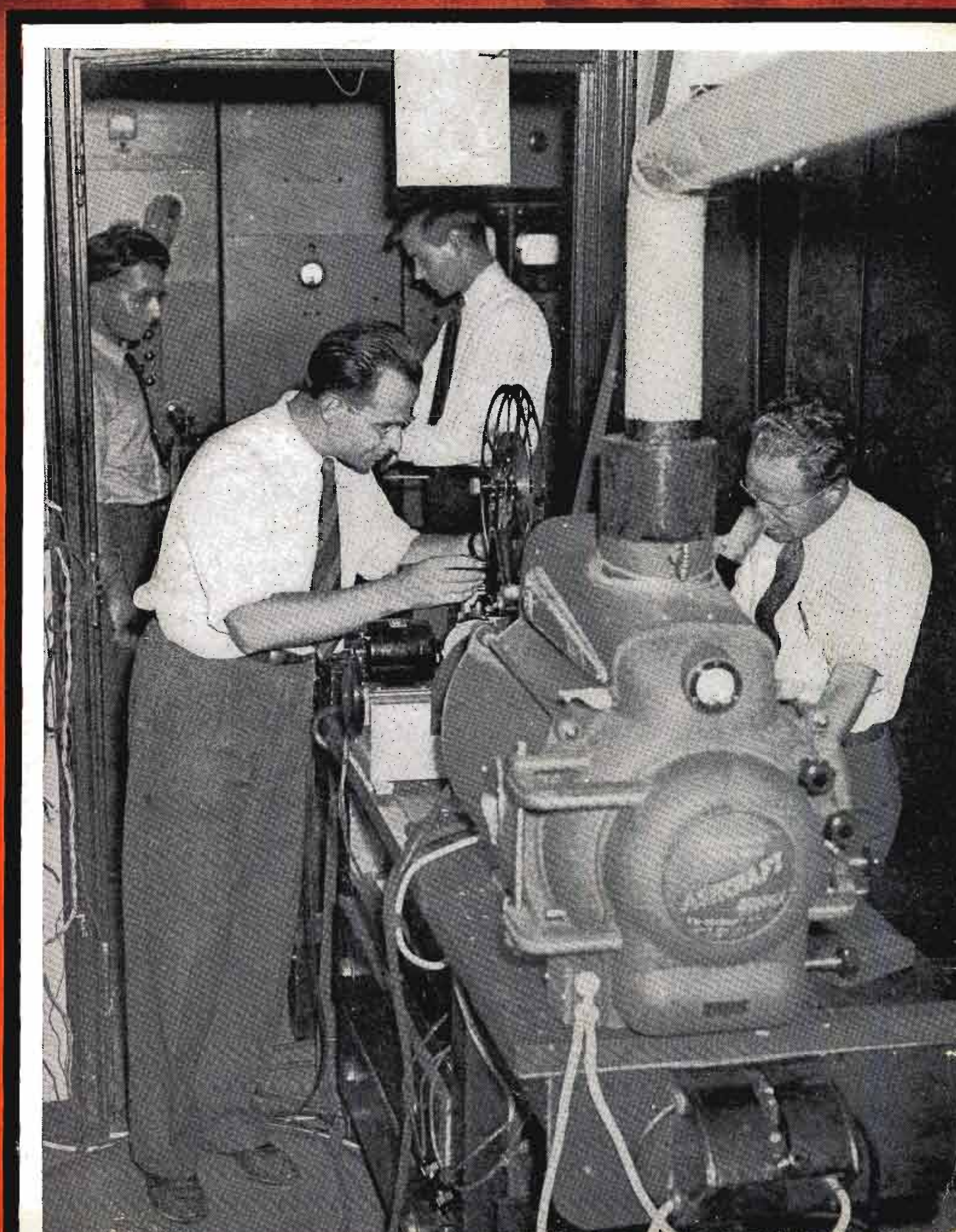
COMMUNICATIONS



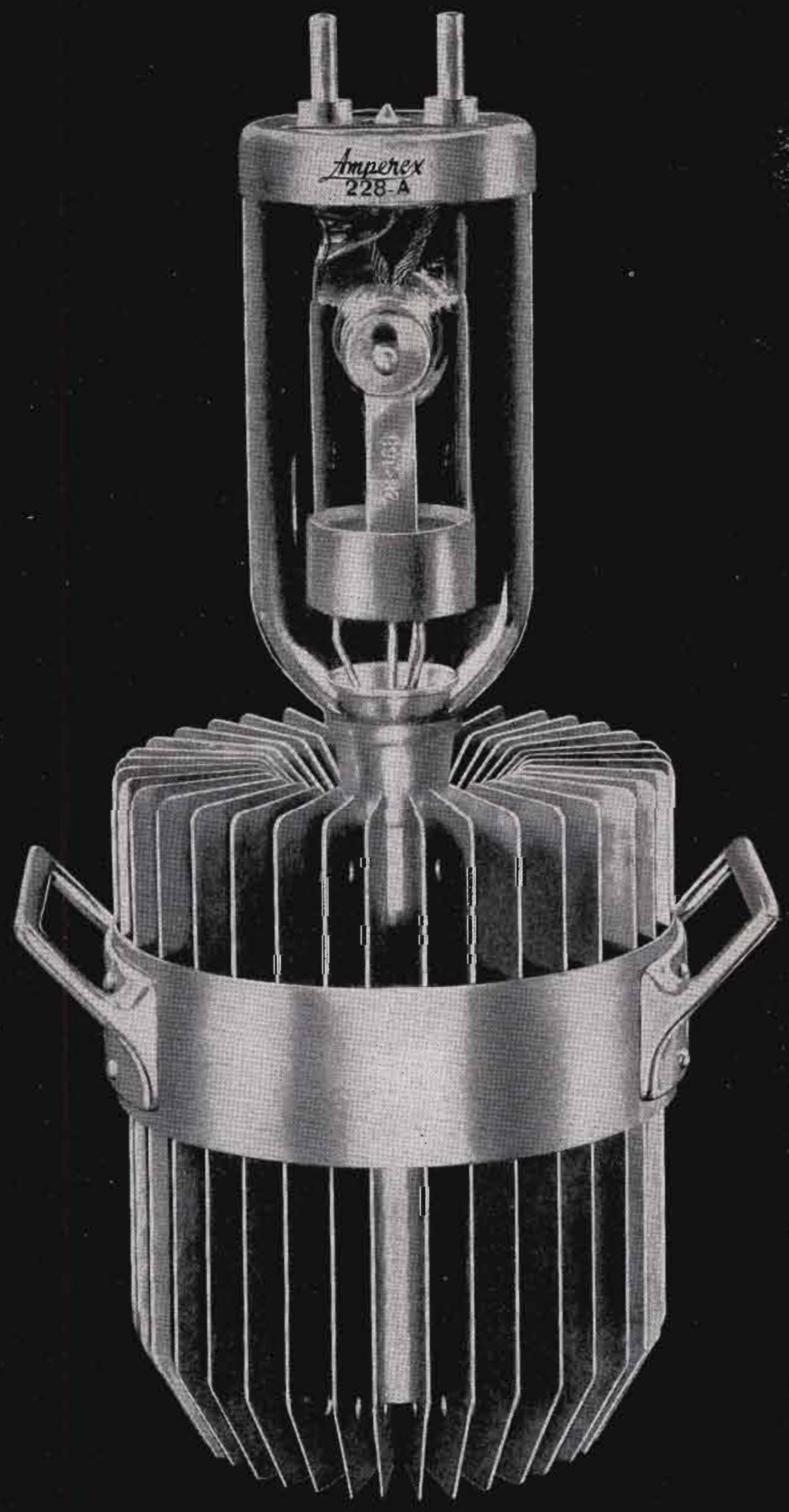
COMMUNICATION
RECEIVERS

TELEVISION

POLICE
RADIO

SEPTEMBER

1 9 4 0



AMPEREX

AIR RADIATORS

FOR WATER COOLED TUBES

AMPEREX engineers have developed a series of Radiators suitable for the forced air cooling of metal anode power tubes which are ordinarily water cooled.

These Radiators are scientifically *designed for the greatest transfer* of heat to the air stream. Their structures are simple, yet they are remarkably efficient. In fact, for some high frequency uses, they are far more desirable than water cooling systems.

AMPEREX Radiators are available with the 891, 892, 342A, 343A, 232C, 220C, 228A and can be readily manufactured for many other types of tubes.

Because of the technical skill required for imbedding the anode into the radiator well, these radiators can only be supplied as an integral part of the tube.

AMPEREX ELECTRONIC PRODUCTS, Inc.

79 WASHINGTON STREET **BROOKLYN, NEW YORK**

COMMUNICATIONS

SEPTEMBER
1 9 4 0

Including Television Engineering, Radio Engineering, Communication & Broadcast Engineering, The Broadcast Engineer.
Registered U. S. Patent Office
Member of Audit Bureau of Circulations

VOLUME 20
NUMBER 9

RAY D. RETTENMEYER
Editor

• Contents •

COVER ILLUSTRATION

Dr. Peter C. Goldmark (left, front) making final adjustments on film scanning device in laboratory of Columbia Broadcasting System, preparatory to first public demonstration of his color television system. With Columbia's chief television engineer are: J. N. Dyer (right, rear), assistant chief television engineer, and Michael Haas (right, front) and D. Doncaster, technicians.

• Editorial Comment •

IT appears that a major television development is in the offing. During the past few months several systems of colored television have been announced and at least one method has been successfully demonstrated.

A system of "Television in Natural Color," patented by R. Lorenzen, was described in a recent issue of COMMUNICATIONS (June, 1940, p. 8). This electronic method requires that both the pickup and receiving cathode-ray tubes have their sensitive photoelectric surfaces divided into separate areas, these areas having either coatings sensitive to red, green and blue, or a uniformly coated screen which responds to each of the three primary colors. At the receiving end an attachment, either a mirror or prism system, is employed to cause the superposition of the variously colored images. The band width required does not exceed the present standard.

Another electronic means of obtaining colored television is under development in the Allen B. DuMont Labs. This method will require a special screen for automatically selecting and rendering the elementary colored images in proper sequence.

On September 4, the Columbia Broadcasting System demonstrated a colored television system invented by their chief television engineer, Dr. Peter C. Goldmark. (See front cover.) The equipment demonstrated used 16-mm motion picture film taken at 64 frames per second and run at 60 frames per second. The picture, which was excellent, contained 343 lines interlaced, although Dr. Goldmark believes that over 400 lines can be obtained without exceeding the 6-mc band. It should be noted here that both Lorenzen and Goldmark have pointed out that the addition of color adds greatly to the apparent detail and definition in the picture . . . a point which was borne out at the CBS demonstration.

There is no doubt that color would add greatly to the entertainment value of television as far as the public is concerned . . . even at increased receiver prices. We wonder then if it might not be wise for the National Television Systems Committee to consider tentative standards for color television?

Published Monthly by the
BRYAN DAVIS PUBLISHING CO., Inc.
19 East 47th Street
New York City
New York Telephone: PLaza 3-0483

BRYAN S. DAVIS
President

JAMES A. WALKER
Secretary

PAUL S. WEIL
Advertising Manager

A. GOEBEL
Circulation Manager

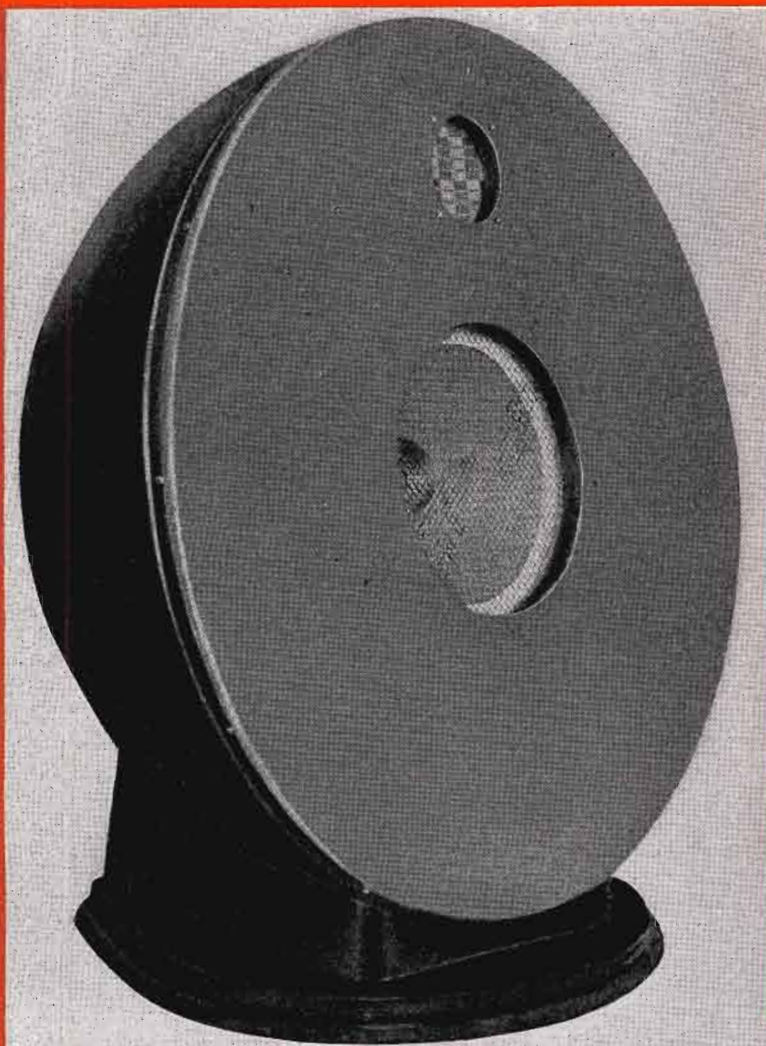
Chicago Office—608 S. Dearborn Street
Telephone: Wabash 1903

Wellington, New Zealand—Te Aro Book Depot
Melbourne, Australia—McGill's Agency

Entered as second-class matter October 1, 1937, at the Post Office at New York, N. Y., under the act of March 3, 1879. Yearly subscription rate: $2.00 in the United States and Canada, $3.00 in foreign countries. Single copies: twenty-five cents in United States and Canada, thirty-five cents in foreign countries.

CINAUDAGRAPH SPEAKERS

WOOFER-TWEETER UNIT

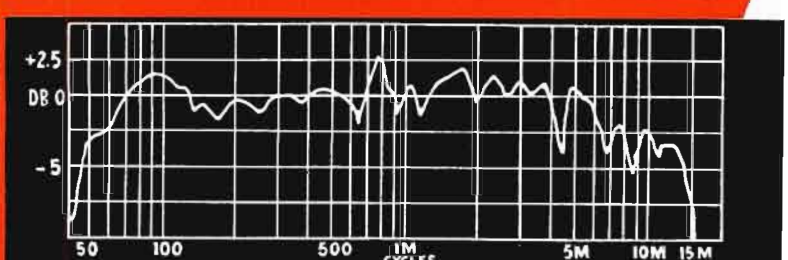


THE IDEAL SPEAKER

for FM, Broadcast Monitor, Auditorium or other High Fidelity Service

The UTC Telesphere baffle is a revolutionary step in speaker baffling. The smooth contours of this baffle prevent internal "cabinet corner" reflections, and uniform spacing from the cone to all parts of the baffle maintains uniform internal phase characteristics. A remarkable improvement in high frequency definition is effected.

No reflexing is used in this infinite baffle to eliminate the "boom" frequently encountered in reflexed units at the peak point.



Type HC-15 watt high fidelity permanent magnet woofer-tweeter combination frequency curve as illustrated uniform from 50 to 15,000 cycles. This combination incorporates the new LM-5-15T tweeter and the new WM-12-15 woofer in a Telesphere baffle. The CN-1500V crossover network is mounted inside the baffle. List Price $127.50

WOOFER-TWEETER COMPONENTS

CINAUDAGRAPH Woofer speakers are specifically designed for low frequency service in woofer-tweeter combinations. In addition to excellent low frequency response, the design effects negligible cone break-up and minimum "hangover."

- ★ WM-12-15—specially designed low frequency woofer (may be used with LM-5-15T)—15 watts output continuously, List **$32.50**
- ★ WM-13-23—a heavy duty 13" woofer—will handle 23 watts continuously, List Price **$60.00**
- ★ WM-15-25—a heavy duty 15" woofer—will handle 25 watts continuously, List Price **$75.00**
- ★ WM-18-30—a heavy duty 18" woofer—will handle 30 watts continuously, List Price **$100.00**
- ★ New High Frequency Tweeter, fully enclosed, response ±5 DB, 1,500 to 17,000 cycles, for 15 watt combinations. For 20 to 30 watt woofer-tweeter combinations, two of these tweeters should be used. LM-5-15T, List Price **$25.00**
- ★ CN-1500V—1,500 cycle crossover network for use with LM-5-15T and a low frequency woofer speaker, matches 6-8 ohm amplifier output, List Price **$12.50**
- ★ CN-1500L—same as above but for matching 500 ohms ... **$17.50**

NO FINER SPEAKER MADE IN ALL THE WORLD

CINAUDAGRAPH SPEAKERS

2 SELLECK STREET ★ STAMFORD, CONNECTICUT

EXPORT DIVISION: 100 VARICK STREET NEW YORK, N. Y. CABLES: "ARLAB"

Compensating for TUBE INPUT CAPACITANCE VARIATION by Double Bias Provision

By JOHN F. FARRINGTON
Hazeltine Service Corp.

IT has long been recognized that the input capacitance of a vacuum-tube amplifier is not independent of the d-c potentials applied to the electrodes of the tube. There have appeared in the technical literature several papers relating to this subject in which the variation of input capacitance of a tube has been calculated as a function of the d-c potentials on the electrodes from consideration of the electronic theory of the vacuum tube. These articles have not indicated how the variable capacitance effect can be overcome within the tube while obtaining variation of the transconductance of the tube and the gain in an amplifier stage. This matter is of particular importance in the design and operation of high-gain, high-frequency amplifiers where small tuning capacitance is used and gain control is desired.

In using a vacuum tube as an amplifier between tuned circuits it is common to employ adjustable negative bias potential on the signal grid to control the gain. When the gain is controlled in this manner in conventional receiving tubes, an appreciable variation in the input capacitance of the tube occurs, which may exceed 1.5 mmfd. A typical example is given by the curves of Fig. 1 which show the input capacitance change vs. grid bias potential for a 6K7 tube and a 6L7 tube. This change in input capacitance will cause detuning of the input selector circuit, the amount depending on the size of the tuned circuit capacitor. Thus, if a 75 mmfd tuning capacitor is used, a 1% change in the resonant frequency of the input selector may result as a consequence of varying the grid bias voltage to obtain substantial gain control action. If fairly selective circuits are used on the input and output of the tube, for example circuits with a Q (= ωL/R) of 100, this detuning will materially broaden and shift the frequency characteristic of the selector-amplifier system. It should be noted that this effect is quite divorced from the effect due to feedback through the tube arising from minute capacitance coupling between the plate and the signal grid electrodes.

