# COMMUNICATIONS

BROADCAST
ENGINEERING
CONFERENCE

INDUSTRY
PREVIEW

RECORDING

JANUARY

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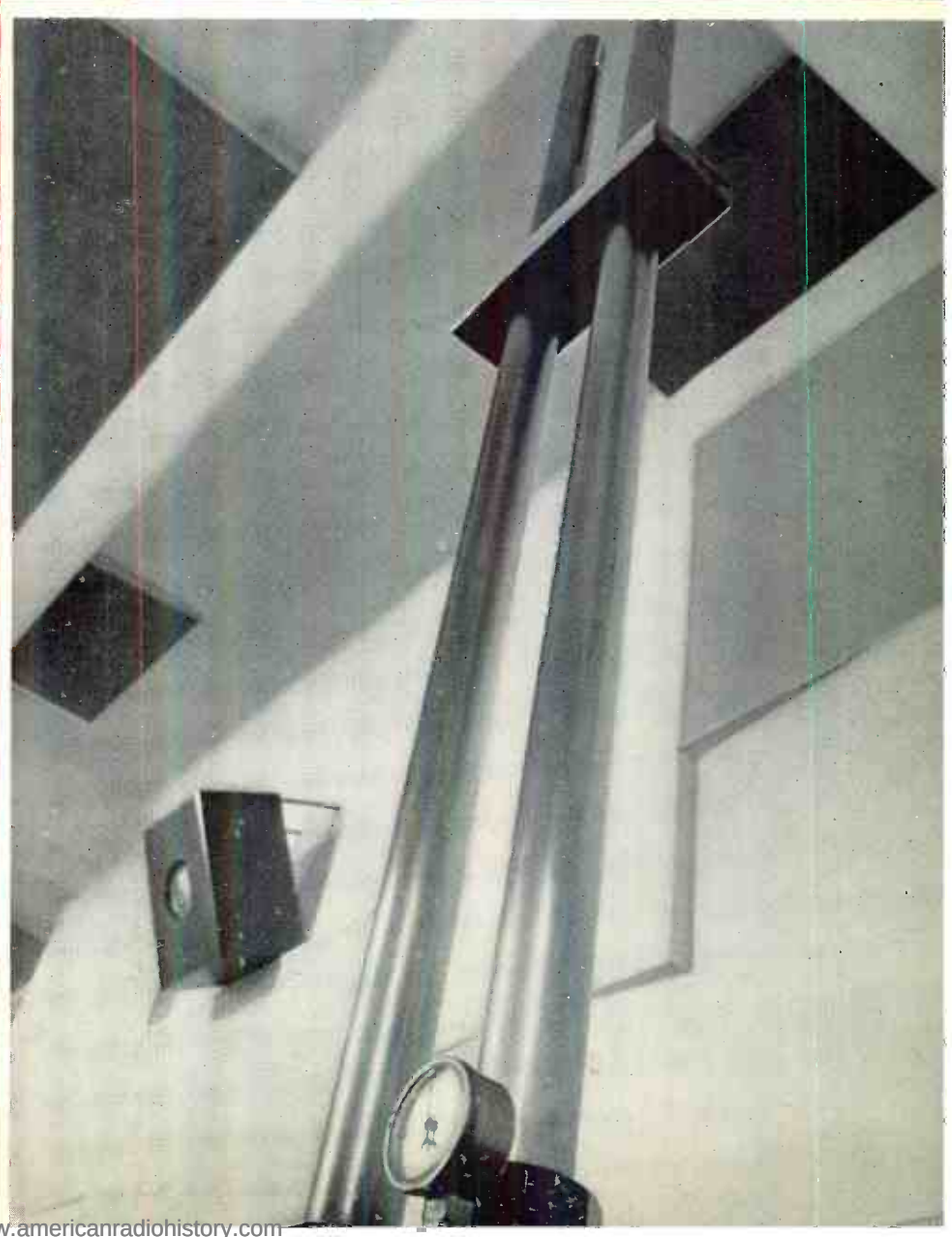

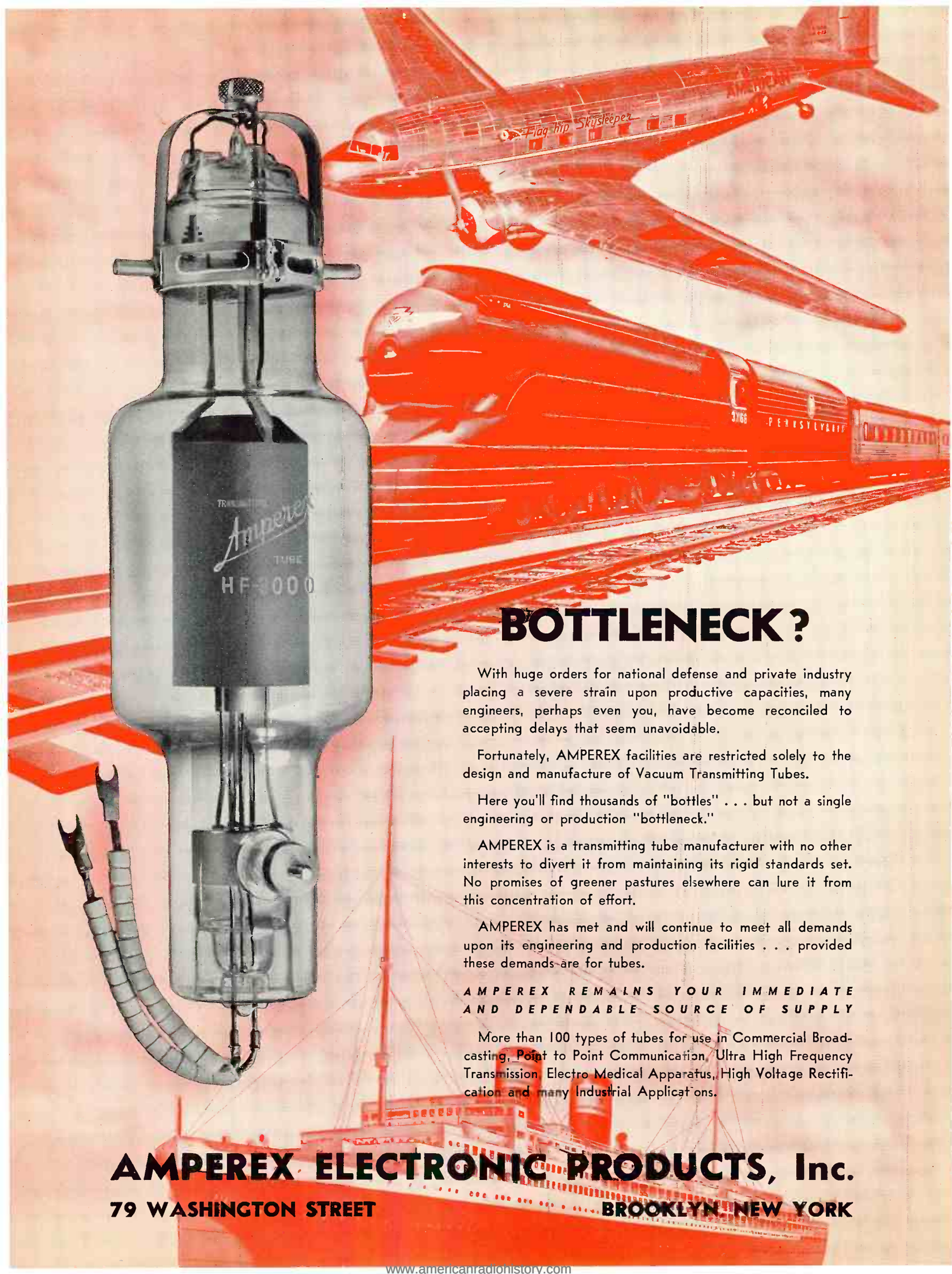


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# COMMUNICATIONS

JANUARY
1941

Including Television Engineering, Radio Engineering, Communication & Broadcast Engineering, The Broadcast Engineer.
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VOLUME 21
NUMBER 1

RAY D. RETTENMEYER
Editor


## •Contents•

COVER ILLUSTRATION

Close-up view of coaxial transmission line connecting transmitter and antenna at W2XOR, WOR's 1-kw f-m installation. Note meter in foreground which indicates pressure of nitrogen gas within the transmission line and the short section of coaxial tubing which acts as a shunt to suppress the second harmonic. Photo courtesy Western Electric Co.



## •Editorial Comment•

BEGINNING January 1, 1941, commercial frequency-modulation broadcasting became a reality. To date, some 29 f-m stations have been authorized by the Federal Communications Commission for full commercial program service. With about 55 applications scheduled for Commission action, it appears that f-m broadcasting will "go to town" in 1941.

While on the subject, it is interesting to note that specific rules will soon be drafted for high-frequency (330,000 kc) radio links to transmit programs from studio to transmitter. Either f-m or a-m signals may be used.

MUCH interest is being evidenced in the coming NTSC-FCC hearing on television which will take place this month. The NTSC has already completed its report on standards, so that the immediate future of television is now in the hands of the FCC. It is sincerely hoped that television will be permitted to proceed on a full commercial basis.

There has been a great deal of development in television of late. Improvement in color television is proceeding quite well, direct pickup now being possible. In addition good images can now be sent over wire lines as was evidenced at a recent IRE demonstration. In our opinion, these developments should hasten the commercialization of television rather than hinder it, since experimental work of this type cannot be carried on indefinitely without some return on the investments of time and money.

THE recent IRE Convention was somewhat disappointing from the standpoint of attendance and number of manufacturers' exhibits. We wonder if this gathering was held too soon after the Rochester Fall Meeting? Perhaps it would be better to hold the annual IRE Convention in the latter part of March or early April in order that it will not be too close to either the Rochester Fall Meeting or the Chicago Trade Show?




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# BROADCAST ENGINEERING CONFERENCE

## Ohio State University

## February 10-21, 1941

THE Fourth Broadcast Engineering Conference has been scheduled for February 10 to 21, 1941, at Columbus, Ohio, and is under the direction of Dr. W. L. Everitt, Professor of Electrical Engineering in charge of instruction in communication at Ohio State University.

The Conference will be held under the auspices of the Ohio State University and will have the official cooperation of the National Association of Broadcasters.

The Third Conference held in February of last year attracted 248 engineers from 35 states. The prominence of the speakers for the Fourth Conference indicates that the steady growth of attendance will continue.

E. K. Jett, Chief Engineer of the FCC, will address the Conference on the timely subject "Communication in National Defense."

A. D. Ring, Assistant Chief Engineer of the FCC in charge of broadcasting will again conduct the "General Discussion and Question Box" concerning broadcast engineering regulation problems. This was one of the most popular sessions last year. New problems that have arisen since that time and Mr. Ring's interesting method of presentation promises to make this an outstanding session.

Discussion about frequency modulation has been accompanied by much discussion on "high fidelity". Harvey Fletcher, of the Bell Telephone Laboratories, is the leading research worker on the response of the human ear and his paper "Hearing, The Determining Factor for High Fidelity" should serve to put in quantitative form many of the conceptions concerning "high fidelity".

Frequency modulation will occupy a prominent place on the agenda and the F-M sessions will be introduced by the dean of wide-band proponents, Major Edwin H. Armstrong of Columbia University.

The National Television Standards Committee was formed late last summer with the official cooperation of the FCC for the purpose of forming television standards agreeable to the whole industry. Dr. W. R. G. Baker, of the General Electric Company and Director of Engineering for the Radio Manufacturers Association, is Chairman of the

(*Continued on page* 18)

### FIRST WEEK—FEBRUARY 10-15

| Time | 9 A.M. to 11 A.M. | 11 A.M. to 1 P.M. | 2:30 P.M. to 4:30 P.M. |
|---|---|---|---|
| Monday Feb. 10 | SPEECH INPUT SYSTEMS<br>C. M. Lewis—RCA<br>J. D. Colvin—RCA | SOUND REPRODUCTION FROM RECORDINGS<br>F. V. Hunt<br>Harvard University | TELEVISION STANDARDS<br>W. R. G. Baker<br>General Electric Company |
| Tuesday Feb. 11 | STUDIO ACOUSTICS<br>Paul J. Washburn<br>Johns-Manville | | COLOR TELEVISION<br>Peter C. Goldmark<br>Columbia Broadcasting System |
| Wednesday Feb. 12 | | GENERAL DISCUSSION AND QUESTION BOX<br>Andrew Ring—FCC<br>Lynne C. Smeby—NAB | THE STATUS OF TELEVISION<br>Harry Sadenwater<br>Radio Corporation of America |
| Thursday Feb. 13 | POLYPHASE BROADCASTING<br>Paul Loyet<br>Central Broadcasting Company | | TELEVISION STATION OPERATION<br>Robert M. Morris<br>National Broadcasting Company |
| Friday Feb. 14 | ROUND TABLE ON RECEIVERS<br>J. Kelly Johnson<br>Hazeltine Corp.<br>E. B. Passow<br>Zenith Radio Corp.<br>W. L. Dunn<br>Belmont Radio Corp. | LOUD SPEAKERS<br>H. F. Olson<br>Radio Corporation of America | TELEVISION FIELD PICKUPS<br>Harold P. See<br>National Broadcasting Company |
| Saturday Feb. 15 | | | |

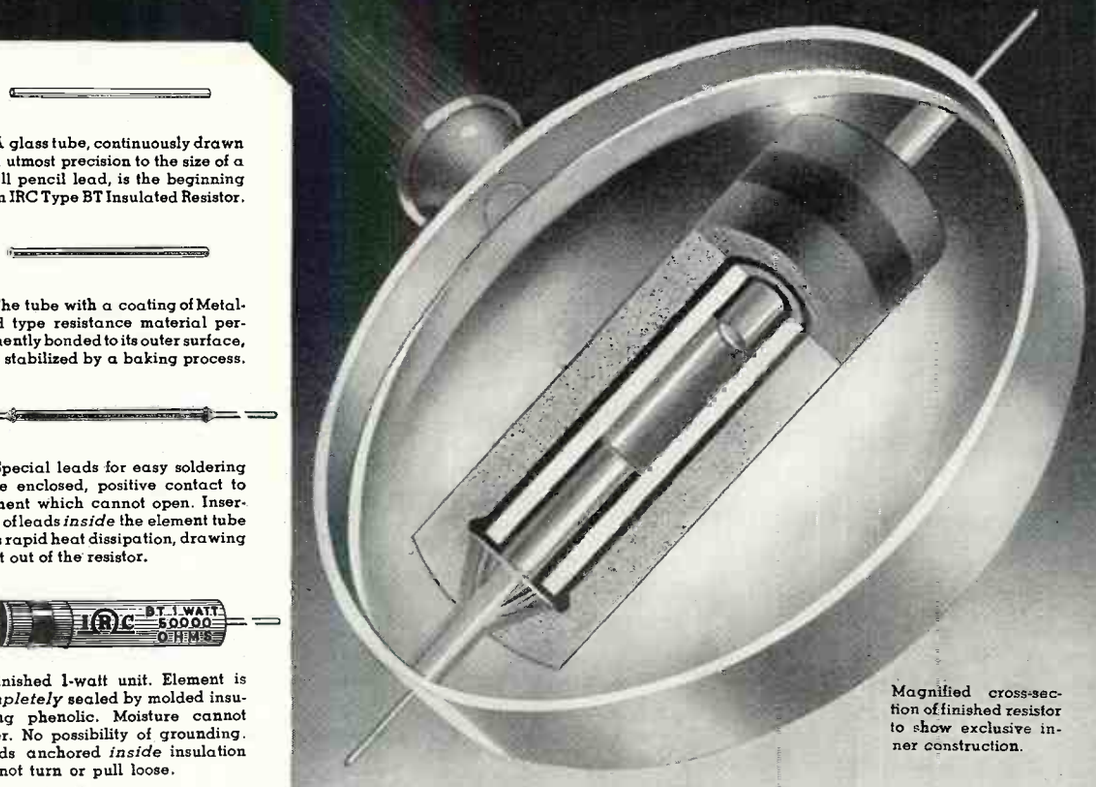
### SECOND WEEK—FEBRUARY 17-21

| Time | 9 A.M. to 11 A.M. | 11 A.M. to 1 P.M. | 2:30 P.M. to 4:30 P.M. |
|---|---|---|---|
| Monday Feb. 17 | THE STATUS OF FREQUENCY MODULATION<br>Edwin H. Armstrong<br>Columbia University | FM ALLOCATION AND COVERAGE<br>Stuart Bailey<br>Jansky & Bailey | HEARING, THE DETERMINING FACTOR FOR HIGH FIDELITY<br>Harvey Fletcher<br>Bell Telephone Laboratories |
| Tuesday Feb. 18 | FM RECEIVERS<br>M. L. Levy<br>Stromberg-Carlson | UHF ANTENNAS AND TRANSMISSION LINES<br>Andrew Alford<br>Mackay Radio and Telegraph Company | UHF TRANSMISSION<br>Kenneth A. Norton<br>Federal Communications Commission |
| Wednesday Feb. 19 | FM FIELD TESTS<br>Raymond F. Guy<br>National Broadcasting Company | | |
| Thursday Feb. 20 | OPERATING PROBLEMS IN FM TRANSMITTERS<br>I. R. Weir<br>General Electric Company | ROUND TABLE ON FM PROBLEMS<br>E. J. Content—WOR<br>Paul deMars—Yankee Network<br>Dan Gellerup—WTMJ | UHF TUBES<br>E. D. McArthur<br>General Electric Company |
| Friday Feb. 21 | FM BROADCAST TRANSMITTER CIRCUIT DESIGN<br>John F. Morrison<br>Bell Telephone Laboratories | | |

### SPECIAL FEATURES

Tuesday, February 11—8 p.m.—Chittenden Hotel—E. K. Jett, "Communication in National Defense"
Thursday, February 13—6:30 p.m.—Dinner, Ft. Hayes Hotel
Saturday, February 15—Basketball Game—Ohio State vs. Purdue
Tuesday, February 18—8 p.m.—Chittenden Hotel—Homer Dudley, "The Vocoder or Remaking Speech Electrically"
Thursday, February 20—6:30 p.m.—Banquet, Ft. Hayes Hotel

# The COLONEL'S LADY and JUDY O'GRADY Are NOT Sisters Under Their Skins!



Magnified cross-section of finished resistor to show exclusive inner construction.

1. A glass tube, continuously drawn with utmost precision to the size of a small pencil lead, is the beginning of an IRC Type BT Insulated Resistor.

2. The tube with a coating of Metallized type resistance material permanently bonded to its outer surface, and stabilized by a baking process.

3. Special leads for easy soldering have enclosed, positive contact to element which cannot open. Insertion of leads *inside* the element tube aids rapid heat dissipation, drawing heat out of the resistor.




A finished 1-watt unit. Element is *completely* sealed by molded insulating phenolic. Moisture cannot enter. No possibility of grounding. Leads anchored *inside* insulation cannot turn or pull loose.


**Flattering and widespread imitation following IRC's development of the Insulated Resistor with its obvious advantages as compared with old-style, non-insulated units has resulted in such uniformity of appearance that it is difficult to distinguish one make from another. *This similarity, however, is only skin deep—only as deep as the insulation.***

What lies beneath is of the utmost importance from the standpoint of performance. The outside insulation is important only because it protects the inside resistance element, prevents shorting and facilitates rapid and economical assembly. Not this protection *but what it protects* is the final determining factor of quality—and it is *underneath* this insulation that insulated resistor similarity ends.

As an outstanding example, the IRC type BT insulated resistors, comprising the unique "Metallized" filament element and specially developed insulating phenolic covering, have humidity characteristics hitherto unobtained. More than 10 cycles of alternate two hour immersions in 100°C. and 0°C. salt solution followed by two hour loadings at normal rating result in an average change in resistance value of less than 10%.

In connection with the present defense program such performance is essential for dependable communication equipment but it is also obviously very important for all commercial applications.

## TYPE BT INSULATED RESISTORS

INTERNATIONAL RESISTANCE CO., 403 N. BROAD ST., PHILA.

# The Reduction of PICKUP TRACKING ERROR

By G. E. MACDONALD

### Introduction

TRACKING error (or tracking angle) is defined as the angle between the tangent to the groove at the needle point and the vertical projection upon the disc of the axis of needle vibration.[1] This is a general definition, to include all types of pickup arrangements, as distinguished from that specifying the projection of the needle upon the disc. It was clearly demonstrated in the paper referred to that the latter definition shows zero tracking error for given conditions in the case of the "needle-tilt" arrangement, when tracking error actually exists.

