions.

Testing the TV Transmitter

Video Amplifier Modulator Frequency Response: The video amplifier frequency characteristic must be capable of essentially flat response to 5 or 6 mc. The low frequencies may best be tested by the application of square waves to the input and observing the amount of tilt on a 'scope whose l-f characteristic is flat down to at least 10 cycles.[1] The tilt allowable in a video amplifier is of the order of two per cent maximum with a sixty cycle square wave. In the circuit of Figure 3 (May, COMMUNICATIONS) there appeared capacitors (C_3, C_4, C_5, C_8 and C_9) which act as l-f compensation elements. Excessive compensation may be observed on a 'scope as a rise in the trailing edge, while under compensation may result in a rise of the leading edge. In every case, each stage should be flat by itself—staggering stages may result in objectionable phase shift and should be avoided wherever possible.

The h-f response of video amplifiers may be best tested by means of a beat-frequency *wobbulator* whose output is linear from about 200 kc to 8 mc, and a 'scope. The characteristic of this 'scope need not be too exacting

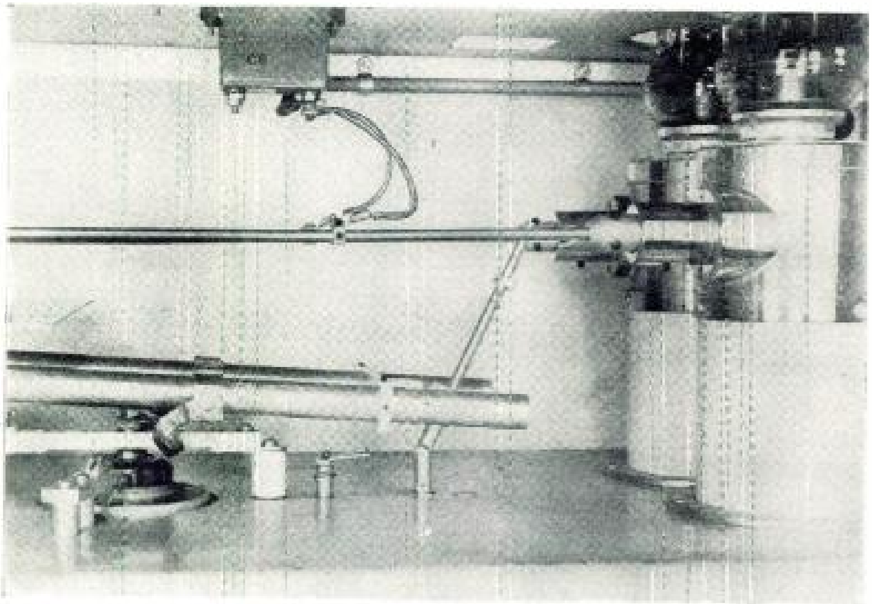


Figure 2
Position of the plate tank and output circuit of the power amplifier.

since a l-f wobbulator sweep is used, and a high impedance linear detector is employed to measure the amplitude response. The May installment Figure 3 (video amplifier) shows that series and shunt peaking is employed with damping across the series elements. L_1, L_7, L_2, L_8 L_4 and L_{10} comprise the h-f compensation. Adjustment is accomplished by varying the powdered iron slugs so that flat frequency response obtains out to at least 5 mc.

As previously stated, each stage should be flat by itself in order to keep phase shift to a minimum. Figure 3 shows a typical setup for this measurement.

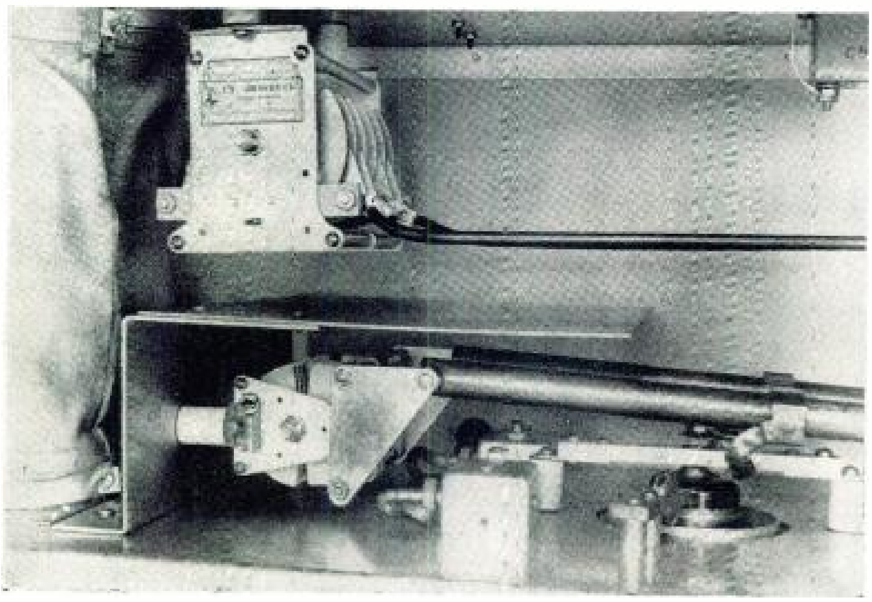
Testing the D-C Restorer: The function of the d-c restorer is to refer all composite video information to the bias level of the modulator. Circuit discussion of this element was reviewed under the section on the *Video amplifier-modulator* in the May issue article. The restoring characteristic may be measured at two points, namely: (*1*) at the grid of the modulator, or (*2*) at the plate of the modulator. Figure 4 shows how a 'scope may be connected for this measurement. Since the end result of the restorer is to keep the sync peak at a constant bias reference in the modulated r-f amplifier, it has been found desirable to measure d-c restoration at the plate of the modulator (in effect at the grid of the modulated amplifier). Connection to the 'scope must be made directly to the deflection plate since the d-c component is the factor in question. With no video signal, the beam on the 'scope is adjusted for center position by means of the positioning control. Video signal is applied to the video amplifier and the peak sync position on the screen must remain at essentially the center position as adjusted above for proper operation. In case the beam is deflected off the face of the cathode-ray tube, an external positioning bias is required which will equalize the static potential. It is important to note that this removes the 'scope chassis from ground potential; therefore, no direct ground connection should be made where external positioning is required.

R-F Passband Characteristic: The r-f passband characteristic is measured on the master[2] series transmitter by means of a built-in r-f wobbulator whose frequency range is ±5 mc about the carrier frequency. Diode pickup sampling circuits are installed in the plate circuit of the modulated amplifier, cathode circuit of the intermediate power amplifier, cathode circuit of the power amplifier, plate circuit of the power amplifier, and in the transmission line output.[1] A 'scope is provided to monitor any three of these pickup points simultaneously. Marker frequencies are provided by injecting the carrier frequency into the modulated amplifier grid circuit, and by inserting absorption type wave traps, tuned to high and low-frequency ends of the passband characteristic, in the plate circuit field of the modulated amplifier. Figure 3 (May article) shows how switch S_1 connects the modulated amplifier grids to either regular r-f drive or wobhulator drive by means of relay K_1.

Initial Adjustments

After initial adjustment of the r-f stages is accomplished, only a few minutes are required to check performance or compensate for tube replacements, etc. Initial adjustment, however, requires a fundamental ap-

Figure 2
Another view of the plate tank and output circuit of the power amplifier.



[1]Du Mont 208 can be used for this application.

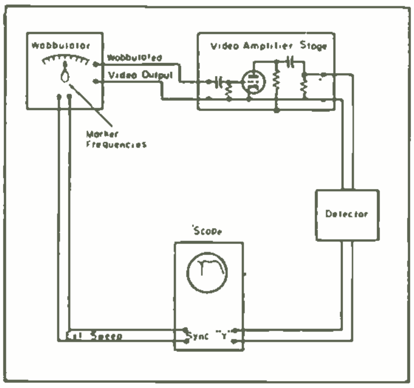


Figure 3

Setup of wobbulator and video amplifier used to determine frequency response.

proach to the problem as previously described. The coupling between stages is reduced to a minimum, and gradually increased until a double hump response is obtained with the low-frequency peak adjusted to carrier frequency and the high-frequency peak to approximately 3 mc higher than carrier frequency—these conditions being observed on the wobbulator 'scope at the various pickup points. The cathode loading and coupling determine the frequency separation and flatness of the response characteristic—frequency separation is predominately affected by coupling, while flatness is a function of loading. Loading is varied by adjusting the point of the cathode connection. Movement toward the open end of the resonant transmission line results in in increased loading. A fine adjustment of this parameter is provided by the movable shorting bar—this factor also has an effect on coupling since the area of coupling is affected by its movement. The foregoing procedure applies to the circuits between the modulated amplifier plate and intermediate power amplifier cathode, and *ipa* plate and *pa* cathode. The output circuit is tuned as indicated above, except that increased loading is accomplished by moving the transmission line connections toward the open end of the resonant line output circuit. Since three 'scopes are provided for observing three patterns simultaneously, any interaction between stages may be observed and corrected without the necessity for many retest checks. The diode samplers most useful for these adjustments are located in the *ipa* cathode circuit, *pa* cathode circuit, and transmission line output circuit. Figure 5 shows a typical passband characteristic for each of the three stages. The bandwidth was adjusted as shown in the first photograph. Curve *A* is the response of the input to the intermediate power *amplifier*. Curve *B* is the response into the power amplifier, and curve *C* is the response of the entire transmitter at the transmission line output circuit. The low frequency end of the sweep is at the left side. The marker shown up near the top of the bandpass characteristic represents 77.25 mc (for channel 5 operation). The second marker to the right represents 80 mc or a frequency deviation of 2.75 mc. The third marker to the right represents a frequency of 81.5 mc or a deviation of 4.25 mc from carrier. It will be noted that on the extreme left of each curve there is a vertical line. This is caused by the

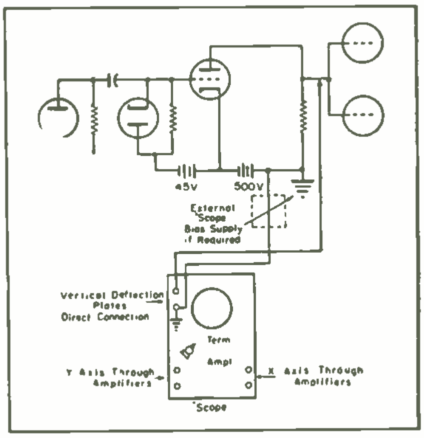


Figure 4

Typical measurement arrangement for determining d-c restorer operation.

lack of sweep over 75% of a revolution of the wobbulator motor. On the remaining 25%, the sweep is initiated and the indicated patterns result. It will be noted that the lower side of the response characteristic becomes more steep as it passes through the amplifiers resulting in adequate suppression of the lower sideband.

Plate-Bias Voltages

It has been desirable from theoretical and practical considerations to operate the class *B* linear amplifiers at a plate potential of 2500 volts with the bias adjusted to 140 volts. This setup allows for optimum transfer linearity, and low plate-to-plate impedance resulting in an efficiency of between 40 and 50% for a bandwidth of 3 mc across the top of the bandpass characteristic.

[To Be Continued]

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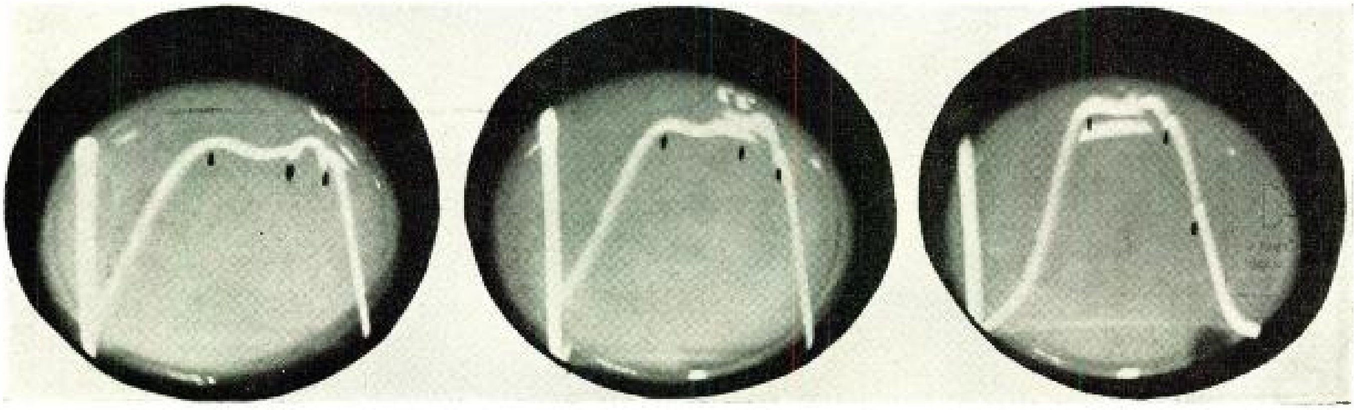
*Du Mont.

Figure 5

Typical pass-band characteristics for each of three points of measurement. (In securing these curves, the transmitter was set up so that 5.04 peak kw was available at black level picture information). The curve at left (A) is the response of the input to the intermediate power amplifier. In the center (curve B) we have the response to the power amplifier, while the curve at the right (*C*) shows the response of the entire transmitter at the transmission-line output circuit. The low-frequency end of the sweep is at the left side. The marker (inked in) shown near the upper left of the bandpass characteristic represents carrier frequency. The second marker to the right represents a frequency deviation of 2.75 mc and the third marker to the right represents a deviation of 4.25 mc from the carrier. It will be noted that on the extreme left of each curve there is a vertical line; this is caused by the lack of sweep over ¾ of revolution of the wobbulator. On the remaining ¼ revolution, the sweep is initiated and the indicated patterns result.



TUBE *Engineering News*

Joint Army-Navy Electron Tube Committee Recommended Subminiatures and Preferred Transmitting Tubes . . . Vest Pocket Transmitter Using Subminiatures . . . Instant-Heating Miniature Tubes

The increased use of printed circuit techniques has emphasized the application possibilities of subminiatures, prompting the Joint Army-Navy Electron Tube Committee to set up a recommended listing of these tubes for equipment design guidance.

In this listing we find the CK512AX, with an E_f of .625, recommended as an audio pentode and for video and power work, and the 5644, also with an E_f of .625, recommended as a voltage regulator.

Eleven types with an E_f of 1.25 appear in another recommended group: The 5676 and 5677 as triodes; 2E31 and 5678 as sharp pentodes; 1Q6 and 2E41 for diode pentode application; CK503AX and CK506AX as audio pentodes; 1C8 as a converter, and VX21 and 5642 as rectifiers.

In the 6.3-volt category there are twelve recommended types: The SX1006, 5645, 5718 and 5719 as triodes; 5633 as a remote type pentode; 5634 as a sharp pentode; 5638, 5639 and 5640 as audio pentodes; SX946 and SX977 as rectifiers and the 5643 as a thyratron.

Subminiature Tube Transmitter

An interesting application of some of these tubes appears in a recently developed Bureau of Standards miniature crystal-controlled a-m transmitter with an output of 4 milliwatts; Figure 1.

Employing some of the latest miniaturization and printed circuit techniques, the transmitter, whose dimensions are 5¼″ x 3″ x ⅞″, was designed for speech transmission on 6.575 kc.