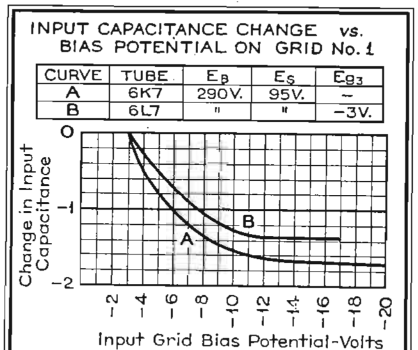


Fig. 1

This paper describes a circuit for overcoming this undesired characteristic of the amplifier tube.* The means employed include the use of a 6L7 mixer type tube as an amplifier and the application of suitably proportioned gain-control bias potentials to the signal input grid and the injector grid of the tube.

To illustrate the operation of this new method of control, the curves of Fig. 2 are presented. These depict the capacitance change measured at the input grid of a 6L7 tube as a function of the bias voltages on the input and injector grids. The capacitance increases with increasing negative bias potential on the injector grid. The parameter for these curves is signal-grid bias potential, E_{g1}. Inspection of these curves shows that over a limited range of the parameter E_{g1} the input capacitance can be held exactly constant by applying to the injector grid a suitable value of potential E_{g3}. The intersection of these curves with the axis of zero change in capacitance is an example of such related bias potential values.

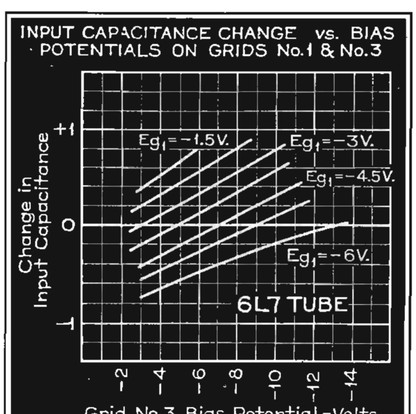


Fig. 2

This suggests the possibility of achieving gain control while maintaining constant input capacitance by applying a-v-c potentials simultaneously and in proper proportion to the input and injector grids. However, for this particular tube the required ratio of E_{g1} to E_{g3} is not constant and therefore an expedient is required to obtain the desired results with a simple fixed-ratio a-v-c source. A solution for this problem is to supplement the fixed ratio of a-v-c potentials applied to the two grids with a variable potential of proper magnitude derived from a resistor in the cathode circuit of the tube. A circuit for accomplishing this is shown in Fig. 3.

Using this circuit with a 200-ohm cathode resistor and the indicated operating potentials, a 2/5 ratio of a-v-c potentials on the input and injector grids (as set by resistors R_1 and R_2) will hold the input capacitance substantially constant over most of the useful a-v-c potential range, as indicated by Curve B of Fig. 4. Other ratios of a-v-c potentials give less desirable results, as depicted by the other curves of Fig. 4. For contrast, attention is again directed to the curves of Fig. 1 which show a marked variation in the input capacitance of 6L7 and 6K7 tubes when only the bias potential on the signal grid is varied.

All of the capacitance change measurements thus far discussed were made

*This subject has been treated by the writer also in the *R. M. A. Engineer*, Nov. 1939, and U. S. Patent 2,209,394.

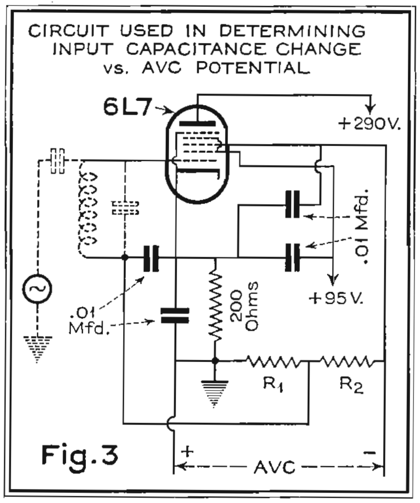


Fig.3

at 450 kc by noting the detuning of a sharply tuned circuit attached to the input grid-cathode circuit of the tube, there being no load impedance in the plate circuit of the tube.

Since the object of the new circuit is to provide an amplifier capable of gain control by a-v-c potential without the customary defect of changing input capacitance, measurements were made on a tuned amplifier using the new control circuit. The circuit tested is shown in Fig. 5. The input and output selector circuits were tuned to 450 kc and had moderately high L/C ratio and a Q of approximately 100 to procure high gain. The tuning capacitance for each circuit was 104 mmfd and the inductance 1.2 millihenries. In Fig. 6 are presented curves for this amplifier which show the shift in the mid-band frequency (Δf_m), band width at half amplitude (W_2) and the stage gain as a function of the a-v-c potential. Only slight deviations in the overall selectivity characteristics occur as the gain is varied some 40 db. It will be noted that the band width at high gain levels is slightly greater than for low gain operation, despite the fact that the circuits are maintained in tune. This was traced to variable loading of the output tuned circuit by the changing plate impedance of the tube as the a-v-c potential was varied.

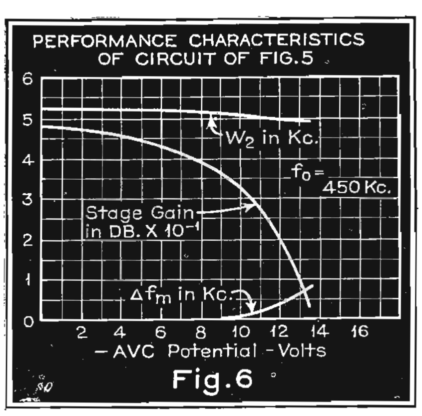


Fig.6

For contrast the amplifier was operated in conventional manner by applying a-v-c potential only to the input grid of the 6L7 tube and grounding the injector grid, and corresponding performance data were obtained as shown by the curves of Fig. 7. It is seen from these curves that the selector characteristics change markedly with a-v-c potential even though the selectors are tuned with not uncommonly small values of capacitance.

While the advantages of this gain control system are evident from the foregoing example, its greatest usefulness is in amplifiers handling higher frequencies, particularly when they are designed with small tuning capacitance to obtain maximum gain.

Several 6L7 tubes were tried in the new circuit. All of them exhibited the

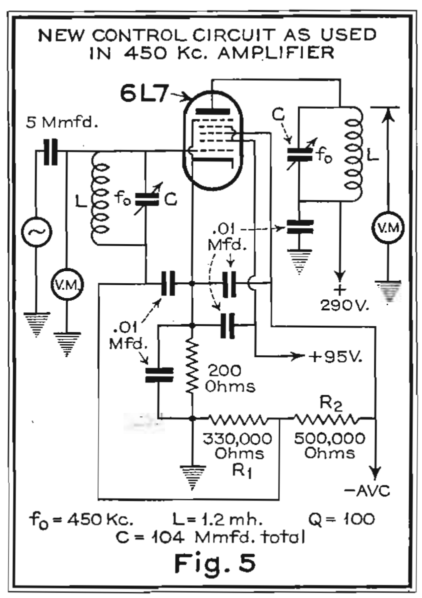


Fig. 5

same general control characteristics. Although there were noticeable minor differences in performance, it was found that the ratio of a-v-c potentials applied to the signal and injector grids for optimum stability of the input capacitance remained between 2 to 5 (as in the illustrative example) and 1 to 3 when a 200-ohm resistor was used.

In the 450-kc tests, in which a tuned input circuit having about 1/3 megohm impedance was used, it was noticed that a slight loading effect on the tuned circuit was produced by the tube when the total bias potential on the grids was less than —2.4 volts. Therefore, it is important in designing the amplifier to provide at least this value of initial bias potential with the cathode resistor.

In the region near cutoff of plate current by the injector grid bias potential, which is at about —13 volts, noticeable overload occurs with signal input amplitudes in excess of .5 volt. In this respect the tube behaves like a sharp

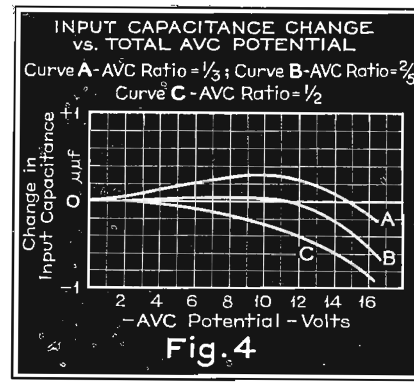


Fig.4

cut-off tube. Therefore, the system as developed around the 6L7 tube must be used only within a range of a-v-c potentials which will insure freedom from overload at the input signal levels employed.

The following explanation is offered as to the operation of the 6L7 mixer tube whereby constant input capacitance and variable gain are achieved. Under normal operating conditions the signal grid and the injector grid are maintained at negative potentials and the screen grid and the plate electrodes are held at fixed positive potentials with respect to the cathode. Electrons pass from the cathode through the signal grid and screen to the plate. Surrounding the grid wires we may imagine there exist zero-potential tubes outside of which are electrons. The space between the grid wires and these tubes constitutes that portion of the input capacitance which is due to the presence of the electrons. By increasing the negative potential on the signal grid, these tubes may be expanded and the input capacitance decreased. However, if the charge density in the region of the grid is simultaneously increased in proper amount, the tubes may be brought to a configuration which will restore the input capacitance to its original value. Such control can be achieved through the medium of the virtual cathode formed between the screen and the injector grid. By mak-

(*Continued on page* 14)

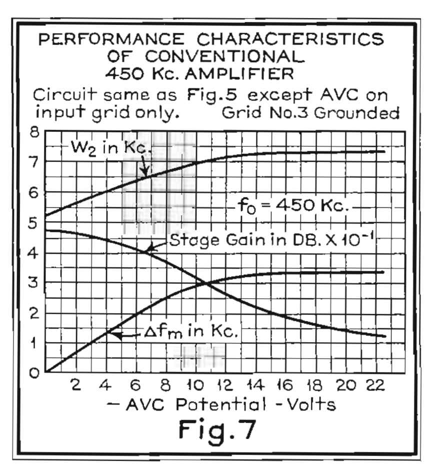


Fig.7

CONTINUOUS WAVE INTERFERENCE

With Television Reception

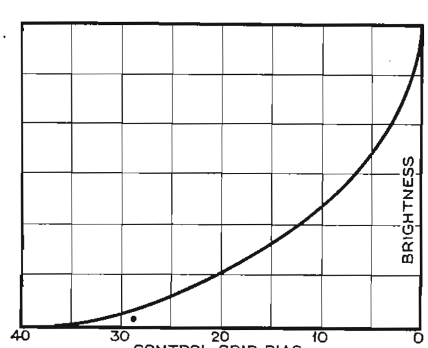
By C. N. SMYTH
Television Laboratories,
Kolster-Brandes, Ltd.
(Company of I. T. & T. Group)

INTERFERENCE with television reception can be very severe due to the large band width employed for this service, and is a much more serious problem than interference with sound broadcasting. Fortunately, however, both have much in common in the methods which can be used to effect suppression.

Interference may be divided into two main categories, damped wave or impulsive type interference and continuous wave interference. The former is caused mainly by radiation from the ignition systems of motor vehicles, sparking in electrical machinery and appliances and from harmonics of spark type transmitters on certain ships. Thermal agitation, noise in circuits and Schott noise in tubes also produce interference of this type within television receivers. The latter type of interference is caused by radiation from short-wave radio or television receivers of the superheterodyne type, medical diathermy apparatus used in hospitals, and harmonics from powerful broadcast and amateur transmitters. Continuous wave interference patterns may also be produced within television receivers, quite apart from any outside sources, due to unwanted couplings between certain circuits causing harmonics of the sound or vision intermediate frequencies to react with the incoming signal*, or due to hum voltages derived from the power-supply frequency and its harmonics, or voltages derived from the harmonics of the scanning frequencies, being injected into the receiver picture amplifier.

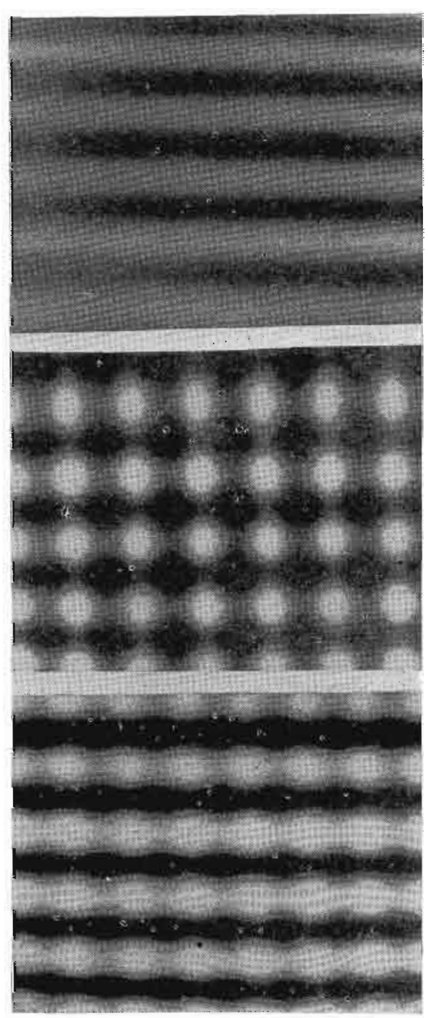
*See Bedford, *Jnl. Tel. Soc.*, March, 1937.

Fig. 3. The exponential light voltage characteristics.



Above: Fig. 1. A typical example of continuous wave interference.

Below: Fig. 4 (a, b, c—top to bottom) (a) Raster with signal; and two (b, c) conditions of interference.



Methods of Reducing Interference

Interference-free reception of sound or television can only be effected if it is possible to locate an aerial in a position where the signal-interference ratio is sufficiently large and where the signal strength is sufficiently strong to swamp the effects of losses in the transmission line and interference encountered in the receiver itself, then providing the receiver is well screened and the power supply adequately filtered, the receiver will reproduce the signal-interference ratio present in the aerial in the frequency pass band of the receiver. If the signal-interference ratio at the aerial is not sufficiently good, then advantage may be taken of the directional and polarizing properties of aerials and an aerial employed which receives waves coming only from the effective direction of the transmitter and with the desired angle of polarization.

Beyond this, the signal interference ratio cannot be improved without reduction of picture quality, by reduction of band width or the use of interference suppression circuits which limit the peaks of picture modulation or leave gaps in the picture where interference signals would normally appear. Such interference suppression circuits are, of course, only applicable to impulsive type interference.

Further improvement lies in the direction of suppression of the interference at the source, but before this can be undertaken with any certainty of success it is necessary to have an exact

Fig. 2. The linear light voltage characteristic.

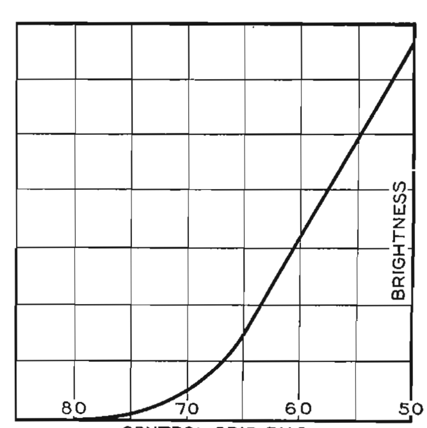


Fig. 6. (Top to bottom, a, b, c, d, e) Various television images taken with interference at a frequency of about 300 kc. Interference to signal voltage ratios: 0, -10, -20, -30, -40 db.

knowledge of the degree of suppression which is desirable.

Continuous Wave Interference

By continuous wave interference is implied the production of spurious modulation frequencies superimposed on the picture signal in the output of the re-

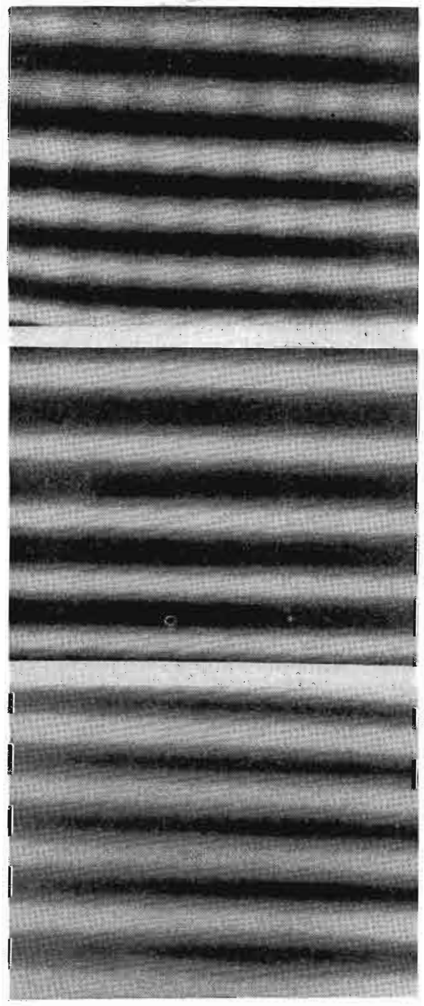


Fig. 4 (d, e, f—top to bottom). Interference levels -20, -30, -40 db. Compare (f) with (a) page 5.

ceiver and appearing as a steady or slowly changing pattern on the picture screen. The effect is often described as a herring bone or feather pattern superimposed on the picture. A typical example is shown in Fig. 1. Such interference is caused by the interaction of an unwanted signal with the carrier frequency of the television transmission, the unwanted signal usually heterodyning the carrier frequency directly, or the intermediate frequency, to produce beats in the video frequency range. In superheterodyne receivers, the effect is also produced by interference from signals in the second channel band, or image signal interference. The problem then is similar to the production of whistle interference in broadcast receivers.

The annoyance value of the interference, its property of destroying the entertainment value of a television program, depends clearly on the signal-to-interference ratio on the resultant picture, or what is almost the same thing, at the output of the receiver vision amplifier or at the grid of the light modulating device.

The signal-interference ratio at the output of the receiver will, in general, be slightly different from that at the input due to the various characteristics of the receiver. The amount of the change will depend on factors such as, the magnitude of the incoming signal, the magnitude of the incoming interference, the type of frequency changer and detector employed, the band width of the circuits in various parts of the receiver, especially of the input cir-

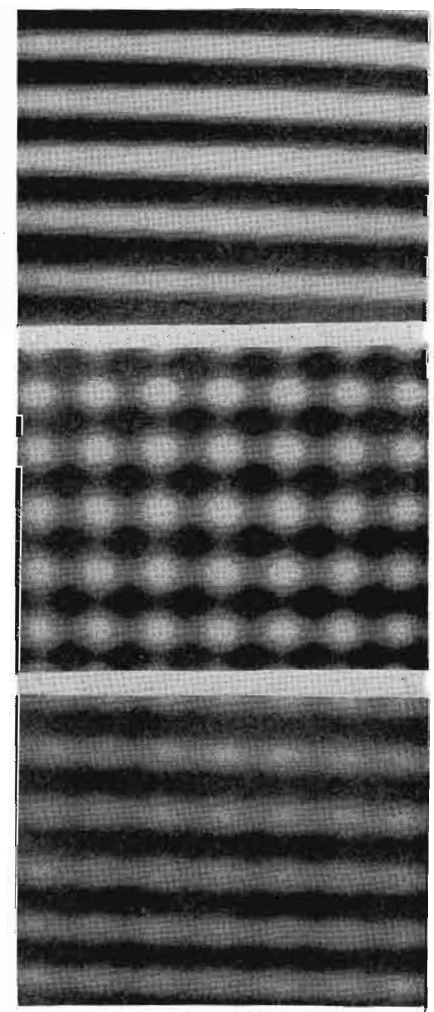


Fig. 5 (a, b, c—top to bottom) Conditions of Fig. 4, but using exponential characteristic (Fig. 3)

cuits, and the relative frequencies of the signal and interference. A detailed analysis of the effects of these various factors can be carried out practically, or mathematically, for any given receiver design in accordance with known methods and so this work is limited to establishing the signal-to-interference ratio which may be tolerated at the grid of the light modulating device.