In recording machines, and dictophones or the early cylindrical record phonographs, the locus of the stylus is a straight line, and perfect tangency to the groove is thereby maintained at every point on the record. In reproduction by means of a pivoted tone arm,[2] the locus of the needle point is the arc of a circle, and perfect tangency to the groove is possible at only one or two points on the record. Hence, tracking error is the result of a pivoted tone arm, and it is obviously an inverse function of the length of the tone arm. It depends also upon the radius of the groove under the needle point, the location of the pivot with respect to the spindle, and the type of tone arm used.

The question of the extent to which tracking error impairs the quality of reproduction and causes deterioration of the walls of the grooves, has been investigated in detail in literature on the subject.[1] Comprehensive listening tests have been performed which would indicate that a reasonable amount of tracking error is not noticeable either in the quality of reproduction or in the wear of the disc. Furthermore, the distortion resulting from tracking error has been determined by means of one of the methods of wave analysis, and the results have been found to agree with the listening tests.[1]

On the other hand, when the tracking error is excessive, no question remains in the mind of a listener who compares the quality with that obtaining under proper tracking conditions. The fact that manufacturers are producing equipment[3, 4] designed to reduce tracking error from amounts termed "normal" for the conventional tone arm, would indicate that even this amount of tracking error is not desirable.

If it be assumed that the high-frequency attenuation occasioned by tracking error is not noticeable, there still remains a number of other opportunities for high-frequency loss within the system. Among these may be mentioned high-frequency needle loss, the reactive drop in the windings of the pickup, and the various losses in attenuator, amplifier, and loud speaker, or telephone line in the case of broadcast equipment. While none of the individual losses may be noticeable, the resultant loss may be very appreciable if proper compensation is not made.

In the design or installation of phonograph or transcription equipment, the reduction of the average tracking error to its minimum value is, in many cases, as convenient as other arrangements resulting in appreciable tracking errors. It was with this thought in mind that formulas have been developed which make possible the ideal installation of any of the main types of tone arms.

Dimensions bearing the subscripts "1" or "2" refer, throughout this paper, to the inner or outer groove, respectively. Further, the term "center groove" refers to that groove equidistant from the inner and outer grooves. Tracking error is considered positive when the tangent to the groove at the needle point lies in a clockwise direction from the axis of needle vibration. Thus, in Fig. 2-A, $e_2$ is positive and $e_1$ is negative.

### Pickup Arrangements

In Fig. 1 the legend is as follows: (S) spindle, (P) tone arm pivot, (L) distance between needle point and pivot, (l) length of tone arm to point of off set, (H) length of pickup, (r) radius of any groove, (T) tangent to groove at needle point, (e) tracking error (in de-

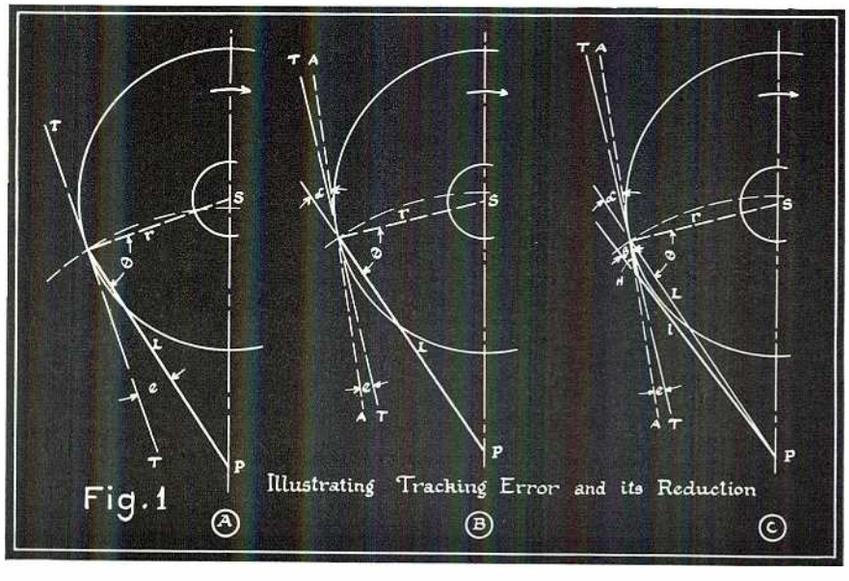



Fig. 1 Illustrating Tracking Error and its Reduction

[1] Benjamin Olney, "Phonograph Pickup Tracking Error", *Electronics*, pp. 19-23, Nov., 1937.

[2] The continued use of the term "tone arm" is unfortunate, in that this term was coined in the days when the member in question served as a sound chamber as well as the pickup support.

[3] Ralph P. Glover, "A Record-Saving Pickup", *Electronics*, pp. 31-32, Feb., 1937.

[4] H. J. Hasbrouck, "Lateral Disc Recording for Immediate Playback with Extended Frequency and Volume Range", *Proc. I.R.E.*, Vol. 27, pp. 184-187, March, 1939.

grees), ($\alpha$) off set angle (for arrangement in B), ($\beta$) off set angle (for arrangement in C), (A) axis of needle vibration, ($\theta$) angle between any radius and L.

In Fig. 1, B and C represent two methods of reducing tracking error. It will be observed that C is a special case of B.

The conventional pickup arrangement, viz., the straight tone arm, is illustrated in A. B also represents a straight tone arm, but one in which the axis of the pickup has been rotated through the angle $\alpha$ in the direction shown. C illustrates the most common form of pickup off set. In this case the angle of off set is $\beta$, rather than $\alpha$. This type is not as advisable from a theoretical standpoint as that illustrated in B, since vertical motion of the needle produces a turning moment about the point of off set through the component of H normal to l. The torsion thus developed is, however, usually compensated for, but in any case it would probably not be serious inasmuch as H and $\beta$ are generally small.

A special case of C is that of the curved tone arm, used to some extent in Europe but seldom met with in this country.

### Modes of Operation

A common "rule-of-thumb" has been to so locate the pivot of the conventional tone arm that the needle point coincides with the center of the spindle, i.e., D = L in Fig. 2-A. This method has been used extensively for phonograph and broadcast equipment, but, as will be shown, it results in a large tracking error for given tone arm and disc dimensions.

A better plan that has often been suggested is the visual alignment of the axis of the tone arm with the tangent to the center groove of an average disc, i.e., the point on the disc at a distance

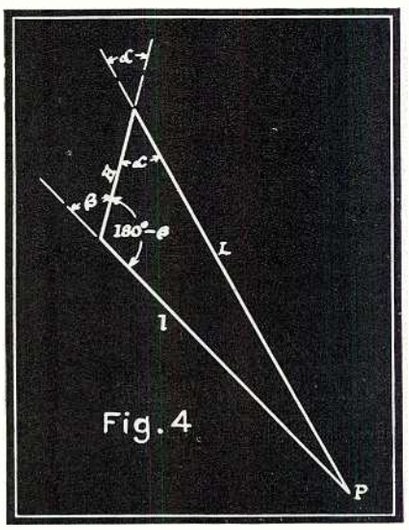


Fig. 4

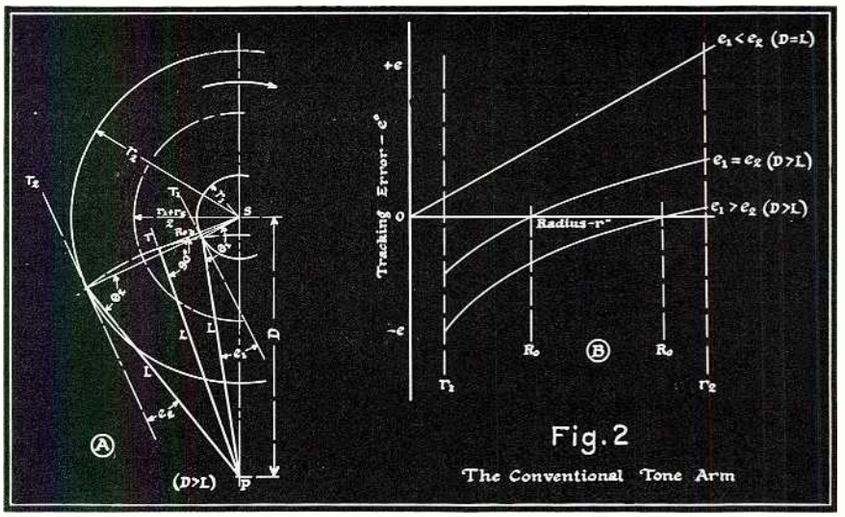


Fig. 2
The Conventional Tone Arm

$\frac{r_1 + r_2}{2}$ of units from the center of the spindle. This has led, however, to the incorrect assumption that the tracking errors at the inner and outer grooves will be small and numerically equal. Assuming the possibility of arriving at a tangent to a groove at a certain point by inspection, $e_1$ and $e_2$ are not numerically equal when the error at $r = \frac{r_1 + r_2}{2}$ is zero, and conversely, if $e_1$ is made equal to $e_2$ the error at $r = \frac{r_1 + r_2}{2}$ cannot be zero.

When the tracking error at the center groove has been made equal to zero, $e_1 > e_2$, and when $e_1 = e_2$ zero error occurs nearer the inner groove than the outer. While the above plan is superior to the former where D = L, it, nevertheless, can be improved considerably.

A fundamental requirement applying to all types of pickup arrangements is that the tracking errors at the inner and outer grooves be numerically equal and opposite in sign, for minimum error.

The use of any of the off-set type of pickups reduces the tracking error still further if the condition $e_1 = e_2$ be fulfilled. Errors not exceeding 4° or 5° at any point on the disc are obtainable with the usual size of transcription equipment if properly mounted.

The question of the best mode of operation for the off-set type of pickup is controversial within certain limits, as will be seen from the following and the tone arm characteristics of Fig. 7.

Two points of zero error exist with any of the off-set type of pickups, and it is possible, by proper adjustment of the variables, to locate these points of zero error at any of a number of positions on the disc, including the dual position of the inner and the outer grooves. When this position has been obtained, a mode of operation results, $e_1 = e_2 = 0$, which is slightly inferior to the general mode, $e_1 = e_2$, with respect to minimum tracking error, but superior with respect to constancy of error throughout the playable range. The variation in tracking error with the mode $e_1 = e_2 = 0$ equals the maximum value of the error, $e_m$. Use of the mode, $e_1 = e_2 \neq 0$ results in a variation in tracking error from $-e_1$ to $+e_2$, or vice versa, which is the equivalent of a variation of $2e_1$ (or $2e_2$). Investigation shows that $e_m$, with the mode $e_1 = e_2 = 0$, is only slightly greater than $e_1$ or $e_2$ with the mode $e_0 = e_2 \neq 0$, hence, the variation in error with the former mode is only one-half that with the latter, approximately.

It has been stated[3] that, for minimum wear of the disc, the variation in tracking error throughout the playable range should be small. This aspect would favor the mode $e_1 = e_2 = 0$, but whether it would offset the slight increase in tracking error of this mode over the mode $e_1 = e_2 \neq 0$ would depend entirely upon the dimensions involved. It may safely be said that there is very little choice between the two modes of operation, and, generally, practical considerations other than minimum tracking error, or variation in the error, decide the mode to be used.

The point of importance is that the specification $e_1 = e_2$ should be the first consideration in mounting any tone arm. If the pivot is located such that $e_1 = e_2 = 0$, less variation in tracking error will result, with a slight increase in the maximum value of the error.

The following section will verify certain statements made above, and will consider the subject in greater detail.

### Principles of Operation

The straight tone arm with off-set pickup is general, and includes all other pickup arrangements. The case of the conventional tone arm ($\alpha = 0$), will, however, be dealt with first.

*I—The Conventional Tone Arm*

The center curve in Fig. 2-B is the characteristic of the mode illustrated in Fig. 2-A, where $e_1 = e_2$. The lower curve is the result of $e_1 > e_2$, and the upper characteristic is drawn for a condition in which a point of zero error does not fall between $r_1$ and $r_2$.

Any movement of the pivot from the position resulting in $e_1 = e_2$, where $e_1$ and $e_2$ are opposite in sign, decreases the tracking error at one groove and increases it at the other. The error at the latter groove will, therefore, be greater than it would under the condition $e_1 = e_2$. The pivot may, of course, be rotated about the spindle without producing any change in $e_1$ and $e_2$, providing that the radius of rotation is unaltered. Consideration of the off-set type of pickup will also lead to the conclusion that $e_1 = e_2$ represents minimum error.

From Fig. 2-A,

$e_1 = \theta_1 - 90°$, or

$\theta_1 = e_1 + 90°$, and

$$\cos \theta_1 = \frac{L^2 + r_1^2 - D^2}{2Lr_1} = -\sin e_1$$

$e_2 = 90° - \theta_2$, or

$\theta_2 = 90° - e_2$, and

$$\cos \theta_2 = \frac{L^2 + r_2^2 - D^2}{2Lr_2} = +\sin e_2.$$

For the condition that $e_1 = e_2$,

$$-\left(\frac{L^2 + r_1^2 - D^2}{2Lr_1}\right) = \left(\frac{L^2 + r_2^2 - D^2}{2Lr_2}\right)$$

The solution of this equation for D results in

$$D = \sqrt{L^2 + r_1 r_2} \quad \ldots\ldots\ldots\ldots\ldots (1)$$

which determines the correct position of the pivot for minimum tracking error.

The triangle of zero error in Fig. 2-A makes $R_o = \sqrt{D^2 - L^2}$. Substituting $L^2 + r_1 r_2$ for $D^2$ in the above gives the point on the disc at which the tracking error is zero; viz.,

$$R_o = \sqrt{r_1 r_2} \quad \ldots\ldots\ldots\ldots\ldots (2)$$

The general equation of tracking error is

$$e = \sin^{-1}\left(\frac{L^2 + r^2 - D^2}{2Lr}\right),$$

where e is positive or negative according to definition stated previously, and r is any radius. By substituting $L^2 + r_1 r_2$ for $D^2$, the equation of tracking error for the condition that $e_1 = e_2$ results. It is

$$e = \sin^{-1}\left(\frac{r^2 - r_1 r_2}{2Lr}\right) \quad \ldots\ldots\ldots (3)$$

The general equation shows that the error at the spindle ($r = 0$) is zero when $D = L$, as would be expected since the axis of needle vibration would then coincide with the tangent. However, (1) shows that D cannot equal L, or be less than L, for the condition that $e_1 = e_2$. Expressed differently, the needle point of the conventional tone arm must fall short of the spindle for minimum tracking error. If $D = L$ an error exists at the inner groove and a larger error of the same sign exists at the outer groove since there is no point of zero error lying between these limits. If D were to be made less than L the condition would be still further aggravated.

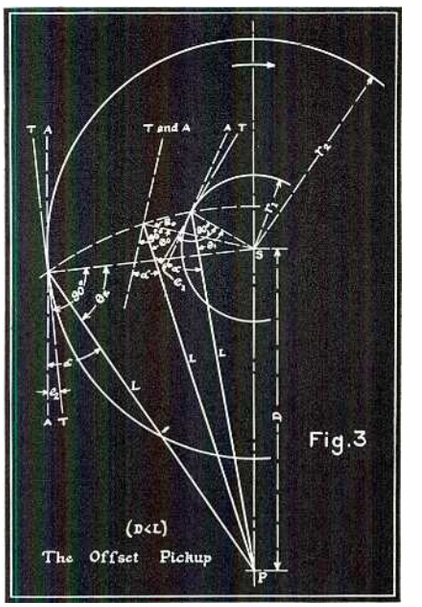


Fig.3

If the tracking error has been made equal to zero at the center groove, $\frac{r_1 + r_2}{2}$ would have to equal $\sqrt{r_1 r_2}$ if $e_1$ is to equal $e_2$. This is impossible, however, since $r_1 \neq r_2$. Zero error, therefore,cannot exist at the center groove and maintain $e_1 = e_2$.

Since $r_2 > r_1$, $r_2 = nr_1$ where $n > 1$. Then

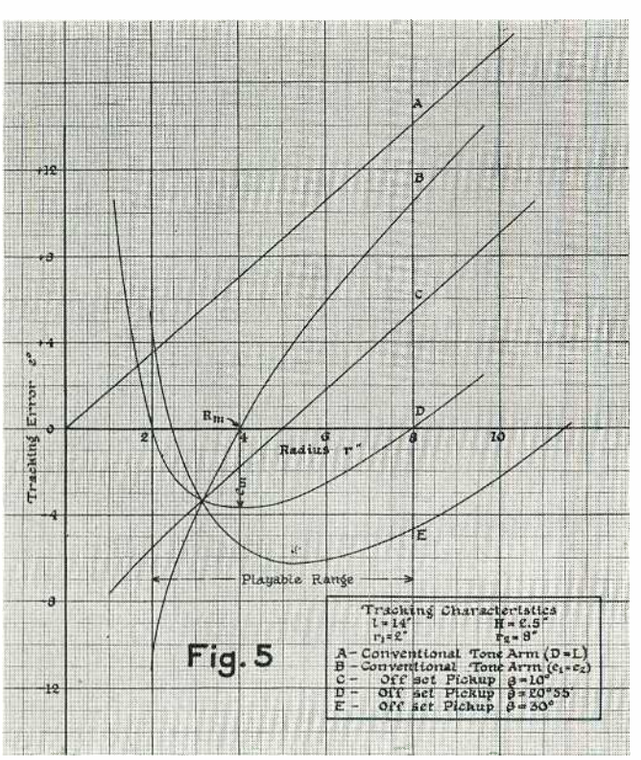


Fig. 5

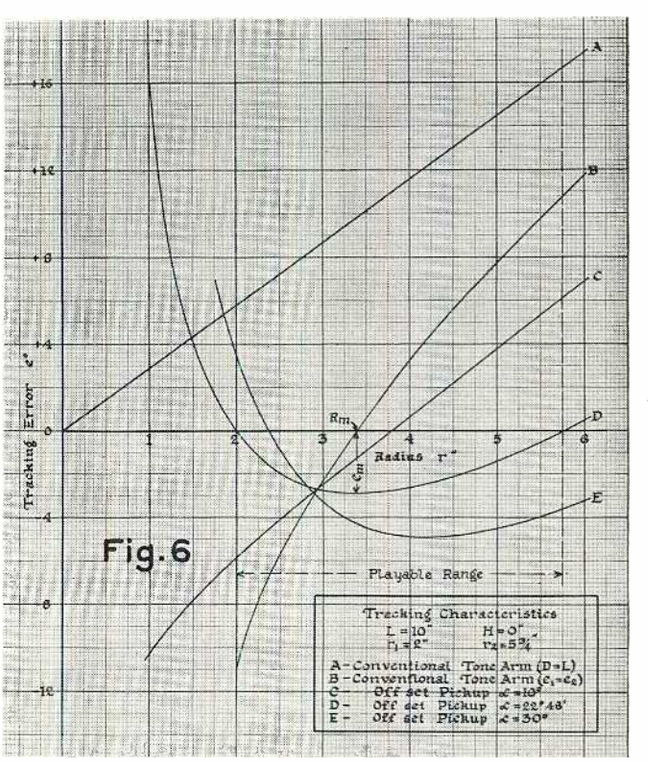


Fig. 6

$$\left(\frac{r_1 + r_2}{2}\right) \div \sqrt{r_1 r_2}$$

$$= (1 + n) \div 2\sqrt{n} = a.$$

For all values[5] of $n > 1$, $a > 1$, and, therefore,

$$\left(\frac{r_1 + r_2}{2}\right) > \sqrt{r_1 r_2}$$

Hence the point of zero error for the condition $e_1 = e_2$ lies nearer the inner groove than the outer.

By altering the position of the pivot, P, in Fig. 2-A such that the error at the radius $\frac{r_1 + r_2}{2}$ will be zero, D will have increased from $D = \sqrt{L^2 + r_1 r_2}$ to $D = \sqrt{L^2 + \left(\frac{r_1 + r_2}{2}\right)^2}$. By substituting $L^2 + \left(\frac{r_1 + r_2}{2}\right)^2$ for $D^2$ in the expressions for $\sin e_1$ and $\sin e_2$ given previously, and dividing $\sin e_1$ by $\sin e_2$, the ratio reduces to $\frac{r_2^2 + 3 r_1 r_2}{r_1^2 + 3 r_1 r_2}$. Then $\frac{\sin e_1}{\sin e_2} > 1$ since $r_2 > r_1$, and, therefore, $e_1 > e_2$. That is, the tracking error at the inner groove is greater than that at the outer when zero error occurs at the center groove.