The transmitter has a crystal oscillator, with a CK569AX operated as a triode driving a CK569AX pentode amplifier. The speech amplifier, with a gain of about 1,500, uses three resistance-capacitance coupled stages, with two CK512AX pentodes and a CK506AX pentode.

The speech amplifier is printed on both sides of a 3/32″ steatite plate 1⅛″ x 2¼″. Power is obtained from a 30-volt dry battery and one of the new 1.4-volt mercuric oxide cells. One-third of the volume of the entire transmitter is occupied by the battery power supply.

The antenna which telescopes within the case can be extended 15″. A two-position switch in the filament circuit is located on the edge of the unit for convenient thumb operation. Batteries are replaced by sliding them out of the metal end of the case. With new batteries the total *B* current drain is approximately 2.1 ma. Standard 30-volt hearing aid batteries yield about 12 hours of continuous service. Since the filament current of 150 ma for 5 tubes places a heavy load on the mercuric oxide cell, useful *A* battery life is limited to 2 hours continuous operation.

The r-f output of 4 milliwatts provides reliable operation at distances up to 200 feet. This performance is obtained with the batteries operating at 80% of their nominal rated voltages. Greater distances of transmission may

(*Continued on page 32*)

Figure 1
Circuit of the Bureau of Standards vest pocket transmitter, using subminiature pentodes.

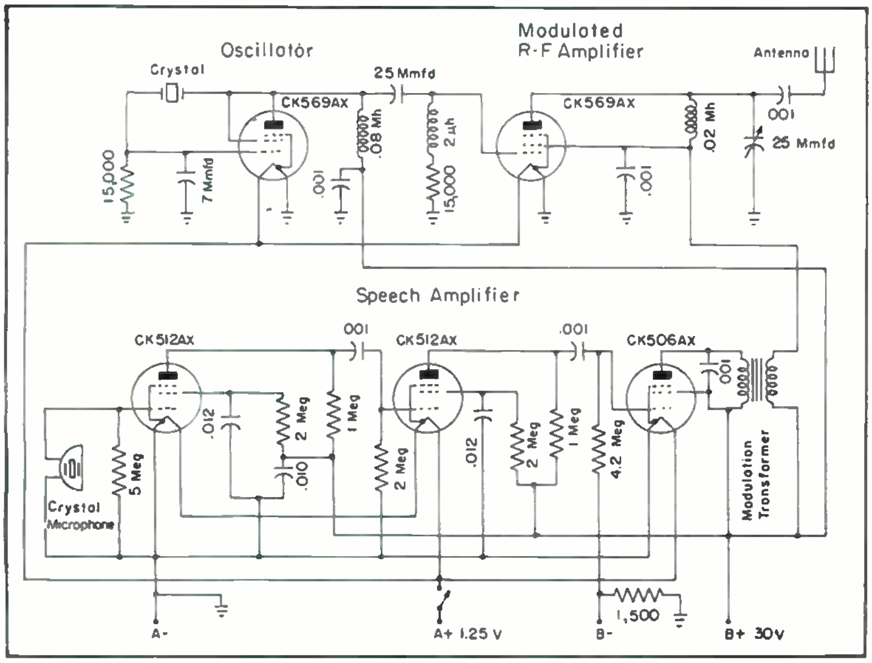


Figure 2
Front view of the 5-tube crystal-control miniature transmitter.

The new Portable Field-Intensity Meter, RCA Type WX-2—shown one-third actual size. A loop antenna is built right into the lid!

At Last—

a truly portable Field-Intensity Meter

• Weighing only 12½ pounds—including batteries, here's a small, compact field-intensity meter of high accuracy that carries around like a portable radio . . . and operates almost as simply. You tune in a signal, adjust a *built-in* calibrating oscillator and receiver gain . . . and *read signal intensity directly in microvolts-per-meter.* No charts, curves, or correction factors to worry about. No computations to make.

Designed with a wide sensitivity range of 10 microvolts/meter to 10 volts/meter, Type WX-2A enables you to make field-strength readings anywhere—from the very shadow of your transmitter, to the toughest location "down-in-the-noise." Plenty of front-end selectivity, too. Loop antenna Q is approximately 100 at one megacycle; An r-f amplifier stage provides a very high order of image rejection.

Power supply; Ordinary flashlight dry cells for the quick-heating tube filaments—and a 67-volt battery of the size used in camera-type radios for the B supply.

A lot easier now to get the facts on your coverage, service area, and antenna efficiency . . . with RCA's new portable WX-2A. Ask your RCA Broadcast Sales Engineer for the facts. Or write Department 23-G, RCA Engineering Products, Camden, New Jersey.

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BROADCAST EQUIPMENT

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ENGINEERING PRODUCTS DEPARTMENT, CAMDEN, N.J.

In Canada: RCA VICTOR Company Limited, Montreal

V-H-F Railroad Radio Link

With Six-Channel Telephone Carrier System

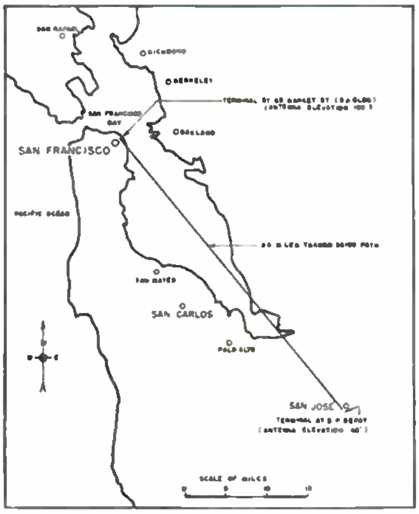
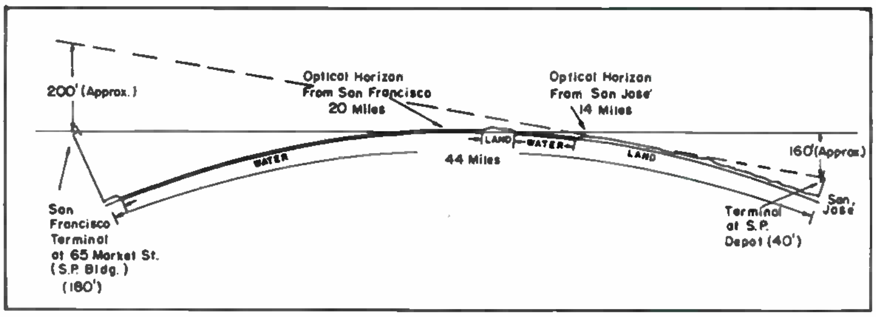


Figure 1

Map of San Francisco Bay area showing the 44-mile transmission path involved in the Southern Pacific Railroad carrier link.

Figure 2

Profile of the San Francisco to San Jose link used in the carrier multiplex tests.



LAND LINE OPERATORS in a number of industries are faced with a double problem:

They are handling growing traffic loads with limited facilities while confronted with sharply increased costs, both for new construction and maintenance of existing lines.

Thus railroads, petroleum pipe-line companies, airports, power utilities and telephone systems have had to seek additional methods of increasing their traffic-handling capacity. Many in these fields have already taken the step with multiplex carrier telephone and telegraph installations.

Now, a great deal of interest is being focussed on the possibility of creating superior, low-cost circuits with new forms of highly-directional point-to-point v-h-f radio links. An extremely successful test using such a link system was conducted recently by Southern Pacific between its office in San Francisco and San Jose, a distance of 44 miles, employing 160-mc equipment.

Equipment Used

An f-m setup[1] was used with bandwidth modifications to accommodate the 200-to-24,000-cps requirement of the carrier. Receiver was a crystal-controlled double conversion superhet with a sensitivity of 0.5 microvolt.

Simultaneous six-channel non-interfering transmission was accomplished through the use of a single-sideband system.[2]

Five of six channels were used for telephone service and the sixth was utilized for transmission of five pulse signaling and two teletype channels operating on sub-channel carrier frequencies in the voice-frequency range. (Sixteen sub-channels can be impressed on one voice channel with this equipment.) Voice-frequency signaling channels are rated at transmission speeds up to 15 pps for dialing service, but in this case were arranged to provide ringdown signaling for the voice channels.

Telegraph transmitters and receivers used for teletype operation were operated at 1,625 and 1,775 cps. Signaling frequencies of 1,945, 2,125, 2,295, 2,465, and 2,635 cps were used for the five pulse signaling sub-channels.

Transmitting Setup

In the transmitting branch of the system, incoming voice-frequency currents enter the terminal and are amplified in a limiter amplifier. The output of this amplifier goes through the low-pass section of a transmitting-line filter to the transmitting-line circuit and becomes the voice-frequency channel.

Other voice-frequency currents enter the terminal at channel-modulator input circuits for the particular channels and are converted to carrier frequencies by their associated modem (*modulator-demodulator*) panels. These panels function as inert frequency-translating devices and include filters, output-level adjusting pads, and varistor-type modulators actuated by carrier-frequency voltages from the carrier-supply panel.

Carrier-frequency output circuits of modem panels for all odd-numbered channels are wired in parallel and connected to one side of the center-tapped winding of the transmitting differential transformer. Similarly, all carrier-frequency output circuits for modem panels of even-numbered channels are wired in parallel to the other side of the same winding of the differential transformer.

This transformer is arranged as an unbalanced hybrid transformer to provide decoupling, for impedance reasons, between the two groups of modem panels. It serves to combine all the carrier currents in the input circuit to the transmitting h-f amplifier. This amplifier operates at a normal gain of 42 db and an output transmitting level of +4 dbm per channel.[3] Amplified carrier currents go to the transmitting-line circuit through the

[1] Sperry Gyroscope Co., RCU-1.

[2] System used in type 42 Lenkurt Carrier equipment.

[3] O dbm equals .001 w in 600 ohms.

high-pass filter section of the transmitting-line filter.

Receiving

In the terminal receiving branch of the carrier equipment, incoming voice frequencies pass through a low-pass section of the receiving-line filter and are amplified by a voice-frequency amplifier. This amplifier operates at a normal gain of 20 db and his an output level of +4 dbm. The signal is then fed to channel 1 terminating equipment on a four-wire basis.

Incoming carrier frequencies go through the high-pass section of the receiving-line filter and to the receiving high-frequency amplifier at an input level of –38 dbm. This amplifier operates at a gain of 42 db and an output level of 4 dbm per channel. It passes the carrier currents to the primary of the receiving differential transformer which provides decoupling for the carrier-frequency sides of the modems used as channel demodulators.

Here the modems function in a manner opposite to those in the transmitting branch. They serve to select and convert the carrier frequencies for each channel to voice frequencies which next go to the terminal demodulator output circuit. En route they pass through a channel-level adjusting control and amplifier having 29-db gain. Again, the varistor-type demodulators

Southern Pacific San Francisco to San Jose 44-Mile Link Employs Duplex Radio (158.19 Mc and 154.57 Mc) and Six-Channel Setup for Intra-Company Telephone and Telegraph Service. Six-Channel System Provides Five for Telephone and the Sixth for Pulse Signalling and Teletype Work.

by PHILIPS B. PATTON

Engineer

Lenkurt Electric Company

are actuated by carrier-frequency voltages from the carrier-supply panel.

Frequencies

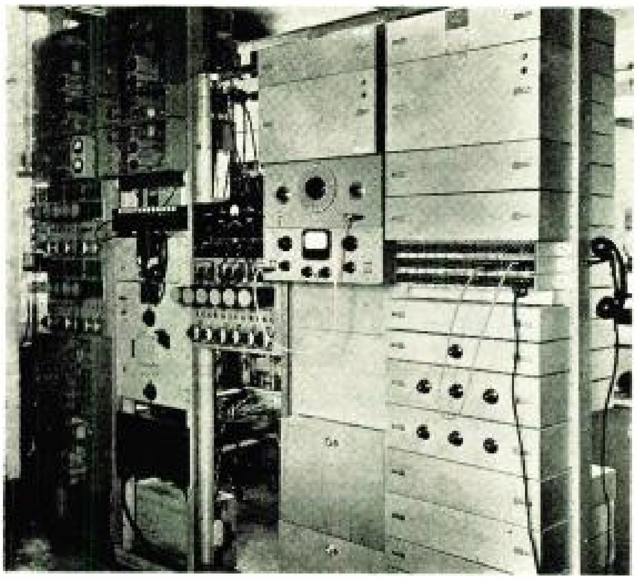
Frequency characteristics of an average transmitting channel are shown in Figure 5. This curve is representative of all channels, any variation usually being less than 1 db over the important part of the frequency range. Receiving-channel characteristics are approximately the same.

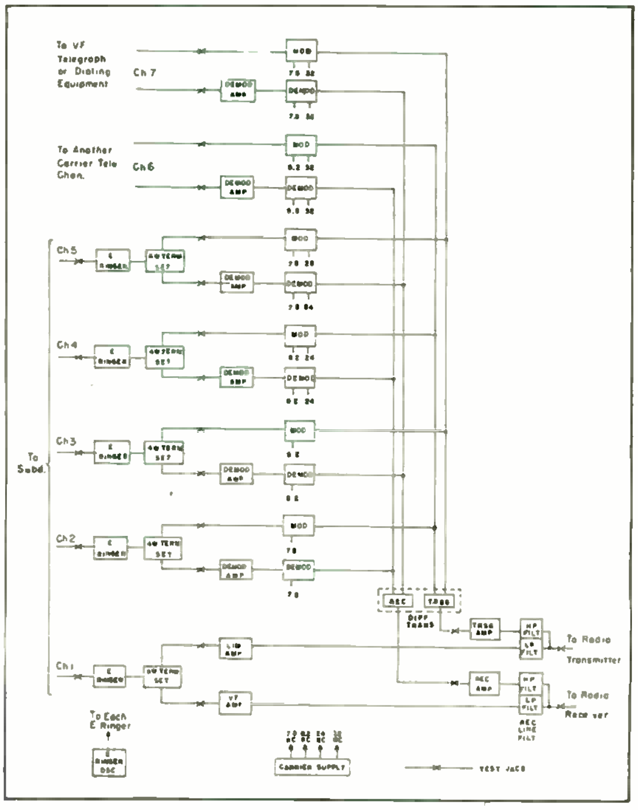
In Figure 6 appears the frequency allocation for a carrier system, showing the spectrum up to 35-channel capacity. Channel 1 is a voice-frequency channel with frequencies from 200 to 3200 cps transmitted directly. The carrier-frequency band used for channel 2 is obtained by modulation with a 7.8-kc carrier, the lower sideband being used. The upper sideband of an 8.2-kc carrier is used for channel 3.

Two stages of modulation are used to obtain carrier currents for channels above the third. Channel 4, for instance, is derived through preliminary modulation of voice frequencies at 8.2 kc to produce an i-f band *B*, which is the upper sideband of 8.2 kc. This

Figures 3 (below) and 4 (right)

Figure 3: Carrier installation in the San Francisco communication headquarters of Southern Pacific. Entire terminal unit is in the right hand rack. The telegraph, measuring and auxiliary units are in the second rack. Figure 4: Block diagram of carrier terminal equipment.





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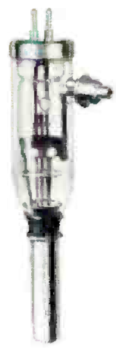
. . . An Outstanding Line Offering Finest Performance and Real Economy

In standard AM and FM transmitters . . . TV transmitters for low or high band operation . . . square loop antenna . . . special new developments including Studio-to-Transmitter Links . . . Dummy Antenna . . . TV Monitors . . . High Power Transmitting and Rectifier Tubes.