Measurements

A series of visual observations has been made, and photographically recorded, to study the effects of the interference on test signals and also on actual programs. No marked divergence of opinion was expressed by any of the observers as to what did or did not represent interference-free reception. Measurements were also made to determine whether c-w interference was more noticeable by reason of its effect on synchronization than on modulation of the picture brightness.

The conditions of the observations were as follows: two cathode-ray type television receivers were arranged for viewing signals from the London trans-

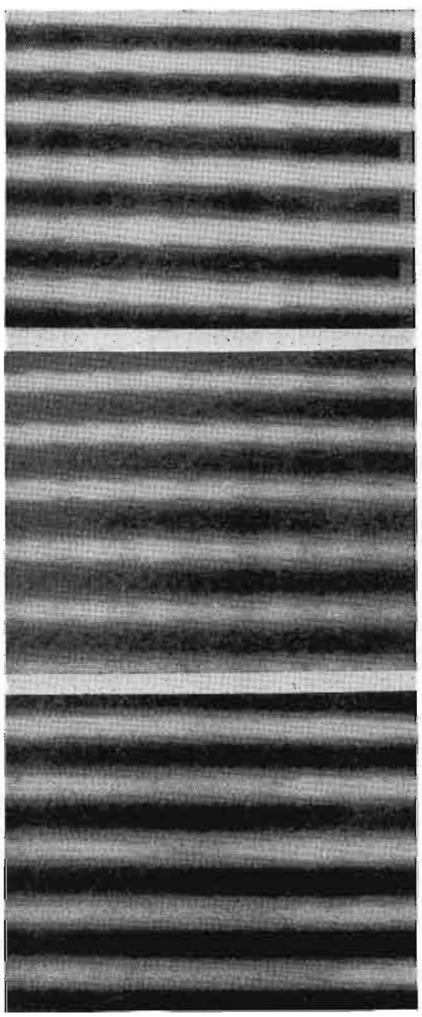


Fig. 5 (d, e, f—top to bottom) Same conditions as Fig. 4 (d, e, f) with exponential characteristic of Fig. 3.

mitter of the British Broadcasting Corporation. One was fitted with a cathode-ray tube having a linear light-voltage characteristic and the other with a cathode-ray tube having an exponential light voltage characteristic. (See Figs. 2 and 3.) The receivers were also arranged so that they could receive a 45-mc carrier modulated 30% at 400 cycles per second instead of the B.B.C. transmission. Both the B.B.C. signal and the test signals passed from the aerial through the normal h-f and l-f amplifying stages of the receiver. Peak voltmeters and cathode-ray oscillographic measuring gear were set up to measure the output signal applied to

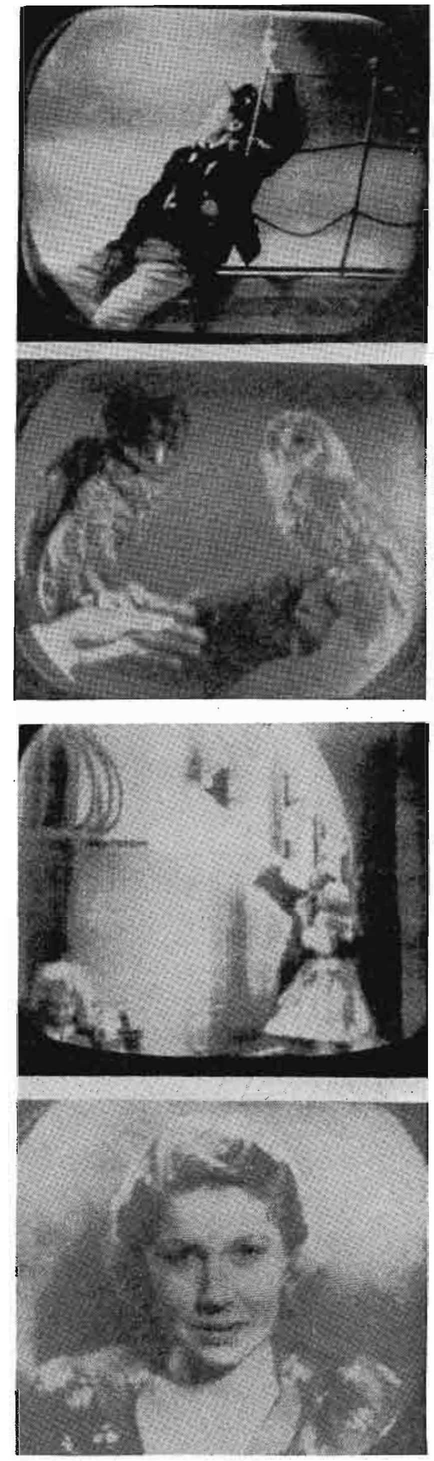
Fig. 8 (a, b, c—top to bottom) Illustrating interference applied to picture modulation and to synchronizing circuits.

the c-r tube modulating grids.

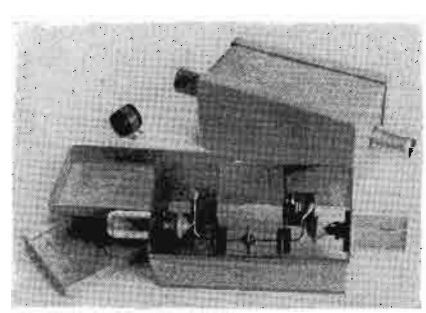
Measured interfering voltages from a continuous-wave oscillator were also arranged to be injected into the cathode circuit of the c-r tube. Thus interference of any desired magnitude or frequency could be mixed with the incoming wanted signal. Hence, interference was not produced, as in practice, by beating of two signals within the receiver, but definitely mixed with the receiver output in known quantity and frequency. The conclusions are shown in the accompanying photographic reproductions.

In Fig. 4, a, b, c, d, e, f were obtained on the c-r tube with a linear characteristic (Fig. 2). The wanted signal con-

(Continued on page 14)



Above: Fig. 7 (a, b, c, d)—top to bottom) Showing the effects of frequency on the appearance of interference. Below: Fig. 9. The high-pass filter.



Some Notes on Diode Detection

PART II*

By ALBERT PREISMAN

RCA Institutes, Inc.

I. Diode Performance—Resistive Circuit

IT is of interest to study first the diode performance when the tuned circuit is assumed to present a source impedance R to the carrier and side-band frequencies, and the load a resistance R_L to the carrier, and a resistance R'_L to the modulation frequencies, where R'_L is equal to R_L and R_g in parallel, Fig. 1. It is therefore assumed that C_g has negligible reactance, and C_L has negligible admittance at the modulation frequency f_m, while the tuned circuit has negligible admittance to the side-band frequencies $(f_c \pm f_m)$. Throughout this discussion, C_L is assumed to have negligible reactance to all high-frequency components flowing through it.

In the preceding section* it was shown that R_L had an apparent resistance to the high-frequency source of $R_L/2$. In the same manner R has an apparent resistance, when viewed from the diode low-frequency output terminals, of value 2R. The envelope appears from these same terrminals as a voltage e_L, composed of a d-c component equal to the carrier peak amplitude E_c, and an a-c component equal to the vector sum of the side band amplitudes, or $mE_c \sin\omega_m t$. The above is sufficient information to proceed with the graphical construction.

This is shown in Fig. 2. First the quiescent point for the unmodulated carrier E_c is determined. Through O, the load line OA for R_L is drawn. Then a rule is slid at an angle θ such that

$$\theta = \cot^{-1}(R_L + 2R) \quad \ldots\ldots\ldots\ldots (1)$$

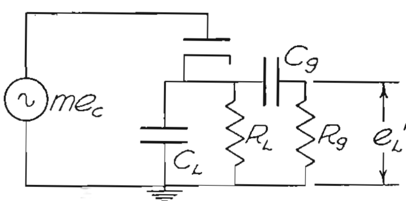
Where it intersects OA in a diode rectification curve, at B, such that CD equals E_c, is the quiescent point. (The load line for $(R_L + 2R)$ is DB). The reader can check that OD is the voltage drop in the apparent source impedance (as viewed from the diode output terminals), CE is the voltage drop in the diode itself, and EO is the voltage developed across R_L.

Now suppose that the carrier is modulated, and that the instantaneous peak carrier voltage me_c is at the moment under consideration greater than E_c (envelope rising above its average carrier value), by an amount ΔE_c. To find the path of operation for the modulated carrier, proceed as follows.

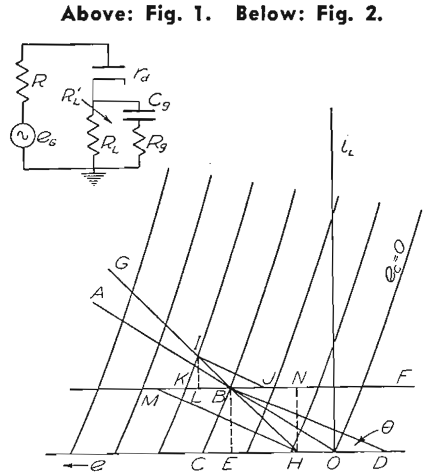
Shift the voltage axis up to B, so that its new position is BF. Through B draw the steeper load line for R'_L, namely GH. Now slide a rule IJ at an angle

$$\theta' = \cot^{-1}(R'_L + 2R) \quad \ldots\ldots\ldots\ldots (2)$$

to a position where its intersection with GH in I is also that of a characteristic curve IK, and such that KJ equals ΔE_c. Then BJ represents the voltage drop in 2R, KL that in the diode, and LB, that developed across the a-c diode load resistance R'_L. This process is then repeated until all values of the envelope have been used.



Above: Fig. 1. Below: Fig. 2.



Since the path of operation is clearly along GH, it is in practice necessary to find the points corresponding only to the peaks of the envelope. It is also evident from the figure that a peak envelope which carries the path of operation beyond H will result in output distortion. This matter will now be discussed in greater detail.

The resistance R'_L to the a-c component of the output current i_L is less than that, R_L, to the d-c component. This would mean that if $m = 1$, the peak modulation voltage is equal to the average, or carrier voltage E_c, and hence the a-c component of i_L would exceed the d-c component, or the total would have to be negative during peak inward modulation. But this is impossible, since the diode cannot conduct reverse current. Hence, the path of operation for inward modulation is first along BG (Fig. 2) and then along the e_L (BH) axis, or the negative peaks of i_L are "clipped," with resulting distortion. This is similar to excessive grid swing in a three-or-more element tube, where the operation is carried beyond plate-current cut-off. There also results some self-rectification with consequent shifting of the operating point away from B.

To avoid such clipping, the maximum modulation of the generated input signal must be less than m. To find this maximum permissible value m', for m, draw MH parallel to IJ, i.e.—at the slope for $(2R + R'_L)$. It is then evident from the figure that the generated carrier voltage is

$$E_c = (CE + EO + OD) = i_{dc}(r_d + R_L + 2R) \quad \ldots\ldots (3)$$

whereas the maximum permissible decrease in the generated carrier envelope is

$$M E_c = (NQ + NB + BM) = i_L(r_d + R'_L + 2R) \quad \ldots\ldots (4)$$

From Eqs. (3) and (4),

$$m' = (i_L/i_{dc})(r_d + R'_L + 2R).$$

But for maximum permissible modulation, i_L just equals i_{dc}, so that

$$m' = \frac{(r_d + R'_L + 2R)}{(r_d + R_L + 2R)} \quad \ldots\ldots\ldots (5)$$

It is to be noted from Eq. (5) that the smaller R'_L is compared to R_L, the smaller m' will be, whereas the greater R is, the more nearly does m' approach unity. In short, R tends to counteract the difference between R'_L and R_L in reducing the value of m', but this, of course, does not indicate that a high value of R is desirable, since the actual output voltage, e_L, would be reduced. The main point in presenting the action of R is to show that the percentage modulation at which clipping just occurs is dependent upon all parameters, including r_d, although it is primarily caused by the lower value of R'_L as compared to R_L. If r_d is comparable to R'_L then the reflection of R into the output circuit will be less than 2R and quite difficult to determine. However, for quite a range of $r_d < R_L$ the above value of 2R holds fairly accurately, and

*See Part I, "Some Notes on Diode Detection," by Albert Preisman, p. 18, August, 1940 COMMUNICATIONS.

indeed, in usual broadcast practice where $r_d << R_L$ (diode approaches the ideal), Eq. (5) reduces to

$$m' = \frac{R'_L + 2R}{R_L + 2R} \quad \ldots\ldots\ldots\ldots\ldots\ldots (6)$$

The difference in total circuit resistance for the envelope $(2R + R'_L)$ and the carrier $(2R + R_L)$ results in a reduction in the envelope at the diode plus load terminals as compared to the generated voltage. From Fig. 2 it is evident that the generated envelope voltage is MQ, and the terminal voltage is BQ (including the drop in the diode). It is also evident that the carrier generated voltage is CD, and the carrier terminal voltage is CO. The percentage modulation m_G of the generated signal is MQ/CD, while the percentage modulation of the terminal voltage, m_T, is BQ/CO. From the diagram it is evident that

$$m_G = MQ/CD = \frac{i_L\,(2R + R'_L + r_d)}{i_{dc}\,(2R + R_L + r_d)} \quad \ldots\ldots (7)$$

and

$$m_T = BQ/CO = \frac{i_L\,(R'_L + r_d)}{i_{dc}\,(R_L + r_d)}$$

Then the percentage reduction in modulation is

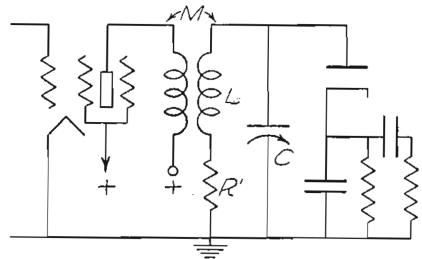
$$m_T/m_G = \left(\frac{R'_L + r_d}{R_L + r_d}\right)\left(\frac{2R + R_L + r_d}{2R + R'_L + r_d}\right) \quad \ldots\ldots\ldots\ldots\ldots\ldots (8)$$

If a greater percentage of modulation is employed than that given by Eq. (6), it will be found that around peak inward modulation, where cut-off of i_L occurs, the envelope terminal voltage will become equal to the generated envelope voltage, whereas for other portions of the modulation cycle Eq. (8) indicates that the terminal voltage will be less. Hence the envelope terminal voltage will be distorted in that it will have its negative half cycles peaked, whereas the output voltage, e_L, will have its negative peaks flattened.

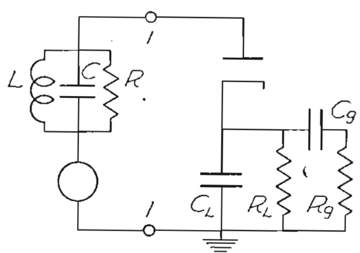
From the above several things are evident:

(1) For the usual diode circuit, where the a-c output resistance is less than the d-c output resistance, a value of modulation less than unity must be employed if distortion is to be avoided. (2) The source resistance tends to counteract this effect, but only in degree, and at the expense of the output signal. (3) The above two considerations also result in a lesser depth of modulation of the carrier voltage developed across the diode and load resistance as compared to that generated in the source.

The construction shown in Fig. 2 tacitly assumes $r_d << R'_L$, for otherwise R would not appear as 2R in the diode output circuit. However, it does take r_d into account in determining the



Above: Fig. 3. Below: Fig. 4.



maximum permissible percentage modulation, m′, and the percentage reduction in modulation. If r_d is negligible, Eqs. (6) and (8) will be found to coincide with those given by Wheeler[1] and also those given by Court[2].

It will also be evident that if a very large inductance whose winding resistance equals R_L be substituted for R_L, or —what is equivalent—a large inductance of negligible winding resistance be placed in series with R_L, and if, in addition, R_g be made equal to R_L, then the d-c and a-c resistances will be equal. In this case, 100% modulation can be

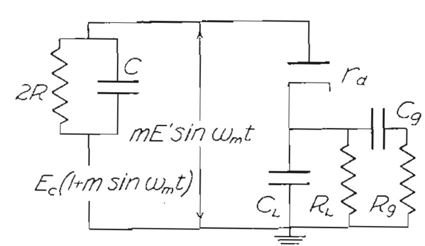


Fig. 5.

accommodated without "clipping." However, the cost and bulk of the inductance, as well as its susceptibility to hum pickup, mitigate against its use in practice.

It is also possible to obtain distortionless operation for 100% modulation with the ordinary type of resistive load by inserting a positive d-c voltage in series with the diode. Its value should be equal to HO (Fig. 2), in which case it would move the load line for R'_L over to the origin O instead of H. However, its value is dependent upon the magnitude of the carrier voltage, E_c, and distortion can occur for values of E_c greater or smaller than the value which just brings the load line for R'_L over to the origin, O. For a complete discussion, the reader can consult Wheeler[1] or Court[2].

2. Diode Performance—Tuned Source Impedance

The analysis given above is sufficient for most practical purposes. However, an actual circuit may be that shown in Fig. 3. The pentode may be regarded as a constant current generator, whose current is $G_m e_{g1}$. This current induces in the tuned secondary coil, having inductance L and resistance R, a voltage $j\omega M G_m e_1$. From this point Fig. 3 may be replaced by Fig. 4 by the use of Thevenin's Theorem, and also in view of the discussion in Section 2* (Fig. 7).