### *II—The Straight Tone Arm With Off Set Pickup* ($e_1 = e_2$)

Only the mode $e_1 = e_2$ will be considered as its advantage has been previously demonstrated.

Fig. 3 illustrates the relative positions of the variables for the mode $D < L$. The general formula developed from Fig. 3 will be found to hold also for the modes $D \geqq L$, as well as for the case of the conventional tone arm where $\alpha = 0$. When a pickup is used in which the dimension H appears (Fig. 1-C), the dimensions $\beta$ and 1 may be expressed in terms of $\alpha$ and L, respectively, and the general formula applied.

The following relationships may be written down directly from Fig. 3:

$$e_1 = 90° - \alpha - \theta_1 \quad \ldots\ldots\ldots\ldots (4)$$

where $\theta_1 = \cos^{-1}\left(\frac{L^2 + r_1^2 - D^2}{2 L r_1}\right)$, and

$$e_2 = \alpha + \theta_2 - 90° \quad \ldots\ldots\ldots\ldots (5)$$

where $\theta_2 = \cos^{-1}\left(\frac{L^2 + r_2^2 - D^2}{2 L r_2}\right)$.

For the condition that $e_1 = e_2$, $\theta_1 + \theta_2 = 180° - 2\alpha$, or

$$\cos^{-1}\left(\frac{L^2 + r_1^2 - D^2}{2 L r_1}\right) + \cos^{-1}\left(\frac{L^2 + r_2^2 - D^2}{2 L r_2}\right) = 180° - 2\alpha \ldots\ldots (6)$$

The left member of (6) is of the form

$$\cos^{-1}\lambda + \cos^{-1}\mu = \cos^{-1}(\lambda\mu - \sqrt{(1-\lambda^2)(1-\mu^2)}).$$

Combining the left member of (6) as indicated, and taking the cosine of both members, results in the form

$$\lambda\mu - \sqrt{(1-\lambda^2)(1-\mu^2)} = -\cos 2\alpha,$$

from which the solution for $D^2$ follows. In order to simplify the final expression let $r_1 r_2 = a$,

$r_1^2 + r_2^2 = c$, and

$2a \cos 2\alpha = z$. Then

$$D^2 = \{[z(c + 2L^2) + 2cL^2 + 4a^2] \pm 2a \sin 2\alpha \sqrt{4L^2(z+c) - (r_1^2 - r_2^2)^2}\} \div 2(z + c) \quad \ldots\ldots\ldots\ldots (7)$$

Since (7) is the solution of a biquadratic equation, four roots result. Two positive roots result from the $\pm$ signs ahead of the radical, of which the greater is impractical and is ignored.

When it is desired to determine the correct location of the pivot of a given tone arm having an off-set pickup, $\alpha$ is known, and (7) would be applied. In the design of any off set type for given conditions, a means of arriving at the optimum angle $\alpha$ would, however, be desirable. Due to the complexity of the solution of optimum $\alpha$, application would be highly impractical, as a few trial values of $\alpha$ would soon determine the optimum value.

If $\alpha$ be made zero in (7), the formula reduces to $D^2 = L^2 + r_1 r_2$, which is the equation of the conventional tone arm.

The tracking error at any point on the disc may be readily determined from

$$e = 90° - \alpha - \theta = 90° - \alpha - \cos^{-1}\left(\frac{L^2 + r^2 - D^2}{2 L r}\right) \quad \ldots\ldots\ldots (8)$$

where r is the desired radius.

From Fig. 3, $\theta_o = 90° - \alpha$, and

$$D^2 = L^2 + R_o^2 - 2 L R_o \cos\theta_o = L^2 + R_o^2 - 2 L R_o \sin\alpha,$$

where $R_o$ is the radius of the groove at which the tracking error is zero, (when $e_1 = e_2$). Solving for $R_o$ gives

$$R_o = L \sin\alpha \pm \sqrt{D^2 - L^2 \cos^2\alpha} \quad \ldots (9)$$

Equation (9) indicates that two points of zero error exist with the off set type of pickup. When $\alpha$ is of such value that $D = L \cos\alpha$ only one position of zero error exists, viz, at $R_o = L \sin\alpha$, and this occurs only when $D < L$. It is apparent that (9) holds for all values of $\alpha$ such that $D \geqq L \cos\alpha$. It may be mentioned, moreover, that the formula also holds in practice for all values of $D < L$, where $\alpha > 0$. due to the relative magnitudes of D and L, and the reducing effect of $\cos\alpha$ on L. When $D = L$ (9) reduces to $R_o = 2L \sin\alpha$ and $R_o = 0$.

A peculiarity of the condition $R_o = 0$ when $D = L$ will now be observed. A consideration of the equation of tracking error, $e = 90° - \alpha - \theta$, leads to a

(*Continued on page 22*)

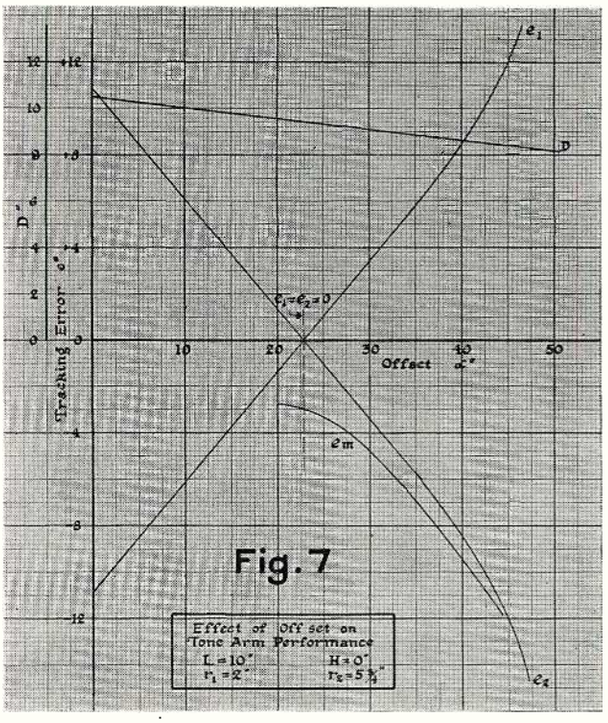



Fig. 7

[5]That a is an increasing function of n for all values of $n > 1$ will be seen from the fact that $da/dn = 0$ and $\infty$ only when $n = 1$ and 0, respectively.

# A TEN-CENTIMETER WAVEMETER

**By S. D. LAVOIE**
Lavoie Development Labs.

THE recent discoveries and developments in velocity-modulated tubes have extended the frequency range of oscillators thereby causing a need for the extension of wavemeters for measurements of frequency in this band.

Wavemeters for measurements at these frequencies have been previously discussed and built using as the basic means the modification and application of transmission-line theory. Several ingenious ideas using a quarter-wave stub as the basis of resonance have been proposed. It is true that various applications of transmission-line theory may be successfully applied to wavemeter designs operating at this frequency. They are capable of precise measurements and their limitations due to multiple resonance effects are not in general too serious.

Several experimenters have built wavemeters of the conventional coil and condenser type capable of receiving signals at frequencies less than one thousand megacycles. It is quite possible, by a proper choice of geometric configuration and precise construction to extend the range of this type of wavemeter to the ten-centimeter band. There is no reason theoretically why a conventional coil and condenser cannot be utilized for measurements of other high frequencies. The limitations of extending the range to frequencies considerably in excess of three-thousand megacycles, in this simple type of wavemeter, generally lie in the minute construction required and the difficulties of maintaining a precise mechanical arrangement. In constructing such a wavemeter care must be exercised in the choice of materials, and a good design with a high circuit "Q," which compares favorably with transmission types of wavemeters, must be utilized.

It is the purpose of this paper to discuss with some detail some of the fundamental considerations in the design of such a wavemeter and the means and various methods for its calibration. Because of the limitation of tubes that will amplify or detect at these frequencies, the problem of utilizing this wavemeter once it has been constructed must be taken into account. It is assumed that interest will be shown in a wavemeter that will perform other duties than that of a secondary frequency standard. Since present work at centimeter-wave frequencies is confined largely to laboratories in the realm of experiment and research, the expense of maintaining a device for identifying frequency alone is not economical; the addition of a high-gain amplifier following the detector circuit has the advantage of extending the use of this wavemeter to that of a receiver as well.

If accuracy is to be built into such a wavemeter for frequency measurements, it is of paramount importance that the circuit have as high a "Q" as possible. This is accomplished by the complete elimination of all insulating material and the proper choice of the geometric design of the tuned circuit, together with complete shielding. As the circuit "Q" is increased to large values, trouble arises in maintaining this value. Effects of loading must also be taken into consideration, that is the proper choice of transmission-line length, as well as the pick-up loop antenna. As the frequency of operation of the wavemeter is increased, the circuit "Q" and the size of the tuned circuit must necessarily be decreased. Hence the operation of wavemeters at a very high frequency does not lend itself readily to as high a circuit "Q" as may be obtained at a lower frequency. The tuned circuit of the wavemeter shown in Fig. 1 has an inductance of 5,000 micromicrohenries and a variable capacity of 1 micromicrofarad maximum value.

The frequency coverage that is built into these ultra-high-frequency wavemeters is dependent almost entirely upon the mechanical tuning difficulties. By proper design it is possible to obtain a frequency coverage of five to one without the usual change of tuning coils as is frequently done in low-frequency tuning systems. The problem involved in band-spread gear reduction, accuracy, etc., render such a wavemeter impractical for general use at this time unless the sacrifice of accuracy to obtain such a frequency coverage could be justified. These problems are similar to those encountered in low-frequency wavemeter design and need no further consideration here.

The use of a transmission-line input has advantage since the wavemeter may be set for convenience at a considerable distance from the frequency source under investigation. It may also have an advantage in the choice of an antenna stub or loop as a pickup source and probe. It is possible with such an arrangement to investigate the variation of polarization and voltage with position. Various lengths of transmission line will reflect a wide variation of impedance to the wavemeter input circuit. The coupling then must be made loose to prevent changes in line impedance from affecting the wavemeter accuracy.

### Ultra-High-Frequency Detector

The choice of a detector for the conversion or demodulation of energy in the ten-centimeter range leaves much to be desired in detector efficiency. It has been found that the best detector efficiency may be obtained with a crystal. Good results may also be obtained with the current acorn variety of diodes. It is also possible to use a three-element tube such as the 955 or 957 with fair results. Of greater importance than the detector choice is the method of applying the centimeter wave voltage to the detector. It is necessary

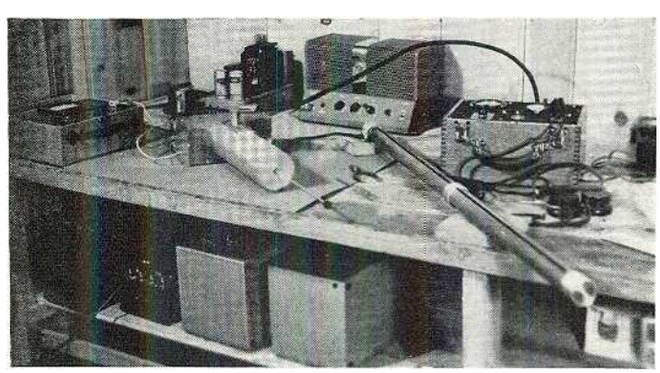


**Photo showing the wavemeter (right), the Lecher wire system and the wave-guide (center front).**

that extreme care be exercised in the placment of parts, ground, shielding, etc.

### Method of Calibrating Wavemeters

Several methods for the calibration of centimeter wavemeters were tried. In general, these methods used as standards a quartz crystal or a good design of a Lecher wire system.

The use of a quartz crystal as a frequency standard has considerable advantage in many respects. It is possible to obtain a good crystal for use as a frequency standard operating at about ten megacycles. By means of a conventional tripling and doubling arrangement, this frequency can be multiplied to sixty megacycles. If considerable power is used at sixty megacycles and the harmonic content increased by conventional methods, a little energy will exist at a high order of harmonics. The tenth harmonic will reach six hundred megacycles and the sixteenth and seventeenth will give a frequency below and above one thousand megacycles. This energy at a standard frequency may be used to calibrate one or more frequency stabilized oscillators operating from 800 to 1,100 megacycles. The harmonic output from these oscillators may in turn be used to calibrate the ten-centimeter wavemeter. The method of comparing the frequency of the ten-megacycle crystal to that of the frequency stabilized 1,000-megacycle oscillator is accomplished by means of a superheterodyne receiver. This ultra-high-frequency superheterodyne has a twenty megacycle i-f and a high order of selectivity.

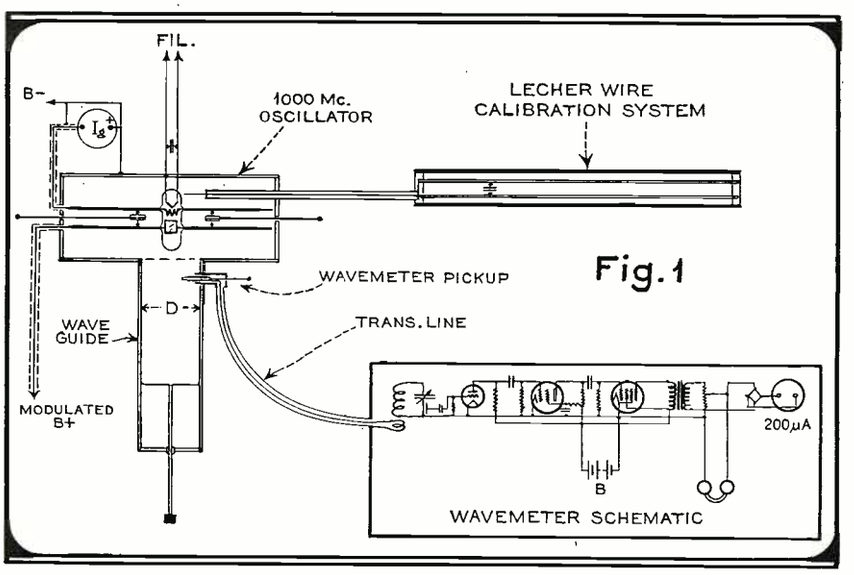
It is quite apparent from this description that this method is unduly complicated and makes use of much special apparatus. Furthermore, the error in the ten-megacycle standard is multiplied by 100 in going to 1,000 megacycles and by 300 in going to the ten-centimeter band. Its chief advantage lies in its use as an independent check on the Lecher wire system.

The method of applying the Lecher wire system as a frequency standard consists of using a frequency-stabilized oscillator operating above and below 1,000 megacycles and calibrating this oscillator with specially designed Lecher wire system. The third harmonic from the oscillator is used for calibration purposes. It is necessary to trap the third harmonic and build up as large a voltage output from the oscillator at this frequency as is possible.

The circuit arrangement for the accomplishment of this result is shown in Fig. 1. To produce a third harmonic voltage at ten centimeters, a wave trap or high-pass filter is necessary in order to produce the least interference at the ten-centimeter detector from the fundamental, which is many times stronger than the harmonic. This is accomplished by means of the wave guide shown in Fig. 1. To eliminate the fundamental and second harmonic, use is made of the relationship for critical frequency of wave guides where $D > \frac{3.68}{2\pi}\lambda$, where D is the diameter of the wave guide and $\lambda = 10$ cm. To eliminate the second harmonic and the fundamental it is necessary to choose D so that $D < \frac{3.68}{2\pi}\lambda$, where $\lambda = 20$ cm.

A further increase in voltage at ten centimeters is obtained by tuning the pickup stub or probe as well as the length of the wave guide. The best arrangement of the independent controls is obtained by retuning each in turn for maximum signals. Once the third harmonic is tuned to maximum response, the frequency of the fundamental is identified by means of the Lecher wire or quartz-crystal standard. By taking measurements of several wavelengths in the Lecher wire system, the error in measurements of the physical length is reduced. Other frequencies above and below ten centimeters are calibrated in like manner. In order to make certain that the wave existing in the wave guide is the third harmonic, it is measured directly by placing the probe or voltage pickup attached to the Lecher wire system in the wave guide. As the Lecher wire is varied through multiples of $\lambda/2$ the impedance is changed and shows variations in the output meter. These variations occur, roughly, for every multiple $\lambda/2$ of the third harmonic and in this manner a rough check of the wave length is obtained. The measurements of wave length taken in or concerned with the wave guide cannot be relied upon for accuracy. An analysis of velocities of waves existing in the guide show different phase velocities, multiple wave propagation, and other conditions that do not lend themselves to accuracy. For this reason, the wave length measurements in the guide should only be relied upon to identify the harmonic producing the voltage existing in the guide.

**Fig. 1. Circuit of wavemeter.**




### Accuracy of Lecher Wire System

The accuracy of the Lecher wire system as a standard is difficult to determine because of the number of variables that must be controlled and taken into account. A brief analysis of these variables and their relationship to the velocity of the wave existing in the Lecher wire system shows the extent upon which these may be relied. It is the purpose of this analysis to show how the velocity of propagation along the Lecher wire system compares with the velocity of a propagated wave in free space. The velocity of propagation of a disturbance along a Lecher wire system is equated from

(1) $V = \frac{\omega}{B}$ Where V = velocity of disturbance, $\omega$ = angular velocity, B = retardation angle per unit length

The retardation angle expressed in terms of line constants is given by

(2)* $B = \omega\sqrt{LC}\left\{1 + \frac{R^2}{4L^2\omega^2} - \frac{R^4}{16L^4\omega^4} + \cdots\right\}^{\frac{1}{2}}$

(*Continued on page 24*)

# LOOKING AT 1940-41 TRENDS


**Jean Rogers, a Powers model, being televised in color at the Columbia Broadcasting System's studios.**

HAVING just completed a most successful year, it appears that the radio industry is destined to be even more prosperous in 1941. Retail sales should increase substantially, due to the fact that the National Defense Program and foreign orders are creating more jobs daily. However, in analyzing the situation one must keep in mind that the international situation can change most rapidly. It is well, therefore, to take all predictions with the reservation "subject to change without notice." With this fact in mind, let us consider the various fields separately.

### National Defense

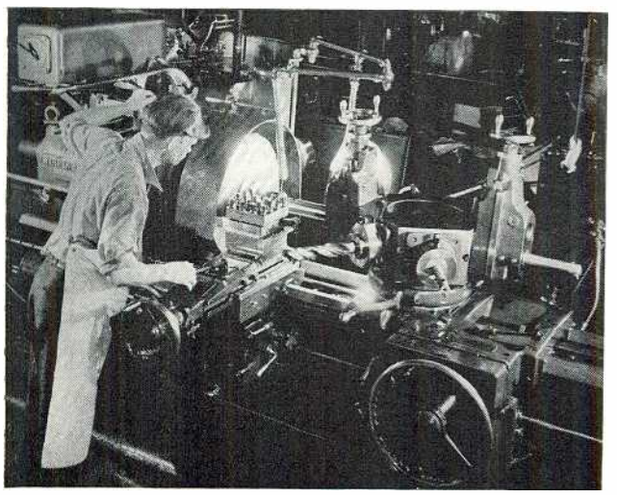
The National Defense Program is the subject of greatest interest to all members of the radio industry. There would seem to be two essential problems that the various organizations in the industry must face . . . both of which concern production. First, there is the problem of expanding plant facilities to meet national defense requirements; second, there must be sufficient production to meet an increased consumer demand for normal peace-time products. In some instances it is likely that the latter type of production may be temporarily suspended; while in connection with the former problem, it should be borne in mind that the industry will have to supply more than equipment, for it must also contribute the products of its research and development facilities, it must supply a certain amount of specialized personnel to the armed forces and it must train new men to replace those called to arms.

It is indeed gratifying to see how well the radio industry is cooperating to meet the National Defense Program requirements. Most organizations are rapidly expanding their plant facilities and devoting a large portion of their time to government orders . . . so much so that in many instances normal orders are from three to six months behind schedule.

We have already pointed out how the radio industry will contribute to national defense[1], so we will not delve further into the subject here . . . except to point out that the Defense Communications Board has had a number of meetings and completed most of its organization work.

