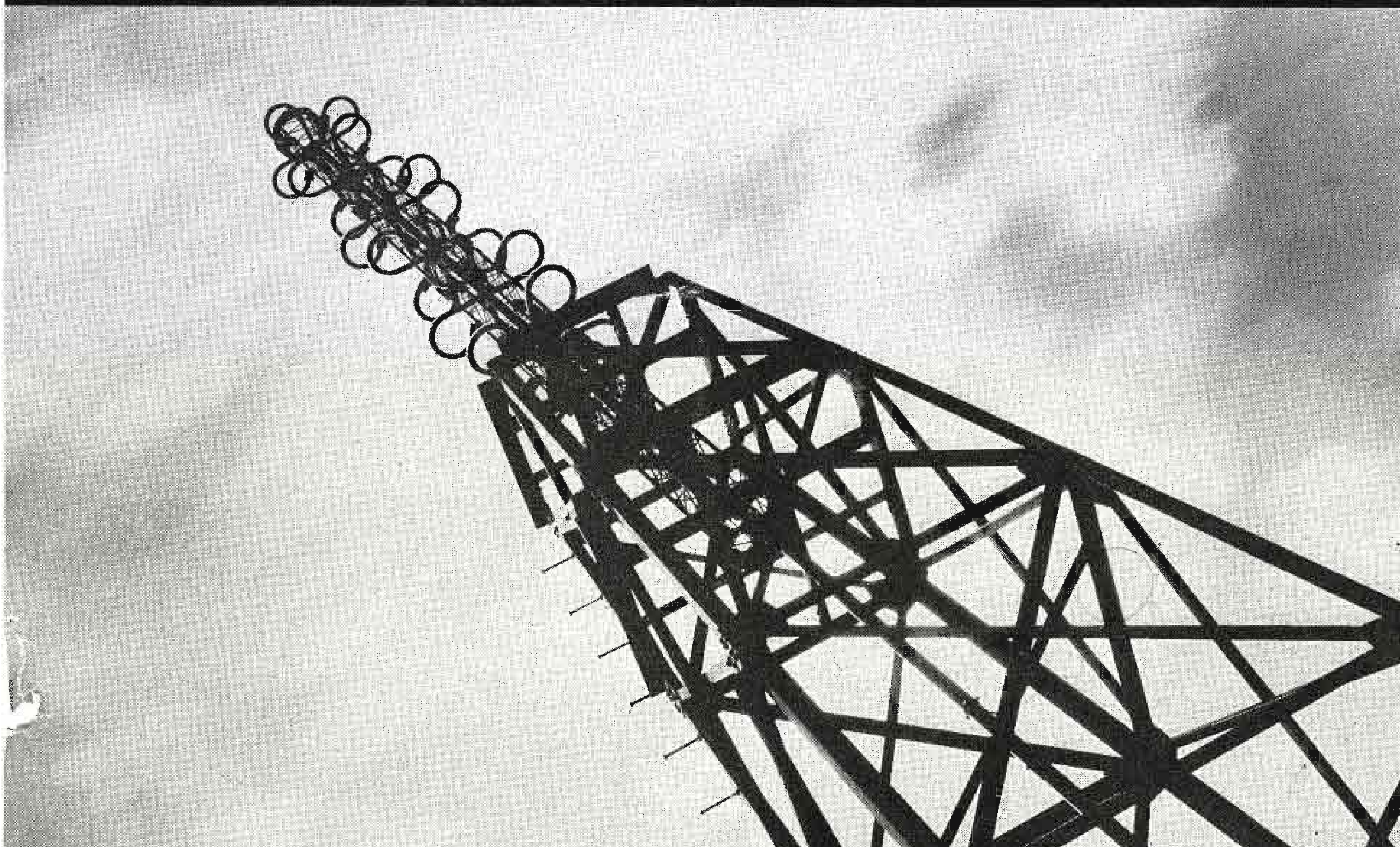
COMMUNICATIONS

INCLUDING "RADIO ENGINEERING" AND "TELEVISION ENGINEERING"



MAY

★ TV TRANSMITTER DESIGN

★ F-M TRANSMITTER FREQUENCY CHECKS

1948

We see increased sales for You!

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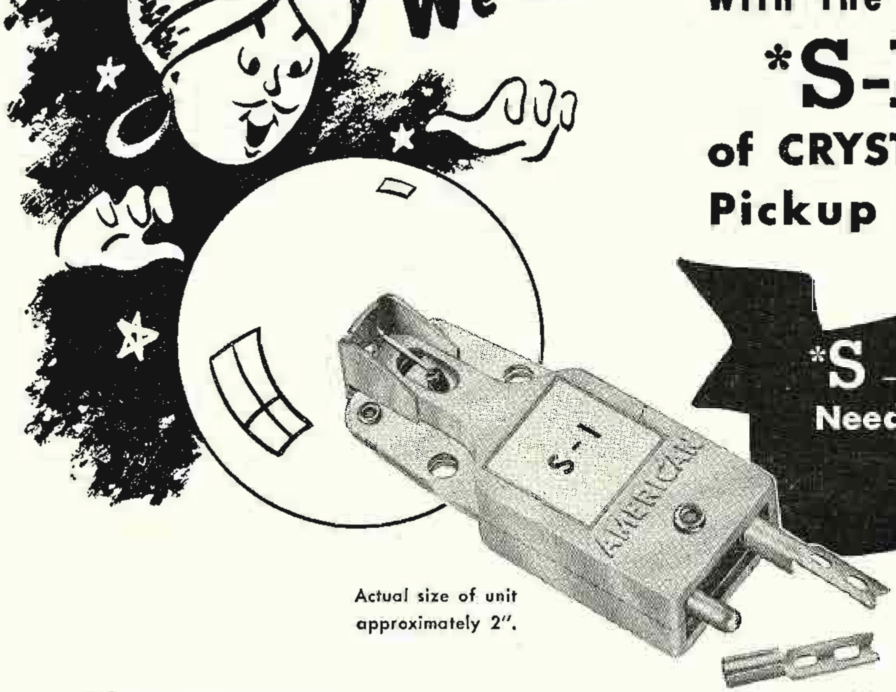
*S-LINE

of CRYSTAL Phonograph Pickup Cartridges . . .



Actual size of unit approximately 2".

*S —for silent operation. Needle talk is practically *Eliminated!*

The first two cartridges in this entirely new line are the S-1 and S-2. Both use an American Model S needle which was engineered in conjunction with the cartridge to produce the characteristics described below. Outstanding features of "S" type cartridges are:

1. **A novel needle guard which protects the needle when tone arm is handled or accidentally dropped.**
2. **Conventional needle set screw making replacement easy.**
3. **Needle chuck designed so that Model S needle can be replaced by any conventional straight or offset needle. (Use of needles other than Model S will modify operating characteristics of the cartridges.)**

MODEL S NEEDLE

Extremely low needle talk from Type S cartridges is due almost entirely to the performance of this newly developed needle. The precious metal stylus (osmium) does not chip and is mounted to a highly compliant vane, assuring maximum needle life and minimum record wear.

MODEL S-1 CARTRIDGE

The first cartridge of the new "S" series has an output of 1¼ volts at 1000 cps on Columbia 10003-M test record (0.5 megohm load resistor). Needle force for best tracking is one ounce.

The S-1 cartridge is an ideal replacement unit for modernization of installations where increased brilliance in tonal quality is desirable. Frequency response flat to 4000 cps discriminates against hiss and objectionable surface noise. This characteristic is especially noticeable when old or worn recordings are played. Cartridge low frequency response to less than 50 cps requires no external equalization.

MODEL S-2 CARTRIDGE

The S-2 is a one-volt cartridge which has a "rolled-off" high frequency response for pleasant listening to all types of recordings and transcriptions. Output tapers gradually from 1000 to 6000 cps. Recommended needle force is one ounce. All the other desirable features of the Model S-1 cartridge are incorporated in the S-2 design.

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American MICROPHONE COMPANY

Dept. 5A, 370 So. Fair Oaks Ave., Pasadena 2, Calif.

MAY, 1948 **VOLUME 28** **NUMBER 5**

COMMUNICATIONS

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COMMUNICATIONS *is indexed in the Industrial Arts Index.*

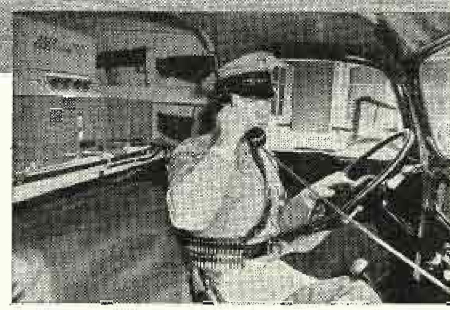
COVER ILLUSTRATION

Six-bay clover-leaf antenna of 10-kw WQXR-FM, mounted atop the Chanin Building in midtown in New York, opposite Grand Central Terminal.

(Courtesy Western Electric)

Published monthly by Bryan Davis Publishing Co., Inc.
52 Vanderbilt Avenue, New York 17, N. Y. Telephone MUrray Hill 4-0170

Link FM—With Sylvania Lock-Ins—Covers New Jersey For Its State Police Radio System

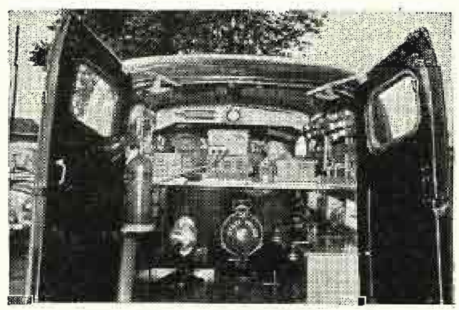


Drivers of both emergency trucks and patrol cars can maintain two-way communication with fixed stations.

Automotive equipment of the New Jersey State Police includes vehicles always on the alert to deal with every emergency. Fleet is spearheaded by 180 patrol cars of the department in addition to 42 patrol cars of the State Motor Vehicle Department which is served by the State Police. These vehicles are constantly in touch with fixed FM stations located at 26 strategic points throughout the state. In addition, emergency trucks carry complete radio equipment equivalent to that of a fixed station!

Link Radio Corporation, manufacturer of the communications equipment, makes extensive use of Sylvania Lock-In tubes to assure unfailing efficiency of this statewide network. Lock-In tubes stay put through vibration and jarring. They have few welded joints... no soldered ones. Elements cannot warp or weave... connections are short and direct. Top location of getter reduces losses... separation of getter material from leads cuts down leakage.

See Sylvania Distributors—or write Radio Tube Division, Emporium, Pa.



Radio equipment in emergency trucks duplicates the set-up used in fixed transmitting stations.

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The superior mechanical and electrical features of Sylvania Electric's famous Lock-In tube make it the ideal choice for equipment on the road, in the air, on the rails, marine radar, FM and television.

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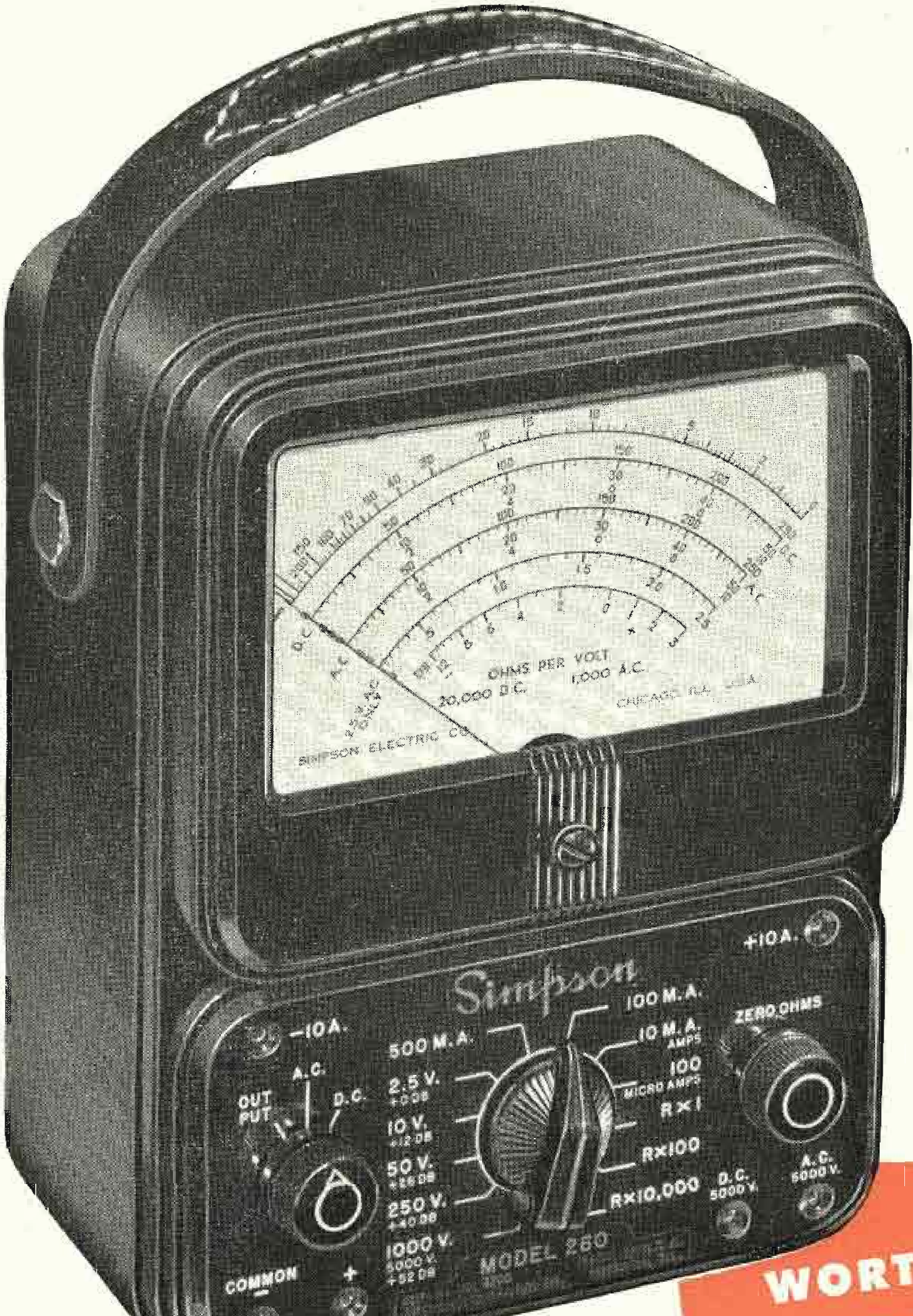

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20,000 Ohms per Volt D.C.
1,000 Ohms per Volt A.C.

Volts, A.C. and D.C.: 2.5, 10, 50, 250, 1000, 5000.

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*Both complete with test leads and 32-page Operator's Manual**

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*No other maker of test instruments provides anything to approach the completeness of the pocket-size 32-page Operator's Manual that accompanies Simpson Model 260. Illustrated with 12 circuit and schematic diagrams. Printed on tough map paper to withstand constant usage.

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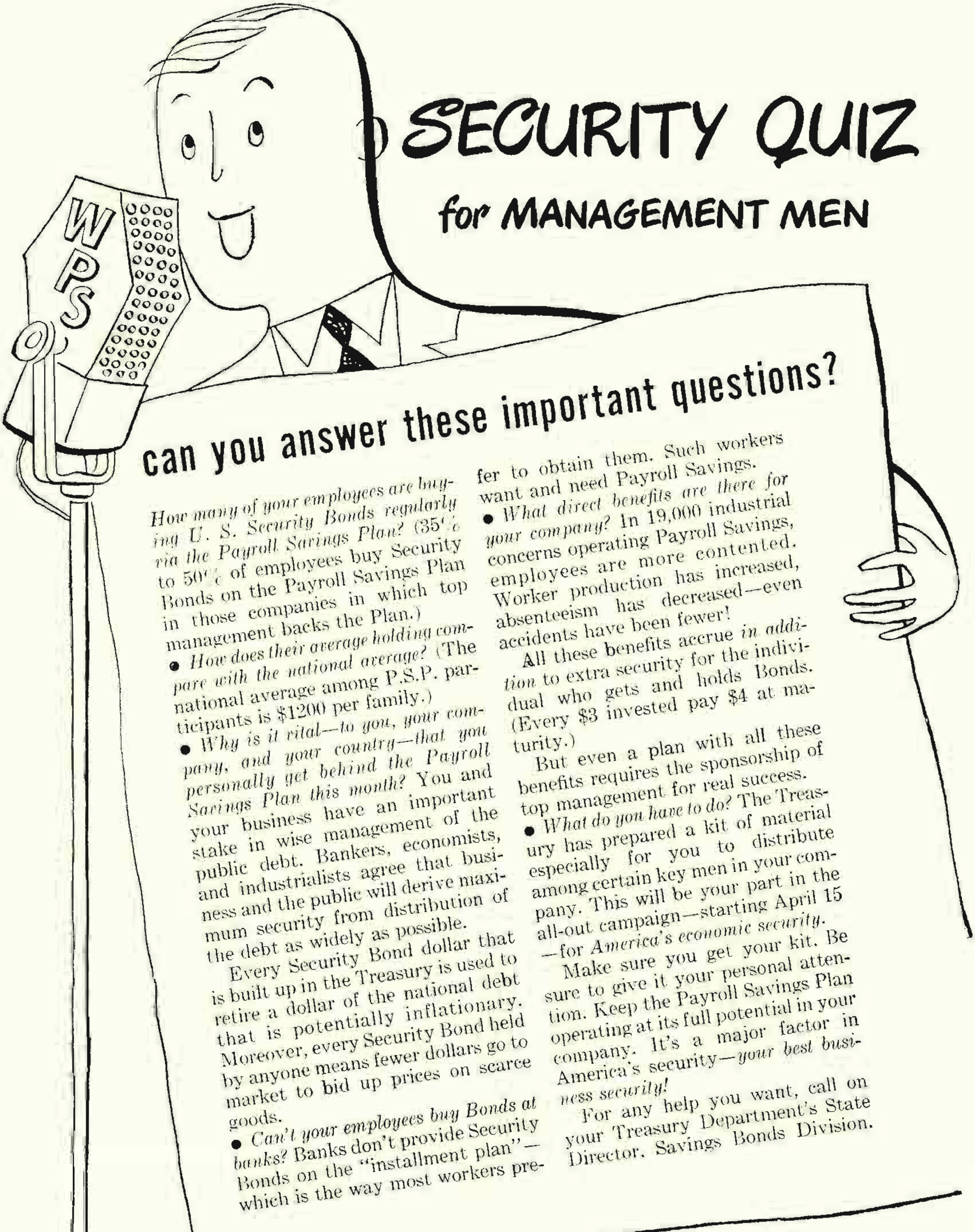
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COMMUNICATIONS

LEWIS WINNER, Editor

MAY, 1948

At the NAB Technical Sessions in Los Angeles

Valuable Data on tv lighting systems and lightweight broadcast-field equipment were disclosed at the recent broadcast-engineering NAB sessions in Los Angeles.

Describing the remote control method of lighting in tv studios, Captain W. C. Eddy, director of WBKB, said that the telelite system now in general use is an excellent lighting tool. This method is built around a standard spindle unit operated remotely by means of manual control lines. Ceiling mounted on the studio gridiron with a quick release clamp, the units can be positioned and operated at any point in the studio providing the desired flexibility required in tv work. Each spindle carries the selected type of light required for the job . . . bank lights for flooding and key lighting, spots for contrast and fluorescent for general illumination. Manual control facilities permit each unit to be rotated through 360° of azimuth and elevated through a complete arc of approximately 170°.

In a discussion of tv lighting sources, Richard Blount of the G.E. Lamp Department, revealed that both tungsten filament and fluorescent sources have important advantages for studio lighting, each complementing the other. Fluorescent lamps can supply the basic level of cool, color-corrected general illumination with either the 3500 or 4500 white fluorescent lamps being satisfactory for the 5655 image orthicon. The tungsten-filament sources provide the control of beam pattern useful in modeling lighting. The tungsten-filament sources produce about 12% visible light, 70% short-wave infrared and 18% long-wave infrared. The fluorescent sources produce 20% visible light and twice as much long-wave as short-wave infrared.

Blount pointed out that the fluorescent lamps may produce noise which varies in amplitude over a wide range of frequencies. Generally, the peak appears at about 400 kc and decreases slightly over the 350 to 1200-kc range, appearing at random frequencies up to and above 5 mc. Some a-c line filters have been designed to eliminate this interference, but none are yet commercially available. There is also interference directly from a lamp bulb but this is ineffective when 10 feet from the lamp.

The ultimate in compactness appeared in a miniature field amplifier with a 60 to 8500-cps response, described by J. L. Hathaway of NBC. Contained in an ordinary brief case, together with microphones and monitoring equipment, the amplifier, complete with batteries, weighs only 12½ pounds. Provision is made for three low level, low-impedance microphones, each of which is amplified in a pre-amp stage prior to mixing. High level mixing is used to obtain optimum signal-to-noise ratio and at the same time permit the use of simple potentiometer type faders.

Among the other unusual features of the amplifier are a built-in line-equalizing oscillator and an automatic audio-gain control. The oscillator is of the phase-shift type and feeds tone into one of the faders during equalizing. The aagc is highly active in restricting peaks which would, if not controlled, cause the vu meter to go off scale and also introduce distortion in the output stage. The aagc system exerts little control on subnormal peaks, but through its use the entire level may be safely increased several db by way of the safety valve action at high levels.

The three faders constitute the only on-the-air controls. There are two low-impedance output monitoring jacks and the telephone line is connected to the amplifier output pad by way of a conventional 3-way plug. A level of +8 vu is fed into a 600-ohm line, the amplifier being capable of delivering +18 dbm to such a line with low distortion.

TV Loses Channel One

Tv after June 14th will no longer have the 44 to 50-mc *channel one*. FCC has ruled that this channel will be set aside for fixed and mobile services. F-m stations operating on this band will be allowed to use the channel until the end of the year.

As a result of this decision, there will be a hearing on the revisions that will have to be made to accommodate the thirteen channels below 216 mc. This hearing will begin on June 14 in Washington.

Another important tv allocation hearing will be conducted on September 20 when the 475 to 890-mc bands will be reviewed with a view to authorizing these channels for black and white or, perhaps, color, too.

USAF Communications Expansion

A Substantial Expansion in air force communications facilities was forecast by Major General F. L. Ankenbrandt, Chief of Air Force Communications, at the recent Armed Forces Communication Association meeting in Dayton. He pointed out that about $55,000,000 will be spent this year for heavy duty radar, GCA and airport surveillance equipment.

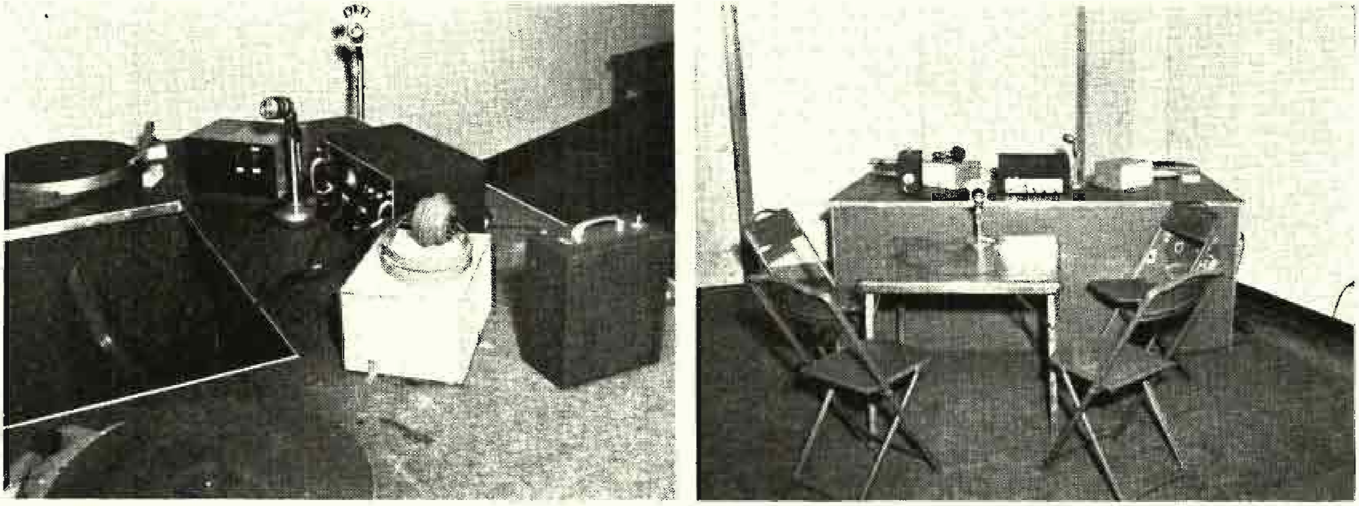
It was also learned that this appropriation will be increased substantially during the next few years as a part of a five-year peace-time mobilization program recently initiated.

Pike Receives Award

Otis William Pike of G.E., was awarded a silver plaque by RMA, JETEC and NEMA at the recent IRE-RMA Transmitter Meeting in Syracuse, for his services as chairman of the Joint Electronics Tube Engineering Council from 1944 to 1947.

The industry is truly grateful to you OWP for a job well done. Congratulations.—L. W.

Design and Construction of a



Equipment employed in the secondary broadcasting studio.

IN THE CONSTRUCTION of a broadcasting studio, the selection of a suitable location and proper facilities is usually of prime importance. However, when constructing a secondary studio in a small city, particularly today, there's not always too much of a choice in locations. In addition there's the problem of installation cost which must not reach too great proportions, because such a studio, being only a supplement to the main studios, is operated for only a small portion of the station's daily operating schedule, and the income is not too substantial.

Currently WIMS is a *daytime* station with our main studios located in Michigan City, Indiana. We were desirous of having a supplementary studio in LaPorte, Indiana, about 13 miles from Michigan City, the studios to be in operation for about 1½ hours per day.

One of the few places available, in the business section of town where we were anxious to have the studio, was a basement floor with a 16'x20' room. Remodeling the room, three of the inner walls were made up with celotex, while the fourth was smooth plaster. The floor was covered with a rug. The combination produced a studio with surprisingly good acoustics, not too live, and not too dead.

Since space was a limiting factor, it was decided to place a console desk in the studio itself, and not make a separate control room. This arrangement would enable one man to announce and operate nearly any type of program, live, recorded, or combination live and recorded. A small office and record library was set up next to the studio, entrance to the studio and office being made from a hallway which runs the length of the building. Other equipment placed in the studio included a piano, small table for roundtable discussions of sports, debates, etc., and twenty chairs to accommodate small audiences, or people participating in programs.

Console Desk

For mounting of the turntables, a remote type amplifier, monitor amplifier, switch boxes, etc., a desk was designed and constructed. The exterior

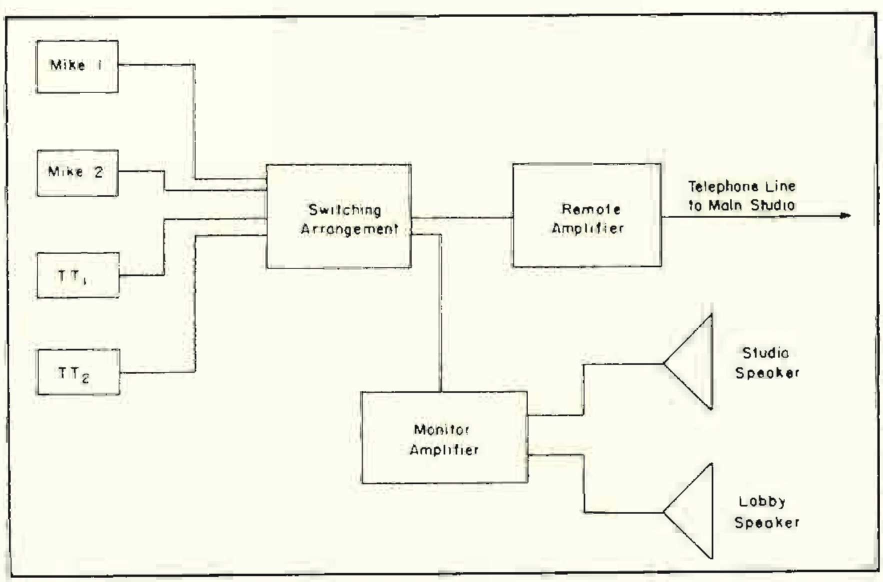
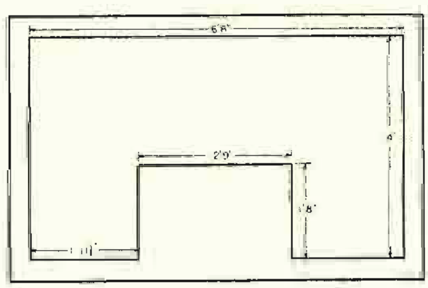


Figure 1
Block diagram of the equipment setup for the secondary studio.

Figure 2
Design and dimensions of the console desk.



Secondary Broadcast Studio

by ROBERT J. SCHILLING, ARTHUR STARK and WARREN SHERWOOD

Chief Engineer — Engineers
WIMS, Michigan City, Indiana

Compact Second Studio, 16 x 20 Feet, Uses Station-Built Console With a Remote-Type Amplifier Which Can Be Removed and Used As a Spare Remote Unit. Other Studio Features Include Monitor Amplifier, Dual Turntable Setup and Two Dynamic Microphones.

of the desk was made of fiber board, with stainless steel molding around the edges. The framework of the desk was made quite heavy to provide sturdy support for the equipment.

The remote amplifier was mounted in the center of the desk, with the turntables on either side of the operator's position. Between the remote amplifier and each turntable was placed a small wooden box, housing the terminal strips and switching facilities. A monitor amplifier was mounted in the lower right hand corner, below the right turntable. This was an effective *out of the way* arrangement for the operator, simplifying monitor controls adjustments. The studio monitor speaker, a 12″ p-m,[1] was mounted on the front side of the console desk.

Console

In place of a conventional console, it was decided to employ a remote type amplifier, together with a separate amplifier to serve as a monitor amplifier, and a suitable switching arrangement, to give near-console performance and versatility. The remote amplifier,[2] serving as the *console,* has been set up so that it can be removed from the console desk and studio in a few minutes, and taken out and employed in its regular capacity, as a remote amplifier. The *console* amplifier, which is essentially flat from 30 to 12,000 cycles, has three input channels, with a choice of 30- or 250-ohm input impedances. In the design of our studio we planned for two microphones and two turntables. Accordingly a dpdt switch was incorporated (S_6) to provide a choice of turntable *2* or mike 2, on one of the remote amplifier inputs.

This proved entirely satisfactory, since in the usual type of recorded program two turntables and only one microphone are required, and the switch (S_6) can be left in the TT_2 position. In the case of a live program, where two microphones are required, chances are that both turntables will not be required. In the event that a program does require both microphones and both turntables, it is simple to switch over from M_2 to TT_2. In the case of a large studio audience participation program, a third microphone might be required. To accommodate this, turntable *1* can be removed from the remote amplifier by merely removing the proper plug from the amplifier and substituting for it a third microphone.

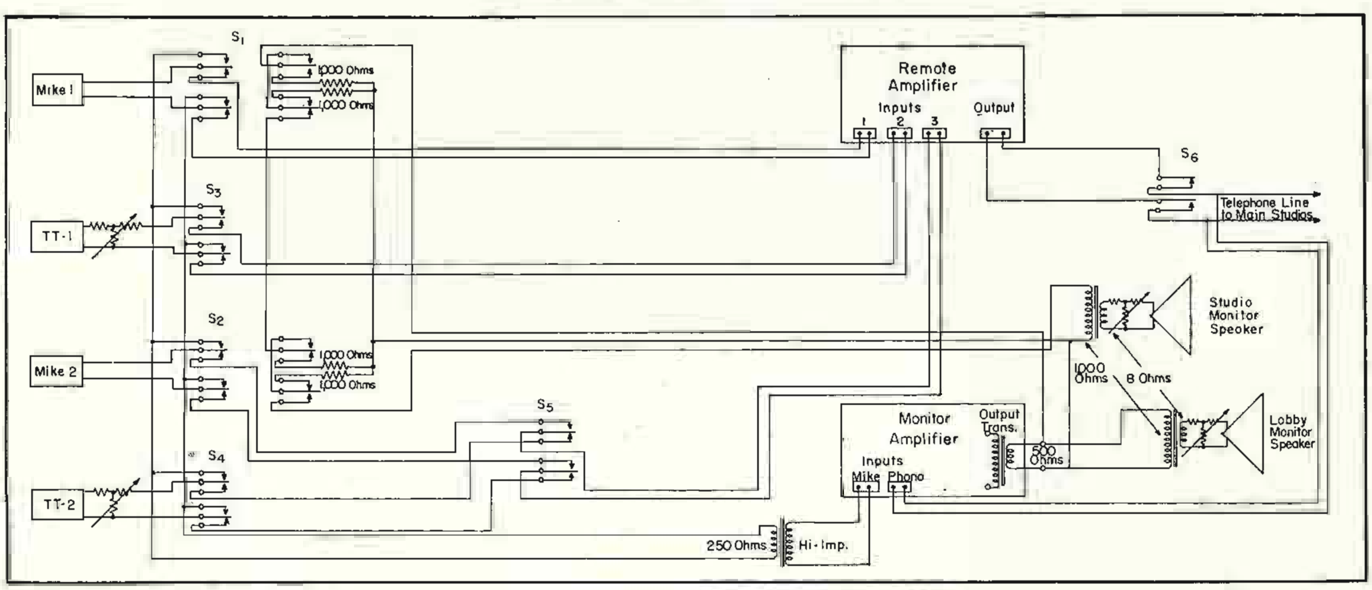
Normal Use of Equipment

Under normal use mike *1* is a desk mike on the console desk, mike *2* is on a tripod base stand in the center of the studio, turntable *1* is to the right of

(*Continued on page* 38)

[1]Jensen.
[2]Gates Dynamote

Figure 3
Switching setup for the remote-amplifier system.



TV Transmitter Design

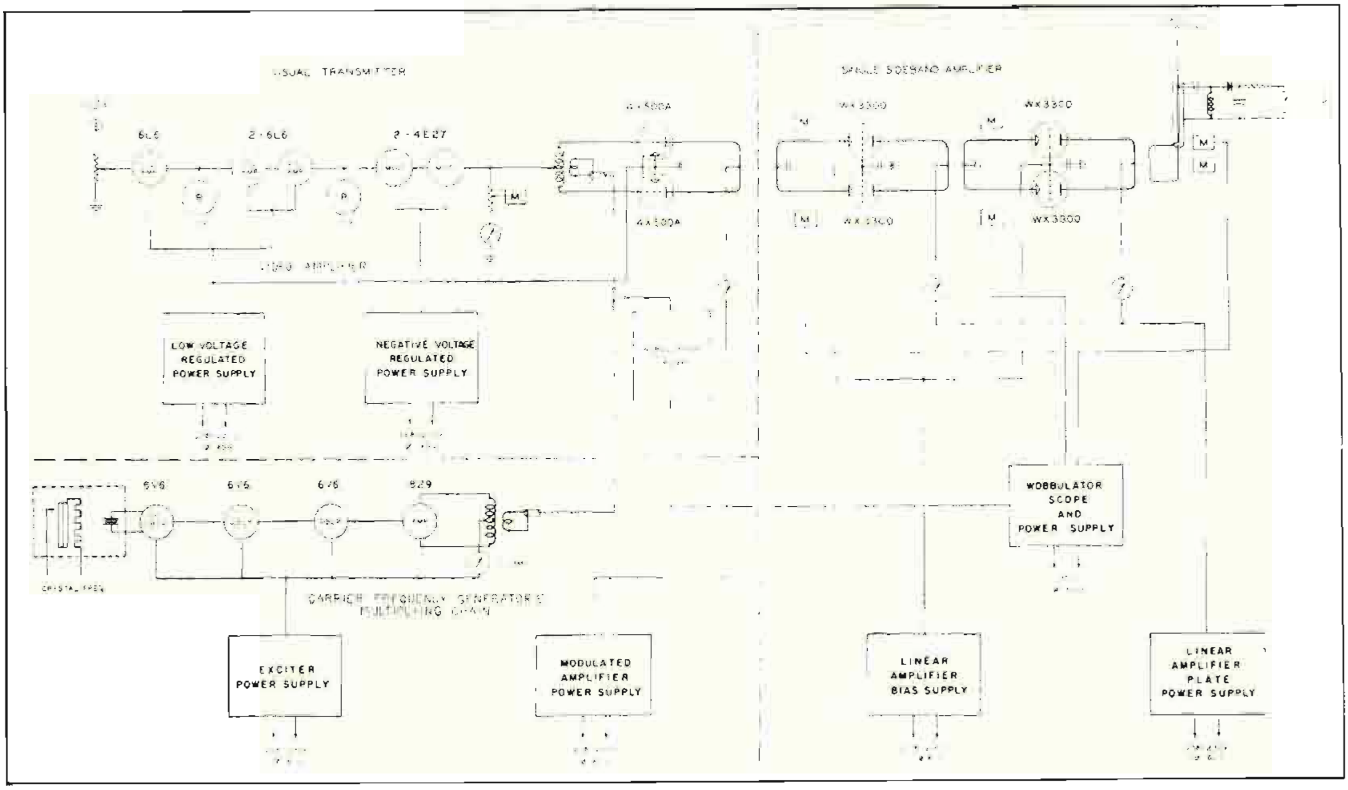


Figure 1
Block diagram of the master series tv transmitter. Dotted lines indicate three unit separation.

THERE ARE three prime aspects of tv transmitting equipment, which, when functioning properly, fit together into a smoothly integrated unit, namely: (*1*) generation of the carrier frequency, (*2*) modulation, and (*3*) amplification subsequent to modulation. That there are many ways of accomplishing this integration is evidenced by the difference in various design patterns.

The three important considerations concerning design are video power required for modulation, the number of linear r-f amplifiers, and the use of a vestigial sideband amplifier. Obviously, wide band video amplifiers capable of supplying voltage and power required for *high level* modulation are costly and inefficient since tubes capable of delivering sufficient power have relatively high interelectrode capacitances. This condition results in the necessity for special h-f compensation and low value load impedances (for high-power installations water-cooled load resistors are required for the video modulator plate load). Where a large number of wide band linear r-f amplifiers are employed, great care must be exercised to maintain perfect neutralization, and to keep the band pass characteristic adequate for satisfactory picture resolution. In addition, class *B* linear amplifiers are inherently low in their efficiency characteristic.

Since single sideband transmission has been standardized, means must be provided for suppression of the unwanted portion. *Progressive circuit attenuation* or vestigial sideband filtering[1] is currently employed for this suppression. In this method the r-f band-pass characteristic of all amplifiers following the modulated stage are adjusted so the upper sideband only is passed.

From the foregoing summary it is obvious that both the high and low level modulation systems have specific merits and disadvantages. The recently-developed *master* series tv transmitter is midway between the two limits: high power video amplifiers are not required and a minimum number of class *B* linear r-f amplifiers are required. Figure 1 shows a block diagram of this series where the dotted lines indicate the three unit separation and the manner in which the circuit functions are related.

Generation of the carrier frequency is accomplished by means of a crystal oscillator and a frequency multiplying chain with a total multiplication factor of eight. A double-ended amplifier stage is used as a straight-through amplifier on the carrier frequency to drive the modulated amplifier.

The modulator unit employs a three-stage wide-band video amplifier, the last stage of which operates as a direct-coupled amplifier with the cathode at a negative potential in order that bias and d-c reinsertion may be applied to the modulated amplifier. Video signals (from the modulator) and r-f drive (from the exciter) are applied to the grids of the modulated amplifier which, when properly adjusted, results in a modulated r-f envelope in the plate circuit of the modulated amplifier. The resultant energy may be used to drive an antenna system directly if low power is desired, or to drive subsequent class *B* amplifier stages.

Amplifiers following the modulated stage must operate as class *B* linears

[1]The vestigial sideband filter is a tuned filter adjusted to dissipate the unwanted sideband in a water cooled load and is installed after the last amplifier.

*DuMont

since deviation from a linear characteristic will provide amplitude distortion, resulting in either sync compression or white saturation. The Figure 1 block diagram shows two class *B* amplifier stages employing identical tube types both of which operate in grounded-grid circuits resulting in tuning simplification and minimum neutralizing problems. The output impedance may be connected for either 72/51 ohm unbalanced or 144/102 ohm balanced pair transmission line.

Generation of Carrier Frequency

Exciter Unit: The circuit arrangement for carrier frequency generation is shown in Figure 2. The principal problem of generating the carrier is maintaining the required frequency stability, namely, ±.002% of the assigned value as specified by FCC. The crystal frequency is one-eighth the frequency of the carrier. A temperature-controlled low-frequency crystal is employed to assure high order of thermal and operational stability (as may be attained with crystals ground for use below 15 mc).

The oscillator is a 6V6 connected in a conventional *tri-tet* circuit. The plate circuit is resonant at twice the fundamental frequency. Two 6V6 doublers follow, resulting in the carrier frequency being applied to an 829B operating as a buffer amplifier.

