PROPOSED NEW TUBE STANDARDS DIAGRAMED


# RADIO WORLD

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The First National Radio Weekly

*668th Consecutive Issue—Thirteenth Year*

15¢ Per Copy

JAN. 12 1935

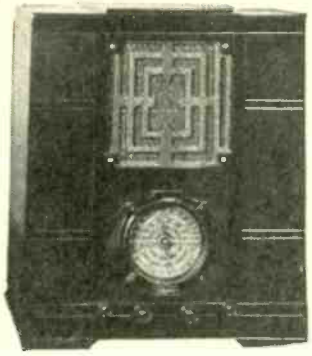

T-R-F Stabilization

Overall Measurements

New, Sensitive Photo Cell

# DESIGN OF AUDIO AND I.-F. CHANNELS

# ALL-WAVE DIAMOND



**DE LUXE TABLE MODEL**
**$32.70**

THE All-Wave Diamond, introduced only a few months ago, has proved the most popular receiver we have ever offered. Customers are completely satisfied, delighted, overjoyed. Not only low price—the lowest, in fact—but performance on full par with that of expensive receivers. We highly recommend the all-wave model to broadcast-short-wave listeners. It is obtainable in two table-model forms, De Luxe, as illustrated, @ $32.75, with eight RCA tubes, or Gothic, @ $31.55, or in a console model, as illustrated, @ $41.70. The set tunes from 150 kc to 22,000 kc (2,000 to 13 meters) by front-panel rotary switching. Foreign reception on short waves is guaranteed. Thus you have world-wide reception. Automatic volume control, tone control, manual volume control, five-band switch, latest RCA tubes, large airplane dial calibrated in frequencies and meters, 8" dynamic speaker, 3-gang condenser, and lowest price are the attractions. The circuit is a superheterodyne and easy to tune. Tone quality and selectivity are excellent. Sensitivity is remarkably high as far as consistent with low noise level.

You can buy the chassis, speaker and tubes, or either table model set, or console model, whichever best suits your needs.

Cat. 1008-WCH, wired chassis, with eight RCA tubes (one 6A7, two 6D6, one 75, one 76, two 42 and one 80) and heavy-duty dynamic speaker, 50-60 cycles, 110-125 v. Primary power consumption 80 watts. Chassis 13" wide, 7" high, 8¾" front to back. Shipping weight 25 lbs.) ............ **$26.10**

Cat. 1008-WCH-25, same as above, except for 25 cycles (25 lbs.) ............ **27.60**

Cat. 1008-WCH-220, wired chassis, etc., for 50-60 cycles, 220 v. (20 lbs.) ............ **26.70**

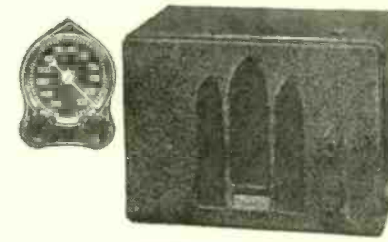
Cat. 1008-WDL, standard chassis in de luxe table model cabinet 14½" wide, 16" high, 9½" front to back (28 lbs.) ............ **32.70**

Cat. 1008-WG, table model in Gothic cabinet (28 lbs.) ............ **31.50**

Cat. 1008-WCO, console model, 21" wide, 36½" high, 12" front to back (51½ lbs.) ............ **41.70**

Cabinet models as listed above are for 50-60 cycles, 110-125 volts, but are also obtainable for 25 cycles, 110-125 volts @ $1.50 extra or for 50-60 cycles, 220 volts @ 60c extra.

**CONSOLE MODEL**
**$41.70**



**DIAMOND AUTO SET**
**$23.95**

OUR previous model Auto Set was so good that the model was not changed in three years. Now at last it has been improved upon, certain mechanical refinements introduced, and tubes of somewhat higher efficiency included. Some of these tubes were not manufactured until recently. Also the set now has a. v. c.

Our 1009-T Auto Radio is a six-tube superheterodyne set, using one 6A7, one 41, one 75, two 78's and one 84, and tunes from 540 kc. to 1,600 kc. It is a one-unit receiver, ruggedly built for long life, and is equipped with a dynamic speaker. It has an illuminated vernier airplane type control. The manual volume control and lock are one combination. The power consumption is 4 amperes.

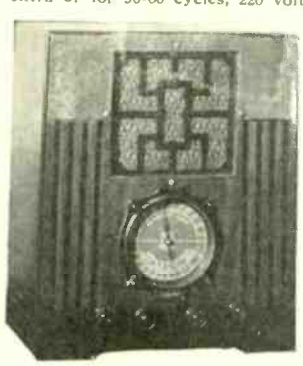
No B batteries required. There is a B-eliminator built in.

This is one of those fascinating auto sets that has single-hole mounting provision, and therefore is a cinch to install. There are only two connections to make: (1) to the ammeter; (2) to the aerial.

The remote tuner is, of course, supplied with the set. And the spark plug suppressors and commutator condenser are supplied also.

The size is 8¾ inches wide, 6 inches high, 6¼ inches front to back. Shipping weight is 18 lbs.

Order Cat. 1009-T, wired, in cabinet, complete with six RCA tubes. Price, $23.95



**2-BAND DE LUXE**
**$20.37**

ANOTHER popular receiver is the dual-wave type that covers the broadcast band and one short-wave band. On that one short-wave band are found the most important foreign stations. The coverage of the Model 1042-PD receiver is: broadcast band (550 to 1,500 kc) and short-wave band (5,500 to 16,000 kc). Therefore the short waves are tuned in from 18 to 55 meters, and that is the band on which the most important foreign program transmitters are working. Anybody who has not had his taste of short-wave reception will do well to be initiated with either of these two dual-band receivers. Model 1042-PG is illustrated at right, and is a superheterodyne for foreign and domestic reception. There are also the following valuable features: built-in antenna, frequency-calibrated dial, separate short-wave switch (no plug-in coils), dynamic speaker, figured walnut cabinet with figured Oriental overlays. And the price of Model 1042-PG is only $19.17 net.

Model 1042-PD, illustrated at left, is the same circuit in a de luxe table cabinet. The two table models have an airplane frequency-calibrated and illuminated dial, and besides can be obtained for battery operation and 32-volt operation. It is a superheterodyne of the switch type, covering the broadcast band and 18 to 55-meter short-wave band. It has automatic volume control and tone control. It is for 105-120 v. 50-60 cycle operation. Primary power consumption 60 watts; shipping weight, 17½ lbs. Net price. **$20.37**

Cat. 1042-PCH, wired chassis, 9" wide, 7" high, 6" front to back; dynamic speaker, five RCA tubes (one 6A7, one 6D6, one 75, one 42 and one 80), 550 to 1,500 kc and 5,500 to 16,000 kc. For 50-60 cycles, 110-125 v. (14½ lbs.) **$17.10**

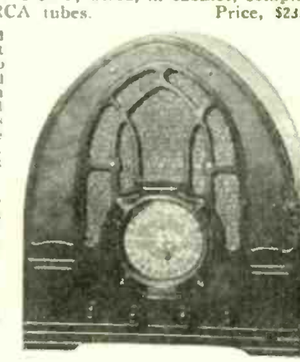
Cat. 1042-PG, table model Gothic cabinet. (17½ lbs.) ............ **$19.17**

Any of 1042 series, 50-60 cycles, 220 v. @ 60c extra; 110-125 v., 25 cycles @ $1.50 extra.