You can count on Federal Broadcast Equipment—from a complete system to an individual installation. Federal Broadcast Equipment brings you the latest in engineering technique and practice . . . high quality of materials . . . precision craftsmanship of the highest order. There is real economy in both initial cost and operation. And you are assured of the finest performance, because Federal sees every job through. This Federal policy upholds a reputation established by more than 38 years of continuous achievement in the radio transmission field.

FEDERAL'S FM 10 KW Transmitter, officially approved by the FCC, has the exclusive "Frequematic" FM Modulator. It reduces distortion and noise well below RMA specifications, and stabilizes mean carrier frequency within 0.001 per cent of assigned value. This transmitter combines outstanding fidelity with economy, accessibility and highly dependable performance.



FEDERAL'S Transmitting Tubes provide long service. They stand up under severe operating conditions, and maintain original characteristics for life.

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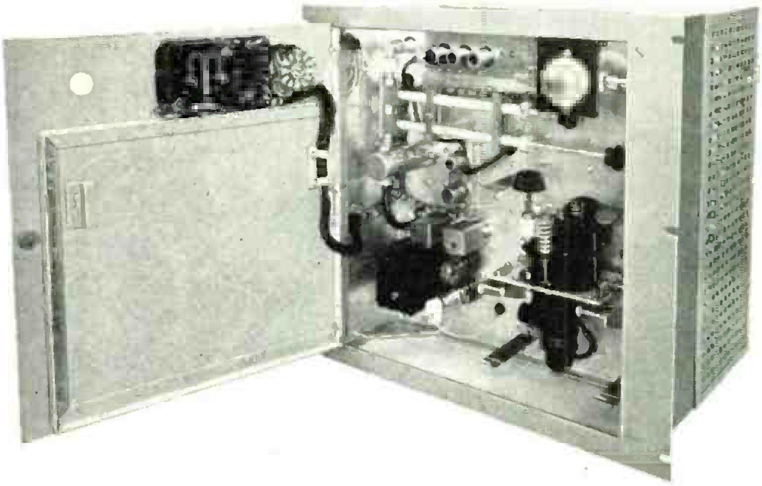
FEDERAL'S Field Intensity Meter accurately measures signal intensity of AM broadcasting stations whether in the standard band of 530-1600 Kc—200 to 400 Kc—1600 to 3600 Kc—or 3600 to 7000 Kc. This 29-lb. unit is portable.

HIGHEST GAIN IN THE FIELD WITH FEDERAL'S SQUARE LOOP ANTENNA. In many installations from coast to coast, this design is producing an effective radiated power of as much as twelve times the Kilowatt rating of the FM transmitter. This means new power and new range for better and wider service. Federal's Square Loop Antenna also brings you simplicity of mechanical and electrical design . . . greater accessibility for maintenance . . . no operational tuning . . . maximum lightning protection . . . immediate delivery and ease of installation.

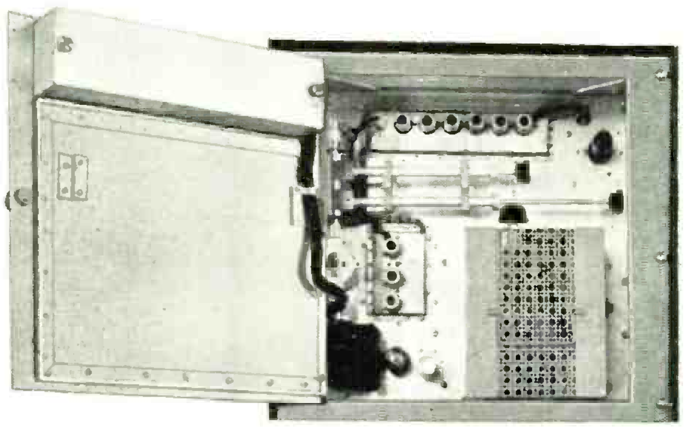
Federal's Studio-to-Transmitter Link for High Fidelity Program Transmission

Here's the new Federal microwave system to eliminate S-T wire and cable circuits. Combining outstanding fidelity – distortion less than 1% over 50-15,000 cycles – low noise level, 65 db below 100% modulation – and a 35-mile "line of sight" range – this system complies with all applicable FCC regulations for good engineering practice. Link consists of a transmitter, receiver and two standard 6-foot parabolic reflectors (4- or 8-foot reflectors supplied on request).

ONE OF MANY NEW DEVELOPMENTS BY FEDERAL TELECOMMUNICATION LABORATORIES

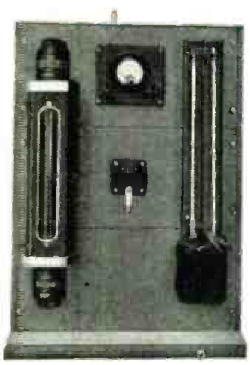


TRANSMITTER employs advanced-design direct frequency modulation and crystal-controlled klystron power oscillator. Complete monitoring facilities include frequency and power measurements, aural monitoring, and vacuum tube metering. Designed for mounting on standard 19" relay rack, it is only 35" high and 13" deep.



RECEIVER is a single superheterodyne which utilizes reflex-klystron local oscillator. It features pre-selection to reduce possibility of spurious interference. Relative stability is maintained within 0.01 per cent with automatic frequency control. Metering is provided for all vacuum tube circuits, carrier level, and crystal current. Same mounting and size as transmitter.

FEDERAL'S De Luxe Studio Console combines control of all facilities of an FM transmitter into one unit – a "nerve center" – convenient, foolproof, and handsome in appearance.



FEDERAL'S All-Metal Dummy Antenna meets the need of the Broadcasting Industry for testing of high power, VHF and microwave (FM and TV) transmitters. No conventional resistors and insulators. Compact, light, water-cooled – determines RF power accurately.

FEDERAL'S Standard 5KW AM Broadcast Transmitter assures high fidelity performance and maximum operating efficiency. Nominal output of 5KW can be transferred instantaneously to 1 KW. Every component is conservatively operated. Every circuit is engineered for maximum life of its elements. A new simplified power supply reduces maintenance to a minimum. Standard operating band.

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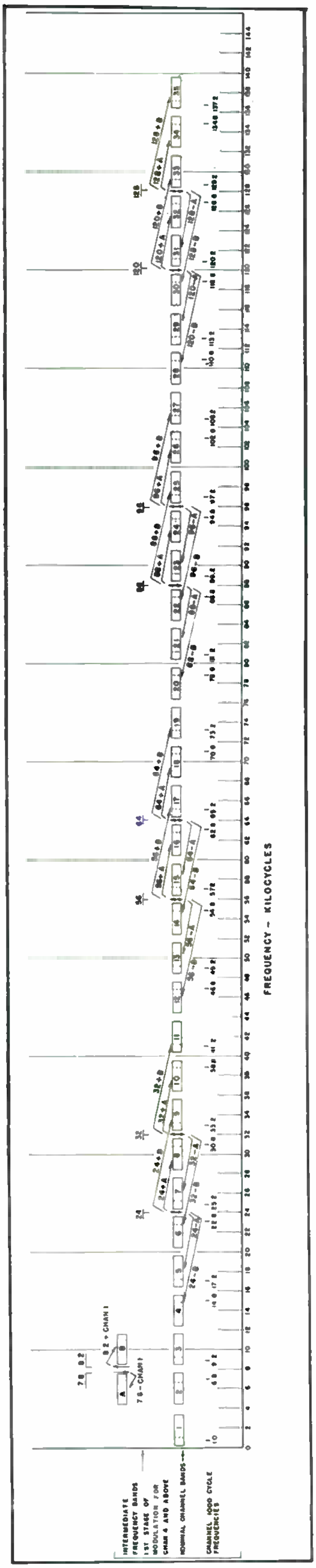


group of intermediate frequencies is next modulated at a carrier frequency of 24 kc with the lower sideband selected for transmission in the frequency range from 12 to 16 kc.

All other carrier-frequency channels are obtained through preliminary modulation at 7.8 or 8.2 kc, to obtain i-f bands *A* or *B*, followed by modulation at higher carrier frequencies for final positioning. This procedure permits simplification of electrical wave filters used to separate the channel frequencies; reduces the number of different carrier frequencies required for modulation and demodulation; and allows uniform spacing of all channels at 4-kc intervals.

Radio Transmission

In the Southern Pacific installation, one of the duplex radio circuits operated on 158.19 mc, while the other was on 154.57 mc. The six channels called for uniform frequency response from 200 to 24,000 cps. Before the carrier was installed, tests were made on the 158.19-mc channel. A 1,000-cps tone was used to modulate the San Jose transmitter and graphic recorder[4] was used to study the received-signal level. Higher noise levels at the San Francisco end suggested this procedure. Over a 100-hr period the signal-to-noise ratio was 40 db or more.

Investigations made with a wide range of antennas disclosed that the most effective design within the limits of practicality is a 16-element array consisting of eight half-wave elements in phase and eight reflectors, vertically polarized. Horizontal polarization showed noise advantages, but more fading prevailed.

Noise at the San Jose terminal was primarily caused by the fact that trucks, buses, and automobiles entered directly into the station enclosure close by the antenna. At the San Francisco end the receiver was adjacent to elevator controls in the Southern Pacific Building where large and frequent arcs were being broken.

The radio equipment was modified in two ways to adapt it to carrier operation. Frequency response was widened to give a level variation less than 1 db within each 4-kc channel from 1 to 20 kc. Between 1 kc and 300 cps, response fell off 2 db, while a drop of 3 db appeared from 20 to 30 kc. To offset the increased noise level produced by the band widening, external r-f power amplifiers were added to the basic sets. These increased transmitting power to about 100 watts. They each used a pair of 4E27 pentodes and had 52-ohm coaxial input and output leads so the standard transmitter could be used as an exciter.

Two units were operated at each terminal, one as a transmitter and one as a receiver. Not only did this relieve the power supplies of an overload, which would have resulted from simultaneous operation of both the transmitter and the receiver in a single unit, but it also provided good shielding between units and avoided possible blocking of receivers in duplex service.

Operation

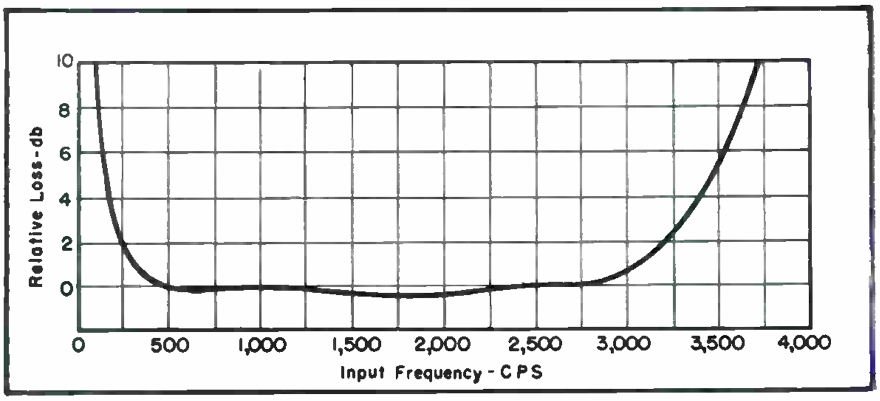
An input level of –10 dbm produced 100 per cent modulation of the transmitter. Accordingly the carrier equipment was adjusted to provide –15 dbm

(*Continued on page* 33)

[4] Esterline-Angus.

Figure 6
Frequency allocation chart of carrier equipment, detailing the assignments up to a 35-channel capacity.

Figure 5
Frequency curve of an average transmitting channel. This reverse type of plot is typical of the telephone type curves prepared to show attenuation characteristics



NOISE Measurements

Concluding Installment[1] of Two-Part Paper Covers Measurements In Rooms, Studios and Plants, and Relationship of Direct and Reverberant Sounds.

by **ROBERT L. MORGAN**

Engineering Sales Manager
Norman B. Neely Enterprises

In making precise measurements indoors the reflected sound energy has another aspect that may appreciably affect the results. The walls of any room will reflect more or less sound, depending on the sound absorptivity of the materials with which they are surfaced. Except in rooms especially treated with a highly sound-absorbent material, the reflected or reverberant sound is often quite high and will tend to obscure the direct sound radiated from a source. As mentioned before, the direct sound decreases in intensity approximately inversely as the square of the distance from the source, while the reverberant sound in a room is independent of the distance but decreases as the absorptivity of the room and its volume increases. Thus in small, live (reflective) rooms, the reverberant energy, at points well removed from the source, may be appreciably higher than the direct energy. This introduces an error in the measurement of direct sound which, under many conditions, may be serious.

Figure 1 shows the approximate relationship between the direct and reverberant sound in the specific room for which these curves were calculated. The diagonal line represents the direct sound, which is shown decreasing inversely as the square of the distance from the source: that is, as the distance of the microphone from the source is doubled, the direct sound energy falls to one-fourth of its original value, or drops 6 db in level. The reverberant sound, which when thoroughly diffuse, is constant, regardless of the position of the microphone in the room or its distance from the source, is represented by the dotted horizontal line across the middle of the drawing. The sum of the direct and reverberant sound, which is the intensity the sound meter would measure, is shown by the curved line asymptotic at both ends to the lines representing the direct and reverberant sound. These acoustic conditions are approximated in a room having an interior surface area of 3,000 square feet, with an average sound absorption coefficient of 50% over the audible frequency range.

It will be worth while to examine this drawing to see what would take place in this room if noise measurements of some device, such as an electric fan, for example, were attempted. At a distance of one foot from the fan, the reverberant sound adds nothing and the sound meter would, therefore, read the correct level of direct sound. However, as the microphone is moved away from the source, the reverberant energy becomes a larger portion of the total and begins to introduce an error. For example, at 4′, the total intensity is about 1 db above that of the direct sound only, which means a 1-db error in the measurement. At 7.7′ from the source, the direct and reverberant sound energies are equal, so that their sum which the sound meter would measure, is 3 db higher than that of the direct sound alone. At about 23′, the error would be 10 db and would increase to greater values as the distance between microphone and source is increased.

It will be seen then, that in this particular room, it would be necessary to place the microphone not farther from the sound source than 4′, to limit the error in measurement to 1 db. It would be inadvisable to attempt to eliminate this error by moving the microphone too close to the sound source. Such a procedure would only tend to favor one part of the noise-producing machine over another part and thus fail to give a good average reading.

It should be borne in mind that this distance of 4′ and all of the information on Figure 1 applies only to this specific room, which has the area and average absorption given. If either

(*Continued on page 35*)

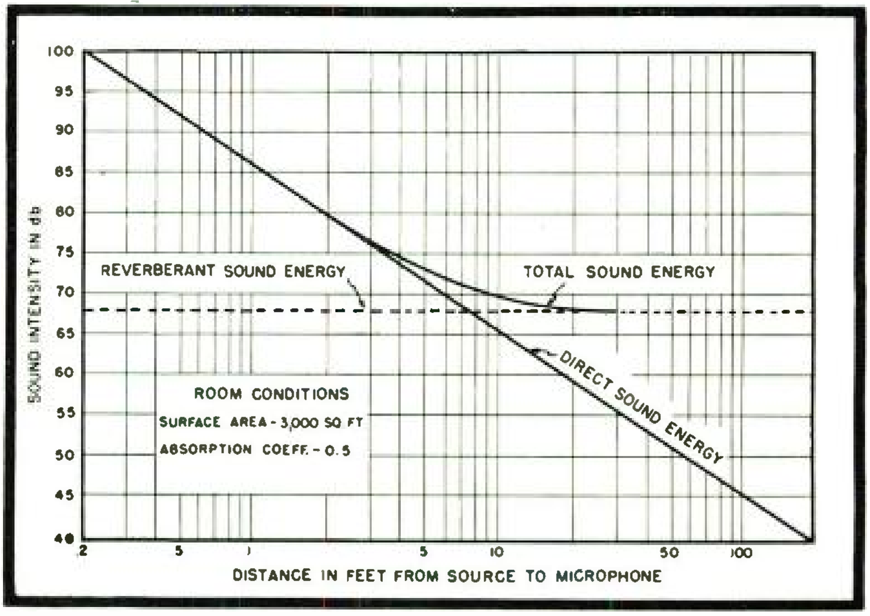


Figure 1
Approximate relationship between direct and reverberant sound.