Trends in Design. Features of Systems, With Special Consideration of Video Amplifier and Modulator Requirements, Modulated Amplifier and Class B Linear Amplifier Stages. D-C Restorer Operation Also Analyzed.

by G. EDWARD HAMILTON

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

The 829B plate circuit is coupled to modulated amplifier grids, a pair of 4X500A tetrodes. All stages in the exciter operate as conventional class C amplifiers and doublers and use lumped circuit constants. Provision for metering each stage is accomplished by a switching arrangement for grid-current indication. The cathode current is metered in the 829B. Tuning circuits are proportioned so that the correct harmonic falls within the variable capacitor range. Resonance of each tuned circuit is shown by maximum grid current in its driven stage.

The 4X500A modulated amplifier grid is loaded with a non-inductive resistor which serves two purposes: (*1*) It loads the 829B driver stage resulting in a relatively constant r-f driving voltage, and (*2*) loading the grid circuit broadens the response curve so that any sum and difference frequencies developed in the grid circuit (by virtue of modulation) will not be attenuated. As in previous stages, the grid tuning control is adjusted for maximum grid current in the 4X500As.

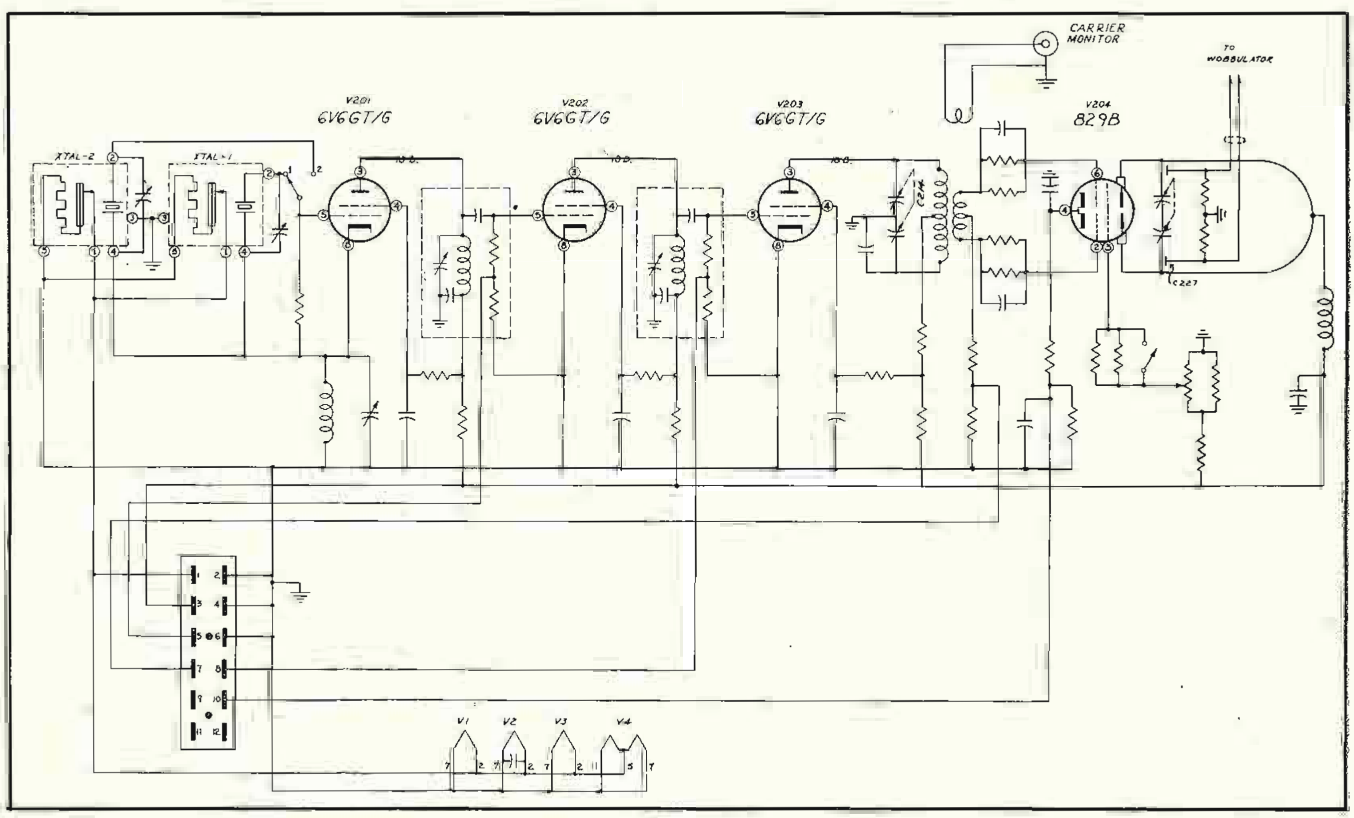
Modulation

Video Modulator Unit: Circuit of the modulated amplifier and its video-

[3]Power supplies in this series provide effective voltage and current regulation between totally black and totally white modulation.

[4]Forced air cooling is employed throughout the transmitter, including tube seal points, to minimize the problem of maintenance.

Figure 2
Circuit arrangement for carrier frequency generation.



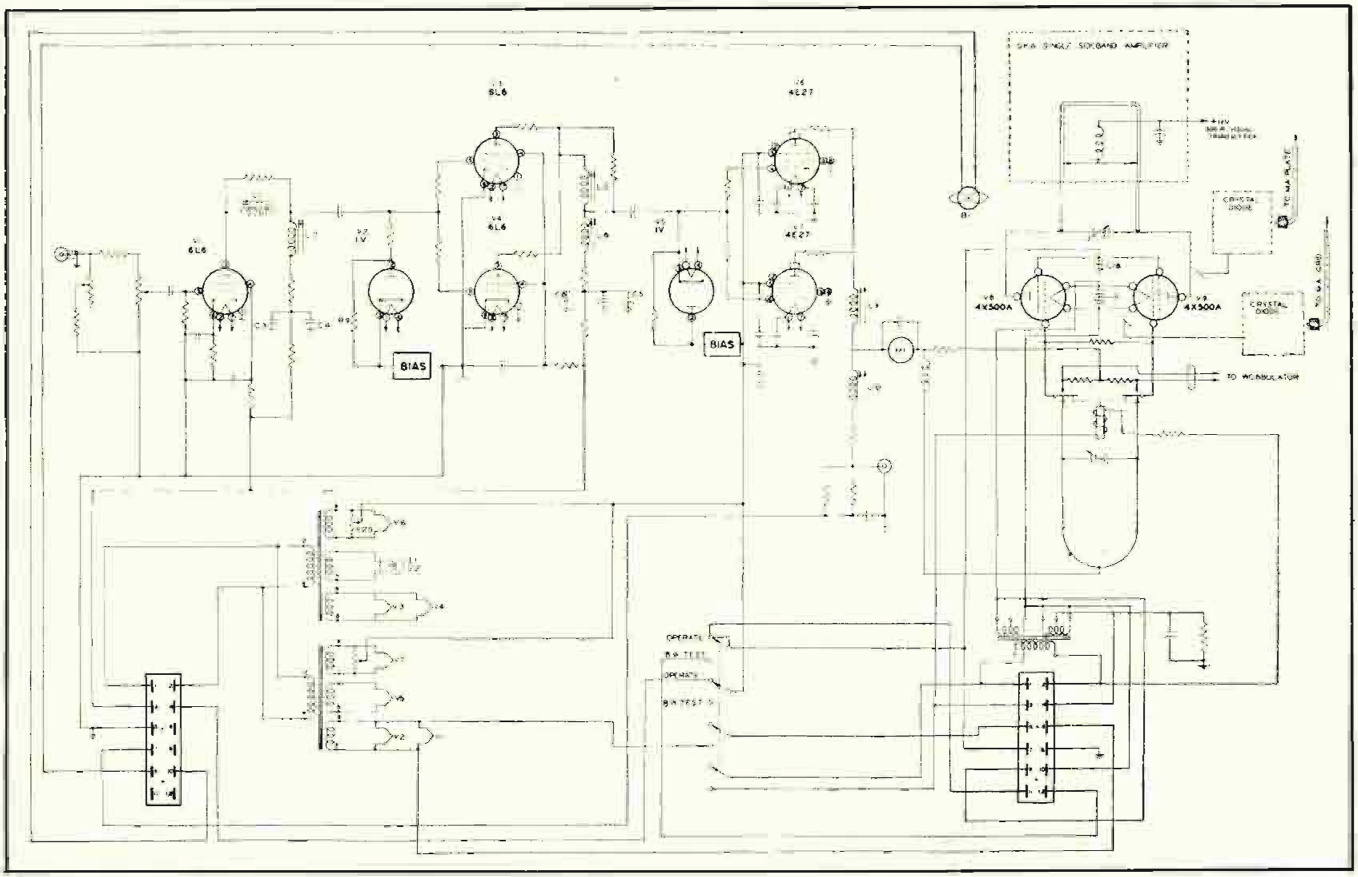


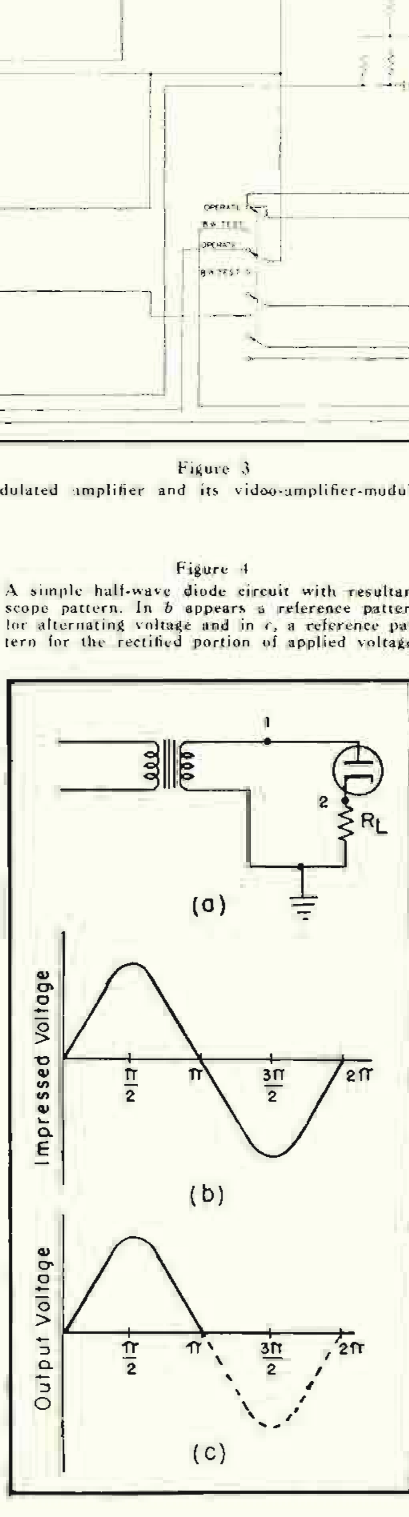
Figure 3
Modulated amplifier and its video-amplifier-modulator.

amplifier-modulator appears in Figure 3. It will be noted that provision is made for substituting an r-f frequency swept, or wobbulation signal for the r-f exciter output.[2]

The video amplifier uses three stages to provide the proper phase-modulating signal and sufficient voltage amplitude to assure full modulation capability. A minimum of one volt input will drive the modulated amplifier to cutoff. A single 6L6, series-shunt peaked, drives a pair of 6L6s in parallel, also series-shunt peaked.

It will be noted that the parallel 6L6 stage incorporates a type 1V d-c restorer. This technique serves to refer the video signal to the bias level of this stage, making it possible to realize the full range of available grid base without distortion for high signal levels. A pair of 4E27s function as the video modulators. The plate load of the modulator serves two purposes: *(1)* Furnishes video signal to the modulated amplifier, and *(2)* produces a negative d-c voltage as bias for the modulated amplifier. Since the grids of the modulated amplifier (4X500) must be negative with respect to their filament (which are at ground potential), it is necessary that the plates of the 4E27s be negative with respect to ground. This is accomplished by connecting the plate load return and the positive plate voltage of the 4E27 to

Figure 4
A simple half-wave diode circuit with resultant scope pattern. In *b* appears a reference pattern for alternating voltage and in *c*, a reference pattern for the rectified portion of applied voltage.



ground, making it necessary to refer the 4E27 cathodes to a negative potential with respect to ground. A variable negative voltage regulated power supply furnishes this potential. The modulated amplifier bias is adjusted by means of the variable plate potential which changes the quiescent plate current, thereby altering the voltage drop across the plate load. The 1V is used at the grid of the modulator to restore the video *sync* signal to the bias reference level. Since the modulator operates as a direct-coupled amplifier, the *restored* signal is carried through to the plate load and serves to maintain sync tips at the quiescent bias level of the modulated amplifier, for changing signal amplitudes. The overall frequency response of the video modulator-amplifier is essentially flat between 10 cycles and 5.5 mc.

Operation of the D-C Restorer

The operation of the d-c restorer is of utmost importance in the tv transmission system since it vitally effects the following parameters:

(1) Holds peak power constant.

(2) Controls average brightness of transmitted picture.

(3) Fixes blanking level at receiv-

[2]Complete data on this unit will appear in a subsequent discussion.

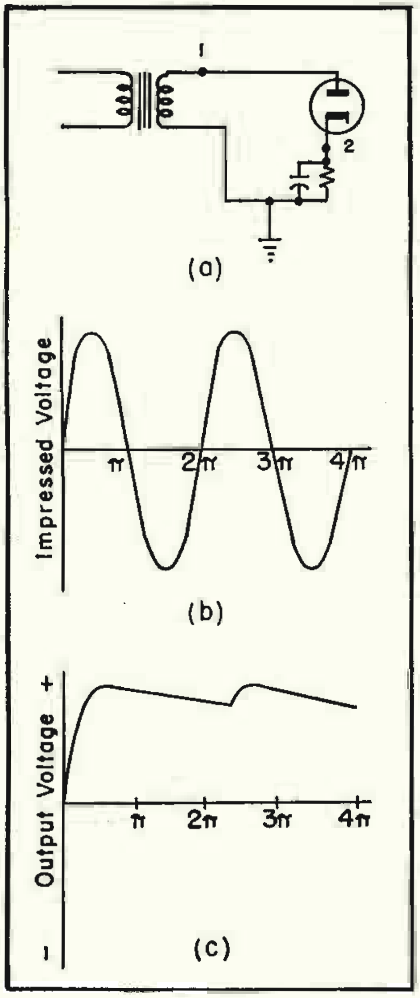
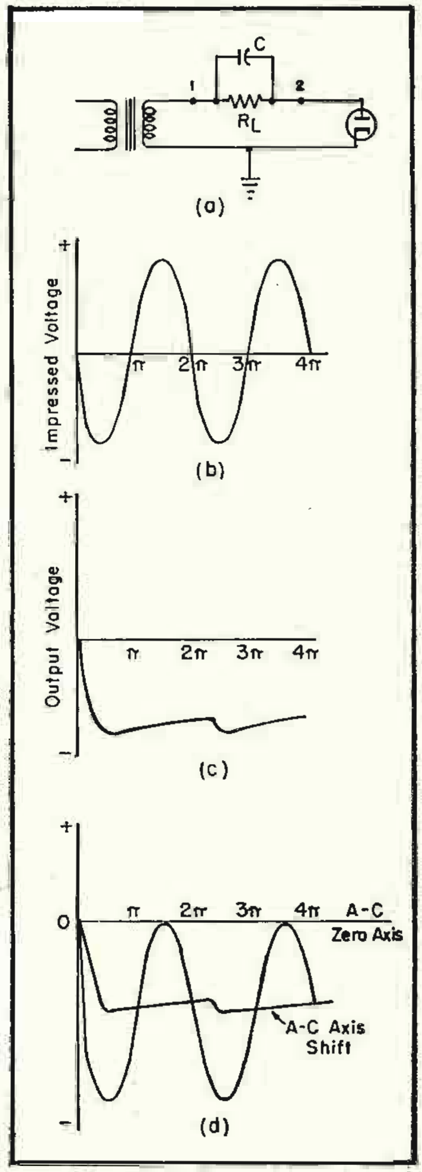


Figure 5
Effect of introducing capacitors across the load resistor.

ers, provided the input sync level is constant.

In tracing d-c restorer operation, the well-known diode phenomenon serves well as a basis of evaluation and comparison. Figure 4 shows a simple half-wave rectifier circuit with the various scope patterns referred to a ground potential. Reversing the diode polarity will result in the negative portion of the cycle shown in (*c*), being produced. It will also be noted that the output load circuit (R_L) contains no capacitance. Figure 5 shows the effect of introducing capacitance across this load resistor; however, since the resulting wave shape decays (*c*), it

Figure 6 (right)
Alteration of Figure 5 by changing position of load resistor and capacitor; *B* and *C* show the voltage across each element (a-c inpnt voltage and d-c rectified component). *D* illustrates how the two voltages add, resulting in the peak of the a-c signal being restored to zero axis position.



may be assumed that the *rc* product is too low. The circuit shown in Figure 5 may be altered by changing the position of the load resistor and capacitor to that in Figure 6. The same wave shapes are shown in Figure 6 as in Figure 5 except that the d-c voltage produced is of opposite polarity. Analysis of current flow through the circuit shows this condition to be normal. Figure 6 (*b*) and (*c*) shows the voltage across each element, namely: an a-c input voltage and a d-c rectified component. Since these two voltages are in series, when measured across the diode, the effect is to superimpose the a-c component on the d-c component resulting in a shift of the zero a-c axis to a new value, that of the d-c rectified component. Figure 6 (*d*) shows how these two voltages add resulting in the peak of the a-c signal being restored to the zero axis position.

Figure 7 shows how the load resistor may be relocated without upsetting the foregoing conditions outlined above. It may be changed further to that of Figure 8 where the transformer is replaced by a video output source such as the plate load of a video amplifier.

Discussion to this point has been limited to symmetrical wave shapes; however, it is well known in a rectifier, such as shown in Figures 5, 6 and 7 that the peak voltage is the maximum voltage above or below the zero reference position. When the *rc* time constant is sufficiently large, the developed voltage is essentially equal to the peak value. The time constant should be sufficiently long to maintain the bias substantially constant for the field interval, but sufficiently short to enable the d-c restorer to follow relatively rapid variations in the average illumination. In order that this criteria be met, it has been found that the time

(*Continued on page* 30)

Figure 7 (below)
Circuit modifications from Figure 6.

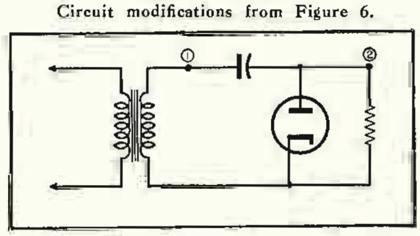
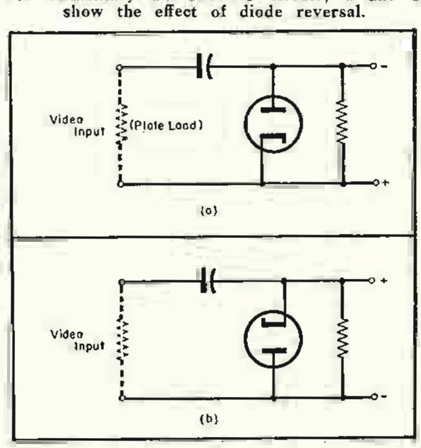


Figure 8 (below)
An elementary d-c restorer circuit; *a* and *b* show the effect of diode reversal.



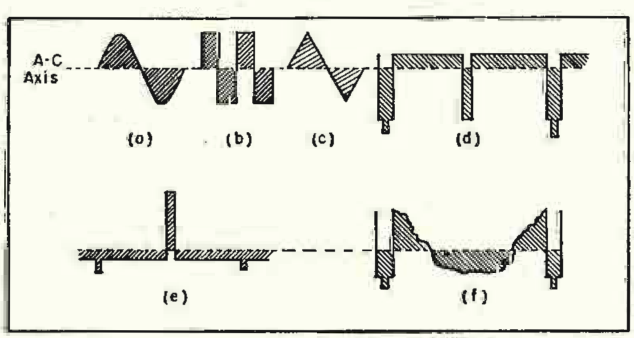


Figure 9
Various wave shapes and manner in which equal areas are established about zero a-c reference axis: *a* is the sinewave; *b*, square wave; *c*, triangular wave; *d*, negative white picture with black spot; *e*, negative black picture with white spot and *f*, typical single line scanning information.

Checking F-M Transmitter Frequencies With WWV

Measurement Technique Employs Specially Designed Secondary Standard With 6F6 Oscillator Driving a 10-kc Multivibrator, Which in Turn Drives a 2-kc Multivibrator. Two Stages of Amplification Provide Harmonic Outputs Of Up To 110 Mc.

by ROYDEN R. FREELAND

Chief Engineer
KOCY-FM, Oklahoma City, Oklahoma

TRANSMITTER FREQUENCY checks are a *must* item on every broadcast-engineering calendar. In f-m v-h-f operation, these checks cannot be conducted in the standard manner. Accordingly, a v-h-f procedure was devised, which has proved quite effective.

As stated by the FCC[1], the primary standard for frequency measurements are the transmissions of WWV, operated by Central Radio Propagation Laboratory of the National Bureau of Standards in Washington, D. C. WWV now has seven or more transmitters operating day and night, insuring reliable coverage of the United States.

The general method of measurement consists of zero-beating a secondary standard with WWV and comparing the output of this secondary standard with the transmitter frequency. A block diagram of this setup is shown in Figure 1.

There are two possible ways to determine the transmitter frequency: (1) Measure the final frequency of the carrier; or (2) measure a sub-harmonic of the final frequency somewhere in the early stages of the transmitter and then calculate the final deviation from assigned frequency.

Since the crystals used in f-m transmitters in general have a frequency of 5,000 kc or lower, it is sometimes more convenient to measure the crystal fundamental or a sub-harmonic of the final frequency. The highest possible harmonic must be checked, however, to reduce multiplication of any error made. An error of 50 cycles in a measurement at 5mc will be an error of 1,000 cycles at the 20th harmonic or at 100 megacycles. The exact harmonic to measure will depend on the equipment being checked.

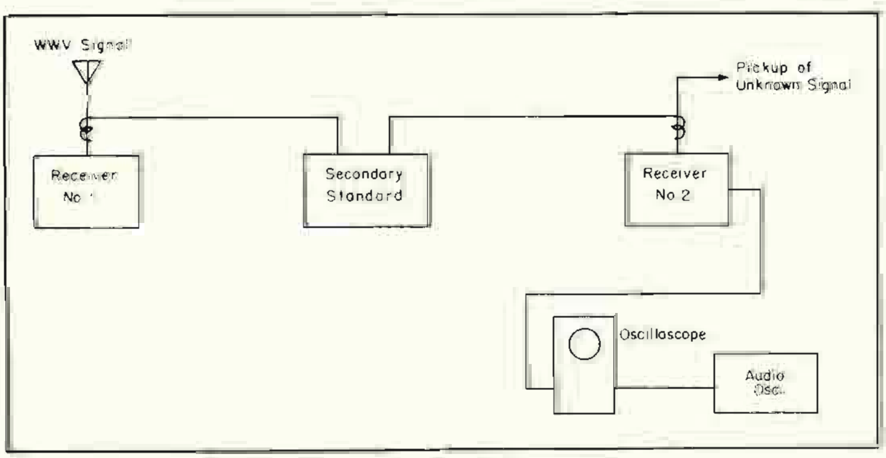
The frequency to be measured should be a multiple of 100 or 10 kc. Although it is possible to measure any harmonic by using an audio signal generator, it is necessary that the signal generator be extremely well calibrated. This leaves open considerable chance for error in the measurements. Where transmitter and monitor crystals have odd frequencies such that the harmonics cannot be conveniently measured, the final frequency must be measured, since it will always be a multiple of 100 kc.

The important piece of equipment in the system is, of course, the secondary standard, the accuracy of measurements depending upon the secondary standard being zero-beated with WWV. It is therefore necessary that the standard be fairly stable and that the frequency of the standard crystal be variable over several cycles. In the case of measuring sub-harmonics, the harmonic output of the standard will normally not fall in such a relationship to the transmitter frequency to make possible a direct comparison. However, by feeding the output of the crystal to a multivibrator, it is possible to have a standard signal which will zero-beat with the frequency being measured.

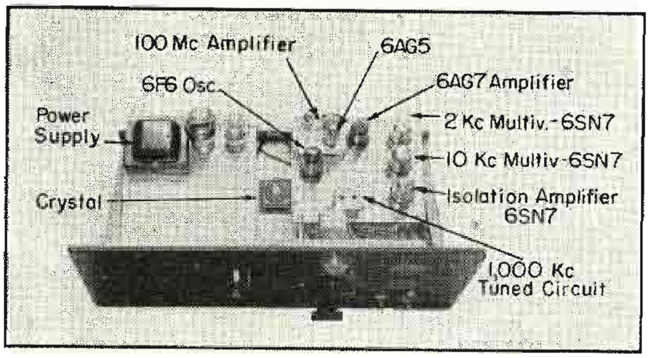
The secondary standard constructed at KOCY-FM is illustrated in Figures 2 and 3 and diagrammed in Figure 4. The standard consists of a 6F6 oscillator driving a 10-kc multivibrator which in turn drives a 2-kc multivibrator. The harmonic output is increased by two stages of amplification. The first amplifier stage (6AC7) amplifies satisfactorily up to approximately 40 mc, and a second amplifier (6AG7) increases the harmonic output of the standard up to 110 mc. Isolation amplifiers are used between the oscillator and the 10-kc multivibrator, and between the two multivibrator to insure more stable operation.

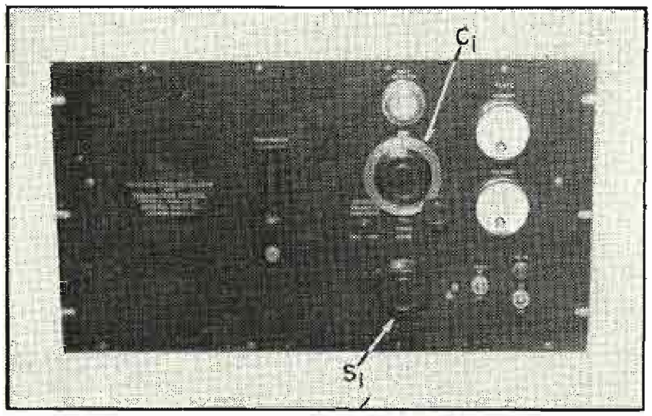
The crystal provides either 1,000 or 100-kc signals. The 1,000-kc signal is

Figure 1
General setup for the frequency-check measurement system at KOCY-FM.



[1] Section 2.7a





Figures 2 and 3
Front and interior views of the secondary standard built KOCY-FM.

used only for reference as it cannot be zero-beat with WWV; crystal specifications state that no capacitor be used across the crystal when oscillating it in the 1,000-kc mode. However, when oscillating the crystal in its 100-kc mode, exact zero-beat with WWV can be obtained by varying a capacitor, C_1.

A ganged switch, S_1, controls the output of the standard. Setting the switch in its various positions makes available three 1,000-kc harmonics: 100, 10, or 2 kc. The 2-kc multivibrator was included in the circuit for experimental use and is not required for measuring the f-m equipment.

The tuned circuit for the 100-mc amplifier is made up of a 7-plate midget variable capacitor, C_2, and a 4½-turn coil, L_1, ⅝″ in diameter and ¾″ long. This amplifier tunes roughly from 60 mc to 110 mc.

The component of the power supply will vary with the builder and therefore the value of resistor, *R*, should be calculated in each case for the correct operation of the *VR* tube. The circuit requires a maximum of approximately 20 ma at 105 volts.

The entire standard including power supply was constructed on the oscillator chassis of an old 50-cycle a-m frequency monitor.

Adjustment of the multivibrators is done by the *cut and try* method. For the 10-kc multivibrator the potentiometer R_1 is set arbitrarily and the output of standard is applied to a communications-type receiver. With the bfo in the receiver on, the number of beats between two adjacent 100-kc beats must be counted. When the multivibrator is adjusted correctly there will be nine beats between two adjacent 100-kc beats. It is normally easier to count these beats in the low end of the broadcast band; i.e., between 600 kc and 700 kc. Adjustment of R_1 is not critical. When operating properly a fairly wide variation in the setting of R_1 will not change the multivibrator frequency. If the multivibrator tends to jump out of step, the signal drive should be reduced by varying capacitor, C_3.

The setup for measurements, shown in Figure 5, includes the standard and

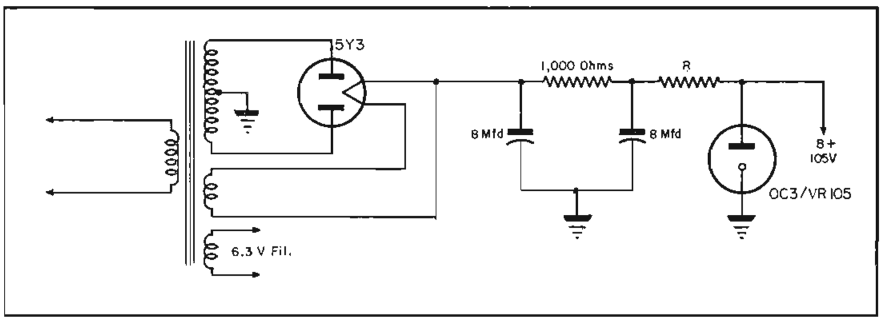
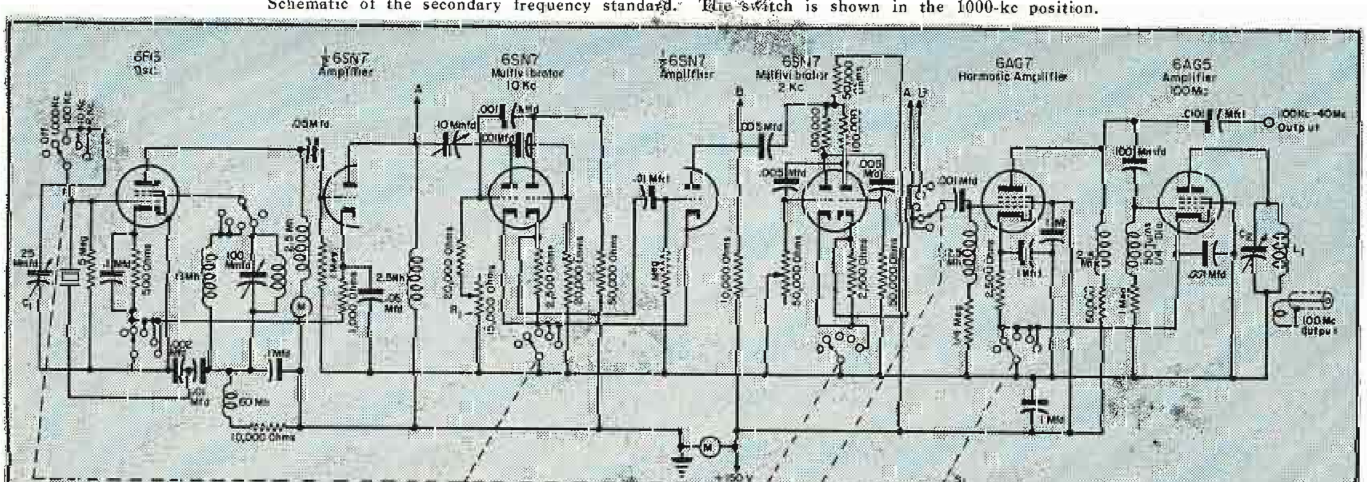
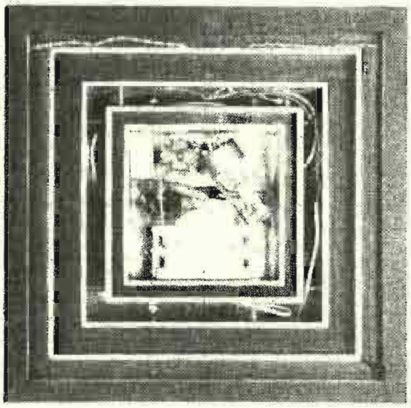


Figure 4a
Power-supply system used with secondary frequency standard.

[2]Bliley SMV-100

Figure 4
Schematic of the secondary frequency standard. The switch is shown in the 1000-kc position.





Interior view of one of the National Bureau of Standards 100-kc standard frequency oscillators, which provide frequency and time interval standards for continuous broadcast to all parts of the world. The quartz crystal unit, in an evacuated container, and part of the oscillator circuit arrangement are shown in a temperature-controlled compartment. Layers of aluminum and felt are used to obtain extremely uniform temperature. In addition to this some of the oscillators are located approximately 25' below the surface of the earth.

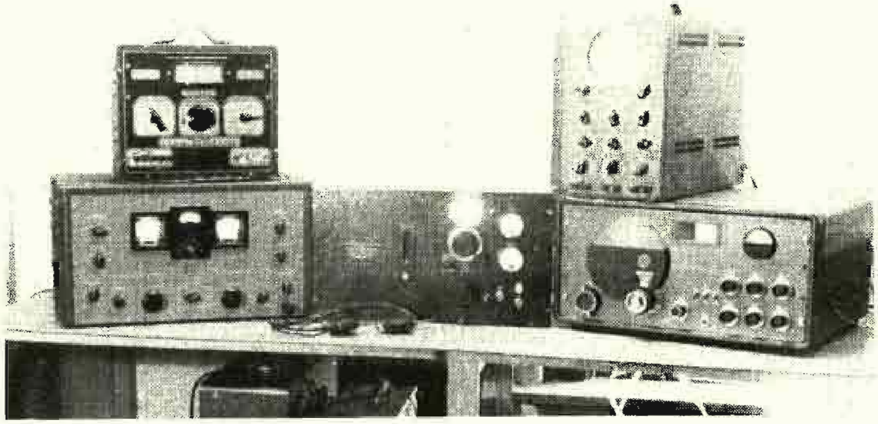


Figure 5
Setup for frequency measurements using the standard and two receivers.

two receivers. The receiver used to compare the standard signal with WWV may be any good type of communications receiver. The second receiver used to compare the standard signal with the signal being measured may be a communications type receiver with an extended tuning range.[3] Where measurements are made at the final frequency, it is possible to use a standard type f-m receiver to beat the standard and unknown signals. A satisfactory beat can be obtained by tuning the f-m receiver slightly off center frequency. A 'scope and audio oscillator may be used if it is desired to measure the frequency difference for comparison with frequency monitor readings.

If the measurements are being made close to the transmitter, the easiest and perhaps the best system is to adjust the transmitter to zero frequency rather than determine the frequency deviation. Where measurements are made remotely from the transmitter it is usually more practical to determine the deviation and then check this with the monitor reading.

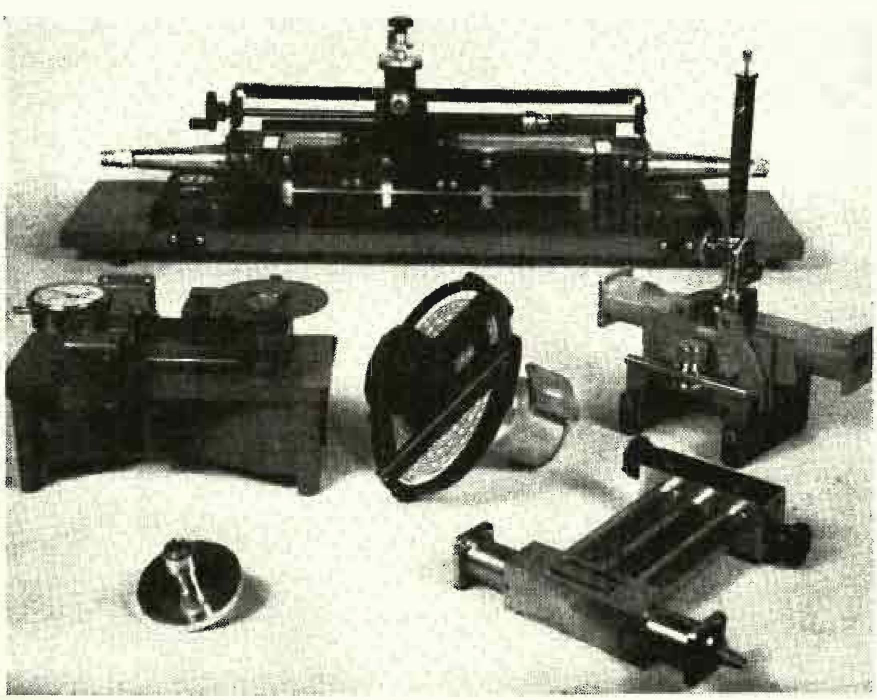
Measurement Procedure

After the standard has been warmed up for several hours, receiver *1* is turned on and one of the WWV eight standard frequencies is tuned in . . . 2.5, 5, 10, 15, 20, 25, 30, and 35 mc, and the standard is zero-beat against one of these frequencies. The zero-beat should be with the WWV carrier and not one of the modulating frequencies.

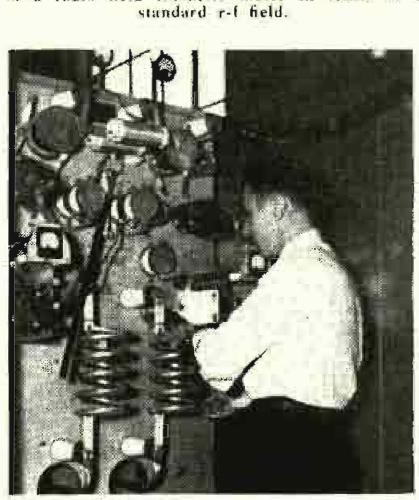
After the standard has been adjusted receiver *2* is tuned to the frequency of the signal being measured. A beat should be heard, the frequency of which will depend upon the deviation of the transmitter from the assigned frequency.

To adjust the transmitter to zero frequency, the transmitter oscillator should now be tuned for zero-beat in receiver *2*. To measure the frequency deviation, the audio output of receiver *2* is fed to the vertical plates of the 'scope and the output of the audio oscillator applied to the horizontal plates. Both signals are adjusted for equal amplitude on the 'scope. Then the audio oscillator frequency is adjusted until a circular pattern appears

(*Continued on page 31*)



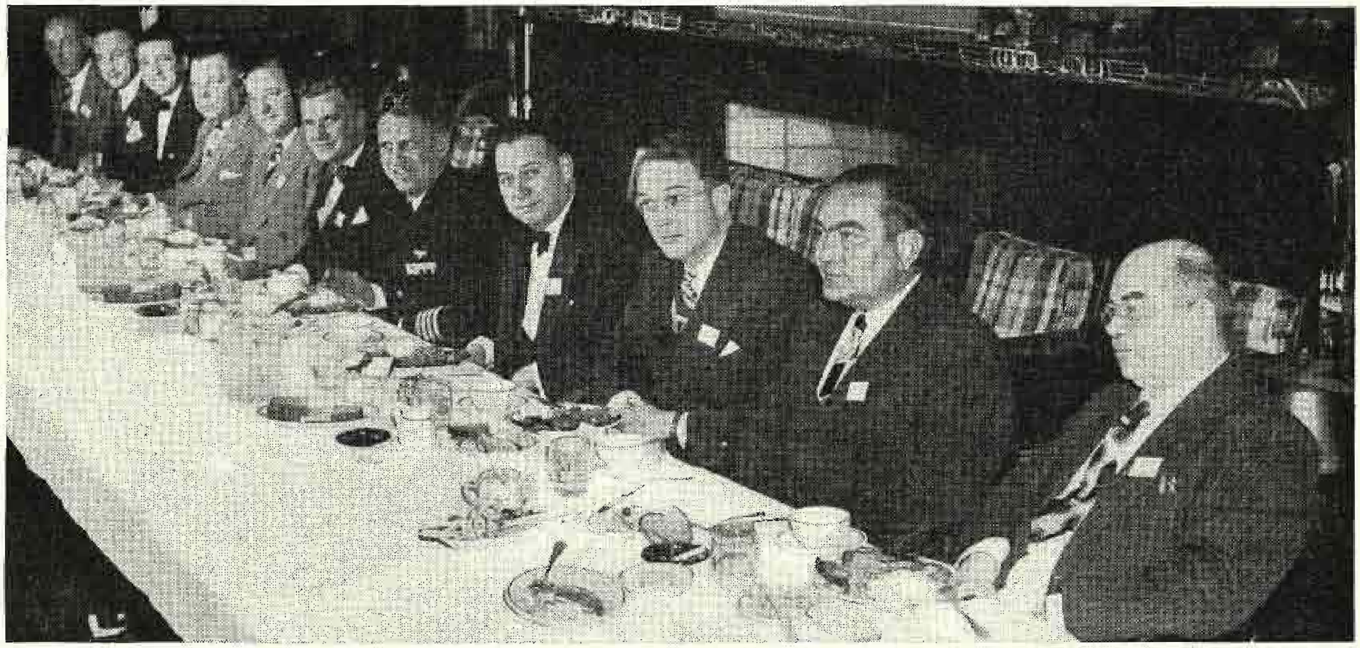
(Left)
A group of measuring instruments and secondary standards in the micro-wave frequency range used at the National Bureau of Standards. Top, coaxial slotted line. Center left to right, waveguide metallized-glass attenuator; cavity frequency meter; slotted-line waveguide. Bottom, coaxial thermistor load impedance (left) and three-stub coaxial impedance transformer (right).



(Below)
Equipment used at the National Bureau of Standards for accurately determining the loop constant of a radio field intensity meter in terms of a standard r-f field.