Cat. 1042-PBCH, battery model chassis for 6-volt storage battery and B battery operation (batteries not supplied); complete with tubes and speaker. (14½ lbs.) **$21.90**

Cat. 1042-PBG, same as above (battery model) in Gothic cabinet, with tubes, speaker. (17½ lbs.) ............ **$23.97**

Cat. 1042-PBD, battery model, in de luxe table cabinet. (17½ lbs.) ........ **$24.17**



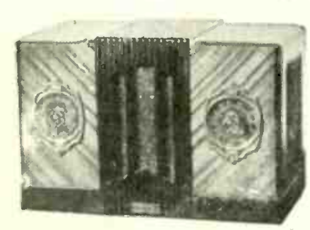
**2-BAND GOTHIC**
**$19.17**

**$13.17**

**$13.77**

**540-1900 KC BROADCAST SET**

FOR those interested only in the broadcast band we have a splendid ac t-r-f model DIAMOND OF THE AIR that tunes from 540 to 1,900 kc, and therefore gets some police and amateur calls as well; that has frequency-calibrated and illuminated airplane dial; and that can be bought, complete with tubes, all wired and ready for operation of its self-contained dynamic speaker (left-hand illustration above) at only $13.17. Order Cat. 1041-XG, for 50-60 cycles a.c., 105-120 volts. The same set is illustrated at right in de luxe cabinet, price $13.77. Order Cat. 1041-XD. Not only may the receiver be bought already in either cabinet, but separately as a wired chassis, with speaker and tubes (less only cabinet). Besides, there is a model for 25 cycles a.c., 90-120 volts, and another for 220 volts a.c., 50-60 cycles. This is a tuned-radio-frequency receiver, five-tube model, using two 6D6, one 6C6, one 42 and one 80. It will be noticed that the economical and electrically strong 6-volt series tubes are used in the receivers proper. The primary power consumption is 55 watts. Not only is this a fine receiver, but it is made right, and every attention has been paid to detail. The airplane type dial is frequency-calibrated, so that the frequencies are read directly. There is provision for phonograph connection. The wired chassis is Cat. 1041-XCH, complete with speaker, tubes, $11.97. Shipping weights of 1041 series, 11½ lbs. 25-cycle models, $1.20 extra. 220-volt models 60c extra.



**2-BAND OBLONG**
**$17.37**

The above set is a two-band 5-tube ac-dc universal receiver for 50-60 cycles, 110-125 volts, and is Cat. 1042-U, $17.37 (10¾ lbs.). It uses one 6A7, one 6D6, one 75, one 43 and one 25Z5. Sold complete with RCA tubes. Ranges, 550 to 1,500 kc, 5,500 to 16,000 kc. Approximate kilocycle calibration. Band change by switching.

Cat. 1042-UE is in the same cabinet, etc., but tunes from 150 to 350 kc and from 540 to 1,500 kc. For European use. Price $18.57, complete with tubes.

Either above, with 220-volt adapter, 90c extra.

**AC-DC MIDGET**
**$11.37**

**Model 1040-V.** 4-tube universal, ac-dc, 90-120 v., wired receiver, complete with four RCA tubes, and coil for the broadcast band only; contained in attractive midget cabinet; dynamic speaker. Shipping weight, 8 lbs. Net price ........................ $11.37

**Model 1040-VSW.** Same as above, except that four coils are supplied for the short waves only, 1500 kc to 20 mgc. Shipping weight, 8 lbs. Net price ............................ $14.97

**Model 1040-VAW.** Same receiver, with broadcast coils, also low-frequency coils (to 110 kc) and short-wave coils (1,500 kc to 20 mgc). Shipping wgt., 8 lbs. Net price.. $16.77

**ADAPTERS**

Auto adapter, complete with suppressor. Cat. 1040-VATAD....... $7.50

32-volt Farm Light Plant Adapter. Cat. 1040-VFLPA ............... $5.60

220-volt adapter for ac-dc use. Cat. 1040-V-220 ........................ .95

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RADIO WORLD
Reg. U.S. Pat. Off.
*The First National Radio Weekly*
*THIRTEENTH YEAR*

Price, 15c per Copy; $6.00 per Year by mail. $1.00 extra per year in foreign countries. Subscribers' change of address becomes effective two weeks after receipt of notice.

Entered as second-class matter March, 1922, at the Post Office at New York, N. Y., under Act of March 3, 1879. Title registered in U. S. Patent Office. Printed in United States of America. We do not assume responsibility for unsolicited contributions, although careful with them.

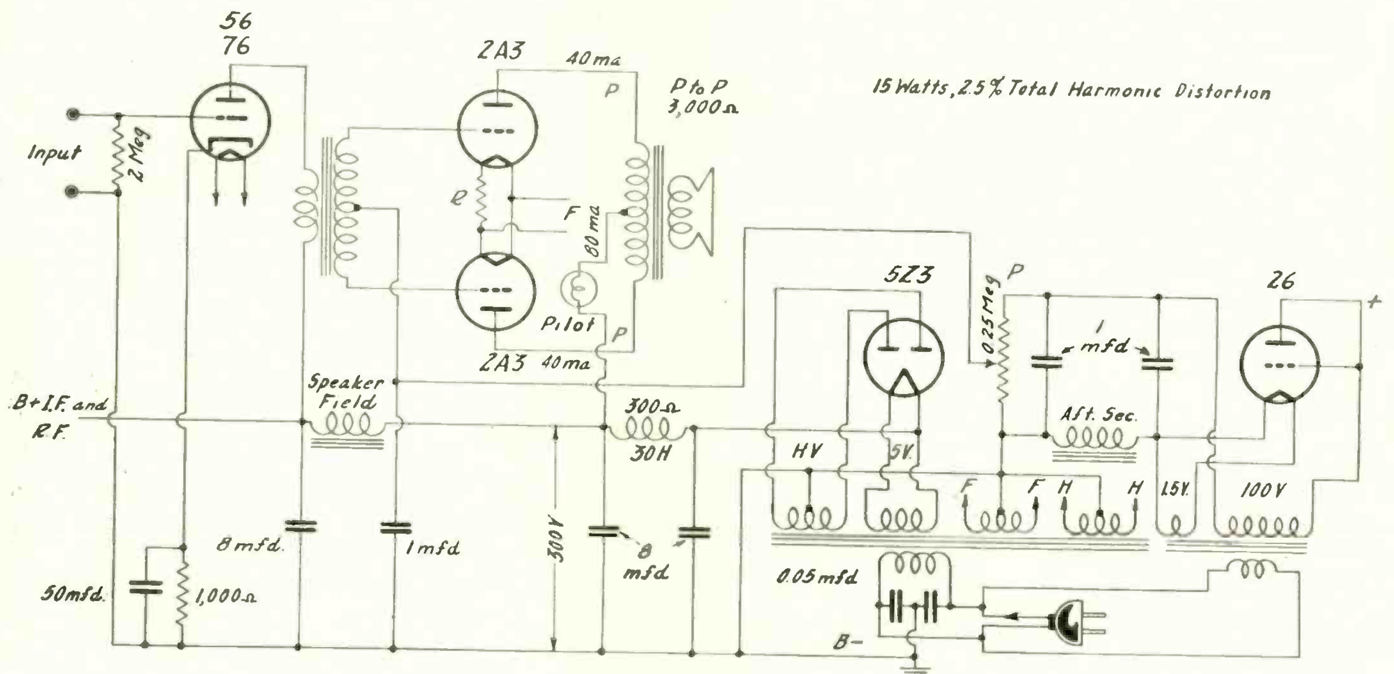
Vol. XXVI | JANUARY 12, 1935 | No. 18. Whole No. 668

*Published Weekly by* Hennessy Radio Publications Corporation, 145 West 45th Street, New York, N. Y.
Editorial and Executive Offices: 145 West 45th Street, New York
*Telephone:* BR-yant 9-0558

# Designs for A.F. and I.F.

## Output is First Consideration—Verified Circuits

***By Francis X. Cameron***




**This may be regarded as the "best bet," using two output tubes. The driver has about 20 volts negative bias. The class AB power tube bias is derived from a separate rectifier type C supply. The voltage across the potentiometer P is not measurable accurately with current-drawing meters, but is set on the basis of power tube plate current.**