[1] *Initial installment appeared in the February, 1948, issue of* Communications.

Coaxial And Separate Two-Way Speaker System Design

Problems Encountered in Design and Production . . . Performance and Cost Considerations . . . Advantages and Disadvantages of Ring and Slab Magnets . . . Horn Flare Considerations . . . Horn Cells . . . Crossover Selection . . . H-F and L-F Units . . . Cabinetry.

by HOWARD SOUTHER

Stephens Manufacturing Corp.

In the formative stages of any art, development is guided by theory. As the art progresses, direct application begins to mold the processes of production. An example of this phenomenon has been the genesis of the coaxial 2-way speaker from the well-known theater 2-way systems employed for well over a decade in motion pictures. This birth and development of the coaxial units from the separate systems has promoted advances benefiting the parent design. Costs of production have been reduced, promoting wide acceptance. Performance of both types of speakers has been improved.

Present Status Of Development

In standard type speakers the single diaphragm commonly used must attempt to reproduce faithfully a tone range of over 8 octaves or 30 to 16,000 cps.

This means that the voice coil attached to the single cone must try to move in and out through the dense flux area of the pole piece as far as ⅜ of an inch on low tones. It must also attempt to vibrate very rapidly over short distances on high notes. To convert bass pulses to acoustic energy efficiently, the diaphragms should be large, and to vibrate rapidly and generate treble tones easily it should be small.

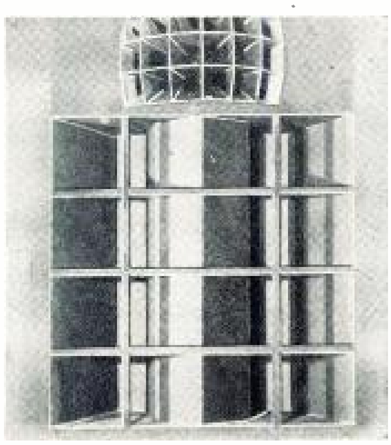
Accordingly a two-way system utilizing two driving units is extremely effective, since we have one unit large in size designed for the range of the first one-half of the audible spectrum, and another unit small in size, which generates the rapid pulses of the remaining tone range.

In addition, it should be noted that bass tones are easily heard throughout the listening area. They act like the waves at the seashore, spreading around intervening objects and flowing out to the listeners on a broad angle. High tones speed like a bullet from a gun in a single direction straight from the axis to the speaker.

For this reason two-way speaker systems provide a nest of dispersing cellular horns as a complement of the high frequency unit. In this manner the higher frequencies are spread through a horizontal and a vertical angle, covering the listening area almost completely.

In Figure 1 appears an illustration of a typical two-way system with a peak-power handling capacity of 80 watts. Usual application will find the unit operating within a range of from 5 to 40 watts. In constructing this unit, the minimum area across the horn opening (70″) was computed on the basis of one-fourth wavelength of the lowest frequency to be reproduced—30 cycles. The same holds true for the high-frequency speaker, the horn openings of which provide a cut off at 400 cycles on the same basis.

Figure 1
An 80-watt separate two-way theatre system.



In average size theaters speaker power capacity is 40 watts peak, and normal levels resolve themselves into the region of 3 to 25 watts. Design is the same as that of the unit shown in Figure 1, but with one-half the number of components.

Figure 2 shows a smaller two-way system with one-half the power. Overall efficiency is 6 db less than for the theater system, an appreciable drop in acoustic conversion power. Space saved over the theater system is due in the main to use of the reflex baffle. Although these baffles are not peculiar only to two-way systems, they have been found necessary for optimum operation where vast amounts of space are not available. Design is such that the resonant period of the enclosure covers a broad band in the lower part of the spectrum, and a release port near the cone opening allows in-phase pulsations to reinforce the frontal wave. The high frequency horn cuts off at 800 cycles. This higher cut-off allows the horn configuration shown to be confined within an 11″ height and 14″ width.

In Figure 3 appears an example of a 20-watt coaxial type of two-way reproducer. The high-frequency unit feeds eight dispersing cells through the pole piece of the cone speaker. This unit is 3 db lower in efficiency than the Figure 2 separate two-way system.

Performance And Cost Consideration In Coaxial Design

The physical design of a coaxial unit is illustrated in Figure 5. It will be noted that one magnet structure supplies flux for both gaps of the individual speakers. The diagram illustrates also the flux path and the use of a shunt around the high-frequency gap to more densely saturate the low end.

Ring And Slab Magnets

The use of ring magnets has been found technically more advantageous, because greater contact area is possible. From the practical standpoint,

Figure 2
A 40-watt separate two-way system (43" x 23" x 15").

however, much less leakage results from the slab magnet construction due to the longer leakage path it is possible to incorporate. Present magnet production technique allows for less costly manufacture of slab structures. The use of Alnico five is, of course, mandatory; incontrovertible superiority of over three times that of the next best alloy is illustrated in Figure 6. We are excluding a platinum alloy from the argument as being totally impractical from the standpoint of cost.

Horn Flare Considerations

The exponential flare has for some time been considered the ideal design for coupling the acoustical energy from the generator at high impedance to the outside air which offers a considerably lower impedance. The formula governing the rate of flare discloses a startling feature. At frequencies above cut-off, velocity and pressure are exactly in phase, resulting in no movement of air in the horn, which in turn precludes the possibility of reflections. However, this is not strictly the case. We know that sound, even below theoretical cut-off frequency, *is* propogated along its length in appreciable quantity. This is due to approximations in the formula which includes no allowances for the varying speed of sound at different altitudes, the impossibility of present generators to be joined perfectly in an acoustic fashion to the horn throat, lack of control of back-pressures in a broad frequency band near the region of cut-off, and others.

Modified Exponential And Straight Exponential Flares

From the practical aspect, these facts would tend to minimize the importance of adhering closely to the exact rate of flare called for by formula. If this point is conceded, an obvious advantage possible through a change in this flare rate presents itself. A broader flare at the mouth of the horns would allow for a more spherically emitted wave shape, resulting in cleaner response because of less discontinuity, and in a shorter horn than would otherwise be required. Horns have been designed for high-frequency units utilizing an exponential flare for three-fourths of their length, and making an easy transition into a much greater flare rate computed from a Bessel function for the remaining fourth. Measurements have revealed no loss of efficiency; in fact, a gain in efficiency has been found in several models produced.

Choice of Horn Cell Configuration

Because there exists a huge potential market for coaxial two-way loudspeakers in the receiver manufacturing field, a study has been made to determine the minimum number of cells required to effect adequate coverage under the conditions in which most receivers are used and placed in the home. It was found that coaxial speakers in widespread use were in the main limited to application in sets costing a thousand dollars. Such sets were of a size which precluded corner placement in the room, which would decrease dispersing requirements.

It has been found that a single cell covers an angle within the limits of 20°. One hundred per cent direct dispersion of high frequencies, therefore, would call for nine cells in the horizontal plane. But it is neither practical from a design consideration, nor necessary from the listener's viewpoint, to be able to hear direct high frequencies more than 60° off the axis. If the size of the cone opening would allow, it would be ideal to mount a horn nest with a 2 x 6 configuration. But within the limits of the size of the design, 2 x 4 is currently the maximum. This allows for 80° horizontal and 40° vertical dispersion, covering 90% of the normal listening area.

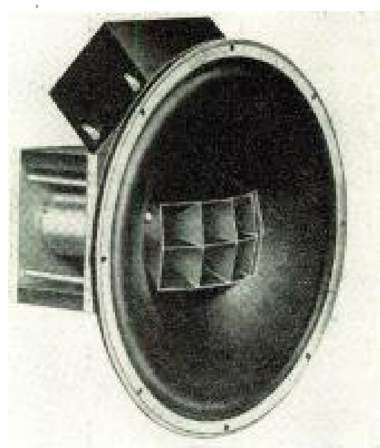
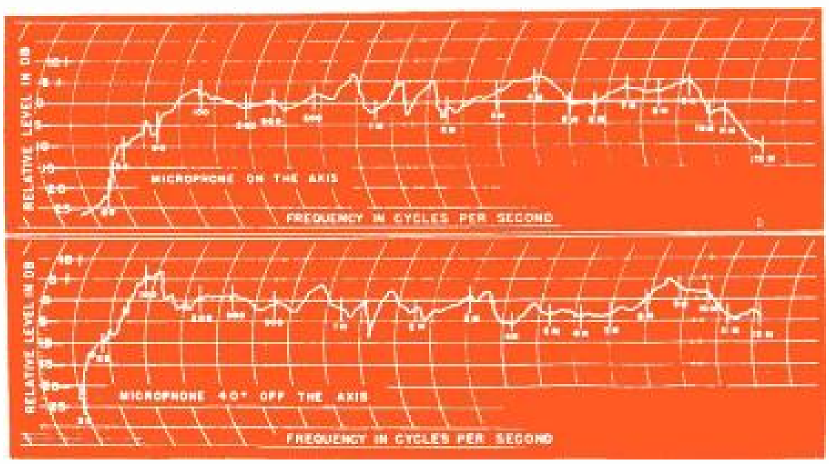


Figure 3
Coaxial type 20-watt speaker, frame diameter 15".

Crossover Selection

In Figure 10 appears a plot of the acoustic action of a cone radiator operating below 1500 cycles. At these frequencies the cone operates in the main as a piston; i.e., the motion is largely linear. In the diagram the cone is mounted on a straight baffle, and if we treat the cone interior as a pressure area, we find the formation of the spherical wave shape required for efficient coupling and minimum discontinuity. In Figure 11, illustrating the acoustic action of a cone radiator above 1500 cycles, we note that due to the large mass of the cone, consequent inertia prevents rapidly oscillating

Figure 4
Response characteristics of coaxial speakers.



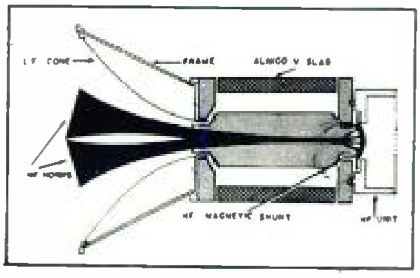


Figure 5
Coaxial unit design.

Figure 6
An illustration of the advantages and disadvantages of ring and slab magnets.

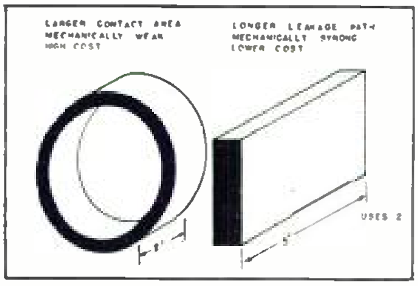


Figure 7
Demagnetization and external energy curves for permanent magnet steels: *A*, ampere turns per square inch (H) and *B*, energy in air gap per cubic inch of iron (joules) for Alnico 5 (A5), Alnico 4 (A4), cobalt steel 36% (CS-36) and Nipermag (NP)

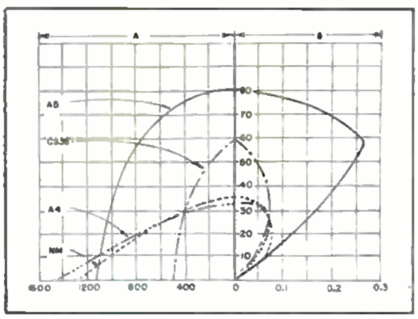
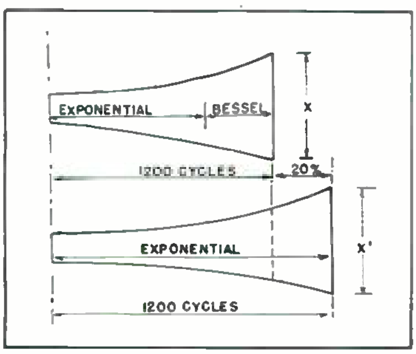


Figure 8
Comparison of modified exponential horn with a straight exponential flare.



high frequencies from moving the entire cone. Extreme loss of efficiency, and, *very important from the standpoint of quality,* non-linear motion results causing phase cancellation, standing waves and a particularly bad form of quality impairment we may attribute to discontinuity of coupling. Strobotac observation has shown a gradual breakup in cones starting around 600 cycles indicating that in the region of 1500 cycles and above this matter becomes most serious.

Therefore, a crossover frequency of approximately 1200 cycles prescribes the upper limit of optimum design for present day speaker structures. In addition, the attenuation should be gradual. About 12 db per octave is considered good practice and is employed universally in the motion picture studios. Established practice suggests air-core coils to eliminate distortion. Metal cases and iron cores materially decrease the *Q* of such networks, causing the level to vary with frequency.

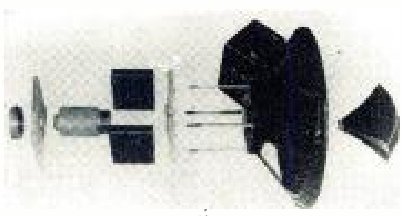
The High Frequency Unit

The high-frequency unit is a delicate mechanism. Tolerances are close. In order to be efficient, excursions as great as one-fourth inch must be allowed for in a unit as small as the 20-watt type. Full output at 1200 cycles puts a great strain on the leads from the voice coil attached to the diaphragm. Consequently lead failure has been the cause of 90% of all high-frequency troubles. In combating this problem, it has been found that ⅛" beryllium copper strips, soldered both with lead solder and aluminum solder, consecutively, have successfully eliminated this difficulty. The introduction of harmonics caused by lead vibration is prevented by dampening.

Diaphragms, which must be stiff and light, may be formed in two ways, by spinning and by drawing. Spinning is more economical and from some standpoints better. Stresses are held to a minimum and more accurate forming results. Drawing, though quicker, calls for high die cost amortization. Spinning limits compliances to designs of the annular type, whereas

(*Continued on page* 34)

Figure 13
Exploded view of coaxial unit.



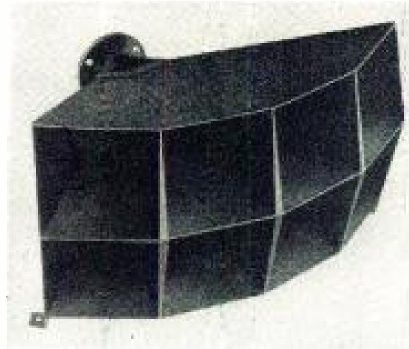


Figure 9
An 800-cycle horn (16" w x 10" d x 11½" overall) with a 2 x 4 configuration, 40° x 80° dispersion.