As viewed from Terminals 1-1, the apparent source impedance is as shown, where $R = \omega^2 L^2/R'$. The apparent generated (open-circuit) voltage is that developed across C before the diode is connected. For the carrier it is

$$e_c = j e_{g1} G_m \omega_c M \frac{1/j\omega_c C}{R' + j\omega_c L + 1/j\omega_c C} = e_{g1}\frac{G_m M}{R'C} \quad \ldots\ldots\ldots\ldots (9)$$

if L and C are adjusted to resonance at the carrier frequency f_c. Similarly, for the upper and lower side bands, the apparent generated voltages are respectively

$$\left.\begin{aligned} e_c^+ &= e_{g1}^+\,(G_m M/R'C) \\ e_c^- &= e_{g1}^-\,(G_m M/R'C) \end{aligned}\right\} \quad \ldots\ldots\ldots (10)$$

It is evident that they are in phase with the input voltages, and in the same ratio: $G_m M/R'C$. Hence the modulated wave is undistorted by the tuned circuit, at least if $\omega_m << \omega_c$. These voltages and the apparent source impedance can be reflected to the output side of the diode circuit, and the circuit will appear as in Fig. 5. At the higher modulation frequencies where C is of some importance, C_g is usually unimportant, so that R_L and R_g in parallel may be replaced by R'_L as in Sec. 1.

While the quiescent point for the carrier voltage is determined as in the preceding section, the a-c path requires the method mentioned previously[3] for its determination. Although fairly accurate linear circuit calculations are possible and generally more desirable, an example will be worked out to show the graphical application.

[1]Wheeler—"Design Formulas for Diode Detectors"—*IRE Proc.*, June, 1938.
[2]Court—"Diode Operating Conditions"—*The Wireless Engineer*, Nov., 1939.

*See Part I, "Some Notes on Diode Detection," by Albert Preisman, p. 18, August, 1940, COMMUNICATIONS.
[3]Preisman—"Graphics of Non-Linear Circuits"—Part I, Section IV, July, 1937, *RCA Review*.

In this example, 2R will be taken as 0.2 megohm; C as 200 mmfd; C_L as 500 mmfd; R_L as 0.125 megohm; and R_g as 0.5 megohm. The diode rectification family is that shown in Fig. 7, and is that for a 6H6 tube.

The problem as given presents formidable difficulties. The rigorous method of attack is to take C_g into account as well as the other diode load parameters. This not only increases the complexity of the circuit and hence the labor, but, due to the large R_gC_g time constant as compared to the period of the modulation frequency to be used (5000 cps), many cycles of operation will have to be traversed before steady state conditions are attained.

This characteristic of the finite operator method is due to its generality and completeness of attack. A similar situation arises if it be employed to solve a choke feed power output stage. In the latter case, a simplification and usually satisfactory approximation is made in assuming that there are two resistive load lines: a d-c load line corresponding to the ohmic resistance of the choke, and an a-c load line corresponding to the load resistance as it appears in parallel with the choke. As a first approximation, these two are assumed to intersect at the quiescent point, which intersection is then shifted to correct for self-rectification. The finite operator method, on the other hand, would give a very narrow load spiral or scroll which would finally, after many cycles, close into a steady state narrow loop practically coinciding with the final position of the load line as determined by the more approximate method.

A similar situation would arise in this problem. However, the phenomenon to be exhibited here is that of "clipping" due to the shunting effect of C_L upon R_L. Hence we shall assume that R_g is a negligible shunt upon R_L, i.e.—that the a-c and d-c resistances are identical and equal to R_L. We shall assign a value of 0.1 megohm to this parameter. This represents the above 0.1 and 0.125 megohm resistors in parallel.

The graphical construction will proceed from the origin of the family of curves rather than from the quiescent point, and 100% modulation will be assumed for e_e as determined by Eq. (9) in conjunction with Eq. (10). The equivalent voltage, as it appears across the output side of the diode circuit, will be taken as

$$e_e = 20 - 20\cos(2\pi 5000\,t) \quad \ldots.(11)$$

While this is a rather low voltage, it will exhibit the "clipping" phenomenon described above, particularly for a modulation frequency of 5000 cps. The circuit parameters given above are entirely practical, although C_L has been chosen rather large to emphasize the effect.

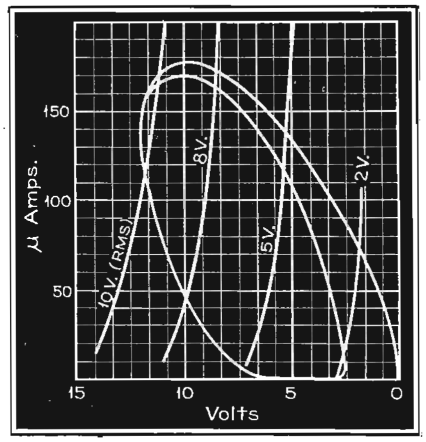


Fig. 7.

Let the voltage drop across R and C be e_1; that across the diode output load Z_L (R_L and C_L in parallel), be e_2. Also let i_{CL} be the instantaneous current through C_L, i_C, that through C, i_R, that through R, i_{RL}, that through R_L, and i_T, the total current.

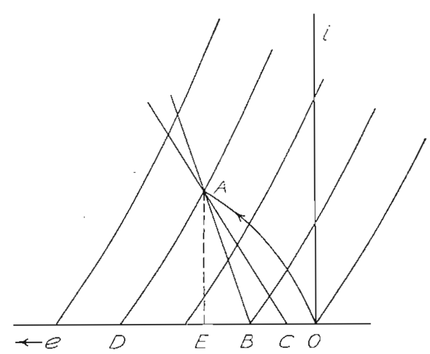


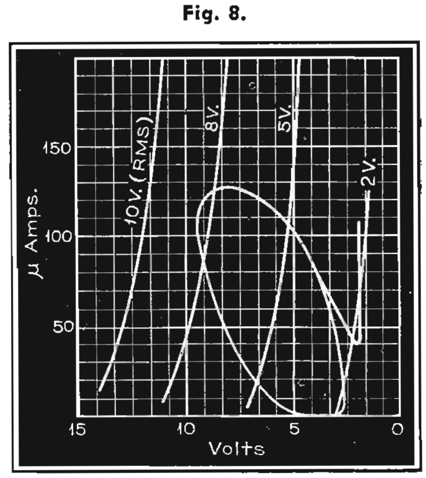
Fig. 6.

Then

$$i_T = i_{CL} + i_{RL} = i_C + i_R \quad \ldots\ldots\ldots(12)$$
$$e_1 = \Delta t/C_L\,(i_{CL} + \Sigma\, i_{CL}) = i_{RL}R_L \quad \ldots\ldots\ldots(13)$$
$$e_2 = \Delta t/C\,(i_C + \Sigma\, i_C) = i_R R \quad \ldots\ldots\ldots(14)$$
$$e_e = e_1 + e_2 + i_T r_d \quad \ldots\ldots\ldots(15)$$

where r_d is the non-linear diode resistance as given by the family of curves.

Fig. 8.



From Eqs. (12), (13) and (14) can be obtained

$$\left.\begin{aligned} e_1 &= i_T Z + Z\Sigma i_C \\ e_2 &= i_T Z_L + Z_L \Sigma i_{CL} \end{aligned}\right\} \quad \ldots\ldots\ldots(16)$$

where

$$Z = (1/R + \Delta\, t/C)$$

and

$$Z_L = (1/R_L + \Delta\, t/C_L).$$

Then, from Eqs. (15) and (16) are obtained

$$e_e - Z_L\Sigma i_{CL} - Z\Sigma i_C = i_T\,(Z_L) + i_T Z + i_T r_d \quad \ldots.(17)$$

Eqs. (16) and (17) form the basis of the graphical construction. Thus, at any stage of the process, Σi_C and Σi_{CL} are known by summing up the currents from the first application of e_e, at which time we can assume, if we wish, no initial charges on C_L and C, i.e.—Σi_C and Σi_{CL} are zero. Therefore the net voltage

$$e_n = (e_e - Z_L\Sigma i_{CL} - Z\Sigma i_C)$$

is known and is applied in a manner similar to that described in the preceding two sections of this article.

In Fig. 6 is shown the construction. The net voltage at the moment under consideration is CD. The voltage $Z_L\,\Sigma i_{CL}$ is laid off from the origin as OB. Through B is drawn BA to represent the finite operator Z_L. Then AC, which represents the finite operator $(Z + Z_L)$, is slid parallel to itself until its intersection with AB in A is also that of a diode rectification curve AD, such that DC equals the net voltage $(e_e - Z_L\Sigma i_{CL} - Z\Sigma i_C = e_n)$. Then AE equals i_T, DE represents the diode voltage drop $i_T r_d$, and EO equals $(i_T Z_L + Z_L\,\Sigma\, i_{CL})$ or e_2, the voltage across the diode load. In addition, it is evident that Eq. (17) is satisfied. The important point to note is that r_d is here a family of curves, and hence the proper member of the family must be selected. This has been done by drawing Z_L or AB at a distance BO $(= Z_L\,\Sigma\, i_{CL})$ from the origin O, so that point E will be distant from O by the amount e_2, the voltage across the diode load.

From AE, the new values of i_{CL} and i_C can be found. To determine i_{CL}, for instance, divide $e_2 (=$ EO$)$ by R_L to obtain i_{RL}. Subtract this from i_T and the difference is i_{CL}. This may turn out positive or negative, depending upon whether C_L is charging from the source or discharging through R_L during the particular time interval Δt. Similarly i_c can be found from e_1 and R. Note that e_1 is equal to BC plus $Z\Sigma i_C$, or alternatively to $(i_T Z + Z\Sigma i_C)$.

The successive values of i_T, Σi_{CL}, Σi_C, i_{CL}, i_C, e_1, e_2, e_n, etc., can be arranged in the form of a tabular schedule, in

(*Continued on page* 18)

Get this new OHMITE *Catalog and Manual*

A Wealth of Valuable Data about Resistors, Rheostats, Tap Switches and Their Applications

IT'S MORE THAN A CATALOG—it's a complete, handy reference on the use of resistors, rheostats, and tap switches in radio and electronic equipment—in the control of motor speed, of heat and light, of signal and supervisory circuits—in products and machine tools—in laboratories, maintenance, and production.

96 PAGES TELL EVERYTHING!

- ★ Valuable Engineering Data!
- ★ Complete Dimensional Drawings!
- ★ Manual of Resistance Measurements!
- ★ Handy Reference Tables!
- ★ Practical Application Information!
- ★ Wide Range of Stock Units and Special Units in Resistors, Rheostats, Tap Switches, Chokes and Attenuators, for R.F., Precision and Industrial Applications.
- ★ Describes New Products!
- ★ Covers the Most Complete Line!
- ★ Tells How to Select the Right Units!
- ★ Helps You Plan Special Units!
- ★ Saves You Time, Effort and Money!

THERE'S NOTHING LIKE IT!

It's truly an encyclopedia of helpful information — an invaluable guide packed full of tangible, usable data for engineers, production managers, and purchasing departments!

Clip this coupon to your company letterhead or write us on company stationery giving your name and position. Catalog 40 will be sent to you at once without obligation.

OHMITE MANUFACTURING COMPANY
4869 Flournoy Street, Chicago, U. S. A.

Please Send Catalog 40. No obligation.

Company Name ....
Individual Name ....
Position or Title ....
Address ....
City .... State ....

Be Right with **OHMITE**

RHEOSTATS ★ RESISTORS ★ TAP SWITCHES

COMMUNICATIONS RECEIVERS

IN the accompanying illustrations are shown a number of the latest communications receivers made available by the various manufacturers. Since the average reader already has a good general knowledge of this type of receiver, detailed circuit descriptions will not be given here. Instead only a few of the outstanding features of the receivers will be covered.

In Fig. 1 is shown the Hammarlund HQ-120-X. This 12-tube superheterodyne covers a continuous range from 540 kc to 31 megacycles (9.7 to 555 meters). The pre-selector stage is of the high-gain type and incorporates a special feature which makes it possible to compensate for various types of antennas—the compensating control, which appears on the panel directly underneath the meter, provides an external adjustment for aligning the circuits with the antenna system in use.

The band-spread control in the HQ-120-X has five scales. The first is an arbitrary scale reading 0 to 200 for calibration in any of the bands covered by the receiver. The four other scales are calibrated in megacycles for the 80, 40, 20 and 10 meter bands.

The crystal filter incorporated in the receiver has five ranges of selectivity controlled from the panel by means of a rotary switch. The first three steps on the switch are for phone reception, varying from broad to fairly sharp, while the fourth and fifth positions are for cw reception. The sixth contact cuts the crystal out of the circuit.

The i-f amplifier of this unit consists of three stages employing iron-core permeability-tuned transformers. The intermediate frequency is 455 kc in line with RMA standards. Further an automatic noise limiter is provided—it operates with the a-v-c either on or off.

The S meter is calibrated to read in S units from 1 to 9. S-1 corresponds to approximately .39 microvolts input at the antenna terminals, while S-9 corresponds to 100 microvolts. The meter is also calibrated up to 40 db above S-9.

Fig. 1. The Hammarlund HQ-120-X.

A beat-frequency oscillator is also incorporated. This oscillator is said to be so isolated that it has no material effect on the operation of the i-f amplifier.

In Fig. 2 is shown the Hammarlund Series 200 Super Pro receiver. The tube line-up for this unit is as follows: 6K7 first t-r-f, 6K7 second t-r-f, 6L7 mixer, 6J7 h-f oscillator, 6K7 first i-f amplifier, 6SK7 second i-f amplifier, 6SK7 third i-f amplifier, 6H6 second detector, 6N7 noise limiter, 6SK7 a-v-c driver, 6H6 a-v-c diode, 6SJ7 b-f oscillator, 6C5 first a-f amplifier, 6F6 second a-f amplifier, 2 6F6 third a-f amplifier (push-pull) 5Z3 high-voltage rectifier, 80 C-bias rectifier.

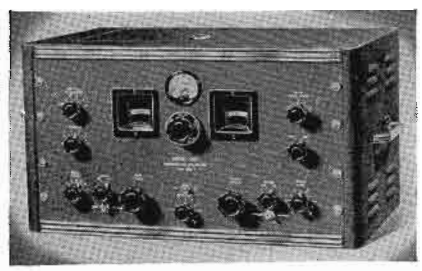


Fig. 2. Hammarlund 200 Super Pro.

It will be noticed that this set has a two-stage t-r-f amplifier ahead of the mixer stage. These two stages are employed on all bands covered by the receiver (two models covering from 540 kc to 20 mc and from 1,250 kc to 40 mc). Also the antenna input circuit is electrostatically shielded from the grid circuit of the first tube to permit the use of low-impedance transmission lines between the antenna and the receiver. The input impedance of the receiver is approximately 112 ohms.

The i-f amplifier employs three stages . . . this to secure a high degree of selectivity. The band width of the i-f amplifier is controlled by a cam arrangement which varies the coupling in two of the i-f transformers. The i-f channel is variable from 16 kc down to 3 kc with the crystal filter out of the circuit, to better than 100 cycles with the crystal in the circuit.

The a-f channel of the series 200 Super Pro is designed for high-quality reproduction. The first stage is a 6C5 triode voltage amplifier. The second stage is a 6F6 triode used as a driver for the output amplifier which is a pair of 6F6's operated in push-pull, Class AB.

The power supply for the SP-200 is a heavy-duty unit designed to furnish filament, plate and grid bias voltages. Being a separate unit, it is connected to the receiver by means of a flexible cable.

The S meter on this receiver has been designed to permit the operator to set the maximum readings to conform with his particular system of recording signal strength in S numbers. In other words, the meter can be adjusted to read S-9 on any signal from 10 to 10,000 microvolts. It is normally adjusted, however, to read S-9 on a 25 microvolt scale.

This receiver is, of course, equipped with a beat-frequency oscillator to heterodyne signals. This oscillator is of the electron-coupled type and is isolated from the rest of the receiver. An automatic-volume-control system is also provided, both r-f stages and the first two i-f stages being automatically controlled.

In Fig. 3 is shown the Hallicrafter Model SX-28 Super Sky Rider receiver.

Fig. 3. Hallicrafters' Model SX-28.

This unit covers the frequency range from 550 kilocycles to 43 megacycles continuously. Its tube lineup is as follows: 6SK7 first r-f amplifier, 6SK7 second r-f amplifier, 6SA7 mixer, 6SA7 h-f oscillator, 6L7 first i-f amplifier noise limiter, 6SK7 second i-f amplifier, 6B8 second detector and S meter tube, 6B8 a-v-c amplifier, 6SK7 noise amplifier, 6H6 noise rectifier, 6J5 beat oscillator, 6SC7 first audio amplifier, two 6V6GT push-pull output amplifier, 5Z3 rectifier.

The r-f amplifier or pre-selector of the SX-28 has two 6SK7 tubes in cascade on bands 3, 4, 5 and 6 (from 2.9 to 42 mc), but uses only one stage on the first two bands (from 550 kc to 3.1

mc). This receiver is said to have an image ratio of 45 to 1 at 28 mc, 350 to 1 at 14 mc and proportionately higher as the frequency is decreased.

The first two i-f transformers are permeability tuned, the adjusting screw being under spring tension. The diode transformer is air tuned with two variable capacitors. These trimmers are also under spring tension to enable them to withstand vibration. In addition the i-f transformers are expanded in two steps permitting either medium or full reproduction of higher frequencies.

This receiver is provided with six ranges of selectivity—broad, medium and sharp with the crystal out of the circuit; broad, medium and sharp with the crystal in use. Also, the SX-28, in line with usual practice, is equipped with an S or signal intensity meter, a beat-frequency oscillator, has double a-v-c action and meploys a noise limiter.

The output stage of the audio amplifier uses two 6V6GT tubes connected in push-pull. These tubes are driven by the 6SC7 double triode. One of the triode sections of this latter tube is used as the inverter to the 6V6GT tubes. A portion of the signal from the plate of the first 6SC7 triode is fed to the grid of the other 6SC7 triode section, thus giving two output voltages in opposite phase.

Another Hallicrafters receiver, the model S-29, is shown in Fig. 4. This is

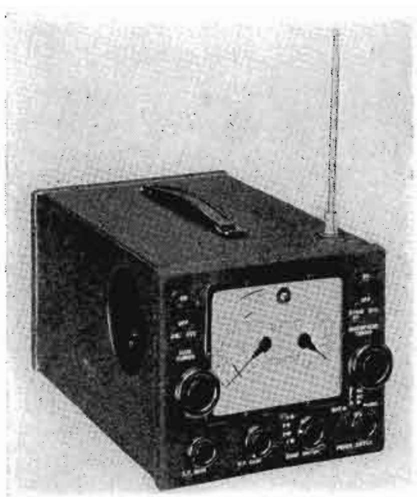


Fig. 4. Hallicrafters S-29.

a battery-powered set covering a frequency range from 540 kc to 30.5 mc in four bands. This set may also be operated from 115 volts a-c or d-c. The tube line-up is as follows: 1T4 r-f amplifier, 1R5 first detector-oscillator, 1P5GT first i-f amplifier, 1P5GT second i-f amplifier, 1H5GT second detector—a-v-c—first audio, 3Q5GT second audio output stage, 1G4GT b-f oscillator, 1G4GT noise limiter, 50Y6GT rectifier. Band spread is provided in the 80, 40, 20 and 10 meter bands.

The S-29 is supplied with its own antenna which is permanently connected in the circuit. Being telescopic, it may be extended to its full length of 28 inches or it may be compressed entirely into the cabinet. However, an antenna plug is provided to facilitate the use of other types of antennas.