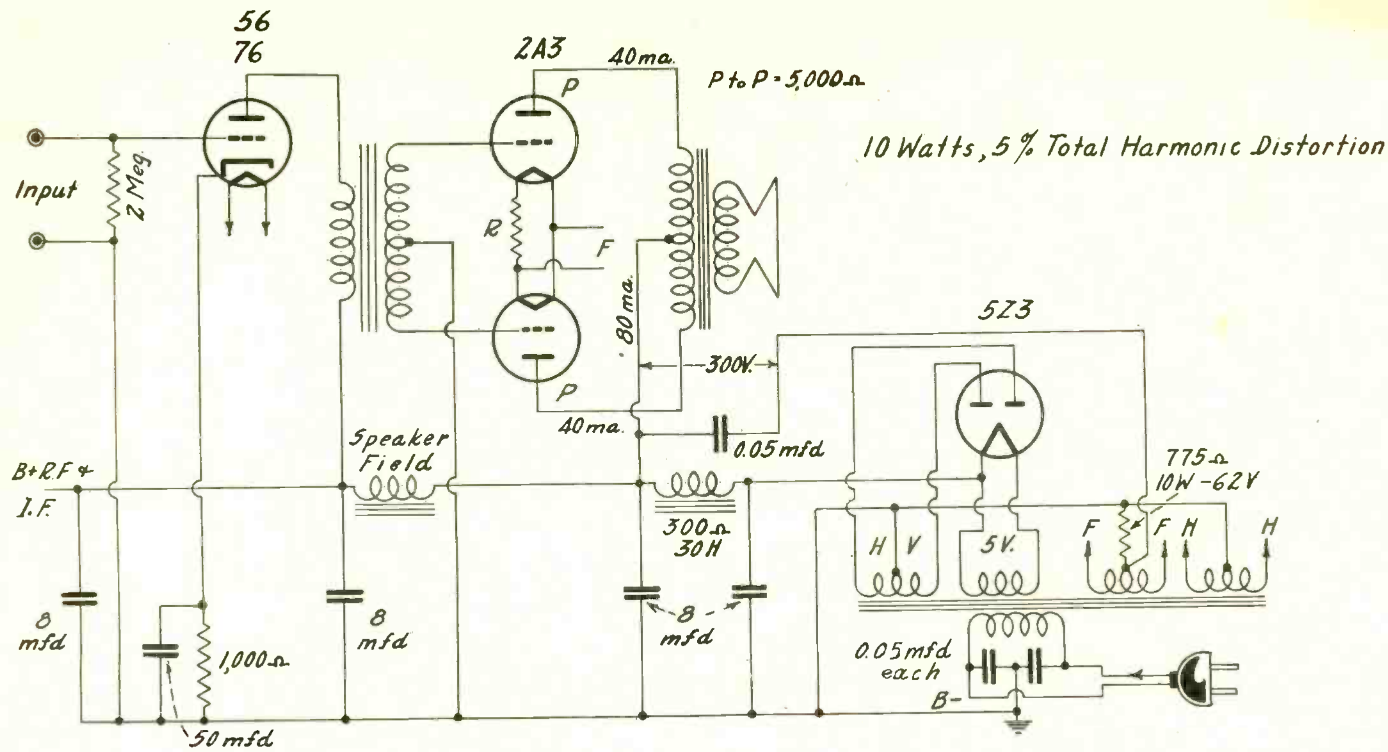
IN the design of a receiver the first consideration is the output stage, following the rule that the last shall be first, though not merely to be contrary. It is like building a bridge and then limiting the load it is to bear. In radio we start with the bridge and apportion the load so that it will come up to practically the full capabilities of the structure.

By an earlier method of reasoning we would design the receiver up to the output stage and select the power tubes on the basis of the work that they are compelled to do, the load they must carry, or, rather, the rate at which they must do a certain work. With modern tubes, improved constants, and the general acceptance of the superheterodyne, we do not follow that earlier course, since we know that we can easily get too much for the huskiest output stage we shall select. It then becomes a case of limiting what is ahead of the output, hence we select the power tubes first so that we know what limits we must impose.

### What Output to Select

For the same reason, any one interested in building a set, or designing one he intends to build, may as well make up his mind first about the output. Shall it be a single pentode? If so the power output, at a rather high distortion level, may be 5 watts. When tube economy is to be considered, the pentode must be selected, because it is the most sensitive tube. We get as much quantity of sound output as we would if we included an extra tube as driver and worked a push-pull triode output. Hence all small or economical sets will have single pentode output. If push-pull is used the power output is about doubled, at the same distortion level, but without any additional quantity of sound.

Energy is work done, power is the time rate of energy. The same period of time is deemed applied to all power considerations. There is no need to define just what the time is. Accept it as a second, if you like. The power comparisons will be just, for the same period,




**The "next best bet" is also Class AB, but uses self-bias. Here it is particularly advisable to equalize the static operation of the power tubes.**

t. Though the time element may not be mentioned, it is understood. All current flow includes this time element. Strictly and technically speaking, the statement that 30 milliamperes flow does not mean anything. Current flow is a statement of a rate of electrical activity, and time is always an element in such a rate. Therefore 30 milliamperes t. would be the precise statement. However, the t. being understood, referring to some period of time, it isn't mentioned, except in formulas.

### Voltage Gain Different

We can therefore understand that the output stage is called upon to handle power, to do work at a certain rate, as distinguished from the other outstanding requirement applicable to a receiver. From stage to stage we seek to build up the voltage more and more, and we need not consider power when we are dealing with the voltage amplification. It takes practically no resonant power to handle the voltage-amplifying and detecting devices. Not until after the detector do we have to think much about power.

If the detector directly feeds an output tube, such as a pentode, we encounter power considerations first in the last tube. Under some circumstances of circuits with driver, meaning audio stage between detector and output tube or tubes, we have to consider power, too. That case would arise principally if the output were Class B-2, of such type that grid current flows in the last tubes, the driver being called upon to make up for the deficiency of these grids to supply enough power for the purpose from their cathodes, especially since losses occur due to the d-c resistance of the grid load. Hence the transformers used generally have a step-down ratio, so the secondary winding will introduce minimum loss.

### Must Supply Much

If we want much power we must supply much. The supply consists of heating the filament or cathode, so that sufficient electrons may be released to the plate, and of putting a sufficiently high voltage on the plate to attract the necessary quantity of electrons in a given time. The voltage being selected within reason, including safety to life despite accidental contact, we must enable large plate current to flow, for if the voltage is considered fixed, the power is proportionate to the current through given resistance.

The foregoing has to do with the power supply, or energizing source, and there is a relationship between this and the maximum undistorted power output, because we find that we must use more current in the plate circuit if the undistorted power output is to be increased. This is a broad rule. It has exceptions.

If we desire to increase the maximum undistorted power output, without increasing the B voltage, we may use push-pull. Notice we need two tubes in place of one tube. We therefore use twice the filament power of one tube, also twice the plate current, since there are two tubes where formerly there was one tube, and we can get an undistorted power output at least twice as much. Biasing, regulation, circuiting in general, and other considerations, affect the factor of increased undistorted power. As an average push-pull may be said to enable four times the maximum undistorted power output.

### The Percentage Distortion

The adjective "undistorted" is used, although there is no undistorted output. Always there is distortion, anything at or below 5 per cent being considered nothing. Lately the practice is being followed of mentioning the power output and the percentage distortion, except in instances when the distortion is so high that it is not wise to mention it, and then just "power output" is mentioned. Yet in some instances reality overcomes prudence. The 43 at 0.9 watt output, under 95-volt conditions, is unblushingly ascribed 11 per cent. total harmonic distortion.