It should also be mentioned that the various engineering schools are cooperating well with this country's defense effort. Nearly all of the leading schools have made plans for establishing special, intensive training courses in appropriate fields. No doubt this training program will be greatly expanded during 1941.

[1] "Communications Contributes to National Defense", p. 3, Nov., 1940, COMMUNICATIONS.



**A new Warner Swasey turret lathe in operation in the P. R. Mallory plant in Indianapolis. Permitting a high degree of accuracy, it is tools such as these that are playing an important part in our National Defense Program.**

### Broadcasting

It now appears that the broadcasting industry had real reason to celebrate its twentieth anniversary in 1940. Gross billings for the four major networks were 8% to 40% higher than in 1939. According to one authority,[2] the billings up to last November 30 were as follows: NBC (red), $36,168,421; NBC (blue), $9,584,706; CBS, $37,205,560; MBS, $4,190,071. With the spreading of the various wars and the tendency of this country to engage more forcefully in foreign affairs, there is an increasing listener interest which will probably result in even higher billings during 1941.

In transmitter design the trend continues toward better appearance and improved mechanical layout to permit quicker servicing. With improvements in circuit design, higher efficiency and better fidelity will be obtained. It is also likely that certain simplifications will be made in the design of transmitters as a result of the development of higher-powered air-cooled transmitting tubes. New emphasis will be placed on directional microphones, acoustical and other constructional materials due to the BMI-ASCAP fight. This is especially true for outdoor broadcasts of sporting events, and gatherings of various sorts where the broadcasters have no control over the type of music that may be used.

During the coming year frequency modulation and television will play an important part in broadcasting. Both subjects, however, will be dealt with in later sections of this article.

[2] *Broadcasting*, Dec. 15, 1940, p. 46.

**Color television, using a standard receiver and a two-color revolving disk was demonstrated by Dr. E. F. W. Alexanderson, General Electric, to members of NTSC. Viewing demonstration with Dr. Alexanderson is George Henry Payne (right) of the FCC.**

A subject that has not received sufficient popular attention during the past year is the work of this country's international broadcasting stations. Now on a commercial basis, these high frequency broadcasters have made definite contributions towards hemisphere solidarity. A number of new stations will make their appearance during 1941.

### Television

The art of television received a severe set-back in 1940. Off to a good start in February when the FCC approved limited commercial operation as of September 1, television was relegated back to an experimental status in May. This action by the FCC resulted in the withdrawal of all merchandising plans and the loss of much consumer interest. Shortly afterwards, however, the Radio Manufacturers Association, in cooperation with the FCC, formed the National Television System Committee (NTSC).[3] This organization set up the following panels: (1) System Analysis, (2) Subjective Aspects, (3) Television Spectra, (4) Transmitter Power, (5) Transmitter Characteristics, (6) Transmitter-Receiver Coordination, (7) Picture Resolution, (8) Synchronization, and (9) Radiation Polarization. Standards have been adopted and the NTSC will submit its report to the FCC on January 27.

Despite its early setback, television development has not lagged. Field tests are still being conducted by all the major stations established previous to the above mentioned ruling. In addition, several systems of color television have received attention. One system has been satisfactorily demonstrated using both film and more recently live subjects. It appears that color television has much to offer and it will undoubtedly receive a great deal of attention during the coming months. From all indications color adds considerably to the entertainment value of television and increases the apparent definition—this without too much in the way of additional cost.

Television relay stations operating around 150 mc have been shown to be feasible. Consistently good results can be obtained for sufficient distances to make television chain broadcasting practical. In this connection, however, it is well to mention that good programs can now be sent over wire lines (coaxial) as was evidenced at a recent demonstration during the annual IRE convention in New York. No doubt experimentation will continue along both lines.

Experimental work will be continued towards obtaining larger images both through the development of larger tubes and by means of projection. It still seems that the desirable picture size for home reception should be somewhere between 18 and 24 inches in width.

An interesting method for producing large-screen television images has recently been patented.[4] This system makes use of a group of small tubes each of which automatically takes its own part of the image. This development will probably receive serious consideration, since it possesses several advantages . . . one of which would be a reduction in tube replacement costs.

[3]The NTSC was formed to represent the radio industry and has representatives from 41 organizations. The total membership of the NTSC, including panels is 137.

[4]Patent No. 2,219,149, "Television System", issued to A. N. Goldsmith, October 22, 1940.

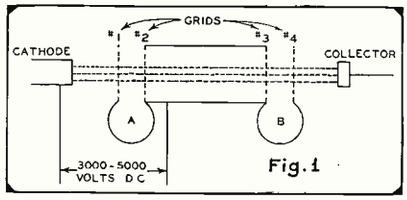



Fig. 1

**Above: Simplified schematic of Westinghouse Klystron. Below: Cross sectional view of the tube.**

During the past year considerable field work was done with portable television equipment housed in carrying cases. Results were reported to be quite satisfactory. This type of equipment should find considerable use once commercial operation gets under way.

### Frequency Modulation

F-m was off to an early and good start in 1940. Early in the year there was organized the F-M Broadcasters, Inc. (FMBI), to coordinate the activities of the various parties interested in f-m broadcasting. The FMBI has done some excellent work in the interests of frequency modulation.

After hearings before the FCC, frequency modulation has been placed on a commercial basis (January 1, 1941). To date the Commission has granted 29 construction permits, with 55 applications still waiting official decisions.

It is interesting to note the standard method that has been adopted for assigning call letters to f-m stations. The first letter is either a W or K, depending upon whether the station is east or west of the Mississippi. This is followed by two numbers indicating the frequency assignment in the 40-mc band. The final letter or letters are used to designate the city or general locality of the station. For example, W63NY might be a New York station operating on 46.3 mc, while K59D might be a Denver station on 45.9 mc.

It is also interesting to note that f-m stations are assigned areas rather than power. In other words, a station will use whatever power is necessary, depending upon antenna height and other limiting factors, to cover a certain specific area.

So far standards have not been set up as to the type of polarization to be used, although it is believed that horizontal polarization is favored. Vertical polarization, however, has an advantage which should not be overlooked, in that a vertical antenna or rod may be used in place of the directive dipole.

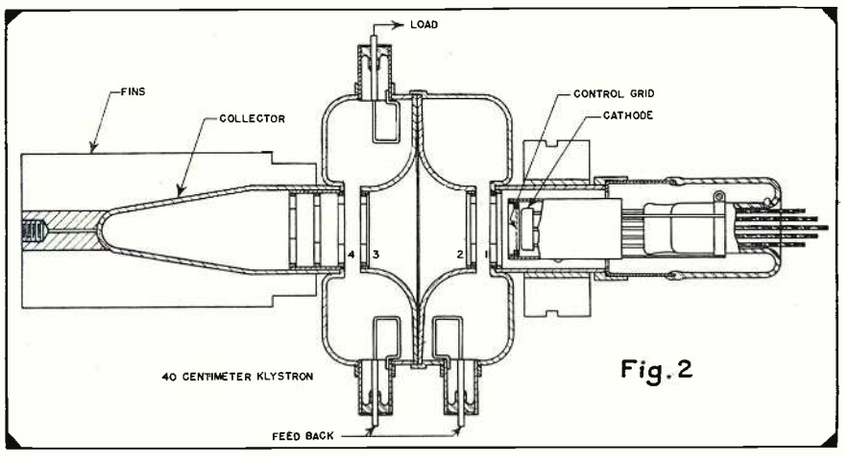



Fig. 2

Broadcast transmitting equipments are available in 250, 1000, 3000, 10,000 and 50,000 watt ratings. At least five manufacturers have announced commercial units, the transmitters varying, of course, in circuit details.

Frequency modulation is finding use for special emergency purposes, in utilities communications and for police service. While some work is being done in the aircraft field, the main stress is being placed on police radio where f-m is gaining ground rapidly, several installations being under test and at least one in actual everyday service. One a-m/f-m transmitter has been announced and it is quite likely that similar units will be made available by other manufacturers . . . the idea being to permit a gradual changeover from one type of service to the other.

There is also a possibility that f-m may be used for the sound and other portions of television signals. F-m, of course, is also being tested by the armed forces of this country.

### Receivers

The number of home radio sets in use in the United States is estimated by the National Association of Broadcasters to be 50,100,000. This represents a net increase of 6,100,000 receivers in use over the previous year.

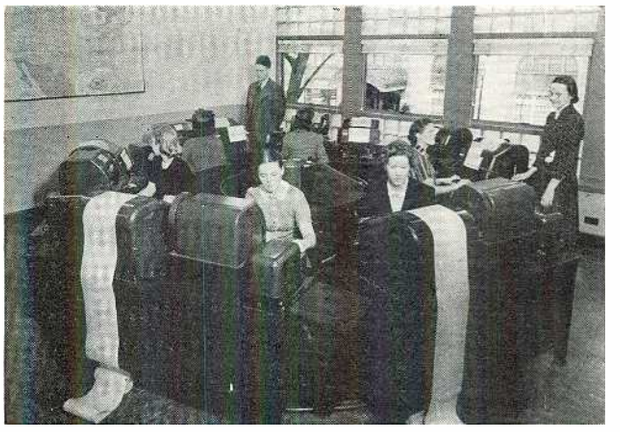
Year-end statistics compiled by the Institute of Radio Engineers show that 11,000,000 radio receivers were produced during 1940, a record-breaking figure. In 1939 approximately 9,000,000 sets were produced. In 1940, table model receivers continued to be the most popular, accounting for 52 per cent of the total. An important new trend was the increased popularity of radio-phonograph console combinations which comprised over 7 per cent of the total. In all there were approximately 1000 different models of radio receivers available. Automobile sets kept pace with a total production of 2,300,000 receivers.

1940 saw the introduction of a new type of receiver, the battery-operated camera-sized portables. These instruments weigh between 4 and 5 pounds, utilize miniature tubes and parts, and operate from a special long-life B battery and a single flashlight cell. Known as personal radios, these sets open up new sales possibilities.

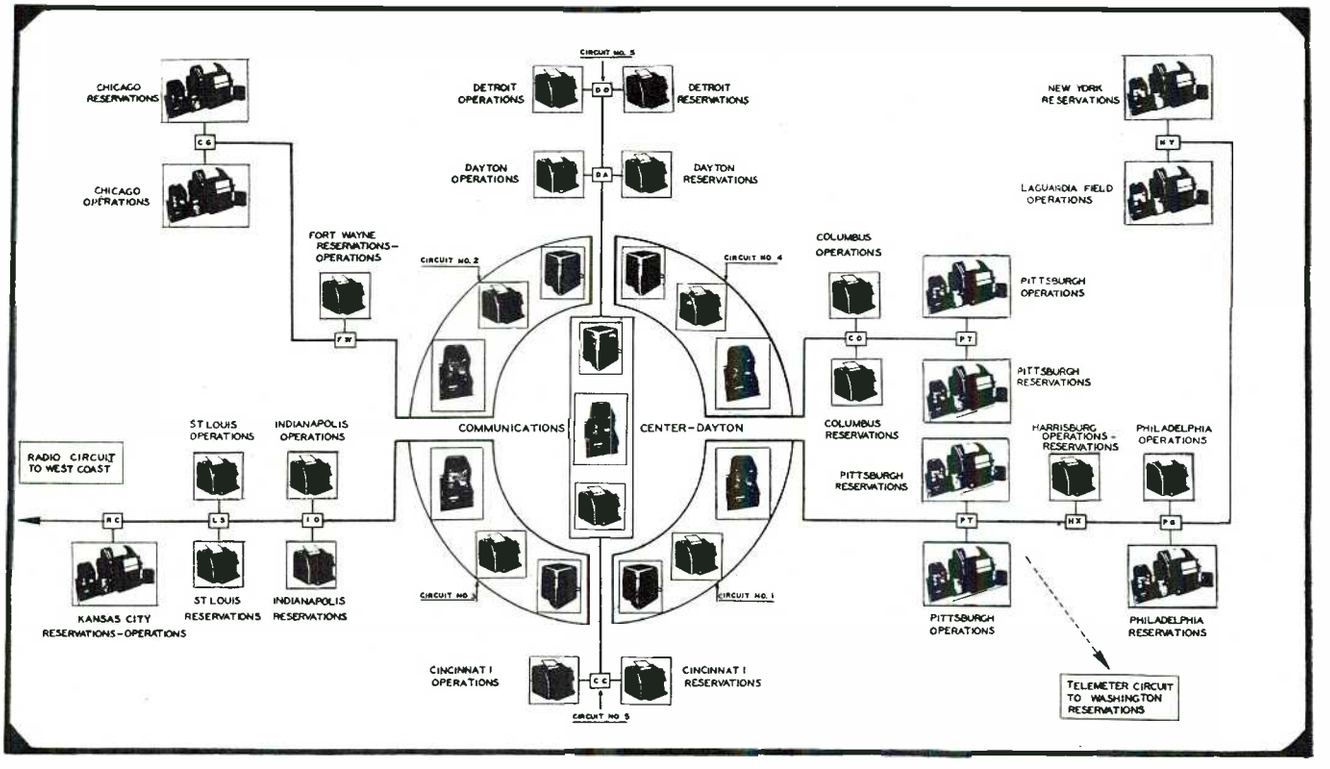
The past year also saw the incorporating of home recording in many console receivers. These units also present some interesting sales features. During the coming months efforts will be directed towards improving quality of the recorder itself as well as records, needles, etc.

Straight f-m and combination a-m/f-m receivers have been introduced by most of the manufacturers. Undoubtedly more models will be made available this coming year, especially so since f-m is now on a commercial basis. While no sales figures are available, it is believed that between 9000 and 10,000 f-m receivers are in the hands of the public. Since quite a number of f-m stations will go on the air in 1941, the sale of

*(Continued on page 28)*



**A center for one of the largest airline teletype systems in the world established in Dayton, Ohio, by Transcontinental and Western Air, to speed up the transmission of nearly 3,000,000 words a month. Eleven employees and a manager, R. L. Ritter, have been assigned to this center. See illustration at bottom of page.**




**A schematic of the TWA teletype network.**

# THE DESIGN OF A DIODE MILLIVOLTMETER

**By CLEDO BRUNETTI & CHARLES W. HARRISON**

Ass't Prof., Elect. Eng.
Lehigh University

Engineering Dept.
W O R

ENGINEERS concerned with voltage measurements find much satisfaction in the use of one or another of the various types of diode voltmeters that have been described in the literature.[1, 2, 3] As one example, many of the usual difficulties encountered in measurement may be overcome by combining a diode rectifier circuit with a d-c electronic voltmeter employing negative feedback. In this manner one eliminates the effect of changes in tube constants on the sensitivity of the device. A high input impedance may be maintained over a wide range of frequencies. In addition there results a linear relationship between input voltage and voltmeter reading, increased range of operation for a single tube and the possibility of converting from one scale to another with ease. A commercial meter of this type has found wide application.[2]

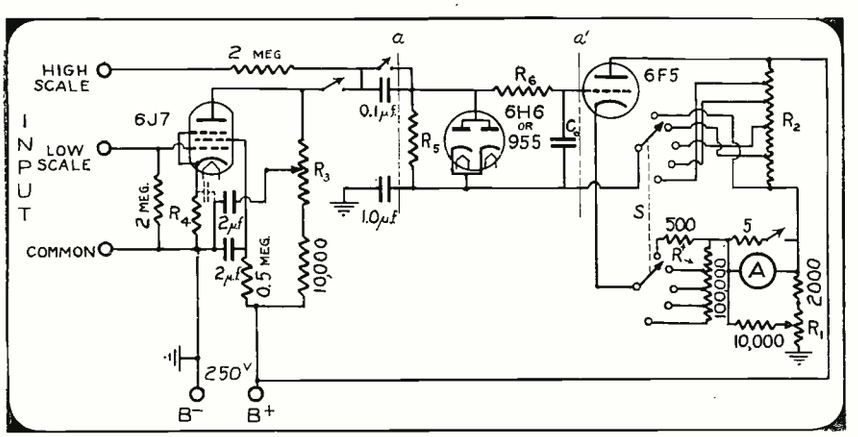
If such an instrument is to be used to measure low a-c voltages it becomes necessary to extend the design and to observe certain factors which influence the sensitivity and stability of the device. It is the purpose of this paper to discuss these factors and to present a circuit combining some well-known features in such a manner as to yield a stable instrument with a full-scale deflection of as low as two millivolts input. Thus voltages lower than one millivolt may be measured with good accuracy. On the other hand with the employment of voltage dividers the instrument can be extended to measure a-c voltages of many hundreds of volts. The accurate measurements of d-c voltages ranging from one-tenth to over one hundred volts is also possible.

The complete circuit of the voltmeter, with the exception of supply voltages, is shown in Fig. 1. As apparent from the figure it comprises three parts: a preamplifier with high input impedance followed by the familiar diode rectifier (included between the lines a–a′) and finally the d-c voltmeter. The a-c voltage to be measured is fed to the amplifier, the output of which is then impressed across the diode circuit. The latter produces a d-c voltage across capacitor $C_o$ proportional to the magnitude of the voltage to be measured. This d-c voltage appears on the grid of the following tube which acts as a stable d-c voltmeter with an ammeter in the plate circuit whose deflection is linearly proportional to the voltage on the grid.

### The D-C Electronic Voltmeter

The circuit of the d-c voltmeter is a modification of that employed in the "reflex" voltmeter described by Medlam and Oschwald.[4] It is essentially a simple triode circuit with a group of degenerative resistors added in series with the cathode. The degenerative action is similar to that taking place in ordinary amplifiers employing this principle.

**Fig. 1. Circuit of complete voltmeter. $R_1$ = 5000 ohms, $R_2$ = 100,000 ohms, $R_3$ = 100,000 ohms, $R_4$ = 1000 ohms, $R_5$ = 1 meg., $R_6$ = 5 meg., $C_o$ = 0.1 mfd. 6H6 or 955 filament voltage = 5 volts. Other filament voltages normal.**




Since the operation of the device is linear, the sensitivity may be determined quite simply with the aid of Fig. 2. When R = 0 the change in plate current ($i_p$) occurring for a given change in grid voltage ($e_g$) is:

$$\left(\frac{\delta i_p}{\delta e_g}\right)_{e_p = \text{constant}} = G_m \qquad \ldots\ldots\ldots\ldots\ldots\ldots (1)$$

where $e_p$ = plate voltage of the tube
$G_m$ = mutual transconductance of the tube.

For a 6F5 tube the value of $G_m$ may be taken as 1500 micromhos. In order

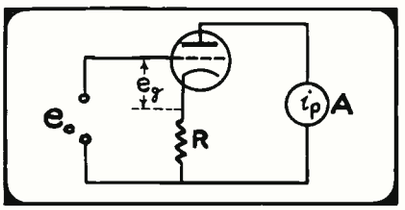



**Fig. 2. Simplified circuit of the d-c voltmeter.**

to produce full-scale deflection on a 100-microampere ammeter placed at A, a change in grid voltage of $100 \times 10^{-6}/1500 \times 10^{-6}$ or 1/15 volt is required. This determines the maximum d-c sensitivity available in a device of this sort.

When $R \neq 0$ the change in plate current occurring for a given change in grid voltage becomes:

$$\Delta i_p = \frac{\mu \Delta e_g}{r_p + R} \qquad \ldots\ldots\ldots\ldots\ldots\ldots (2)$$

$r_p$ = plate resistance of the tube
$\mu$ = amplification factor of the tube

The actual voltage appearing between grid and cathode is now less than $\Delta e_o$, the voltage impressed on the grid circuit, by an amount equal to the drop across resistor R, so that:

$$\Delta e_g = \Delta e_o - R\,(\Delta i_p)$$

which inserted in (2) leads to

$$\Delta i_p = \mu \frac{[\Delta e_o - R\,(\Delta i_p)]}{r_p + R},$$

or

$$\Delta i_p = \frac{\mu \Delta e_o}{r_p + R\,(1 + \mu)}$$

Dividing by $\Delta e_o$ we have, in the limit,

$$\left(\frac{\delta i_p}{\delta e_o}\right)_{e_p = \text{constant}} = \frac{\mu}{r_p + R(1+\mu)} = \frac{G_m}{\frac{1}{r_p} + R(1+\mu)} \quad \ldots\ldots(3)$$

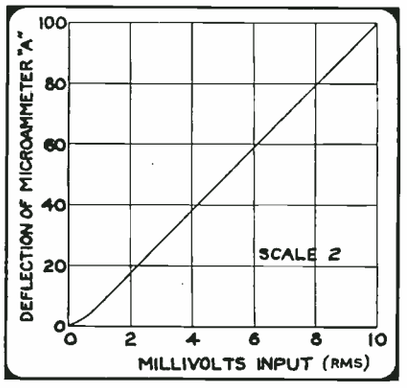
Since $\mu = G_m r_p$.