In Figs. 5 and 6 are shown the Howard Models 435 and 437 communications receivers, respectively. The 435 is a 6-tube set, while the 437 is a 9-tube job.

The 435 uses a 6K8G mixer oscillator, a 6SK7 i-f amplifier, a 6SQ7 a-v-c—detector—first a-f, a 6K6G output tube, a 6C5 beat-frequency oscillator

Above: Fig. 5. Howard 435.

Below: Fig. 6. Howard 437.

and an 80 rectifier. It covers a frequency range of 550 kc to 43 mc in four bands. While designed for operation from 105-125 volts a-c, it can be furnished to operate from battery supply or from a 6-volt source. In line with conventional procedure, this receiver has electrical band spread, a-v-c and a beat-frequency oscillator.

The Howard Model 437 is a more elaborate unit, incorporating a stage of r-f preselection on all bands, noise limiter, i-f crystal filter, a-f and r-f gain controls, band spread, as well as connections for external battery power supply and an external speaker.

The tube line-up and functions in the 437 are as follows: 6SK7 r-f amplifier, 6K8G mixer oscillator, two 6SK7 i-f amplifiers, 6SQ7 a-v-c—detector—first a-f, 6K6G output, 6C5 beat-frequency oscillator, 6H6G noise limiter, 80 rectifier. Like the model 435, this receiver covers the frequency range of 550 kc to 43 mc continuously in four bands.

A carrier level meter to indicate the signal strength in microvolts is available. This instrument may be used with either the 435 or 437 receivers.

The National NC-100A is an 11-tube superheterodyne covering the frequency

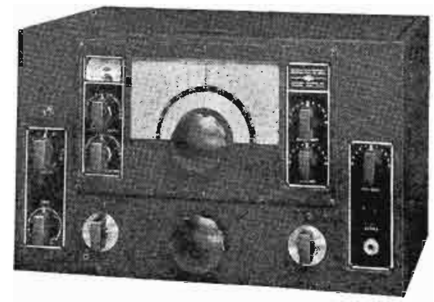


Fig. 7. National's NC-100.

range from 540 kc to 30 mc continuously in five bands (Fig. 7). The circuit used on all ranges consists of an r-f stage, separate first detector and high-frequency oscillator, two i-f stages, an infinite impedance diode detector and a transformer-coupled push-pull pentode output stage. The second detector utilizes one set of elements of a dual triode, the other triode section being used as a noise limiter. A second dual triode is used for first a-f and a-v-c. The tubes used for these functions are as follows: 6K7 r-f preselector, 6J7 first detector, 6J7 h-f oscillator, two 6K7 as first and second i-f, 6C8G second detector-limiter, 6F8G a-v-c—first audio, 6J7 b-f oscillator, two 6F6G push-pull output, 80 rectifier.

The NC-100A receiver is available in several models differing for the most part in speaker size, power supply (battery models available), crystal filter units, etc.

The National NHU receiver (Fig. 8) is designed for high-frequency operation in the range from 27.5 to 62 mc. This spectrum is covered in the following three bands: 27.5 to 36 mc, 34 to 46.5

Fig. 8. The National NHU.

mc, and 45 to 62 mc. It employs a superheterodyne circuit, using a 956 as r-f preselector, a 954 as first detector, a 955 h-f oscillator, 6K7 first i-f, 6K7 second i-f, 6K7 third i-f, 6C8G second detector—noise limiter, 6C8G c-o-n-s—first audio, 6SJ7 a-v-c, 6SJ7 c-w oscillator, 6V6G audio output. The power supply employs a type 80 rectifier. The normal drain of the receiver is 65 ma at 200 volts . . . the heater circuit takes 3 amps at 6.3 volts. Battery model receivers, with 180 volts of B supply, operate with a current drain of 60 ma.

There are several unique design features incorporated in the NHU. A large knob on the panel slides in or out to engage either the tuning condenser or the range-changing system. Inertia type tuning is used with a ratio of approximately 70 to 1. The pointer is positively driven by rack and pinion and moves vertically when the coil range is changed so that it always points to the proper frequency. The coils are mounted radially in an aluminum turret which is turned into position by the knob. Directly above the coil turret is the three-gang tuning condenser. The r-f circuit and tubes are inside the frame of the condenser . . . this to give short leads from coils to condensers to tubes.

The NHU is of course equipped with an oscillator for tuning in weak signals, as well as a crystal filter for obtaining varying degrees of selectivity. A signal strength meter is also incorporated.

The RCA AR-77 communications type receiver is shown in Fig. 9. This unit is a 10-tube superheterodyne covering the frequency range from 540 to

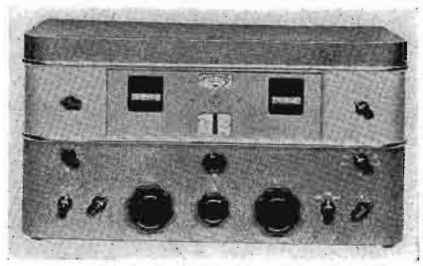
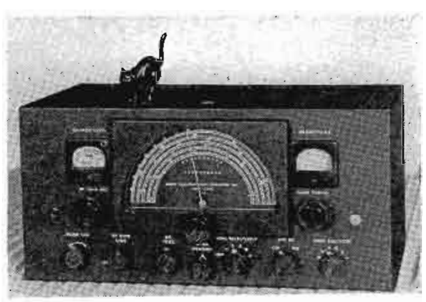


Fig. 9. The RCA AR-77.

31 mc in six ranges. The circuit contains one tuned r-f stage, two 455 kc magnetite core i-f stages with variable selectivity crystal filter, automatic volume control, and two a-f stages with degeneration in the output stage.

The tube complement of the AR-77 is as follows: three 6SK7 r-f and i-f amplifiers, 6K8 first detector and h-f oscillator, 6H6 second detector and noise limiter, 6SQ7 a-v-c and a-f amplifier, 6F6 audio output, 6SJ7 beat-frequency

Fig. 10. The RME-99.



oscillator, 5Z4 rectifier and a VR-150 voltage regulator.

The AR-77 is equipped with a carrier-level meter calibrated in 6 db steps to S-9 and to 40 db beyond. Band spread is of course provided. Also available for this receiver is an extended range console type loudspeaker having a frequency range flat within plus or minus 4 db from 60 to 5000 cycles, a power handling capacity of 10 watts and a voice coil impedance of 2.3 ohms at 400 cycles.

Fig. 10 shows Radio Manufacturing Engineers RME-99 receiver. This unit uses a 7A7 first r-f, 7B8 first detector-mixer, 7A4 heterodyne oscillator, VR-150 voltage regulator, three 7A7 i-f stages, 7F7 second detector and first audio, 7A6 noise limiter, 7A4 beat oscillator, 7C5 output, 80 rectifier. The tuning range is from 540 kc to 33 mc, with calibrated band spread being used from 3500 to 4000 kc, 7000 to 7300 kc, 14,000 to 14,500 kc, and 28,000 to 30,000 kc. An illuminated carrier level meter is provided. This instrument is calibrated in units of 6 db as well as in R units. A new type of crystal filter gives six degrees of selectivity and controlled phasing. In addition, this receiver has a noise silencing circuit as well as provision for automatic gain control. A standard 105-125 volt 50-60 cycle power supply is provided, although other voltages and frequencies can be secured.

Double Bias—continued from page 4

ing the injector grid potential more negative the virtual cathode is moved nearer to the screen, and the charge density in the vicinity of the signal grid is increased. Thus, by controlling simultaneously and properly the potentials on the signal and injector grids, the input capacitance can be held constant, while the bias potentials operate to control the signal grid-to-plate transconductance and the gain of the amplifier tube. It should be noted that both gain-control potentials are changed in like sense to maintain constant the input capacitance and that they consequently are cooperative in their effect upon the transconductance.

Since pentodes also have virtual cathodes they will operate in a manner similar to the 6L7 tube. Commercial receiving tubes of this type are not as adaptable to the control circuit as the 6L7 tube. However, worthwhile results have been obtained in television amplifiers employing the 6AC7 tube where its input capacitance was the major tuning capacitance.

Addendum

Since the completion of this work there has appeared in the *Wireless World* of October 13, 1938, page 340, a brief article describing a control circuit similar in principle to that described here. A pentode was used.

Other references of interest are as follows:

D. O. North, "Analysis of the Effects of space Charge on Grid Impedance," *Proc. I.R.E.*, January, 1936, p. 108.
F. B. Llewellyn, "Operation of Ultra-High-Frequency Vacuum Tubes," *B.S.T.J.*, October, 1935, page 632.

Continuous Wave Interference—continued from page 7

sisted of the 45-mc sine-wave modulated oscillator and produces the horizontal bars seen in the picture. A sinusoidal modulation was employed so that the interference would have every opportunity to present itself, whether in the black, white of half tones of the picture. (a) shows the raster with signal but without interference. (b) shows condition (a) but with an interfering sine-wave signal of equal amplitude superimposed. The frequency of the interference is about 100 kc and is synchronized with the horizontal scanning frequency to produce the vertical pattern. (c, d, e, f) reproduce the conditions of (b), but with interference levels of -10, -20, -30, -40 db, respectively. It is to be noted that (f) is indistinguishable from (a).

Fig. 5 (a, b, c, d, e, f) reproduces the conditions of Fig. 4 (a, b, c, d, e, f) exactly but on the receiver with the cathode-ray tube having an exponential characteristic (Fig. 3).

Fig. 6 shows various television images taken with interference at a frequency of about 300 kc. The interference was not deliberately synchronized with the horizontal scanning frequency but the

interference pattern remained practically steady for the period of the observations. The ratios of interference to signal voltages are: (a), 0 db; (b) -10 db; (c) -20 db; (a) -30 db; (e) -40 db. It can be judged from a comparison of Figs. 4 and 5 that the difference in the appearance of interference is not sufficiently marked to make the reproduction of a series of television images for both types of c-r tubes necessary.

Fig. 7 (a, b, c) shows the effects of frequency on the appearance of the interference. The signal-interference ratio in each case is 20 db. (a) shows a very low-frequency interference such as may be caused by hum from the power-supply, (b and c) show frequencies of about .5 and 1 mc, while (d) shows a frequency of about 2.5 mc equal in intensity to the picture modulation.

In Fig. 8, (a), (b) and (c) illustrate interference applied to the picture modulation and to the synchronizing circuits in addition to the normal synchronizing pulses. In (a) the signal-interference ratio is 20 db, in (b) 30 db, and in (c) 40 db. In (c) the effect of the interference on the signal is still to be noted although it is no longer noticeable as a brightness modulation. These observations were made to determine whether the interference was likely to be more noticeable by reason of its effect on synchronization than on modulation; it will be appreciated that the effect of interference on synchronization will depend to a marked degree on the receiver design and that it is not possible to form any hard and fast conclusions in this connection.

Conclusions

The conclusions which have been deduced from these observations are as follows:

(1) If the interference is 40 db below the level of the picture modulation it will not be visible.

(2) If the interference is 30 db below the level of the picture modulation, it is noticeable but not sufficiently severe to cause reduction of entertainment value when the picture is viewed from the normal distance.

(3) If the interference is 20 db below the level of the picture modulation, it will seriously interfere with the entertainment value of the picture.

(4) If the interference is 10 db below the level of the picture modulation, the resulting picture is worthless for entertainment purposes.

(5) If, due to the receiver design, the interference is superimposed on the synchronizing pulses a signal-interference ratio of 40 db will not seriously distort the picture although it may be just noticeable. A ratio of 30 db will cause

serious distortion in certain types of receivers.

(6) The frequency of the interference does not affect its annoyance value providing it is higher than about 5 times the frame frequency and of lower frequency than that required to provide equal resolution in horizontal and vertical directions. If the frequency is very low and synchronous with the frame scanning (e.g., derived from power-supply hum) a signal-interference ratio of 20 db may not seriously interfere with reception; while at very high frequencies—higher than the highest modulation component in the system—the picture is not seriously distorted even by interference equal to the signal.

(7) The annoyance value of the interference is not affected by the brightness level at which the picture is reproduced providing the picture is reproduced with reasonable fidelity.

(8) A simple picture such as black lettering on a white background without any half tones can be reproduced without appreciable loss of detail in the presence of considerable interference if the amplifier or light source is overmodulated in both the black and white directions.

(9) The characteristics of the light source do not affect the annoyance value of the interference in general but only determines the parts of the image in which the interference is most visible (i.e., black or white parts) in the same way as the characteristic effects the reproduction of half tones in the image itself.

(10) For the condition of interference-free reception (i.e., signal-interference ratio in excess of 40 db) the signal-interference ratio at the input of the receiver is not in general different from that at the receiver output, due to the fact that with so minute an interfering signal little cross modulation is likely to occur in the receiver itself.

The steps which can advantageously be taken to reduce the occurrence of continuous wave interference may be summarized as follows:

First, the receiver must be adequately screened against the effects of electromagnetic or electrostatic induction fields, the power supply must be carefully filtered and the filter currents earthed independently from the aerial earth system of the television receiver, otherwise filtering of the power supply may defeat its own object and only result in increased induction into the receiver circuits. Directional and polarized aerials must be employed where necessary, and the receiver fitted with adequate pre-selection before the first amplifier tube (if necessary by the addition of a band-pass filter in series with the aerial transmission line) thus preventing unwanted frequencies from introducing cross modulation by overloading of the first tube in the vision amplifier. Finally, in the receiver itself, much can be done by a careful choice of intermediate frequency to avoid the effects of second channel interference from outside, and harmonic interference occurring inside superheterodyne receivers.

At the source, interference suppression should be effected so that the interference field at a reasonable distance from any electrical apparatus cannot exceed a level 40 db below the field strength which it is desired to protect. In order to achieve this, it is necessary: to suppress the radiation of oscillator frequencies and harmonics from broadcast and television receivers by means of screening, power-supply and aerial filtering, and (by circuit design) by planned layout of components earthing and routing of the wiring: to prevent radiation from medical diathermy apparatus by complete screening and power-supply filtration, and to eliminate radiation of harmonic frequencies from broadcast and amateur short-wave transmitters.

A photograph of a simple high-pass filter with a cut-off frequency of 40 mc is shown in Fig. 9. Such a filter if inserted in the aerial circuit will help very considerably in reducing unwanted signal pickup and in preventing oscillator radiation in television receivers in which the oscillator frequency is lower than the signal frequency.

• • •

RADIOSONDE TECHNICIANS SOUGHT BY GOVERNMENT

In connection with the National Defense Program the United States Civil Service Commission has announced an examination to secure radiosonde technicians for Government Service. The salary of the position is $2,000 a year, less a retirement deduction of 3½ percent.

Persons appointed will have responsibility for the installation, inspection, and maintenance of radiosonde ground equipment at new stations in Alaska, the continental United States, and the Caribbean area. Applicants will be rated on their experience as shown in their applications, and on corroborative evidence. While experience in the installation, maintenance and repair of radio equipment forms the greater part of the requirement, applicants must have had at least 6 months of experience in the installation, maintenance and repair of radiosonde ground receiving and recording equipment. It is anticipated that it may be difficult to secure sufficient qualified eligibles because of this specialized requirement and the fact that this field of activity is new. The Commission will, therefore, rate applications as they are received at the Washington office until further notice. Applicants must not have passed their sixtieth birthday.

Further information regarding the examination is contained in the formal announcement, which with the proper application forms may be obtained from the Secretary of the Board of U. S. Civil Service Examiners at any first- or second-class post office, or from the U. S. Civil Service Commission, Washington, D. C.

• • •

PROF. NOBLE JOINS MOTOROLA

Daniel E. Noble, professor of electrical engineering at the University of Connecticut and authority on frequency modulation, has resigned his position with the school to accept the directorship of Research & Advanced Development for Motorola Radio, it was announced by Paul V. Galvin, president of the Galvin Mfg. Corporation.

• • •

DIODE DETECTION

(*Continued from page* 10)

order to systematize the work. Where possible, slide rule calculations should be made to shorten the work, as in the calculations for i_{CL}, e_n, etc. Note that these could also be obtained graphically, but the graphical process is best reserved for such work as must be done on the non-linear element itself, here r_d.

In the example cited, 20° intervals in the cycle were chosen, so that $\Delta t = 1/18 \times 1/5{,}000 = 1/90{,}000$ second. Then $Z = 18{,}330$ units, and $Z = 43{,}400$ units. From Eq. (29) it is evident that at the start ($t = 0$), $e_c = 0$ volts. In addition, zero initial charges are assumed for the two condensers. During the first time interval, e_c is assumed to have the constant value of 1.2 volts, which it actually attains at the end of the time interval. Since $\Sigma i_{CL} = i_C = 0$, e_n is therefore 1.2 volts, too. The first position of Z_L is also evidently through the origin, Fig. 7, and the intersection with Z and a diode curve is such that $i_T = 15$ μ-amperes, and $e_2 = 0.3$ volts, while $e_1 = 0.7$ volts. Then $i_{RL} = 3$ μamps., $i_{CL} = 15 - 3 = 12$ μamps., and $Z_L \Sigma i_{CL} = 0.22$ volts. Similarly $i_R = 3.5$ μamps., $i_C = 11.5$ μamps., and $Z\Sigma i_C = 0.5$ volts. Therefore $Z_L \Sigma i_{CL} + Z\Sigma i_{CL} = 0.72$ volts.

During the next time interval, Δt, e_c rises to 4.7 volts. Therefore $e_n = 4.7 - 0.72 = 4.0$ volts. The operator Z_L is now drawn through 0.22 volts. Its intersection with Z and the proper diode curve is at a value of $i_T = 50$ μamps., and $e_2 = 1.0$ volt, while $e_1 = 0.5 + 2.3 = 2.8$ volts. The several computations are then made as in the first step, and the process repeated. For the initial conditions chosen, the load loop does not close until about 1½ cycles have been computed. It will be observed that the loop is flattened at the bottom, since i_T cannot become negative. Over this flat part, it will be found that e_n is negative, so that Z and Z_L intersect on the voltage axis, and i_T is therefore zero. The diode curve that intersects with the above two operators is the appropriate one that meets the axis e_n units to the right of the intersection, and then, of course, proceeds along the axis to the left, as in the case of Class AB balanced amplifier constructions. The flat portion of the loop represents a period of time during which the condensers discharge through their respective resistances, thus diminishing Σi_{CL} and Σi_C, hence $Z_L \Sigma i_{CL}$ and $Z\Sigma i_C$ until their sum is less than e_C, whereupon e_n becomes positive once more, i_T becomes greater than zero, and the loop rises once again. The steady-state condition is given by the narrower loop in the figure.

The above circuit, however, is amenable to fairly simple and accurate analytical treatment. Thus, the a-c component of i_L, or i_m, is given by

$$i_M = e_m/(Z_L + 2Z) \quad \ldots\ldots\ldots\ldots (18)$$

where e_m is the voltage corresponding to the modulation envelope, and

$$Z_L = R'_L/(1 + j\omega C_L R_L),$$

and

$$Z = R/(1 + j\omega CR),$$

where R'_L is R_L and R_g in parallel.