Push-pull has the advantage of balancing out the even order harmonics from the output. The harmonics are in the stage but do not appear in the output. In this way arithmetic half the total harmonic distortion is eliminated. In terms of amplitudes, more than half the distortion is suppressed. Then, if tubes and loads are used so as further to minimize distortion, that is, where the total would be 5 per cent without push-pull, the reduction is at most to 2.5 per cent. The only example of 2.5 per cent found in present-day receiver practice is the push-pull 2A3 Class AB-1 with fixed bias, output 15 watts at 2.5 per cent total harmonic distortion. In other words, this is the best possible output at present, without going in for tubes beyond the receiver class.

### The Output Classification

The amount of negative bias largely determines the classification of the output. Classes A, B and C are in ascending order of negative biases. Classes intermediary are AB and BC. In Class A plate current always flows when the tube is in operation. In Class AB the plate current in each tube flows during at least half the signal cycle but not for the full cycle. In Class B, where the plate current is zero in each tube until the signal excites the grid, plate current flows in one tube for half the cycle. Class BC has plate current flow for less than half the cycle, yet for a considerable part of the cycle. Class C has plate current flow for less than half the cycle. All above classes, except A, are push-pull necessarily; and Class A of course may be push-pull.

To distinguish between circuits with and without grid current conditions, the number 1 is suffixed to the letters for conditions of no grid current, and the number 2 for conditions of grid current, e.g., AB-1, AB-2.

### Best and Worst

We have thus encompassed the two extremes, the makeshift pentode output tube, required under some circumstances,

*(Continued on next page)*

# Self-Generating Photo Cell

## Device Has Sensitivity 123 Microamperes per Lumen

### By Wallace W. Edge

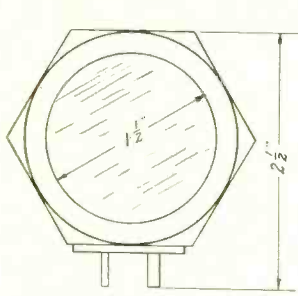



Fig 1


Fig 2

THE Pioneer photo cell, developed by Samuel Wein, authority on photo cells, belongs to that series of light-sensitive cells which function without a source of potential in series with it. However, the cell may be used with excellent results in series with small potentials, i.e.; up to 10 volts a.c. or d.c.

This photo cell is housed as shown in Figs. 1 and 2. It consists of an iron disc, 1¾" diameter, with a thin film of crystallized selenium and on top of it is sputtered a more or less translucent film of metallic silver. Electrical contact is taken fro mthe iron disc and from the translucent silver film by means of a phosphor bronze "contact ring" on which there is a series of small fingers. The elements of the cell so formed are enclosed in a brass hexagonal-shaped container which is chromium plated and highly polished. External electrical contact from the iron disc and the phosphor bronze contact ring is accomplished by means of the two insulated pins on the bakelite piece in the base.

### Sensitivity Rating

A 150-watt lamp was tested on a photometer bench and placed at such a distance from the cell as to give 100 foot candles. Under this condition, the output of the cell was found to be 150 microamperes, using a 10-ohm meter. This gives 1.5 microamperes per foot candle. Since the active surface exposed to light is 1.5" in diameter or .0122 sq. ft. in area, the sensitivity of the cell is computed to be 123 microamperes per lumen. The meter used in these measurements was a Weston four-range instrument, of which the 200 microampere scale was used. The range, as stated, had a resistance of 10 ohms.

When exposed to 100 foot candles of light the pioneer cell gave readings of 125 microamperes down to 122 microamperes. Taking the 122 as the 100% point, the characteristic curve in Fig. 3 was obtained.

The reduction in current seen in the curve is due to the extremely low resistance in the meter, setting up a physical reaction between the metals of the cell (iron, selenium and silver). This reduction is not noticable when meters of higher resistance are used in testing the cells.

This cell, when exposed to 100 foot candles, was turned to different angles and readings taken. The results of this test are seen in Figure 4. It will be noted that when the incident light strikes the cell at a 45° angle, the generated current is still more than 50% of its normal value.

### Spectral Sensitivity

The readings of spectral sensitivity were taken on a Bausch and Lomb spectro-photometer, using a sensitive galvanometer as the current indicator. The results of this test are shown in Curve 5, where it will be seen that a broad range in blue and green is obtained. At the violet end the source was so deficient that the readings were unreliable and small errors were magnified, thus the dotted part of the curve.

The color sensitivity of the Pioneer cell is quite similar to that of the human eye, except that the peak occurs at a wave length of 6,250 Angstrom units instead of 5,550 Angstrom units as in the case of the eye.

The cell being of the self-generating type, it may be used without external voltage application, but if the object is to operate a relay, then a sensitive relay is necessary. Use of the extra voltage enables actuation of practically any of the less expensive relays, i.e., the 1,000-ohm type.

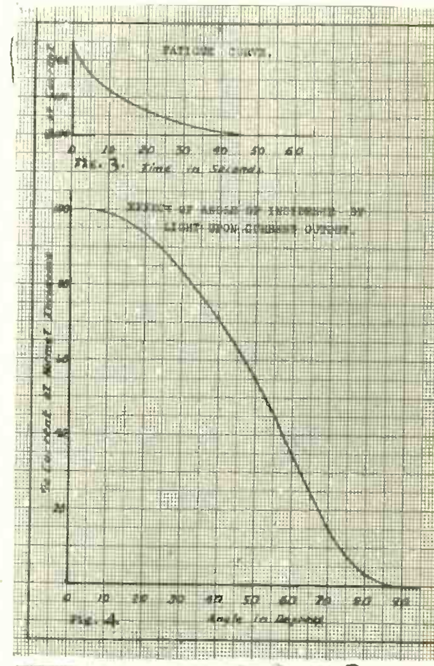



Fig. 3.

Fig. 4.

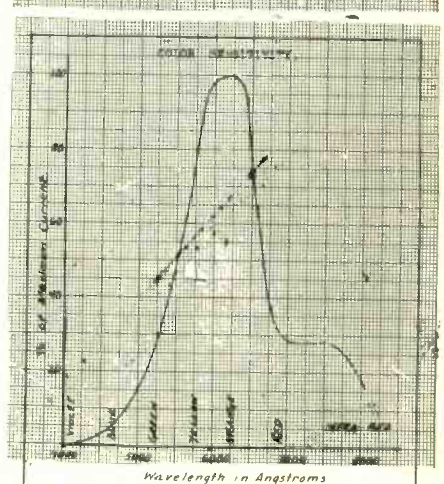



Fig 5

# Phone Dial Selects Sending Frequencies

Selecting any one of ten frequencies by merely twirling a telephone dial, waiting an instant for the dial to return and automatically put the carrier on the air, is a feature of the latest radio transmitter designed for aviation ground stations and for coastal and ocean-going vessels. The frequency shifting device resembles a miniature telephone board serving ten dial telephones. Automatic control is so complete that the user's voice may be made to put the transmitter on or off the air instantly or to shut it down completely after an interval of from one to fifteen minutes.

Any ten frequencies in the range of 2 to 18 megacycles are available and the transmitter is pre-adjusted to those desired. Shifting from one to another merely involves the redialing of a single digit. The dial controls a standard telephone selector switch which closes the proper latching relay on one of ten vertical rods.

This rod is then raised by a solenoid relay, closing the circuits to the tuning unit in each amplifier stage which has been pre-adjusted to operate on the desired frequency. The dial can be located at any convenient place, thus providing a simple and effective remote control.

Ten quartz plates, one for each frequency, maintain the carrier within .025 per cent of the assigned frequency. The transmitter, delivers from 300 to 400 watts depending upon the operating frequency, with a total input power of approximately 3500 watts and can be operated on CW, MCW or phone with 100 per cent modulation.