VETERAN WIRELESS OPERATORS ASSOCIATION NEWS

RCA BUILDING 30 Rockefeller Plaza, New York, N. Y.



At the speakers table of the VWOA Chicago Chapter annual dinner cruise, which was held in the Adventurer's Club. Left to right: George Martin, RCA Marine (VWOA committee); Fritz Franke, Hallicrafters; Joe Wallace; Louis Baer, Standard Metal Products (VWOA committee); Bill Halligan, president, Hallicrafters; Les Gorder, American Television Institute (VWOA committee); Capt. H. R. Horney, U.S.N., Commanding Officer, Combat Information Center Training School, who was guest speaker; Thomas L. Rowe of WLS, who was chairman; Royal Higgins (VWOA committee); Walt Marsh, Allied Radio Corp. (VWOA committee) and H. Herndon, Regional Director, FCC.

Personals

VWOA VETERAN MEMBER Delos Wilson Rentzel has been nominated by President Truman for the post of CAA Administrator to succeed T. P. Wright.

Rentzel will resign several top-level positions in activities related to communications including his post as president of Aeronautical Radio, Inc., and the airlines, to step into governmental circles. He was formerly chairman of the Radio Technical Planning Board's aeronautical radio panel, and was vice chairman of the Radio Technical Commission for Aeronautics, the government-industry organization which formulated the basic plan for the currently-accelerating research, development, and installation program designed to provide more efficient airways. He was a director of Airborne Instruments Laboratory, Inc., of Mineola, N. Y.

Prior to joining AR Inc. in 1943, he was director of communications for American Airlines and associated with that organization and its predecessor companies for more than 12 years.

Born in Houston, Texas, in 1909, Rentzel is a graduate of Texas A & M College. He lives with his wife and two young sons in Park Fairfax, Va. He has held a private pilot's license and owns part interest in a two-place aircraft.

D. W. Rentzel, who has been named by President Truman, to become the new CAA Administrator.

MEMBERS OF VWOA were shocked to hear of the death of Mrs. Fred Muller, wife of VWOA life member, Capt. Muller, U. S. N. R. . . . George Bailey, president of ARRL and executive secretary of the IRE, addressed the boys on UN radio communications at the recent Spring meeting held at the Fireplace Inn in New York City. . . . VWOA life member Commander Arthur F. Van Dyck attended the recent annual RMA-IRE Spring transmitter meeting at Syracuse. . . . Life member Brig.-General David Sarnoff, president of RCA, delivered the keynote address at the Armed Forces Communications Association meeting at Dayton, Ohio. DS, who is prexy of the association, described the ultra important role of communications in peace and war. . . . Honorary member W. A. Ready, president of the National Company, attended the recent IRE Convention in N. Y. City.


The 5-KW AM TRANSMITTER*...
* The RCA 10-KW AM transmitter, Type BTA-10F, is identical in size and appearance to the BTA-5F you see here. Over 125 transmitters of this series now in operation.
(Photo courtesy of Radio Station KOOL, Phoenix, Arizona)
RCA
BROADCAST EQUIPMENT
RADIO CORPORATION of AMERICA
ENGINEERING PRODUCTS DEPARTMENT, CAMDEN, N.J.
In Canada: RCA VICTOR Company Limited, Montreal

with 10-kilowatt insurance

BTA-5F. The one 5-KW AM Transmitter that insures easy increase to 10 KW at any time! Power changeover is simple . . . inexpensive . . . quick. *Because it was planned that way.*

When you install the BTA-5F Transmitter for 5-KW operation there is just one tube in the power amplifier stage (left-hand cubicle in view below). But note the additional tube socket already mounted in place. To increase power to 10 KW, you need only buy the simple modification kit (described in box at right). With the parts contained in this kit...and the few simple circuit changes required, changeover can be made "overnight." It's easy...it's inexpensive. You need lose no air time.

Naturally, you can also buy this transmitter originally for 10-KW operation (specified as Type BTA-10F). Both models—the BTA-5F for 5-KW operation, and the BTA-10F for 10-KW operation—have the same sleek, well-finished, business-like appearance shown by KOOL's installation on the opposite page. Both models have the true unified front . . . an *exclusive feature* of RCA high-power AM transmitters. This front is an integral piece *separate from the compartment enclosures.* It greatly facilitates flush-mounting...and improves appearance of the installation by several times.

And careful planning like this goes right on through. For instance, this transmitter is equipped with one of the most complete centralized control systems ever designed for *any* transmitter . . . with all the necessary controls, circuit breakers and relays needed for fully automatic operation or step-by-step manual operation. It has push-button motor-tuning for its high-power stages...and instantaneous power control reduction. It can be furnished with matching cabinet end-extensions for housing antenna phasing, monitoring, test and audio equipment. These extensions have front sections that become an integral part of the overall unified front—another exclusive RCA feature of great importance in station appearance. And note this too: the 5-KW BTA-5F uses only 24 tubes (6 different tube types); the 10-KW BTA-10F uses only 27 tubes (6 different types).

• • •

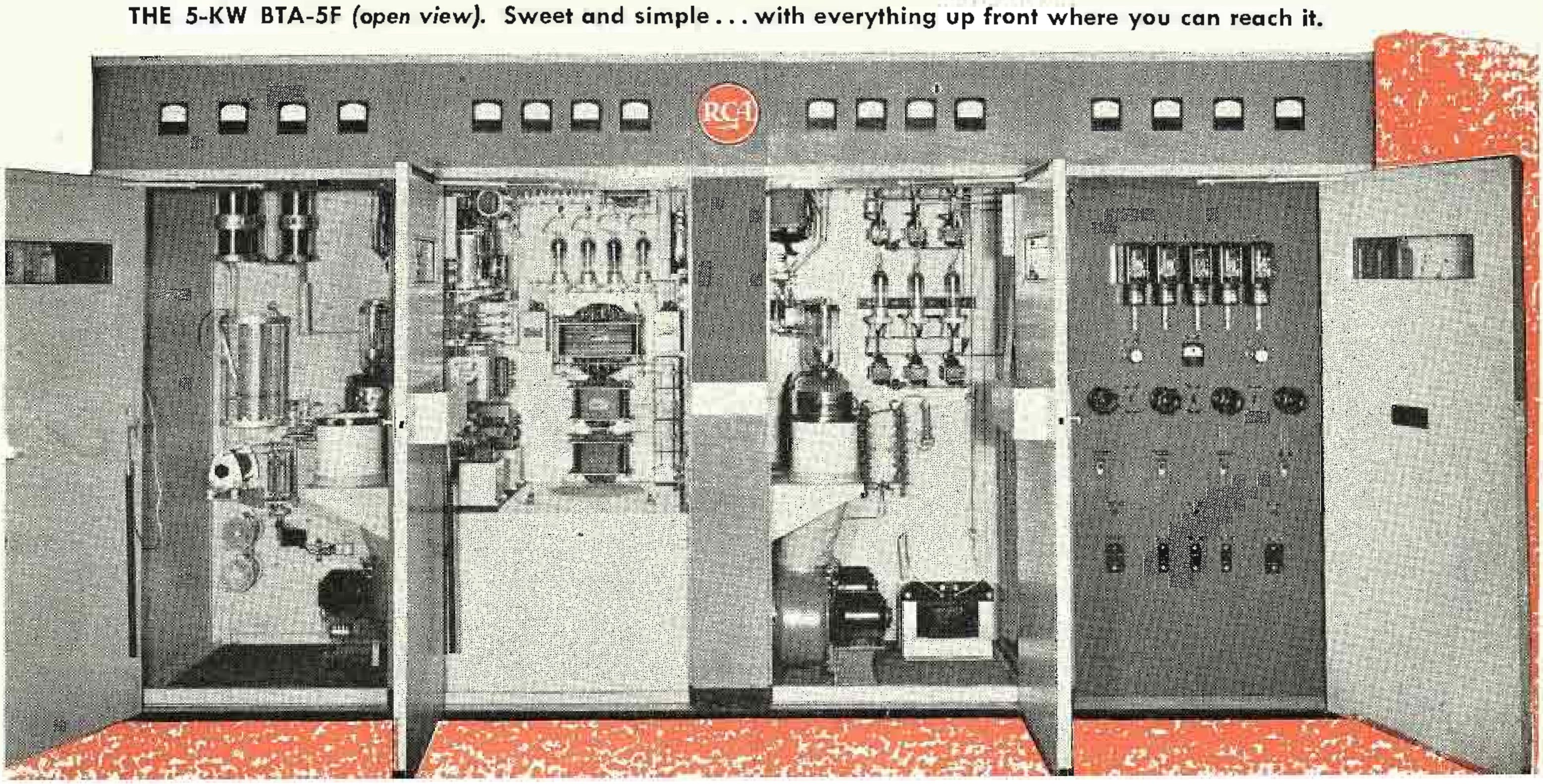
Here, we believe, is the finest streamlined station installation ever engineered for standard-band broadcasting . . . with all basic circuits proved in more than 125 transmitters of this series now operating throughout the world. Get the details from your RCA Broadcast Sales Engineer, or write Department 23-E.

This simple kit (MI-7267-A) takes the BTA-5F to 10 KW . . . inexpensively and without one change in station layout.

- **One blower**
- **Two filament transformers**
- **One 10-KW modulation transformer**
- **One reactor**
- **All necessary hardware**

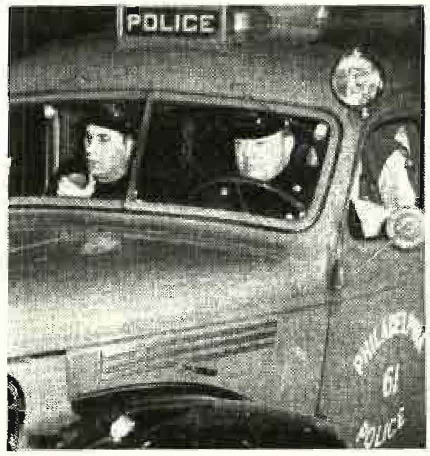
The Transmitter Control Console — standard equipment with every BTA-5F and BTA-10F.

THE 5-KW BTA-5F ***(open view).*** **Sweet and simple . . . with everything up front where you can reach it.**



Relaying telephone calls to radio police cars patrolling the streets of Philadelphia. Cabinet at left houses remote control relay system for duplex operation.

Philadelphia police-emergency car equipped with duplex radiotelephone system.



Philadelphia Police Duplex Two-Way F-M System

Three Police Boats, and 239 Prowl Cars, Patrol Wagons and Official Cars Equipped With Two-Way Setup, With Talk-Out on 74.06 and Talk-Back on 155.97 Mc.

by RALPH G. PETERS

Two-way F-M systems have become priority police-department requirements throughout the country, in large and small cities and townships. Complete coverage, an acute problem in large metropolitan areas, is rapidly being solved through the careful application of many advanced design and installation features.

An interesting example of a metropolitan-area solution is the recent 250 car installation[1] in Philadelphia to patrol 130 square miles. Official cars, prowl cars and patrol wagons, and three police boats are among the radio-equipped mobile units. In addition, cars of the fire chief, two deputy chiefs and two rescue squads, and three fireboats are also equipped with their setups. Mayor Bernard Samuel's car is also tied in with the two-way system.[2]

In excess of 330,000 calls a year, 800 to 1,000 a day, are being routed over the system, which features the duplex method of operation.

System coordination is organized and followed through in the radio dispatching room, on the seventh floor of City Hall. Here four men answer constantly-buzzing telephones and jot down notes on the nature and location of a disturbance, accident or possible crime. Their notes are passed through a slot into a sound-proof dispatcher's booth. A large electrically controlled map on the wall of a phone room indicates the location of various cars at all times. Within the dispatcher's booth is a microphone and remote console plus an elaborate set of toggle-switch panels that aid the dispatcher in keeping track of the cars, and learning if they are in or out of action.

The dispatcher assigns squads and answers incoming calls.

In a disaster the first two-way radio-equipped police car to arrive at the scene automatically takes over as the headquarters for transmitting and receiving messages pertaining to the affected area. A blue and yellow triangular sign is placed atop the car, reading, *Police Radio*. The commanding officer at the scene of a disaster may establish as many mobile sub-communication stations as necessary.

The establishment of a communication headquarters in emergencies permits coordination of all incoming and outgoing messages, thereby eliminating confusion, which would result were orders coming in from many police cars, often simultaneously. During such emergencies as many as 100 calls an hour, almost continuous conversation, have been logged.

Duplex Operation System

Talk-out is accomplished on 74.06 mc, and talk-back is on 155.97. A

(Continued on page 30)

[1] Motorola.

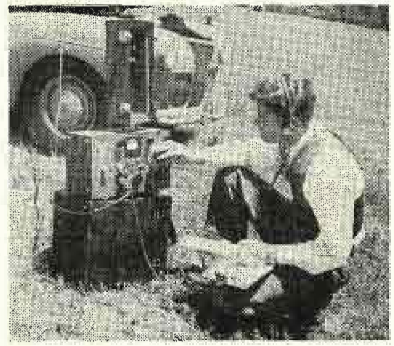
[2] Two-way system is under the direction of James H. Malone, Director of Public Safety. Associates include Harry M. Simon, Chief of the Electrical Bureau; Frank O. Schierf, Superintendent of Fire Alarms and Radio Systems; Anthony Repici, Supervisor of Radio Maintenance; Thomas P. Burns, Assistant Superintendent of Police in Charge of Operation of Police Radio and Communication, and Captain Charles News of the Police Radio Division.

Test Instruments In The Broadcast Station

Part III of Series, Covering Uses of R-F Bridge, Decade Resistance Box and Field-Strength Meter in Broadcast Measurement Work.

by HERBERT G. EIDSON, Jr.

Chief Engineer, WIS and WISP
Technical Director, WIST



Eidson at the controls of the field-strength meter used at WIS.

IN THIS, the concluding installment, three more important pieces of measurement equipment will be discussed: the r-f bridge, decade resistance box, and the field-strength meter.

The R-F Bridge

At our stations a 400-kc to 60-mc type r-f bridge[1] is used.

The bridge (Figure 1) is used with a series-substitution method for measuring an unknown impedance in terms of its series-resistance and series-reactance component. The resistance is read from a variable capacitor dial directly calibrated in ohms (0-1,000), the reactance being read from the variable capacitor dial directly calibrated in ohms (0-5,000) at a frequency of 1 mc. The resistance dial reading is independent of frequency, and the reactance dial reading increases linearly with frequency. For frequencies other than 1 mc the reactance dial reading must therefore be divided by the operating frequency in mc.

As will be noted in the circuit, the resistance of the unknown depends upon a change in capacitance C_{R1}; the reactance upon a change in capacitance C_{x1}.

In normal practice the reactance control C_{x1} is set at some value above zero ohms, say 200, and the bridge is balanced initially. If the unknown reads below this setting the sign is negative; if above 200 then the reactance is inductive. In measuring a great amount of capacitive reactance the initial balance is made with C_{x1} set at the extreme end from zero (5,000). In addition, a small switch is thrown from *L* to *C* which changes the values of the *C* and *R* in two legs of the bridge.

A measurement is made by first balancing the bridge with the *unknown* terminals shorted, then rebalancing with the short circuit removed and the unknown impedance connected to the *unknown* terminals.

If the resistance or reactance component of the unknown impedance falls outside of the direct reading range of the bridge indirect measurements can be made through the use of an auxiliary parallel capacitor and the use of formulas.

Any well shielded r-f oscillator having an output voltage of 1 to 10 and an adequate frequency stability will serve as generator.

For detector work, any well-shielded receiver having a sensitivity of 1 to 10 microvolts will serve. It should have an adequate r-f sensivity control and a local oscillator to beat against the i-f produced by the generator. It has been found much easier to balance the bridge when the *LO* is turned off and a modulated wave is obtained from the generator, the modulation being in the order of 400 cycles.

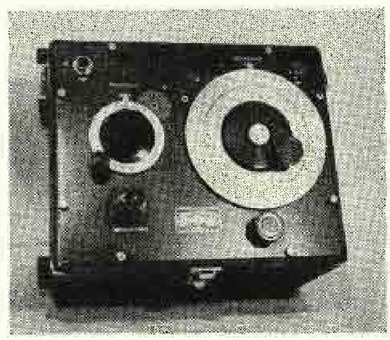
We use a bridge for:

(*1*) Measuring *R* and *X* of antennas.

(*2*) Measuring different points in

(*Continued on page* 36)

[1]G-R 916-A



The r-f bridge used by Eidson.

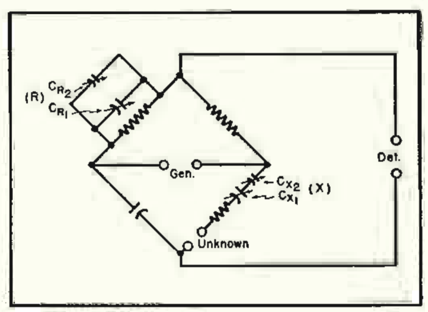
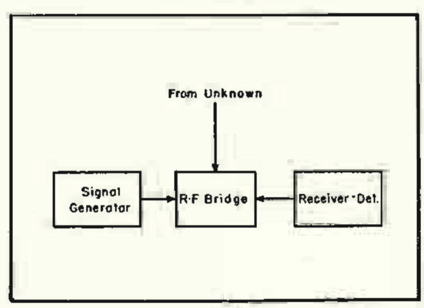


Figure 1
Basic circuit of the r-f bridge used at WIS.

Figure 2
Standard setup for measuring an unknown impedance.



TUBE *Engineering News*

The Dyotron Microwave Oscillator . . . Low-Noise Amplifier With Grounded-Cathode Triode in First Stage And Grounded-Grid Triode in Second Stage.

A NEW TYPE of s-h-f tube, the dyotron, which is unusually stable, has a very wide tuning range, and can be used in local oscillators or signal generators at frequencies up to 3,700 mc, was described at the recent IRE National Convention by E. D. McArthur.

The tube, developed under a U. S. Navy Bureau of Ships contract, is essentially a triode in that it uses the same physical method for producing an alternating component of plate current, i.e., the current flow from the cathode varies with the electrode field at the cathode just as does any conventional triode or tetrode.

The electrical distinction between the dyotron and the triode lies in the method of obtaining the varying electric field at the cathode and in the method of utilizing the resulting high-frequency current.

The dyotron is based on the thesis that ordinary grid excitation voltage can be abandoned and enough a-c current derived from the anode field to support oscillations. To do this, the phase of this current component must be reversed and the tube so designed that the current is large enough to supply the output circuit power consumption.

To realize these conditions, the usual excitation or feedback voltage between grid and cathode must be zero. This was accomplished in the dyotron by building into the tube a capacitor of about 70 μμfd which effectively short circuits the grid and cathode.

With the built-in capacitor, which must be as close as possible to the active grid and cathode area, the tube becomes a two-terminal device. The grid and cathode act as one a-c electrode and the anode is the other. It is still possible, of course, to have a d-c bias voltage on the grid. Thus we find that, if an a-c voltage exists between these two terminals, most of the electric field lines which start at the anode will terminate on the grid, but some will reach through the grid to the cathode. This anode field, reaching through the grid, creates the voltage term, $e_{g2} \sin \omega t$. Since this cathode field does not depend on there being any impedance between grid and cathode, the input bypass capacitor, while eliminating the usual grid-cathode field, has no effect on the penetrating field from the anode.

Electrically, therefore, the need for a feedback circuit as well as the usual tuned input circuit has been eliminated, and there is nothing left but the single output circuit. The dyotron thus becomes a simple two-terminal oscillator whose frequency is determined by resonance in a single circuit which is connected between grid and anode and which can be tuned by one control.

Most of the experimental work was done with tube models which were simple modifications of the standard 2C39 triode.

Since performance was based on the use of the electron transit angle, a wide tuning range would not ordinarily be expected. Experiments showed, however, that there was a considerable spread in transit angle at any frequency and voltage due to the nonuniformity of the grid. Despite this the negative conductance was great enough so that with circuits of moderate Q the transit angle varied about ± 30 before oscillations ceased.

Three experiments were conducted to study wide tuning ranges of the tube. In the first, oscillation characteristics were taken using a single coaxial cavity with a piston tuner with two types of tubes identical in all respects except for interelectrode spacing. With this one circuit and the two

Band-center, Mc	Overall noise factor		R. opt.	Bandwidth, Mc,		Tubes used in cascade	Degradation of noise-factor when L is omitted, db
	ratio	*db*	*ohms*	input circuit	overall		
6	1.06	1.25	15,000	2*	1	6AK5-6J4	Not measured
30	1.35	1.35	2,500	12*	6	6AK5-6J4	0.2
180	3.5	5.5	400	30**	2.5	6J4-6J4	2.5

*Double-tuned.
**Single-tuned.

Table 1. Results obtained experimentally using the cascade circuit at the input of 100 db amplifiers at 6, 30, and 180 mc.

types of tubes, oscillations were obtained over the continuous range from 370 to 3,700 mc, a ratio of 10:1. In another experiment, the oscillation range was explored using one tube and one cavity. Nothing was varied except cavity piston position. No voltage nor output coupling adjustments were made. Under these conditions the oscillator tuned over the range from 1,800 to 2,800 mc. For this range the total supply voltage was 300 volts, the plate current was 60 ma and the power output varied from 100 to 350 milliwatts. If the voltage was varied to keep the transit angle approximately constant, the tuning range became 1,400 mc to 3,200 mc.

A signal generator has been built for general laboratory work using the same type of tube which, with a single tuning control, covers the range from about 1,100 to 2,900 mc. Throughout this range the power varies considerably although the plate voltage is constant and there are no mode shifts nor spurious oscillations.

The frequency stability seems to be due to a combination of circuit simplicity and the fact that capacity variations due to grid or cathode expansion no longer affect the frequency much since these two electrodes are thoroughly bypassed.

Cold Cavity Response

In a typical experiment it was found that the cold cavity response was about 1,600 mc with no power whatever on the tube. After switching on cathode and plate voltages, the total frequency shift mounted to about 1.2 mc and occurred in the first ten minutes. After this period the frequency variation was in the order of ±10 kc and was almost entirely a function of cavity temperature. Additional measurements over a period of a few hours at 2,600 mc showed that the frequency variation with temperature was about 40 kc per degree and that with temperature and voltage control it was possible to get an oscillator frequency stability of one part in 10^6.

Low-Noise Amplifier

THE APPLICATION of triodes in low-noise cascade circuits has been widely studied. In 1944, Henry Wallman, A. B. Macnee and C. P. Gadsen instituted a series of experiments with such systems at M. I. T., developing an amplifier which employed a grounded-cathode triode first stage and grounded-grid triode second stage. They obtained noise factors as low as .25 db at 1 mc, 1.35 db at 30 mc and 5.5 db at 180 mc.

An analysis of the unique low-noise circuit was offered, for the first time, at the IRE National Convention.

In Figure *1* appears a basic circuit diagram of the amplifier.

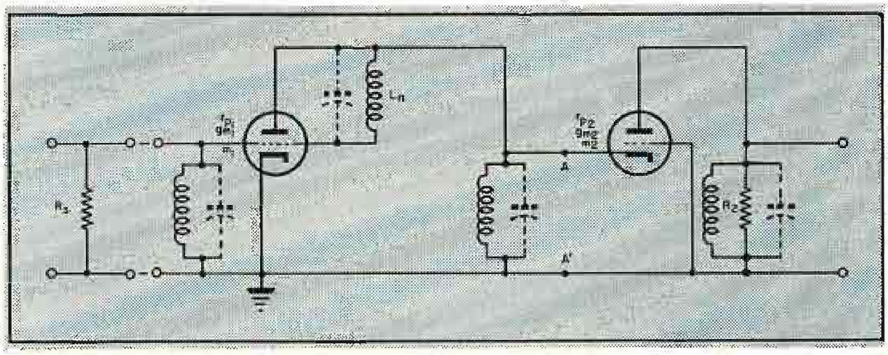


Figure 1

Basic circuit of the Wallman-Macnee-Gadsen low-noise amplifier, which consists of a grounded-cathode triode in the first stage and a grounded-grid triode in the second stage.

The inductances in the circuit are adjusted to be midband resonant with their associated capacities. The coil, L_n, which is parallel resonant with C_{gp}, is not necessary for stability, but is used to achieve low noise-factor. In amplifiers operating at a midband frequency, as high as 180 mc, it was possible to omit L_n with complete preservation of stability, although its omission increased the noise-factor from 5.5 to 8 db.

Bandcenter Behavior

In studying the bandcenter behavior of the amplifier, it can be assumed that R_2, the load resistance of the grounded-grid stage, is considerably smaller than r_{p2}, as is usually the case for wideband amplifiers. Thus the input resistance of the grounded-grid stage is $1/g_{m2}$; this is the resistance at the right of AA′.

The resistance, looking to the left at AA′ is, r_{p1}. (Typical values are about 200 ohms for $1/g_{m2}$ and 6,000 ohms for r_{p1}. It is this combination of a very low resistance to the right and a high resistance to the left at AA′ that provides the crucial characteristic of the grounded-cathode grounded-grid combination, with regard to both stability and noise-factor. In particular, the voltage amplification of the grounded-cathode stage alone is thus g_{m1}/g_{m2}. For usual tubes this is about unity. This very low amplification makes the first stage very stable.

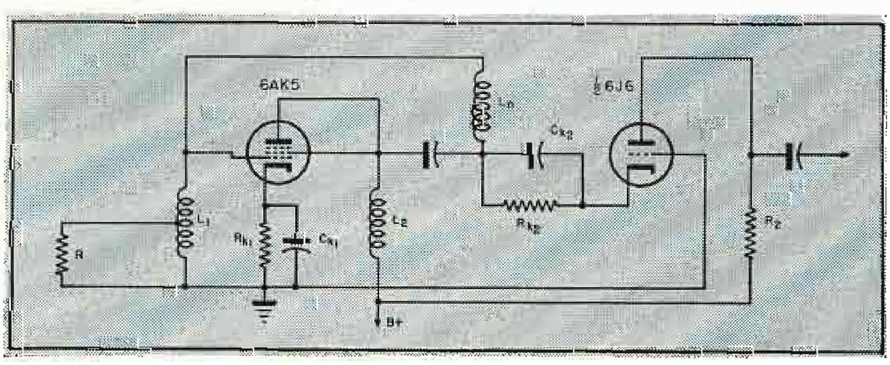
The voltage amplification of the grounded-grid stage is $g_{m2}R_2$. Therefore the overall voltage amplification of the cascade is $g_{m1}R_2$. It will be noted that this amplification is independent of g_{m2}. It is desirable to have a large g_{m2} to keep the voltage amplification of the first stage small and thus assure its stability.

30-Mc I-F Amplifier

By using a 30-mc i-f amplifier with cascade low-noise input, it has been possible to build a 3,000-mc receiver with an r-f noise factor of 7.4 (= 8.7 db), as measured with a 3,000-mc klystron noise source.

Figure 2

A typical cascade low-noise circuit. The d-c from the grounded-grid stage flows through R_{k2}, L_2 and L_1.



Short Receiving-Antenna Design Factors

Major Problems Involved in the Design of Short Receiving Antennas (With An Electrical Length of Less than 10°, Roughly Under 10′, At Standard Broadcast Frequencies), Particularly For Aircraft Application.

by HARVEY KEES

Chief Engineer
Engineering Services, Inc.

ON AIRCRAFT, short antennas are commonly employed with 200-500 kc radio range and 200-1600 kc radio-compass receivers, where satisfactory performance is usually obtainable with symetrical wire *T* antennas having eight-foot horizontal and one-foot vertical sections. Both sets are used for the reception of vertically-polarized signals, and the optimum receiving antenna is a non-directional, vertical one which is insensitive to horizontally-polarized fields. Ambiguous information is more likely to obtain from range-receiver installations which respond to other than vertically-polarized signals, and when used with radio-compass receivers such antennas tend to reduce bearing accuracy as a result of a broadening of the nul in the directional pattern obtained from the loop and sense-antenna combination used with this set.

Broadcast Reception

Since broadcast stations employ vertical antennas, maximum receiver sensitivity to the vertically-polarized transmitted signals is obtained with vertically-polarized receiving antennas. Any horizontally-polarized pickup in a broadcast antenna serves only to increase background noise and selective fading.

Antenna Theory

At this point it may be well to review some of the basic principles of antenna operation and generally-accepted definitions. Let us consider the hypothetical case of a short, say, two foot, vertical rod used as an antenna in the standard broadcast band.

If such an antenna is used for transmission, the lower end of the rod is connected to one terminal of an r-f signal generator, and the other terminal of the signal generator is grounded. The current that flows from the signal generator is due to the capacity of the rod to ground. This is so because the rod obviously has negligible series resistance and inductive reactance at broadcast frequencies. In fact, the current flowing at any point in the rod depends on the capacity-to-ground of the section of rod above that point. Thus the most current flows at the base of the rod, and the current tapers off to zero at the tip of the rod. The situation that obtains in practice is graphically illustrated in Figure 2.

The term *effective height* of an antenna is an arbitrary one which probably would be better understood if it were called *effective length.* At any rate, it is merely a measure of the receiving effectiveness of an antenna structure, as compared to that of an antenna which has uniform current distribution throughout its length. By definition, the *effective height* of a two-foot vertical rod, surmounted by a large top-loading capacity plate so that the currents at the base and at the apex of the rod are approximately equal, is two feet. The *effective height* of a two-foot rod with no top-loading plate, whose current tapers off linearly to zero at the apex, is one-half its actual physical height, because the average current in the rod is one-half that of the top-loaded rod with uniform current distribution.

The strength of an r-f field is usually given in volts per meter, meaning volts per meter of *effective height* of the receiving antenna. That is, in a field strength of 100 volts/meter an antenna with one meter *effective height* will have 100 volts induced in it and have an open-circuit voltage of 100 volts. Similarly, the same antenna would have an open circuit voltage of 100 millivolts where the r-f field strength was 100 millivolts/meter. This is simply an arbitrary, and commonly used, way of describing the intensity of an r-f field.

It follows from elementary circuit theory that the voltage any antenna is capable of delivering to a load is dependent upon the internal impedance of the antenna. For example, actual measurements show the *effective height* of a two-foot vertical rod is one foot and that its internal impedance is approximately that of a 5-mmfd capaci-

Figure 1*a* (left) and 1*b* (right)

At *a* is a typical receiver input circuit used with a short antenna. Capacity of leadin between antenna and receiver is shown at C_a and at C_b, we have the stray lead capacity in a receiver. The trimmer C_1, is used to compensate for variation in antenna and leadin capacities. The tuned circuit with C_2 presents a very high impedance to the antenna. In *b* appears an equivalent circuit for a short antenna and capacitive load. The voltage induced in the antenna by the r-f field, which is directly proportional to the antenna height, is indicated at eH. C_o is the receiver input and leadin capacity. V is equal to the voltage produced at the input terminals which depends on the values of C_a, C_o and eH.

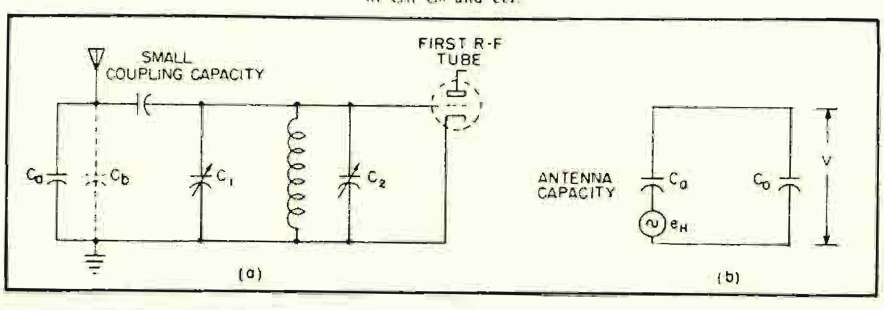
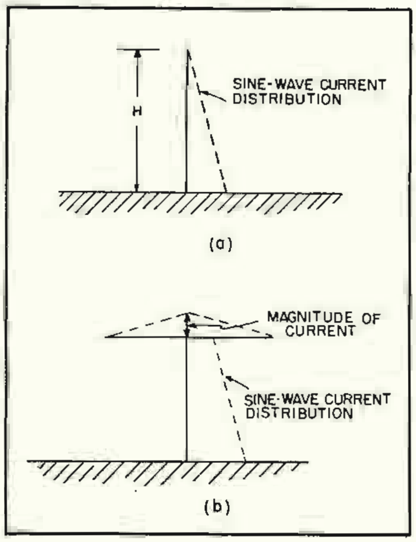


Figure 3 (right)
Symmetrical 7′ antenna performance.



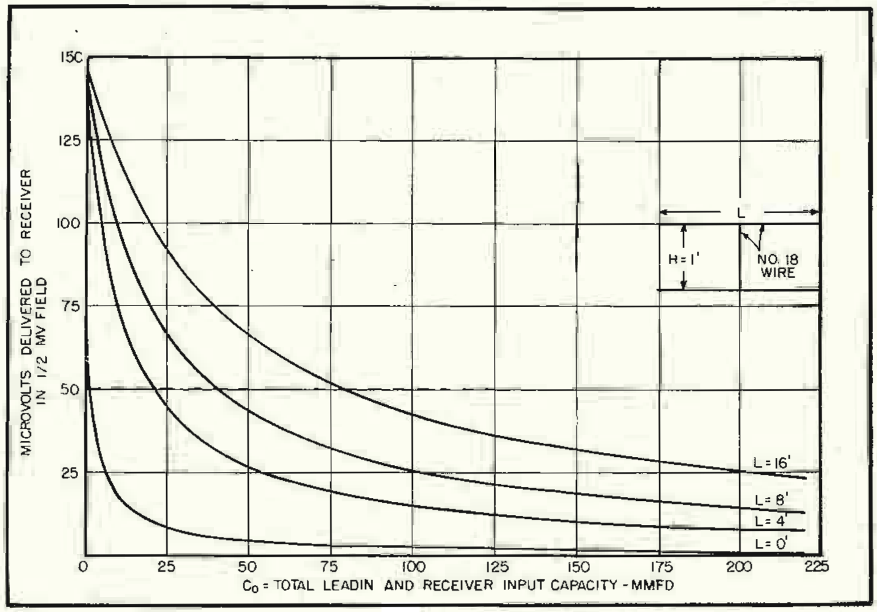


Figure 2 (left)
Current distribution on short antennas, with and without top loading. In top view, we have a short vertical antenna with no top load. The sinewave current distribution is a straight line function for angles under 5°. At the bottom is a drawing of a short antenna with top loading. The magnitude of current is proportional to the top load capacity, since the sine-wave current distribution is linear for antenna lengths under 5°.

tor. It is possible to devise another type of antenna structure also having an *effective height* of one foot, but whose internal impedance is considerably less than that of the two-foot rod: for example, a one-foot rod surmounted by a symetrically located horizontal rod eight-feet long. Actual measurements show this latter antenna has an *effective height* of one foot and the impedance of a 25-mmfd capacitor. Thus, the latter antenna, which has the same *effective height* as the former, is capable of delivering considerably more power from an r-f field to a finite load (such as, say, a receiver with a 500-ohm resistive input).

In Figure 1*a* appears the schematic of the antenna circuit of a receiver designed for use with short antennas. The antenna feeds a load consisting of the lead-in and receiver—input capacity. The input capacity of a well-designed receiver is usually under 20 mmfd, and open-wire lead-in capacity is approximately 5 mmfd for each foot of length.

The equivalent circuit of a short antenna connected to a receiver is shown in Figure 1*b*, where the antenna is considered as a signal generator whose impedance is the capacitive reactance of the antenna, and internal emf is equal to the product of the effective electrical height of the antenna and the field strength of the impinging signal. The load on this generator consists of the receiver-input and leadin capacities in parallel.

Thus

$$E = (e)(h)$$

Where:

E = voltage induced in antenna by r-f field
e = r-f field strength
h = effective electrical height of antenna

However, not all the voltage induced in the antenna reaches the receiver input terminals, because of the internal impedance of the antenna.

$$V = (E)\ (C_a)/(C_a + C_o) = (e)\ (h)\ (C_a)/(C_a + C_o) \qquad (1)$$

Where:

V = receiver input voltage
C_a = total antenna capacity
C_o = receiver-input and leadin capacity

Now, if it is assumed that the current at the top of the vertical section of a symetrical *T* antenna is directly proportional to the top-loading capacity and that the current distribution is a straight line, as illustrated in Figure 2, an equation can be written relating the actual physical height and effective electrical height of the structure in terms of the capacities involved.

Thus

$$h/H = (C_a + C_1)/(2)\ (C_a) \qquad (2)$$

Where:

H = physical height
C_1 = top-load capacity

Combining equations (*1*) and (*2*)

$$V/e = (H)(C_a + C_1)/(2)(C_a + C_o). \qquad (3)$$

Equation (*3*) describes the performance of short symetrical *T* antennas in terms of easily determined quantities: the antenna capacity, C_a; the top load capacity, C_1; the leadin and receiver input capacities, C_o; and the physical

(*Continued on page* 34)

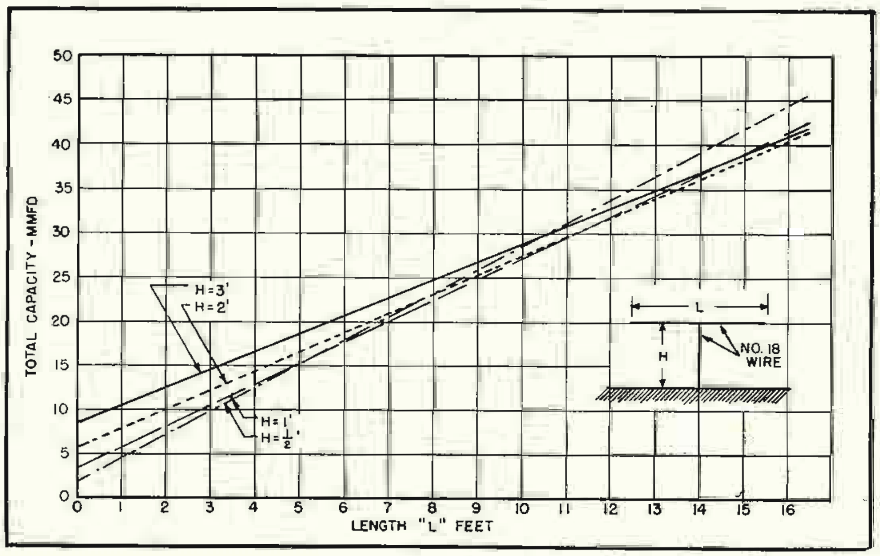


Figure 4
T antenna capacity plot.

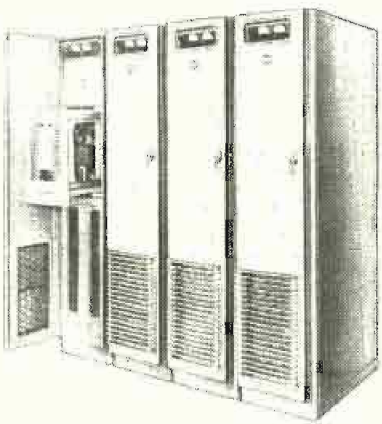
The Industry Offers

RADIO RECEPTOR ADAPTABLE TRANSMITTING UNITS

Transmitting units, known as the Telepak, have been announced by Radio Receptor Co., Inc., 251 W. 19th St., New York City.

Units use a basic frame and a series of separately removable units or cells which can be accommodated in this basic frame. The cells are of standardized construction and proportions and range in physical size from 1/2 of the stack height of the basic frame to a full stack, as may be required for the power requirements involved.

Cells are individually removable from the cabinet, and are individually ventilated. They are supported in the cabinet by means of removable shelf supports.



NEW EIMAC PRODUCTS

Three new products have been announced by Eitel-McCullough, Inc., San Bruno, Calif.

One item is a 10-60 mmfd variable vacuum capacitor, VVC60-20, which will handle 40 amperes of current at 20,000 volts.

The second item is a 4-400A power tetrode for power amplifier service in 1 kw f-m broadcast transmitters in the 88-108 mc band.

The third product is a 4-400A/4000 air-system socket designed for use with the type 4-400A power tetrode.

CLARE D-C RELAY

A plug-in type d-c relay, type J, has been developed by C. P. Clare & Co., 4719 West Sunnyside Avenue, Chicago 30, Illinois.

Supplied with standard octal base plug. Overall length of relay and plug is 3⅝". Length of relay installed is 2 15/16" from the panel.

Features of the relay include independent twin contacts, high current carrying capacity, large armature bearing area, high operating speed and large contact spring pileups.

RCA FLYING SPOT C-R TUBE

A *Flying Spot* cathode-ray tube, 5WP15, for use in a video-signal generator which permits the televising of individual station call letters, test patterns, or picture material from interchangeable film slides or opaque material, has been developed by the RCA tube department.

Tube is 5" in diameter. It is a source of intense acting energy for scanning slides or opaque material.

A new phosphor is used in the tube. The phosphor which has a metallized back to double the effectiveness of the flying spot, emits very strongly in the near-ultra-violet region of the spectrum. In addition, the ultra-violet radiation has extremely short persistence, reducing to a single network the amount of equalization needed to minimize blurring or trailing in the reproduced picture.