The d-c component of i_L, or i_C, is due to a voltage corresponding to the carrier amplitude, e_c, and is given by

$$i_c = e_c/(R_L + 2R) \quad \ldots\ldots\ldots\ldots (19)$$

The percentage modulation of the carrier and also of the d-c output current is

$$m_C = i_m/i_C = (e_m/e_c)\left(\frac{R_L + 2R}{Z_L + 2Z}\right) = m_G\left(\frac{R_L + 2R}{Z_L + 2Z}\right) \quad \ldots\ldots (20)$$

where m_G is the percentage modulation of the carrier voltage e_c. But m_C cannot exceed unity, since i_m cannot exceed, at its negative peak value, i_C, since then the diode current would be reversed, which is impossible. Hence the maximum value of m_G that corresponds to $m_c = 1$ is, by Eq. (20)

$$m_G = (Z_L + 2Z)/(R_L + 2R) \quad \ldots (21)$$

The terminal voltages (envelope and carrier) across the diode and Z_L are related to the generated voltages e_m and e_c, respectively, by

$$\left.\begin{aligned} e_{Tm} &= e_m \frac{Z_L}{Z_L + 2Z} \\ e_{Tc} &= e_c \frac{R_L}{R_L + 2R} \end{aligned}\right\} \quad \ldots\ldots\ldots\ldots (22)$$

The percentage modulation of the terminal carrier voltage is

$$m_T = e_{Tm}/e_{Tc} = (e_m/e_c)\,(Z_L/R_L)\left(\frac{R_L + 2R}{Z_L + 2Z}\right) = m_G\,(Z_L/R_L)\left(\frac{R_L + 2R}{Z_L + 2Z}\right) \quad \ldots\ldots (23)$$

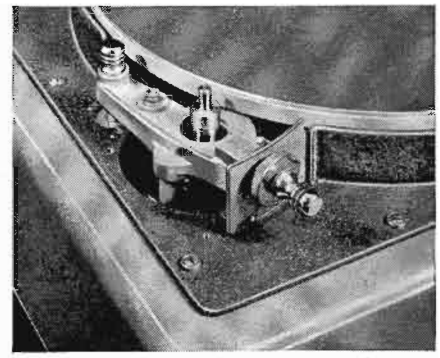
The maximum value of m_T is also unity, since otherwise the instantaneous voltage would reverse across the diode, whereupon the latter would short out the signal voltage, and thus prevent the latter from having any appreciable reverse value. Hence the maximum value of m_G for $m_T = 1$ is

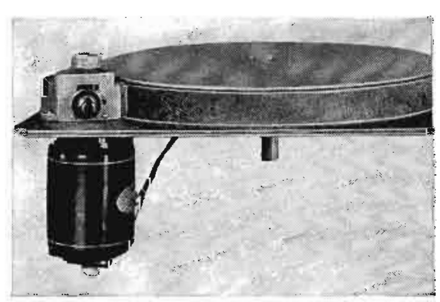
$$m'_G = (R_L/Z_L)\left(\frac{Z_L + 2Z}{R_L + 2R}\right) = (R_L/Z_L)\,m_G \quad \ldots\ldots\ldots\ldots (24)$$

In short, the permissible value of m_G here is greater than that given by Eq. (22), so that for the circuit postulated, clipping due to current cut-off is the limiting factor. The above derivation assumes r_d is negligibly small, whereas the graphical construction does not.

For the example given, m_G comes out to be 59.3%. If R_L is taken as 0.125 megohms, m_G is 54.8%, so that no great error was made in assuming that the a-c and d-c load lines are indentical. At

(*Continued on page 26*)





Police Radio Equipments

In selecting radio equipment, the police communications departments may choose from many types of apparatus. While the selection of such equipment presents an interesting subject, there are so many problems involved that it is beyond the scope of this paper. Instead we shall confine ourselves to brief reviews of some of the more recent apparatus announced by the various manufacturers. This, we hope, will serve to indicate in some measure the design trends in this field.

Frequency Modulation

During recent months frequency modulation has come to the fore. As this publication has often pointed out editorially, f-m seems to possess a number of advantages for this type of service: (1) comparative freedom from noise, (2) minimum interference between properly spaced stations on the same frequency, and (3) better overall reception with less fading caused by steel bridges, elevated structures, and the like.

In this connection, it is interesting to note that the Connecticut State Police have installed a state-wide f-m system, under the supervision of Prof. D. E. Noble of the University of Connecticut. This set-up is comprised of 10 fixed location f-m transmitters (250 watts each) at various headquarters stations, as well as 225 two-way mobile units in patrol cars.

The Chicago Police Department, fol- a demonstration conducted in that city (Fig. 1), issued specifications for an f-m installation. This system calls for 200 patrol cars equipped with two-way units and 16 fixed stations.

The Fred M. Link frequency-modulated main station transmitter is shown in Fig. 2. Designated as type 250-UFS, this crystal-controlled unit is rated at 250/400 watts r-f output and is designed for use in the 30 to 40 megacycle band. Features include: indirectly illuminated meters, safety electrical door interlock, and a key lock to prevent unauthorized entrance. Space is provided in the cabinet for the inclusion and coordination of a rack mounted main station receiver. Provision is also made

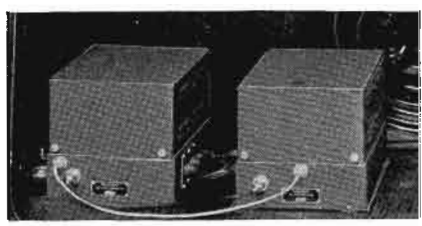


Fig. 9. The Western Electric 228A police equipment.

for a remote control unit in the form of a sloping front desk console.

Fig. 3 illustrates the Link Type 25-UFM frequency - modulated mobile transmitter. It is rated at 25 watts r-f output, but 30 watts may be obtained under continuous operating conditions. Like the unit just described, it is crystal controlled, utilizes the same phase shift system of modulation and is designed for use in the 30-40 mc band. As can be seen, the 25-UFM is completely self contained, a single chassis carrying transmitter, dynamotor power supply, relays and component parts.

Another Link unit is the 11-UF f-m receiver. This unit is intended for use with the transmitters previously discussed, being suitable for either a-c or

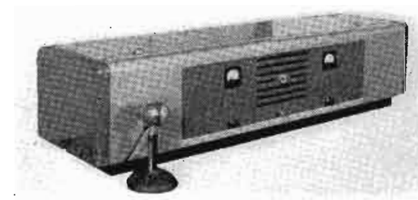
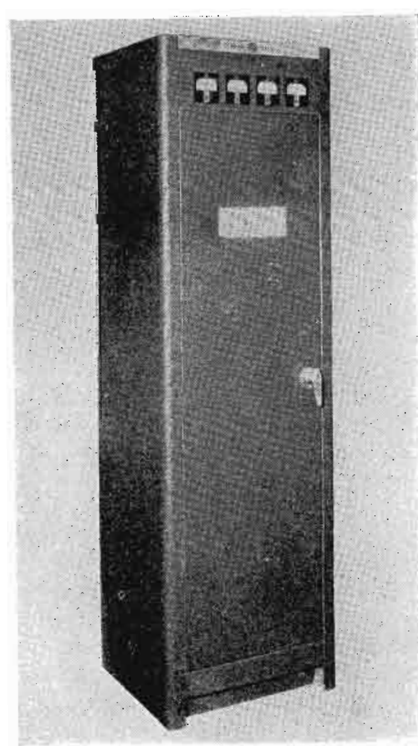


Fig. 8. The RCA 50-watt headquarters transmitter.

d-c operation. In the circuit, both local oscillators are crystal controlled. Other features are squelch circuit, limiter action with signals less than 1 microvolt per meter, 40-kc r-f band width, filter to attenuate all frequencies above 2800 cycles, 500-ohm output and shock mounting. The necessary power supply is furnished as a separate unit.

The Radio Engineering Laboratories also have a line of frequency modulated transmitters and receivers for police use. One of the mobile units supply 25 watts of carrier in the 30-40 mc band, operating from a 6-volt battery. The frequency swing employed is 30 kc at 100% modulation. The transmitters are

Fig. 5. The General Electric 250-watt f-m transmitter.



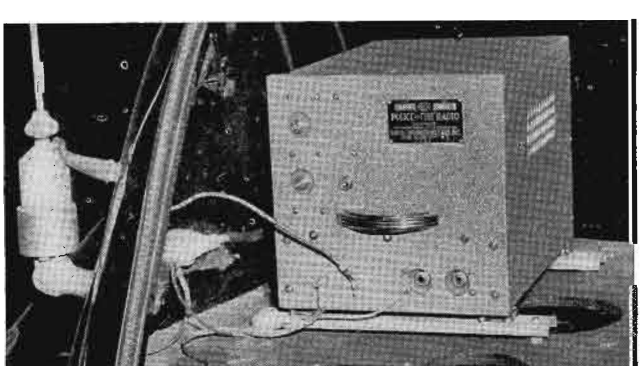


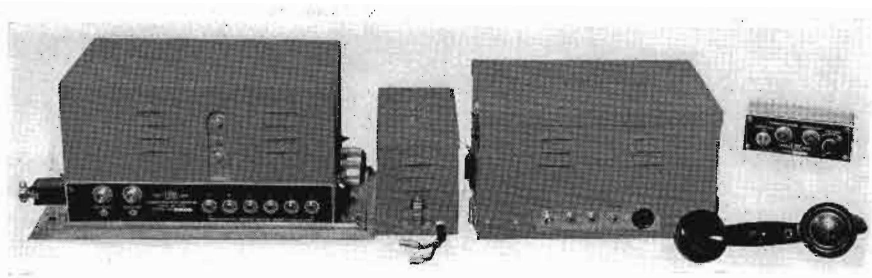
Fig. 1. (Left) The Radio Engineering Laboratories f-m equipment used in the tests conducted for the Chicago police department.

equipped with filters to cut off all frequencies below 200 kc and above 3000 kc. In addition, double limiter circuits are employed in these crystal controlled units.

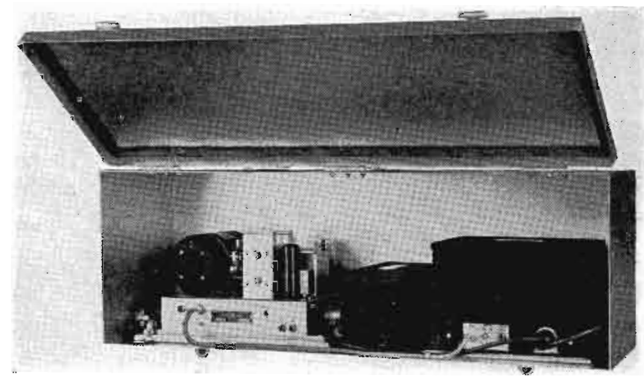
Installation of the mobile apparatus may be made in two ways. Both the transmitter and receiver may be housed in one case in the back of the car, with the necessary control equipment located on the dashboard, or the transmitter and receiver may be separately mounted. A unique antenna tuning device is used between the transmitter and the car antenna.

The General Electric frequency-modulated mobile police-radio equipment is shown in Fig. 4. Designed for operation in the 30-40 megacycle range, it consists of a 25-watt transmitter, a receiver and a control unit. It is available for mobile operation using either a dynamotor or a heavy-duty vibrator power supply, or as a station transmitter using 115-volt 50/60 cycle power supply. In addition, it should be kept in mind that the a-c power transmitter may also be used as an exciter for a 250-watt station house transmitter.

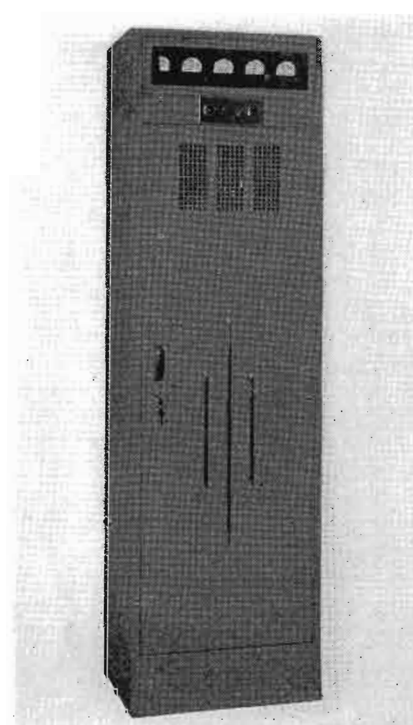
The transmitting equipment shown in Fig. 5 is the G-E 250-watt station transmitter designed for operation in the 30-42 mc region. Two types of control equipment are available. One is a simple unit, consisting of a standard telephone set containing in addition to the microphone a receiver volume control and a push-to-talk button . . . it is used where the distance between the transmitter and the control point is short. A remote unit contains a low-level microphone preamplifier, an automatic level control and push-to-talk button.



Above: Fig. 3. The Link Type 25-UFM mobile f-m transmitter.



Right: Fig. 7. The Link Model AMTR mobile a-m equipment.



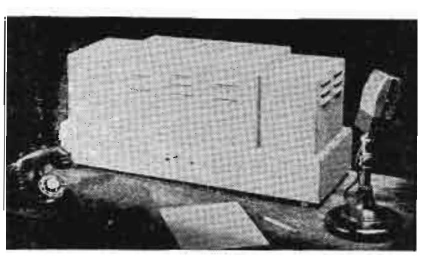
Lower right: Fig. 2. The Link 250-PFS f-m transmitter.

Amplitude Modulation

Before discussing amplitude-modulated police equipments, it seems well to point out that nearly every manufacturer of police radio has available equipments for the various bands alloted to this type of communication. These systems will vary in power from 5 to 1000 watts depending upon the type of service for which they are intended. Obviously, then, it would be physically impossible to cover all of these equipments in one issue of this publication. As a result, we shall confine ourselves to a few of units that may have escaped the attention of the reader.

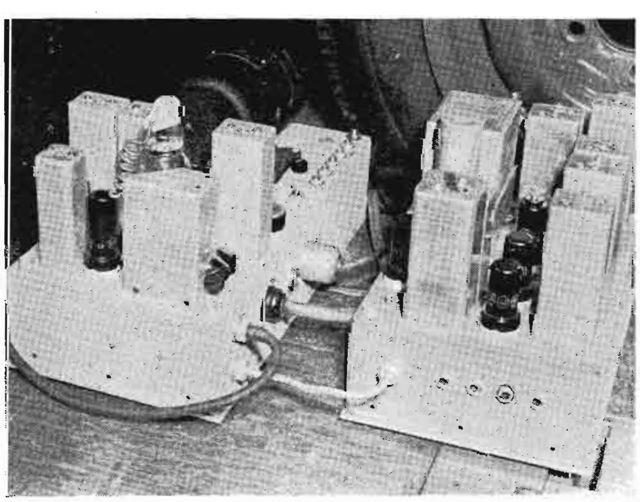
In Fig. 6 is shown a G-E Type G-12 ultra-high-frequency station transmitter. This unit has an outlet of 25 watts in the 30-42 megacycle band. It is completely self-contained, including power supply, speech amplifier, and modulator. The r-f circuit consists of a crystal-oscillator stage and harmonic generator, doubler stage and final p-a stage. The audio circuit has three speech-amplifier stages, a tone oscillator and a Class AB modulator stage.

The Link Model AMTR mobile equipment is shown in Fig. 7. This installation is designed for the ultra-high-frequency band of 30 to 40 mc. The crystal controlled transmitter has an output of 15/20 watts. The mounting shown is one type of weather proof

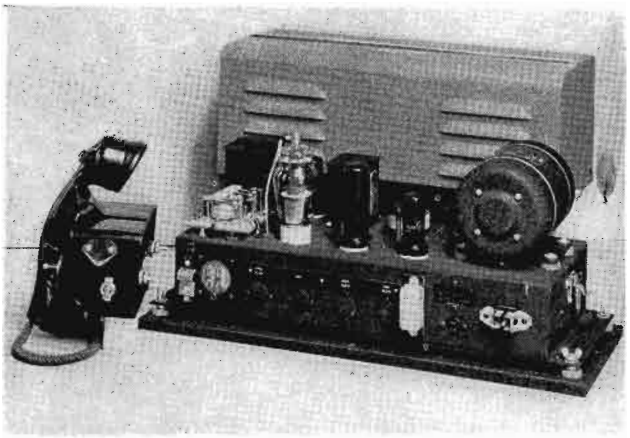


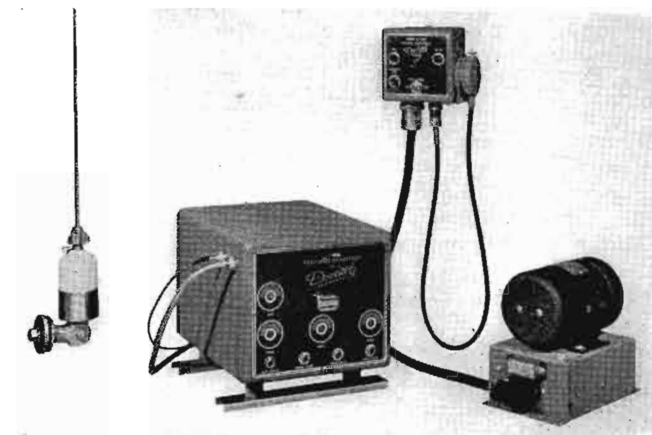
Upper left: Fig. 6. The G-E ultra-high-frequency a-m station transmitter.

• • •



Left: Fig. 4. The General Electric mobile f-m police equipment.





Above left: Fig. 16. The Harvey Radio mobile equipment. Above right: Fig. 15. The Doolittle 15x mobile transmitter.

mounting. Left to right in the photo is transmitter, receiver power supply, and receiver.

Referring to Fig. 8 we see the RCA Type MI-7821 50-watt headquarters transmitter. This crystal-controlled unit is designed to cover the range from 30 to 40 megacycles, although models are available for the 1500-2600 kc band. This radio equipment is complete in one cabinet, space having been provided for a receiver. In case it should be desired to operate this equipment remotely, provisions have been made for a line input. The overall dimensions of the cabinet are 50" by 13⅞" by 12⅛", the weight 200 pounds.

The police installation shown in Fig. 9 is comprised of the Western Electric 28A transmitter (left) and the 28A receiver. The basic units of this system are the transmitter, the receiver, antenna, control unit, telephone handset and loudspeaker. The transmitter includes a dynamotor for plate supply. It operates directly from a 6-volt battery, delivering 15 watts of carrier power. It is intended for use in the 30-40 megacycle range. The receiver is a 10-tube superheterodyne and is crystal controlled.

The Collins 231C autotune transmitter is shown in Fig. 10. This unit is available in three models for 500, 1000 or 3000 watts. It is designed to permit the selection of any of ten frequencies in the 2500 to 20,000 kc range (1500 to 20,000 kc special). Provision is made for either remote or local control.