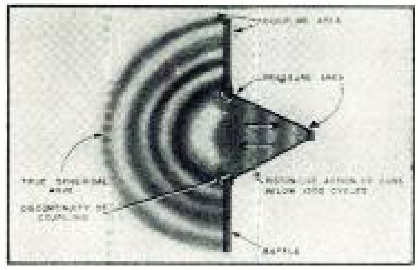


Figure 10
Acoustic action of a cone radiator below 1500 cycles.

Figure 11
Acoustic action of a cone radiator above 1500 cycles.

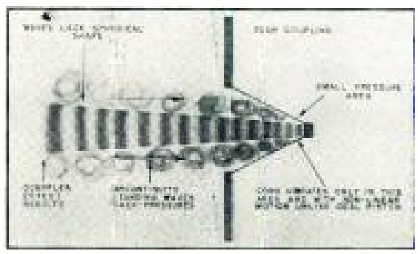


Figure 12
A high-frequency unit.

VETERAN WIRELESS OPERATORS ASSOCIATION NEWS

Personals

VETERAN MEMBER Chas. E. Drew of Tuckahoe has sent in his renewal. . . . Oldtimer S. Specter has forwarded a note stating that he has changed his address to Mobile, Ala. Letter came from San Juan. Apparently S S is on his way to Mobile. . . . Lt. Col. M. Fernandez had been transferred from Chicopee Falls, Mass., to Washington, D. C., to Communications HQ M-ATS. . . . Johnny Lohman has become a member. Welcome J. L. John,as many seasoned veterans know, is with Mackay and lives out at College Point. . . . Life member Pete Boucheron's mail is piling up, returned due to lack of forwarding address. Anyone know his whereabouts? . . . Dewey Sturgell of Redwood City, Calif., has become a VWOA member. Perhaps Dewey can help the boys locate a few feet of redwood for that bungalow you would like to build. . . . Geo. E. Schellhas advises that he is located at Guayama, P. R. Wonder what took him there. . . . Another new member is W. R. Kipp of RMCA, Baltimore, Md., who has recently been transferred to Norfolk, Va., as district superintendent. . . . H. E. Ballentine of New Brighton, S. I., and H. D. Taylor of West Hartford, Conn., became VWOA members earlier this year. Ballentine started his radio career in 1915 as an amateur, and received his Commercial First Class ticket in 1919. He has taken active part in Navy and Coast Guard radio affairs. Has also been a Reservist. Taylor's radio career began in 1917 with Marconi W. T. Co. as a seagoing operator. He joined RCA later and today is chief engineer and plant manager of WTIC, Hartford, Conn. . . . Joe Graham of Woburn (Wah'Ban), Mass., is doing a grand job monitoring for the FCC at their Millis station. . . . Al Dowd has moved from Union City, N. J., to Packanack Lake, N. J. . . . Charlie Pannell now has an office in the RCA Building. . . . C. R. Spicer has changed his address to Daly City, Calif. . . . Don De Neuf, who recently became chief engineer of the *Rural Radio Network*, Ithaca, N. Y., has forwarded some very interesting facts about the rural service.

VWOA old timers, Earl Nelson and Samuel Freedman at a recent VWOA get together in New York City.

The system consists of six f-m stations located in stragetic points in the state of New York, providing coverage to about 40 counties. Profits of the organization will be used for research, education and public welfare. . . . James Devenport and Al Koehler are still enjoying life on the Bounding Main. . . . Robt. W. Hale of Ft. Wayne, Ind., reports that his dues were delayed due to illness. Hope all is well now. . . . Phil Partridge has recently been appointed radio supervisor of the Clark County, Nevada, Sheriff's Radio Communication system. Phil is also engaged in development work at the radio laboratory of the Nevada Electric Co., at Las Vegas. He's having a little trouble getting a number for his new home, but you can get him on c-w on 40 meters by calling W7UB. . . . Bill Stedman continues to keep busy doing conversion work on U. S. Maritime Commission ships at Atlantic Basin Iron Works Shipyard. . . . Peter Cuda advises he is still fighting heavy interference on 500 and 8280 kc. Pete failed to say what ship he was on. . . . H. D. Hayes, FCC engineer-in-charge at Chicago, has sent in his dues. . . . Charlie M. Hodge, whose home is in San Francisco, continues his assignment as radio technician with the Arabian American Oil Co., at Drahran, Saudi Arabia. Gets his mail only by air. . . . Walter W. Hofmann of Kahuku, Oahu, T. H., sends his best 73's. . . . Oldtimer Sam Freedman is a busy writing man these days. He's preparing a book on transmitter design and operation, has written a couple of technical yarns for *Radio News* and *CQ*, writes a bi-weekly taxicab radio column for a taxi paper and has completed a text on microwaves. . . . At a recent VWOA meeting Frank Orth of CBS told the boys that he just returned from a Florida vacation where he had one grand time. . . . George Duvall is as busy as ever at his television installation shop and particularly active in the installation of antennas. . . . Old timer Ben Beckerman told ye writer at an oldtimer's meeting that "the foundation and cornerstone of radio communications can be seen here tonight." . . . Among those who couldn't attend the Spring meeting were E. H. Price who reported that he wouldn't be able to attend since there was quite a Marine Show at the Grand Central Palace which required his attendance. . . . Anthony J. Brizzolau wrote in to say that he was up at his farm at Croydon, New Hampshire and couldn't make the meeting either. . . . Duty at the U. S. Navy prevented David S. Little from coming to the Spring meeting. . . . M. G. Carter was on watch on May 20 and unfortunately couldn't attend the get-together. . . . F. M. Quigley reported that Haraden Pratt was quite ill and wouldn't be able to attend our Spring meeting. . . . Jack Poppele was out in Los Angeles attending the NAB meeting and thus couldn't attend. . . . Mrs. M. Marshall dropped us a note to say that the OM would not be able to attend since he is now on his way to India and Japan. Good luck on your trip. . . . The birthday of Arthur Van Dyck and a subsequent celebration prevented attendance at the Spring meeting. A.D. said: "My bodily presence is demanded elsewhere. However I'll be with you in the Marine Room in spirit, and if my radar and loran are working late in the evening I might navigate through that watertight door after all. Best wishes for a grand evening." . . . Memo to everyone: Please send in news about heroic or meritorious deeds to Bill Simon. Include the name of the operator, name of ship and date of event. And please send in personal news notes, with photos where possible, reporting your present work, future plans, etc.

Impedance Matching Techniques

Analysis Reveals That Relationships Which Should Exist Between Source and Load Impedance for a Given Network Is Not Necessarily One Which Is Matched. Rather It Is One Which Is Determined Wholly by the Desired End in View and the Circuit Component That Is Variable or Under Control . . . Networks Containing Elements That Are Linear Are Considered.

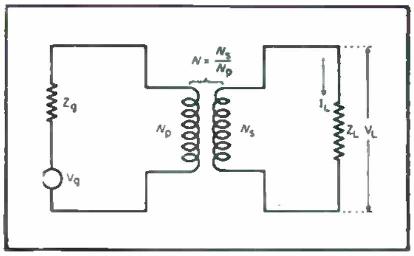


Figure 1
Generalized equivalent circuit.

by WILLIAM J. KESSLER

Assistant Research Engineer
Engineering and Industrial Experiment Station
University of Florida

MUCH HAS BEEN WRITTEN about the virtues of impedance matching. In fact, it seems to have become a popular misconception that an impedance match between source and load is the ideal condition to be realized wherever and whenever possible.

It is quite true, of course, that to obtain maximum power across a load when the load impedance is the only variable, that impedance must be the conjugate of the source impedance.[1] However, the load impedance is not always the *independent variable* and, furthermore, maximum power developed across the load is not always the *dependent variable*. Frequently it is desirable to obtain either maximum voltage across the load or maximum current through the load rather than maximum product across the resistive component, or power, for any one of three variables: (*1*) Generator or source impedance; (*2*) load impedance; or (*3*) degree of match existing between these two elements.

Method

The necessary network conditions for maximum voltage, current, or power may be readily determined by well known mathematical processes by treating the voltage, current, or power as the dependent variable, and the generator impedance, load impedance or transformation ratio N, (Figure 1) as the independent variable. Differentiating each dependent variable with respect to any one of the three independent variables, equating the result to zero, and solving for the independent variable will yield the value necessary for either a maximum or a minimum of the dependent variable. The maximum-minimum ambiguity may be resolved by simply noting the sign of the second derivative upon substitution of the results of step one. If the sign of the second derivative is positive, the dependent variable is a minimum. The opposite, or negative, sign indicates a maximum for this quantity.

Maximum Voltage

Whenever maximum voltage across the load impedance is desired, the foregoing method can be applied only if an expression for V_L in terms of Z_g, Z_L and N can be found. Referring to the generalized equivalent circuit shown in Figure 1, such an expression for V_L can be written almost directly, that is,

$$V_L = \frac{V_g N Z_L}{Z_L + N^2 Z_g} \qquad (1)$$

where it is assumed that the primary and secondary of the transformer are sufficiently closely coupled so that the expression $N^2 = Z_s/Z_p$ will not be seriously invalidated. Should the load impedance be the only variable with the ratio of transformation and the generator impedance remaining constant, the maximum (or minimum) voltage, V_L, will exist for some value of Z_L determined as follows:

$$\frac{dV_L}{dZ_L} = \frac{N^3 Z_g V_g}{(Z_L + N^2 Z_g)^2} = 0 \qquad (2)$$

Solving for Z_L by inspection, it is seen that $Z_L = \infty$. To determine if this represents a maximum or minimum voltage across the load, by observing the sign of the second derivative, results in

$$\frac{d^2V_L}{dZ_L^2} = \frac{-2N^3 Z_g V_g}{(Z_L + N^2 Z_g)^3} \qquad (3)$$

The minus sign indicates that V_L will be a maximum when Z_L is infinite, or, in an engineering sense, when Z_L is made as large as is practical or is open circuited. The value of V_L under these conditions can be determined by taking the limit of equation (*1*) as Z_L approaches infinity, that is,

$$\lim_{Z_L \to (\infty)} \frac{V_L}{V_g} = \lim_{Z_L (\infty)} \frac{N}{1 + \frac{N^2 Z_g}{Z_L}} = N$$

or

$$V_L = N V_g \qquad (4)$$

By inspection of equation (*1*) it is found that V_L will be a maximum if Z_g is the only variable when $Z_g = 0$ and, as before, $V_L = NV_g$.

Should both Z_L and Z_g be constant and only the ratio of transformation N vary, the value of N is found to be equal to $(Z_L/Z_g)^{1/2}$ for maximum V_L. This will be recognized as being the ratio necessary to affect an impedance match between the source impedance and the load impedance.

It is thus evident that in order to secure maximum output voltage from a given network, the load impedance must not simply be made equal to the generator impedance, but as large as is practical. Then, should the ratio of transformation and the generator impedance also be variable, the generator impedance should be made as small as

(*Continued on page* 31)

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[1] W. L. Everett, *Communication Engineering*, second edition, pp. 49-50, McGraw-Hill Book Company, New York.

News Briefs

INDUSTRY ACTIVITIES

KDFC's F-M transmitter atop Mt. Beacon, near Sausalito in Marin County, California, will go on the air in August. KDFC will radiate a 33-kw watt signal designed to serve nearly 3,000,000 people in the greater San Francisco Bay area.

The Hewlett-Packard Company, Palo Alto, Calif., has completed construction of new plant facilities totaling 20,000 square feet.

James H. Kellogg, president of Kellogg Switchboard & Supply Co., Chicago, addressed the California Independent Telephone Association at Los Angeles recently.

Mr. Kellogg reported that all thoughts of a *recession* which may have been prevalent last December have been dispelled because of world conditions and their effect upon the enormous purchasing power of the American government available to the European Recovery Program.

Commenting on the fact that the nation is now in a period similar to the days of 1940 when the United States was girding itself for its defense program, Mr. Kellogg said:

"Approaches to our company have already been made by the Signal Corps and we are told that over 11,000 United States industrial plants are being surveyed by the Armed Services to determine their capacity to produce war products in an emergency. In Chicago we are again hearing the all-too-familar words 'allocations,' 'priorities' and 'the draft.' "

The New York Chapter of APCO held a recent meeting at Syracuse, N. Y., as guests of G. E.

Lieutenant M. Boland of the Syracuse Police Dept. made the arrangements.

Twenty-one Mariners Pathfinder 10-cm radars, made by Raytheon Manufacturing Company, Waltham, Mass., have been ordered by The Atlantic Refining Company, Philadelphia.

The Penn-Allen Broadcasting Company, controlled and operated by World War II veterans at Allentown, Pa., have arranged to purchase a 500-watt G. E. television transmitter.

Transmitter is to be installed on South Mountain four miles south of the city.

John F. Rider Laboratories have leased about 11,000 square feet at 480 Canal Street, New York City.

The 1948 Rochester Fall Meeting of the IRE and RMA Engineering Department will be held November 8, 9 and 10 at the Sheraton Hotel, Rochester, New York.

Frank A. Gunther, REL vice president, recently conducted a demonstration of high fidelity f-m relay broadcasting via WHOO-FM, Orlando, and WNDB FM, Daytona, before the Florida Association of Broadcasters. The relay path involved was over 100 miles long.

The Buckeye Pipe Line Company of Lima, Ohio, plans to install a Motorola 30- to 40-mc f-m system.

The Buckeye, parent company of the Northern Pipe Line Company of Pennsylvania and the New York Transit Company, Inc., has lines extending through Indiana, Pennsylvania, Ohio and New York with branches in Illinois and Michigan. Central station installations will be made in offices and pumping stations at Lima, Cygnet and Toledo, Ohio, and at Samaria and Trenton, Michigan. Ultimately 2-way radio will cover the entire line. To start, 100 vehicles of the company will be radio equipped.

LITERATURE

Lenkurt Electric Co., 1126 County Road, San Carlos, Calif., have prepared an 8-page bulletin, No. CX39A, on Lenkurt type 32 carrier systems. Publication describes the overall system, shows the relationship between maximum performance and minimum maintenance, and displays some of the facilities behind the design, development, and manufacture of Lenkurt equipment.

The Instrument Division of Allen B. Du Mont Labs, Inc., 1000 Main Avenue, Clifton, N. J., have published a catalog covering cathode-ray tubes, oscillographs, allied equipment and accessories. Features a wide selection of standard tubes and instruments.

PERSONALS

General William H. Harrison had been elected president and a director of International Telephone and Telegraph Corporation.

Colonel Behn, who with his brother Hernand founded the company in 1920, will continue as chairman and chief executive officer.

General Harrison was formerly vice president in charge of operations and engineering of A. T. & T.

Gen. W. H. Harrison

James F. White has been appointed eastern manager of the new Eastern sales office of Andrew Corp. at 421 Seventh Avenue, New York. Also assigned to the new office is Paul F. Walker, Andrew sales rep.

J. F. White

Rural Radio Network's sixth f-m station, located at Turin, New York, will go on the air in August. This station, like the other five, will operate on a relay network basis.

Donald K. de Neuf is chief engineer of the network; Walter A. Knight, assistant chief engineer; John Dinter, Wethersfield station supervisor; Bud Kordalewski, Bristol Center station supervisor; Les Connelly, Ithaca station supervisor; Lou Agresti, De Ruyter station supervisor; Jim Trewin, Cherry Valley station supervisor; Stan Hickinbottom, Turin station supervisor; Tom Humphrey, audio facilities supervisor; Bill Perkins and Joe Sanford, field engineers; and Bob Wolverton, field maintenance.