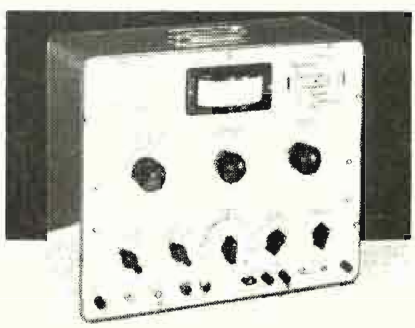
* * *

HICKOK TV ALIGNMENT GENERATOR

A tv alignment generator, model 610, has been developed by The Hickok Electrical Instrument Company, 10521 Dupont Avenue, Cleveland 8, Ohio.

Unit permits alignment on any of the 13 tv channels from 44 to 216 mc, alignment of all traps with a calibrated signal modulated or unmodulated, and insertion of an accurate marker at any point along the i-f response curve.

Other features include facilities for aligning i-f or r-f sections by single stage method, aligning of tv receiver independent of any local tv station, and aligning of channels 7 through 13 directly by calibrated f-m oscillator. Instrument also provides a crystal-controlled frequency, modulated or unmodulated, from 1 to 16 mc.



KOTRON SELENIUM RECTIFIER

Kotron half-wave selenium rectifiers, in 75, 100 and 200-ma units, have been announced by Standard Arcturus Corporation, Kotron Division, 54 Clark Street, Newark 4, N. J.

Rectifier is constructed flat, all the elements mounted in one plane.

STEPHENS MICROPHONE

A *Tru-Sonic Phase Modulated* microphone, type C-1, has been developed by Stephens Manufacturing Corporation, 10416 National Blvd., Los Angeles 34, Calif.

Microphone is said to employ the principle of *carrier frequency phase modulation*.

The pickup assembly is ovoid in shape and 2" x 1½". Features of the microphone are said to be true and absolute linearity of response, pressure-operated at all frequencies, polar pattern at all frequencies, and almost completely one-half sphere, down 3 db at 90° off the axis.

LANGEVIN 8-WATT AMPLIFIER

An 8-watt dual channel amplifier has been announced by the Langevin Mfg. Corp., 37 W. 65th Street, New York 23, N. Y.

Has two low-gain high-impedance input channels. Three sockets in each of the two input channels permit the use of various combinations of plug-in equalizers, transformers and voice filters.

Unit can be used with crystal pickup or high impedance tuner, crystal microphone, G.E., Pickering pickup or equivalent, low impedance microphone or phono reproducer or 150/600-ohm line.

Has two volume controls, one for each channel.

* * *

KINGS MINIATURE CONNECTORS

Miniature connectors, handling up to 50 watts of r-f power and requiring no soldering of braid wires or inner connector when used with coaxial connector cable, have been announced by Kings Electronics Co., Inc., 372 Classon Avenue, Brooklyn 5, N. Y.

* * *

MILLEN SINGLE-SIDEBAND SELECTOR

A single-sideband selector, 92105, made under an exclusive patent license from the McLaughlin Research Laboratories of LaJolla, California, has been announced by the James Millen Mfg. Co., Inc., Malden, Mass.

Utilizes two crystals, four tubes complete with their own power supply, r-f and a-f gain controls, and telephone type lever switch for shifting between upper and lower side bands.

TV Transmitter

(Continued from page 15)

constant should be at least $10T$, i.e.,

$RC = 10T$

Where: T = the television picture field interval

Wave shapes non-symmetrical in character establish their a-c reference axis at the level about which the area above the axis is equal to the area below it. Figure 9 shows various wave shapes and the manner in which equal areas are established about the zero a-c reference axis.

•

Police F-M

(Continued from page 22)

single *hat-pin* antenna is used on the mobile units for transmission and reception. An ingenious line-matching and stub-filter network is used between the mobile transmitter and receiver.

In operation these stubs create open circuits so that outgoing transmission signals follow only the closed circuit path to the antenna and cannot cross over into the receiver. In reception the reverse is true: the signals coming from the antenna find an open circuit to the transmitter and follow only the closed circuit path to the receiver.

A duplicate setup is used as insurance against breakdowns. Two complete central stations are housed under the dome of City Hall, with a set of relay circuits cross-linking the various receivers and transmitters. It is possible to select any one of them for operation by remote control from the broadcast booth. If a unit breaks down, a flip of the switch activates another.

This *double* system also includes the remote control console in the broadcast booth. A standard upright central station cabinet has been equipped with two complete remote controls, and interconnected to provide switching of the pre-amp and line-amp units in case of a breakdown.

The antenna installation is on the City Hall dome, 547′ above sea level.

Because of the unusually high-noise level in the downtown area, talk-back signals are picked up on receivers located on a hill approximately 470′ above sea level, and about four miles northwest of City Hall. From the hill talk-back is carried by telephone wires to the broadcast booth. An auxiliary transmitter to cover emergencies is now being installed in the transmitter station on this hill.

F-M Frequency Checks

(*Continued from page* 18)

on the screen of the 'scope indicating a 1:1 frequency ratio. The setting of the audio oscillator tuning dial will now indicate the frequency deviation. Where sub-harmonics are being measured, the deviation indicated by the audio signal generator is multiplied by the number of the sub-harmonic to determine the deviation at the final frequency. For example, if the signal measured is 1/10 the final frequency the measured deviation should be multiplied by 10 to determine the final frequency shift.

To determine whether the transmitter frequency is high or low, the standard frequency is shifted in a known direction and whether the frequency difference with the transmitter increases or decreases is noted.

Throughout the measurements, *the zero-beat between the standard and WWV must be maintained carefully.*

During transmitter measurements, the audio input to the transmitter should be short-circuited so that no modulation occurs. The short-circuit is recommended because any random noise modulating the transmitter, whether audible or not, will make a distinct beat note impossible.

If the measurements are made in the close vicinity of the transmitter, difficulty may be had in reducing the signal pickup to such a value as to obtain a satisfactory beat. It was found when making the measurements in a strong signal field, considerable signal was introduced into the receiver through the speaker and power cords. At the KOCY-FM transmitter measurements could be made in the near vicinity of the transmitter only if the exciter was operated without the final amplifiers.

Frequency monitor crystals can be checked in a similar manner as that described for the transmitter. Normally a loop of wire placed near the monitor oscillator tube will pick up sufficient signal to obtain a beat. In the case of one monitor,[4] the 5,400-kc calibrate crystal can be checked very easily by direct comparison to 100-kc harmonics. The *running* crystal usually has such an odd fundamental frequency that it is best to check it at its final frequency (transmitter frequency plus 5,400 kc). Of course, when adjusting or measuring the transmitter frequency, an indirect check is made on the monitor. Therefore the one measurement will generally be sufficient.

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[3]Hallicrafters SX-42

[4]G.E.

News Briefs

INDUSTRY ACTIVITIES

Plans for professional groups within the IRE were announced recently.

Groups whose organizations are now being actively promoted include an audio, video and acoustic group, and one for the broadcast engineering field.

Two types of groups are visualized under the new system: vertical, illustrated by the broadcast engineering group; horizontal, as in the audio, video and acoustic group.

Each group will elect its own chairman, vice chairman, and executive committee.

Gray Research and Development Company, 16 Arbor Street, Hartford, Conn., has opened a sales office at [illegible] Fifth Avenue, New York City.

The Emeloid Company, Inc., is now at its new plant at Hillside, N. J., a suburb of Newark.

WSBA-FM, York, Pa., has increased its transmitter output to [illegible] kw by adding an RCA grounded grid amplifier unit, employing two 7C24s in parallel.

The station uses a two-section pylon transmitting antenna, radiating an effective output power of [illegible] kw.

A preliminary RMA committee on problems of industry mobilization and military production was recently appointed by Max F. Balcom, RMA president.

Fred R. Lack, vice president of Western Electric, was named chairman of the new RMA government liaison committee. Other members of the committee are Frank M. Folsom, executive vice president of the RCA Victor Division, and W. A. MacDonald, president of Hazeltine Electronics Corp.

KDTH-FM, Dubuque, Iowa, is now installing a [illegible] kw W.E. fm transmitter and an 8-bay cloverleaf antenna on top of one of the bluffs along the Mississippi River. Effective radiated power will be [illegible] kw.

The Fairmount Park Commission in Philadelphia is equipping the motor vehicles of the park guard with [illegible] two-way Philco mobile radiotelephones.

Equipment includes a transmitter-receiver, microphone, control unit and antenna.

PERSONALS

P. B. Reed and C. A. Lallar have been appointed field sales administrators in the Eastern and Western regions of the RCA engineering products department. Reed will make his headquarters in Camden, while Lallar will maintain an office at [illegible] S. Hope Street, Los Angeles.

Dr. Robert A. Millikan, retired director of the California Institute of Technology, and winner of the Nobel Prize for Physics in [illegible], will address the IRE West Coast convention, which will be held on Sept. 29, Oct. 1 and 2, at the Biltmore Hotel in Los Angeles.

Lt. Commander R. E. Trapeur (U.S. Navy, retired), has joined FTR as sales representative in northern California.

Richard Reimer has also joined FTR as representative in southern California.

James Edward Everett has been appointed Measurements Corp. sales representative for the States of Illinois, Indiana and Wisconsin.

Everett's office will be at 615 Davis Street, Evanston, Illinois.

J. E. Everett

James J. Tynan has been named sales manager of the commercial products division of Raytheon. Kenneth V. Curtis has been named product manager. William A. Gray continues as assistant sales manager.

Melville Eastham, chief engineer and former president (1915-1944) of the General Radio Company, received the 1948 New England Award, at the annual meeting of the Engineering Societies of New England, at Boston.

M. Eastham

Marcus A. Acheson is now chief engineer for the radio tube division of Sylvania Electric Products Inc. Acheson was formerly manager of the advanced development department of the Sylvania Central Engineering Laboratories at Kew Gardens, N. Y.

Raymond K. McClintock has become assistant to Acheson. McClintock was formerly engineering manager for Sylvania's international division.

Irving Rose, who was president of Remco Electronic. Inc., New York City, died recently.

Charles F. Stromeyer, vice president of the Hytron Radio and Electronics Corporation of Salem, Massachusetts, has become president of Remco. William W. Roberts, chief engineer, will continue as vice president.

LITERATURE

Allied Control Company, Inc., 2 East End Avenue, New York 21, N. Y. have prepared a relay guide.

Data presented include maximum contact arrangements; contact rating current, d-c and a-c; coil operation, a-c and d-c; coil data in volt amperes a-c or watts d-c; maximum d-c ohms of standard coils; maximum rated volts of standard coils; dimensions, including length, width and height; weight in ounces.

Sorensen & Company, Inc., Stamford, Connecticut, have released a 20-page catalog describing electronic control of voltage and current.

A *key chart* which permits a basic regulator to be modified to fit an unusual set of conditions appears in the catalog.

Catalog also contains photographs of applications, circuit diagrams, efficiency and performance curves.

The Industrial Photographic Division, Eastman Kodak Company, Rochester 4, New York, have released a 4-page catalog describing Kodak linagraph films and papers for use in instrument recording.

The booklet describes 11 films and papers used to record oscillograph traces and similar phenomena. Complete information is given regarding speed, contrast, color sensitivity, etc.

P. R. Mallory & Co., Inc., 3029 E Washington St., Indianapolis 6, Ind., have prepared a 80-page **manufacturer's catalog, Number 1,** which covers the Mallory line of capacitors, contacts, rectifiers, resistors, switches, vibrators, welding tips and holders, special metals and alloys, as well as their line of special metallurgical products.

Hazard Insulated Wire Works, division of the Okonite Co., Wilkes-Barre, Pa., have prepared a 48-page building wire guide, with data on insulations, wires and cables, splicing tapes and insulating finishes.

Engineering tables on characteristics of stranded and solid copper wire, current carrying capacities, temperature conversion, etc., are also offered.

Lenkurt Electric Co., 1124 County Road, San Carlos, California, have prepared a 24-page booklet, **Trancors by Lenkurt** describing their line of molded magnetic cores, core assemblies, coil assemblies, and filters.

Discussed are properties of powders; mechanical considerations related to the parts; performance notes on finished units; and frequency, permeability, Q, and temperature stability characteristics of the three standard powders listed.

Audak Tuned-Ribbon Pickup

The tuned ribbon reproducer, Audak's model 79-G, described in the *New Products* column of April COMMUNICATIONS was specifically designed for use in Garrard record changers.

Receiving Antennas

(Continued from page 27)

height, H. The ratio V/e, receiver input voltage to r-f field strength, can be considered as a measure of the efficiency of an installation.

Performance Graphs

The antenna performance curves of Figure 3 were calculated by equation (3). The graphs give the voltage delivered to a receiver by the indicated antennas, as a function of leadin and receiver-input capacity, in the presence of a ½ millivolt meter r-f field. The curves are for antennas having a vertical height of one foot, but the abscissa can be multiplied by the antenna height in feet to obtain approximate answers for antennas with heights of other than one foot. Equation (3) should be used where greater precision is desired.

Figure 4 gives the capacity of wire *T* antennas, calculated from equations (129) and (134), section 2, paragraph 31 of *Radio Engineers' Handbook* (First Edition) by F. E. Terman. In some instances, such as on aircraft, flat, horizontal metal plates may be used to advantage as top-loading elements; however, it is rather difficult to calculate capacity curves for them because their capacity depends on the shape, as well as the area, of the plates. From the standpoint of capacity/area, long narrow top-loading elements are the most effective. The use of flat, vertical top loading sheets is not generally recommended as it is desirable to concentrate the top-loading capacity at the top of the antenna structure.

Practical Applications

The following information should be obtained before an antenna design is attempted:

(1)—The field strength of the weakest signal it is desired to receive. A value of ½ millivolt meter is considered by the FCC as the minimum useful signal from standard broadcast stations.

(2)—Receiver sensitivity, expressed as the minimum r-f input voltage required at the antenna terminals to produce satisfactory receiver output.

(3)—Receiver input capacity, which can be estimated from an inspection of the mechanical layout of the receiver, or measured on a *Q* meter with the receiver tuned to the *Q* meter frequency.

(4)—Leadin capacity. This is the capacity-to-ground of the leadin wire from the input terminals of the receiver to the base of the antenna. Open-wire lead-in capacity can be determined from Fig. 76, section 2, paragraph 31 of Terman's *Radio Engineers' Handbook* (First Edition). A value of about 5 mmfd/foot is obtained with #18 wire, ½" off a metal surface.

Sample Computation

As an example, suppose in an antenna for an aircraft radio-range receiver, (*1*) it is desired to receive ½ millivolt/meter signals, (*2*) an input voltage of 25 microvolts is required for the receiver, (*3*) the receiver input capacity is 25 mmfd, and (4) the leadin length is five feet of open wire having a total capacity of 25 mmfd.

It will be noted that the combined leadin and receiver-input capacity is 50 mmfd, and that 25 microvolts are required to operate the receiver satisfactorily. Figure 3 shows that a wire *T* antenna one-foot high requires a four-foot horizontal section to deliver 25 microvolts to the receiver. The rough estimate made from Figure 3, by multiplying the abscissa by ½, will show that an antenna ½-foot high with a 12-foot horizontal section will also do the job.

A more precise prediction can be made for the ½-foot antenna by use of equation (*3*). From Figure 4 it will be noted that the total capacity of a ½ by 10-foot wire *T* has a capacity of 28 mmfd and that the capacities of the vertical and horizontal sections are 2 and 26 mmfd, respectively. By equation (*3*) the voltage delivered to the receiver is

$$V = [(28 + 26)/(2)\ (28 + 50)]\ (½)\ (.305)\ (½) = 0.026 \text{ millivolts}$$

which is sufficient for the receiver.

Broadcast Reception

It seems to be the general consensus that a long wire stretched out in a random manner is a good broadcast receiving antenna. On the other hand, a consideration of equation (*3*) and antenna theory indicates that a vertical wire of the maximum practical height will give optimum results. A simple experimental check will prove the theory. If a broadcast receiver with an output indicator is set up in an open area and connected to a ten-foot wire antenna, it will be found that much more voltage is delivered to the receiver when the wire is stretched vertically than when the same wire runs horizontally. It requires only a little careful experimentation to confirm that best broadcast reception is obtained with antenna having the maximum possible vertical height and capacity concentrated at its top. Attention is called to the fact that many so-called all-wave *noise-reducing* antenna systems actually provide little noise reduction in the broadcast band where what is supposed to be the leadin actually functions as the antenna, top loaded by a short-wave doublet.

Test Instruments

(*Continued from page 23*)

our three-tower phasing unit and recording them so that future checks can be made.

(*3*) Initially tuning the r-f amplifier* of our transmitter. These values are also recorded.

(*4*) Measuring accurately the *R* and *L* of our composite dummy load.

(*5*) Checking *Q* of capacitors in stock.

(*6*) Measuring any unknown in terms of X_L, X_C and *R* within the limits of the bridge.

The Decade Resistance Box

The resistor box can be secured in almost any combination of variable losses desired. The most common one is a three-decade box having three potentiometers, the first giving a total resistance of 1 ohm in steps of .1 ohm. The second has a total resistance of 10 ohms in steps of 1 ohm, and the third a total of 100 ohms in steps of 10 ohms. To increase the range of the box, another decade can be added so that the total *R* available would be over 1,100 ohms in steps of .1 ohm.

The improved-type decade boxes are designed to be used with r-f in the broadcast band, i.e., there is a negligible amount of inductance in the windings.

We have found three uses for the decade resistance box:

(*1*) Measurement of antenna resistance (substitution method).

(*2*) Use as a standard.

(*3*) Application as the *known* arm on a bridge.

Field Strength Meter

The field intensity meter** we use covers a range of 200 to 7,000 kc, using four different electrostatically-shielded loop antennas. The loop for 530 to 1,600 kc is in the top cover of the instrument, a small toggle switch being used to select the lower portion or the upper portion of the standard broadcasting band.

Measurements can be made on signals as low as 20 microvolts per meter or as high as 10 volts per meter.

Facilities are provided for operating an external 5-ma recording milliammeter.

It is possible to operate the set from batteries mounted within the unit, but

*Doherty circuit
**Federal 101C

it is usually operated from a six-volt storage battery. A vibrator type power supply provides the plate voltage.

In application, the radiated field to be measured is tuned in on the shielded loop antenna and noted.

The amplitude of the unknown voltage is determined by comparison to a signal of the same frequency and known voltage, which is also introduced into the loop.

A superhet receiver, which serves as a means of comparison, is used in conjunction with a calibrated attenuator.

The following formula is used to determine the strength of the received signal in microvolts per meter:

$$e = \frac{KAM}{f}$$

Where:

e = Microvolts per meter
K = A constant found in table of instruction book
A = Attenuator setting
M = Output meter reading in microamperes
f = Frequency of received signal in kc

The field intensity meter is used to determine the strength in exact figures of a given radiated signal. Thus after a series of readings is made, the total area of a radio station's primary coverage may be plotted and measured with a planimeter to obtain the final figure in square miles.

The radiation efficiency of a given antenna may be found by measurements with this meter and with the use of charts and tables. The general efficiency of an antenna system is gauged by millivolts per meter, per kilowatt, unattenuated, at one mile. The rules and regulations set forth the figure of 265 to be an antenna of practically perfect radiating characteristics.

There are two stations, to our knowledge, that have exceeded this figure: WLW and WISH.

Here at WIS the figure is 199. (Our antenna height is .204 wavelength which is below the optimum of .625 λ).

Test Equipment Rack

The test equipment rack shown in the photos was constructed of ¾″ angle iron for the supporting corner legs and ½″ angle iron for the framing of the five shelves. All shelves are 20″ x 28″ and made of ⅜″ plywood; they are spaced 16″ apart except for the bottom shelf, this being 12″. The whole frame is all-weld construction and was made locally at a cost of $19.00. The frame is painted black, the shelves medium gray.

Secondary Studio

(Continued from page 11)

the operator, and turntable 2 is to the left of the operator.

Microphones, Pickups, And Turntables

At present two dynamic microphones[1] are in use. A velocity (ribbon) microphone is on order, and will be used for certain program applications. Several types of microphone stands are kept available for use in different program applications.

Two turntables[2] are employed, while the pickup arms are tuned-ribbon type. The output level of the pickups is considerably greater than that of the microphones. This caused some difficulty, because with the master gain on the amplifier set sufficiently high for microphone operation, the output level of the pickups was so high that records could not be faded down smoothly with the individual faders used on the remote amplifier. This difficulty was overcome by placing a 250 ohm constant impedance *T* pad in each turntable line to lower the output level of the pickups.

Switching Arrangement

The switches employed are of the lever action, anti-capacity type. S_1 and S_2 are associated with the two microphones, the *up* position being monitor (auditioning or cueing), the *down* position being program. Placing S_1 or S_2 in either monitor or program position opens the line to the studio speaker, so that there's no possibility of feedback. When the studio speaker line is opened a 1,000-ohm resistor is placed across the monitor amplifier output, thus keeping a correct impedance match. Using this switching arrangement for cutting the speaker, when microphones are in operation, eliminates the expense of installing a relay system. S_3 and S_4 tied in to the two turntables, in the same manner as S_1 and S_2 are employed with the microphones, except, of course, that S_3 and S_4 do not cut the studio speaker line when placed in monitor or program positions. S_5, as previously mentioned, provides a choice of using mike 2 or turntable 2. S_6 is a *program cut* switch, which merely opens or closes the remote-amplifier output circuit to the telephone line. Terminal strips[3] were used as a means of conveniently

[1] Electro-Voice 635
[2] Rek-O-Kut
[3] Audax 74A

connecting the various leads going to the turntables, mikes, switches, etc.

Monitor Amplifier

A 14-watt p-a amplifier[7] was chosen as the monitoring amplifier. This particular amplifier has two separate input channels, one microphone and one phonograph, each having its own gain control. The mike-input channel is employed for monitoring and cueing purposes, while the phono channel is connected across the telephone line going to the main studios. The phono channel thus serves to monitor programs originating in the LaPorte studios as well as programs originating in the Michigan City studios, since the line is cued at all times at the main studios, when the Michigan City studios are in operation. A matching transformer is used ahead of the microphone (cueing) channel of the amplifier to effect an impedance match from the 250-ohm mikes and turntables to the high-impedance amplifier input. No matching transformer is used on the phono channel. Being a high resistance unit, bridging it across the phone line does not affect the phone line characteristics, and the gain and quality of the amplifier are satisfactory, even though there is an impedance mismatch.

The monitor output is fed to two monitoring speakers; the 500-ohm tap on the monitor output transformer was used, and associated with each speaker is a line to voice-coil matching transformer, and an 8-ohm *T* pad for varying each speaker's volume separately. An 8″ p-m,[8] mounted in wall baffle, is used as a lobby speaker.

Installation Comments

Some hum difficulties were experienced in the original installation. However, proper placement of a-c lines, and common grounding of all the equipment, brought the hum down to a very low level. The frames of the lever action switches were grounded to eliminate hand capacity effects. While the power supply for the remote amplifier is well shielded, it was found that it must be kept some distance away from the desk microphone to completely eliminate hum pickup from this source.

This installation has definitely increased our listening audience, since we can now give adequate service to schools, religious organizations, local news coverage, and the like, in both Michigan City and LaPorte.

MASTER AUDIO SYSTEM

Center section of the master audio control setup being built for WHN. Equipment with six studio-control consoles and twelve audio racks will be installed in the new WHN studios at 711 Fifth Avenue, New York City. At the controls are H. J. Lavery (left) and J. F. Palmquist of the RCA broadcast audio section.

TV TRANSMITTER INSPECTION

J. Leonard Reinsch, kneeling (left), managing director of the James M. Cox radio stations, and chief engineers of three Cox stations inspecting one of the three RCA 5-kw tv transmitters purchased for each of the Cox stations. Left to right: E. L. Adams, WHIO, The Miami Broadcasting Company, Dayton; C. F. Daugherty, WSB, The Atlanta Jonrnal, Atlanta; P. G. Walters, of RCA's Atlanta office; M. C. Scott, WIOD, The Isle of Dreams Broadcasting Corp., Miami; Reinsch; and M. A. Trainer, manager of RCA Television Equipment Sales.

---

[6]Jones
[7]Knight
[8]Jensen

ADVERTISERS IN THIS ISSUE

COMMUNICATIONS INDEX

MAY, 1948

TO MEASURE

- RESISTANCE
- INDUCTANCE
- CAPACITANCE
- STORAGE FACTOR
- DISSIPATION FACTOR

IN

ANY LABORATORY

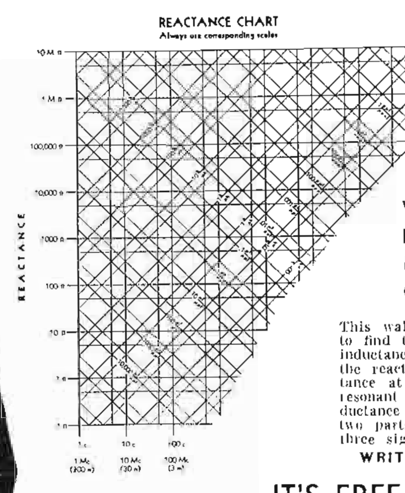
COMPLETELY self-contained, portable and always set-up for immediate use, this impedance bridge is indispensable in any laboratory where electrical equipment is used. No hastily putting together a circuit, finding an oscillator and a detector and then a power supply . . . they are all here permanently assembled in an accurate instrument . . . always ready to use at any time.

Over the major portion of its ranges this bridge is accurate for the majority of routine measurements in any laboratory. The ranges are:

RESISTANCE: 1 milliohm to 1 megohm
INDUCTANCE: 1 microhenry to 100 henrys
CAPACITANCE: 1 micromicrofarad to 100 microfarads
STORAGE FACTOR (X/R): .02 to 1000
DISSIPATION FACTOR (R/X): .002 to 1

The bridge includes built-in standards, batteries, a 1000-cycle tone source for a-c measurements, a zero-center galvanometer d-c null detector, and terminals for a headset for 1000-cycle detection. Provision is made for use of an external generator for measurements over a wide range from a few cycles to 10 kilocycles. Direct-reading dials add greatly to the ease and rapidity with which measurements can be made.

Type 650-A Impedance Bridge . . . $240.00
In Stock for Early Shipment



WRITE FOR THIS REACTANCE CHART

This wall-size chart is designed to find the reactance of a given inductance at a given frequency; the reactance of a given capacitance at a given frequency; the resonant frequency of a given inductance and capacitance. It is in two parts to be read to two or three significant figures

WRITE FOR YOUR COPY

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

COMMUNICATIONS

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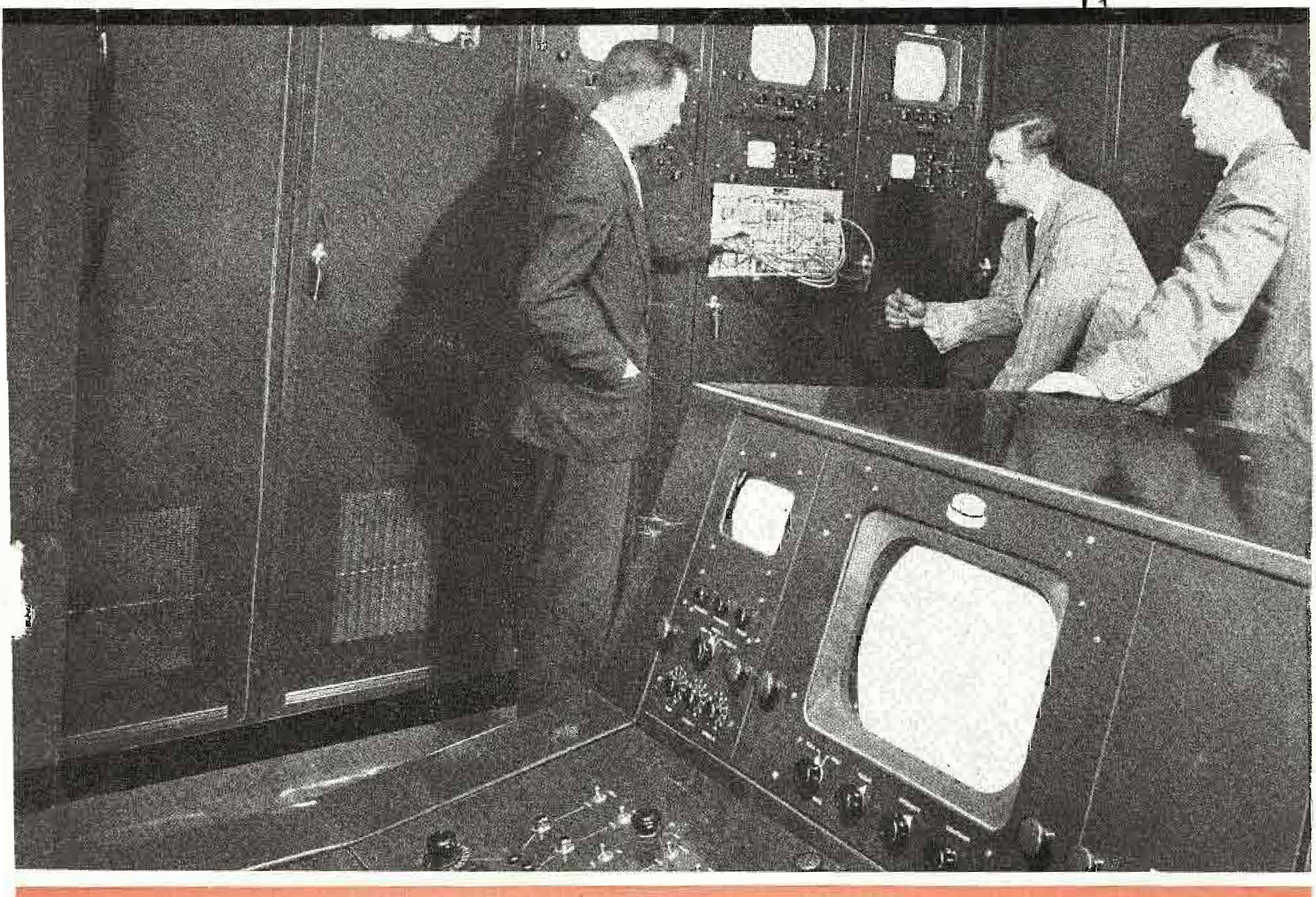


AUGUST

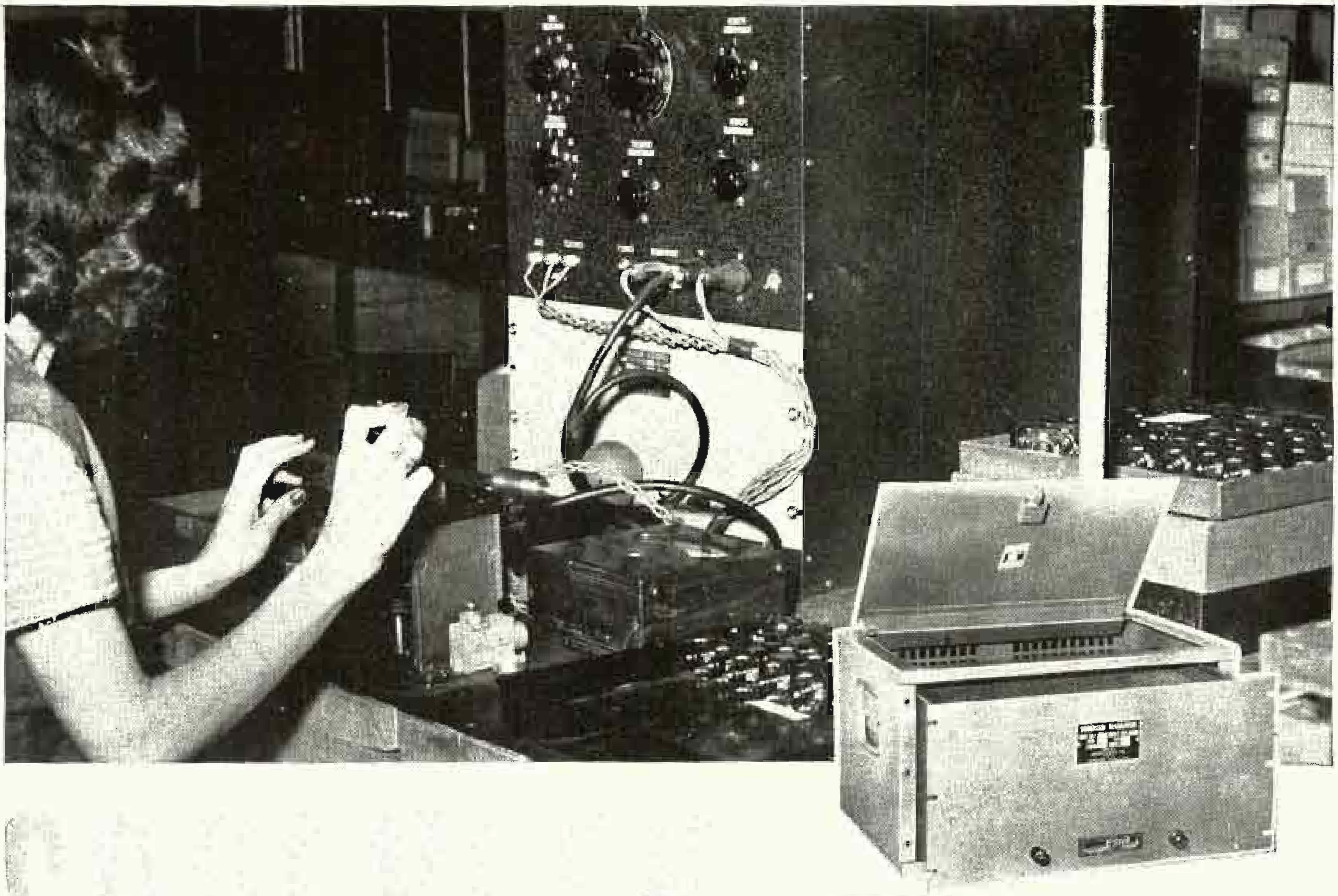
★ DYNAMOTOR DESIGN

★ TV TRANSMITTER MEASUREMENT TECHNIQUES

★ SIGNAL GENERATORS FOR F-M AND ANTENNA MEASUREMENTS

1948

PRECISE VOLTAGE REGULATION FOR TESTING RELAYS



Spencer Thermostat Company uses Sorensen voltage regulators to test their Klixon C-6360 motor starting relay. They say, "Sorensen regulators speed up our testing processes by providing a steady supply of current enabling us to turn out a uniform product."

Model 1000 shown provides full protection of your unit against *OVER LOAD* and *OVER VOLTAGE*.

PROTECTS

Sorensen protects your equipment against over load and over voltage and at the same time provides regulation of 2/10 of 1% with a minimum of wave distortion and wide input ranges. Precision Klixons are themselves assembly line tested with Sorensen regulators. In turn, Klixon units installed in Sorensen equipment provide automatic shut-off of the output in case of over load. In practically all AC and DC units the Heinemann circuit breaker incorporated into Sorensen regulators insures against over voltage.

Write today and arrange to have a Sorensen engineer analyze voltage regulation requirements in your plant. He can select a standard Sorensen unit from 150 VA to 20 KVA to fit your most exacting application.

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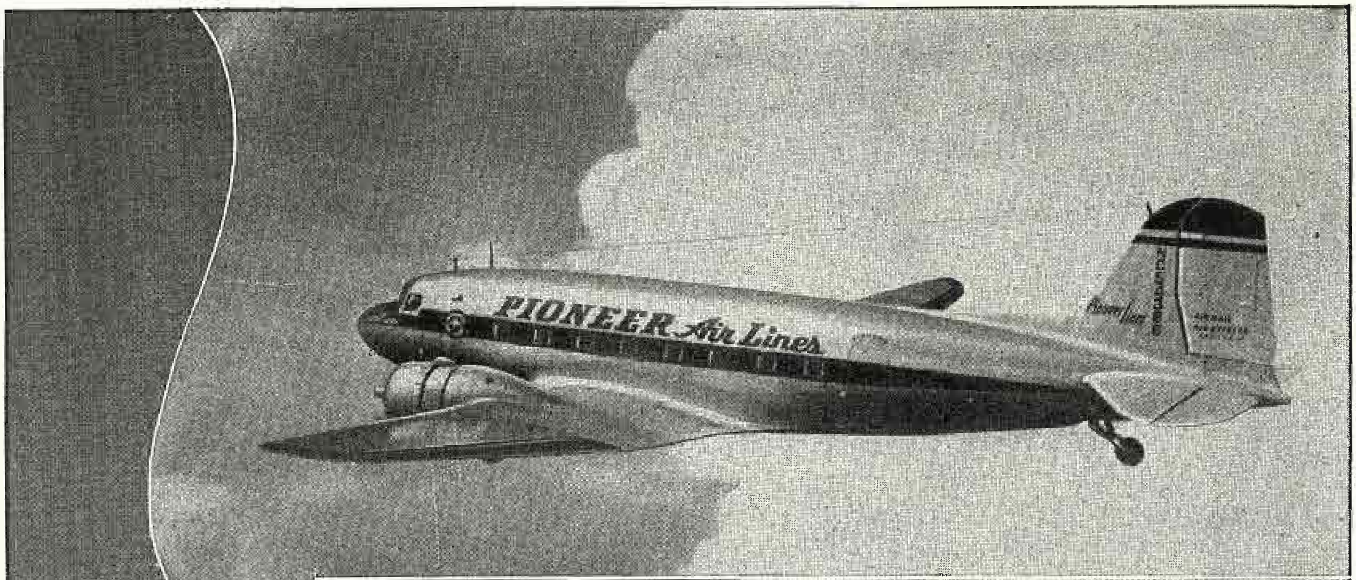


WILCOX - *First Choice of*

PIONEER *Air Lines*

PIONEER EQUIPS GROUND *STATIONS WITH

Wilcox Type 378A Package Radio

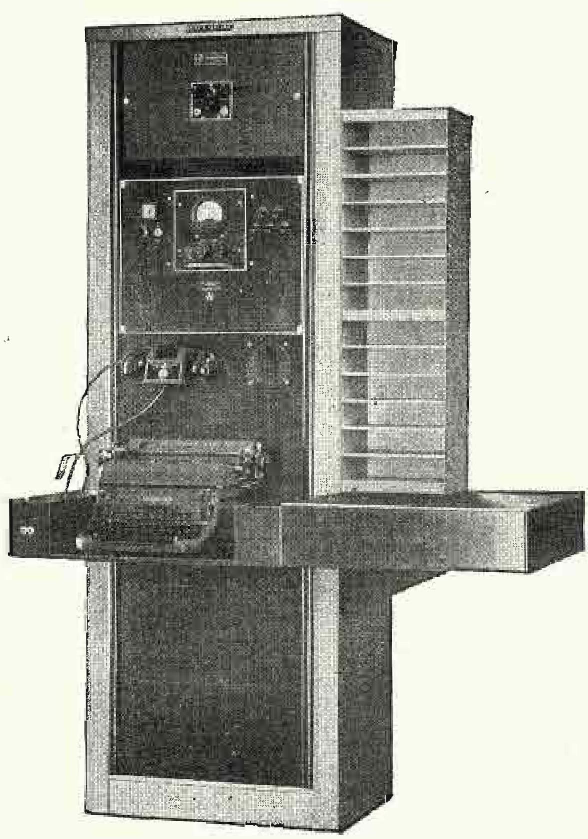
PACKAGE DESIGN SPEEDS YOUR INSTALLATIONS The Type 378A is *complete* from microphone to antenna, ready for connection to power mains. It is designed for aeronautical VHF ground-air communications at smaller traffic centers.

PROVEN COMPONENTS INSURE QUALITY AND PERFORMANCE—The Type 305A VHF Receiver and Type 364A VHF Transmitter (50 watts) are the principal components of the 378A. Long used separately and field-tested by leading airlines, these units are now available in package form.

NEW AIDS TO CONVENIENT OPERATION The telephone handset with its convenient push-to-talk button, serves as both headphone and microphone, with an auxiliary loudspeaker for incoming calls. The 378A includes desk front, message rack, and typewriter space—there are no accessaries to be added.

LOCAL OR REMOTE CONTROL—If desired, the control panel can be removed and the 378A remotely controlled, either by re-installing the panel at the operating position or by simple adaptation to your existing control equipment.