The system consists of two units. The rectifier unit contains a 200 volt grid bias rectifier, 800 volt and 2500 volt plate rectifiers employing mercury vapor tubes, an audio amplifier and all the control relays. The transmitter unit contains all the radio frequency generating and amplifying apparatus together with the dialing and switching mechanism. The entire equipment is completely self-contained and employs no rotating machinery, except a small fan which is used for circulating air about the power amplifier tube in the transmitter.

This equipment has been designed by Bell Telephone Laboratories for Western Electric Company for use at radio stations where it is necessary to operate on a number of different frequencies with a minimum of lost time in changing from one frequency to another.

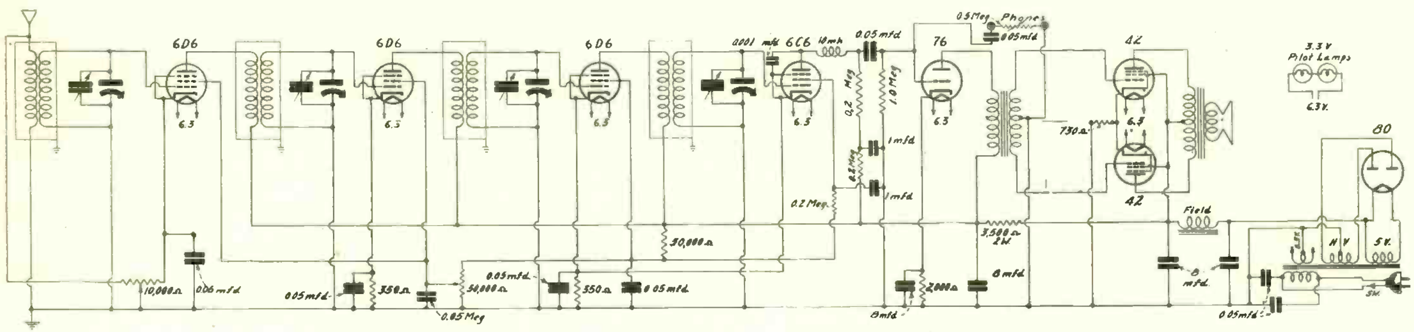
# New Government Short-Wave Station List Imminent

**The publishers of Radio World are informed that the new edition of "World Short-Wave Radiophone Transmitters," issued by the U. S. Government, Department of Commerce, Washington, D. C., will be issued this month and that copies due subscribers for this paper will be mailed as soon as possible.**

# R-F Channel Stabilization

## Other Vital Adjustments for 8-Tube T-R-F Set

*By Herman Bernard*




**High-class performance is enjoyed on this 8-tube tuned-radio frequency set built by the author. The stabilization method (potentiometer at left) may be applied to any set.**

THE tuned-radio-frequency receiver has attractions for many builders, not without reason, but there are difficulties, and on the solution of these depends the success of the receiver. There may be something amiss with the front end of a superheterodyne, such as incorrect bias, shorted screen bypass condenser, and the like, and still there will be reception, and perhaps good reception, so long as the oscillator is oscillating. The r-f level of the super may not be in adjustment, still the difference is not that between reception and non-reception at all, or even between good sensitivity and intolerably low sensitivity. With a t-r-f set it is different. Misalignment is very serious. Also, adjustment of the circuit for maximum practical attainment, encompassing not only the simple alignment but the more difficult suppression of oscillation, is rather critical. The difference between the right condition and the wrong condition is all the difference in the world. Many stations, close selectivity, high sensitivity, compared to few stations, broadness and small gain.

So with the question of oscillation suppression the builder may have his most trying moments. It has therefore been suggested that an infallible method be introduced, to render this adjustment very easy for anybody, and also to have it constitute a solution consistent with almost any type of coil, one with large or small primary. This last requirement has some limitations.

### Why the Two-Winding Coil

The simple two-winding coil is believed by the author to be more satisfactory than the type with choke coil built in, where a turn or two would be around the secondary for the capacity coupling effect, while one end of this winding went to plate, as did the choke, and the other end of this winding open, choke return to B plus. This method has its advantages, perhaps, but they seem not to be applicable to t-r-f sets as a rule, because the large inductance primary makes for broadness at the high frequencies of the broadcast band, due to the necessarily high resistance of the universally-wound choke coil. It is true that amplification is levelled somewhat, but it is also true that selectivity is made to diminish as the frequencies increase. The natural trend of any t-r-f circuit is that the selectivity decreases with increase in frequency, barring regenerative effects, and therefore a system that yields less selectivity where it will be less anyway, simply makes matters worse. Hence the two-winding coil.

The stabilization method was suggested in a note printed recently in these columns and consists of introducing a resistance network common to the cathode of the first tube and to the antenna circuit. The device used was a 10,000-ohm potentiometer, although similar devices of higher resistance may be used, 50,000 ohms probably the limit. The receiver is tuned to the highest frequency that it reaches, or to some station near that, and there will be oscillation. There should be. It is the agreeable faculty of t-r-f sets to be squealy when the set is practically finished, this being the sign of a healthy child, like the whelp or a newborn babe with lusty lungs and long expectancy of life.

### Suppression of Squeals

The potentiometer is deemed positioned for small resistance between arm and cathode, and as this arm is gradually turned there will be reached a point where there is a complete suppression of the squealing. The arm is left thus and the receiver tuned to lower frequencies, merely as verification that no squeals are present anywhere else on the dial. If a squeal appears, readjust the arm some more in the same direction as before until this last stronghold of trouble is silenced.

The receiver is now stable and will remain so. The control is shown as a potentiometer, and indeed one may be used, adjusted as directed, and left in the satisfying condition. If the arm is turned too far there will be loss of both sensitivity and selectivity. When the position is just right there will be all the selectivity and sensitivity that the system normally affords, and the additional question then crops up as to whether so much is put into the detector, due to improved conditions, as to overload it when the set is in an operating condition, and locals are tuned in. However, we shall refer to the overload question later, in more informative detail.

A few words about the simple theory of the stabilization method. First, moving the arm away from the cathode introduces more resistance between cathode and ground, the arm being grounded of course. More resistance means the negative bias is increased. Thus the working gain is reduced, but the reduction is in the direction of reception. An oscillating receiver is inconsistent with satisfactory reception in this type of circuit. Therefore anything working toward reception where there was no reception before is in the nature of a gain. This is one of the instances where the gain is achieved by taking a loss. Stock market players will appreciate perhaps that this is possible. Radio technicians know it from their own experience with sets.