For $\mu >> 1$, (3) becomes

$$\left(\frac{\delta i_p}{\delta e_o}\right)_{e_p = \text{constant}} = \frac{G_m}{1 + R G_m} \quad \ldots(4)$$

Comparison of equation (4) with (1) shows that the introduction of R results in a decrease in the sensitivity. A larger change in the impressed grid voltage is required to produce the same change in plate current. Equation (4) may be used to find the required value of R for any range over which it is desired to have the voltmeter operate. In particular, if the same 100-microampere ammeter is used at A (with a 6F5 tube) and it is desired to obtain a full-scale deflection for a ten-volt change in $e_o$, equation (4) shows a resistance of 100,000 ohms will accomplish the desired result. Regardless of the range of variation of the impressed grid voltage a value of R may be selected to limit the maximum change in plate current to that corresponding to the original full-scale deflection on ammeter A. Thus with proper adjustment of the plate and grid-bias voltages *for each new value of R,* the tube is made to work over the same portion of its $i_p - e_g$ characteristic for all range settings of the voltmeter. The sensitivity of the instrument then varies only with the magnitude of R.

The manipulation of ranges may be accomplished in a conventional manner by a two-ganged switch S having five taps. One of the sections of S inserts different values of R in series with the cathode while the other section changes




the grid-bias voltage to restore operation to the same point on the tube characteristic. Thus, at zero input voltage* the same plate current flows for all values of the cathode resistor R. The initial current in ammeter A is balanced to zero by adjustment of the rheostat $R_1$. The diode rectifier circuit is so arranged that an increase in input voltage produces a greater negative d-c voltage on the grid of the following triode resulting in a decrease in the plate current of the latter. The ammeter A is connected into the circuit in reversed polarity and $R_1$ adjusted to give zero deflection with no input voltage. In this manner when an a-c input voltage is applied, the decreasing plate current produces a positive deflection on ammeter A. It is not necessary to employ a sensitive ammeter at this position. A 500-microampere microammeter will work as well as a 100-microampere ammeter (although not as sensitive) provided the tube characteristic is linear over a plate-current range of 500 microamperes. The more sensitive the ammeter the smaller the portion of the tube characteristic employed and the easier it is to select and maintain a linear operating range on the characteristic.

*See Fig. 1.

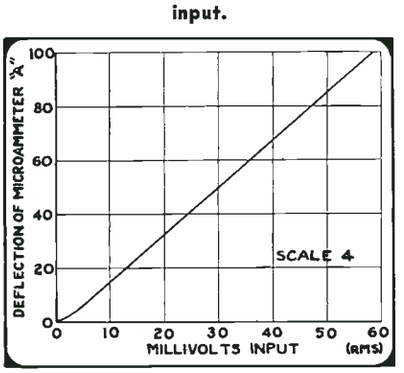
### The Diode Rectifier

Since this type of circuit has been amply described in the literature[2,3] the following discussion will be confined to the ratio of rectification and stability of operation. As the result of the rectifying action of the diode, the condenser $C_o$ (Fig. 1) is charged to the peak value of the a-c voltage impressed on the rectifier. The presence of resistor $R_5$ makes it possible for the d-c voltage appearing across $C_o$ to vary in proportion to the peak input voltage.

*(a) Ratio of Rectification*

In the diode rectifier it is desirable to obtain a linear relationship between impressed a-c voltage and output d-c voltage. This relation holds very closely for large impressed voltages but as the voltage to be measured becomes smaller a departure from linearity is noticed. The ratio of rectification may be defined as the quotient of the change in output d-c voltage by the peak value of the sinusoidal voltage impressed on the rectifier.[5] The change in output d-c voltage is used since the latter does not drop to zero when the impressed a-c voltage is removed. A simple test will show that the ratio approaches unity at large values of impressed voltage, but for small voltages drops considerably. With no input voltage on the voltmeter a small diode current flows as the result of the initial velocity of the electrons leaving the filament. By keeping this current as low as possible, for example, by using a large value of $R_5$, the ratio of rectification is increased. Even with this improvement it is difficult to attain a high ratio at very low input voltages. The result is a slight curvature near the origin of the calibration curve of the voltmeter as seen in Fig. 4. Because of the ease with which one may shift to a new scale the presence of the remaining curvature is not a serious matter.

**Fig. 4. (A left; B below) Typical calibration curves for low scale input.**



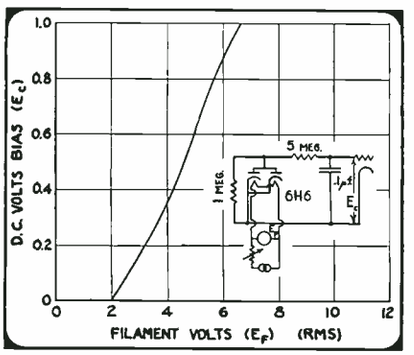




**Fig. 3. Grid bias on triode of d-c voltmeter as function of diode filament voltage with no input signal.**

*(b) Stability of Operation*

The d-c voltage produced across $R_5$ by the diode current flowing through it at zero input voltage supplies a negative bias to the grid of the following triode which influences the stability of operation. Fig. 3 shows how this bias varies as a function of the filament voltage for a 6H6 tube. With the normal filament voltage of 6.3 volts an unstable condition may be observed which appears as a continuous drift in the deflection of the ammeter A. The apparent cause of this is the fluctuation in magnitude of the d-c bias produced by the 6H6 tube. Reducing the filament voltage to 5 volts produces a fairly constant d-c bias across the following amplifier resulting in much improved stability. The same type of behavior is noticed when the 6H6 tube is replaced by a type 955 acorn tube. As in the case of the 6H6 the 955 operates better with 5 volts on the filament than the rated 6.3 volts. A further improvement in the stability results when the filament voltage of either tube is

made lower than 5 volts but the drop in ratio of rectification which follows lowers the overall sensitivity of the device considerably. For this reason a value of 5 volts represents a satisfactory medium.

### The Pre-Amplifier

A single stage of resistance-coupled amplification employing a pentode tube may be used which will be relatively stable in operation. The output resistor $R_3$ may be varied to provide adjustable gain and thus to enable ammeter A to be set to full-scale deflection for any desired value of input voltage. While the diode circuit and the d-c voltmeter may be designed to be fairly independent of frequency the response of the pre-amplifier will influence the calibration of the complete voltmeter at high frequencies.

The amplification of the pre-amplifier over a limited range of audio frequencies is given by

$$\alpha = \frac{\mu R'_3}{r'_p + R'_3} = \frac{G'_m R'_3 r'_p}{r'_p + R'_3} = G_m R_T \quad \ldots\ldots\ldots (5)$$

where $R_T = R'_3 r'_p/(r'_p + R'_3)$

and

$G'_m$ = mutual transconductance of the 6J7 tube = 1185 micromhos

$r'_p$ = plate resistance of the 6J7 tube = 1 megohm

$R'_3$ = effective plate load resistance (between plate and ground).

### Overall Selectivity

The overall sensitivity of the voltmeter may be computed by considering in turn each of the three component parts. If the ratio of rectification of the diode rectifier is expressed by $\beta$ the overall response is:

$$\frac{\delta i_p}{\delta e_x} = (G'_m R_T)\,\beta \frac{G_m}{1 + R G_m} \quad \ldots\ldots (6)$$

**Fig. 5. Typical calibration curve for high scale input.**

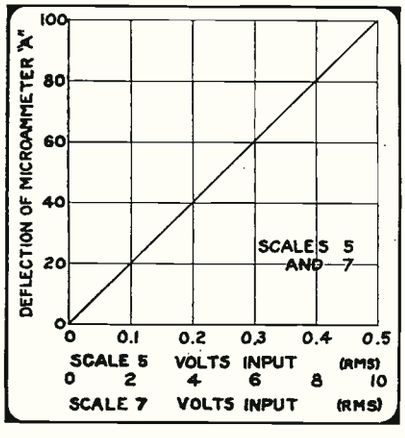
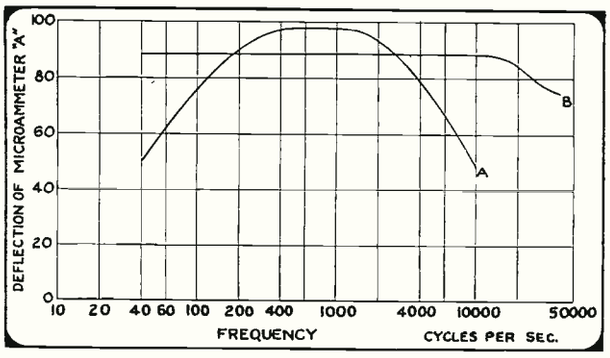



**Fig. 6. Overall frequency response. Curve A: Input held constant at 0.09 volt (r-m-s), $R_3$ = 500,000 ohms, $R_4$ = 10,000 ohms bypassed with 1.0 mfd., diode type 6H6. Curve B: Input held constant at 0.20 volt (r-m-s), $R_3$ = 100,000 ohms, $R_4$ = 1000 ohms (not by-passed), diode type 955.**




where:

$e_x$ = voltage impressed at the input terminals of the voltmeter.

$i_p$ = current in ammeter A.

Over the normal operating range the relation between $i_p$ and $e_x$ is linear, so that the input voltage required to produce full-scale deflection on the ammeter A will be

$$e_x = \frac{A(1 + R G_m)}{G_m G'_m R_T \beta} \text{ volts (peak value)} \quad \ldots\ldots\ldots\ldots\ldots (7)$$

where A is the full-scale indication of the ammeter in amperes.

Maximum sensitivity occurs when the degenerative resistor R is zero. For a value of $R_T$ of 100,000 ohms, and $\beta$ equal to 0.4 at full scale (for small input voltages) an input voltage of 0.0014 volt (peak value) will give full-scale deflection on the 100-microampere ammeter at A (Fig. 1). Actually, however, it is not advisable to make R zero. Because of the difficulty of maintaining the bias supplied by the rectifier at zero input voltage absolutely constant it is best to supply an additional, though small, self-bias in the cathode circuit of the 6F5 triode. This tends to reduce the unstable effect of a slight fluctuation in the bias supplied by the rectifier. A minimum value of R to supply the proper self-bias for stable operation is found to be 500 ohms. The maximum sensitivity then becomes $(0.0014)\ (1 + 500 \times 1500 \times 10^{-6})$ or 0.0025 volt (peak value) for full-scale deflection. Other minor factors unaccounted for in the calculations act to reduce this sensitivity to a value slightly less than 0.0028 volt, peak value, or 0.002 volt, rms value, for full-scale deflection (assuming a sinusoidal input voltage). It is clear that by employing a microammeter requiring less than 100 microamperes for full-scale deflection the overall sensitivity may be increased further.

### Discussion

Figs. 4 and 5 show a set of typical calibration curves for the completed voltmeter. A sinusoidal voltage was used in these measurements. The calibration shown in Fig. 4-a is representative of the results obtained for the three most sensitive ranges. The curves for scales 1 and 3 (not shown), which yield full-scale deflections for rms inputs of 2 millivolts and 30 millivolts, respectively, have essentially the same shapes as that of scale 2. Curve A of Fig. 6 shows the frequency response of an instrument designed to operate at a fixed frequency in the neighborhood of 1000 cycles over a wide range of input voltages. In this case the a-c amplifier is operated with as great a gain as is practical. If it is desired to provide a sensitive meter to operate over a large range of frequencies it is necessary to revise the design slightly. A type 955 acorn tube acting as a diode may be substituted for the 6H6 tube. This improves the response at the higher frequencies. Checks on the stability and sensitivity show the former to be unchanged but the latter to decrease somewhat from the value obtainable with the 6H6 tube in the circuit. This apparently is due to the lower ratio of rectification of the acorn tube. The decrease in sensitivity does not, however, appreciably affect the linearity between the input voltage and recording meter deflection.

An analysis of the pre-amplifier acting alone may show a frequency response which drops off at both the high and low values of frequency. This may be remedied by the introduction of a small amount of negative feedback and by reducing the plate-circuit resistance, $R_3$. The negative feedback is obtained by removing the by-pass condenser connected across $R_4$. This also improves the stability of operation. The lower value of $R_3$ appearing in parallel with and therefore tending to reduce the effect of the distributed capacity of the rectifier circuit aids further in bringing up the response at the high frequencies. The result of these changes is shown by curve B of Fig. 6. While the present design of the instrument has been confined to the audio range the application may be extended to higher frequencies if desired, the upper limit being fixed mainly by the response of the pre-amplifier. Additional precautions will be necessary such as the use of a pre-

*(Continued on page 22)*

# GL-880

## A *MIDGET* IN SIZE—A *GIANT* IN OUTPUT

*Three-fifths actual size*

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### *To Get the Most from Your Tube Dollar Be Sure to Specify GL-880's*

GL-880 is the largest of the G-E developed tubes for high-frequency (FM and television) services. Its background is more than 28 years of G-E tube experience.

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*G-E 50,000-watt FM broadcast transmitter*

**GENERAL ELECTRIC**

161-18

# VETERAN WIRELESS OPERATORS ASSOCIATION NEWS

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

### 16th Annual

THE Sixteenth Anniversary of our Association will be celebrated with a Dinner-Cruise at the Hotel Astor on Tuesday evening, February 11th, 1941. (It was erroneously stated in the December page that the date would be the 1st of February). It's our standard date the 11th of February. The next day, for many of us at least, is a Holiday—Lincoln's Birthday.

The theme of this Cruise will be "National Defense." Prominent members of the Defense Communications organization will be present to outline the details of the Communications industry's part in National Defense. We extend a cordial invitation to all members of the industry to take part in this affair.

In order that a maximum number of our members and friends may take part in this event the tickets are priced at cost—$3.00 per person. (Really below cost, when you consider the incidental expenses, etc.) We urge all to make their purchase of tickets early so that final plans may be made to accommodate properly those who attend.

In order to stimulate interest in code proficiency, our Association will sponsor a series of events with suitable awards to the winners. In the near future a contest will be held to determine the World's fastest operator. This contest will include commercial, government service, and amateur operators. A prize will also be given to the winner of the Army Amateur Radio System's annual code proficiency contest usually conducted about this time of year. Contests will be initiated among the new members of the armed forces and prizes given to those who make the greatest progress in code proficiency in a given period. Our Association, consisting entirely of former "Knights of the Wireless Key" is in a unique position to so recognize the proficiency of present day and "to be" Wireless operators.

Some of these events may have transpired at the time of our Cruise and if so the winners will be present to receive their awards.

There will be many highlights at the Dinner—awards, entertainment, reminiscing and dancing until the wee hours. May we have the pleasure of greeting you then?

Tickets may be obtained from us at Radio City or from any officer or committeeman.

### Marconi Memorial

In pursuance of the policy of our Association of keeping alive the memory of the founder of our profession, the late Guglielmo Marconi, plans have been formulated for a suitable monument to be erected in the "New" Battery Park in New York City.

The present Battery Park will be completely rebuilt as a result of the Battery-Brooklyn Tunnel which will be constructed in the very near future. In line with previous splendid efforts of Park Commissioner Moses of New York City in his campaign for beautifying the metropolis, Battery Park will soon be one of the most beautiful sights in the greater city.

The bas relief of Marconi which formed the frontispiece of the Italian Building at the New York World's Fair has been obtained by our Association. With a suitable background and complemented by the present Wireless Operators Monument the bas relief will occupy a most prominent position in the New Battery Park. The construction of this tribute to our founder and to memory of those brave wirelessmen who gave their lives at the post of duty will be financed by the Marconi Memorial Fund which was initiated by our Association shortly after the decease of Marconi.

Our Marconi Memorial Fund Committee is headed by David Sarnoff, President of the Radio Corporation of America. It is through his cooperation and negotiations conducted by George Clark, our Secretary, with Commissioner Moses and the executives of the Italian Pavilion that this Memorial to a great man will soon be consummated.

### Personals

Lieut. Carl O. Peterson, a member of both Byrd Antarctic Expeditions, is now on active duty aboard the *U. S. S. Ranger*. Carl was extremely active in the Naval Reserve Communications system before going on active duty. We're sure he's doing a fine job. Good luck COP . . . J. R. "Jack" Poppele, one of our Directors and Chief Engineer of the Bamberger Broadcasting Service — WOR — recently gave an interesting talk on frequency modulation and the part the new system of broadcasting will play in the future, over the facilities of the Mutual Broadcasting System. Jack is Chairman of the Engineering Committee of Frequency Modulation Broadcasters, Inc. and he should know his subject . . . To Mr. and Mrs. William J. McGonigle, a daughter, Jean Marie born October 31, 1940. Which partially explains delay in answering correspondence recently . . . George Clark has been spending much time in Washington recently . . . All those in the New Orleans area should contact A. F. (Steve) Wallis re plans for the Annual there on February 11th. He is Mackay Radio Superintendent there . . . Members of our profession have taken up all kinds of endeavors since parting from brass pounding. The real estate agent from whom our prexy rented a house recently is a former wireless operator. The new home address—331 Lafayette Avenue, Brooklyn, N. Y. . . . O. B. Hanson, V-P and Chief Engineer of NBC and a Life Member of our Association was recently commissioned a Captain in the Signal Corps Reserve . . . Harold P. Westman, Secretary of the IRE did his usual splendid job of handling the recent IRE Convention in New York City . . . Glad to hear from George Duvall a real oldtimer and to learn that he plans to be at the 16th Annual . . . We'll be glad to include a Personal about you in this page. Just communicate with us at the above address. 73-MC.

• • •

## BROADCAST CONFERENCE

(*Continued from page 2*)

Committee and he will discuss the formulation of standards. It is anticipated that the work of the Committee will be concluded by Conference time.

Of recent interest has been color television, brought to the foreground by Dr. Peter Goldmark, who is in charge of television engineering for the Columbia Broadcasting System. Dr. Goldmark will describe the color system he has developed and demonstrated for CBS.

A new feaure of the Fourth Conference will be laboratory periods during which the members of the Conference will have an opportunity to make broadcast station measurements with the latest test equipment. Manufacturers will supply the equipment and instructors. General Radio Company and the RCA Manufacturing Company have already promised cooperation in this new venture, and several others have signified their intention to do so.

Dr. Everitt, Director of the Conference, is the author of the book "communication Engineering" used in some 60 schools. He received his Ph. D. from Ohio State University in 1933 and he is a fellow in The Institute of Radio Engineers and the American Institute of Electrical Engineers. Dr. Everitt has been Professor of Electrical Engineering in charge of instruction in communication at Ohio State since 1926.

Those who are interested in the Conference should address Dr. W. L. Everitt, Director of the Conference, Ohio State University, Columbus, Ohio, and they will be placed on the mailing list to receive further details concerning the Conference.