Network headquarters are at 118 North Tioga, Ithaca, N. Y.

P. L. Coggeshall has joined the sales staff of FTR representing its mobile radiotelephone division in Northern California and Northern Nevada.

Harry Tarbell is now with FTR, and will cover the State of Oregon and southern Idaho for Federal's mobile radiotelephone division.

Harvey W. Smith has joined the engineering staff of Lenkurt Electric Co., San Carlos, Calif. where he will be in full charge of design and construction of transformers both for carrier application and custom manufacture.

John M. Otter has been elected vice president and general sales manager of Philco Corporation.

Junius R. Clark, former vice president of the Fawick Airflex Company, Inc., has purchased the entire capital stock of the Sterling Manufacturing Company, 9205-9223 Detroit Ave., Cleveland, Ohio, from Walter M. Scott.

Company now produces instruments, a-c and d-c, for the automotive, electrical, industrial, radio and hearing aid fields, including ammeters, voltmeters, milliameters, battery cell testers, hearing-aid testers, etc.

E. H. Vogel has been appointed to a new manager of marketing post in the general sales division of the Electronics Department of General Electric.

A. A. Brandt, the department's general sales manager since 1943, will continue in that position and will manage the general sales division which now has full operating division status.

L. E. Pettit has been named manager of a new advertising division in the Electronics Department of G. E. Pettit will operate at staff level under the manager of marketing and will be responsible for general supervision of all the department's advertising and agency relationships.

Paul Chamberlain has been appointed manager of sales in the G. E. transmitter division, succeeding Philip G. Caldwell who has joined the American Broadcasting Company.

Walter M. Skillman succeeds Mr. Chamberlain as manager of sales in the receiver division. He was formerly sales manager of standard line radios.

William B. Lodge is now vice president in charge of general engineering for the Columbia Broadcasting System.

Lodge has been Columbia's director of general engineering since November, 1944.

D. C. Summerford has resigned as assistant technical director of WHAS to become technical director for the Mid-America Broadcasting Corporation of Louisville, Kentucky, now installing a new 5,000-watt 1080-kc station.

Mr. Summerford is also president of the Shawnee Broadcasting Company, operating radio station WBEX, Chillicothe, Ohio.

Joseph K. Rose has been appointed to head the Chicago office of John F. Rider, Publisher, Inc., 6240 North Francisco Avenue. Rose was formerly service manager for Wells Gardner and Co.

Dr. Robert D. Huntoon, assistant chief of the atomic physics division, National Bureau of Standards, was recently awarded a distinguished physical science achievement award by the Washington Academy of Sciences for 1947, for his research in "the advancement of electronics and its application to other sciences and to modern ordnance."

Dr. Huntoon joined the staff of the Bureau of Standards in 1941 and assisted in the early development of proximity fuses.

Donald E. Ward has been appointed sales manager for Reeves Soundcraft Corporation, 10 East 52nd Street, New York City.

Dr. Henry H. Hausner is now a member of the Metallurgical Research and Development Laboratories of Sylvania Electric Products, Inc.

Joseph H. Humble has been appointed general sales and advertising manager of the Kester Solder Company, Chicago.

Dr. J. Howard Dellinger, chief of the Central Radio Propagation Laboratory of the National Bureau of Standards, has retired, after 40 years of Government service.

Dr. Dellinger will act as a radio consultant and adviser, and continue his present work as chairman of the Radio Technical Committee for Aeronautics. He will spend the summer attending sessions of the International Radio Consultative Committee in Stockholm, Sweden, and of the Provisional Frequency Board in Geneva, Switzerland.

E. D. Cooper, formerly manager of the Radio Specialties Division of Isolantite Corp., has joined General Ceramics and Steatite Corporation, Keasbey, New Jersey, as sales engineer, handling their new line of coaxial cable and wave guide equipment.

Howard H. Weber has been named chief engineer of the wire and cable department of United States Rubber Company. A. S. Basil is now general sales manager.

Jack Sadowsky, manager of electronic components for the Equipment Sales Section of the RCA Tube Department at Harrison, N. J., died recently.

The Industry Offers

AMPEREX 5-KW AIR COOLED AND WATER COOLED TRIODES

High-frequency water-cooled and air-cooled 5-kw triode amplifier and oscillator tubes, types 492 and 492-R, have been announced by Amperex Electronic Corporation, 79 Washington Street, Brooklyn, N. Y. Maximum rating of 5 kw plate dissipation is said to apply up to a frequency of 150 mc.

The 492-R dissipates full power with an air flow of 170 cfm. The 492 anode is capable of dissipating 5 kw of power with a water flow of 3 to 5 gallons of water per minute. The water jacket is an integral part of the tube, and a separate adaptor is provided for connection to external water lines. For high-frequency coaxial circuits, the water jacket is readily adaptable for extension into standard 2" copper tubing of any length to permit adjustment for a particular frequency.

Has a thoriated filament. Plate voltage of both tubes, 7,500.

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ELECTRO-VOICE TORQUE DRIVE CRYSTAL PICKUP CARTRIDGES

Crystal pickup cartridges employing torque-drive design have been produced by Electro-Voice, Inc., Buchanan, Michigan. Acts as a mechanical transformer and provides a *gear ratio* between record groove and the crystal.

Weighs 1/5 ounce Has low mass drive system, high lateral and vertical compliance, zero output for vertical movement, moisture-proofed crystal and replaceable whisker needle (osmium-tip or sapphire-tip).

Size, 1 3/32" x 11/16" x 5/16".

Available in low, medium and high-voltage outputs.

For full information, write for torque-drive bulletin No. 141.

BOONTON SIGNAL GENERATOR

An a-m signal generator, type 211-A, designed for testing and calibrating of omnirange receiving equipment operating within 88 to 140 mc has been developed by Boonton Radio Corp., Boonton, N. J.

Instrument consists of an r-f assembly, modulator and oscillator assembly, panel and meter assembly, and external dual regulated power supply unit.

Master oscillator coverage of 88 to 140 mc in one range. Vernier frequency dial has 100 divisions and is coupled to the main tuning capacitor through a 120:1 gear drive.

Either of two crystals providing 110.100 mc and 114.900 mc may be selected by a switch for use individually or in combination with the master oscillator to standardize its output frequency.

Master oscillator stability is said to be ± 0.25% from 88-140 mc; crystal oscillator, ± 0.0035% at 110.100 mc and 114.900 mc, operating temperature range 10°C to 50°C.

Modulation capabilities: 0-100% with internal oscillator or an external oscillator capable of supplying 2 volts across 100,000 ohms.

Distortion said to be 5% or less at 95% amplitude modulation.

Modulation meter has two ranges, 0-30% and 0-100%. Two modulating frequencies, 400 and 1,000 cycles in internal audio oscillator.

Instrument contains a demodulator or detector which supplies to front panel terminals a portion of the demodulated carrier. At 60% amplitude modulation, this voltage is 3.8 volts with a source impedance of 3,600 ohms.

Output attenuator is of single ended piston type; range is 0.2 volt to 0.1 microvolt.

* * *

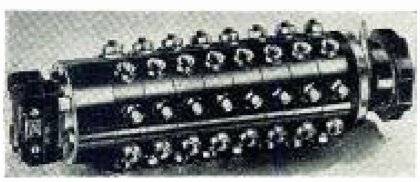
TESCO ROTARY TAP SWITCH

A *Tesco Rotary Tap Switch* has been developed by the Eastern Specialty Co., Phila., 40, Pa.

Each switch section with 7 active positions and one off position is rated at 50 amperes, continuous duty, with an overload capacity of 75 amperes. As many as 12 switch sections in tandem may be operated in parallel to handle a maximum current of 600 amperes.

A current interrupter consisting of one or two microswitches, rated at 10 amperes, and operated by detent action, opens the source of power when the switch is rotated toward a new position, so that no arcing occurs at the switch contacts.

Individual switch sections measure 2½" diameter over the housing, 3¼" over the terminal studs, length ¾". Bulletin No. 57 provides complete operating data.



SCOTT SOUND LEVEL METER

A sound level meter using subminiatures and covering the range from 34 to 140 db above the standard ASA reference level, has been developed by Hermon Hosmer Scott, Inc., 385 Putnam Avenue, Dept. C, Cambridge 39, Mass. Instrument, type 410-A, includes all three standard ASA weighting characteristics to duplicate the response of the ear at various levels, has a two-speed meter, provision for using extension cable, optional types of microphones, vibration pickups, etc., and analyzers or filters. The unit is 10½" long, 2½" in diameter, and weighs slightly over two pounds including batteries.

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RAYTHEON SUBMINIATURES

Subminiatures, type CK5703/CK608CX, have been developed by the Special Tube Section of Raytheon Manufacturing Company, Newton, Mass.

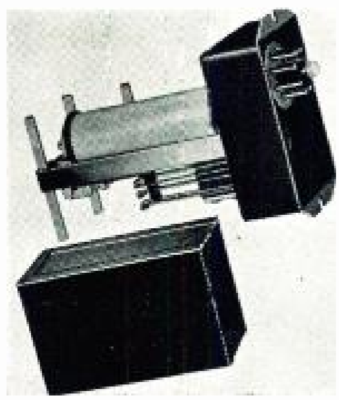
Tubes are heater-cathode triodes with rated mutual conductance of 5,000 micromohos and amplification factor of 25. Tubes have a 3-watt plate dissipation and capable of an output of nearly 1 watt at 500 mc.

* * *

CLARE PLUG-IN RELAY ASSEMBLY

A dust-tight plug-in relay base and cover has been developed by C. P. Clare & Co., 4719 West Sunnyside Avenue, Chicago 30, Illinois.

Assembly consists of an a-c or d-c relay mounted on a dust-tight base, the terminals brought through a Neoprene gasket, closely fitted. The steel cover, secured to the base by a thumb nut, can be readily removed for inspection of the relay. Either a standard radio-type plug as illustrated, or a 15-point plug of different design complete the installation.



HEWLETT-PACKARD VTVM

A vacuum-tube voltmeter, the 400C, which provides readings from .1 millivolt to 300 volts, throughout a range of 20 cycles to 2 mc, has been developed by Hewlett-Packard Company, 395 Page Mill Road, Palo Alto, Calif.

Calibrated linear scale reads directly in rms volts or in db based on 1 milliwatt into 600 ohms. Special output terminal permits use of the 400C as a wide-band stabilized amplifier, for increasing gain of oscilloscopes, recorders and measuring devices. Maximum gain is 54 db. In service as a voltmeter, instrument may be used for direct hum or noise readings, to determine transmitter and receiver voltages, audio, carrier or supersonic voltages, power gain or network response.

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PHILCO F-M/TV VISUAL ALIGNMENT GENERATOR

A visual alignment generator, model 7008, which includes a crystal-diode h-f probe for use in examining the response curve of individual stages and the 4.5 video trap, has been developed by Philco.

Has a crystal calibrator which provides check points every 5 mc; an a-m (marker) generator, operating over a frequency range of 3.2-250 mc; an f-m generator, covering a range of approximately 4-120 mc and 145-260 mc with a variable sweep width of 15 mc maximum deviation; an a-f generator, operating at 400 cycles; 'scope; and a common power supply.

The cathode ray tube is a 3MP1 type employing electrostatic deflection, and is said to have a deflection sensitivity of better than 25 millivolts per inch at maximum vertical-amplifier gain. The screen is a medium-persistence, green-fluorescent type and is supplied with a removable crosshatch screen. Screen is constructed of laminated sheets of plastic so that the scribed markings are sandwiched in between two sheets, and cannot be damaged by handling. The cathode-ray tube is mounted in a separate swiveled housing which can be folded into the main housing.

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G.E. GAS-FILLED THYRATRON

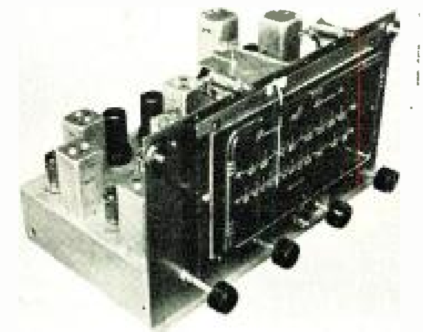
An inert-gas filled midget thyratron, type GL-5663, has been announced by the tube division of G. E.

The tube, 1½" high, has a typical heating time of ten seconds, and a peak inverse and peak forward voltage rating of 500. The anode current ratings are 60 ma instantaneous and 20 ma average.

BROWNING F-M/A-M TUNER

An f-m/a-m tuner, model RJ-12A, has been announced by Browning Laboratories, Inc., 750 Main St., Winchester, Mass. An r-f amplifier is used in both f-m and a-m sections. The a-f response of the f-m section is said to be flat from 10 to 15,000 cycles ± 1½ db. A drift compensating network is said to eliminate drift after a two minute warmup period. Less than 10 microvolts required to produce 30 db noise reduction, through use of dual limiters in the Armstrong circuit. The a-m section employs recently developed triple-tuned i-f transformers and a high frequency extending network so that the audio response is flat from 20 to 6600 cycles ± 3 db. Sensitivity is 5 microvolts.

A connector in the rear of the chassis for phono input allows the volume control to be employed when playing records. The f-m antenna input is 300 ohms balanced to ground and connected so that the entire f-m antenna and feeder system also functions as the a-m antenna.



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TRIPLETT VOLT-OHM-MIL-AMMETER

A volt-ohm-mil-ammeter, type 630, featuring six d-c volt ranges from 0-6,000, at 20,000 ohms/volt and six a-c ranges to 6,000, at 5,000 ohms/volt has been announced by the Triplett Electrical Instrument Co., Bluffton, Ohio.

Available also are five d-c ranges from 0-60 microamperes to 0-12 amps; resistance ranges to 100 megohms; db from —30 to +70.

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BROOK ELECTRONICS AMPLIFIER

A remote-control model amplifier, designed essentially for custom-built radio-phonographs, has been introduced by Brook Electronics, Inc., 34 DeHart Place, Elizabeth 2, New Jersey.

Designated model 10C3, the amplifier consists of two separate units. The smaller of two chassis contains preamp stages, input jacks, and all operating controls. The larger chassis contains a 30-watt power amplifier and power supply. Four input channels are provided, one of which is high-gain with internal equalization for use with low-level magnetic-type pickups.

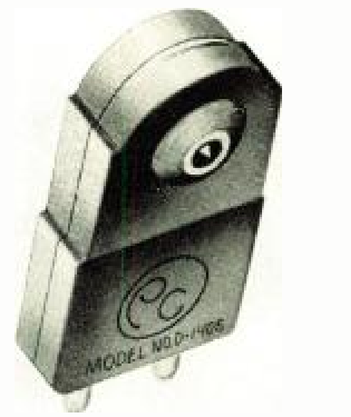
Low-mu triodes are used throughout. Frequency response is said to be flat within .2 db from 20 to 20,000 cycles.

PICKERING MICROGROOVE CARTRIDGE REPRODUCER

A pickup, model D-140S, designed for the microgroove, fine-line slow-speed, recordings, has been announced by Pickering and Co., Inc., Oceanside, Long Island, N. Y. Sharp diamond stylus radius is .001".