**Pioneer aircraft are also 100% equipped with the new WILCOX Type 361A Airborne VHF Communication System.*



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AUGUST, 1948 **VOLUME 28** **NUMBER 8**

COMMUNICATIONS

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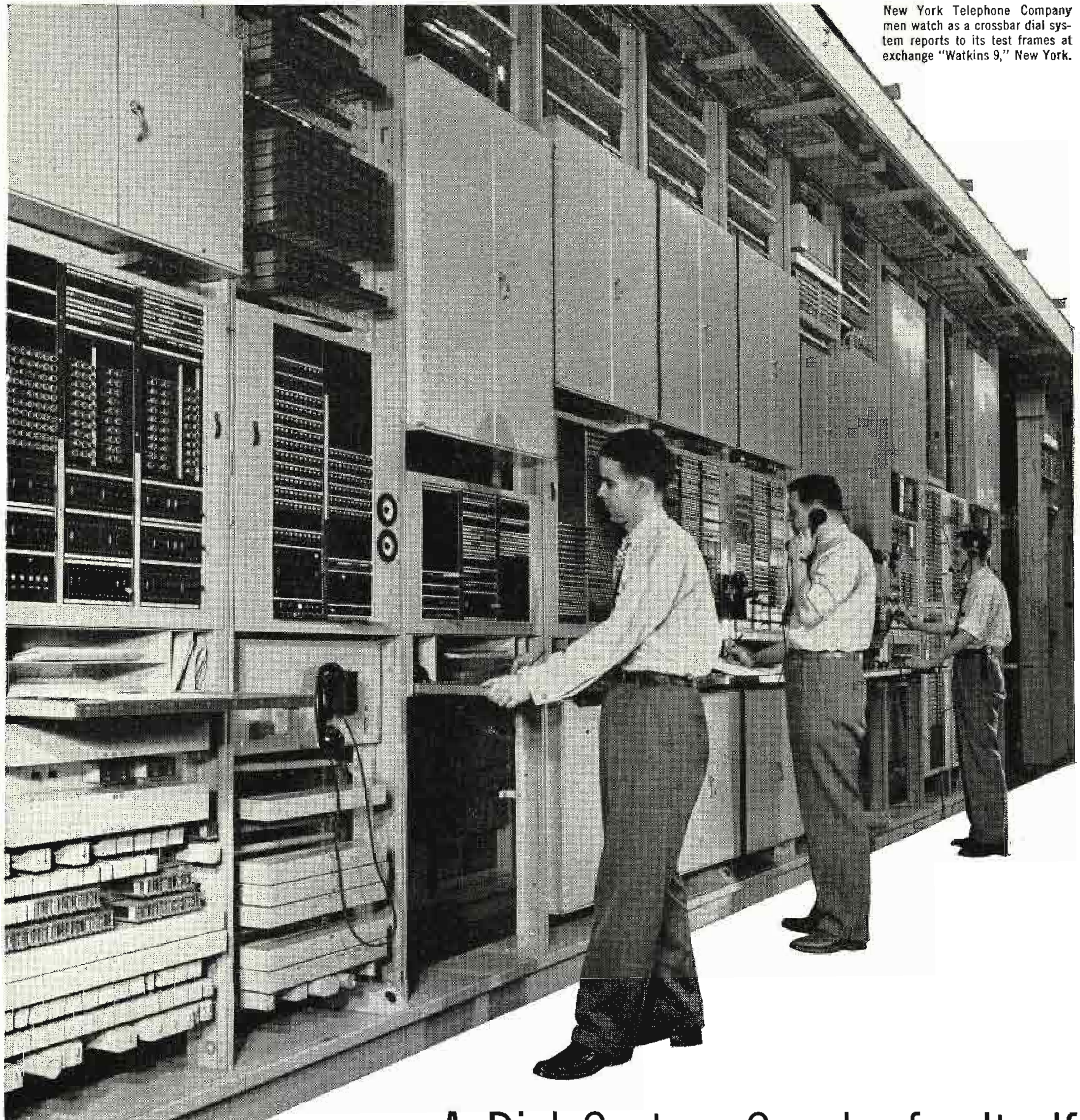
COMMUNICATIONS is indexed in the Industrial Arts Index.

COVER ILLUSTRATION

Master control installation at the DuMont tv network station WTTG, Washington, D. C., which provides synchronizing signal facilities for all the studios in the station and serves as a termination point for picture signals from live-talent and film studios, as well as remote and incoming network programs.

Published monthly by Bryan Davis Publishing Co., Inc.
52 Vanderbilt Avenue, New York 17, N. Y. **Telephone MUrray Hill 4-0170**



New York Telephone Company men watch as a crossbar dial system reports to its test frames at exchange "Watkins 9," New York.

A Dial System Speaks for Itself

As dial systems have been improved, so also have the means of keeping them at top efficiency. Even before trouble appears, test frames, developed in Bell Telephone Laboratories, are constantly at work sending trial calls along the telephone highways. Flashing lamps report anything that has gone wrong, and the fault is quickly located and cleared.

If trouble prevents one of the highways from completing your call, another is selected at once so that your call can go through without delay. Then on the test frames lights flash up telling which highway was defective and on what section of that highway the trouble occurred.

Whenever Bell Laboratories designs a new telephone system, plans are made for its maintenance, test equipment is designed, and key personnel trained. Thus foresight keeps your Bell telephone system in apple-pie order.

BELL TELEPHONE LABORATORIES *EXPLORING AND INVENTING, DEVISING AND PERFECTING FOR CONTINUED IMPROVEMENTS AND ECONOMIES IN TELEPHONE SERVICE*

SECURITY QUIZ

for MANAGEMENT MEN

can you answer these important questions?

How many of your employees are buying U. S. Security Bonds regularly via the Payroll Savings Plan? (35% to 50% of employees buy Security Bonds on the Payroll Savings Plan in those companies in which top management backs the Plan.)

• *How does their average holding compare with the national average?* (The national average among P.S.P. participants is $1200 per family.)

• *Why is it vital—to you, your company, and your country—that you personally get behind the Payroll Savings Plan this month?* You and your business have an important stake in wise management of the public debt. Bankers, economists, and industrialists agree that business and the public will derive maximum security from distribution of the debt as widely as possible.

Every Security Bond dollar that is built up in the Treasury is used to retire a dollar of the national debt that is potentially inflationary. Moreover, every Security Bond held by anyone means fewer dollars go to market to bid up prices on scarce goods.

• *Can't your employees buy Bonds at banks?* Banks don't provide Security Bonds on the "installment plan"—which is the way most workers prefer to obtain them. Such workers want and need Payroll Savings.

• *What direct benefits are there for your company?* In 19,000 industrial concerns operating Payroll Savings, employees are more contented. Worker production has increased, absenteeism has decreased—even accidents have been fewer!

All these benefits accrue *in addition* to extra security for the individual who gets and holds Bonds. (Every $3 invested pay $4 at maturity.)

But even a plan with all these benefits requires the sponsorship of top management for real success.

• *What do you have to do?* The Treasury has prepared a kit of material especially for you to distribute among certain key men in your company. This will be your part in the all-out campaign—starting April 15—for *America's economic security.*

Make sure you get your kit. Be sure to give it your personal attention. Keep the Payroll Savings Plan operating at its full potential in your company. It's a major factor in America's security—*your best business security!*

For any help you want, call on your Treasury Department's State Director, Savings Bonds Division.

The Treasury Department acknowledges with appreciation the publication of this message by

COMMUNICATIONS

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COMMUNICATIONS

LEWIS WINNER, Editor

AUGUST, 1948

Microwave Links

THE U-H-F/S-H-F BANDS of 2,000 to 8000 mc, in the blueprint and pure experimental stage for quite awhile, have teed off the drawing board and out of the lab to become one of tv's best friends. In use in relay links, the microwave bands have been found to be ideal as a point-to-point transmission agent.

Although in use for nearly two years, only recently, with the expanding telecast services, have the relays had a genuine opportunity to prove their commercial merit. The links have been a blessing to new telecasters, permitting them to go on the air with remotes when studios were not completed. And the variety of field programs afforded through the use of remotes has been a boon to the tv'ers.

The enthusiasm for the air links also stems from the wider bands afforded by the radio line over the coaxial cable. Fading and reflection, two of the major problems which worried many, has been overcome in most installations.

Many novel link arrangements are being used by telecasters, particularly where studio facilities are not available. At one New England tv station a leased link with dishpan antennas and a commercial setup with a horizontal dipole is used. The leased link operates at 3930 mc and dipole arrangement at 2000, the dishpan circuit picking up the dipole telecast from the ball park over a 1¼-mile circuit and transmitting to the permanent tv antenna some 5 miles away. At another New England station, leased 3930-mc facilities were used until a commercial 6500 to 7050-mc dishpan link could be installed atop the tv tower. This circuit has served to loop community ball park games, military demonstrations, stadium concerts, as well as programs from New York on the New York-to-Boston repeater link.

The s-h-f line has proved its effectiveness on numerous long-distance links too: New York to Schenectady, New York to Philadelphia to Washington, and Chicago to South Bend. And before the year is over, Chicago may be linked to New York via a microwave link.

Several types of link systems are being used. In one, operating on the 6500 to 7050-mc band, the normal power output for the transmitter is 100 milliwatts, feeding into a 4′ reflector, providing an antenna gain of 5000. Another model is said to have a transmitter output of 50 watts, employing a magnetron oscillator with direct frequency modulation. Frequency range of this system is 1990 to 2110 mc, and antenna gain with a 4′ dish is 320, and 8′ dish, 1280.

Telecasters have found the remote systems extremely reliable. Bugs in some of the fixed link circuits have been ironed out to the point where stations can operate automatically, achieving the unattended classification originally planned.

The successful application of the 2000 to 8000-mc bands for link service has introduced a striking and exciting new field, which is destined to become an extremely vital factor in the communications world, particularly television. In a salute to this new service, the October issue of COMMUNICATIONS will feature a comprehensive report on the status of the art, in which microwave possibilities and tv will be thoroughly probed.

Troposphere and Distance in TV

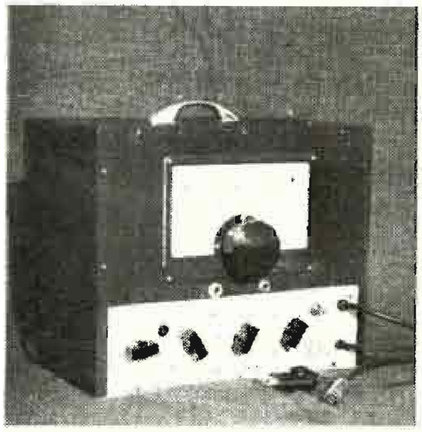
EXTREMELY IMPORTANT DATA disclosing the relation of the troposphere and distance in tv were revealed by T. T. Goldsmith, Jr., director of research of the Allen B. DuMont Laboratories during the recent allocation hearings in Washington. He pointed out that under certain conditions the density, and consequently the dielectric constant of the atmosphere may not decrease continuously and uniformly with altitude. Such conditions may be caused by temperature variations which in turn may be caused by the earth's cooling immediately after sunset, or by the motion of temperature fronts. He stated that a situation may exist in which a dense layer of air occurs a short distance above the earth's surface. Under such conditions, a wave may be trapped between these two boundaries. This produces in effect a parallel plane wave guide and the energy, instead of being uniformly radiated in all directions, is confined and guided along close to the surface of the earth. Such a condition, he explained, may result in the signal strength at a distant point being many times greater than that predicted by the ground wave theory alone. While these effects occur more or less at random and, consequently, cannot be relied upon for a dependable service, Goldsmith explained that they do, nevertheless, provide a very serious interference problem, necessitating the separation of stations considerably further than would be indicated by a consideration of ground wave theory only. He pointed out that at 100 miles on 82 mc the ratio of the actual signal received to that of the ground wave signal exceeds 7:1 for 10% of the time measured, or 50:1 for 1% of the time. Continuing this analysis, Goldsmith said that it is quite probable that the more rapid attenuation of the high frequency ground wave more than compensates for the increasing troposphere factor, with the result that a shorter minimum spacing may be permitted between co-channel stations at the higher frequencies.

JTAC

ON PAGE 34 of this issue appears a questionnaire prepared by FCC at the request of the recently formed Joint Technical Advisory Committee, concerning the status of the 475 to 890-mc band for tv, which will be the subject of a FCC hearing on September 20 in Washington. Answers to these questions would be extremely helpful in formulating decisions at this all-important Washington session.

We urge you to read these pertinent questions and reply to as many as possible. Industry and government will be grateful for your help.—L. W.

High-Output Signal Generator For Antenna Measurements



Front view of signal generator. Controls are, from left to right: Zero set variable capacitor, bandswitch with four positions, modulation with 30%, 50% and 100% points marked, r-f output 1000-ohm control with the power switch on the same shaft, and a *lo-hi* output toggle switch which can be seen above the small scale neon *on* indicating light.

Instrument Particularly Useful for Measurement Work When Station Is Off the Air and There Are Strong Skywaves From Stations Operating on Same Frequency as Antenna Being Measured. High Output Permits Application During Summer Static Periods, Measurement of Antennas With Resistance as Low as 25 Ohms, Checking of Matching Networks and Transmission Lines, Etc.

by **HERBERT G. EIDSON, Jr.**
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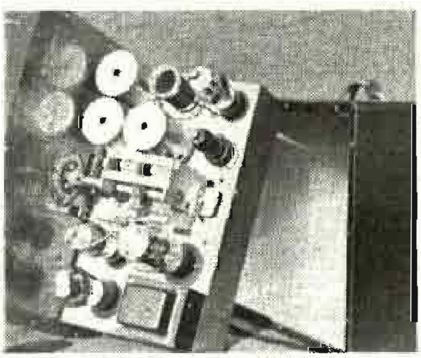
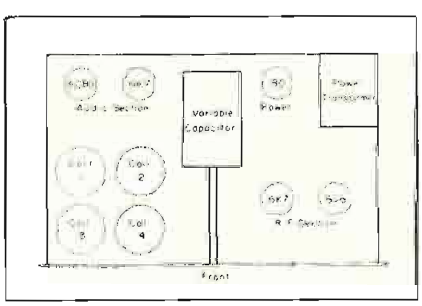


Interior view of the signal generator.

Layout of the generator



In making antenna measurements the usual procedure is to measure the resistance and reactance of the antenna at three or four points on each side of the operating frequency, these points being 5 or 10 kc apart. As there are many stations that operate all the night through, the engineer usually finds himself trying to find a sharp null point on his bridge while a strong *five* session comes pounding through on his 'phones. The remedy, of course, is to use a signal generator with high enough output to effectively override any reasonably strong signal or static which will be encountered. However, it is normally necessary to set the bridge to the limit indicated by the maker of the instrument usually in the neighborhood of ten volts.

Conventional receiver-alignment type signal generators tested, provided output ranges from .1 to 1 volt maximum, an output too low to be effective in combating the aforementioned types of interference.

In view of these characteristic design features, it was decided to build an r-f bridge which would feature:

(*1*) Output at any point, within the standard broadcast band, across a low-impedance output load, at least ten volts.

(*2*) Bandspread, within the above mentioned band, such that points 5 kc apart can be read with accuracy.

(*3*) Stable oscillator, after a few minutes warmup period.

(*4*) Modulator capable of modulating output 100% with a 400-cycle internal tone, with a distortion of not more than ten per cent.

(*5*) Tight shielding so that radiation will be kept to a minimum.

(*6*) Wide-frequency range so that it can be utilized for receiver work.

Signal-Generator R-F Section

A 6K7 r-f oscillator, operating in an electron-coupled circuit generates the r-f voltage which drives the control grid of a 6V6 cathode follower in the generator. The oscillator is tuned by a 14-plate variable capacitor with a minimum capacity of 10 mmfd and a maximum of 250 mmfd. (The larger section of the two-gang capacitor shown in the photograph is not used.) A double-pole, four-position wafer switch is employed to switch in each of four coils (380 to 800 kc, 800 to 1.47 mc, 1.47 to 2.75 mc and 2.75 to

7.1 mc); turn data appears in table 1. Plug-in type standard coil forms are used for ease of initial coil construction. Each coil has a small postage stamp-type variable across it to allow greater ease in dial calibration.

Cathode Follower

The cathode follower provides a low impedance output of approximately 500 ohms at full output. When using the generator for receiver work, a small toggle switch is used to place a 2-megohm resistance in series with the output. Variable output is obtained by using a 1,000-ohm potentiometer in parallel with the 6V6 cathode resistor. A .001-mfd blocking capacitor removes the d-c.

Audio Section

A 6C8 wein bridge audio oscillator is used to generate a 400 cycle tone which modulates the r-f oscillator. Two *RC* combinations in the grid circuit of the first section of the 6C8 control the frequency of oscillation.

The output of the modulator is introduced into the grid of the cathode follower, along with the r-f voltage from the r-f oscillator, using the Heising system of plate modulation. A 47,000-ohm resistor is used to drop the r-f oscillator plate voltage so that 100% modulation is possible.

10,000-Ohm Variable Used

A 10,000-ohm variable resistor, which varies the bias on the 400-cycle oscillator and controls the severity of oscillations, is a screw driver slot type pot mounted so that it can be adjusted by removing a small cover plate on the front panel. This adjustment is critical with line voltage and it will be found that there will be no oscillations when the supply line voltage is low unless an adjustment is made.

The S_2 Switch

A switch (S_2) provides a means for removing the audio modulating voltage from the output. It is on the shaft of the volume control which controls the amount of 400-cycle modulation. The dial is calibrated in percentage of modulation and can be done with the help of a 'scope.

Band	Frequency Range	Description
1	380-800 kc	155 turns #30 enameled solid wire, tapped at 35th turn from bottom.
2	800 kc-1.47 mc	65 turns #30 enameled solid wire, tapped at 22nd turn from bottom.
3	1.47-2.75 mc	50 turns #20 enameled solid wire, tapped at 16th turn from bottom.
4	2.75-7.1 mc	22 turns #20 enameled solid wire, tapped at 9th turn from bottom.

Table 1
Coil data.

Input/Output Jacks

Two jacks are placed in the modulator stage, for *input* and *output*. The former can be used when an external oscillator is desired to be used, while the latter can be utilized for obtaining a 400-cycle test tone for other uses.

R-F Filtering

R-f is filtered out of the power cord by the use of 80 millihenry chokes in each lead, bypassed on each side to ground by .01 mfd capacitors. The output line is made up of four feet of flexible single conductor shielded microphone cable fitted with two alligator clips at the end. (For use with an r-f bridge, a special shielded plug must be used.)

Cabinet

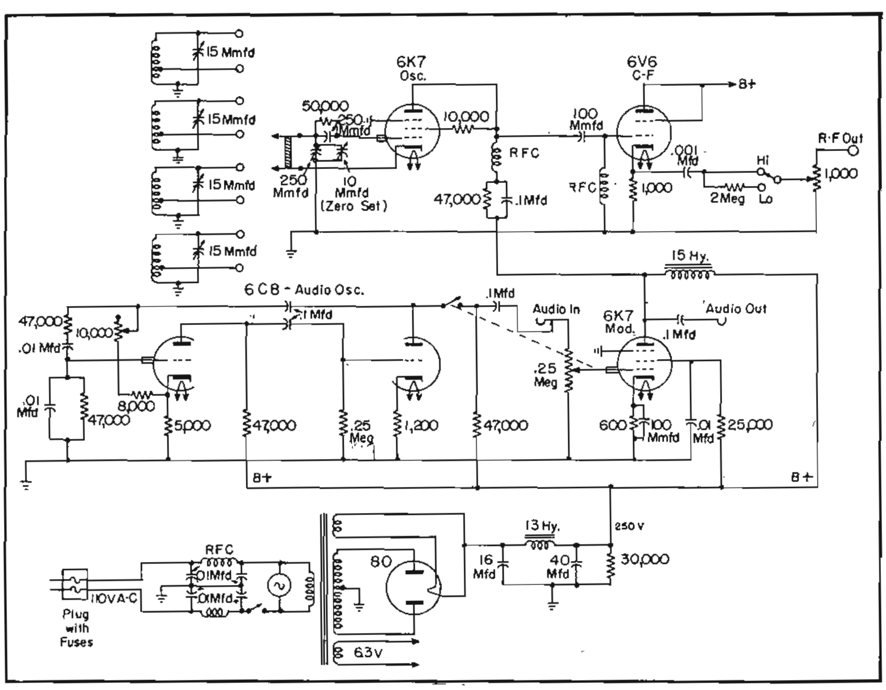
The cabinet (10¾" high, 13¼" wide and 8" deep) is made up of ⅜" plywood, covered with imitation black leather cemented on by waterproof lineolum paste. The inside of the cabinet is well shielded with thin aluminum sheeting, held into place with small wood screws and tacks.

Calibration

The simplest method of calibration is with a signal generator, known to be reasonably accurate, and a communications type receiver. Calibration of the standard oscillator should be checked by beating its output against stations whose frequency is known (i.e., broadcasting stations, WWV transmissions). To fill in the gaps in frequencies above the broadcast band, harmonics can be used. When this oscillator is calibrated, the composite instrument can be calibrated by beating its signal against that of the known oscillator. Light pencil marks are made on the cardboard dial face initially and then are later neatly inked over.

Tests

The signal generator has been operating now for several months and has performed satisfactorily in every way. Strong barmonics have been found up to 30 mc which can be used in alignment of short-wave receivers.



Circuit diagram of the unit. (S_2 mentioned in text is in plate circuit of 6C8.)

TV

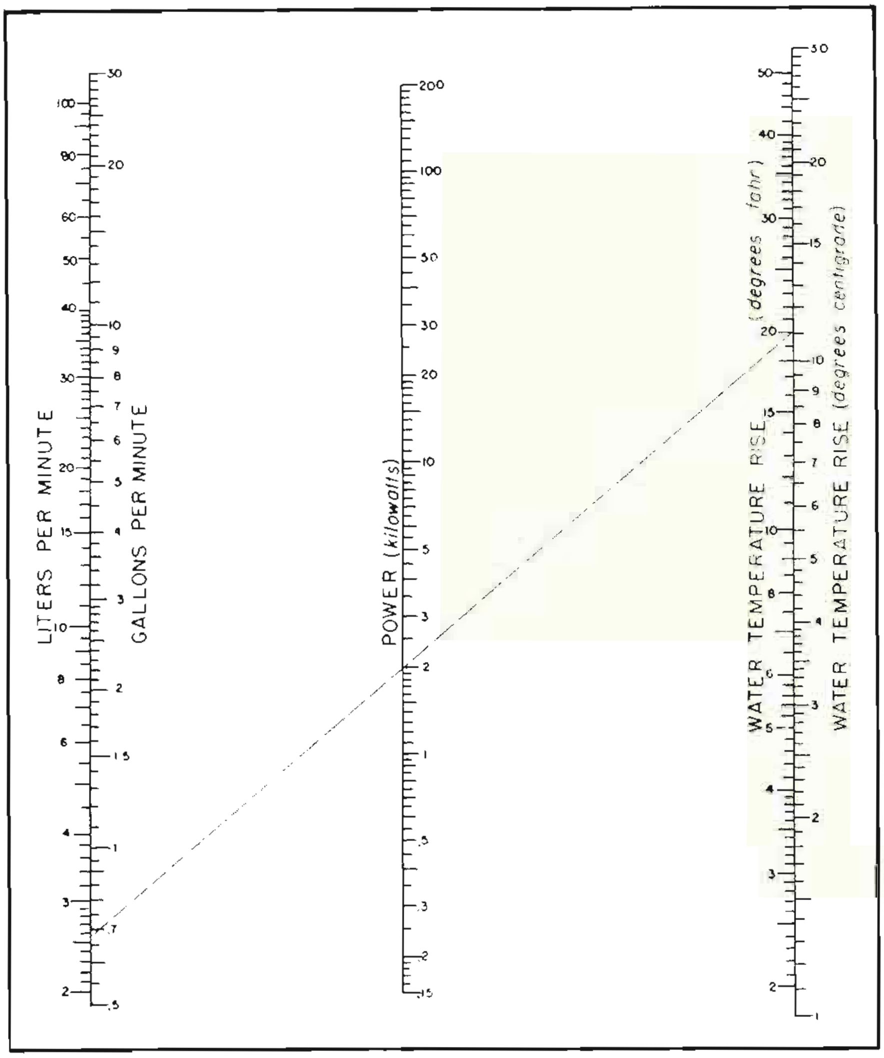
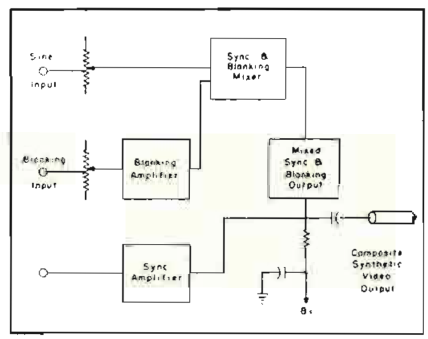


Figure 1
Nomograph for power dissipated in water-cooled devices (*Courtesy FTR*)

Figure 2
Block diagrams of synthetic composite video mixing systems.



Measurement of power output at high frequencies presents problems not present at lower frequencies, since instruments for voltage and current applications are not yet available. In addition to instrument limitations, their inclusion would upset the resonant circuits. One satisfactory method, however, is the calorimeter method. In this system, the transmission line to the antenna is disconnected and terminated with a pure resistance equal to the characteristic impedance of the line. The dummy load is of special design which presents a proper resistive match, and is also geometrically designed so that it is coaxially installed in the transmission line. A coolant is passed over the resistance element and the temperature differential between input and output is determined. Rate of flow of the coolant is measured in volume per unit time. Power dissipated in the load resistance is then calculated from the temperature differential, rate of flow, and specific heat of the cooling fluid. Since water is the usual coolant, a nomograph, such as illustrated in Figure 1, may be used for a semi-direct indication. It must be remembered that to determine peak power output, it is necessary that sync modulation be applied so that 25% of the total output amplitude is represented in sync signal. This percentage may be determined by means of an r-f percentage modulation 'scope or other means previously described. Assuming the correct modulation percentage of sync, a factor of 1.68 is used to convert the average power output (as determined by the calorimeter method) to speak power output. After determining the peak power output, it may be desirable to calibrate the transmission line voltmeter for future reference. The voltage (corresponding to peak power) may be determined from the relation:

$$W_{pk} = \frac{V^2}{Z_o}$$

or

$$V = \sqrt{W_{pk} Z_o}$$

Where: W_{pk} = peak power output in watts calculated from the dummy load measurements and using the 1.68 conversion factor.
Z_o = characteristic impedance of the transmission line.
V = rms voltage on transmission line.

Calibration is effected by varying the coupling of the diode into the transmission line r-f field—adjustment being correct when the voltmeter reads the voltage as determined in the previous calculation.

Measurement of Transmitter Regulation

Transmitter regulation is the change in peak signal amplitude from an all-white to all-black picture. This figure gives an overall indication of the impedance of all power supplies, operation of d-c restorer, a-c line supply, r-f driver impedance, etc. Any of the modulation indicators may be used for this measurement; however, the most r-f convenient instrument is a r-f waveform monitor[1] which is calibrated

Transmitter Design

directly in percentage modulation. A setup is made for white picture signal whose sync to video ratio is 30/70. Modulation is adjusted for sync down to 75% of peak and white down to 15% of peak. The modulation indicator is set to peak signal = 100%. The video input is then changed to a totally black picture (sync only) whose amplitude is the same as the sync level for a white picture. Decrease of total amplitude may be measured directly in percentage on the r-f 'scope, and the change in amplitude from the 100% value is the total regulation. The minimum standard of the change in peak signal amplitude from an all-black to all-white picture shall not exceed 10% of the signal amplitude with an all-black picture. This factor should be measured with the transmitter operating under conditions of rated peak power output.

Measurement of Output Variation

Variation in output is the change in peak amplitude during a period not exceeding one frame in length. The r-f 'scope previously described is most satisfactory for this measurement. Since noise levels may change with modulation amplitude, it is desirable to measure output variation under conditions of black picture and white picture. In either case the procedure is the same. The 'scope is adjusted to give 100% modulation for the maximum signal excursion during the frame period, and measurement is made of the lowest value of sync peak during the same interval. The change in amplitude from the 100% reference value is the variation in output. The minimum standard of the variation of output shall not exceed 5% of the average of the peak signal amplitude. This factor should also be measured with the transmitter operating under conditions of rated peak power output.

Measurement of Amplitude Versus Frequency Response

An amplitude versus frequency response characteristic is a description, by means of a graph, of the ratio of sine wave output voltage to input voltage applied to the input terminals of

(*Continued on page 32*)

[1]DuMont type 5034-A.

Part IV. . . . Concluding Installment. . . . Covering Measuring Techniques: The Measurement of Transmitting Power Output (Calorimeter Method), Measurement of Transmitter Regulation and Output Variation, Measurement of Amplitude Versus Frequency Response, and Measurement of Transient Response.

by G. EDWARD HAMILTON

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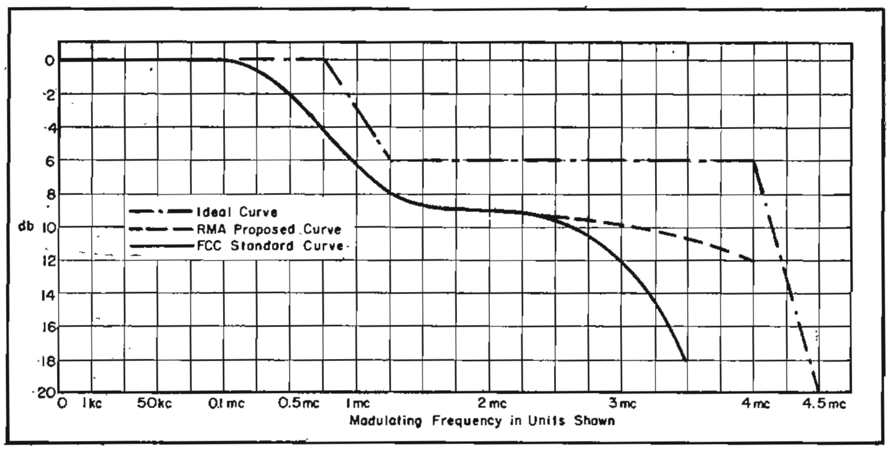
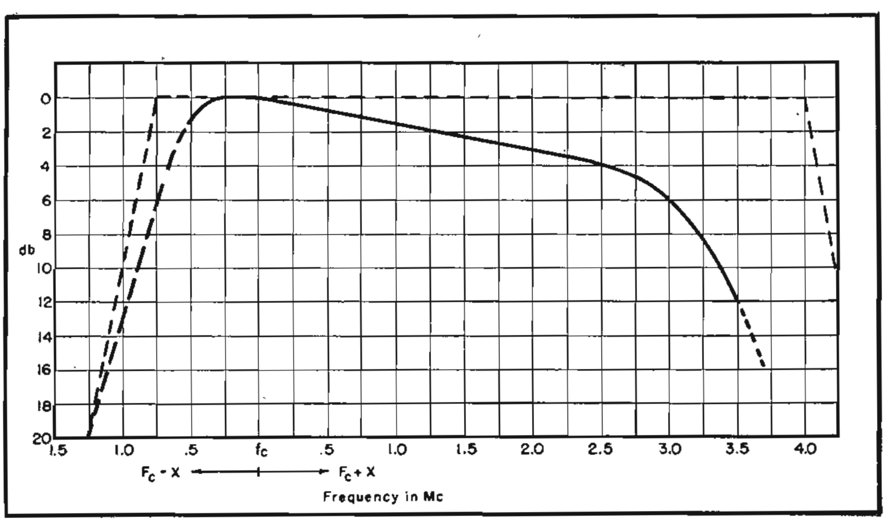


Figure 3
Curve showing how the amplitude response of a tv transmitter may vary with respect to frequency from the ideal characteristic.

Figure 4
Pass band of the r-f output characteristic required to produce the amplitude-response characteristic as specified by the FCC.



APPLICATIONS OF SCREEN-GRID SUPPLY Impedance In Pentodes

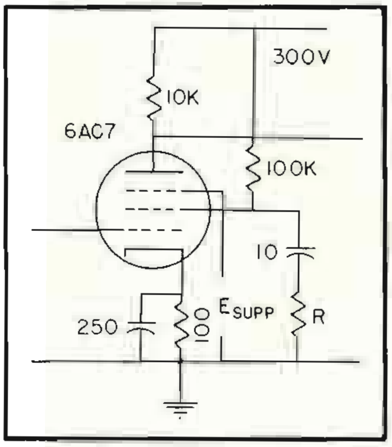
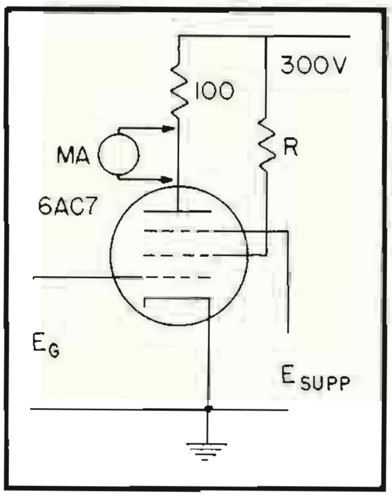


Figure 1
Experimental amplifier.

IN THE NORMAL METHOD of operation a single-stage amplifier will produce a phase reversal between the input and output voltages. Pentodes when operated in this way have a screen-grid voltage supplied by a source with a very low internal impedance. It is known that the screen-grid supply impedance will produce a degenerative effect, decreasing the gain of the amplifier.[1] Further study has indicated that this effect might be increased to the point where the amplifier gain would be zero, and that a still greater increase in screen-supply impedance would cause the amplifier gain to increase from zero, but with opposite phase.

Figure 2
Circuit for drawing static curves.

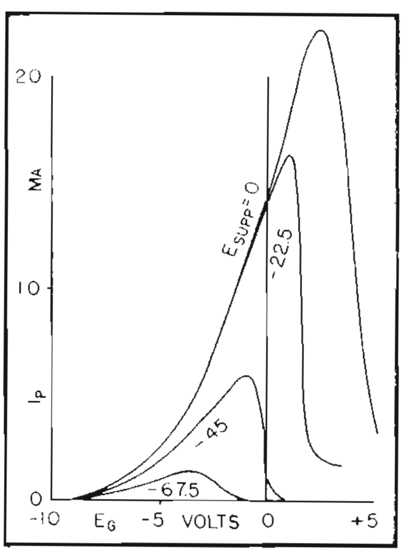


Experimental Results

Since constants such as $\mu_g - \mu_{sg}$ and $\mu_{sg} - \mu_p$ are not commonly supplied by manufacturers it is difficult to calculate the magnitude of these effects. Therefore the single-stage amplifier shown in Figure 1 was set up with provision for varying the a-c impedance of the screen-grid supply without affecting the d-c supply. With the suppressor grid grounded, the gain of the stage dropped to one-half of its original value when *R* was increased from zero to 100,000 ohms. However, with a negative bias of 45 volts on the suppressor the gain decreased to zero when *R* was adjusted to 7,500 ohms. This effect indicated that the magnitude of the effect of a-c screen-grid voltage on plate current was equal to that of the control-grid voltage, and opposite in direction. With a further increase of *R* the gain increased, the output voltage of the plate then being in phase with the control grid voltage. Evidently the negative bias on the suppressor grid caused the formation of a space charge between the screen grid and suppressor grid, which effectively increased $\mu_{sg} - \mu_p$.

In order to study this effect, with a view toward practical applications, a series of static curves was plotted for circuit of Figure 2. These curves, Figures 3 and 4, indicated that the plate current reached a maximum with a certain value of control grid voltage, and decreased on each side of this value. This characteristic is a function of both suppressor grid bias and

Figure 3
Characteristics of suppressor grid voltage as parameter.



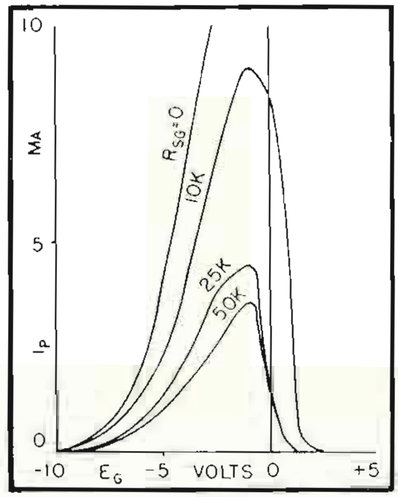


Figure 4
Characteristics of the screen-grid supply resistance as parameter.

Figure 5
Phase inverter.

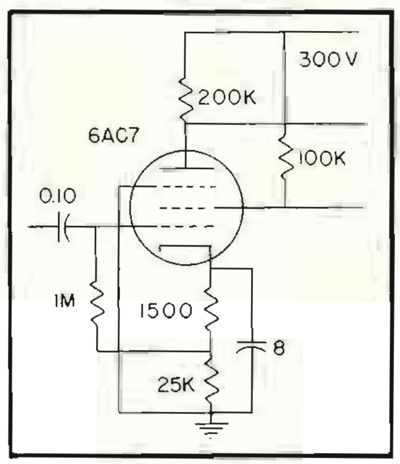
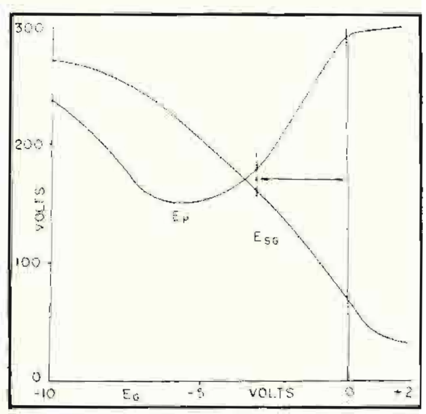


Figure 6
Static characteristics of phase inverter.



Analysis Shows That the Phase of the Output Voltage of a Pentode Amplifier Can Be Reversed by Insertion of an Impedance in the Screen Circuit. Interpretation Has Provided Development of Several Circuits, Such as a Phase Inverter, A-C and D-C Coupled Trigger Circuits, Relaxation Oscillator and Negative-Resistance Oscillators.

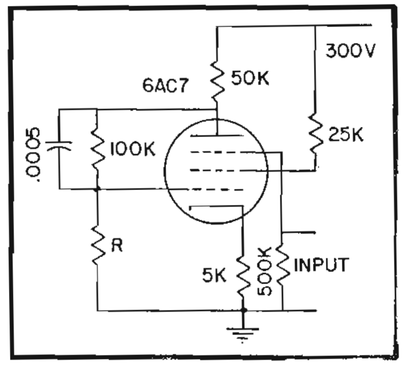


Figure 7
A d-c coupled trigger circuit.

by PETER G. SULZER

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screen grid supply impedance, and is not observed with zero screen grid supply impedance. The negative slope to the right of the maximum suggests various applications.

Phase Inverter

Since the plate and screen grid voltages are 180° out of phase, the circuit may be used for driving a push-pull amplifier. In Figure 5 appears a circuit that gave good results. The voltage gain from control grid to either output was about 30, which is comparatively high for a single-tube phase inverter. The curves of Figure 6 which give the static characteristics of the circuit, indicate that the balance is good and the distortion low. The arrow indicates the normal operating range of the circuit as a class *A* amplifier. If an exact balance is required it can be obtained conveniently by varying the plate-load resistance. If the screen-grid resistance is changed in an attempt to secure a balance, it is found that the output of the plate circuit varies also, which makes adjustment difficult.

D-C Coupled Trigger Circuit

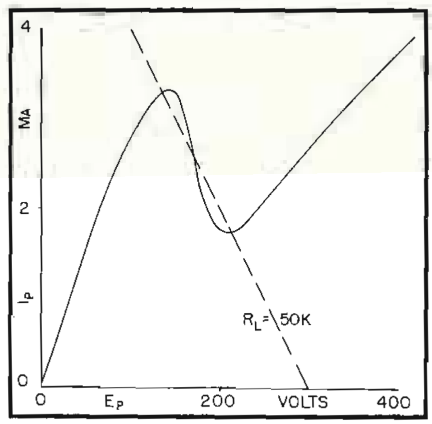
By providing a d-c path from the plate back to the control grid, as in Figure 7, a trigger circuit having two stable conditions of operation can be obtained. A plate characteristic for this circuit appears in Figure 8; it will be noted that there is a negative slope over part of the plate voltage range. If a load resistance is inserted, as shown by the broken line, there will be two equilibrium values of plate current and voltage.[2] The circuit may be shifted from one condition to the other by changing any of the electrode voltages. It is convenient to use the suppressor grid for this purpose, since it is normally returned to ground. A small positive voltage applied to the suppressor grid will give the higher value of plate current, while a small negative voltage will give the lower one. This circuit has various applications,*** such as an amplifier for phototubes, or a frequency divider. Since the suppressor grid current is very small, it may be used for measuring small currents by developing a voltage across a high resistance connected between the suppressor grid and ground. This application has been used as an alarm connected to a vacuum system. The current from the collector of an ionization gage passes through the above-mentioned resistance, and operates a relay in the plate circuit, which in turn operates a buzzer.

A-C Coupled Trigger Circuit

By replacing the d-c path from plate to control grid with a capacitor it is possible to obtain a circuit having

(*Continued on page 37*)

Figure 8
Plate characteristics of d-c coupled trigger circuit.



**Formerly with Radio Propagation Unit, Holabird Signal Depot, Baltimore, Md.*

***This paper is based on research conducted prior to present affiliation.*

****Trigger circuit application also applicable to the phantastron.*

Figure 10
Relaxation oscillator.