# Variable Voltage

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- ★ SMOOTH CONTROL
- ★ EXCELLENT REGULATION
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- ★ NO DISTORTION

# VARITRAN CONTROL UNITS

## For Controlling: Rectifier output, Motors, Heaters, Lights, Line voltage

***METHOD OF OPERATION*** The UTC Varitran is a simple autotransformer with turns arranged on one layer so that every exposed turn may be used as a tap. A special non-fusing contact can be moved to any position on the winding, permitting the exact voltage desired to be obtained. The regulation and efficiency are excellent and no distortion of wave form occurs. The output voltage is independent of load.

| Type | Input Voltage | Output Voltage | Watts | Max. Amps. | Figure | Net Price |
|---|---|---|---|---|---|---|
| V-0 | 115 volts | 0-130 | 230 | 2 | A | $7.50 |
| V-0-B | 230 volts | 0-260 | 230 | 1 | A | 9.50 |
| V-1 | 115 volts | 0-130 | 570 | 5 | B | 10.00 |
| V-1-M | 115 volts | 0-130 | 570 | 5 | C | 15.00 |
| V-2 | 115 volts | 0-130 | 570 | 5 | A | 9.00 |
| V-2-B | 230 volts | 0-260 | 570 | 2.5 | A | 11.50 |
| V-3 | 115 volts | 0-130 | 850 | 7.5 | A | 14.00 |
| V-3-B | 230 volts | 0-260 | 850 | 3.75 | A | 18.00 |
| V-4 | 115 volts | 0-130 | 1250 | 11 | A | 20.00 |
| V-4-B | 230 volts | 0-260 | 1250 | 5.5 | A | 25.00 |
| V-5 | 115 volts | 0-130 | 1950 | 17 | A | 32.00 |
| V-5-B | 230 volts | 0-260 | 1950 | 8.5 | A | 37.00 |
| V-6 | 115 volts | 0-130 | 3500 | 30 | A | 60.00 |
| V-6-B | 230 volts | 0-260 | 3500 | 15 | A | 70.00 |
| V-7 | 115 volts | 0-130 | 5000 | 44 | A | 87.00 |
| V-7-B | 230 volts | 0-260 | 5000 | 22 | A | 95.00 |

### *VARITRAN RATINGS*

Standard Varitrans are designed for 115 or 230 volt service. The respective output voltages are 0-130 and 0-260 volts. The Varitran autotransformer current and wattage rating is based at 115 volts. The maximum current can be taken at any point from 0 to 20 volts and from 95 to 130 volts, tapering off to 50% of maximum at the 65 volt point.


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# GANGED IMPEDANCE BRIDGE

## ● A bridge for mea suring the characteristic impedance of lines at audio frequencies

**By D. B. GREEN & PAUL K. HUDSON**

Dept. of Electrical Engineering
Ohio University

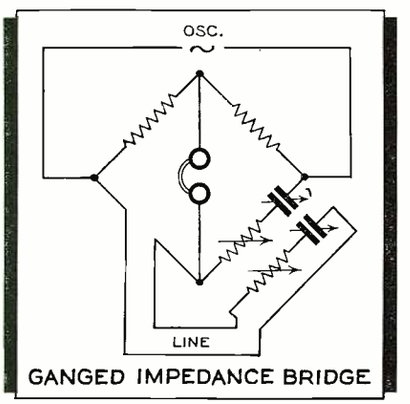
A CONVENIENT bridge has been devised for quickly measuring the characteristic impedance of audio-frequency lines. This bridge shown in the figure is based on the principle that when a line is terminated in its characteristic impedance the input impedance will equal its characteristic impedance, both in magnitude and in phase angle.

$$Z_{in} = Z_o = Z_t$$

where $Z_{in}$ = the input impedance of the line
$Z_o$ = the characteristic impedance of the line
$Z_t$ = the impedance terminating the line

Both ends of the line must be available. This is almost always the case in a laboratory, and in actual practice, there is usually an identical auxiliary line that can be used as a return line.

Any good bridge resistance-ratio arms can be used. The authors used a decade bridge. The input of the line is connected to the X-arm and the output end of the line is terminated in a standard variable resistor and a standard variable condenser in series. A similar condenser and resistor are connected in series in the standard arm of the bridge, and located adjacent to the terminating units.



GANGED IMPEDANCE BRIDGE

The operator balances the bridge by using one hand on each condenser and turning them both together keeping the two units on the same tap. Then using the same procedure on the two resistors, a balance is reached when the value of the units reaches the value of the characteristic impedance. This balance becomes very sharp by going from resistors to condensers a few times. The characteristic impedance is then the value read off the standard units R and C, that is

$$Z_o = R - \frac{j}{\omega C}$$

A commercial model of the above bridge which the writers have called the ganged impedance bridge might be made with the standard units ganged so that two dials only would be necessary.

# OVER THE TAPE

### PREMAX CATALOG

Premax Antenna Catalog, No. R-41, covers vertical radiators, horizontals, police, marine and commercial antennas, mountings and insulators. Rather complete data is given. Write to Premax Products, Division Chisholm-Ryder Co., Inc., Niagara Falls, N. Y.

### FEDERAL BULLETINS

Several new bulletins have been issued by Federal Telegraph Co., 200 Mt. Pleasant Ave., Newark, N. J. These bulletins give rather complete specifications and technical data on the following transmitting tubes: F-131-A, F-131-R, F-110-X, F-129-R, F-129-B and F-127-A.

### WEBSTER-CHICAGO CATALOG

"Sound of Tomorrow" is the title of a new catalog, No. 440, available from Webster-Chicago Corp., 5622 Bloomingdale Ave., Chicago. This booklet covers various types of amplifiers, remote mixer controls, microphones, recording equipment, speakers, etc.

### EICOR MOVES

Eicor, well-known manufacturers of dynamotors, small aircraft d-c motors, power plants, and converters, are now located in their larger plant at 1060 W. Adams St., Chicago. Greatly increased facilities have been provided in these new quarters for design and production to take care of the company's growing business.

### ASTATIC CATALOG

Catalog No. 40 covering microphones and pickups is available from the Astatic Microphone Lab., Inc., Youngstown, Ohio. Much constructional data and specifications are given in this 18-page bulletin. Write to the above organization.

### CALLITE APPOINTMENT

The Callite Tungsten Corp., through Sales Manager D. R. Donovan, announces the appointment of Harold M. Malm as Factory Sales Engineer. A former Callite metallurgist, Mr. Malm returns in this new capacity after serving some time as design engineer and metallurgist for the Lee Spring Co. of New York. He will work out of the home office at Union City, New Jersey, concentrating on special alloy wire applications for the paper, chemical, machine and other industries.

### HARVEY RADIO PLANT

The Harvey Radio Labs., Inc., are just completing the erection of modern assembly shops adjoining the machine shop which they have maintained for several years at 447 Concord Ave., Cambridge, Mass. All future correspondence should be sent to this new address.

### RCA PROMOTIONS

Promotions of three RCA Manufacturing Company executives at the Harrison, N. J., plant to positions of increased responsibility has been announced by E. W. Ritter, Vice-President in charge of production and engineering activities. Although young in years, all are veterans in the RCA organization and have a combined service total of 53 years.

John A. King has been named Harrison Plant Manager in charge of all operations, after having served nearly three years as Manager of Manufacturing. Arlan S. Kelley has been appointed Manager of Manufacturing, stepping up from Assistant Manager. Dr. G. R. Shaw, Manager of Research and Engineering, has been named to assist Mr. King in Engineering Management.

### PIONEER GEN-E-MOTOR EXPANDS

Impetus from national defense program activities as well as increased demand for its products from regular non-military channels has caused the Pioneer Gen-E-Motor Corporation of Chicago to double its present plant area, according to a recent announcement by D. E. Bright, President. The company has purchased the former Grigsby-Grunow big No. 2 Building situated at 5841 West Dickens Ave.,

Chicago. The plant, purchased from the Chicago Title and Trust Company, trustee, for $75,000 comprises a total of 80,000 square feet, consisting of a one story factory unit as well as a three story frontage office section.

### INTERNATIONAL STANDARD ELECTRIC APPOINTMENT

At a meeting of the Board of Directors of International Standard Electric Corporation held Tuesday, January 7, Mr. Henry M. Pease, formerly Vice-President, was elected President of the Corporation. Colonel Sosthenes Behn, who is Chairman of the Board of International Standard Electric Corporation has been serving as President. International Standard Electric Corporation is the subsidiary of the International Telephone and Telegraph Corporation which controls the greater part of I. T. & T's. communications manufacturing properties and operations throughout the world. Colonel Behn is President and Mr. Pease is a Vice-President of I. T. & T.

### DRAFTED AND ENLISTING WOR EMPLOYEES TO RECEIVE DIFFERENTIAL COMPENSATION

WOR employees subject to the draft or those who enlist in the Army or Navy will receive a financial differential between their civil and military salary for varying lengths of time depending on the term of their WOR employment. This announcement was made to the station's staff by Alfred J. McCosker, President of WOR.

Staff members who have been with WOR for a year or longer will receive the difference between their salaries at the time of leaving and the pay they will receive for military service for a period of three months after leaving the station.

Those who have been with WOR for less than one year will receive the difference between their WOR salaries and their military pay for one month.

In addition, Mr. McCosker announced that full salary will be paid for vacations which have accrued to an employee at the time of his leaving for military service. Also, all privileges determined by length of service will be considered as accruing during the period of service.

### LEARADIO APPOINTMENT

Henry W. Roberts, for many years the Radio Editor of *Aero Digest* magazine, recently joined the staff of Lear Avia, Inc., as Director of Public Relations. He is now in charge of Learadio press and advertising matters. Affiliated with aeronautics since 1928, Mr. Roberts began specializing in aircraft radio in 1934. His work is familiar to thousands of readers, in this country and abroad, and won for him the 1940 Harmon Medal, "for literary contributions to the science of aeronautics and radio communications." Mr. Roberts makes his headquarters at Lear Avia offices at 30 Rockefeller Plaza, New York, N. Y.

### LATHE CATALOG

The South Bend Lathe Works, South Bend, Indiana, has just issued a new general catalog which is said to be one of the most complete lathe catalogs ever published. The catalog has 112 pages and contains over 240 illustrations. It shows 50 different sizes and types of South Bend back-geared, screw cutting lathes for manufacturing, tool room and general shop work. A copy will be mailed on request.

(*Continued on page 26*)

## Diode Millivoltmeter —continued from page 16

amplifier tube of extremely low input capacitance, short leads and small resistance and capacity elements in the amplifier and rectifier circuits.

An a-c power supply may be employed if desired. If this is done it will be necessary to provide some sort of d-c voltage regulation. This need not be elaborate since a total plate current of about five milliamperes is taken. A circuit described by Bousquet[6] may be employed with excellent results. Proper shielding of the input leads from stray 60-cycle and high frequency pick-up is desirable at the most sensitive ranges. With the circuit of Fig. 1 a low-scale input impedance of approximately 2 megohms may be maintained over most of the audio range, the value falling to 1.5 megohms at a frequency of 10 kc.

The instrument may be calibrated to read either the peak or rms value of the input voltage provided the latter is sinusoidal. If harmonics are present the instrument should be calibrated to read peak values only. Use of the instrument as a wide-range ammeter may also be had by employing suitable shunt resistances across the input terminals. With the arrangement of Fig. 1, ten operating ranges are possible varying from a full-scale sine wave input of 0.002 volts rms to a full-scale input of close to 200 volts rms.


### Acknowledgment

The authors wish to acknowledge the laboratory assistance of Joseph A. Waldschmitt, Packard Research Fellow at Lehigh University.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## Pickup Tracking Error —continued from page 8

conclusion other than $R_o = 0$ when $D = L$.

$$\theta = \cos^{-1}\left(\frac{L^2 + r^2 - D^2}{2\,L\,r}\right),$$

which becomes $\theta = \cos^{-1}\left(\frac{r}{2L}\right)$

when $D = L$. As $r \to 0$ $\theta \to 90°$ and $e \to -\alpha$, rather than zero as indicated by (9). This may be explained as follows: as r becomes infinitesimal, the tangent to the arc at the needle point approaches D in position. When $r = 0$ the former circle of which r was the radius is now a point, and the position of tangency coinciding with D at this time is only one of an infinite number of possible positions. Hence the tangent also coincides with the axis of needle vibration thereby making the tracking error zero. While $e = 0$ when $r = 0$, the error approaches $\alpha$ in magnitude as $r \to 0$, and the function would be considered discontinuous at $r = 0$.

Unlike the conventional tone arm, zero tracking error can exist at the center groove $\left(r = \frac{r_1 + r_2}{2}\right)$ with the offset type of pickup when $e_1 = e_2$. This occurs when $D = L$, and the value of $\alpha$ resulting in this mode is

$$\alpha = \sin^{-1}\left(\frac{r_1 + r_2}{4L}\right).$$

Equation (9) holds also for the special case of the conventional tone arm. If $\alpha$ be made zero, the formula reduces to $R_o = \sqrt{D^2 - L^2}$, which may be further reduced, as shown previously, to $R_o = \sqrt{r_1 r_2}$.

Owing to the fact that there are two positions of zero tracking error for all values of $\alpha$, with the exception of $\alpha = \cos^{-1}\left(\frac{D}{L}\right)$ referred to above, there is a point between the two positions of zero error where the error reaches its maximum value, providing the function is continuous between these two points. The function is continuous when $D < L$, and discontinuous when $D \geq L$. The solution of $de/dr = 0$ for r, is the radius at which maximum error occurs.

The derivative of $e = 90° - \alpha - \theta$ with respect to r is $de/dr = -d\theta/dr$, where $\theta = \cos^{-1}\left(\frac{L^2 + r^2 - D^2}{2\,L\,r}\right)$.

$$-\frac{d\theta}{dr} = \frac{r^2 - L^2 + D^2}{2\,L r^2 \sin\theta},$$

and when $de/dr = 0$, $r^2 - L^2 + D^2 = 0$, or

$$R_m = \sqrt{L^2 - D^2} \quad \ldots\ldots\ldots\ldots (10)$$

where the position of maximum error is designated by $R_m$. The maximum error is

$$e_m = 90° - \alpha - \cos^{-1}\left(\frac{R_m}{L}\right) \quad \ldots (11)$$

which results from the substitution of (10) into the equation of error.

In the case of the pickup illustrated in Fig. 1-C and Fig. 4 it is usually convenient to express D in terms of l and $\beta$. The substitution of the following expressions in (7) makes this possible.

From Fig 4,

$$L^2 = l^2 + H^2 - 2\,lH\cos(180° - \beta) = l^2 + H^2 + 2\,lH\cos\beta \quad \ldots (12)$$

and

$$\alpha = \cos^{-1}\left(\frac{H^2 + L^2 - l^2}{2\,H\,L}\right) \quad \ldots\ldots (13)$$

Substituting (12) for $L^2$ in (13), and simplifying, results in

$$\alpha = \cos^{-1}\left(\frac{H + l\cos\beta}{\sqrt{l^2 + H^2 + 2\,lH\cos\beta}}\right) \quad \ldots\ldots\ldots\ldots\ldots (14)$$

### *III.—The Straight Tone Arm with Off Set Pickup*

$(e_1 = e_2 = 0)$

The advantage of this mode was mentioned under "Modes of Operation." Moreover, the expression for D is simpler than in the mode $e_1 = e_2 \neq 0$, and a practical solution of optimum $\alpha$ is possible.

From equations (4) and (5) the requirement that $e_1 = e_2 = 0$ makes $\theta_1 = 90° - \alpha = \theta_2$. Hence,

$$\frac{L^2 + r_1^2 - D^2}{2\,L\,r_1} = \frac{L^2 + r_2^2 - D^2}{2\,L\,r_2},$$

from which

$$D = \sqrt{L^2 - r_1 r_2} \quad \ldots\ldots\ldots\ldots (15)$$

Thus $D < L$ for this mode, which requires that the needle point must extend beyond the spindle. The similarity

existing between (15) and (1) will be observed. However, in (1) $D > L$ and the needle point falls short of the spindle when using the conventional tone arm for the condition $e_1 = e_2$.

The requirement of zero error at inner and outer grooves makes $L \sin \alpha \pm \sqrt{D^2 - L^2 \cos^2 \alpha}$ equal to $r_2$ or $r_1$, depending upon the use of the positive or negative sign, respectively. That is, $L \sin \alpha + \sqrt{D^2 - L^2 \cos^2 \alpha} = r_2$, and $L \sin \alpha - \sqrt{D^2 - L^2 \cos^2 \alpha} = r_1$. The sum of the two equations is

$$2L \sin \alpha = r_1 + r_2 \quad \ldots\ldots\ldots\ldots (16)$$

$$\alpha = \sin^{-1}\left(\frac{r_1 + r_2}{2L}\right) \ldots\ldots\ldots\ldots (17)$$

Equation (17) provides a simple means of predetermining the optimum angle of off set ($\alpha$) for given disc and tone arm dimensions.

Substituting (15) for D in the general equation of tracking error results in

$$e = 90° - \alpha - \cos^{-1}\left(\frac{r^2 + r_1 r_2}{2Lr}\right). (18)$$

in which e is the error at any radius r.

Equations giving the radius ($R_m$) at which maximum error ($e_m$) exists, and the value of the maximum error are developed in the following:

As previously shown

$$de/dr = -d\Theta/dr$$

From (18),

$$-\frac{d\Theta}{dr} = \frac{r^2 - r_1 r_2}{2Lr^2 \sin \Theta}.$$

$-d\Theta/dr = 0$, $R_m = \sqrt{r_1 r_2}$ $\ldots\ldots (19)$

Substituting (19) for r in (18) gives

$$e_m = 90° - \alpha - \cos^{-1}\left(\frac{r_1 r_2}{L R_m}\right) \ldots. (20)$$

It is of interest to note that, in the case of the conventional tone arm, $\sqrt{r_1 r_2}$ gives the location of zero error for the condition $e_1 = e_2$, while the same expression gives the location of maximum error with the off set pickup operating under the mode $e_1 = e_2 = 0$.

In the case of a tone arm containing the dimension H (Fig. 1-C and Fig. 4), $\alpha$ is expressed in terms of $\beta$ by means of the following transformation. Substitute (14) for $\cos \alpha$ in $\sin \alpha = \sqrt{1 - \cos^2 \alpha}$ and reduce to $\sin \alpha = \frac{l}{L} \sin \beta$.

Substitute this in (7) for $\sin \alpha$ giving

$$\beta = \sin^{-1}\left(\frac{r_1 + r_2}{2l}\right) \ldots\ldots\ldots\ldots (21)$$

### Summary of Formulas

The formulas listed below make possible the optimum location of the pivots of the main types of tone arms. Those

giving the locations of zero and maximum errors, and the magnitudes of the latter, aid in the design of new equipment, and give desirable information concerning new installations more readily and accurately than would curves of "tracking error—to—radius."

*I—The Conventional Tone Arm*

$$D = \sqrt{L^2 + r_1 r_2} \quad \ldots\ldots\ldots\ldots\ldots\ldots (1)$$

$$R_o = \sqrt{r_1 r_2} \quad \ldots\ldots\ldots\ldots\ldots\ldots (2)$$

$$e = \sin^{-1}\left(\frac{r^2 - r_1 r_2}{2 L r}\right) \quad \ldots\ldots\ldots\ldots (3)$$

*II—The Off Set Pickup* ($e_1 = e_2$)

$$D^2 = \{[z(c + 2L^2) + 2cL^2 + 4a^2] \pm 2a\sin 2\alpha \sqrt{4L^2(z + c) - (r_1^2 - r_2^2)^2}\} \div 2(z + c) \quad \ldots\ldots\ldots (7)$$

where $a = r_1 r_2$,
$c = r_1^2 + r_2^2$, and
$z = 2a \cos 2\alpha$.

$$e = 90° - \alpha - \cos^{-1}\left(\frac{L^2 + r^2 - D^2}{2 L r}\right) \quad \ldots\ldots\ldots\ldots\ldots\ldots (8)$$

$$R_o = L \sin \alpha \pm \sqrt{D^2 - L^2 \cos^2 \alpha} \quad \ldots (9)$$

$$R_m = \sqrt{L^2 - D^2} \quad \ldots\ldots\ldots\ldots (10)$$

$$e_m = 90° - \alpha - \cos^{-1}\left(\frac{R_m}{L}\right) \quad \ldots\ldots (11)$$

Transformations for Fig. 1-C:

$$L^2 = l^2 + H^2 + 2lH\cos\beta \quad \ldots\ldots (12)$$

$$\alpha = \cos^{-1}\left(\frac{H + l\cos\beta}{\sqrt{l^2 + H^2 + 2lH\cos\beta}}\right) \quad \ldots\ldots\ldots (14)$$

*III—The Off Set Pickup*
($e_1 = e_2 = 0$)

$$D = \sqrt{L^2 - r_1 r_2} \quad \ldots\ldots\ldots\ldots (15)$$

$$\alpha = \sin^{-1}\left(\frac{r_1 + r_2}{2L}\right) \quad \ldots\ldots\ldots\ldots (17)$$

$$e = 90° - \alpha - \cos^{-1}\left(\frac{r^2 + r_1 r_2}{2 L r}\right) \quad \ldots (18)$$

$$R_m = \sqrt{r_1 r_2} \quad \ldots\ldots\ldots\ldots\ldots (19)$$

$$e_m = 90° - \alpha - \cos^{-1}\left(\frac{r_1 r_2}{L R_m}\right) \quad \ldots (20)$$

Transformation for Fig. 1-C:

$$\beta = \sin^{-1}\left(\frac{r_1 + r_2}{2l}\right) \quad \ldots\ldots\ldots\ldots (21)$$

**Practical Examples**

The curves in Fig. 5 and Fig. 6 illustrate the reduction in tracking error that can be obtained from the use of an off set pickup. The characteristics in Fig. 5 have been drawn for a conventional tone arm, and a tone arm of the type illustrated in Fig. 1-C, for an average transcription disc. Fig. 6 gives the characteristics for 10-inch conventional and off-set types when used with the standard 12-inch record.