### Why Resistance Increases

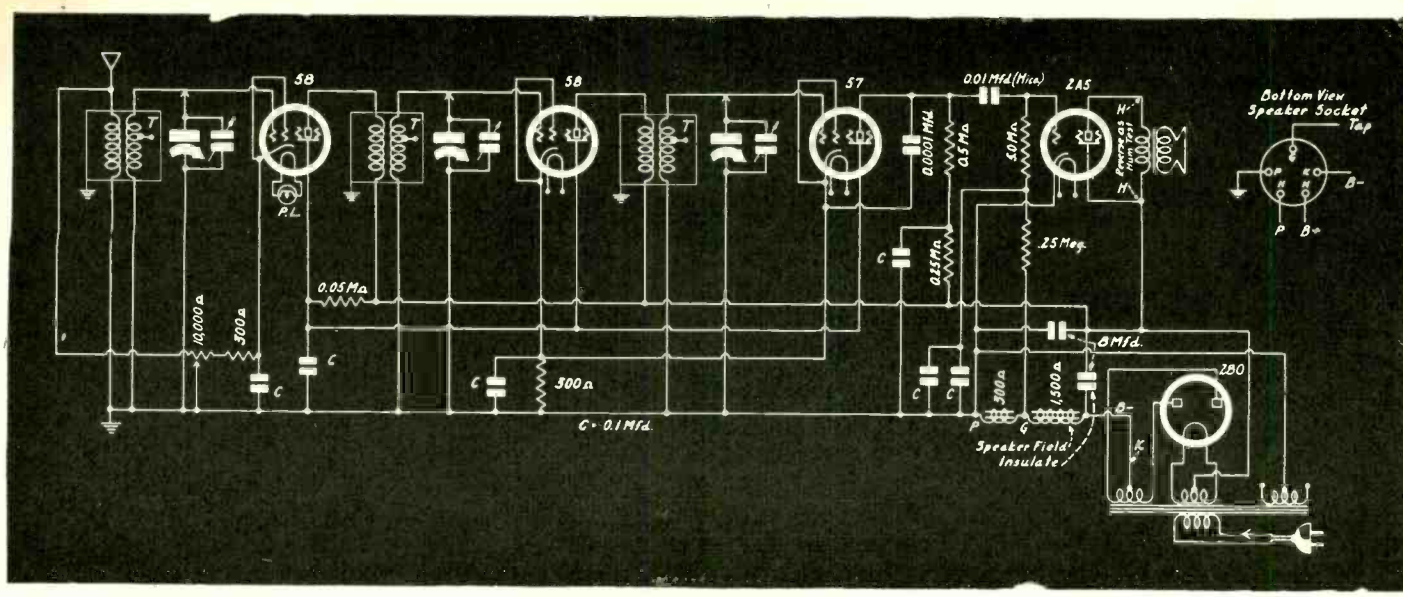
At the same time that the negative bias on the first tube is being increased the resistance across the antenna winding is being decreased. The condition of oscillation may be expressed as one which results in too little resistance in the tuning channel. Reducing the value of a parallel resistance across a tuning coil's primary or secondary is the equivalent of increasing the resistance in the circuit so far as radio frequencies are concerned. This is true because the impedance of the coil depends considerably on the value of the d-c resistance, and the lower this resistance, the lower the impedance. The lower the parallel resistance across a tuned circuit or its coupling coil, the higher the equivalent series resistance in the tuned circuit, since there is lower impedance in either instance (reduced parallel resistance or increased series resistance). Indeed, there is a precise formula for converting the parallel value to the equivalent series value, and vice versa. Hence by decreasing resistance, in a d-c sense, we increase the tuned-circuit resistance, in an r-f sense, and by using less get more, just as we established a gain by taking a loss. Anomalies like that are the daily meat of radio technique.

### As Sensitive as a Super

It is obvious that there is a point at which the two considerations meet, when the bias is made sufficiently high, in the light of the new resistance confronting the tuned circuit through the coupling to the antenna coil, since the two considerations start from one extreme, oscillation, and move in the same direction, toward stabilization. It is this meeting point that we establish by potentiometer adjustment. And, as intimated, the method is applicable to practically any t-r-f set, the one diagramed on this page, or to any other.

When the correct position is established there will be sensitivity comparable to that of a superheterodyne, indeed, equal to that of any superheterodyne that is

*(Continued on next page)*




**The stabilization method is derived from the volume con trol method common to some small t-r-f sets, and was thought of because the stabilization point was found often in the circuit shown above.**

(*Continued from preceding page*)
worked above the noise level. It is easy indeed to get down to the noise level with the eight-tube t-r-f set diagramed. A simple way to move up from the noise level is to lengthen the antenna, but this requires special consideration, and will be treated presently.

There is nothing to bar the t-r-f set from affording fullest practical sensitivity, regardless of the type of receiver with which it is compared, but there is a limitation on the amount of practical selectivity attainable. This arises from the necessity of using a four-gang condenser to tune the required circuits for utmost selectivity, the impossibility of perfect identity of capacity at any and all settings, no matter what trimming is done, and unlikelihood that the coils will be so precisely matched that if the condenser were true all the way the trimming would take care of the capacity vagaries arising from wiring, tubes, etc., and other similar factors.

The condition is necessarily imposed that we are limited in selectivity, hence have not a free hand or a wide berth. So we look to the antenna system. We know that a short antenna makes for greater selectivity, because it constitutes looser coupling between the receiver and the transmitting stations, and all forms of decreased coupling (other resistance factors unchanged) make for increased selectivity. Therefore though we could move back to above the noise level using a receiver of the t-r-f type that obligingly reaches that level, by lengthening the antenna, we would not care to adopt that remedy incautiously, because we might be reducing selectivity too much. So we use a short antenna.

The 8-tube receiver shown has been operating for a few months in the author's home on a piece of wire only long enough to reach from the receiver to the floor, and still the lowest frequency local station, WMCA, 570 kc, comes in strong. This fact is mentioned in support of the assertion that the gain is tremendous, for poorly-prepared t-r-f sets usually will produce very feeble response at the low-frequency end of the dial.

## Antenna Resistance

This is therefore a good test. After the set is stabilized, test out on a low frequency. In New York City this might be done for both WMCA (570 kc) and WEAF (660 kc). The antenna may be made a bit longer, say, six feet or so, if needed to bolster up low-frequency tuning, but selectivity checked up to determine whether the antenna is too long.

The stabilization method outlined should be applied when the antenna is the very one you intend to keep in operation, say six feet, because decreasing the antenna length decreases the r-f resistance, or lengthening the antenna increases the resistance, another verification of the fact that short antenna make for high selectivity.

It may not be possible to maintain so-called 10 kc selectivity all over the dial. In the first instance, 10 kc selectivity has no significance. The expression states nothing about the input delivered to the antenna by the two stations 10 kc apart that are being compared, and the practical selectivity will of course depend very largely on these values of input. If a strong local is to be compared to a medium-strong DX station, it would be possible to enjoy reception from the DX station, although not without some show of interference (not much) from the local. The tested example was that of WOR, 710 kc, compared to WLW, 700 kc. It was easy to enjoy and fully understand the WLW program, but there was a background sound suggesting that WLW was not the only station on the air, and indeed it wasn't, for there was WOR going strong, only 10 kc away. Many supers having ten tubes do no better.

The selectivity may not be constant. If the stabilization is properly done the greatest selectivity may be expected in the middle of the band, roughly, from 800 to 1,100 kc, with somewhat less at the two ends, less at the high-frequency end because regeneration, of which there will be some present, does not quite nullify the natural increase in tuned-circuit resistance with frequency, and less selectivity at the low end because the regenerative action becomes practically nothing.

## Realities from Experience

These facts are set forth as realities determined from a receiver actually built and tested and providing what the author considers quite satisfactory reception from all viewpoints. The only additional suggestion he would make is that some might want to replace the potentiometer with fixed resistors, and may do so by measuring the resistance between arm and one extreme, and between arm and the other extreme, with the potentiometer completely disconnected from circuit, and then introducing the necessary fixed values of resistance to replace the potentiometer network. This is particularly apropos since the chassis may have no provision for retention of the stabilization potentiometer.

The potentiometer farther to the right is the one used for volume control, the screen voltage on the first and second r-f tubes being varied. This method is acceptable with the type of tubes shown in the 8-tube set, because the potential difference between screen and cathode is maintained practically constant, owing to the current change effected by the screen voltage change. The same applies to the 58 and 57 tubes, which may replace the 6D6 and 6C6 at 2.5-volt heater feed, the driver being a 56.

It is necessary to have the volume control ahead of the detector so that the detector will not be overloaded. Of course the detector could be so treated that on the loudest local signal it did not overload, but then the sensitivity would be reduced, and tone would be injured, because there would not be enough signal on any save reception of loudest locals to buck the bias sufficiently, hence there would be too much operation near the cutoff end of the plate current characteristic.

## Key to Detector Overload

The values imprinted may be taken as recommended, for satisfactory reception under any conditions, save the severest. Where some local or locals are very, very strong; the negative bias may be lifted a bit by putting a resistance of 1,000 to 2,000 ohms between detector cathode and the cathode of the r-f tube ahead of detector, and running a bypassing condenser from detector cathode to ground. This condenser may have practically any value, say, 0.05 mfd. as minimum. The reason a small value is practical is that there is audio regeneration in the circuit.