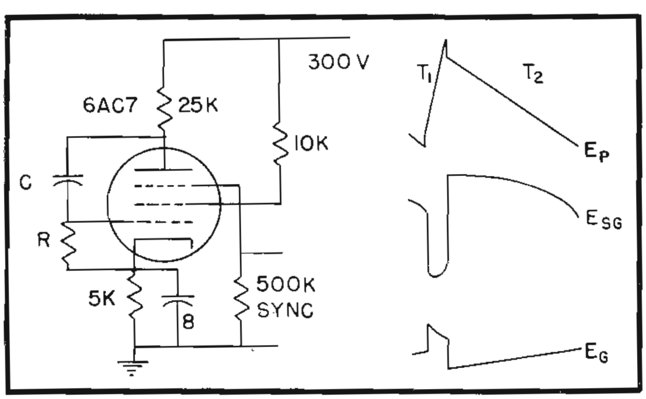
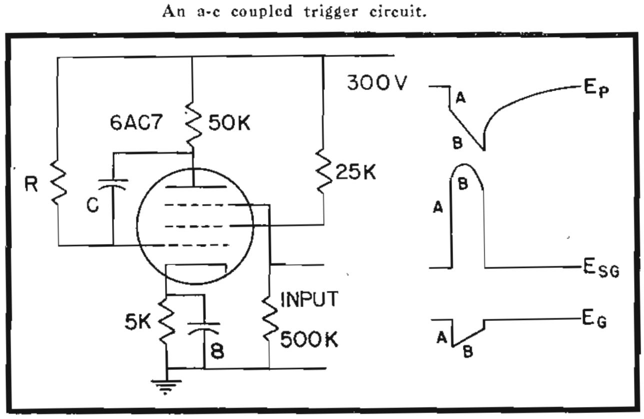
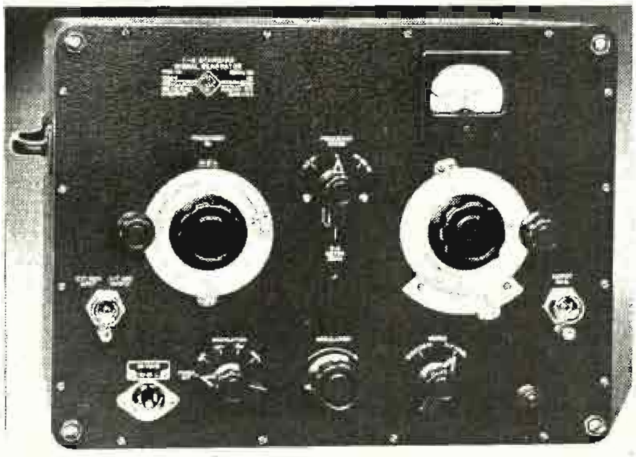


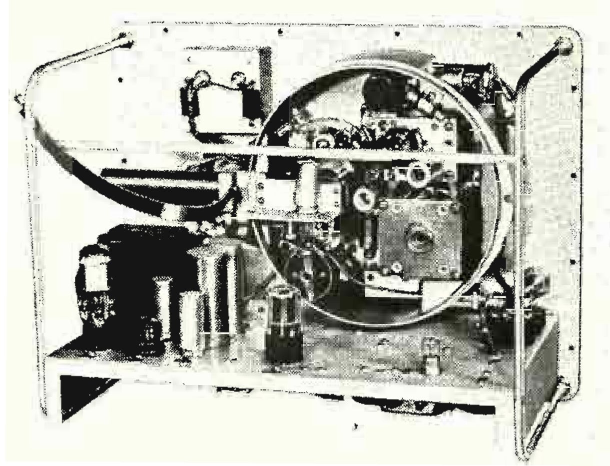
Figure 9
An a-c coupled trigger circuit.



Panel view of the f-m signal generator. Note the adjustable indicator and auxiliary scale for standardizing the attenuator in terms of the meter reading



View of the chassis from the rear. All r-f components are mounted within the cylindrical casting. The spun aluminum cover is held in place by the flexible strap shown at left.



A Standard Signal Generator For F-M Broadcast Service*

by DONALD B. SINCLAIR

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Signal Generator For Testing F-M Receivers Features Oscillator-Reactance Circuit, Adjustable Indicator and Auxiliary Scale For Standardizing Attenuator in Terms of Meter Reading, and Thyratron 6AQ6 6H6 Rectifier and Regulator Circuit.

During the war, our labs accumulated quite a bit of experience with f-m standard-signal generators. We had developed a beat-frequency generator for the old f-m broadcast band, and this was adapted to different frequency ranges, both by changing the separation between the fixed and variable beating frequencies and by multiplying the beat frequency with electronic frequency multipliers. The performance of the resulting generators, however, was not entirely satisfactory. Spurious beats were always a problem, particularly in covering wide frequency bands, and difficulty was experienced in obtaining outputs of more than a few millivolts. Output tuning, in turn, introduced extremely difficult ganging problems.

Other approaches were therefore tried. The frequency ranges to be covered were wide, and reactance-tube modulators were not found satisfactory. A standard-signal generator using a Miller-tube modulator was found to perform well, but very accurate tracking of the plate tuning of the Miller tube with the oscillator tuning was found necessary, and the instrument was fussy to build and adjust. A design was finally attempted, again based on the beat principle, in which the then new butterfly circuits and lighthouse tubes were used to generate higher frequencies than those previously used. This generator covered a frequency range of 20 to 250 mc, with beating frequencies in the neighborhood of 600 to 800 mc. It gave adequate performance but was large and expensive, required considerable power input, and was not completely finished when it was turned over to the Cambridge Field Station of the Watson Laboratory at the end of the war.

It was decided, at this time, that a simpler design was necessary if a satisfactory commercial standard-signal generator was to be obtained. Experience had shown that narrow frequency ranges were very much easier to produce than wide. The limited objective of obtaining coverage of the r-f and i-f channels for the f-m broadcast service was therefore accepted.

The fundamental requirements of the instrument appeared to be:

(*a*) A band covering the 88- to 108-mc r-f range.

(*b*) A band centered at the 10.7-mc standard RMA i-f.

(*c*) A deviation range up to at least 200 kc for sweep-generator applications.

(*d*) Low modulation distortion.

(*e*) Low incidental a-m.

(*f*) An output range from 0.1 μv to at least 0.1 volt and preferably 1 volt.

(*g*) Shielding adequate for operation at the 0.1 μv level.

Oscillator-Reactance Tube Circuit

It seemed feasible to accomplish these objectives with a reactance-tube

*From a paper presented at the New England Radio Engineering Meeting.

modulator, and an oscillator working directly into a mutual-inductance-type attenuator; Figure 1.

This somewhat unorthodox circuit, patterned after the stable circuit described by J. K. Clapp,[1] was chosen both because it is inherently a stable circuit and because it gives a deviation that varies only slowly with the oscillator frequency.

In this circuit the tuning is accomplished by a variable-capacitor section in series with the tuning coil in the grid-plate path and a ganged section between grid and cathode, while the reactance tube is connected across a fixed capacitor in the plate-cathode path. The series capacitance around the plate-grid-cathode-plate loop varies inversely as the square of the frequency. At low frequencies the fixed plate-cathode capacitance plays a considerable part in determining the oscillator frequency. As the frequency is raised, however, it has less and less effect, as its reactance becomes progressively smaller and smaller compared with the reactance of the variable capacitance. There is therefore a tendency for the deviation to decrease as the frequency is raised, and it actually turns out that the deviation varies inversely as the frequency instead of directly as the cube.

This relatively slow variation of deviation with oscillator frequency is desirable because little compensation is needed to make the deviation independent of oscillator-frequency setting.

To obtain a deviation independent of oscillator frequency with the circuit illustrated it is necessary that the capacitance deviation produced by the reactance tube should increase linearly with the frequency. Over a narrow frequency range, however, an increase following a square-power low is satisfactory. It was found that a variation of this kind took place quite automatically in the 88- to 108-mc range because of resonance rises in the grid and plate circuits between the interelectrode capacitances of the reactance tube and the lead inductances. Proper choice of components and mechanical layout were therefore substituted for a ganged compensation system.

Output System

A novel mutual-inductance attenuator and voltmeter developed by Dr. A. P. G. Peterson for a higher frequency standard-signal generator was found very well adapted to this instrument and was incorporated substantially without change.

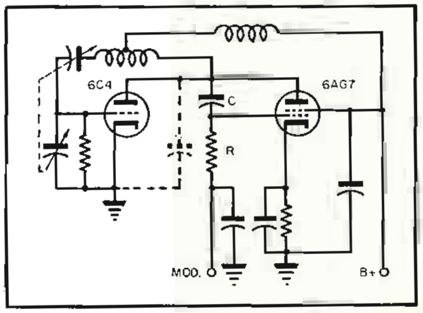


Figure 1
Basic oscillator reactance-tube circuit.

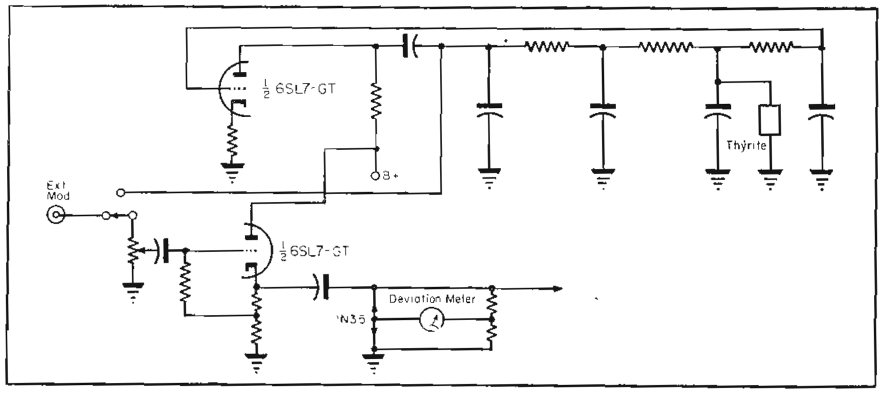
It has been our experience that the maximum voltage output from a standard-signal generator is never quite enough and that, therefore, as much as possible of the generated power should be available at the output terminals. The best way of obtaining this maximum output appears to be to use a sending-end termination at the pickup loop, and a smooth connecting system of the same characteristic impedance that can be extended by coaxial cables to the point where the voltage is needed. This system gives constant open-circuit voltage and constant output impedance, equal to the cable characteristic impedance, at any point along the circuit. No power is wasted in attenuators or receiving-end terminations, and the open-circuit voltage is less than that induced in the pickup loop by only the small attenuation in the cables.

The principal difficulty in making successful output systems of this kind at high frequencies has been to obtain a satisfactory mechanical design that would incorporate a loop yielding adequate pickup, and a resistance termination having no appreciable reactance. These apparently incompatible requirements were mutually solved in the design by making the pick-up loop an open-wire transmission line of the same effective characteristic impedance as the coaxial line it feeds, and placing the terminating resistance in a well, where it terminates the loop. The lumped capacitances to ground at the ends of the loop are actually balanced against the distributed capacitance and inductance of the loop itself so that the loop becomes a π-type artificial-line section of the proper characteristic impedance, and the length of the resistor leads and the well diameter and depth are proportional to minimize the termination reactance. Satisfactory performance can be obtained with this system at frequencies up to 500 mc, and the principal departure from perfection at frequencies up to 108 mc is the tolerance of $\pm 2\%$ in the resistance of the carbon resistor and variations in the characteristic impedance of the cable.

The method of monitoring the input is also of interest. Transverse magnetic fields attenuate down a pipe at a rate of 32 db/diameter, while axial magnetic fields attenuate at a rate of about 67 db/diameter. It is desirable to excite the attenuator with only one of these fields, so that the field distribution will not vary down the pipe and the calibration in db will be linear. A mode suppressor was therefore placed across the mouth of the attenuator to minimize any axial field. It consists of brass strips, soldered across the attenuator opening, that are bent to conform with the magnetic field of the TE1-1 mode in a wave-guide of circular cross-section. The currents induced in these strips by any axial component of field effectively cancel that component in the immediate vicinity. A monitoring loop across the mouth of the attenuator, outside the pipe but in close proximity to the mode suppressor, therefore lies in a field that is of the same type as that in the pipe itself. It has been experimentally confirmed that the ratio of the voltage induced in the monitoring loop to that induced in the pickup loop at any given attenuator setting is constant, inde-

(*Continued on page* 35)

Figure 2
Modulation circuits.



[1] March, 1948, IRE.

Dynamotor Design

Nine Factors Involved in Dynamotor Design: Wattage Output and Input, Ripple Requirements, Continuous or Intermittent Duty, Ambient Temperature Conditions, Regulation, Weight and Size, Starting Characteristics, Service Conditions, and Vibration Requirements.

by K. H. FOX

Chief Engineer
Bendix Aviation Corp.
Red Bank Division

A DYNAMOTOR, which is a combination motor and generator wound on a single iron stack, differs from a motor generator because it has only the common iron system, while a motor generator has separate iron circuits. Because of the common use of the iron by both the input and output, the action of a dynamotor is different from that of a motor generator. The output voltage, which cannot be regulated by changing the field excitation, could be expressed as follows:

$$E_{output} = \left[E_{in} - I_{in} R_{in} \frac{T_{out}}{T_{in}} \right] - I_{out} R_{out}$$

That is: The output voltage is equal to the input voltage minus the voltage drop in the input circuit (which is the voltage directly applied at the input commutator), times the turns ratio of output to input, minus the voltage drop in the output circuit. If the previous formula were analyzed, it would be noted that neither the speed or field excitation or flux appear in it. This is perfectly true, and it is one of the major features in the use of a dynamotor. When the input voltage varies, as it will on a battery or generator circuit, the output voltage changes by the same percentage. Inasmuch as the turns ratio is fixed once a unit is wound, there is no way of changing this ratio for purposes of controlling the output voltage.

Wattage output will be the governing factor in deciding the size of a unit. To maintain a normal temperature rise, the unit must be of sufficient size to dissipate the heat generated from the loss wattage of the unit. For instance, a 20-watt output dynamotor with 50% efficiency would have to dissipate approximately 20 watts of heat, while a 200-watt unit with 60% efficiency would have to dissipate approximately 130 watts of heat. (For a general illustration, it is assumed that all the losses are converted to heat.) The heat dissipation is handled in two ways. The first is to have a totally enclosed unit and to depend on the transfer of heat from the external surfaces. This unit will be the larger of the two classes. In the second method an integral fan is attached to the unit to draw air through it and thus cool it more effectively. By using a fan, the rating of a unit can be raised approximately two and a half times over the totally enclosed rating.

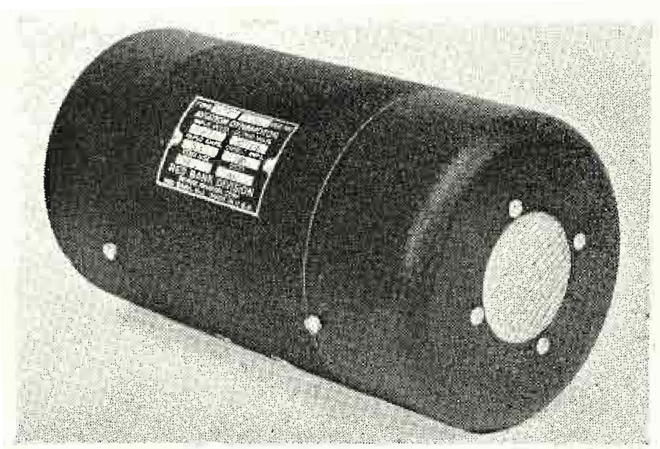
The heat losses may not be the limiting factor for a given wattage output. As wattage is made up of both voltage and current, an excessively high voltage with a small current may require a larger unit for the same wattage output, because the high voltage in the armature will require more room for extra insulation, and also creepage paths must be longer for external circuits. These extra precautions increase the size of a unit.

Input voltage also affects the size of a unit. For the same wattage output a 6-volt input unit will be larger than a 26-volt input unit. This is due to the fact that the current for the 6-volt unit is considerably higher than that for the 26-volt input. That means larger wire, bigger commutators and brushes.

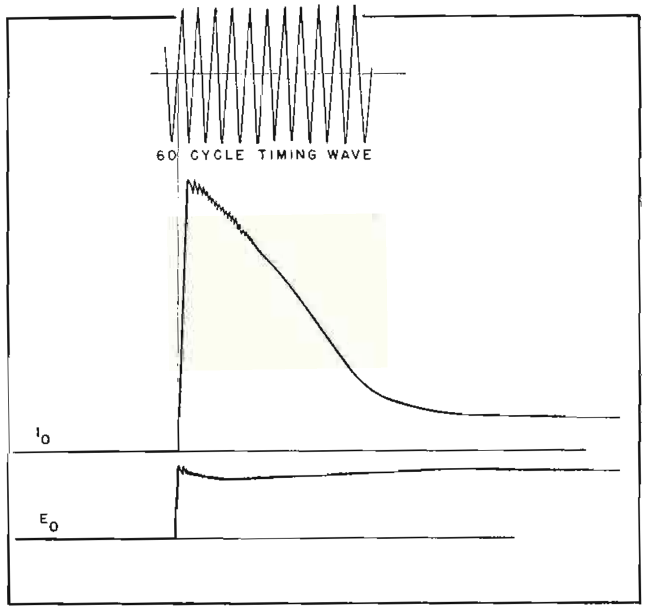
The size of dynamotor brushes is very important. The temperature of the commutator depends largely on the current density in the brushes. If the current density in the brushes is high, bad commutation will result, which will cause short life of both brushes and commutators. The grade of the brush must also be proper for the value of input voltage. When the unit runs, a film builds up on the commutators. This film varies for different grades of brushes, and each grade produces a film of different resistance. From this it will be seen that the grade of brush on the *A* side plays an important part in determining the voltage of the *B* side. If the input voltage is low, the brush must have low specific resistance and have a film of low resistance, or the voltage drop through the brushes and film would be too high a percentage of the input voltage.

One of the more elusive factors to be considered in designing a dynamotor is that of ripple. In producing d-c by means of a dynamotor, what one gets is not strictly d-c, but rectified a-c. In the rectifying, the resultant voltages vary by as much as 1 per cent from the actual direct current value. In other words 99% would be d-c and 1% would be variable d-c. This is variable d-c, because the amplitude changes, but the polarity does not. The normal way to measure the variable d-c voltage is to place a 2-mfd capacitor in series with a rectifier voltmeter and place these directly across the output. The capacitor blocks out the d-c voltage, but passes the variable component, which is read on the voltmeter. Brushes for a specific unit are chosen or discarded on their ability to commutate with a minimum of ripple. Anything that will affect the steady output of d-c will affect the ripple value.

It is well known that silicon iron has a different permeability in the direction of the grain than it has at right angles to it. If the laminations in the armature were stacked so that the grain was all in the same direction, the permeability of the complete armature would change as it revolved through 360°. This would cause the flux that flows through the armature to fluctuate and increase the variable part of the d-c output, which is known as ripple. In the early stages of development, it was thought necessary to rotate each lamination from the next one by one tooth, so that a uniform flux path would occur. Later investigation proved this unnecessary if the punch-



View of a dynamotor with a 5.6 v d-c input and 420 v d-c output.



Right: Observed running data on a dynamotor with a starting amp of 108 and starting time of .232 second. In this plot $E_A = 24.2$: $I_A = 15.5$; $E_B = 536$; $I_B = .450$.

ings are scrambled and random stacked.

In the normal motor or generator, the armature slots usually run straight and parallel with the shaft. In the dynamotor, to smooth out the abrupt change from minimum to maximum flux, the slots are skewed in a spiral so that the change is more uniform and gradual.

Along the same line, to further smooth out the changes in flux, it was also found very desirable to flare the tips of the pole shoe. The major part of the pole face is on the circumference of a circle with the center at the center of the armature shaft. The pole tips, from about one-quarter of the way in from the end must flare on a line tangent to the pole face circle at the one-quarter mark.

In the windings, it is very necessary that all coils have exactly the same number of turns. Most output coils are wound separately in forms and then inserted in the armature. In winding these coils, it is possible to vary by one or two turns, unless great care is observed or an automatic winding machine used. The variations of turns from coil to coil increases the ripple.

After the windings are in the slots, the coils must be connected to the proper bars, so that when the brushes pick up the voltage the coil sides will be in a neutral zone. If the lineup is not held very closely, the ripple will be high.

The surface of the commutator has an important function in keeping the ripple down. It should be free from burrs, scratches, and anything that might cause a brush to chatter. Some claim that the surface should be smooth as a mirror, and others that a very fine microscopic thread should be turned on the surface. Both methods have their good and bad points. Needless to say, the brushes must ride smoothly and steady to provide arcless commutation and produce good ripple characteristics.

The ripple must, of course, be filtered out for quiet operation of equipment used with the dynamotor.

In electronic apparatus, background hash is hard to overcome. Some of this hash is generated in the dynamotor and is picked up by the electronic system both as conducted and radiated noise. During investigations to attempt to reduce this value, it was discovered that the physical position of the input and output windings in the armature had an important bearing on the amount of hash generated. Originally the high voltage winding was wound in the armature first and then the motor winding was wound on top. With this method, it is possible to machine wind the motor winding and thus reduce the cost of the unit. However, the noise is considerably reduced by putting the motor winding on the bottom and the output winding on top. This is a more expensive way of winding an armature, but the better performance justifies the added cost. An additional method for reducing the hash is the addition of small bypass capacitors across the commutators and brushes.

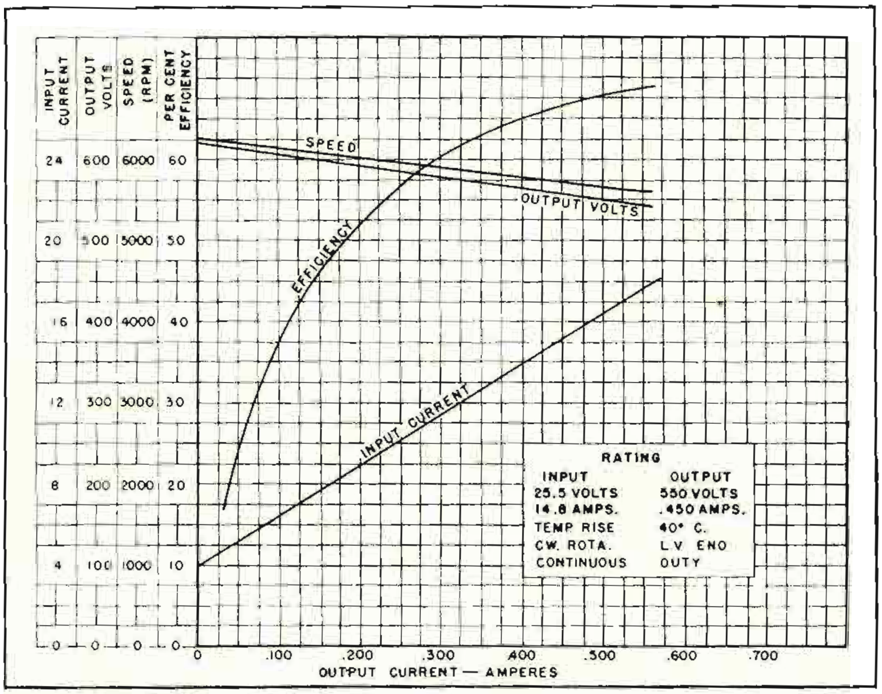
The next consideration is duty. Units are classed as intermittent or continuous. Continuous duty machines are always larger than intermittent duty ones for the same output watts. Temperature rise is the factor that governs the size of the dynamotor.

There are innumerable cycles for intermittent duty units. For instance, one cycle could be one minute on and three minutes off. That is a 25% duty cycle. Classing a duty cycle in per cent could be very misleading. A cycle of fifteen minutes on and forty-five minutes off is still a 25% cycle. However, a unit that could stand one minute on might not be able to stand fifteen minutes continuously.

There is another factor in the duty line to be considered, and that is the type of operation, or how often a unit is started and stopped. In some applications, a unit is started and runs for a long period of time before it is shut down. Another may start and stop very frequently. Special care must be exercised on units that start and stop many times.

Dynamotors are required to operate under many different circumstances from the poles to the tropics, from below sea level to fifty thousand feet of altitude, and from dry operation to that of operating immersed. The ambient temperature requirements influence the design of a unit in that the higher the ambient the larger the unit for a given output. The insulation must be capable of withstanding the higher temperatures without failing. This means thicker and heavier insulating materials. In turn, it makes the slots bigger to accommodate the thicker material. In the higher ambients, the heat transfer is less, so the losses must be kept down. This calls for heavier wire, which again makes the unit bigger and heavier.

Bearings and bearing lubrication are a problem, particularly if there is a hot and cold test to be met. And yet there is no successful high *and* low temperature grease. A single grease may be good for either high or low



Performance characteristics of a dynamotor with the input voltage maintained constant at 25.5 volts.

temperature, but not for both. For high ambient use, the bearings must be capable of being relubricated at short intervals. The most common type of bearing for dynamotors is the ball bearing. Plain or sleeve bearings have been used from time to time, but leave much to be desired from their performance.

Dynamotors are sometimes required to operate in explosive atmospheres. If this is so, special construction must be used. The explosion proof unit must be capable of having an explosive mixture set off inside the unit and not ignite an explosive mixture surrounding the unit. This means two things. The shell and end covers must be strong enough to withstand the force of the explosion and also have the type of joints that will not allow the flame inside to reach outside and ignite the surrounding mixture. This type of unit is the biggest and heaviest for any given rating because of its construction and the fact that it cannot be fan-cooled.

One of the main operating characteristics is that of regulation. This is expressed in percentage and is found by subtracting the full-load voltage from the no-load voltage and dividing by the full-load voltage with the answer multiplied by one hundred:

$$\text{Reg} = \left[\frac{E_{\text{no load}} - E_{\text{full load}}}{E_{\text{full load}}} \right] \times 100$$

When these measurements are made, the same input voltage must be maintained. The normal regulation for a dynamotor is in the neighborhood of 17%. To get good regulation, it is necessary to use large enough wire in the armature so that the *IR* drop for both the *A* and *B* winding is low. If this drop is low, then the difference between the no-load voltage and the full-load voltage would also be low, and good regulation would automatically follow. If a unit requires some special output value such as a high voltage, a small wire size must be used. The regulation would then be high. These factors are all interrelated and must all be considered when deciding on the proper unit for any particular application.

Dynamotors vary in efficiency from 45% to 60%, depending on which end of the rating a frame has to work. The more watts taken from a certain frame size unit, the higher the efficiency will be. This is due to the fact that a good percentage of the loss is more or less fixed for a given frame size. A dynamotor to produce 15 watts continuously on a 28- or 14-volt system would be 2 3/4" in diameter, 4 1/2" long, and weigh 3 1/2 pounds. A dynamotor to produce 60 watts continuously on a 28- or 14-volt system would be 4" in diameter, 7 3/4" long, and weigh 9 pounds, 11 ounces.

In the aircraft applications, weight and size are very important considerations. Space is not abundant in an airplane, and the more weight the plane has to carry as equipment, the less it can carry either as bomb load or pay load. In the commercial airlines, one extra pound has been estimated to cost as much as $1,200 a year. With this in mind, the engineer must use extreme ingenuity and be constantly on the lookout for new ways and means to decrease the weight and size and yet not sacrifice performance or service life.

The motor side of a dynamotor with low wattage output is normally a shunt motor. When the wattage increases, it is necessary to do something to keep the starting current from becoming abnormally high. For if this happens, injury may occur to some parts of the circuit, but the main difficulty is in the fusing of the units. When the starting current is too high, it takes such a large capacity fuse to handle it that there is no protection for the dynamotor even under 300% overload. The starting current is reduced by adding series turns to the field coil, thus compounding the motor end. It is possible in this manner to bring the starting current within allowable limits, but in doing so some regulation must be sacrificed. This is due to the added *IR* drop in the input circuit, which changes between no load and full load conditions.

Dynamotors are required to start fast and, in many cases, very often. They often must operate at −55° C after soaking at this temperature for a long period of time. These starting characteristics are obtained by the same series field that is used to reduce the starting current. This gives the necessary torque for quick starts and fast acceleration even at the very low temperatures.

All dynamotors are required to operate in a smooth and non-vibrating manner. This is accomplished by dynamically balancing the armatures. To dynamically balance an armature, it is set up on spring supported bearings, so that by reading the point to the bearings, and the amount of unbalance is read on a meter while at the same time a stroboscope lamp is synchronized with the point of unbalance, so that by reading the point shown while the armature is rotated, the operator knows where to add balancing solder to overcome the unbalancing couple.

Vibration may also be caused by rough bearings or by bearings that have been exposed to dirt and have picked up some dirt in the grease. The normal allowable maximum amplitude of vibration on the heads of a dynamotor is in the neighborhood of

(Continued on page 30)

TUBE *Engineering News*

Measuring Sensitivity and Gain of Receiving System R-F Amplifiers and Converters Operating in the F-M and TV Bands, Using Power Input to the Circuit. Application of 829-B at V-H-F.

When an r-f amplifier and converter circuit, of the type shown in Figure 1, is used, sensitivity measurements are conventionally made by connecting a standard signal generator supplying a modulated signal to terminals *(1-1)* through a specified *dummy antenna* network, and then adjusting the signal to produce a specified standard output from the receiver. In a low-frequency receiver, it is common practice to obtain additional data by connecting the signal generator successively to points *(4-4)*, *(3-3)*, and *(2-2)* through a low-impedance blocking capacitor. The frequency and voltage of the signal generator are adjusted for each test point to give the standard receiver output.

The voltage input at the i-f required at terminals *(4-4)* to give the standard output may be described as the voltage sensitivity of the receiver at the first i-f grid. Similarly, the inputs at the signal frequency required at points *(3-3)* and *(2-2)* may be described as the voltage sensitivities at the converter grid and at the r-f grid, respectively. The radio of the required input at *(4-4)* to the required input at *(3-3)* is the conversion voltage gain from converter grid to i-f grid provided that the receiver is nearly free of feedback effects. The ratio of the required input at *(2-2)* to the required input through the dummy antenna to *(1-1)* is frequently referred to as the antenna circuit gain, but it must be understood that the dummy antenna is considered as part of the antenna circuit for this definition.

High-Frequency Considerations

At high frequencies, the attempt to make these measurements with the foregoing method leads to erroneous and misleading results. The major difficulty is caused by the substantial reactances of even short pieces of wire at high frequencies. A signal generator is calibrated in terms of the open-circuit voltage across its terminals, but it is physically impossible to bring these terminals exactly to the points at which voltage-sensitivity measurements are desired, even when the terminals are at the end of a flexible cable.

It is possible, however, to introduce a measured amount of power into a circuit of a receiver without en-

Figure 2
Signal generator to resonant circuit connections for maximum power transfer. Maximum power is transferred to tuned circuit when capacitor C and C_1 are adjusted so that the impedance of the circuit between point *a* and ground is resistive and equal to *r* which is the sum of the added resistance *R* and the internal resistor of the generator. The method applies to either circuit shown here.

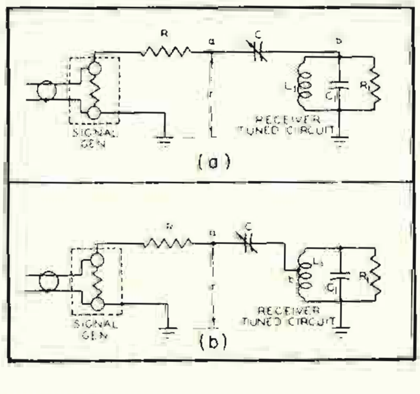
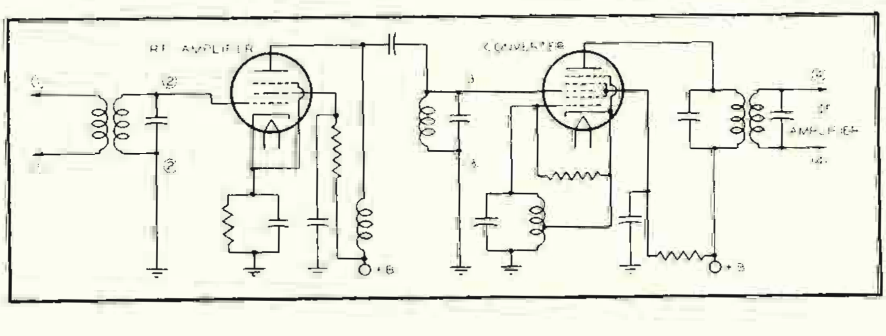


Figure 1
A typical r-f amplifier and converter circuit used to study sensitivity and gain in the f-m and tv bands.



countering similar difficulties; Figure 2. In this setup, a resistor *R* and an adjustable capacitor C are connected between the signal generator and the receiver tuned circuit. Maximum power will be transferred to the tuned circuit when capacitors *C* and C_1 are adjusted so that the impedance of the circuit between point *a* and ground is resistive and equal to *r*, which is the sum of the added resistance *R* and the internal resistance of the generator. (The method applies to either circuit of Figure 2.) Although the required capacitor adjustments will be different, the amount of power which can be transferred with a given signal-generator terminal voltage is the same for either circuit. When the adjustments for maximum output have been completed, the available power, *P*, is equal to the power transferred to the receiver circuit and is given by the equation

$$P = e^2/4r$$

Where: *e* is the open-circuit voltage at the generator terminals,

and *r* is the sum of the added resistance *R* and the internal resistance of the generator.

In practice, resistor *R* is connected to the high-potential terminal of the signal generator, and the adjustable capacitor *C* is connected between the resistor and a point near the high-potential end of the receiver circuit under consideration. A value of approximately 300 ohms. for resistor *R* has been found suitable for frequencies near 100 mc. At other frequencies, however, different resistor values may be more suitable. Two pieces of hookup wire twisted together may be used for the adjustable capacitor *C*. The circuit is tuned to resonance with the signal frequency by use of whatever tuning means are provided and the receiver output is noted. Various adjustments of the series capacitance are tried, with readjustment of the receiver circuit to resonance in each instance, until the adjustment giving maximum receiver output is found. The signal-generator voltage is then adjusted to the value giving standard power output from the receiver and this voltage is recorded. The power sensitivity can then be computed from the signal generator voltage and the resistance, *r*.

Example

In applying the foregoing method, an f-m circuit similar, but not identical, to Figure 1, was used. Tubes were a 12BE6 as a converter and 6NJ6 as an r-f amplifier.

The signal frequency used was 98 mc frequency modulated with 400 cycles. The receiver output was 50 milliwatts. A 260-ohm resistor was

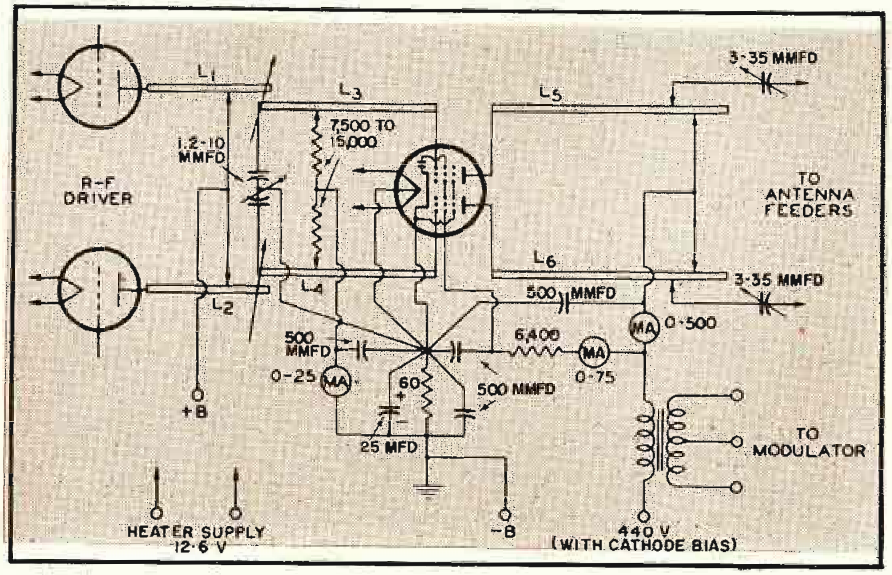


Figure 3
A v-h-f plate-modulated pushpull r-f power amplifier (operating at about 200 mc) for the 829-B.

used, the output resistance of the signal generator being 26.5 ohms, giving a total resistance of 286.5 ohms. Since the antenna circuit of the receiver was designed for 300 ohms, this resistor can also be used for the dummy antenna. Connections corresponding to points (*2-2*) and (*3-3*) of Figure 1 were made through a twisted-wire capacitor and connections to (*1-1*) were made through the resistor only. The measurement values secured appear in Table 1.

The power ratio (*3-3*) to (*2-2*) is the effective power gain of the r-f amplifier stage. This ratio represents the real advantage in sensitivity obtained by adding the r-f stage to the receiver, and, therefore, conveys more significance to the designer than a measurement of grid-to-grid voltage gain.

Advantages of Method

When measurements are made at the input circuit of the converter tube (*3-3* Figure 1), an important advantage is obtained, because the signal is introduced with only a slight disturbance of the circuit by the measuring equipment. The impedance of the input circuit to the signal frequency is reduced to half its normal value, but the impedance of the circuit to the oscillator frequency changes very little. At high frequencies, the amount of oscillator-frequency voltage induced in the signal-grid circuit is frequently an important factor in determining the performance of the converter tube. Consequently, a method of measurement which does not affect the induced voltage gives a better indication of tube performance than a method in which the signal grid is effectively short-circuited to ground.

The 829-B

Recently the type 829-B pushpull r-f beam power amplifier was announced to supersede the 829.

In Figure 3 appears a typical v-h-f plate-modulated pushpull r-f power amplifier, operating at approximately 200 mc, in which this tube can be used. The coils L_3 and L_4 are composed of ¼″ copper tubing, approximately 10″ long and spaced about ⅞″ between centers. The L_5 and L_6 coils are of ⅜″ diameter copper tubing, about 7″ long and spaced approximately ⅞″ between centers. Dimensions of L_1 and L_2 are dependent on the type of driver tube used but usually are similar to L_5 and L_6. The coupling of L_1, L_2 and L_3, L_4 must be adjusted for optimum grid excitation. The grid resistors in the L_3 L_4 circuit should be adjusted at voltage node.

For stable r-f amplifier operation, the 829-B must be shielded. One method of doing this is to mount the tube with one end through a hole in a metal plate so that the edge of the hole is close to the internal shield of the tube. Since at v-h-f short leads are essential, r-f bypassing must be accomplished close to the tube terminals. Ribbon leads acting as plates of the bypass capacitors are effective.

[*Data based on copyrighted information supplied by RCA*]

Table 1
Measurements tabulated with typical f-m receiver.

Point of Input	Signal Generator Output (volts)	Available Power P (watts)
(*3-3*)	125×10^{-6}	13.7×10^{-12}
(*2-2*)	23×10^{-6}	0.46×10^{-12}
(*1-1*)	23×10^{-6}	0.46×10^{-12}
Power ratio (*3-3*) to (*2-2*)		29.6
Power ratio (*2-2*) to (*1-1*)		1.0

VETERAN WIRELESS OPERATORS ASSOCIATION NEWS

Benjamin Wolf Retires

VETERAN BENJAMIN WOLF, known to all old-timers as the manager in charge of the FCC monitoring station at Grand Island, Nebraska, retired recently, with forty-two years of Government service to his credit. (The Grand Island station was the first primary radio monitoring station to be set up in the United States, the site being chosen because of its central location.) His plans for the future are not definite, except for one thing—he is going to do a lot of fishing.

Benny's first work was with the U. S. Navy, where he enlisted in 1905 as an electrician. He was discharged in 1913 as a chief radio electrician, and soon after was appointed inspector in the radio division of the Department of Commerce.

When the first World War came on, he reenlisted in the Naval Service as a lieutenant, and was made communications superintendent of the 13th Naval district. He retained a commission in the Naval Reserve for many years, later retiring from the Reserve with the rank of lieutenant commander.

In 1915, BW was named special agent in charge of the exhibit of the Department of Commerce at the Panama-Pacific International Exposition, and was awarded a silver medal for his services. While on this duty he saw the first tiny audions exhibited by Dr. de Forest, and has never lost sight of them since!

Happy fishing, Benny!

Dr. Lee de Forest Biog.

IT IS ABOUT time to dedicate a few paragraphs to our honorary president, Dr. Lee de Forest. The grand old audioneer is working hard. During the summers he is deep in the realms of color television, his habitant being Chicago; winters, he revels in the more delicate atmosphere of Los Angeles. Incidentally, he has completed his long-promised autobiography, which is due for printing this month. You'll get full notice in time to buy a copy before the edition is completely exhausted.

VWOA veteran Benjamin Wolf, who retired recently from government service. He had been in charge of the FCC monitoring station at Grand Island, Nebraska.

Recently, Doc paid a visit to the Bureau of Ships, Navy Department, Washington, which, under its old name of Bureau of Steam Engineering, bought much of his early equipment. In fact, the division was known as the Bureau of Equipment when his first spark sets were installed, at Key West and other points.

Doc was greatly impressed by the progress made by Navy men in electronic equipment. He was especially interested in the automatic tuning feature of one of the transmitters, expressing a desire to *tear into it* and see how it worked! This shows that the old spirit is still there, for he demonstrated the same urge when he inspected the first vacuum tube transmitter, on the S. S. *George Washington*, in 1925, when he was the guest of Chief Pickerell and operator Tony Tamburino, both veteran VWOA members.

Later, Doc was taken to Annapolis and there saw a fairyland of high frequency. According to the story, when he inspected the method of melting ice from the antennas by heavy currents of power frequency, he remarked that it was "one of his old patents, but the Navy could use it!" The Navy spokesman (or recorder) remarked that "it had expired, anyway."

Honorary member Brig. Gen. Frank E. Stoner, chief of communications at United Nations, who was in Palestine recently to set up U.N. radio contacts.

Personals

HONORARY MEMBER Brig. Gen. Frank E. Stoner, who is now chief of communications at the United Nations, and was in Palestine recently to set up U.N. radio contacts, asked his office to phone VWOA for names of operators who would like to pound brass and do some general operating in Palestine. Several veteran VWOA boys did a bit of scouting which we hope resulted in the ops for the all-important international job. . . . Bill Simon recently returned from a week's vacation. Bill reports that his oldest daughter has graduated from high school and is scheduled to enter Houghton College, Houghton, N. Y., this fall to major in religious education. Incidentally Bill's vacation spot is out at Rocky Point, not far from the towers and plant of RCAC on the north shore. . . . Honorary member Paul Galvin, president of Motorola, retired recently as chairman of the RMA set division. Upon recommendation of PG, the RMA board of directors voted to continue the association's policy not to sponsor or endorse any public or trade shows of television or radio receivers. . . . We are indebted to George Clark for the interesting facts about Benjamin Wolf and Doc DeForest, this month. Thanks sincerely, George!