Another interesting police transmitter is the Harvey Wells 100-watt unit, designated as the 100-FT. This unit, which is shown in Fig. 11, is for low frequency police service (1500-7000 kc). It is a single frequency crystal-

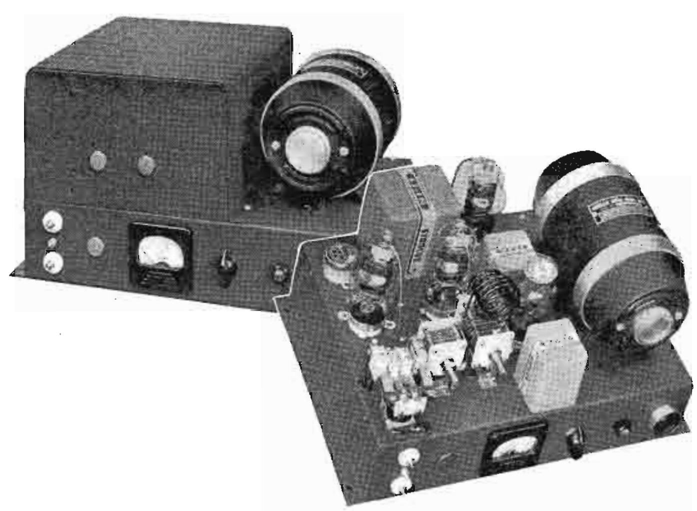
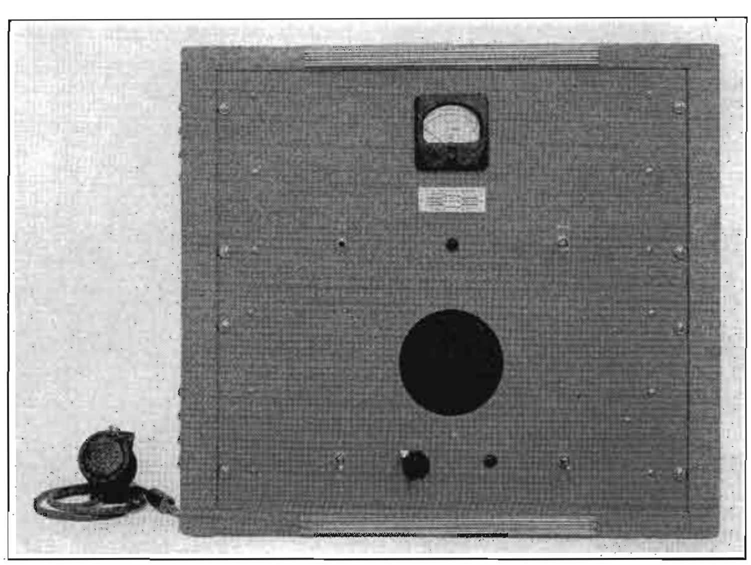
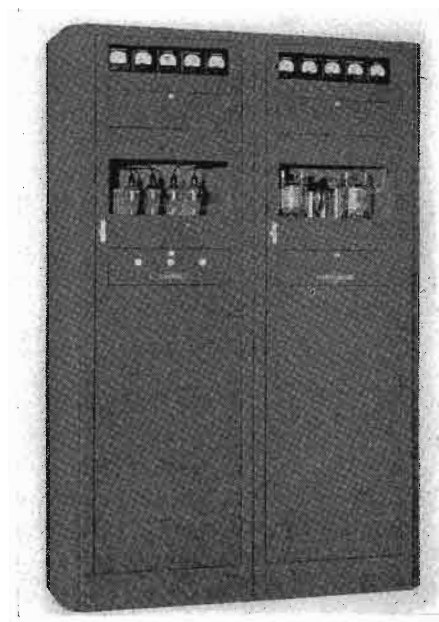


Fig. 13. Two views of the Stancor 30-M equipment with cover in place and with cover removed.



Left: Fig. 14. The Kaar central station radio system.



Right: Fig. 10. The Collins autotune transmitter.

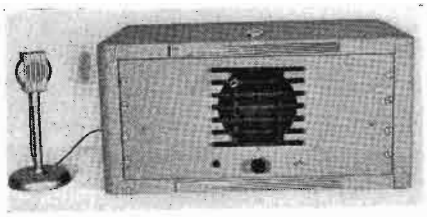


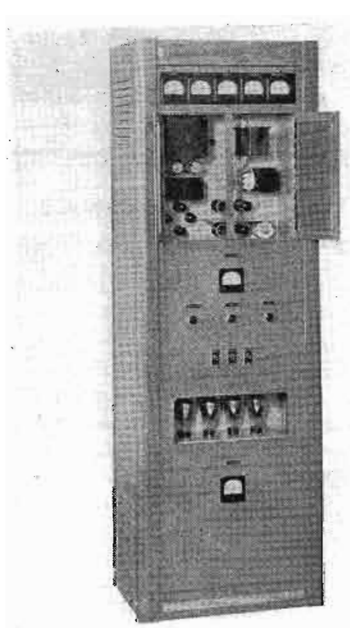
Fig. 12. The Bassett headquarters police radio telephone.

controlled job. The tube complement is as follows: r-f section—813, 6L6, 6V6; a-f section—(2) 807, 6F6, 6SF5, 6H6; rectifier section—(4) 866, 5Y3G, 5U4G.

The Bassett CS-50TR headquarters radio telephone is shown in Fig. 12. This unit consists of a transmitter and receiver operating in the frequency range 1.5 to 40 mc. The power supply is of course from 115-volt 60-cycle source. Carrier output is rated at 25 to 35 watts. The tube line-up for the transmitter is: 807, 6A6, T21, 83—for the receiver; 6SK7, 6SJ7, 6N7, (2) 6S7, 6SQ7, 6SF5, 6F6, 6H6, 80.

Another interesting unit is the Stancor 30-M transmitter kit shown in Fig. 13. The 30-M is crystal controlled and operates on any frequency between 28 and 42 mc. Power is obtained from a 6-volt storage battery using either a vibrator or generator. Power output is 23 watts. This unit uses four low-drain quick-heating tubes . . . three HY69 and one 6A4. The plate circuit of the HY69 oscillator is tuned to twice the crystal frequency, while a second HY69 also doubles in its plate circuit and operates at inputs up to 32 watts. A 6A4, triode connected, is used as speech amplifier and drives a third HY69 as a Class A1 modulator. Both the plate and the screen of the final HY69 are modulated.

Fig. 11. The Harvey-Wells 100-watt police transmitter.



A Kaar central station police radiotelephone system is illustrated in Fig. 14. This is available in several models for medium (1600-1712 kc or 2300-2500 kc) or ultra-high-frequency (30 to 40 mc) use and in powers of either 8 or 20 watts. In the figure the transmitter is the top unit, while the receiver is housed directly below. Power is from standard and 110-120 volt 60-cycle line. Complete control of the transmitter is from the front panel and the switch on the microphone.

The Doolittle 15X mobile transmitter, shown in Fig. 15, uses filamentary type tubes that requires no power from car battery during stand-by periods. It has 20 watts power output and operates on frequencies between 30 and 40 megacycles. Crystal control, Class C final r-f amplifier, Class B modulation and push-to-talk are standard features. The control unit contains on-off switch, volume and squelch control.

Fig. 16 shows the Harvey Radio PM-15 mobile equipment. This transmitter has 15 watts output and operates in the 30-42 mc region. It is equipped with a French type handset with push-to-talk control. An added feature of this equipment is a cowl mounted safety horn which works through the transmitter output and is controlled from the dashboard through the hand microphone.

• • •

OVER THE TAPE

NEELY INCREASES PERSONNEL

Norman B. Neely, West Coast manufacturers' representative specializing in technical equipment, announces the addition to his technical staff of Tom Bissett. Mr. Bissett enters Mr. Neely's employ with a good foundation of engineering education and considerable practical experience, having operated his own radio service and sound equipment business.

NEW NAME

The firm of Doolittle & Falknor, Inc., has renamed the company Doolittle Radio, Inc. According to E. M. Doolittle, President of the company, personnel, procedure and policy remain the same.

HOLLYTRAN CATALOG

Hollywood Transformer Co. has just released several catalog sheets describing tapped equalizer inductors, input transformers and similar items. This company specializes in high-quality transformers and chokes supplied to customer specifications and have also just released a new specification sheet for the customer's use in asking for quotations on or ordering special transformers. These sheets and others are available on request from Norman B. Neely, 5334 Hollywood Boulevard, Hollywood, California.

EICOR BULLETIN

Eicor, Inc., 515 S. Laflin St., Chicago, have issued an interesting bulletin on their line of dynamotors for various types of service, such as police, aircraft, marine, etc. Copies of this bulletin may be secured by writing to the above organization.

WHEN YOU CHANGE YOUR ADDRESS

Be sure to notify the Subscription Department of COMMUNICATIONS at 19 E. Forty-seventh St., New York City, giving the old as well as the new address, and do this at least four weeks in advance. The Post Office Department does not forward magazines unless you pay additional postage, and we cannot duplicate copies mailed to the old address. We ask your cooperation.

OHMITE CATALOG MANUAL

A new, comprehensive 96-page industrial catalog and engineering manual has been issued by the Ohmite Manufacturing Company, 4835 Flournoy St., Chicago. This book is more than a catalog—it is more nearly an encyclopedia of helpful facts and information on the selection and application of resistors, rheostats, tap switches, chokes, and attenuators. It contains much engineering data, handy reference tables, dimension drawings, illustrations, special guide pages, and a manual of resistance measurements. Copies of the Ohmite Catalog 40 will be sent to engineers, production managers, purchasing agents or executives who send in their names on company stationery, stating their positions.

RADIO RECEPTOR BULLETIN

Ultra-high-frequency airport traffic control transmitters are described in a bulletin issued by Radio Receptor Co., Inc., 251 W. 19 St., New York City. Write for Bulletin No. 5002.

BURTON-ROGERS BULLETIN

Burton-Rogers Co., 857 Boylston Street, Boston, Mass., have issued a bulletin on their line of professional antennas for police and fire department radio cars. Copies may be secured by writing to the above organization.

CARTER BULLETINS

Carter Motor Co., 1608 Milwaukee Ave., Chicago, have made available two interesting bulletins. One bulletin covers a new heavy-duty genemotor, while the second gives data on their genemotors for police, marine and aircraft use.

CALLITE TUNGSTEN EXPANDS

The Callite Tungsten Corporation has added approximately 100,000 square feet of floor space to its facilities through the acquisition of a large factory property neighboring its main plant at Union City, New Jersey. This step has been made necessary by the general expansion of the Callite business and by the transfer to Union City of the production of round, flat and shaped wire of standard and special alloys of the recently acquired Harris Alloys, Inc.

NEW NAME

The Webster Company, 5622 Bloomingdale Ave., Chicago, Ill., manufacturers of sound equipment, record changers, metal stampings, tools and dies, announces the adoption of "Webster-Chicago Corporation" as their new corporate title. They advise that the change was made to save confusion in the mind of the public due to the fact that the product carried the name "The Webster Company" while the trade popularly referred to both the product and company as "Webster-Chicago."

MISSISSIPPI RIVER INSTALLATION CONTRACT TO GATES

Complete radio equipment for six river towboats and one ground station to be located at Cape Girardeau under a recently authorized grant by F. C. C. has been contracted by Erlbacher Brothers, Cape Girardeau, Mo., with Gates American. This is the first installation of this kind to be made on the Mississippi River. Each towboat transmitter has 100 watts power with provision for five-frequency operation and boats are equipped with especially designed crystal-control five-frequency receivers. The ground station is voice controlled and connected with the standard telephone service for probable service.

VETERAN WIRELESS OPERATORS ASSOCIATION NEWS

W. J. McGONIGLE, President   RCA BUILDING, 30 Rockefeller Plaza, New York, N. Y.   GEORGE H. CLARK, Secretary

Dr. de Forest's Birthday

MONDAY, August 26th, was a day of two-fold celebration for Chicago members of the radio industry, first the birthday of Dr. Lee de Forest, the "Father of Radio," Honorary President of VWOA, and the advent of National Radio Day. Radio Station WGN opened the celebration in the afternoon by presenting Dr. de Forest to their listening audience in an interview in which he told of his first experimental work in Chicago forty years ago.

Two hundred members, representing all branches of the radio and communications industries, attended a banquet at the Drake Hotel Monday evening to pay homage to Dr. de Forest on his 67th birthday. U. A. Sanabria, President of the American Television Laboratories, introduced Dr. de Forest, who told of his early days in the development of radio tubes and related many amusing anecdotes connected with his pioneering work with the wireless telephone and radio.

Guests at the speaker's table were William Halligan, President of The Hallicrafters, Inc., and Chairman of the Chicago Chapter of VWOA; E. S. Riedel, General Sales Manager of Raytheon Production Corp.; J. K. Johnson of Hazeltine Laboratories; Lt. Com. R. H. G. Mathews, representing the ARRL; "Nick" Carter of Carter Manufacturing Company; Peter Jensen of Utah Radio Parts Company, all of whom delivered short talks on their early days in radio and paid tribute to the work of Dr. de Forest. Mr. Riedel presented Dr. de Forest with a miniature Raytheon tube watch charm and chain, the smallest commercial tube now manufactured. Mr. Halligan read a letter forwarded to Dr. de Forest by the Federal Communications Commission outlining the position of amateurs in present-day broadcasting.

Two mammoth birthday cakes were served, each piece containing a small spear-

Left to Right: William Halligan, Dr. Lee de Forest and E. S. Riedel at the de Forest's birthday celebration in Chicago.

shaped glass from which a toast was drunk to the health and future happiness of Dr. de Forest. A presentation was made of an ornate hand-made glass motif with the figures "67" forming the center design. Dr. de Forest made an eloquent closing address to the members of the industry.

Robert J. Stahl, Jr., (right) winner of the Marconi Scholarship, being interviewed by Hal Styles (left), while Stahl Sr. looks on.

During his stay in Chicago, Dr. de Forest collaborated with Sanabria in the American Television Laboratory, completing the work on their new Pilotless Television Torpedo Plane.

De Forest Day at S. F.

The following radiogram was sent by our prexy to:

"Hal Styles, Chairman, Los Angeles-Hollywood Chapter, Veteran Wireless Operators' Ass'n:

"Unanimously acclaimed by scientific societies the world over as one of the greatest of modern day scientist-inventors and unquestionably a benefactor of mankind without peer, Dr. Lee de Forest, the genius of radio, well deserves the tribute you pay him this 'Lee de Forest Day' at the San Francisco World's Fair. Beloved by all who have the privilege of knowing him, our Association of Veteran Wireless Operators, to fittingly commemorate this day, takes pride and pleasure in presenting the highest honor within our power to bestow—the Veteran Wireless Operators' Association Gold Medal of Honor—to Dr. de Forest in appreciation of his magnificent efforts and accomplishments in the radio art. Our Association collectively and our officers, directors and members individually extend to Dr. de Forest on this memorable day our most sincere good wishes for his continued good health and happiness. George Clark, one of Dr. de Forest's earliest co-workers and a wireless pioneer in his own right—now our national secretary—joins me in sending most affectionate regards to Doc. We salute 'Lee de Forest Day' at the San Francisco World's Fair. 73.—Bill McGonigle, National President, Veteran Wireless Operators' Association."

Diode Detection—continued from page 19

low modulation frequencies the construction of Fig. 2 is permissible, since C_L and C have negligible susceptance. The maximum permissible modulation is then given by Eq. (6), and for this example comes out to be 92.3%.

In Fig. 8 has been plotted the load loop for a 20-volt generated carrier wave modulated 59.3% by a 5,000-cycle frequency. The equation of the envelope is therefore

$$e_e = 20 - 11.9 \cos (2\pi 5000\, t) \quad \ldots (25)$$

It will be observed that the loop is just perceptibly flattened, and this is not only considered good agreement with Eq. (22), but also that Eq. (22) is definitely a maximum value for the permissible modulation, since "clipping" just occurs for this value. In passing, it is well to note that rarely if ever, is such high modulation encountered in practice at such a high modulation frequency. The question may still arise in the reader's mind as to what happens when a strong low frequency and weak high frequency complex modulation wave is impressed. This can be answered by the graphical method, but, unfortunately, each wave shape requires individual treatment. This question in general has never been satisfactorily answered for a whole host of nonlinear circuit problems.

ROCHESTER FALL MEETING

THIS year the Rochester Fall Meeting will be held on November 11, 12 and 13. The place, as usual, will be the Sagamore Hotel, in Rochester, N. Y.

While the complete program for this gathering will appear in our October issue, we present here a tentative schedule of the technical papers to be given at this meeting.

MONDAY, NOVEMBER 11

9:30 A. M.—Technical Session

"Measurement of Electrode Temperatures of Tubes during Exhaust and Operation," A. D. Power, RCA Mfg. Co., Radiotron Division.

"Notes on the Use of Inverse Feedback in Electric Phonographs," Henry P. Kalmus and Dorman D. Israel, Emerson Radio & Phonograph Corp.

"Recent Improvements in Frequency Modulation Receiver Design," J. A. Worcester, General Electric Co.

2:00 P. M.—Technical Session

"The Role of the Limiter in F.M. Noise Suppression," C. W. Carnahan, Zenith Radio Corp.

"The Application of Inductive Tuning to Ultra-High Frequencies," B. V. K. French, P. R. Mallory & Co.

"A Phase Curve Tracer for Television," Bernard D. Loughlin, Hazeltine Service Corp.

TUESDAY, NOVEMBER 12

9:30 A. M.—Technical Session

Annual Message of RMA Director of Engineering, Dr. W. R. G. Baker, General Electric Co.

"Common-Channel Interference from Two Frequency Modulated Signals," H. A. Wheeler, Hazeltine Service Corp.

"Radio Tubes Today," R. M. Wise, Hygrade Sylvania Corp.

2:00 P. M.—Technical Session

"The Coaxial Tuning Condenser," Frank W. Godsey, Jr., Sprague Specialties Co.

Subject and Speaker to be announced later. RCA Mfg. Co., Victor Division.

6:15 P. M.—Fall Meeting Dinner (Stag)

Toastmaster: A. F. Van Dyck.
Speaker: J. S. Knowlson.
Subject: The Radio Industry.

WEDNESDAY, NOVEMBER 13

9:30 A. M.—Technical Session

"Special Oscilloscope Tests for Television and Waveforms," A. V. Loughren and W. F. Bailey, Hazeltine Service Corp.

"Extending the Range of Audio Reproduction," H. F. Olson, RCA Mfg. Co., Victor Division.

"The Kettle Drum Baffle," R. T. Bozak, Bozak Associates.

"Improvements in High Fidelity Audio Frequency Amplifiers," Lincoln Walsh, Consulting Engineer.

2:00 P. M.—Technical Session

"The Evolution of a New Type of Metal Receiving Tube," D. W. Jenks, General Electric Co.

"Discussion of Fluorescent Materials," B. F. Ellefson, Hygrade Sylvania Corp.