It will be observed from Fig. 7 that $e_1$ and $e_2$ decrease with increasing $\alpha$ until they become zero. Further increase in $\alpha$ causes the tracking errors to change sign and increase. Small values of $\alpha$ make $D > L$, and the tone arm operates in the same mode as the conventional tone arm but with slightly decreased error. The larger values of $\alpha$ make $D < L$, which is the more usual mode for the off-set pickup. The mode $D = L$ may result in very satisfactory operation for the off-set pickup, whereas this mode, when applied to the conventional tone arm, results in a very appreciable tracking error at the outer groove, particularly when using a short tone arm and/or a large disc. The small variation in tracking error and the small value of the maximum error for the mode $e_1 = e_2 = 0$ are illustrated by curves "D" in Fig. 5 and Fig. 6.

**Acknowledgment**

The author wishes to extend his thanks to Mr. J. W. Porteous, Dept. of Electrical Engineering, University of Alberta, Edmonton, Alberta, for reading and criticizing this paper.

## Wavemeter —continued from page 10

For the condition

$$\frac{R^2}{8\omega^2 L^2} << 1$$

$$(3)\quad V = \frac{1}{\sqrt{LC}}$$

where L is the inductance per unit length of line
And C is the capacity per unit length of line
Equating L, C, and V in the same set of units we have

$$L = \frac{4 N \log_\epsilon \frac{d}{r}}{10^9} \text{ henrys per cm length}$$

$$C = \frac{K 10^9}{4 C^2 \log_\epsilon \frac{d}{r}} \text{ farads per loop cm}$$

where K = dielectric constant of medium between wires
N = magnetic permeability of medium between wires
C = ratio of electromagnetic units of quantity to electrostatic $= 3 \times 10^{10}$ cm/sec

replacing these values in 3 we have

$$(4)\quad V = \frac{C}{\sqrt{K\mu}} \text{ for } K = 1, N = 1, V = C$$

all the necessary conditions to effectually produce a velocity of electrical disturbance along a Lecher wire system equal to the velocity propagated in free space are given in these simple relationships. It is necessary then that the Lecher wire line be so constructed as to fulfill these conditions.

The condition imposed by (4) may be met by making the parallel lines self supporting along the path that the regular recurring impedance variation is to be measured. The number of wave lengths over which successive maximum impedance may be measured is limited by the length of line that may be unsupported by insulation.

The conditions imposed by (2) $\frac{R^2}{8\omega^2 L^2} << 1$ may be directly calculated from the physical constants of the line. This may be restated in another way

$$\frac{8\omega^2 L^2}{R^2} >> 1 \text{ or } 8\theta^2 >> 1 \text{ where } \theta = \frac{\omega L}{R}$$

Assuming an accuracy of one part in a thousand is desired, it is possible to estimate from this relation the necessary "Q" to make this accuracy hold.

In order to reduce the possibility of having the Lecher wire system pick up stray voltages and in order to reduce the effect exerted by other objects in the immediate vicinity on the resistance of the line, it is necessary to shield the Lecher wire system. It is important that the diameter be kept considerably less than a half wave length of the smallest wave to be measured in order to preclude the possibility of setting up waves inside the shielding. If an accuracy greater than one part in one thousand is desired, the mechanical structural effects of temperature, condition of wires must be taken into account. In this case, the mechanical problem may be found more difficult than the electrical problem.

*For derivation of 1 and 2 the reader is referred to Pierce, "Elec. Oscillation & Waves."

## OVER THE TAPE

(*Continued from page* 21)

### MICO INSTRUMENT BULLETIN

The Mico Instrument Co., 10 Arrow St., Cambridge, Mass., have issued a bulletin describing the mico engraver, a pantograph machine adaptable to lettering tasks associated with experimental work as well as the routine production of panels, nameplates, etc. Rather complete information is given.

### ASTATIC BULLETIN

A new Astatic bulletin describes their latest model low-pressure, permanent-stylus crystal pickup. A copy may be obtained by writing to the Astatic Microphone Lab., Youngstown, Ohio.

### HYGRADE SYLVANIA POLICY—MILITARY TRAINING AND SERVICE

Hygrade Sylvania Corporation has taken its place among the manufacturing companies who will grant pay allowances to military draftees, according to a statement of policy on military training and service issued by the company. The company will grant one month's pay at current earnings at the time called to all employees who enlist for military training and service and who have six months of service to their credit with the company. Also, one month's pay at current earnings will be given to men who enlist for 3 or 6 years regular Army or Navy services. The complete policy, to be in effect up to September 16, 1941, is as follows:

Employees who are called, or who voluntarily enlist, for a twelve-month period, will be granted a twelve-month leave of absence, plus forty days allowed for re-employment application.

When an employee returns from training and service, he will either be restored to his former position or to one of equal status and pay, provided that:

(1) The employee has received a certificate of satisfactory completion of military training and service.

(2) He is qualified to perform the duties of the job.

(3) He makes aplication for re-employment within forty days after he is relieved from training and service.

(4) Circumstances are such that it is not impossible to restore the employee to his old job or one of equal status and pay.

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(State If Manufacturer, Broadcast Station, etc.)
Product .....

training, the company paying the cost of premiums. This coverage will be maintained as long as the service is on a one-year, peace-time basis, or until the Government provides War Risk or similar insurance coverage.

Time spent on active training duty by employees who are called and who voluntarily enlist for a twelve-month period will be counted as company service, the employee being considered on leave of absence. Training service time will be construed the same as active company service in determining eligibility for vacation payment.

### UNIVERSAL MICROPHONE DEFENSE CONTRACT

Universal Microphone Co. has been awarded a contract under the defense program by the U. S. Army Signal Corps for a large quantity of carbon-type microphones to be used for various communication activities.

The west coast factory is being reorganized, and new equipment added to assembly lines with increased personnel, in order to maintain a constant production of 300 microphones a day on the special government contract starting Feb. 1.

Procurement officials for the Navy Dept. have also asked for reservation on fifty percent of the Universal output facilities within a short time.

Every effort will be made, however, to continue production for the usual jobber-dealer channels, according to James R. Fouch, president and general manager. The cooperation of the trade will be asked, he says, in stipulating orders well in advance so as not to interfere with the assembly activities for the defense program.

Every square foot of Universal's three story Inglewood factory is being utilized at the present time with employees working double shift.

• • •

**Shown below is an engineer at work in the shielded test booth in the Cornell-Dubilier laboratory where studies of line noises and their elimination are constantly carried on. The results of these investigations are among the data presented in a series of articles now running in the "C-D Capacitor."**

## Looking at 1940-41—continued from page 13

these units should go up quite rapidly.

There has been considerable engineering advance in the design of auto radios incorporating short-wave bands. The use of band spread for easy tuning, and improved limiter circuits for reducing ignition interference have made short-wave auto radio reception quite satisfactory. Perhaps some of the auto radios announced in 1941 will also include f-m.

In communication receivers there is a trend towards the incorporation of higher frequency bands. Better circuit design, careful mechanical layout, improved testing methods have all contributed to better quality sets. One a-m/f-m communications type receiver was introduced in 1940.

### Tubes

As usual, there has been much activity in this fundamental field. Special emphasis is now being placed on the development of tubes for ultra-high-frequency service.

In this respect, the Klystron offers some interesting possibilities as a u-h-f generator as it is adaptable to frequencies between 600 and 30,000 mc. It is believed that this tube is of sufficient interest to include a brief description of it here.

In Fig. 1 is shown a diagram of a Klystron reduced to its essential elements, while Fig. 2 shows a cross section drawing of the tube. Electrons from the oxide-coated cathode drift toward grid 1, a small r-f voltage is impressed between grids 1 and 2 by a circuit A. As this voltage varies from positive to negative it accelerates and retards the electrons at different rates. Between grids 2 and 3 no additional stimulus is provided to the electrons. However, the electrons arrive at grid 3 in large bunches due to the difference in velocities and induce a voltage between grids 3 and 4. This induced voltage has a large amplitude compared with the exciting voltage, its frequency depending upon the frequency of the exciting voltage and the distance between grids 2 and 3. At 40 cm an output of 150 watts can be obtained.

Since the first air-cooled 5-kw transmitter was announced several years ago, continued research has permitted the extension of air cooling to tubes in the highest power class. No doubt even better cooling means and more efficient tube operation will result from additional research along these lines.

The development of miniature receiving tubes has permitted the construction of the "personal" type of radio. It is likely that scientific work will continue along these lines toward the design of more efficient miniature tubes and perhaps even smaller ones.

Another interesting trend in receiving tubes is the tendency towards standardization and the production of fewer tube types. The preferred tube program has met with considerable success and may partially account for the fact that there has been fewer tubes types announced this year. So far as we can see, however, the program has had no detrimental effect on development work.

### Aeronautical Radio

The general trend in this field is towards more compact and lighter unit design. During the coming year there is likely to be some unique developments in radio compasses, and new uses found for terrain clearance indicators. A new system of fluorescent panel lighting has been announced and will probably find considerable use. Radio-controlled sea-drome lights should also find considerable use.

A great deal of stress will be placed on the production of aeronautical radio equipment. This will probably lead to the development of new and better equipments for final testing at the end of the production line.

The development of larger and larger planes will permit of more complex and accurate radio devices, since power supply requirements can be increased.

### Police Radio

Undoubtedly the outstanding achievement in this field was the installation and field tests of frequency-modulation systems. Results of these tests were quite satisfactory and f-m is likely to expand in this field.

Police departments will have to play an active and cooperative part in the National Defense setup. In this connection the APCO will probably act a feature role. This organization dedeserves much credit for coordinating the police communications setup.

### Recording

This seems to be an almost limitless field. New uses and better equipment are coming to the front almost daily. There has been considerable improvement in recording methods and equipments during the past year. Excellent quality can now be put on records, sufficient to justify their use in wide-band frequency modulation broadcasting. Work continues on both tape and magnetic recording methods. Several developments can be expected along these lines in coming months.

### Materials

Materials will play an all important part in our national defense effort. While it is possible that shortages will develop in specific materials, this does not appear to be a too serious problem at the moment. In certain cases, however, materials may be restricted to meet defense needs.

While the developments in this field are too numerous to mention here, they take the form of improved quality of insulating materials, ceramics, plastics, etc., better methods of moulding, machining and the like.

• • •

## FANTASOUND

THE first public showing of Walt Disney's Fantasia, at the Broadway Theatre, New York City, unveils an entirely new type of motion picture sound recording and reproduction, called Fantasound, which projects a third-dimensional effect of sound and music. It is expected that within a few years leading theatres, in order to show this new type of screen entertainment, will have to be equipped with this type of sound equipment.

Fantasound causes sound actually to move with all action on the screen. The realism in sound is accomplished by the use of a number of loudspeakers placed at different points behind the motion picture screen. If a bee buzzes into the scene, for instance, to circle around the screen and off again, loudspeakers are automatically cut on and off to follow its progress. This drone can also be heard traveling all around the theatre.

For every group of loudspeakers used in the theatre, there has to be a separate source of synchronized sound. So when Mickey Mouse appears on the right, a control mechanism switches on the loudspeaker directly behind him and veers the sound to another speaker when he moves.

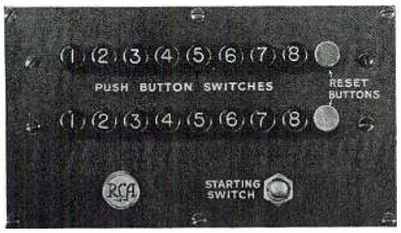
In recording the orchestra was divided into five sections—strings, basses, woodwinds, brasses and percussions. Each section was covered by three microphones, and recorded on a separate track. Also, there were three additional straight recordings, two on film, one on records, and a beat track giving the beat, entrance cues, etc., which the cartoonists used to synchronize the action to the music. Each of these tracks could be blended in any way with any other track or combination of tracks, so that actually any single instrument, section or the whole orchestra could be heard coming from any one point on the screen.

# THE MARKET PLACE

## NEW PRODUCTS FOR THE COMMUNICATIONS FIELD

### SELECTIVE CALLING DEVICE

A new control device for mobile radio systems, by means of which any one car or group of cars can be called without disturbing the other receivers in the same system, has been developed by the Emergency Communication Section of the RCA




Manufacturing Co., Camden, N. J. Known as the RCA selective calling equipment, it may be applied to any new or existing radio system. The equipment consists of a transmitter coding unit assembled on a standard speech-input rack, and receiver decoding units similar in size and appearance to ordinary mobile receivers. The control panel of the transmitter coding unit has two rows of eight buttons, from which as many as 200 different combinations of numbers can be used.

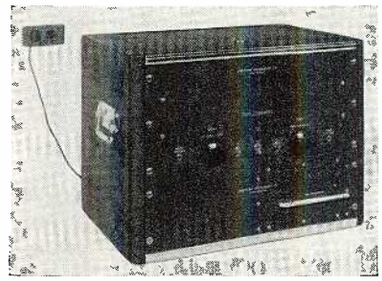
Selection of one receiver out of the system of receivers is accomplished by means of timed impulses of audio tone transmitted over the radio carrier to the receiver. The transmitter coding unit output is connected to the audio input of standard radio telephone transmitters. The decoding unit at the receiver responds or does not, depending upon the combination of pulses transmitted.

When the proper combination is received, a relay is tripped which in turn can be used to actuate any desired signalling device, such as a light, buzzer, bell or wigwag signal, to call the field crew's attention. The decoding unit may be set up to respond to two separate coded signals, making it possible to call one car, one group of cars, or all the cars at once.

To illustrate: with one hundred receivers the following combinations would be possible. (1) Each car set up for individual call, utilizing 100 of the possible combinations. One additional combination can be set up to which all of the 100 receivers will respond, providing a general call. (2) Each car set up for individual call. In addition, the cars can be divided into groups (a supervisor and several service cars, for example), with each group assigned a separate combination. Thus, calls could be made to each car alone, or to any of the groups.

### TIME STANDARD

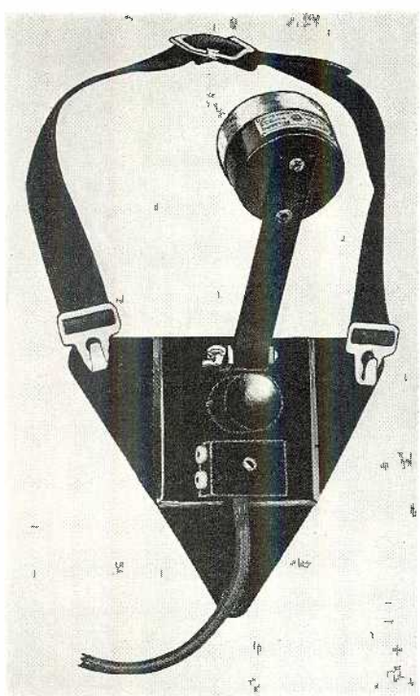
A tuning-fork controlled time standard is shown in the accompanying illustration. This instrument consists essentially of an electronically driven 500-cycle tuning fork and an electrically isolated pickup and



power amplifier as the source of the output power. The fork is free of all mechanical connections. It is suitable for the following uses: (1) driving galvanometers for oscillographs, oscillograph cameras, etc., (2) driving synchro-chronographs, (3) a time standard for adjusting watches, clocks, motors, generators, etc., (4) A source of modulating current for signal generators and radio beacons, (5) a source of constant frequency sine wave voltage for all types of a-c bridge circuits, (6) Geophysical and structural explorations. For further information write to the American Instrument Co., 8010-8020 Georgia Ave., Silver Springs, Md.

### "DISPATCHER" MIKE

Universal Microphone Co., Inglewood, Calif., this month started to distribute through the usual trade channels its newest item known as the dynamic "Dispatcher" model, designed especially for operators of wired music systems. The breastplate type of microphone will leave the operator's hands free to place the phonograph disc on the turntable at the central operating and control room.



### INTERFERENCE LOCATOR

The Sprague Model IL-2 interference locator is a new device, designed in cooperation with public utility engineers and radio

interference specialists to provide an inexpensive, sensitive and rugged portable device for the location of radio interference. The locator operates either from self-contained batteries for portable operation, or directly from 115-volt a-c or d-c lines. It is equipped with directional loop antenna mounted on top of the cabinet when in use. An adjustable pole antenna is also provided as standard equipment. Sprague Products Co., North Adams, Mass.

### RCA TUBES

The RCA Radiotron Division, RCA Manufacturing Co., Inc., Harrison, N. J., have made available the following new tubes:

RCA—1629 electron-ray tube (indicator type)

RCA—8000 oscillator, r-f power amplifier modulator.

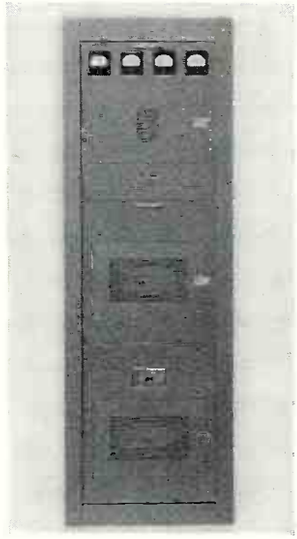
The 1629 is a high-vacuum, heater-cathode type of tube designed to indicate visually, by means of a fluorescent target, the effects of a change in the controlling voltage. The tube, therefore, is essentially a voltage indicator and as such is useful as a convenient and non-mechanical means of indicating adjustment of a circuit to the desired conditions. Because of its 12.6-volt heater and its 7-pin base, the 1629 is suitable for service in aircraft radio equipment. In this equipment and other equipment subject to vibration and shock, the 7-pin base provides ample friction to hold the base in its socket.

The 8000 is a transmitting triode having a maximum plate dissipation of 150 watts under ICAS conditions. In self-rectifying oscillator circuits, such as are often used in therapeutic applications, two 8000's are capable of delivering a useful power output (at 85% circuit efficiency) of 550 watts. The 8000 is rated for operation with full

input at frequencies up to 30 megacycles, but it may be used with reduced plate voltage and input at higher frequencies up to 100 megacycles.

### RADIO TRANSMITTER

In the accompanying illustration is shown the Communications Company Model 60 radio transmitter. This transmitter is a 150-watt, four-channel unit designed especially for aeronautical ground stations, general point-to-point communication and for marine telephone use aboard vessels. Frequency selection is by means



of relays and the transmitter may be completely remote controlled. Complete information may be secured by writing to Communications Co., Inc., 2700 Ponce de Leon Blvd., Coral Gables, Florida.

### AUDIO OSCILLATOR

Jackson Model 652 audio oscillator provides an audio frequency voltage developed at its fundamental frequency. The basic design of the instrument is entirely different from the beat frequency type of audio

oscillator. For complete information and for the special features of this unit, write The Jackson Electrical Instrument Co., 122 Wayne Ave., Dayton, Ohio.

### AIRCRAFT RECEIVER

A new aircraft radio receiver, especially designed for use in light aircraft, has just been placed on the market by Harvey-Wells Communications Inc. of Southbridge, Mass. Designated as Type AR-2-A, this four-tube receiver weighs only nine pounds complete with heavy duty batteries, battery case, cables, and headphones. The receiver cabinet measures

only 6 inches wide by 4¾ inches high by 4 inches deep, yet all parts are easily accessible. The superheterodyne circuit employs a stage of r-f amplification and has ample audio output to over-ride cockpit and motor noises. The tuning range is continuously variable from 198 to 405 kc. The receiver also has a front panel "Tune-Tower" switch which selects either a separate pretuned control tower channel or variable tuning.

### LUBRICATING OIL

Davenoil announces a new lubricating oil prepared for laboratory test equipment, watches, cameras, microscopes, etc. . . . Furnished with metallic applicator. Additional information from The Davenoil Co., 158 Summit St., Newark, N. J.