Stub Tuners For Power Division

Controlling Division of Power Between Vertically and Horizontally Polarized Components at F-M and TV Frequencies.

by CARL E. SMITH[1]

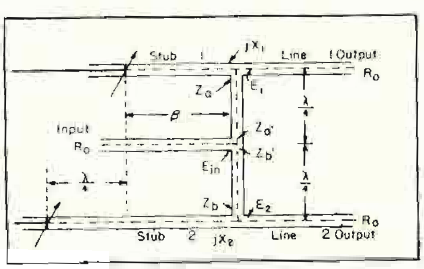
Vice President, In Charge of Engineering, United Broadcasting Company

At high frequencies such as used in f-m and tv broadcasting it is often desired to divide the power into two loads or antennas, and employ a power dividing arrangement. The system has been used very effectively at WHKX to control the division of power between the vertically and horizontally polarized components.

Qualitative Explanation

First let us consider qualitatively how this power divider functions. If stub *1* short is $\frac{\lambda}{4}$ from line *1* it will appear as an open circuit where it joins on to the concentric line. Now if stub *2* is $\frac{\lambda}{2}$ from line *2* it will present a short circuit where it joins on to the concentric line and thus prevent the power flowing to output *2*. Furthermore, since this short circuit is $\frac{\lambda}{4}$ from the junction of the input concentric line it will look like an open circuit at this point, with the result that the power will flow into the input concentric line having a characteristic resistance of R_o. All of the power will flow past the junction of line *2*, junction of stub *1* and on out through line *1* with a good impedance match at all points. Next, let us consider that both stubs are moved in $\frac{\lambda}{4}$. Then in a similar fashion all of the power will flow out of transmission line *2* and no power will flow out of transmission line *1*. If the transmission lines are matched into their characteristic resistance then these stubs can be moved through this quarter wavelength, maintaining $\frac{\lambda}{4}$ difference in length, and the power will be gradually shifted from one transmission line to the other and an impedance match will be maintained at the input and output terminals at all times.

Figure 1
Concentric line stub tuner power divider arrangement used at WHKX.



Quantitative Analysis

Now we will consider the quantitative analysis of this power divider. In Figure 1 the input impedance at the junction of stub *1* is,

$$Z_a = \frac{R_o(+jX_1)}{R_o + jX_1} \qquad (1)$$

Where:

Z_a = ohms input impedance at stub *1* junction

R_o = ohms characteristic resistance of line *1*

jX_1 = ohms reactance of stub *1*

And the input impedance at the junction of stub *2* is,

$$Z_b = \frac{R_o(+jX_2)}{R_o + jX_2} \qquad (2)$$

Where:

$$Z_b = \frac{R_o(+jX_2)}{R_o + jX_2}$$

R_o = ohms characteristic resistance of line *2*

jX_2 = ohms reactance of stub *2*

Since stub *1* is β degrees in length, the reactance of this stub can be written as

$$jX_1 = jR_o \tan\beta \qquad (3)$$

And since stub *2* is β + 90 in length,

$$jX_2 = jR_o \tan(\beta + 90) = -jR_o \cot\beta \qquad (4)$$

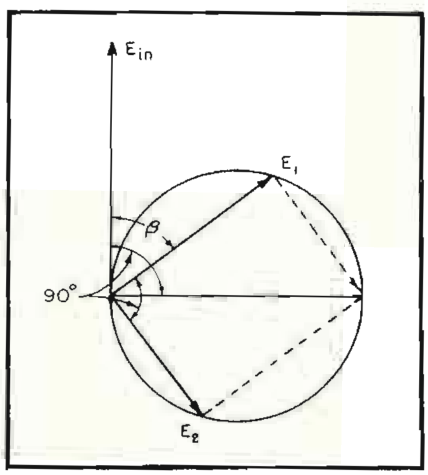
To show that the input impedance is always equal to the characteristic resistance R_o we can set up the equation of the input at the junction of the two transmission lines. Since Z_a and Z_b are both a distance of $\frac{\lambda}{4}$ from this junction they are transformed to the following values at the junction point.

$$Z_a' = \frac{R_o^2}{Z_a} \qquad (5)$$

and

$$Z_b' = \frac{R_o^2}{Z_b} \qquad (6)$$

Figure 2
Circuit diagram showing the relationship of phase β and the voltage vectors in a concentric line stub tuner power divider.



[1] *Also president of the Cleveland Institute of Radio Electronics.*

If the input is always equal to R_o, then we should have the following identity

$$R_o = \frac{Z_a' + Z_b'}{Z_a' + Z_b'} = \frac{\frac{R_o^2}{Z_a} \cdot \frac{R_o^2}{Z_b}}{\frac{R_o^2}{Z_a} + \frac{R_o^2}{Z_b}} = \frac{R_o^2}{Z_a + Z_b}$$

or $$R_o = Z_a + Z_b \qquad (7)$$

Now substituting equation *(3)* into equation *(1)* and then in equation *(7)* for Z_a, and substituting equation *(4)* into equation *(2)* and then in equation *(7)* for Z_b we get

$$R_o = \frac{R_o\,(j\,R_o \tan\beta)}{R_o + j\,R_o \tan\beta} + \frac{R_o\,(-j\,R_o \cot\beta)}{R_o \;-j\,R_o \cot\beta}$$

$$1 = \frac{j \tan\beta}{1 + j \tan\beta} - \frac{j \cot\beta}{1 - j \cot\beta} \qquad (8)$$

Multiplying both sides of the equation by $(1 + j \tan\beta)\ (1 - j \cot\beta)$ we have

$$1 - j \cot\beta + j \tan\beta + \tan\beta \cot\beta$$
$$= j \tan\beta + \tan\beta \cot\beta - j \cot\beta + \tan\beta \cot\beta$$

Since $\tan\beta \cot\beta = 1$, it is evident that this equation is an identity and therefore the stub tuners operated as shown in Figure 1 will always present a pure characteristic load to the generator, regardless of how the power is divided between the two loads which must always present a characteristic resistance load of R_o to the power divider network.

Vector Diagram

It is also of interest to note the voltage magnitudes and phase relationships of the voltage vectors in this power dividing network; Figure 2. If it were not for the 90° phase delay in the $\frac{\lambda}{4}$ wavelength lines from the common feed point to the shorting stubs, the input vector would lay along the diameter of the circle diagram. It will be noted that the phase of output *1* is always 90° in advance of the phase of output *2*. As the power to output *1* increases from zero to maximum the phase retards from zero to 90° as shown in Figure 2. At the same time the power to output *2* will vary from maximum to zero and the phase retards from 90° to 180°. The

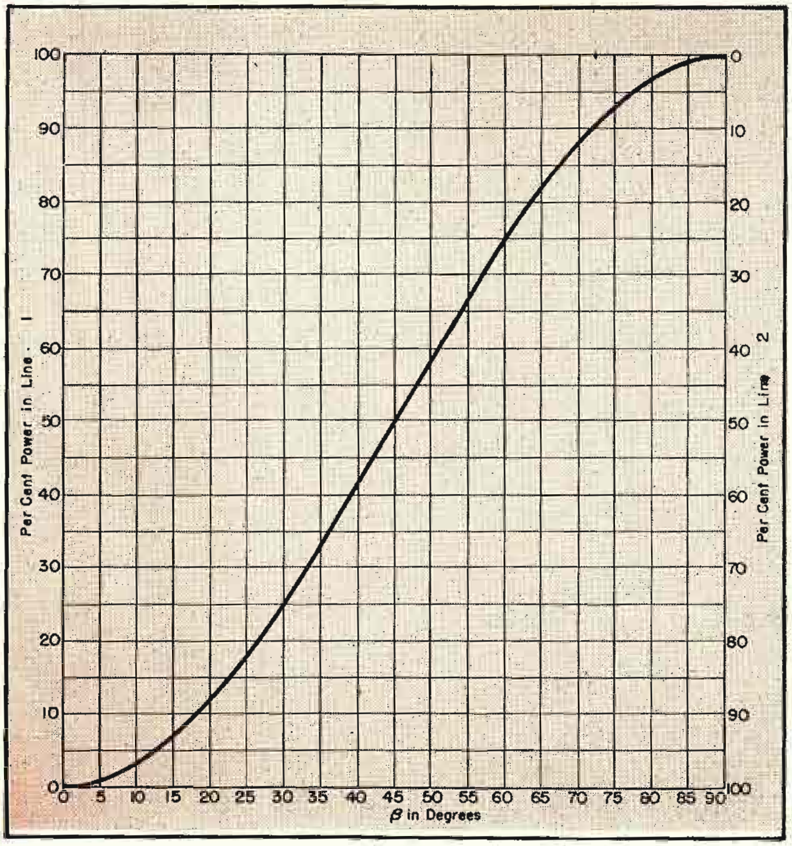


Figure 3
Plot of P_a and P_b as a function of β; total power is expressed as 100%

angle β is the same as the electrical angle illustrated in Figure 1.

Power Division Curve

The power division as a function of stub placement can be derived from an analysis of equation *(7)*. The inductive reactance in Z_a must equal the capacitive reactance in Z_b. This can be proved by equating the reactance components of equation *(8)* equal to zero and showing that the equation is an identity. The resistance components of equations *(7)* and *(8)* can be written as

$$R_o = R_a + R_b = \frac{R_o \tan^2\beta}{1 + \tan^2\beta} + \frac{R_o \cot^2\beta}{1 + \cot^2\beta} \qquad (9)$$

The power division in the two loads is proportional to the respective resistances. Therefore, the power in line *1* is

$$P_a = P_t \frac{R_a}{R_o} = P_t \frac{\tan^2\beta}{1 + \tan^2\beta} \qquad (10)$$

and the power in line *2* is

$$P_b = P_t \frac{R_b}{R_o} = P_t \frac{\cot^2\beta}{1 + \cot^2\beta} \qquad (11)$$

Where:

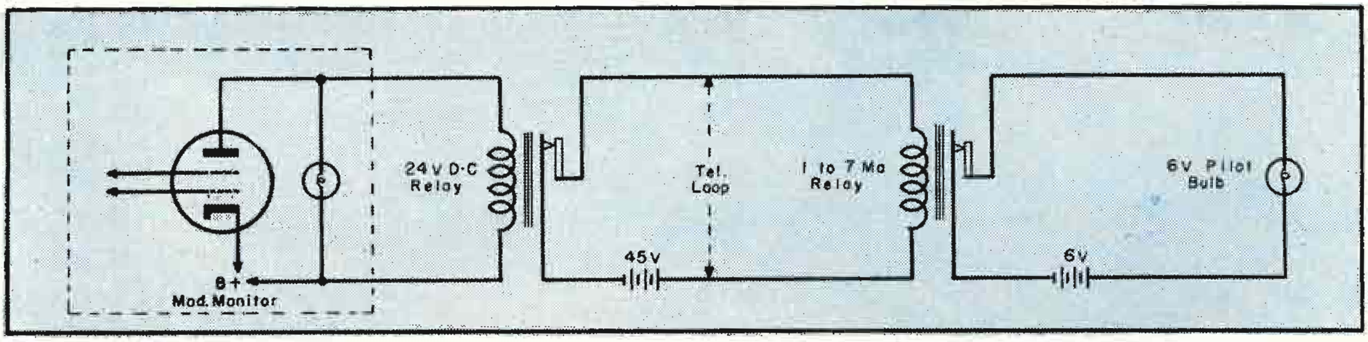
- P_t = watts total power
- P_a = watts power in line *1*
- P_b = watts power in line *2*
- R_a = ohms resistance at junction of line *1*
- R_b = ohms resistance at junction of line *2*
- R_o = ohms characteristic resistance
- β = degrees length of stub as shown in Figure 1

P_a and P_b have been plotted in Figure 3 as a function of β. The total power is expressed as 100%.

Example

In a concentric line stub tuner power divider, as shown in Figure 1, the characteristic resistance is 52 ohms. If output *1* is to receive 600 watts and output *2* is to receive 400 watts, what is the proper adjustment of the stubs?

Solution: Referring to Figure 3 the stubs must be set such that $\beta = 52°$.



A Studio Modulation Monitor Setup

Synchronized Light-Flash Monitor Setup Devised to Help Announcer Maintain Studio-to-Transmitter Program Levels.

by WILLIAM J. KIEWEL

Chief Engineer
KROX, Crookston, Minn.

MODULATION MONITORING as used in small stations is often not too satisfactory. The usual practice is, of course, for the announcer to ride gain at the studio by means of the console vu meter. If the announcer is inexperienced, careless or used to a different console, several days of inefficient operation must be overlooked while he is learning. Even then difficulties may be experienced, particularly when using bi-directional mikes, since the vu meter reads both peaks while the modulation monitor reads only one. Some error may be introduced due to phasing.

Meter and Flashing Light

Our modulation monitor[1] employs the customary meter and flashing light. It was felt that a light flashing similarly in the studio would assist the announcer in achieving proper gain control and thus improve volume level at the transmitter.

Direct Line Connection

Accordingly we rewired one jack in the jack panel at each end and connected the spare line directly across the bulb in the modulation monitor without going through equalizers.

(Our transmitter is located about three miles from the studio and connected by an operating loop and a spare. Both loops are equalized, but their resistance without the equalizing circuit is 300 ohms each.)

Use of Unequalized Line

Another jack enabled us to jack quickly into the spare line equalized. By using the unequalized spare line across the bulb and a bulb of the same type (G.E. 120 v 6 watt) at the studio end, we achieved a simultaneous light circuit, the light at the studio flashing in synchronization with the one in the monitor, with no effect on the monitor. It was noted, however, that when the light was not flashing, each side of the telephone line was 150 volts above ground. Since the telephone company would not tolerate such a condition the system was redesigned to isolate the line with relays. An immediate improvement was noticeable in the volume level at the transmitter. The engineer no longer had to have his hand on the gain control whenever the announcing staff changed shifts.

D-C Relay at Transmitter

At the transmitter end we used a spst 24 v. d-c relay wired in parallel with the lamp in the modulation indicator. Operating only on peaks the relay will not chatter on the a-c supplied to it. Almost any relay will work, but it should have a resistance of at least 500 ohms, or the light in the modulation monitor will not operate properly. Incidentally, across the points of this relay we placed a 45-volt battery, in series with the telephone loop (equalizers disconnected). At the studio end of the loop we inserted an army surplus relay designed to operate on 1-7 ma. A 6-volt battery was placed across the contacts with a 6-volt pilot light in series.

Wide Application Possibilities

This system which is approved by the manufacturer of the monitor could be used anywhere with slight changes to compensate for various line resistances.

[1] [illegible] Radio [illegible]

Figure 1 (above)
Circuit of the synchronized flash system employed in the studio

Broadcast Studio Design*

by LEO L. BERANEK

Technical Director
Acoustics Laboratory
Massachusetts Institute of Technology

New Approach to Studio Design Suggests Preservation of Flat Surfaces and Adjustment of Walls So That No Two Are Parallel.

THERE ARE FOUR PRIMARY conditions to deal with in small studio design which have not always received proper attention in the past:

(*1*) There are unsufficient resonant possibilities at low frequencies.

(*2*) It is not possible to locate both the source and microphone so that they make use of all the normal modes of vibration available.

(*3*) Flutter echos must be contended with at the higher frequencies.

(*4*) The absorption of ordinary acoustical materials at low frequencies is too small, hence, a *booming* effect results.

Generally the solutions involve some sort of means for sound diffusion in the studio. As a result a *fad* has arisen for building studios with polycylindrical linings, multiple-layered plywood interiors and hemispherical *bumps*. It appears that perhaps an adequate job of design can be done without going to the extreme expense that is indicated by these current trends.

To remedy the low frequency problem, let us look at the question of studio shape. A study of the other regular shapes such as spherical, cylindrical or eliptical reveals that even less satisfactory coupling between source and pickup exists. Hence, the desirable trend is away from regularity, not toward more of it.

Scientific evidence indicates that we can preserve flat surfaces, and still greatly improve the coupling between microphone and source by adjusting the walls so that no two of them are parallel to each other. This leads to interesting results. In the first place, the skewing of the walls shifts the resonant frequencies, some of them upward, some downward. In most cases this shifting results in the unbunching of the frequencies of the modes of vibration and gives a more even distribution along the frequency scale.

A second result is obtained. There is a crosscoupling between modes of vibration in skewed rooms which does not exist in rectangular rooms. That is to say, when we sound a low frequency tone in a room with skewed walls, one (or two) modes of vibration will be excited. In a skewed room, however, several more adjacent ones will be excited because of crosscoupling. Hence, there will be a better transfer of energy from the source to the microphone because more modes act as the carrier. Another interesting effect results. These adjacent modes have their own frequencies of free-vibration. When a number are decaying at once, they will beat against each other and will produce a sort of vibrato effect—nearly imperceptible to the ear—but something which every string instrumentalist or vocalist attempts to produce when he plays or sings.

The question arises now as to how much distortion of the sidewalls there should be. The general answer is that there should be as much as possible. One is, however, limited by economic considerations and considerations of appearance and convenience. As an example of a suitable compromise, we

(*Continued on page* 33)

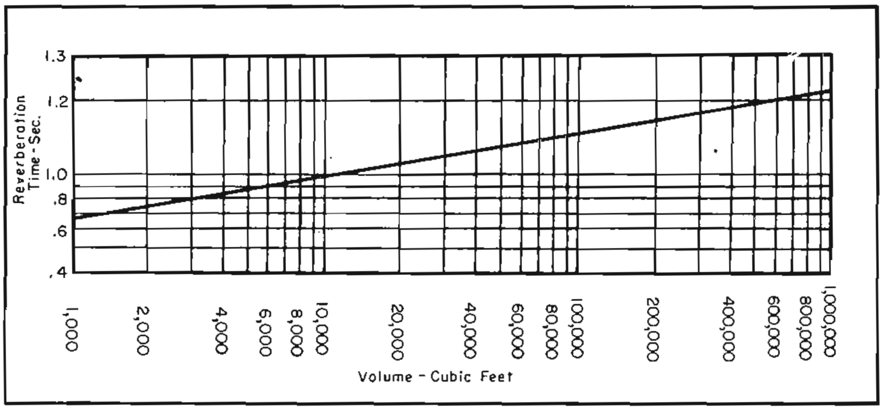


Figure 1
Relationship between optimum reverberation time and volume of a room. Beranek indicated that this relationship should be satisfied in the basic design of a studio.

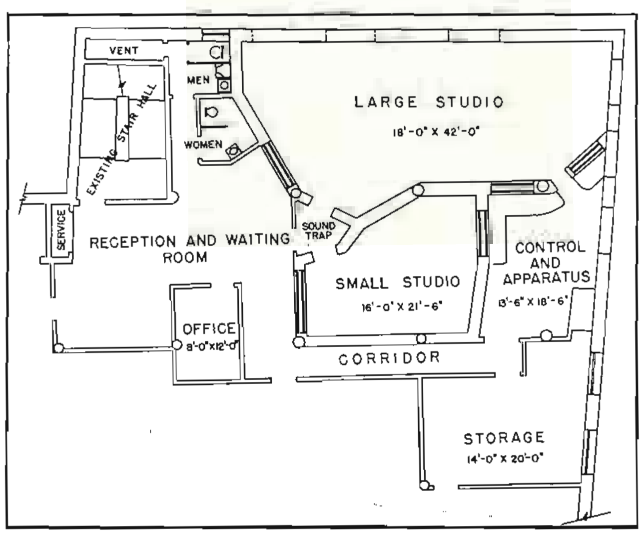


Figure 2
Layout of a studio with non-parallel walls.

*From a paper presented at the New England Radio Engineering Meeting.

Power-Line CARRIER COMMUNICATIONS

Part II of Paper on 50 to 150-kc Systems. Presented are Data on Electronic Transfer Units, Multi-Station Duplex Arrangements and Calling Systems.

by R. C. CHEEK

Central Station Engineer
Westinghouse Electric Corp.

IN THE FIRST PORTION[1] of this paper the general features of carrier-communications simplex and duplex systems were analyzed, with specific data being offered on a single-frequency manual-simplex system and a two-frequency duplex arrangement.

In this, the concluding article, are offered data on a single-frequency automatic simplex system, multi-station duplex system and the many different types of calling systems which are employed in carrier-communications circuits.

The single-frequency automatic simplex system is the most versatile of all the power-line carrier communication systems. The number of stations on a given channel is not limited to two, as is the case with the usual two-frequency duplex system; it permits a single conversation among several stations on the channel; and it permits operation with two-wire telephone extensions and through PBX boards without requiring balance of a hybrid unit.

The electronic transfer unit is the key unit in an automatic simplex assembly. It is the unit that performs automatically the switching functions required for changing the assembly from the stand-by condition to the transmitting or the receiving condition, as required.

The operation of the electronic transfer unit can best be understood by reference to Figure 1. The equipment is normally in the stand-by condition; that is, no signal is being received and none is being transmitted. The transmitter is blocked by voltage 1 and the radio-frequency circuits of the receiver are energized, ready to detect the presence of an incoming carrier signal. The bias-controlled amplifier is blocked in the stand-by condition by voltage 2 so that no audio output from the receiver reaches the telephone line. During periods when no carrier signal is being received, the avc circuits of the receiver increase the gain to such an extent that noise on the channel might become annoying if the bias-controlled amplifier were not blocked during such periods.

In the stand-by condition, the transmitting audio amplifier is unblocked and ready to amplify voice signals from the telephone line. Reception of a carrier signal will cause the transmitting audio amplifier to be blocked, so that no transmission can take place, once reception has started, until the equipment returns to stand-by condition. On the other hand, if an outgoing voice signal reaches the transmitting audio amplifier from the telephone line when the equipment is in the stand-by condition, it will cause the entire receiver to be blocked so that no signal can be received until conditions return to stand by. The switch from transmit to receive and vice versa therefore requires that the equipment pass through the stand-by condition in each direction. The functioning of the transfer unit for changing from stand-by to transmitting and receiving is as follows:

Transmit

An audio signal (3) from the telephone line passes through the transmitting audio amplifier and is applied simultaneously to the transmitter and the transfer unit. The audio signal is

[1] COMMUNICATIONS, August, 1947.

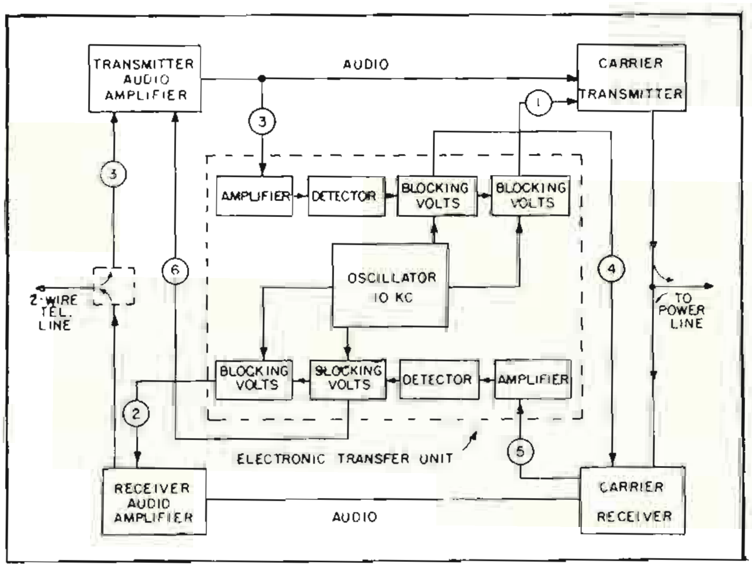
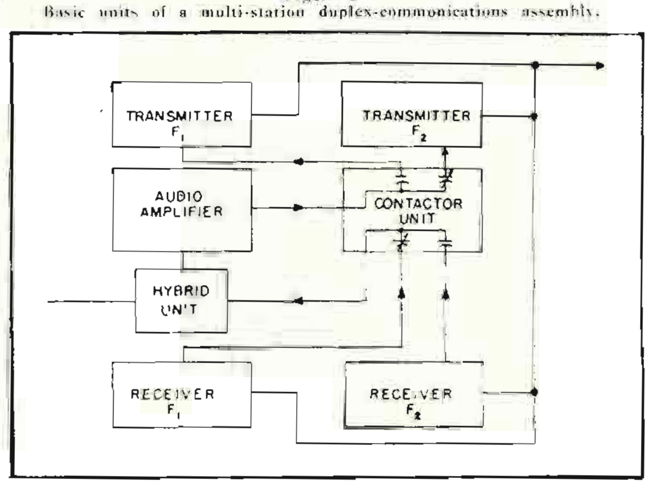


Figure 1 (left)
Functional diagram of electronic transfer unit.

Figure 2
Basic units of a multi-station duplex-communications assembly.



further amplified in the transfer unit and then rectified by a diode detector. The positive bias produced by the rectified signal is applied to the grid of a small thyratron, which breaks down and begins to rectify a 10,000-cycle voltage applied to its place by an oscillator within the unit. The negative voltage which then appears across the thyratron load resistor is used to block the radio-frequency circuits of the receiver (voltage *4* of Figure 1) and simultaneously to stop a second thyratron from rectifying a 10,000-cycle signal. The extinguishing of this second thyratron removes blocking voltage *1* from the transmitter, allowing the audio signal that initiated the switching function to be transmitted. The entire sequence of operations described occurs in 2.5 milliseconds or less, so that not even the first syllable of the outgoing speech is lost.

The disappearance of the audio signal from the telephone does not instantly return the equipment to the stand-by condition. Resistance-capacitance time delay circuits with adjustable time constants are provided in the diode rectifier circuit to prevent the actuating bias from disappearing immediately when speech ceases. This time delay can be adjusted to allow return to stand-by conditions at the end of words, phrases, or sentences, depending upon the preference of the user of the equipment.

Receive

The incoming carrier signal (*5*) is taken from the output i-f stage of the receiver and applied to an amplifier in the electronic transfer unit. The amplified signal is rectified by a diode detector, and the resulting bias is used to cause a thyratron to break down and start rectifying a 10,000-cycle voltage supplied by the oscillator in the transfer unit. Current through the load resistor in the thyratron plate circuit produces a negative bias voltage *6*, which is used to block the transmitting audio amplifier. The same voltage simultaneously extinguishes a second thyratron, removing blocking bias *2* from the receiving audio amplifier and permitting the incoming signal to reach the telephone line. This entire operation occurs in 2 milliseconds or less.

The disappearance of the carrier signal removes the actuating bias furnished by the diode rectifier and causes the opposite sequence of events, returning the equipment to the stand-by condition.

The applicability of the conventional two-frequency duplex system is somewhat limited because the system can be used only for point-to-point channels. It is possible to use the ordinary two-frequency duplex system in a so-called master-station duplex arrangement in which one terminal can communicate with any one of several others, none of which can communicate with each other. This arrangement is seldom satisfactory, however, and it is not widely used. The multi-station duplex system is not subject to this limitation of the conventional duplex system, and it provides the advantages of duplex communication between any two of a number of stations on a channel.

Basic Units of Duplex System

The basic units of the multi-station duplex system are shown in Figure 2. Comparison with Figure 6 (Aug. issue) shows that a transmitter unit, a receiver unit, and a contactor unit have been added to the conventional two-frequency duplex assembly. None of the other units of the conventional assembly are duplicated, such units as the audio amplifier, the rectifiers, the switching and hybrid panels, and the calling and ringing equipment being used in common by both receivers and both transmitters.

Only one transmitter and one receiver are used at a given station during a conversation. Which transmitter and which receiver are used depends upon the point of origin of the call. Designating the two frequencies as F_1 and F_2, for example, all stations would normally receive on F_1. A station originating a call, however, transmits on F_1. The F_1 transmitter is selected by the calling party by the simple act of picking up the telephone handset. The closing of the d-c circuit through the hook switch operates a relay which causes the contactor unit to apply the output of the audio amplifier to the audio terminals of transmitter F_1. Simultaneously the contactor unit energizes the transmitter and applies the output of receiver F_2 to the audio hybrid unit. At the called station, the reception of the carrier signal from the calling station on receiver F_2 operates a relay whose contacts open to prevent the transfer from transmitter F_2 to transmitter F_1 from being made by the contactor unit when the called party replies. Transmitter F_1 and receiver F_2 at the calling station and transmitter F_2 and receiver F_1 at the called station remain energized throughout the conversation. When the conversation is completed, the hanging up of the telephones at both stations returns conditions to normal, with all stations receiving on F_1.

Calling Systems

A number of different systems of establishing a call over a carrier channel are in general use. Among the more important are: code-bell calling, voice calling, automatic-bell calling, and dial-selective calling.

Code-Bell Calling

Code-bell calling is the system of calling so often used on rural party lines in which all telephones on a given circuit ring, the desired party being indicated by a code made up of long and short rings. The calling party transmits the code by turning a hand generator or applying 60-cycle voltage to the line with a push-button on his telephone instruments. A relay in the carrier set actuated by calling voltages between 16 and 60 cycles operates in accordance with the coded signal to apply 60-cycle modulation to the transmitter. At the other terminal or terminals of the carrier channel, the receiver output energizes a circuit selective to 60-cycle modulation. This circuit in turn operates a relay which applies ringing voltage (either 20 or 60 cycles) to the telephone extensions, causing all telephones to ring in accordance with the coded signal. Code-bell calling may be used with either a-c or d-c telephone extensions, and is by far the most popular system of calling in power-line carrier work.

Voice Calling

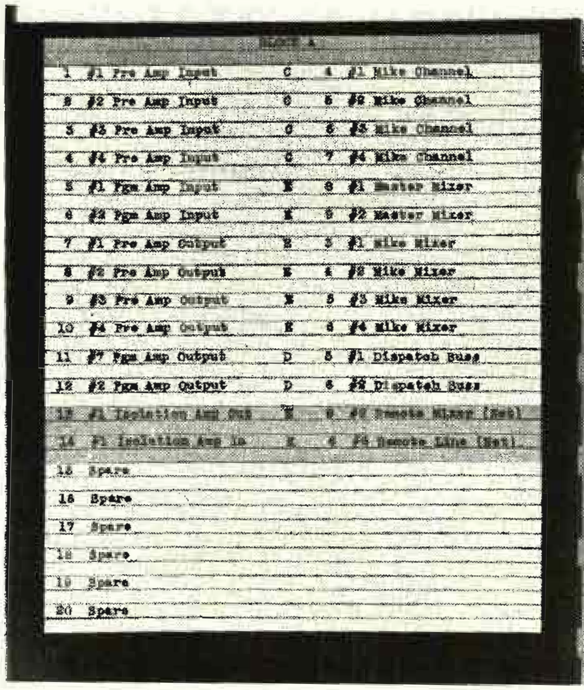
In the voice-calling system, the call is placed by simply speaking the desired party's name into the telephone transmitter. Loudspeakers with individual amplifiers are provided at all telephone extensions to call the desired party. The loudspeaker is disconnected when the telephone instrument is picked up. Calling by voice is supplemented in some installations, especially those where ambient noise level is high, by a high-frequency audio tone, which is transmitted at the option of the calling party. A push-button or keyswitch is provided for this purpose. Voice calling can be used with either a-c or d-c lines.

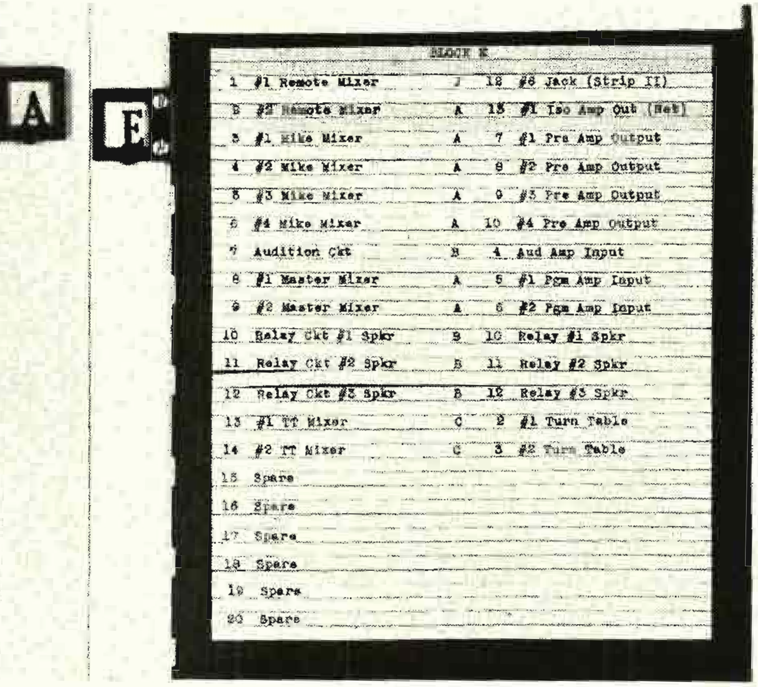
Automatic Bell Calling

In the automatic bell-calling system, the bells on the telephone instrument or instruments at the opposite terminal are rung automatically when the calling party picks up his handset. The ringing continues for a few seconds and then is cut off automatically. To

(*Continued on page* 35)

Organizing Studio Facilities





Figures 1 and 2

Typical terminal block designed for a distribution frame for indexing and filing of electrical circuits, which permits rapid location of all circuits. In broadcast work, two types of terminal blocks are used: one for a-f and another for power. Terminal block A, at left, terminates a cable connected to the terminal block in rack or cabinet A.

The coordination of technical facilities is an extremely important factor in broadcast-station organization, affording quality production and showmanship and contributing to good engineering practice.

Systematic Organization

Smooth operation requires a systematic organization of studio equipment and a rigid adherence to the system employed. The system must permit continual expansion of facilities without sacrificing flexibility or operational simplicity.

Wire Communications Uses

For many years two continually expanding systems of wire communication, the telephone and telegraph, have employed an equipment-organization method that is excellent for radio communications facilities, too.

Filing System

Actually it is a filing system wherein electrical circuits are carefully filed and indexed. The filing cabinet of such a system is called a distribution frame. Every circuit is readily located because it is terminated or *filed* on the distribution frame according to a definite plan. Then all interwiring of equipment is accomplished by connecting short *jumper* wires between various terminals on the frame.

System Simplicity

Once equipment has been installed, it need not be moved about should changes in interwiring become necessary or desirable from an operational standpoint. It is only necessary to change a few short jumper wires.

Letter-Filing Similarity

On the other hand, should it become necessary to remove a piece of equipment to a different location, it may be moved to another cabinet or some point where a cable containing spare wires is terminated; the other end of the cable being terminated on the distribution frame. The operation is similar in some respects to filing a reclassified letter in a different folder in a letter file.

Application to Broadcast Stations

The distribution frame consists of a metal frame upon which has been mounted a number of terminal blocks. In a broadcast studio, two types of terminal blocks are required: one for audio and one for power circuits. An audio terminal and a power terminal block are needed for each rack or cab-

With A Filing System

Filing System, Providing Indexing and Filing of Electrical Circuits on a Distribution Frame, Can Be Applied to Broadcast Stations to Trace Audio and Power Circuits. Procedure Facilitates Maintenance, Permits Partial Pre-Assembly of Equipment, Pre-Wiring Before Studios Are Completed, and Simplifies Installation.

by THOMAS D. REID

Technical Staff, Melpar, Inc.
Formerly, Audio Engineer, WASH-FM

inet of equipment, each connected by a separate cable to its respective audio or power terminal block in the distribution frame. Separate conduits are required for each cable.

Indexing the System

Some form of designation indicating to which cabinet or rack each block is connected is the first step in indexing the system. Thus, cabinet or rack *A* is represented on the frame by *block A*; cabinet or rack *B*, by *block B*, etc. The terminals of audio blocks are usually numbered by pairs, while the terminals of power blocks are usually numbered individually.

Index Sheet

A separate index sheet, kept for each block on the frame, discloses in tabular form . . . designation of the block, orderly listing of the pair numbers, brief description of the use of each pair, and the block and terminals to which each terminal or pair of listed terminals is connected by jumper wire.

Flexoline

Flexoline,[1] or a similar indexing system, is best suited to this type of work because it permits minor changes to be made in the interwiring without the necessity of retabulating an entire sheet for each of the terminal blocks involved. It also permits color coding certain important circuits throughout the entire index, permitting them to be traced quickly by color. A good example is the color coding of a network circuit. Colored *spaghetti* could be used on the wires at the terminals to tie in with the color coding of the indexing system.

Figure 1 illustrates the manner in which information is tabulated for terminal block *A*. This block terminates a cable or group of wires connected to the terminal block in rack or cabinet *A*.

The pairs of terminals are listed first. After each listing follows a brief description of the use of the pair.

Use of Color Coded Leads

Pairs 13 and 14 of *block A* are color coded. The equipment connected to these pairs of terminals are part of an important network circuit, with pair *13* terminating the output of the No. *1* isolation amplifier, a jumper connecting pair *13* of this block to pair *2* of block *E*, which terminates the No. *2* remote mixer.

Troubleshooting Uses

Pair *2* of block *E* in Figure 2 is also color coded. The information on the strip representing this pair also tallies with the information given on the index of block *A*. However, the information is in the reverse order. This brings out an interesting point, the system is automatically cross-indexed.

Another important advantage of this system is that it simplifies troubleshooting. Most trouble in studio equipment could be eliminated quickly if the source of trouble could be quickly located. Often it amounts to the simple replacement of a tube and this system permits rapid troubleshooting by quick tracing of circuits.

Equipment Pre-Assembly

A rather novel advantage of the system is that it permits partial pre-assembly of the equipment and pre-wiring before studios are completed and even before some of the equipment is on hand. The cables between the rack terminal blocks and the frame terminal blocks can be made up beforehand if the length of its conduit is known. If the interwiring plan is known, the jumper wires may be applied to the frame before final installation. Equipment, if at hand, can be mounted in the racks or cabinets and wired to the terminal blocks before the equipment is installed in the studio. The entire studio system, in fact, could be set up on a factory floor and tested.

Filing System Rules

Because this system is essentially a filing system certain rules must be met. To have a system there must be a plan; and that plan must be adhered to if complications are to be avoided. All who work with the system must be thoroughly familiar with the rules if the system is to work efficiently. One person should be in charge of this system, make all decisions and see that they are properly executed.

[1] Acme Visible Records, Chicago, Ill.

The Industry Offers

DOOLITTLE F-M FREQUENCY AND MODULATION MONITOR

A frequency and modulation monitor, FD-12, for the f-m emergency services has been announced by Doolittle Radio, Inc., 7421 S. Loomis Blvd., Chicago 36, Ill. Handles one, two, three or four frequencies anywhere between 25 and 170 mc and checks frequency deviation and percentage of modulation.

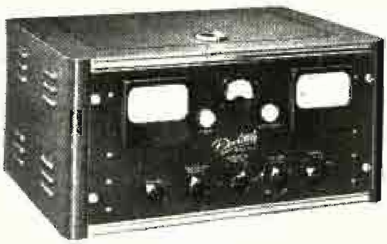
Provided with plug-in type antenna coils.

The unit employs crystals which are thermally controlled for those frequencies above 50 mc. The accuracy is said to be guaranteed to be .0025% over the range of 15° to 50° C.

Direct reading of modulation up to 20 kc on positive or negative peaks and the peak flasher to show over modulation can be set at any value from 5 to 20 kc for either positive or negative peaks.

Sensitivity for measuring is 500 microvolts or less across the antenna terminals. The circuit is so designed that it is possible to measure distortion in a transmitter.

Has 500-ohm output for a-f monitoring.



JAMES KNIGHTS STABILIZED HEAT CRYSTAL HOLDER

A crystal holder with a large 7-pin base designed to accommodate crystals from 80 to 10,000 kc with a 6.3 v heater, and operating temperature of 50° C ±1° has been developed by James Knights Co., Sandwich, Illinois. Available as double oven on special order. Crystals electrostatically shielded.

SYLVANIA AUTO RADIO TUNERS

Precision tuning assemblies built to order for auto radio receivers are available from the Parts Department of Sylvania Electric Products, Inc., Emporium, Pa. Service provided includes tooling for production, metal stamping, plating, fabrication and overall assembly of component products built to customer specification.

KLYSTRONS NOW AVAILABLE FROM RCA TUBE DEPT.

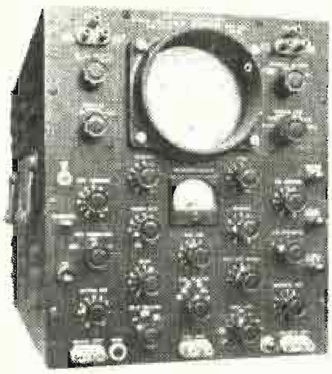
Klystron tubes are now being marketed by the RCA Tube Department.

First of the type to be offered are 2K26 and 2K25, used principally in microwave relay equipment for tv transmission and in multi-channel communications equipment.