Detector overload is evidenced by tuning in the strong station at two points close together, practically silence in between. Increase the resistance between the two cathodes until this trouble is stopped. Cross-modulation will not be present, since the first tube's bias is high.

The diagram of the 8-tube set represents a few improvements over the diagram printed in the December 29th issue, including now the simplified stabilization, method, some more B filtration, by adding an 8 mfd. condenser and a resistor in the detector plate circuit, and giving the detector screen a better voltaging condition for quality detection.

By the way, the quality is particularly good for a pentode output. The push-
(*Continued on next page*)

# Wave Velocity Varies Much

## New Finding Upsets Established Technique

### *By A. F. Lee*

DURING the early days the term of wavelength, in meters, was quite commonly heard. Since it was a fundamental unit, no discussion of radio was possible without its mention. However, as time went on and the science became more clearly understood, the term wavelength soon was recognized as inadequate and misleading. This was so since wavelength could not be actually measured in physical length in feet or meters. Also it was quite dependent on the velocity of the radio wave, which varies between fairly wide limits. Besides, absolute wavelength differences had no significance unless the wavelengths between which the difference existed were expressed numerically.

On the other hand, the frequency of the rapid radio-frequency oscillations were readily measurable and controllable and the term frequency soon displaced the term wavelength.

**The No. 1 Formula of Radio**

It is conceivable that the wavelength of a radio wave is more readily visualized than its frequency and so it is that this term was used at first in preference to frequency. Since wavelength and frequncy are reciprocal units, one or the other could be used for the purpose and the simplicity of visualization of wavelength caused its general adoption. But, as has been indicated above, later developments have shown the inadvisability of using this term.

The reciprocal relationship between wavelength and frequency is such that the wavelength is equal to the velocity of the radio wave divided by the frequency. Or, to put it in terms of a formula:

$$\lambda = \frac{V}{f}$$

This is quite a simple formula on its face and is the number one formula in radio. Though it contains but three factors, one of them is difficult to appreciate. That is the velocity of the radio wave. Many have been the attempts to measure the velocity of a radio wave and for a long time it was accepted as being 186,000 miles per second, or 300,000,000 meters per second. But, the inevitability of progress doomed this value as incorrect and subsequent measurements of greater accuracy revealed this velocity value to be in the region of 184,000 miles per second or 299,820,000 meters per second. It can thus be seen that tables of wavelength-frequency conversions on the basis of 300,000,000 meters/second were inaccurate and that they were in need of revision upon the basis of this new velocity figure. This wholesale change indicated very vividly that the term wavelength was not at all satisfactory.

**Velocity Found to Vary**

Now we come to the new year of 1935 and we find that this table is again inaccurate. For, at a recent meeting of the American Association for the Advancement of Science, in Pittsburgh, Pa., Dr. Harlan T. Stetson announced that he has measured the velocity of radio waves and has found that sometimes radio waves vary greatly in their velocity even to the extent of half the former accepted figure, or 93,000 miles per second. What an unheaval this causes in our wavelength technique. More clearly does the treachery of wavelength shine forth. It can no longer be trusted to give us a clear picture of a radio wave, and so we should discard it now. Frequency should now be used to depict the resonance characteristics of a radio wave.

**Geographical Upset, Too**

Dr. Stetson further states that he believes this changing feature of a radio wave's velocity to be due to the fact the nearer the path of the radio waves to the earth's north magnetic pole, the more will the wave be retarded in its speed. Since the electro-magnetic wave's velocity depends upon the electronic density of the conducting medium, it is believed that conditions in the earth's ionosphere are materially affected by the pattern of the earth's magnetic field.

Though this new announcement by Dr. Stetson affects radio quite seriously, it does not stop there. Our understanding as to how wide the Atlantic Ocean is and as to just where the various cities on our earth are located with respect to each other becomes almost as uncertain as in the days of Columbus.

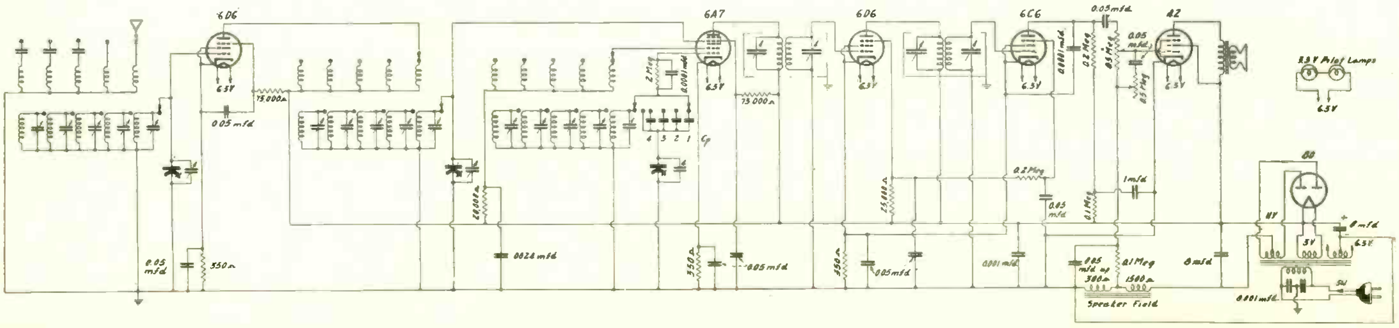
# How to Improve Low-Note Response

(*Continued from preceding page*)

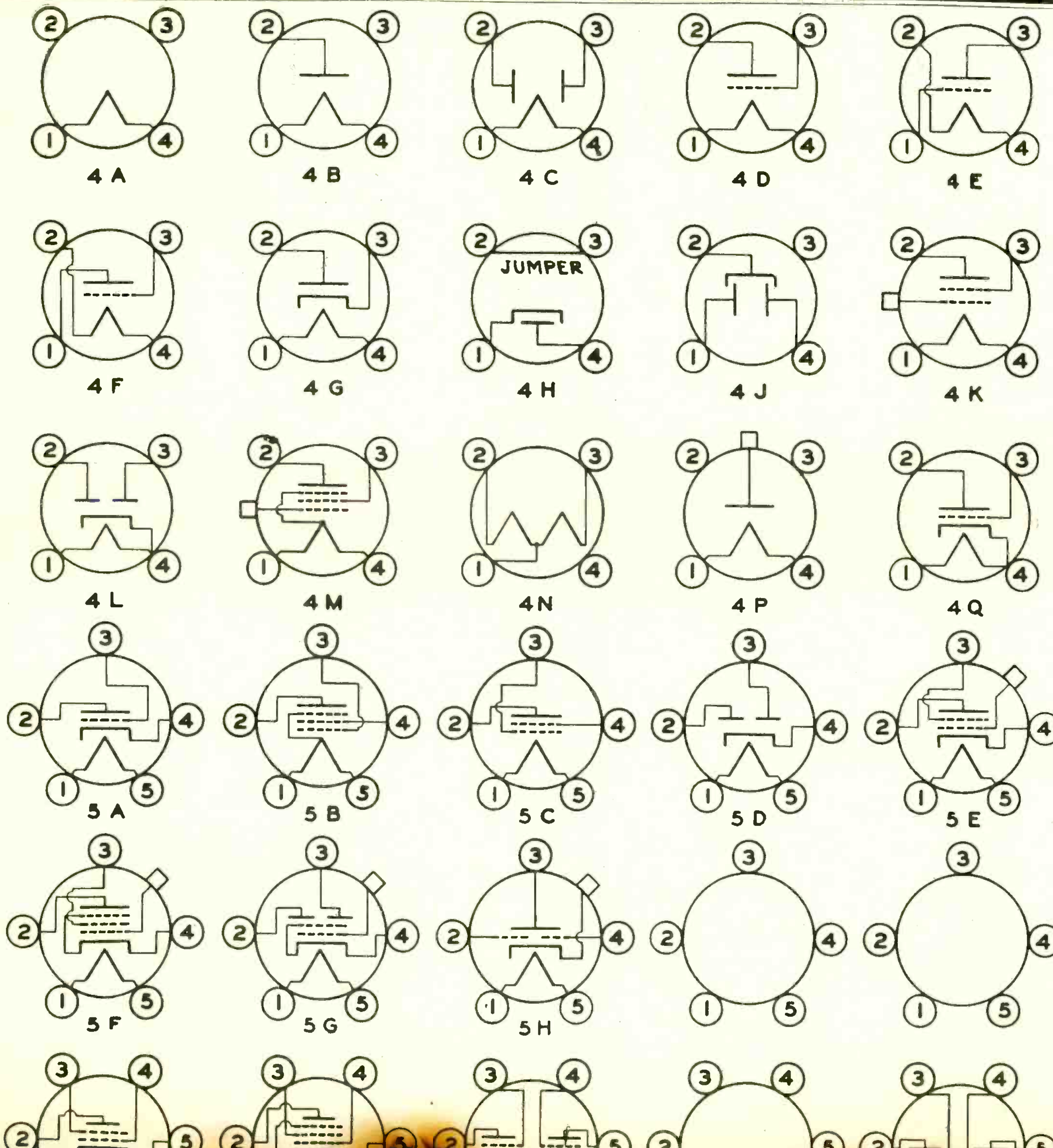
pull stage is unusual, in that the screen grid tubes are used in Class AB-1, as pentodes. The usual case is that of such tubes such as triodes, but far more will be taken out this way, in quantity of sound, and of course sensitivity is an important consideration, and thus ably aided. The plate voltage measured between cathode and B plus after the choke through which all B current flows should not be less than 300 volts. Actually, 350 volts were used. The negative bias will run around 40 to 50 volts, and may be adjusted by biasing resistor change, until the low-note response is strongest in the speaker.