### AUDIOPOINTS

Audio Devices have announced a new and improved line of cutting styli. Careful inspection and a new manufacturing process is said to have produced a stylus with a reduced noise level. In addition the high-frequency response is said to also be improved. Further data on these new styli may be obtained by writing to Audio Devices, Inc., 1600 Broadway, New York City.

### G-E TUBE

A new mercury-vapor rectifier, bearing the type number GL-866A/866, has been added to the General Electric tube line for amateur and commercial service. Completely interchangeable with present-type GL-866 and GL-866A rectifiers, the new tube makes possible the higher rating of the GL-866A at the price of the GL-866.

The GL-866A/866 has a spiral edgewise-wound cathode with its axis vertical and surrounded by a heat-conserving shield which is at cathode potential. The glass envelope is of the dome type with the anode placed at the lower end of the small


portion of the dome. Thus there is a very small space between the edge of the anode and the glass, minimizing ionization at the back of the anode and near the anode lead. The anode lead is also enclosed in a glass "pantleg." The tube has a standard medium four-pin base, and is of unusually sturdy construction.

The rating of the new tube is: filament voltage, 2.5 volts; filament current, 5 amperes; maximum inverse peak plate voltage, 10,000 volts; average plate current, 0.25 ampere; maximum instantaneous plate current, 1.0 ampere.

Further information may be secured from the General Electric Co., Schenectady, N. Y.

## MOBILE AMPLIFIER

Thordarson has just announced an 18-watt mobile amplifier. This unit operates from either 6 volts d-c or 115 volts a-c. The amplifier includes an electric phono motor and pickup. Constant motor speed is said to be assured from either battery or a-c operation. Ten or twelve-inch records may be played. Further information may be secured from Thordarson Electric Mfg. Co., 500 W. Huron St., Chicago.

## PICKUP

In the accompanying illustration is shown a new model of Audak's "Relayed-Flux" Microdyne pickup. The frequency response of this unit is said to be flat within plus or minus 1½ db to over 10,000 cycles.

Several other features are also claimed for this unit. Complete information may be secured by writing to the Audak Co., 500 Fifth Ave., New York City.

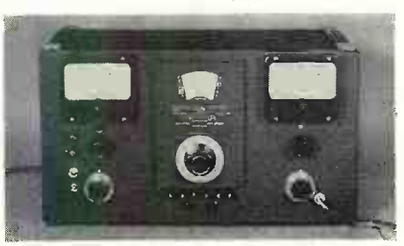
## PUSH-PULL VIBRATORS

The Turner Co., Cedar Rapids, Iowa, have added a new product to their line . . . push-pull vibrators. These units are designated as "push-pull" since they employ an equal amount of magnetic power to push and then pull the reed and its contacts.


The manufacturer claims some ten advantages for these vibrators. A free manual may be secured by writing direct to the Turner Co.

## STANDARD SIGNAL GENERATOR

A new laboratory standard signal generator, Model 65-B, has been made available by Measurements Corp., Boonton, N. J. This unit covers a frequency range



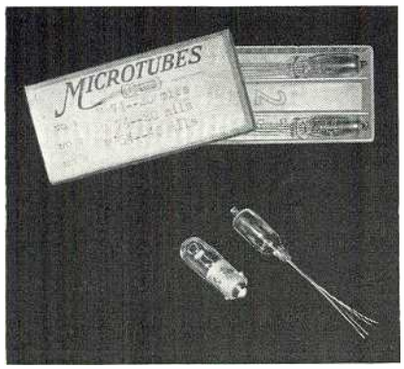
from 75 kc to 30 mc in six push-button selected ranges. Modulation is continuously variable from zero to 100% of either 400 or 1000 cycles or external source. A low-distortion modulating amplifier is built into the unit. Output voltage is continuously variable from .1 microvolt to 2.2 volts. Literature is available from the above organization.

### CRYSTAL LAPPING EQUIPMENT

The Precision Crystal Labs., 1211 Liberty St., Springfield, Mass., have designed and developed special machines for cuttting and grinding raw quartz into accurate finished crystals. Their latest development is a final lapping device which is said to produce crystals uniformly flat and parallel. Data on Precision products may be secured by writing to the above organization.

### MICROTUBES

In the accompanying illustration is shown several of the new Microtubes recently placed on the market. Suitable for hearing aid requirements, these new tubes are said to have a life expectancy in excess of 7000 hours. The two voltage am-




plifier tubes have 20 mil filaments each, while the output tetrode has a 40 mil filament. A series-parallel connection permits operation direct from a 1.4 volt cell. Curves and technical information may be secured by writing to Microtube Labs., 2414 Lawrence Ave., Chicago.

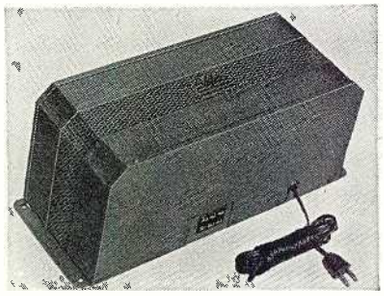
### POLY-DIRECTIONAL MICROPHONE

The new Cardak (model 725) features a variable sound pick-up pattern. A control (screw driver slot) allows the microphone to function as a true cardioid for elimination of sound striking it from the rear or (in extreme opposite position) as a bi-directional for elimination of sidewall re-

flected sound. It is adjustable for various combinations of reflected sound, thereby correcting feedback or reverberation conditions. The response is substantially flat from 30 to 10,000 cycles, it is said. Literature from manufacturer, Electro-Voice Mfg. Co., Inc., 1239 South Bend Ave., South Bend, Indiana.

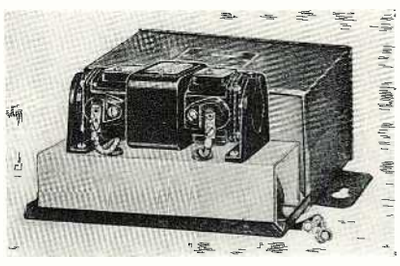
"STEADI-VOLT"

UTC announces a new type of voltage regulator for maintaining constant voltage for laboratory apparatus, production testing and heating equipment, electronic instruments, etc. The input voltage may vary from 95 to 130 volts. The output voltage is maintained within one per cent accuracy. There is a negligible variation in output voltage from no load to full load, permitting the use of the device at any rating up to its maximum value, it is said. In addition, a triple output receptacle is provided affording 110, 115, or 120 volts output. Further information may be secured from the United Transformer Corp., 150 Varick St., New York City.



MAGMOTOR

The Carter Motor Co., 1608 Milwaukee Ave., Chicago, makers of dynamotors and converters for aircraft, police, marine radio, and general use since 1932, announce the purchase of the Magmotor Police Radio Power Supply Division from the American Bosch Corporation of Springfield, Mass. All patents covering permanent-magnet dynamotors together with tools, dies, patterns and trade marks, become the property of the Carter Motor

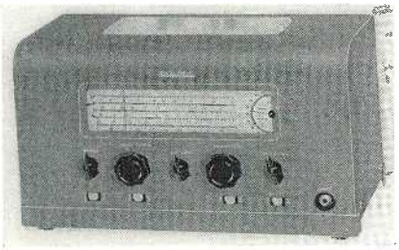


Co. who will maintain full service for all former American Bosch customers.

The magmotor is unique in principle; no field coils are used. Alnico permanent magnets take their place, increasing efficiency, reducing size and weight, and eliminating heat, it is said. Magmotors will run continuously for more than 5000 hours before brushes require changing. They are suitable for power supply for frequency-modulation police radio.

### COMMUNICATION RECEIVERS

Howard announces a new line of communication receivers, tuning from 550 kc to 43 mc (545 to 7). All models have a stage of tuned-radio-frequency on all bands. Illustrated is Model "435-A" which has seven tubes (including rectifier) and a built-in Howard-Jensen speaker. The seven tube model is designed so that



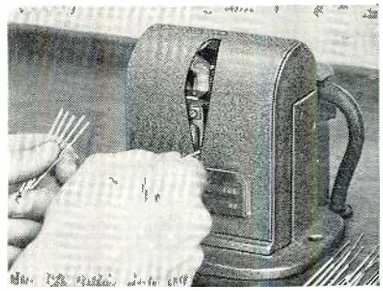
it can be returned to the factory at any time and changed into an eight or nine tube model. Accessories, including a two-stage preamplifier, monitor and carrier-level meter, are available and can be added at any time. Write to Howard Radio Co., 1731 Belmont Ave., Chicago, for Bulletin 102 for further details.

### RADEX TEST EQUIPMENT

The Radex Corp., after moving into larger quarters early last year, are now branching out into the radio test equipment field. Two new signal tracers have been made available. One model operates from a-c; the other is battery operated. Complete information may be obtained by writing to the above organization at 1733 Milwaukee Ave., Chicago.

### WIRE STRIPPER

A new type of wire stripper is announced by the Ideal Commutator Dresser Co., 4035 Park Ave., Sycamore, Illinois. This device is suited for stripping cotton, silk and rubber coverings from fine stranded



or solid wires. There's no possibility of cutting strands, nicking, scraping or injuring the wire in any way for the blunt blade cannot harm the finest wires, it is said. Literature is available.

### TIMERS

The Industrial Timer Corp., of 101 Edison Place, Newark, N. J., announce the addition of a new buzzing timer to their family of synchronous motor-driven electrical instruments. Six standard models are available:

BHR 1M— 1 to 55 seconds
BHR 3M— 5 seconds to 2 minutes 45 seconds
BHR 6M—15 seconds to 5 minutes 30 seconds
BHR 15M— 1 minute to 14 minutes
BHR 30M— 1 minute to 28 minutes
BHR 1H— 1 minute to 55 minutes

Custom built instruments can be built quickly for time controlled operations up to 60 hours. Further information may be secured from the manufacturer.

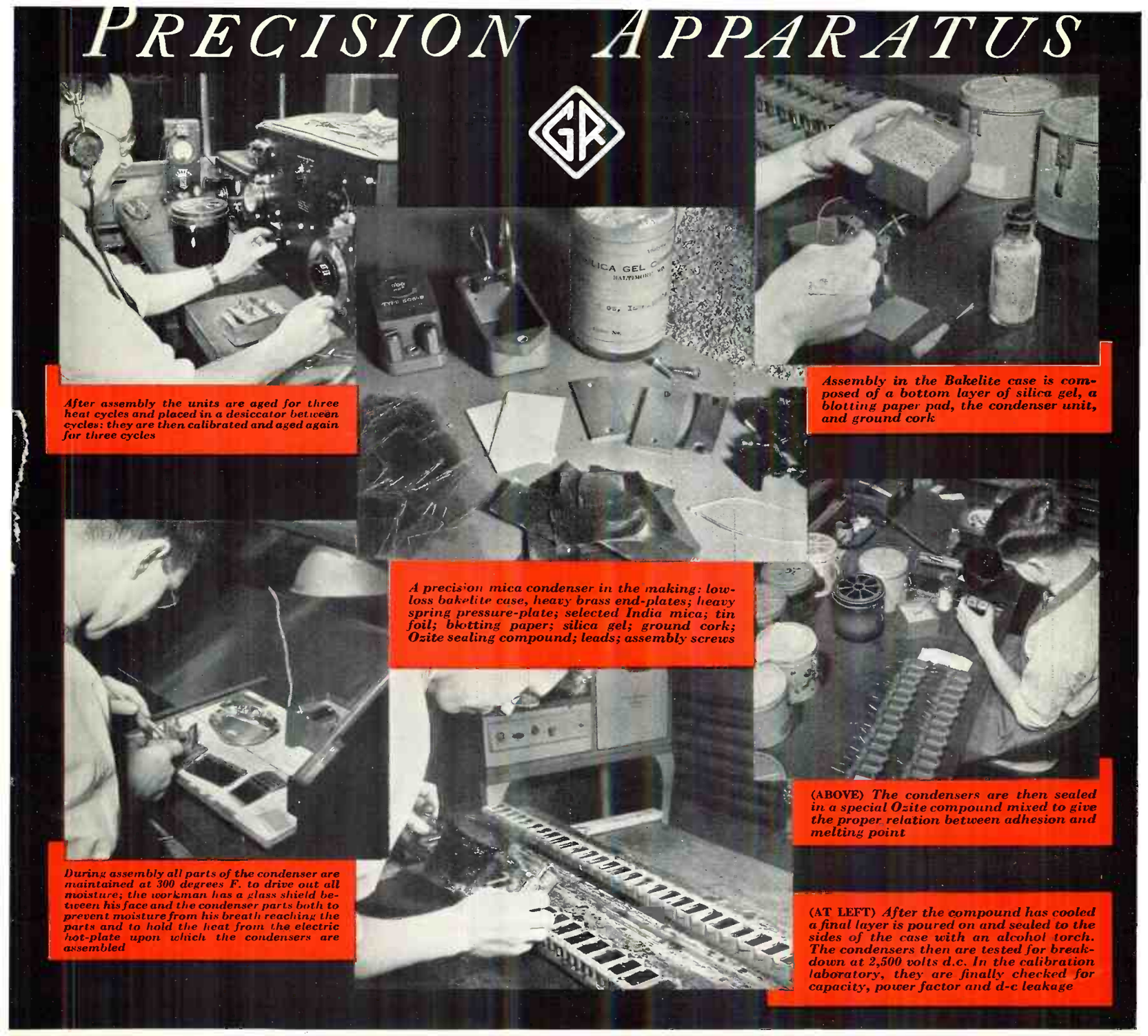
### PLUG-IN FILTER

In the accompanying illustration is shown the new Sprague multi-section plug-in filter for reducing radio interference. It is designed for installation at

the power outlet to which the interfering device is connected. The unit measures 2½" by 1¾" by 1 7/16". It is for use on 115 volt a-c and d-c lines only. Sprague Products Co., North Adams, Mass.

## Index to Advertisers

# PRECISION APPARATUS



*After assembly the units are aged for three heat cycles and placed in a desiccator between cycles: they are then calibrated and aged again for three cycles*

*Assembly in the Bakelite case is composed of a bottom layer of silica gel, a blotting paper pad, the condenser unit, and ground cork*

*A precision mica condenser in the making: low-loss bakelite case, heavy brass end-plates; heavy spring pressure-plate; selected India mica; tin foil; blotting paper; silica gel; ground cork; Ozite sealing compound; leads; assembly screws*

*During assembly all parts of the condenser are maintained at 300 degrees F. to drive out all moisture; the workman has a glass shield between his face and the condenser parts both to prevent moisture from his breath reaching the parts and to hold the heat from the electric hot-plate upon which the condensers are assembled*

(ABOVE) *The condensers are then sealed in a special Ozite compound mixed to give the proper relation between adhesion and melting point*

(AT LEFT) *After the compound has cooled a final layer is poured on and sealed to the sides of the case with an alcohol torch. The condensers then are tested for breakdown at 2,500 volts d.c. In the calibration laboratory, they are finally checked for capacity, power factor and d-c leakage*

SEVERAL years ago General Radio assigned an engineer to investigate the design of small fixed condensers having sufficient stability and low losses for use in precision circuits, such as beat-frequency oscillators, bridges and standard-signal generators.

The available condensers had several serious shortcomings including very poor stability with time, inexact accuracy of adjustment, high and variable power factor.

After a number of months of research, the Type 505 and Type 509 Condensers were developed. While designed primarily for use in G-R instruments, hundreds of these condensers have been sold separately for precision circuits and apparatus.

In the Types 505 and 509 Condensers selected India mica is used, each piece being carefully inspected for scratches and other mechanical defects which cause high dielectric losses. Mica, despite its excellent dielectric properties, is fairly high in its moisture absorption characteristics, a property which adversely affects its power factor. In these condensers the mica and its associated tin foil are kept at a temperature of 300 degrees F for a considerable time before the condensers are assembled, during assembly, and thereafter until sealed.

To keep the condensers dry after assembly, they are placed in a bakelite case with a mixture of silica gel and ground cork and are then sealed with an Ozite compound. The amount of desiccant sealed in is such that there can be 2,000 complete changes of air due to leakage before the desiccant will be used up.

Changes in pressure can cause appreciable changes in capacitance. In these condensers the stack is heavily loaded with a stiff spring under considerable tension to a point where the change in capacitance with pressure is very small. During assembly, each unit is carefully aged through a number of heat cycles to increase stability.

The resulting characteristics are such that these condensers make admirable secondary standards of capacitance and are of such physical form that they are readily adapted to use in precision measuring instruments. All Type 505 units are adjusted within 1% or 10 μμf whichever is larger, and Type 509 units within ¼%; the temperature coefficient of capacitance is less than +0.01% per degree C between 10 degrees and 50 degrees; the power factor of almost all of the units at 1,000 cycles and 25 degrees C is less than 0.05%; the leakage resistance in most of the units is greater than 100,000 megohms. These condensers are available in standard capacitances from 100 μμf to 1 μf at prices between $3.50 and $48.00.

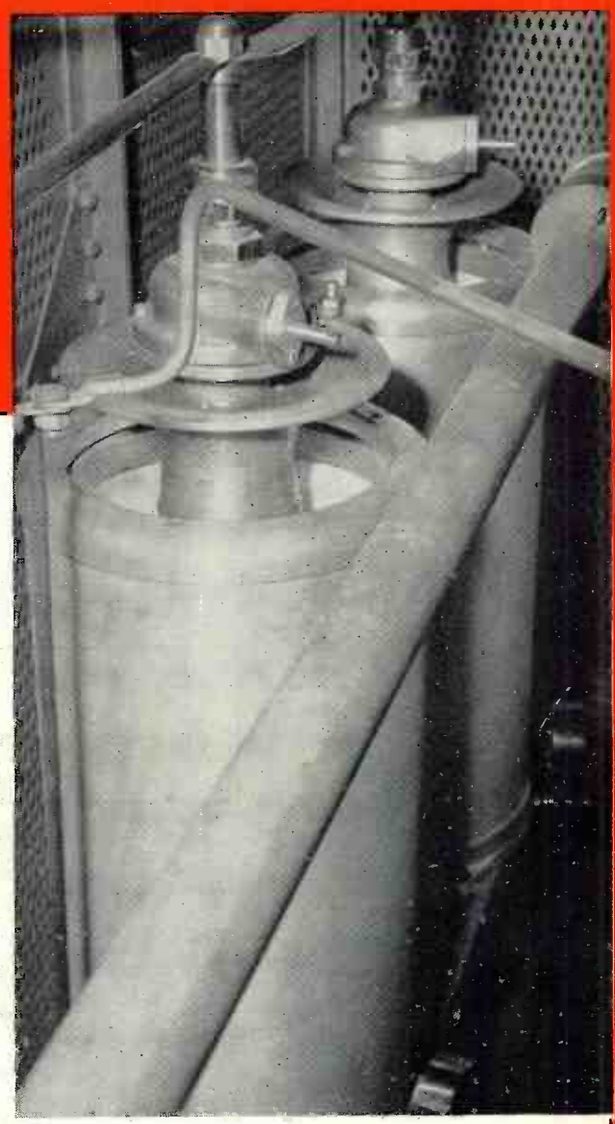
**GENERAL RADIO COMPANY**
**Cambridge, Massachusetts**
BRANCHES IN NEW YORK AND LOS ANGELES

*Since 1915 Manufacturers of Precision Electrical Laboratory Apparatus*

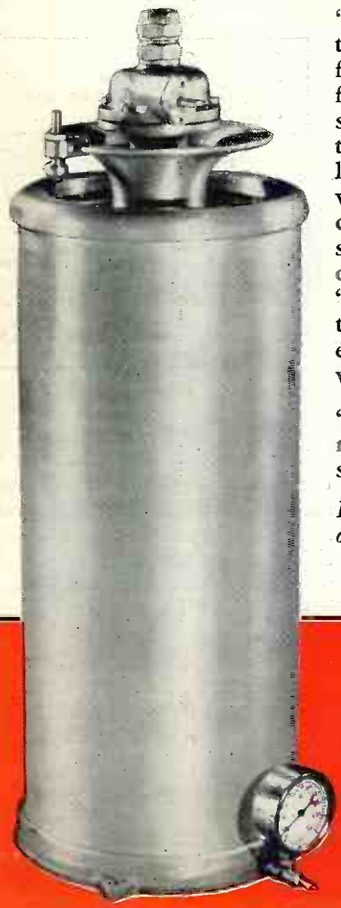
# "HAD TO RE-ADJUST FINAL AMPLIFIER COUPLING CIRCUITS BECAUSE OF LAPP CONDENSER'S LOW LOSS"

**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.