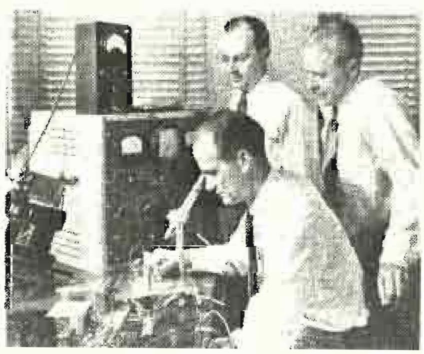
BROWNING LAB OSCILLOSYNCHROSCOPE

An oscillosynchroscope, model OL-15B, for observation of transient and recurrent phenomena involving wide ranges of frequencies, has been announced by the Browning Laboratories, Inc., Winchester, Mass. A five-inch c-r tube with 4,000 volts accelerating potential is used.

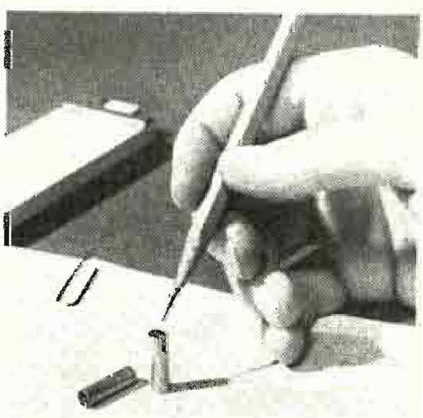
Other features include a vertical amplifier bandwidth of 6 mc, recurrent sweeps of 5 to 50,000 per second and driven sweep rates of 25 microseconds per inch to 250 microseconds per inch. An internal trigger generator is also provided as well as a variable delay circuit which may be used to provide delayed triggers or a delayed sweep either internally or externally triggered. A calibration device provides measurement of deflection sensitivity through the amplifier.



BELL LABORATORY TRANSISTOR



Above, Dr. William Shockley (seated) and Dr. John Bardeen (left) and Dr. Walter H. Brattain, who initiated and directed the development of the recently announced Bell Labs *transistor*, employing a semi-conductive material soldered to a metal base, which can serve as an amplifier or oscillator. Below, the transistor, which has produced amplification up to 20 db.



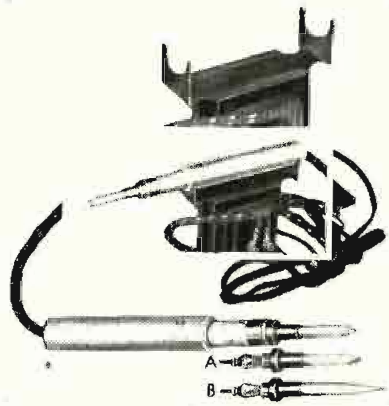
TRANSVISION SOLDERING IRON

A soldering iron called "Solderton," which weighs three ounces, has been announced by Transvision, Inc., New Rochelle, N. Y.

Iron features interchangeable thin tipheads, fingertip control; bakelite handle with cork covering; heater element incorporated in each tip head.

The iron is said to heat up within 20 seconds from a cold start.

Iron supplied for operation on 115-v a-c 50-60 cycles, through transformer supplied with iron, or 6-8 volt a-c or d-c without transformer (from an automobile battery). Choice of three tip heads: long, stubby, or medium short heads. Overall size of iron is [illegible]x15 in.

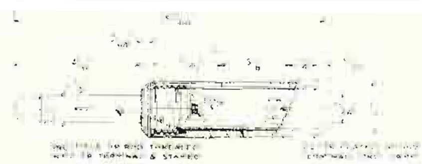


SWITCHCRAFT LITTEL-PLUG

Littel-Plug featuring a dual-purpose sleeve terminal which can be clamped over the metal braid of shielded wire cables, to provide a cable anchor has been announced by Switchcraft, Inc., 1328 N. Halsted Street, Chicago 22, Illinois. Can be soldered or be clamped over outer insulation of unshielded 2-conductor cable. An extra lug is provided in the terminal for wire connection.

A one-piece tip rod threads into the tip terminal and is staked to insure tightness.

Available in red or black tenite handles or nickel plated handles for shielding. All exposed metal parts nickel plated. Fits ¼" diameter jacks. Body and handle ⅜" outside diameter.



RCA 500-WATT TV TRANSMITTER

A 500-watt tv transmitter, type TT-500-A, has been announced by the RCA Engineering Products Department.

Used with this transmitter, a three-section RCA super turnstile antenna, which has a gain of approximately four, can radiate an effective output of about 2 kw.

Transmitter is housed in two identical cabinets which can be installed as one unit measuring 86" wide, or arranged as individual cabinets, each 37" wide.

The video section consists of the carrier generating circuits, video amplifiers, modulator, power supplies, and the necessary control circuits. High level modulation is employed in the power stages, permitting meter tuning of the preceding r-f stage as straight-forward class C amplifiers.

Another feature of the video portion of the transmitter is the clamp-circuit type of d-c insertion used in the grid circuit of the modulator, which is said to automatically maintain the proper black level.

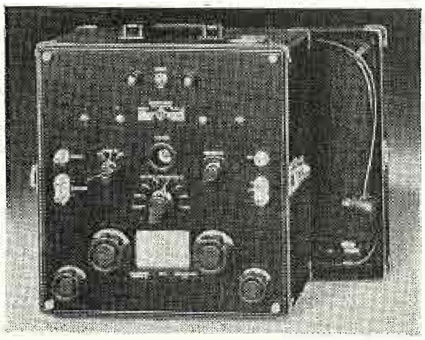
The sound section of the transmitter consists basically of a 250-watt f-m sound transmitter (type BTF-250A).

GENERAL RADIO CAPACITANCE TEST BRIDGE

A capacitance test bridge, type 1611-A, which measures capacitance over the range of 1 mmfd to 10,000 mfd has been announced by General Radio Company, 275 Massachusetts Avenue, Cambridge 39, Mass. Over this entire range an accuracy of ±(1% + 1 mmfd) is said to be maintained. The dissipation factor range is 0 to 60%. The frequency of the test voltage is 60 cycles.

A feature of the bridge is a zero-compensating circuit that balances out the initial capacitance and dissipation factor at zero setting of the dials.

Self-contained, including visual null detector and operates from the 60-cycle power line. Over-all dimensions are 14½"x16"x10".



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DU MONT CATHODE-RAY OSCILLOGRAPH

A c-r 'scope, type 250, with three different channels through which signals may be applied to the vertical deflection plates (high gain, capacitively coupled amplifier, medium gain, directly coupled amplifier, and direct connections to the deflecting plates) has been announced by Allen B. Du Mont Laboratories, Inc., Clifton, N. J.

Built-in voltage calibrator for calibrating the sensitivity of vertical amplifier circuits is put into use by a second switch which connects the calibrator to the inputs of the Y-axis amplifier.

Signals are applied to the horizontal deflection plates through a similar choice of channels, and a fourth position of the horizontal selector switch connects the sweep-circuit output to the amplifier input.

The recurrent range of the linear time base is 1 cps to 150 kilocycles per second, and the duration of the driven sweep is continuously variable from 1 second to 20 microseconds.

The cathode-ray tube used is the type 5CP-A which, with intensifier, operates at a total accelerating potential of 3,000 volts.

* * *

CARTER ROTARY CONVERTERS FOR WIRE AND TAPE RECORDERS

Rotary converters for use with wire and tape recorders, sound projectors, receivers, etc., have been announced by Carter Motor Co., 2644 North Maplewood Ave., Chicago, Illinois.

Converters are said to deliver a pure a-c output without filtering.

Bulletin, No. 748, illustrating and describing the converters is available. Bulletin includes a *selector chart* which tells the proper converter to use in each application to assure complete operating satisfaction.

Telecast Engineering Clinic

TELECAST ENGINEERING design, production, installation, operation and maintenance were featured topics of a five-day series of sessions held recently at the Camden facilities of RCA for nearly 100 broadcast engineers.

Presented by tv specialists at RCA including M. A. Trainer, H. E. Gihring, C. D. Kentner, R. A. Meisenheimer, L. J. Wolf, R. W. Masters, J. E. Young, T. M. Gluyas, E. H. Potter, W. J. Poch, J. H. Roe, N. S. Bean, G. H. Goble, R. V. Little, Jr., C. A. Rosencrans, R. J. Smith, N. F. Smith, E. Stewart, D. D. Halpin, E. S. Clammer, H. J. Markley, P. J. Herbst, W. W. Watts, T. A. Smith and A. R. Hopkins, the sessions covered discussions of 23 subjects. These included the basic television transmitter, antennas and antenna equipment, pylon antennas, transmitter test and assembly, typical station operation, studio equipment, camera equipment (television film projectors, kinescope photography and relay and auxiliary apparatus), tv video and audio systems, commercial television operation, tv test and measuring equipment, and tv transmitter and receiver service and contract procedure.

Most of the meetings were held in the theatre in the main building at Camden. Several, however, were conducted in the field. For instance, the f-m and tv antenna sessions were held at the development laboratories where a complete demonstration of tv and f-m antennas was conducted. In another on-location visit, engineers visited station W3XEP the tv experimental station of RCA, operating on channel 10.

In a visit to a typical studio, the broadcast men received complete instruction on the operation of the assortment of equipment used there.

A visit to the research laboratories at Princeton concluded the five-day clinic.

At W3XEP, the RCA experimental tv station in Camden, during the tv clinic, with Dale Kentner, supervisory engineer of transmitter design at the console controls. Looking on: Carl Olson, KLAC; Lewis Evenden, WJVB; John March, WARC; Harold F. Huntsman, KLAC; Bob Emch, WARC; Seymour Raymond, WFMJ; Kenneth Hewson, WOXBV; R. H. Musselman, WSAN; J. Leahy, RCA Victor; Scott N. Hagenau, WSBT-WSBF; Charles Kibling, WBRY; Ed Clammer, RCA (sales); John P. Riley, Jr., RCA (sales); Frank B. Ridgeway, WEBR, and ye editor.

STACKPOLE MOLDED TRANSFORMER CORES

Horizontal deflection and flyback transformer cores molded from iron powders for tv applications have been announced by the Electronic Components Division, Stackpole Carbon Company, St. Marys, Pa.

Two standard types are available: Type 10034, a large rectangular unit with sliding hub, designed for universal use with any tv tube where magnetic deflection is used. Type 10748, smaller *spool* type, recommended where space is at a premium and where tubes are no larger than 10".

ELECTRO-VOICE SPEECH CLIPPER

A speech clipper, model 1000, which is said to effectively increase the ratio of consonant-to-vowel intensity by clipping the peaks of the vowels while limiting the peaks of the consonants to that of the pre-set modulation percentage has been announced by Electro-Voice, Inc., Buchanan, Mich.

Clipper operates directly from any high impedance microphone into the microphone input of a conventional speech amplifier. The gain of the speech-clipping pre-amplifier is purposely held to unity at an average clipping value so no overload will occur in the main amplifier input stages. Filament and plate power is obtained from the main amplifier.

Tv Transmitter Design

(Continued from page 9)

the video amplifier. There are two means by which this characteristic may be measured: (1) An ideal linear detector whose output is properly terminated in conjunction with a h-f 'scope,[7] or (2) an r-f waveform monitor whose r-f response is flat ±5 mc from carrier frequency. The r-f 'scope response may be checked by means of the built-in r-f wobbulator included in the transmitter.

To be assured that the transmitter is operating under typical operating conditions, it is desirable to supply sync plus synthetic video signal. The latter component may be injected from a suitable h-f generator in place of the camera signal. It has been found more desirable to use a mixing system which will take sync, blanking, and sine wave signals and mix them in a manner such that composite video is available, plus a variable pedestal level, from which the sine signal may obtain a zero axis position. Such an instrument is shown in block diagram in Figure 2. The modulating signal is set up for 30% sync 70% video and a reference value of 100 kc applied. Assuming that the r-f 'scope is used as a measurement device, the percentage of video signal (sine wave modulation) is determined—toward black as the upper limit and toward white as the lower limit. The difference between these values is the reference value at 100 kc, and may be considered as 100%. The *synthetic video* signal (sine wave frequency) is changed in discrete steps and the same process of measurement employed—the ratio of the individual frequency response to the 100 kc reference is the voltage ratio of signal amplitude response. These voltage ratios may be converted to db for convenience. Extreme care must be exercised to keep the input signal at constant amplitude over the entire frequency spectra by means of constant 'scope monitoring—a 'scope flat out to 5 mc is essential. The overall frequency response of the system is primarily affected by the passband of the class *B* linear and modulated amplifier stages, and the video amplifier and modulator stages. Figure 3 shows the minimum standard requirements for the FCC and proposed RMA standards with respect to total amplitude response of a television transmitter. The r-f passband characteristic required for the minimum video frequency response of the transmitter is shown in Figure 4.

[7] DuMont 248

Transient Response

The foregoing measurements provide an overall performance indication of the television transmitter; however, items such as overshoot, pulse rise time, leading white distortion, trailing ghosts (ringing) and time delay characteristics have not been considered. These may be classified under the term *transients*. Standards have not yet been established for these factors, but techniques for their measurement are being developed.

A transient response measurement useful for evaluating performance in the h-f range can be obtained by using, for a video input signal, a symmetrical square wave repeating at a frequency of about 100 kc. The square wave must be substantially undistorted in the sense that rise time be in the order of .03 microsecond. An ideal television receiver is required, having an r-f and i-f passband characteristic whose deviations from the ideal are within a tolerance to be specified. In addition, a 'scope having a rise time comparable with the applied square wave with Z axis or equivalent markers is required. Degradation of the square wave showing effects of overshoot, ringing, etc., as measured by means of this equipment will give an indication of the transient response. Standards for the measuring equipment and transmitter performance are being investigated with promise for early specification.

Credits

The author is grateful to Leonard Mautner and P. Brown for their assistance and criticisms in the preparation of this manuscript.

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Broadcast Studios

(*Continued from page* 25)

can consider the small broadcasting station shown in Figure 2. The outer edge of the building has two walls which were not at 90° with respect to each other. Also, every attempt was made to break up parallelism between the walls of the studios except where existing columns did not permit it. Because we were unable to eliminate all parallel walls, we had to place on the flat surfaces either patches of absorbing material or *bumps*. These *bumps* or patches diffuse sound reflections and the possibility of flutter is eliminated.

In probing the low-frequency absorption problem Professor Paul Boner, of the University of Texas, employed structures made of parallel sheets of plywood. These structures were formed by taking two ⅛" sheets and spot-glueing them at a number of positions. They were generally mounted with an airspace behind them and braced so that each panel resonates at a different frequency. Generally, the sizes of the airspace behind the panels varied so that a wide variety of resonant possibilities result. There is no need for the cylindrical shape which he describes except to produce diffusion where needed. This diffusion may be accomplished by the use of splays with flat surfaces.

An alternate arrangement might be to use two sheets of thin metal and chemically treat the surfaces in contact, so that frictional losses would take place. Or else to spray on one of them a rubber-like coating and to place it in contact with the second panel. To the best of my knowledge, this sort of structure has not been tested, and it offers itself as an interesting development problem.

Final judgment as to what treatment is best must await psychological studies. Unfortunately, to date, no adequate psychological experiments are underway.

News Briefs

INDUSTRY ACTIVITIES

The Joint Technical Advisory Committee, the joint advisory group recently established by the IRE and the RMA to advise the FCC and other bodies on matters relating to radio allocations and standards, are now seeking data on various problems concerned with the 475-890-mc band which will be the subject of a FCC hearing on Sept. 20.

At the request of JTAC, members of the FCC staff have prepared six pertinent questions which would supply very helpful u-h-f information:

(1) What is the present state of development of equipment in the band 475 to 890 mc, in regard to:
   (a) transmitters, tubes and components;
   (b) receivers and components;
   (c) antennas, transmission lines and related equipment for transmission and reception?

(2) How much experimental work has been undertaken on tv systems in this band, with respect to field operation (transmitter hours operated, number and distribution of receivers, and propagation tests) and laboratory work (development of receivers, transmitters and tubes)?

(3) What consideration has been given to the costs of television systems for this band, particularly to the reduction of receiver costs, and the transfer of cost burdens to the transmitter?

(4) What areas of service might be expected in this band, based on the following assumptions:
   (a) a particular system using one of the following typical bandwidths: 6, 12 or 20 mc;
   (b) radiated power available now and expected to be available, say, 10 years in the future;
   (c) receiver sensitivity;
   (d) at each of the following typical frequencies: 475, 675 and 890 mc?

(5) What co-channel and adjacent-channel separations would be appropriate under the assumptions made in item 4?

(6) How many channels would be available in the 475 to 890-mc band on the assumptions of item 4, and how might they be allocated among the 140 metropolitan districts of the United States?

Any information related to these questions should be communicated directly to the secretary of JTAC, L. G. Cumming, IRE, 1 East 79 Street, New York 21, New York.

The State of New Jersey has awarded Motorola, Inc., a contract to supply the Department of Conservation Forest Fire Service with a state-wide two-way f-m communications system consisting of [illegible] base stations and [illegible] mobile units.

Equipment will operate in the 30-mc band with automatic repeater equipment.

A 10-kw Westinghouse f-m transmitter will soon be placed in operation by WSB-FM, owned by the Atlanta Journal.

Station WSB has for the past four years been operating a 1-kw transmitter on a developmental basis.

The transmitter will be installed on a new site, where a building and 1000-foot tower are being erected for both f-m and tv, located on one of the highest hills approximately three miles from the center of Atlanta. The construction of the new f-m-tv center is under the direction of C. F. Daugherty, chief engineer of WSB.

The cornerstone for the first of a group of research laboratories for Sylvania Center, in New York City, was laid recently by Walter E. Poor, chairman of the board of Sylvania Electric Products, Inc.

During the ceremony a microfilmed record of all employees, stockholders, employee publications, plants and catalogues of present company products were deposited in the cornerstone.

The initial laboratory building which, with equipment, will represent an investment of approximately a million dollars, will be dedicated late this fall.

Don Lee Broadcasting Corp., of Los Angeles, Cal., will soon install a GE channel 2 tv transmitter at Lee Park atop Mt. Wilson.

The station will change its call letters from W6XAO to KTSL.

PERSONALS

William A. Browne has been named merchandising supervisor for the Radio Division of Sylvania Electric Products, Inc. He will supervise the coordination of design, production and merchandising of test equipment for radio Service Men.

Martin Kiebert, Jr., has joined Raymond Rosen and Company and will be responsible for the engineering, design and sale of all telemetering equipment.

Charles J. Lemieux, Farnsworth Television & Radio Corporation senior engineer in charge of the Capehart laboratory, died recently.

Fred Harmon Seaver has joined FTR as sales representative covering the Far West territory for the mobile radio division.

Charles A. Hampton is now FTR sales rep for the mobile radiotelephone division, covering the state of Washington and Northern Idaho.

Eugene L. Berman has been named Shure Brothers rep in the northern California territory. Mr. Berman was sales manager of Shure Brothers from 1937 to 1938.

E. L. Berman

Leo L. Hefterline, Jr., has been appointed general manager of Sorensen and Company, Inc., 375 Fairfield Ave., Stamford, Conn. He has been with Sorensen since early 1946, when he joined the company to work very closely with the late Mr. Sorensen as a development engineer. Shortly after Mr. Sorensen's death he became senior engineer and later chief engineer.

L. L. Hefterline, Jr.

Glen McDaniel, vice president and general attorney of RCA Communications, Inc., has been elected a vice president of RCA to serve on the president's staff.

David C. Adams, assistant general counsel of the NBC, is now vice president and general attorney of RCA Communications, Inc.

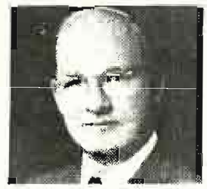
Fabian Lewis has been appointed manager of telephone and telegraph sales of Raytheon.

Joseph P. Bannon has been appointed field sales manager of the RCA Victor Home Instrument Department.

J. K. Poff has been appointed manager of a distributor sales department of Erie Resistor Corporation, Erie, Pa. Newly formed department will handle parts jobber sales of tubular ceramic bypass and coupling capacitors, high voltage television capacitors, ceramic trimmers, temperature compensating ceramic capacitors, button silver mica capacitors, insulated and non-insulated carbon resistors, etc.

Poff was formerly sales service engineer with the Astatic Corp.

Ralph T. Brengle, president of the National Association of Relay Manufacturers, has discontinued his operations as Ralph T. Brengle Sales Co., to devote his full time to Potter & Brumfield, 549 W. Washington Blvd., Chicago 6, Ill.



R. T. Brengle

Raymond Rosen & Company, 32nd and Walnut St., Philadelphia 4, Pa., has formed a new wholly-owned subsidiary company, Raymond Rosen Engineering Products, Inc., to handle all of the business formerly handled by the Engineering Products Division.

President of the new company is Raymond Rosen, and vice president and general manager, Louis P. Clark, formerly the general manager of this phase of the business when it was operated as a division. The other officers are Thomas F. Joyce, secretary, and Joseph Wurzel, treasurer.

John C. Van Groos, 1406 South Grand Avenue, Los Angeles 15, Calif., has been appointed Shallcross field engineer for the states of California, Nevada and Arizona.

G. E. Gustafson, Zenith Radio Corp. vice president in charge of engineering, recently received the President's Medal of Merit for his contribution to victory in World War II.

LITERATURE

Sylvania Electric Products, Inc., Emporium, Pa., have released an 8-page power and transmitting tube booklet covering such data as rated plate dissipations (from 30 to 125 watts) in the following services: r-f power amplifier and modulator, class B and AB; r-f power amplifier and oscillator, class C telegraphy; r-f power amplifier, class B telephony; plate modulated r-f power amplifier, class C telephony; grid modulated r-f power amplifier, class C telephony; suppressor modulated r-f power amplifier, class C telephony; and rectifiers. Bulletin also includes tube base diagrams and tabulation of tube types by base arrangement.

Kopp Glass, Inc., Swissvale, Pa., have released a 24-page bulletin describing glass products for signal, technical and industrial purposes, including color filters, industrial lenses, instrument covers and sight glasses, signal lenses, etc. Copies may be obtained direct from J. L. Newton.

The Broadcast Equipment Section of the RCA Engineering Products Department have released a 7-page brochure providing information on 5-kw and 10-kw a-m broadcast transmitters.

Contains simplified schematic diagrams of the transmitter circuits, specifications on the design of the transmitters, suggested layouts of the equipment in a typical broadcast station installation, and data on the control console and other accessories designed for use with either of the transmitter units.

Entitled *AM Broadcast Transmitters, Types 5-FT-3 and 10-F*, the brochure can be obtained from any RCA district sales office or by writing to Department 51-, RCA Engineering Products Department, Camden, N. J.

Andrew Corp., 363 East 75th St., Chicago 19, have released a 4-page bulletin describing how Andrew put WKOW, Madison, Wis., on the air recently.

Cannon Electric Development Company, 3209 Humboldt Street, Los Angeles 31, Calif., have published a 6-page bulletin, W-348, offering dimensional data on W connectors (Nos. 16, 22 and 34), together with photos of underwater geophysical applications. W connectors are said to withstand pressures up to 250 pounds or approximately 550'.

Shells are brass with nickle finish. Special rubber packing pushing and heavy threaded construction keeps the connector sealed tightly.

American Microphone Co., 370 South Fair Oaks Avenue, Pasadena 2, Calif., have published a 12-page catalog describing dynamic and crystal microphones, phono pickups, handsets and floor stands.

Carrier Communications

(Continued from page 27)

repeat the ring the calling party must hang up the telephone instrument and remove it again, or close the hook switch manually and then release it. Since it is the closure of the d-c circuit through the telephone transmitter that initiates the application of calling voltage to the carrier set, automatic bell-calling systems require d-c telephone extensions. Because this system provides no means of indicating which telephone on an extension should be answered, it is in general used only on point-to-point carrier systems where only one extension is used at each end of the channel. A carrier channel linking two PBX boards provides an ideal application for the automatic bell-calling system.

Dial-Selective Calling

In the dial-selective calling system the desired number is dialed in exactly the same way as is done on ordinary dial-telephone system. Each carrier set includes its own line-selector unit, which receives incoming dial pulses and applies ringing voltage to the desired extension. Each of these selector units is in itself a complete private automatic telephone exchange. The automatic simplex carrier system with selective calling provides nearly every operating feature found on modern dial-telephone systems, such as a busy signal, and a revertive or ring back signal, local intercommunication, executive right of way or preferential service, and a disconnect signal.

As many as ten separate extensions at as many as ten different terminals can be selected by the selector unit. The unit provides for selection of one line by another at the same station, independently of the carrier channel.

Although a party attempting to originate a call normally receives a busy signal if the channel is in use, the dial selective calling unit provides for making any one or more extensions *preferred* for dispatchers and others who must be able to interrupt routine conversations and take over the channel in emergencies.

Power Supply for Carrier Communication Assemblies

It has been almost universal practice in the past to use 120- or 240-volt a-c supply for carrier communication sets. At locations remote from firm generating sources, it has been common practice to use motor generator sets or converters, automatically started upon loss of normal a-c supply, to provide power for the carrier set during emergencies. This practice is still followed on long-haul channels using relatively high-powered communication sets, but the development of carrier communication assemblies capable of operating directly from 125-volt or 250-volt station batteries has made it possible in many cases to provide uninterrupted carrier communication much more economically and without the maintenance problems associated with rotating equipment and accompanying control devices.

F-M Signal Generator

(Continued from page 13)

pendent of frequency. The monitoring voltage can, therefore, be read on a diode voltmeter as a measure of the attenuator input.

Modulation System

Some of the details of the modulation system used in this generator are shown in Figure 2. One-half of a 6SL7GT twin triode is used as a cathode-coupled amplifier to drive the reactance-tube grid. A full-wave rectifier of germanium crystals is used to measure the audio voltage, and the distortion introduced by the rectifier load is made negligible by the low impedance of the cathode circuit.

The other half of the 6SL7GT is used as a phase-shift oscillator to generate an internal 400-cycle modulating frequency. A four-section series-resistance shunt-capacitance phase-shift circuit determines the frequency. A thyrite varistor across the shunt capacitor of the third section limits the amplitude. No adjustments are necessary to maintain the frequency within $\pm 2\%$ and the overall distortion below 1%.

The main problem to be surmounted in this section was the heavy capacitive loading in the reactance-tube grid circuit. A fairly large bypass capacitance was necessary to prevent excessive capacitive reactance in the resistive element of the phase-shifting network. This capacitance was further increased by the bypass necessary to minimize leakage at the point where the modulation lead entered the oscillator-reactauce-tube casting. Although only a few volts are necessary to obtain a deviation of 200 kc, clipping of the output of the cathode-follower stage occurred at the higher audio frequencies, until the impedance level was raised by interposing a choke between the two bypass capacitors to form a constant-k low-pass filter having a 15-kc cut-off.

Power Supply

An unconventional circuit suggested originally by Gilbert Smiley and developed by Dr. W. Norris Tuttle is used in the power supply. This circuit uses a thyratron both as the rectifier and as a series tube in a voltage-regulator circuit.

With the usual electronic voltage-regulator circuit the power input from the line varies linearly with the line voltage over the working range, and the increase in power, as the line voltage increases, is dissipated in a series tube. At normal line voltage there is therefore some power loss in the series tube, even in the ideal case. In a practical circuit there is often substantial loss because of the heater power for the large series tube.

If a thyratron rectifier is used, however, the power input can be made constant over a range of line voltages, since the firing angle can be adjusted to pass only enough current to maintain the load power constant. This can be accomplished automatically by using a shunt tube to control the grid voltage in the same way as in the conventional circuit, the power loss of the series tube then being completely eliminated.

To control the thyratron firing-angle, a component of line voltage is shifted 90° in phase and applied in series with the variable d-c bias. When the phase is properly chosen the grid voltage rises to its most positive value at the time when the plate voltage is passing through zero from positive to negative. For high negative d-c biases the thyratron does not fire at all. As the d-c bias is progressively decreased, however, the thyratron first starts to fire at the end of the positive half-cycle of plate voltage, and then fires earlier and earlier until ultimately it fires at the beginning of the positive half-cycle. A smooth control of firing angle is thereby achieved with the variable d-c voltage obtained from the shunt tube, and the performance is comparable to that of a conventional regulator.

Credits

Henry C. Littlejohn was responsible for the mechanical design of this instrument and Albert M. Eames made the instrument work.

Dynamotors

(*Continued from page 16*)

.0007" as measured on a vibrometer. The vibrometer is an instrument that multiplies small vibrations by means of a mirror and light beam, so that when the period of vibration is fast enough, the amount of movement shows up as a solid band of light on a calibrated glass scale.

Dynamotors often must operate at high altitude. The altitude problem in a dynamotor consist of brush and commutator wear, which also causes ripple and a large amount of hash or background noise. Dynamotors will normally operate up to about 20,000 feet before the effect of the lower density air is felt. At higher altitudes, the brush life becomes much shorter. An attempt has been made to overcome this fault by using altitude treated brushes. These brushes will do the job in some instances, but the brush life is still very much less than that at sea level. The only sure way to test altitude requirements is to flight test the equipment. The results obtained in altitude chambers still do not completely duplicate the results obtained by actual flight tests.

Multiple Input/Output Designs

All of the preceding discussion has been concerned with single input, single output units. Dynamotors have been built with as many as five individual windings. These windings have been divided into units with single input and four outputs or with double inputs and triple outputs. Any variation is possible, because any winding may be used either as an input or output by using the proper turns and wire size and making the correct connections.

A very desirable quality in a dynamotor would be to have a constant output voltage regardless of changing input voltage or load. A satisfactory way of doing this without the use of external regulators has not been devised, but engineers are working on this problem, and some preliminary patents have been filed. Units are being built, that have regulated outputs, by using a carbon pile regulator and they have proven very satisfactory.

A great deal of engineering effort is being applied toward the goal of smaller units and higher outputs along with the research toward regulating inherently. It should not be too far in the future before major developments are available to dynamotor users.

Screen-Supply Impedance

(*Continued from page* 11)

only one stable value of plate current: Figure 9. At rest, the control grid will have a slight positive bias, because R is returned to $B+$. Characteristics of the circuit are such that the plate current will be zero when the control grid is about ½-volt positive with respect to the cathode, and will also be zero when the grid is 8-volts negative with respect to the cathode. Between these two values of control grid voltage plate current will flow. This can be predicted from Figure 4 which, however, is not drawn for the same operating conditions.

Positive Pulse Application

If a positive pulse is applied to the suppressor grid, the plate current will increase, and the control grid will be driven negative by the coupling through capacitor, C. The grid voltage will continue to increase negatively until it is 8 volts below the cathode at which plate current is very nearly cut off. During this period the screen grid current has rapidly decreased and the screen grid voltage increased. These effects are indicated at A on the waveforms in Figure 9, and can also be seen on the oscillograms, Figure 11A. Capacitor C will now start to discharge, increasing the control-grid voltage and the plate current. This will continue over region B of Figure 9 until the control grid voltage has reached –4. At this point the plate current passes through its maximum value. As the control grid becomes still less negative the plate current starts to decrease driving the control grid rapidly positive, the circuit returning to its initial condition. The recovery time is a function of the product RC and is directly proportional to C, but is not directly proportional to R.

Trigger Circuit Uses

This circuit has the usual trigger circuit applications. For instance, portion B of the plate voltage may be used for the horizontal deflection in a driven sweep oscilloscope, while portion B of the screen grid voltage may be applied to the control grid of the cathode-ray tube to increase the intensity dring the sweep.

Relaxation Oscillator

If resistor R of Figure 9 is returned to the cathode instead of $B+$ there are

(*Continued on page* 38)

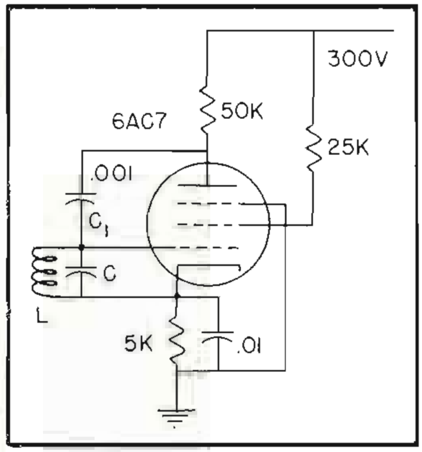


Figure 12
Two-terminal negative-resistance oscillator.

no stable equilibrium conditions, and the circuit functions as a relaxation oscillator. Its characteristics may be studied with the aid of Figure 10. During time, T_1, the plate current is cut off, because the control grid is positive with respect to the cathode; see Figure 4. In this interval capacitor C charges through the control grid to cathode resistance of the tube and the plate load resistance. As the plate voltage approaches $B+$ the charging current decreases and the control grid becomes less positive with respect to the cathode. At this instant the plate current is once more cut off, or very nearly so; there is only a slight decrease in plate voltage during this process. Capacitor C then starts to discharge; the control grid becomes less negative with respect to the cathode and the plate current increases. This takes place as C discharges, and the plate voltage decreases, all of which occurs during T_2. Eventually, as the control grid voltage approaches the cathode potential the plate current starts to decrease; see Figure 4. Because of the coupling through capacitor C the control grid voltage rapidly increases to a positive value and the

Figure 13
Three-terminal negative-resistance oscillator.

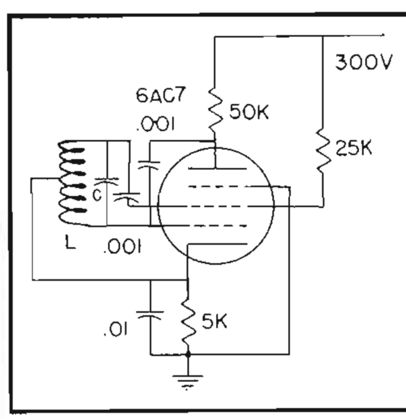


plate current is cut off. The oscillograms, Figure 11*B*, show that the plate voltage is of good saw-tooth form, making the circuit suitable for use as a sweep oscillator. The screen grid voltage of the oscillator may be applied to the control grid of the cathode-ray tube as a *return trace eliminator*. The vertical discontinuities in the plate voltage have been exaggerated in Figure 10; they are very significant as far as the method of operation is concerned, but are almost invisible on an oscillogram. The circuit will produce a good saw-tooth on frequencies as high as 50 kc. Synchronizing voltage may be applied to the suppressor grid.

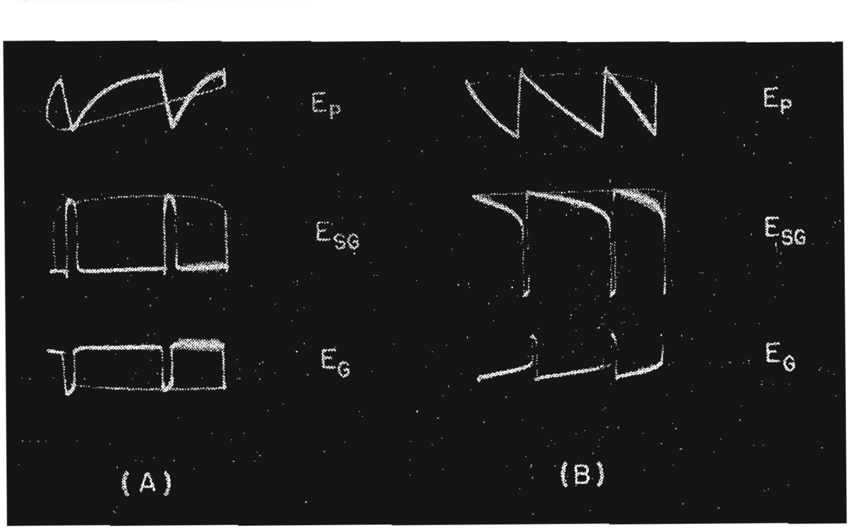
Negative Resistance Oscillators

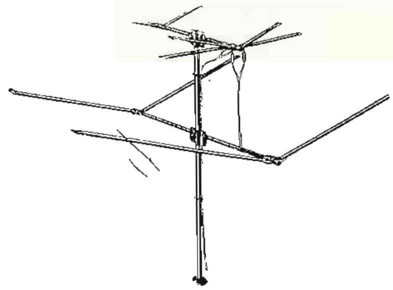
If resistance R of Figure 9 is replaced with a tuned circuit a negative-resistance oscillator, Figure 12, will be obtained. The value of negative resistance appearing between control grid and cathode can be predicted from the negative slopes of Figures 3 or 4, assuming that all of the a-c plate voltage is applied to the control grid, which will be the case if the reactance of C is very low at the operating frequency. Negative resistances as low as 200 ohms have been measured. If the Q of the tuned circuit LC is sufficiently high, the operating frequency will be determined by these constants. Oscillation will also occur if the tuned circuit is inserted in the plate circuit, or in the screen-grid circuit. Oscillations have been obtained on frequencies as high as 2.5 mc; the shunt capacitances in the untuned portions of the circuit are the limiting factor in this case.

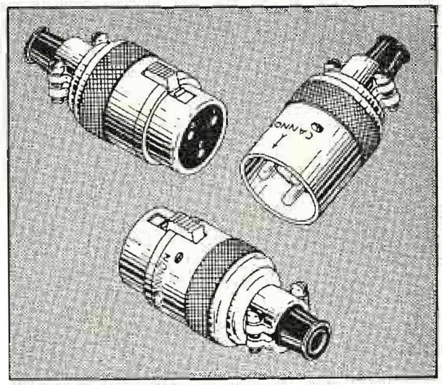
The frequency of oscillation may be increased by connecting the tuned circuit as shown in Fig. 13, which gives a three-terminal oscillator. All circuit reactances which tend to limit the maximum frequency of oscillation are then tuned out, and the circuit will function at frequencies up to 50 mc or higher.

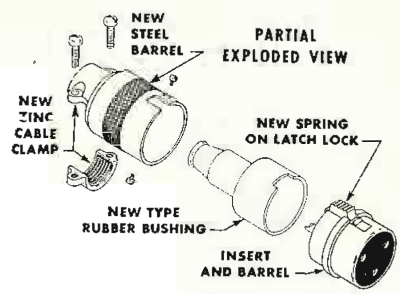
[1]Terman, Hewlett, Palmer and Yan, *Calculation and Design of Resistance Coupled Amplifiers Using Pentode Tubes*, Transactions of AIEE, Volume 59, p. 89; 1940.
[2]Brainerd, Koehler, Reich and Woodruff, *Ultra High Frequency Techniques*, p. 169, Van Nostrand; 1942.

Figure 11
Oscillograms illustrating characteristics of trigger and relaxation oscillator circuits. In *B* it will be noted that the plate voltage has a satisfactory saw-tooth form necessary for sweep oscillator systems.









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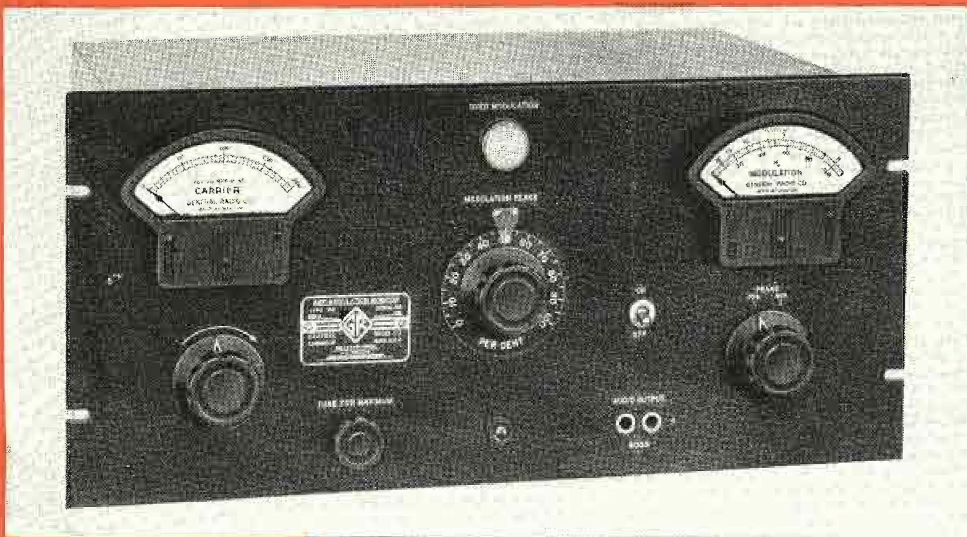
AUGUST, 1948

for A-M BROADCAST MEASUREMENTS



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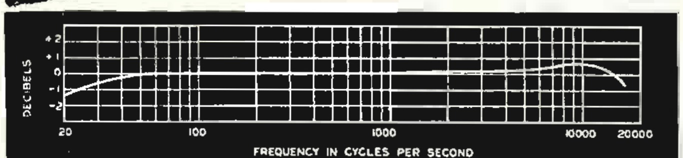

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The BN2A is plenty flexible, too. You can feed the program to the output channel and the public address system *simultaneously*. You can isolate the remote amplifier and feed the cue circuit into the PA *direct*. You can monitor both circuits. You can switch in as many as four microphones—through the four microphone inputs provided (inputs 3 and 4 are switchable to mixer 3). And you can run the BN2A from a battery simply by removing the power line connector—and plugging in the battery cord.

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Mixing Channels	Three	Power Source	105-125 v. a. c. (or battery)
Microphone Input Combinations	Four	Size	14½"L., 9½"D., 10"H.
Freq. Response (±1.0 db)	30-15000 cycles	Weight	29 lbs. (complete with a-c cable and spare tubes)
Noise Level	-70 db below +18 dbm	Cabinet	Deep umber-gray metalustre wrinkle. Removable aluminum front cover.
Distortion	Less than 1% rms		
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