Cartridge tracks the recordings with a stylus pressure of 5 grams, or approximately 1/6 of an ounce.

Has a *Keystone Clip Mounting* which permits conversion from the standard cartridge to model D-140S.



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BENDIX FRACTIONAL H-P D-C MOTORS

A line of fractional horse-power, d-c motors designed for trim-tab actuators, stall-warning systems, bank-change switching and other applications, has been announced by the Red Bank Division, Bendix Aviation Corporation, Red Bank, New Jersey.

These motors, designed to meet the requirements of AN specifications are available in various voltage ratings, clock, counter-clock or reversible rotation, and with pinions, worms or plain shafts. Motor diameter is 1⅝", length (less shaft) 2 9/16" and weight 12 ounces.

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INDUSTRIAL DEVICES HI-VOLT NEON-INDICATOR VOLTMETER

A voltmeter, covering a range from 1,600 to 15,000 volts a-c, the Hi-Volt model 500, has been announced by Industrial Devices, Inc., Edgewater, N. J. Device is intended for testing high-voltage transformers. It is not recommended for use on high-power supplies other than those of the current-limiting type, except by those familiar with the technique of high-voltage measurements and the precautions necessary.

The unit utilizes a neon lamp indicator. A knob is turned until the neon lamp extinguishes, when the voltage is read directly off the dial. This device is designed for use only with transformers having one side grounded. A 15-megohm multiplier is incorporated in a 7" long prod which is integral with the meter. The current drawn is less than 1 ma.

(*Continued on page 36*)

Preamp Maintenance

(*Continued from page 9*)

be used, the terminating resistance shown in the circuit should be chosen to properly terminate the attenuator used. If the preamp has a given input impedance, which is of proper value to terminate the attenuator, no terminating resistor need be used. The isolation transformer should provide the required impedance ratio to match the oscillator to the attenuator which should have an impedance corresponding to the given value.

The input of the preamp may be balanced to ground or single-ended. The attenuator chosen should be of the corresponding type and should provide a maximum loss at least equal to the gain of the preamp. The ground connection to the input circuit of the preamp should be made as recommended by the manufacturer. The output circuit of the preamp should be terminated by a non-inductive resistor equal to the output impedance of the preamp. The Figure 1 circuit is used with balanced circuits. In Figure 2 we have a setup with unbalanced circuits.

The oscillator and preamp should be permitted a sufficient warm-up period to assure stability. The oscillator should be set to 1,000 cps and the output adjusted until the No. *1* vu meter (input) reads +4 vu. Sufficient attenuation should be inserted so that the output level as indicated by vu meter No. *2* is approximately +4 vu.[1]

An alternate method is to insert an additional amplifier, having sufficient gain for the purpose, ahead of the volume indicator. The frequency response of this amplifier should be determined and used to correct any readings taken.

Adjustment of Level

To determine the correct output level, preamp operating instructions should be studied carefully. The appropriate test circuit from Figures 1 and 2 should be selected and the foregoing suggestions applied if the preamp output is insufficient to operate a standard volume indicator. The audio oscillator should be set on 1,000 cycles and the output level adjusted until the No. *1* volume indicator (oscillator output) reads either +4 vu or ±0 db, depending on the type of volume indicator used.

The attenuator should be adjusted until a convenient reading is obtained on the No. *2* volume indicator.

Determining Oveload Point

The output of the audio oscillator should be kept constant at +4 vu; the attenuation ahead of the preamp decreased in 4 db steps or the oscillator output alternately increased and the output volume indicator observed. A point will be reached where the output level increase is less than the corre-

[1] If the preamp output level is substantially below +4 vu, the vu meter across the output load resistance may be replaced by a vtvm of greater sensitivity, provided the output of the preamp is single-ended. The ground terminal of the vtvm should be connected to the grounded output lead. If the preamp output transformer contains a center-tap ground, then a properly terminated isolation transformer must be inserted, since vacuum-tube voltmeters require a ground on one leg for stability purposes.

sponding increase in input level due to the amplifier overload. When the overload point has been found for 1,000 cycles, the audio oscillator should be adjusted to 30 cycles, 10,000 and 15,000 cycles and the overload point at these frequencies determined. It may be helpful to plot the input level versus output level to determine the amplitude characteristics of the amplifier.

The highest value of output level before overloading is detected should be noted. *All subsequent frequency response measurements are to be made at an output level of approximately 10 db below this point.*

Frequency Response of the Preamp

A frequency run should be taken with the preamp input level adjusted as indicated previously, so that the resulting output level at the 1,000-cycle reference frequency is at least 10 db below the overload point as determined above. The frequency response runs should be made at output levels of 5 db above and below the original value. If the runs are in agreement within ±.25 db, it can be assumed that the preamp is operating within the linear range.

If the frequency response of the preamp is within ±1 db from 50 cycles to at least 10 kc it may be considered satisfactory for use. If it should depart from the above, the manufacturer's bulletin should be consulted and suitable steps taken to correct any deficiencies.

Stabilization

(*Continued from page 8*)

can readily be seen by comparing Figure 1 with Figures 5 and 6. One disadvantage, however, should be pointed out. The feedback stabilization system must be calibrated; that is, it does not permit the frequency to be known directly as is the case where the source of the oscillation is an accurately known quartz crystal. Once the calibration of the unit has been made, however, its simplicity and ease of operation far surpasses the frequency multiplier units.

References

[1]*Microwave Instrument Blind Landing System*, Electronic Industries; February, 1946.*

[2]Dahl, Ernest A., *2660 Mc Train Communication System*, Electronics; January, 1946.

[3]George, W. D.; Lyons, H.; Freeman, J. J., and Shaull, J. M., *The Microwave Frequency Standard at the Central Radio Propagation, Laboratory*, Report CRPL-8-1, 9-4, U. S. Department of Commerce, National Bureau of Standards, Central Radio Propagation Laboratory, Washington, D. C.

[4]Straus, H. A.; Rueger, L. J.; Wert, C. A.; Reisman, S. J.; Taylor, M.; Davis, R. J., and Taylor, J. H., *Fire-Control Radar MPG1*, Electronics; December, 1945.

[5]Holdam, J. V.; McGrath, S., and Cole, A. D., *Radar for Blind Bombing*, Electronics; May and June, 1946.

Impedance Matching Techniques

(*Continued from page 26*)

practical, *after* which the value of N should be adjusted to *match* these two impedances.

Maximum Current

The conditions for maximum current through the load impedance, if Z_g or Z_L is the variable, is most easily determined by inspection after dividing equation (*1*) by Z_L. It is seen that I_L is a maximum when either Z_L or Z_g (or both) is equal to zero or is a minimum. If the transformation ratio N is the variable, the criterion is

$$\frac{dI_L}{dN} = O$$

The value of N is found to be $(Z_L/Z_g)^{1/2}$, demonstrating that N should be adjusted to match the fixed impedances. It is again easily seen that to obtain maximum I_L, when all three network elements are variable, both the load impedance and its generator impedance should be made as low as practical after which these two impedances should be matched by adjusting the value of N.

Maximum Product of Voltage And Current, or Power

Taking the resistive components and the transformation ratio as the variables, while the reactive components are equal and opposite, the output power will be a maximum, when

$$\frac{dP_L}{dR_g} = O, \frac{dP_L}{dR_L} = O \text{ and } \frac{dP_L}{dN} = O$$

where

$$P_L = \frac{V_g^2 N^2 R_L}{(R_L + N^2 R_g)^2} \qquad (5)$$

In the first case ($dP_L/dR_g = O$) it is found that the output power is a maximum, if

$$R_g = -R_L/N^2$$

This indicates that R_g should be a negative resistance which cannot be realized physically. However, it is readily seen by inspection of equation (*5*) that P_L is a maximum and finite when R_g is a minimum or equal to zero.

For the two remaining cases it is found that for maximum output power the load resistance, if the transformation ratio N is the only variable, or the two resistances should be matched by means of the transformer, should be made equal to the generator resistance. If the load and generator impedances are complex and have fixed angles, the above results are also valid when considering only their absolute values.[2]

Conclusion

The foregoing results serve to stress the fact that the relationship existing between source impedance, load impedance, and degree of match, is determined entirely by which network components are variable, and whether it is desirable to obtain maximum voltage, current, or power across the load impedance.

Variable	Maximum Voltage	Maximum Current	Maximum Power
Z_g	$Z_g = O$	$Z_g = O$	$Z_g = O$
Z_L	$Z_L = \infty$	$Z_L = O$	$Z_L = Z_g$
N	$N^2 = \frac{Z_L}{Z_g}$	$N^2 = \frac{Z_L}{Z_g}$	$N^2 = \frac{Z_L}{Z_g}$

Figure 2

Tabulation of the results arrived at through application of procedures discussed in this paper. It may be seen that if all three circuit components are variable, an impedance match should be affected only after the source and load impedances are adjusted for optimum values.

[2]L. A. Ware and H. R. Reed, *Communication Circuits*, second edition, pp. 37-38, John Wiley & Sons, Inc., New York.

PORTABLE FIELD INTENSITY METER

Portable field intensity meter recently developed by RCA, weighing 12½ pounds with batteries and measuring 12" x 8½" x 5½". The meter (type WX-2A) provides direct readings.

Tube News

(*Continued from page* 14)

be obtained by increasing the *B* voltage.

JANETC Preferred Transmitting Tubes

A PREFERRED LIST of transmitting tubes has also been prepared by the Army-Navy committee.

There are ten classifications: Triodes, tetrodes, twin tetrodes, pulse modulation, magnetrons, vacuum, gas rectifiers, grid control, clipper tubes and gas switching.

In the triode group are the 2C39A, 2C43, 6C22, 9C21, 9C22, 100TH, 250TH, 450TH, 811, 880, 889RA, 893A and 893AR. Tetrodes include the 4D21, 5D22, 807W and 4X150A. The 829B and 832A are recommended as twin tetrodes. For pulse modulation seven types are specified: 3D21A, 3C45, 3E29, 4C35, 5C22, 6C21 and 715C.

The magnetron group includes the 2J30-34, 2J48, 2J51, 2J58, 2J60, 2J61A-62A, 3J21, 4J50, 4J51, 4J52, 4J54-59, 4J78, 5J26, 5586 and 5657. In the vacuum group we have the 2X2A, 3B24W, 371B, 5R4GY, 836, 1616 and 8020. Gas rectifiers include the OZ4A, 3B28, 4B26, 4B32, 6C, 16B, 857B, 869B, 1005, 1006 and 5517. For grid control we have the 2D21, C6J, 6D4, 393A, 394A and 884. Clipper tubes include the 3B29, 4B31 and 719A.

Two classifications are used for the gas switching approved types, the ATR and TR. In the ATR group we have nine tubes: 1B35, 1B36, 1B37, 1B44, 1B51, 1B52, 1B53, 1B56 and 1B57. There are five types in the TR group: 1B26, 1B27, 1B32, 1B50 and 1B60.

The 3B4

A MINIATURE instant-heating filamentary type r-f beam-power pentode for use in v-h-f portable mobile equipment as a class *C* oscillator, frequency multiplier and r-f amplifier, was recently announced by Hytron. Typed the 3B4, it utilizes a 1.25/2.5-volt filament, with current ratings of 330 and 165 ma, respectively.

Can be used as an r-f power amplifier and oscillator in class *C* telegraphy and f-m with d-c plate voltage of 150, d-c screen-grid voltage of 135 and d-c control-grid voltage of –75.

Useful power output, when the tube is used as a class *C* oscillator at 100 mc is about .45 watt with 90 volts plate and 1.25 watt with 150 volts on the plate, with 2.5 volts on the filament.

V-H-F Link

(Continued from page 20)

per channel for a 1,000-cps zero-dbm input signal to the two-wire hybrid. A 30-db *T* pad in the receiver output line reduced the 20-dbm output to a −10 dbm input level for the carrier terminal.

Carrier equipment* used in this test normally operates with a level of −13 dbm at the modulator input and +4 dbm at the demodulator output. Two-wire terminations are obtained with four-wire terminating sets which include attenuation pads to reduce the incoming level from the switchboard to −13 dbm. Pads are also provided to reduce the receiving level at the switchboard to the desired value.

The carrier equipment can be adjusted for any desired transmitting level toward the radio transmitter over a range from about +3 dbm to −43 dbm and for operation on incoming signal levels in the range of −21 dbm to +10 dbm. The equipment operates at 600-ohm impedance on both the voice- and carrier-frequency sides.

First operating tests on this installation revealed such quiet circuits that listeners thought the equipment was dead. Signal-to-noise ratio was 60 db or more. At all other times ratios better than 30 db have been maintained.

Satisfactory conversations have been held over the complete 88-mile circuit produced by patching together two of the channels at San Jose and talking between two stations in the San Francisco offices of Southern Pacific.

One of the two telegraph sub-channels was used to replace a wire circuit between San Francisco and San Jose. The other was repeatered at San Jose for wire connection to a teletype at Watsonville, 100 miles from San Francisco. The teletype circuit to San Jose gave a range of 80 points from San Francisco to San Jose and 75 points in the return direction.

*Lenkhurt type 42.

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WLWT TV TRUCK

Thirty-two passenger bus converted for mobile tv work at WLWT, Cincinnati. Bus accommodates 2 cameras, over 1,500' of cable, portable microwave transmitter, sound equipment, monitoring and switching apparatus and in addition, seats for 22. Features of the bus include air conditioning and fluorescent lighting.

Speaker Systems

(Continued from page 24)

compliance of the tangential type may be employed where drawing is used The greater excursion possible is offset, perhaps, by the fact that linear movement is accompanied under torsion, which may in turn affect response. Subjective tests indicate no great disparity in operation.

Mounting the diaphragm should be fast, accurate and easy. In the unit illustrated mounting is accomplished with no special skill or centering devices. Annular recesses center the unit positively and the diaphragm assembly is secured by only three screws.

The Low-Frequency Assembly

The low-frequency assembly consists of the frame, cone and voice coil with compliance. The frame must be strong and not subject to warping. Tolerances must be close to eliminate ad justments which would slow up production. For this reason no stampings are used, and the frame is accurately machined from non-warping aluminum castings of thick section.

A curvilinear designed cone is employed in our models to allow more driving area within the 15" diameter allowable. It was recognized when this choice was made that a straight-sided cone might theoretically supply more stiffness. Tests proved no discernible weave or cone breakup, and increased efficiency was apparent from the additional driving area, totaling over 125 sq. in.

The low-frequency voice coil in our speakers is copper wound. Conductivity is higher than for aluminum, though mass is greater. The use of aluminum in the voice coil is limited to the high-frequency unit, where mass increase would seriously affect the upper limit of response.

Quality Improvement

Perhaps because the listening audience has been easily satisfied, or more likely because the audience has not known how to articulate its dissatisfaction, and perhaps because acoustic design must be treated subjectively and this violates the objectivity of the engineer, speaker research and design have been neglected.

Surveying the art, we find many questions still unanswered. Why, for instance, have we seized upon flimsy paper cones and heavy metal diaphragms as the basis for our ultimate design, which to date have fallen far short of their goal?

What happened to the Klystron condenser speaker? Why was this design not pursued to the ultimate?

Where are the ideal piston type designs, and the infinite cellular unit designs?

Even in theater woofers today we are content with a folded horn or a short straight horn that violates even our present acoustic knowledge.

Yes, the problems are many. Acoustic engineers have quite a development and research program facing them.