"Summary of the Significance of the Papers at This Meeting," Donald Fink, McGraw-Hill Publishing Co.

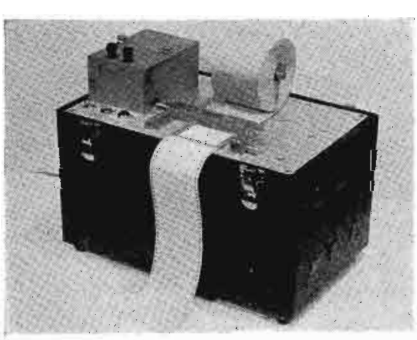
THE MARKET PLACE

CINEMA ENGINEERING CONTROL

The Cinema Engineering Company has just announced their Model 1658 attenuator. This unit, although in the lower brackets, has 2% wire wound resistors, reamed sleeve bearing and ground shaft and precision surfaced contact points embodying the same precision and careful workmanship found in the higher-priced C-E Controls. The 1658 control is available as a 20-step ladder attenuator to all standard specifications. A similar unit is also available in a potentiometer control. A catalog sheet is being issued on this item and is available on request to the Cinema Engineering Company, 5334 Hollywood Boulevard, Hollywood, California.

POWER LEVEL RECORDER

A new power level recorder has been made available by Sound Apparatus Co., 150 W. 46th St., New York City, for



making an automatic record of the transmission characteristics of any electro acoustic apparatus. The instrument can be equipped with various types of input potentiometers . . . available are db potentiometers in steps of ¼, ½, ¾ and 1 db, as well as linear and phon potentiometers for making loudness measurements. The instrument is built for 110 volts, 60 cycles. Literature is available from the manufacturer.

COIL BOBBIN

A new type of electric coil bobbin has been developed by the Precision Paper Tube Company, 2033 Charleston Street, Chicago, that enables manufacturers of

small motors, relays, solenoids, reactors, photo electric devices and other electrically actuated equipment, to use the bobbin coil rather than the layer wound coil. These new bobbins are made of either Kraft or Fish paper, or a combination of both, depending on the requirements. The paper is spirally wound on a steel die on automatic machines to form a tube of convenient length, which is cut into proper bobbin sizes. The flanges are of vulcanized fibre, die cut to the exact size and shape and pressed over the ends of the tubes. The ends of the tubes are swaged, locking the flanges in place. Impregnating the bobbin with a special lacquer increases its strength and forms a seal between the tube and flange and improves electrical characteristics. Round, square or rectangular bobbins of any size can be made with the same degree of accuracy. Complete information, literature and samples of these new bobbins can be obtained by writing to the manufacturer.

ELECTRONIC LABS. BULLETIN

Electronic Laboratories, Inc., 122 W. New York St., Indianapolis, Indiana, have issued two new pieces of literature covering their line of converters and custom built power supplies. Copies may be secured by writing to the above organization.

KELVIN-WHEATSTONE BRIDGE

A portable instrument combining the features of the Kelvin and Wheatstone bridges has been made available by Shallcross Mfg.

Co., 10 Jackson Ave., Collingdale, Pa. Total resistance range is from 0.00001 ohm to 11.11 megohms. It may be secured either with or without a galvanometer. Write to the manufacturer for bulletin 146-2G.

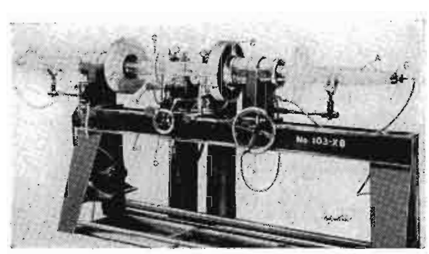
AUDAK CUTTER

The Audak Co., 500 Fifth Ave., New York City, announce a High Fidelity cutter which, it is said, overcomes distortion

and has a flat response to over 9,000 cycles. The new cutter is available in three models: H2, H3, and H4, in various price ranges. A descriptive bulletin may be obtained directly from Audak.

GLASS WORKING LATHE

The Eisler Engineering Company, 740-770 South 13th Street, Newark, New Jersey, has developed a horizontal butt sealing and general glass working lathe No. 103-XB. This type of machine is employed extensively for the production of large electronic tubes where metal and glass have to be sealed together and various other cylin-



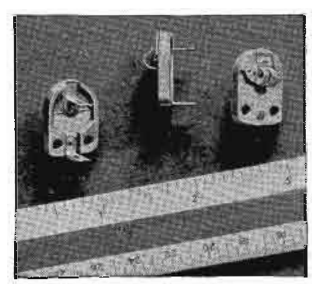
drical glass work can be performed. The machine will take tubing up to 6" in diameter and can be supplied for larger sizes. A great many operations can be performed on this machine, some of which are: (1) flare making, (2) stem making, (3) butt sealing, (4) "T" sealing, (5) glass piercing, (6) sealing metal to glass, (7) drawing and shaping of glass, etc.

DISTORTION SET

The Hewlett-Packard Co. has just released their 320A distortion measuring set. This unit was designed to meet the demand for a reasonably priced item to allow radio stations, laboratories, public-address operators and maintenance men to make distortion measurements quickly and easily. The 320A may be used with any signal generator and oscilloscope to give distortion readings at two different frequencies. Several other new instruments are just being released and literature describing the entire line will be sent on request to the Hewlett-Packard Company, 481 Page Mill Road, Palo Alto, California.

CERAMIC TRIMMER CAPACITOR

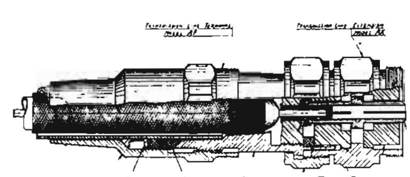
Fixed plate bonded to the ceramic base, eliminating the variable air film. Variable plate rotates on a ground ceramic surface. Equally stable at all capacity adjustments. Provides negative temperature compensa-



tion of .0006 mmfd/mmfd/°C. Power factor less than 0.1%. Capacity change with humidity or temperature cycling less than 0.5%. Available capacity ranges 2 to 6, 3 to 12, 7 to 30, 60 to 75 mmfd. Manufactured by Centralab, Milwaukee, Wis.

CABLE CONNECTORS

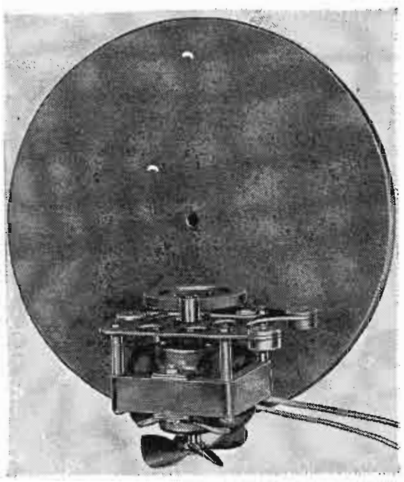
A new line of co-axial cable connectors has just been introduced by the Selectar Mfg. Corp., 30 W. 15th St., New York



City. Designed for commercial airlines, the new connectors are also suitable for mobile and stationary installations and are said to simplify the connecting of gas-filled high-frequency transmission lines. Obtainable in various sizes, types and models to accommodate transmission lines ⅜", ⅝", ¾" and ⅞". Extensions, elbows, antenna terminals and chassis types are available in various sizes.

RECORDING MOTOR

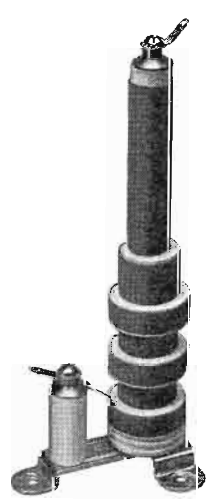
Alliance Manufacturing Company, Alliance, Ohio, announces its new Model 90 recording motor and turntable assembly designed for use with individual feed and cutter designs. It makes available an in-



expensive turntable and motor assembly suitable for incorporation in individual complete recording mechanism. The motor is available with 9" turntable only, being designed to record up to 8" blanks with good speed regulation. The assembly is of the friction drive type.

TRANSMITTING CHOKE

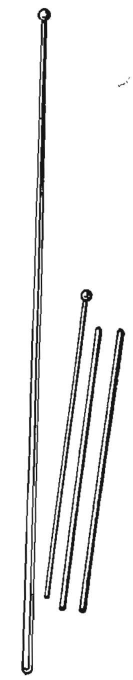
The problem of energy absorption by radio-frequency chokes when used in transmitting circuits has been simplified, according to the manufacturer of the r-f choke



illustrated above. It is known as the Type R-175 and is designed for use on the 1.7, 3.5, 7.0, 14.0 and 28.0 megacycle bands. This choke is suited for parallel as well as series fed circuits employing a maximum d-c plate supply of 3000 volts, and the wide band choke operates successfully in parallel fed circuits without appreciable energy loss. National Company, Inc., Malden, Mass.

MOBILE ANTENNAS

Brach offers several types of antennas in the police radio field. The Brach PA-83T is suitable for the lower frequency



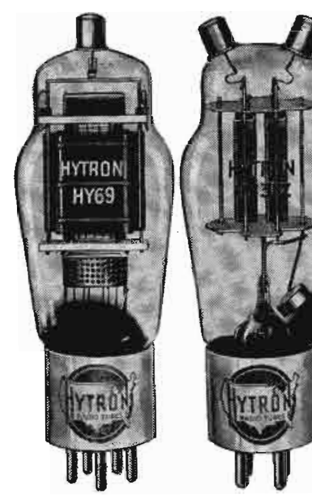
part of the u-h-f police range and the Brach Pa-72T for the high-frequency end. Both of these antennas are constructed of chrome molybdenum steel tubing specially tempered and finished in a deluxe satin chrome triple plate finish. Monel plug-in joints are used throughout. The No. PA-38M and No. PA-27M non-corrosive monel antennas are of the plug-in type and are suited for use as an end-fed or grounded antenna. The end-fed antenna mount No. RA-3 is designed to provide low loss entrance through the body of the car, and fits all surfaces regardless of body contour. All metal parts are constructed of brass, triple plated with a chrome finish. For receiving purposes Brach offer No. PA-IR-54, a single section 54-inch chrome molybdenum antenna with special cowl mounting. L. S. Brach Mfg. Corp., 55 Dickerson St., Newark, N. J.

INSTANT HEATING TUBES

A new instant-heating twin-triode has been added to the Hytron line of transmitting tubes. The HY31Z, as it is known, contains two high-mu triode sections, having characteristics that make the tube suited for zero-bias Class B modulator applications.

The HY31Z has a continuous-service maximum rating of 500 volts at 150 ma for both sections and when operated at this rating an undistorted output of approximately 50 watts is obtainable. This tube uses an instant-heating thoriated-tungsten filament having such characteristics that the filament and plate-supply motor generator can be turned on simultaneously without damage to the tube. It was designed as a companion to the HY69, instant-heating beam power tetrode. When used together, these two tubes make possible the design of mobile equipment which is instant-heating in operation and, therefore, requires no battery drain during standby periods.

Of interest to users of the HY69 is the fact that this tube is now available in an



improved construction utilizing ceramic internal insulator. Both the HY31Z and HY69 are products of the Hytronic Laboratories Division of the Hytron Corporation, 76 Lafayette St., Salem, Mass.

TARTAK-UNITED TELETONE

Paul H. Tartak, President of the Oxford-Tartak Radio Corp., has just acquired a substantial interest in the United Teletone Corp., speaker manufacturers, located in Stamford, Conn.

F-M TRANSMITTERS

TWO frequency-modulated broadcast transmitters designed for high fidelity broadcasting and other special communication services have recently been announced by RCA Manufacturing Co. While both models are for operation in the 26 to 108 megacycle range, one model is for f-m broadcasting only while the other has facilities for either f-m or a-m operation. Both transmitters are designed for power output of 1000 watts into a 70 to 600 ohm transmission line.

The audio input can be optionally connected for response within plus or minus one db from 30 to 15,000 cycles of either a flat or RMA standard pre-emphasis characteristic. The latter is flat to 500 cycles, plus 16 db at 10,000 cycles, and plus 20 db at 15,000 cycles.

An audio input level of plus 8 vu is required for 75-kc swing (100% modulation) with a single test frequency. Average transmission requires approximately zero vu audio input for 75-kc swing. The audio distortion of both sets is guaranteed to be less than 2% RMS at 75-kc swing.

• • •

AIRCRAFT INSTRUMENT PANEL ILLUMINATION

ONE of the more important discoveries in connection with recent airplane development is a method of instrument panel illumination perfected by Electronic Laboratories, Inc., of Indianapolis.

The new method of illumination, known as black light or ultra-violet-ray instrument panel illumination, is made possible by the recent development of the small 4- and 6-watt fluorescent lamps.

Working in conjunction with U. S. Army Air Corps engineers, Electronic Laboratories has incorporated the fluorescent lamp in a special type holder with a Corning black glass surface on top and an open vent below. Beneath the outer surface of the holder is a shutter which can be easily rotated to regulate the amount of light on the instrument panel.

An important feature of the lamp is that the spectrum light band attained has no detrimental effects on the eyes or skin and yet has almost maximum effect on phosphorescent material which may be used in the instrument dials, it is said.

Index to Advertisers

LOW DISTORTION OSCILLATOR

WITH VERY WIDE RANGE

INCORPORATING an inverse feedback circuit of very high selectivity, the G-R Type 608-A Oscillator supplies good output at twenty-seven discrete audio frequencies remarkably low in harmonic distortion. This oscillator makes possible bridge measurements at the lowest audio frequencies with considerably higher accuracy than has been possible heretofore. It provides a very rapid means for obtaining a large number of audio frequencies for testing. In the broadcasting station its use, with suitable auxiliary equipment, for harmonic distortion measurements has become quite general.

FEATURES

- **WIDE FREQUENCY RANGE**—20 to 15,000 cycles in 27 steps selected immediately by two push-button switches; any additional frequencies within this range can be obtained by connecting three resistors to appropriate terminals.
- **ACCURATE CALIBRATION**—within ± 2% or 1 cycle of the frequency engraved on the panel.
- **GOOD STABILITY**—at room temperatures the frequency will not drift more than 1% over a period of several hours.
- **THREE OUTPUT IMPEDANCES**—500-ohm balanced to ground; 500-ohm unbalanced; 5,000-ohm unbalanced . . . selected by push-button switches.
- **LOW HUM LEVEL**—less than 0.05% or 0.1 millivolt.
- **EXCELLENT WAVEFORM**—adjustable by means of harmonic control on panel; at maximum power output harmonics are 5% of output voltage; when output voltage is reduced by 10% total harmonic content is reduced to 0.2%; harmonics can be reduced to less than 0.1% for all output frequencies with the 5,000-ohm output circuit.
- **MAXIMUM OUTPUT POWER**—with the 5,000-ohm circuit, approximately 0.5 watt; with the 500-ohm circuits, 80 milli-watts.

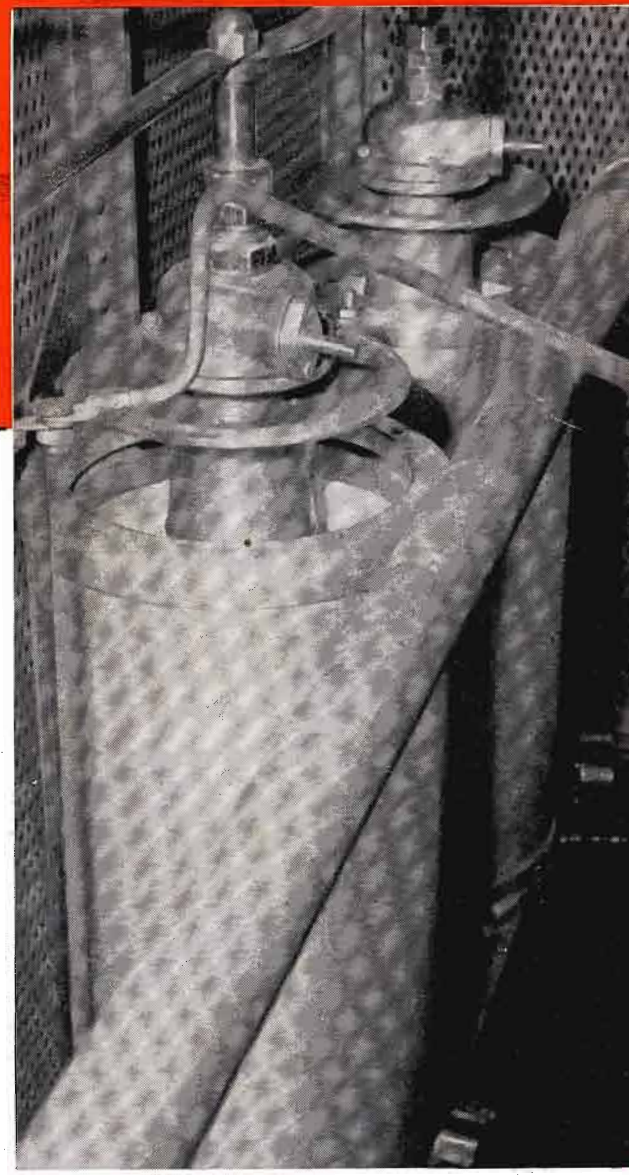
TYPE 608-A OSCILLATOR $260.00

● **WRITE FOR BULLETIN 634 FOR COMPLETE DATA**

GENERAL RADIO COMPANY CAMBRIDGE MASSACHUSETTS

"HAD TO RE-ADJUST FINAL AMPLIFIER COUPLING CIRCUITS BECAUSE OF LAPP CONDENSER'S LOW LOSS"

writes L. W. STINSON, KVOO



L. W. STINSON

"The two continuously variable 1000 mmf Lapp gas-filled condensers were originally ordered as part of a plan to change over our 50 kilowatt transmitter to a modern high-efficiency type of circuit. Plans did not call for an immediate changeover, so they were installed in the regular circuit to replace the solid dielectric condensers in use. For this temporary installation the variable capacitance feature was used only to adjust the unit to a fixed value with a radio frequency bridge; minor changes were made in the neutralizing circuits and the Lapp units inserted in the same postion as the old bank of twelve mica capacitors.

"We had not anticipated that the increase of efficiency due to the gas-filled units would necessitate re-adjustment of the final amplifier coupling circuits but such was the case, as the increased impedance presented to the tube anodes raised the efficiency above optimum linear amplifier operating conditions. This of course, is a testimonial to the Lapp claim of 'low loss' features, and permitted us to transfer just that much more power to the antenna and to discard the air blower which had been found necessary to hold the temperature rise of the mica units to a safe value. As best we can determine, the gas-filled units operate at the ambient temperature.

"Our condensers, received in February, 1939, were filled to 200 pounds nitrogen shortly after arrival. Since then they have required absolutely no service of any kind."

Descriptive literature and list of 54 models in three voltage ratings available on request.

LAPP INSULATORS

LEROY, N. Y., U. S. A.