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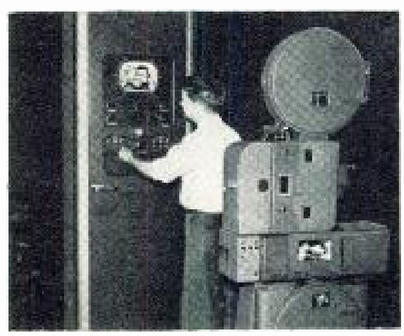
SOUND MOVIE PROJECTOR FOR TV



RCA's 35-mm sound motion projector, which features electronically-triggered, high-intensity *gap-lamp* which is said to be virtually free of heat and eliminates the need for a moving shutter. The periodic flashes of the lamp, coupled with a specially-designed film drive mechanism, make it possible to use standard 35-mm film, which normally operates at 24 frames per second, to provide the 60 interlaced fields, or 30 frames per second required for tv. Operator is shown at the monitor and changeover control rack, which contains the switches for the remote starting and stopping of the projector, as well as the remote controls for operating a slide projector.

Noise Measurements

(Continued from page 21)

of these factors is varied, the plot would no longer hold and the distance from source to microphone for a 1-db error would have a different value. However, knowing the room conditions, a set of curves similar to those of Figure 1 can always be drawn up, using the following approximate formula:

$$\frac{E_R}{E_D} = \frac{16\pi D^2(1-\alpha)}{S\alpha},$$ where E_R and

E_D are the reverberant and direct sound energies respectively, D is the distance in feet from source to microphone, S the interior surface area of the room in square feet and α is the average sound-absorption coefficient of the room surface. A reasonable approximation of alpha may be calculated from published tables of the sound absorption coefficients of building materials, by multiplying the area of each surface material by its absorption coefficient to obtain absorption units, totaling the units and then dividing by the total surface area. Alpha may also be more accurately obtained by calculation from a measurement of the reverberation time of the room.

The value of D, when E_R equals E_D and their ratio is unity, is the point where the curves cross to give a total 3 db higher than either curve. Other points on the total energy curve can be obtained by converting the plotted decibel values of E_R and E_D to relative energies, adding and reconverting to decibels.

A drawing such as this should be available in acoustic test rooms where precise sound measurements are made, as with it, one can readily determine the microphone distance that will give an accuracy consistent with the precision of other factors affecting the measurements.

Noise measurements are sometimes made in power houses, transformer sub-stations and other locations where high magnetic fields are present. Such fields may often be picked up by low-level, high-impedance portions of the equipment to give erroneous noise readings. To guard against this, it is advisable to use as short a microphone cable as possible, and to check the minimum reading by covering the microphone tightly. Often orienting the microphone or substituting a crystal for a dynamic microphone will reduce the pickup to a satisfactorily low value.

A review of the foregoing will disclose many possibilities for results

(Continued on page 36)

(*Continued from page 35*)

that, to the uninitiated, might seem incomprehensible or inconsistent. However, with attention to the points brought out, the engineer making noise measurements for the first time can avoid many of the more common errors, and can save himself from the embarrassing position of distrusting his own equipment. A close scrutiny of the results of acoustic measurements is always profitable, but the sound-measuring equipment usually deserves questioning last of all. Most modern sound meters are well built, care having been taken to make them dependable, stable, and accurate. When one considers the other more probable causes of an inconsistent reading he will be more inclined to place the meter in the position of Caesar's wife—"above suspicion."

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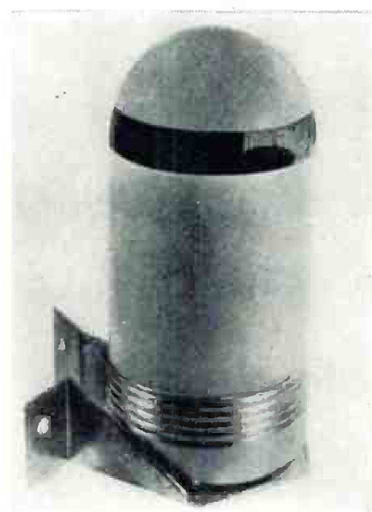
The Industry Offers

(*Continued from page 29*)

FISHER-PIERCE PHOTOELECTRIC LIGHT CONTROL

Photoelectric controls, for the control of aircraft obstruction lights on towers, have been announced by the Fisher-Pierce Company, 72 Ceylon Street, Boston 21, Mass.

Controls turn on automatically at 35 foot-candles and turn off at 55 foot-candles. One model, 61305, is rated to control 500 watts of incandescent lamp load, and another model, 61306, is rated to control 3,000 watts. Both operate at 120 volts, 50 to 60 cycles.



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KAY ELECTRIC MEGALYZER

A v-h-f spectrum analyzer, the *Megalyzer*, has been announced by Kay Electric Company, Pine Brook, N. J.

Unit can be used as a monitoring instrument for communication systems studies and analysis, and observe simultaneously all signals within a frequency sweep band 30 mc wide within the 30 to 300 mc range. Sensitivity said to be better than 200 microvolts. Narrow frequency resolution of 100 kc.

Megalyzer may also be used as a sweeping oscillator for conventional alignment work.

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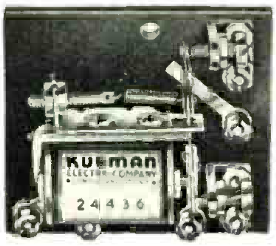
KURMAN SPLIT ARMATURE RELAY

A relay with a split armature, type 24, developed for automatic controls, keying, antenna changeover, burglar alarms, and closed circuit applications, has been announced by the Kurman Electric Co., Inc., 35-18 37th St., Long Island City 1, N. Y.

Rated sensitivity, .014 watt d-c; .3 va a-c. Adjusts to operate at .005 watt, and from .01 to 115 volts d-c or a-c.



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G.E. SINGLE SIDEBAND SELECTOR

A single sideband selector, type YRS-1, has been developed by the Specialty Division of G. E.

Device is said to afford a reduction of distortion due to selective fading for long distance reception of a-m signals. According to George F. Devine, commercial engineer for the division, a complete single sideband system, transmitter and receiver, would permit twice as many signals or stations in a band and would increase transmitter efficiency by up to 75%.

Carrier drift, within limits, is followed by means of a locked oscillator eliminating any need to follow small variations in transmitter frequency or drift in the receiver's local oscillator.

There are four pushbuttons on the device, one for dual sideband reception with reinforced carrier, one for normal reception and one for selection of each sideband. Designed for use with receivers having an i-f of about 455 kc.

* * *

TURNER MIKES

A bi-directional velocity type microphone and improved cardioid microphone have been developed by The Turner Company, Cedar Rapids, Iowa.

Velocity microphone, model 87, has a single element ribbon generator supported in an Alnico V magnet. Has shielded output transformers to exclude hum pickup. Response is said to be held to within ±5 db from 80 to 10,000; level, 62 db below 1 volt/dyne/sq cm at high impedance. Has a 4-position output switch permitting use with 50, 200, 500 ohms, or high impedance inputs.

Cardioid microphone, model 77, features a wide-range pickup at the front and a sharply attenuated output at the rear. Discrimination between front and rear is said to be approximately 15 db at all frequencies; response is within ± 5 db from 70 to 10,000; level, 62 db below 1 volt/dyne/sq cm at high impedance. Equipped with 4-position output switch giving 50, 200, 500 ohms, or high impedance output; tilting head, and quick-disconnect cable.

Turner type 77.

* * *

W. E. REPRODUCER ARM GUARD

A guard, type 706A, for the 5A reproducer arm has been announced by Western Electric.

The guard serves as an automatic latch type support for the reproducer arm and reproducer during intervals between the playing of records.

Guard consists of two main assemblies, a guide housing which mounts on the reproducer panel and a follower assembly which is attached to the reproducer arm.

(Continued on page 38)

The Industry Offers

(*Continued from page 37*)

ROLLIN V-H-F/U-H-F SIGNAL GENERATOR

A power type standard signal generator, model 30, with 5 watts nominal r-f output, 50-ohm impedance with a 160-db range of attenuation (15 volts to .10 μv), and provision for cw, a-m or pulse operation, has been announced by the Rollin Company, 2070 N. Fair Oaks Ave., Pasadena 3, Calif. Signal generator can be tuned from 40 to 400 mc, and has a spiral dial scale nearly 4' long, calibrated at intervals of 1% in frequency.

* * *

ROBINSON RECORDING MACHINE

A lathe type recorder for professional work in stations and recording studios, has been announced by the Robinson Recording Laboratories, 2022 Sansom Street, Philadelphia 3, Pa.

Improved belt drive and dynamically balanced parts are said to reduce the *wow* factor to .01% on both 78 and 33 1/3 speeds.

Five pitches are available with either inside or outside start: 88, 96, 112, 120 and 128 lines per inch. Quick feed or spiral is obtained by a large hand wheel. Provision is made for eccentrics and safety groove cutting.

* * *

TRIG TOWERS

Trig Towers in self-supporting and guyed types have been announced by the Rostan Corp., 203 East 44th Street, New York 17, New York.

Of triangular design and fabricated of 61 ST 6 aluminum alloy. Ladder with 15" rung spacing, is integral with one side of tower.

Produced in 10' sections, the free standing type comes in heights of 10'-20'-30' and 40' and the guyed type in heights from 10' to 100'.

Designed to withstand 90 miles per hour winds. Guy towers support 200 pounds with a projected area of 10 square feet of round members of 6 2/3 square feet of flat surface. The self-supporting towers will support 200 pounds with a projected area of 7½ square feet of round members.

* * *

PEERLESS ELECTRICAL AUDIO TRANSFORERS

A *20-20 line* of audio transformers, which are said to be flat within 1 db from 20 to 20,000 cycles has been developed by the Peerless Electrical Products Division of Altec Lansing Corporation, 6920 McKinley Ave., Los Angeles 1, Calif.

MEASUREMENTS CORP. BROAD-BAND TRANSFORMER

A broad-band transformer, type M-286, designed for matching 72-ohm coaxial to 300-ohm balanced line in the range from 40 to 220 mc. has been announced by Measurements Corp., Boonton, New Jersey.

While the unit was developed primarily for use with Measurements type 80 standard signal generator, in conjunction with a 72-ohm matching pad, it is adaptable to other signal generators in the frequency range of the transformer. It may also be used for matching coaxial 72-ohm lines to receivers having an input impedance of 300 ohms. The transformer yields a voltage step-up of 1:2.

The 72-ohm termination of the transformer has AN type UG-21/U (Navy type 49268) coaxial fitting; soldering lugs are provided for connections to the 300-ohm termination.

* * *

REK-O-KUT RECORDER

A 12" disc recorder, the *Challenger*, has been announced by the Rek-O-Kut Company, Inc., 38-01 Queens Boulevard, New York.

Features include a *Master-Pro* patented overhead feed mechanism, dual speed 12" turntable and chassis constructed of aluminum castings, instantaneous speed change to 78 or 33 1/3 rpm, and a high-fidelity amplifier for recording and play back. Has a 15" pickup arm.

* * *

CANNON ELECTRIC UTILITY PILOT LIGHT

Electric utility colored pilot lights for signal applications, warning, decoration, and general illumination, have been developed by Cannon Electric Development Company, 3209 Humboldt Street, Los Angeles 31, California.

Available in one type of 8-prism lens to four separate lens or more, mounted on a plate 4½" wide, the depth varying with the number of lens. Lens come in five colors of unbreakable plastic, and are lighted by 93S8 lamps for single contact bayonet base of 12 v, 15 cp; or 6S6 candelabra lamps for screw base in 15 v types.

A variation of the pilot light, the DPF9 uses a 9" 6 w fluorescent lamp for illumination purposes only.

Bulletin No. UPL-1 contains further data.

ADVERTISERS IN THIS ISSUE

COMMUNICATIONS INDEX

JULY, 1948

for DISTORTION and BRIDGE MEASUREMENTS at 2 to 15,000 CYCLES

THIS highly stable oscillator with unusually low distortion is of the resistance-tuned type and operates on the inverse feedback principle developed by General Radio

The Type 1301-A Low-Distortion Oscillator is especially suitable as an a-f power source for bridge use, for general distortion measurements, to obtain frequency characteristics and to make rapid measurements of distortion in broadcast transmitter systems.

● *The normal range of this oscillator is 20 to 15,000 cycles. The Range Extension Unit (above) lowers this range by a full decade to 2 to 15 cycles, greatly extending its usefulness to frequencies considerably below those heretofore practicable.*

With its very high stability, unusually low distortion and many operating conveniences, the Type 1301-A Low-Distortion Oscillator fills a universal need in distortion and bridge measurements.

TYPE 1301-P1 RANGE EXTENSION UNIT $70.00

FEATURES

- **WIDE FREQUENCY RANGE** — 20 to 15,000 cycles (with Range Extension Unit, 2 to 15,000 cycles)
- **CONVENIENT TO USE** — 27 fixed frequencies, selected by two push-button switches in logarithmic steps — any desired frequency between steps obtained by plugging in external resistors
- **THREE OUTPUT IMPEDANCES** — 600-ohm balanced to ground; 600-ohm unbalanced; 5,000 ohm unbalanced
- **EXCEPTIONALLY PURE WAVEFORM** — Distortion not more than the following percentages: with 5,000-ohm output 0.1% from 40 to 7,500 cycles; 0.15% at other frequencies. With 600-ohm output 0.1% from 40 to 7,500 cycles; 0.25% from 20 to 40 cycles and 0.15% above 7,500 cycles
- **HIGH STABILITY** — Frequency is not affected by changes in load or plate supply voltage. Drift less than 0.02% per hour after a few minutes operation
- **ACCURATE FREQUENCY CALIBRATION** — Adjusted to within 1½% ± 0.1 cycle
- **NO TEMPERATURE OR HUMIDITY EFFECTS** — In ordinary climatic changes, operation is unaffected

TYPE 1301-A LOW-DISTORTION OSCILLATOR $395.00

GENERAL RADIO COMPANY

Cambridge 39, Massachusetts

90 West St., New York 6 — 920 S. Michigan Ave., Chicago 5 — 950 N. Highland Ave., Los Angeles 38

RUBBER RECIPE

Rubber compounds to the tune of some 35 million pounds a year go into Bell System plant. Each compound must meet many requirements for resistance to humidity, oxygen, ozone, light and abrasion. The right properties depend on skillful selection and compounding of ingredients; this is one of the jobs of Bell Laboratories.

Sulphur, one essential ingredient of rubber, can also be corrosive. That seemed to rule out rubber on telephone cords. But Bell chemists found that if they held sulphur to the bare minimum, corrosion ceased. Now your handset cord has long life, is less susceptible to moisture as, for example, from a wet umbrella.

Connecting your home to the telephone wire on the street is a "drop" — one hundred feet or more of rubber-insulated wire. Once this wire was protected from ozone, light and abrasion by an impregnated cotton braid; but water leached the impregnant, and the braid rotted. Bell chemists tested scores of synthetics, and selected neoprene as an exterior covering with many times the life of braid.

Rubber is only one of many types of insulation developed by the Laboratories for the Bell System; insulation is only one of the Laboratories' problems in providing a quick, economical path for your voice.

BELL TELEPHONE LABORATORIES

EXPLORING AND INVENTING, DEVISING AND PERFECTING FOR CONTINUED IMPROVEMENTS AND ECONOMIES IN TELEPHONE SERVICE.