An easy way to get a desirable low note for this test is to return the grid of the first r-f tube to one side of the heater instead of to ground, and then hear the hum in the speaker. Alteration of the bias for is thereupon performed until the hum is heard loudest, within some reasonably low limit of bias, say, not less than 30 volts, although the upper limit may be determined exclusively on response, and without regard to C voltage. This method is simply the application of practically the only way that one can attain improved matching between output and a given load (the speaker transformer), and consists of alteration of the a-c resistance of the output to a point where greatest low-note energy transfer is established. This frequency is selected because in the low-note region the greatest speaker sluggishness may be expected, hence the test is made in a manner to bring out the most pronounced difference.

The value of 730 ohms for push-pull biasing was not selected not because it is the same as the value recommended for the same output tubes in Class AB, but because the previous test was made, which determined the selection. The speaker transformer was rated as one with 5,000 ohms primary load, plate to plate, but observations indicate that the ohms load must have been somewhat higher. However, the test allows for matching of the tubes to speakers of quite different ohms load output ratings and often spares a replacement.




**Here is an all-wave six-tube superheterodyne. Considering the broadcast band, the 8-tube tuned-radio-frequency circuit, page 9, is more sensitive than the above.**




# NEW TUBE DATA

*By Harry Murman*

THE general standards committee of Radio Manufacturers Association has adopted new tube standards. These provide for the designation of types of receiving tube bases and pins by a system of three digits. The first digit is a number indicating the quantity of base pins. The second figure is a letter indicating the size and type of base shell. The third digit is a letter indicating the pin arrangement.

Hence, pins, shell and arrangement or sequence of pins comprise the foundation of the system.

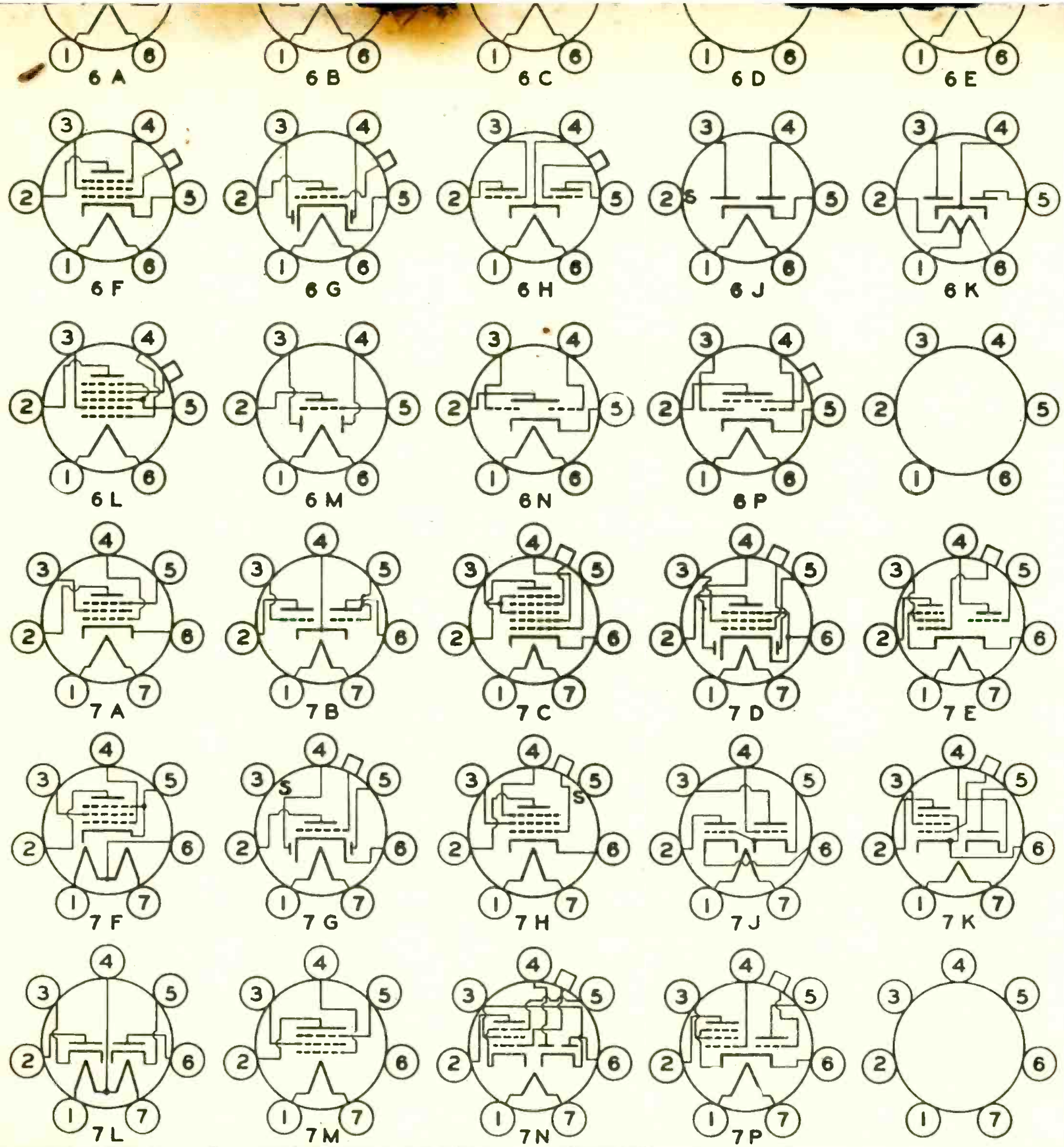
The first diagram shows the shells by their letters from A to H, and of course the system permits of additional letter designations for any other type shells that may be introduced, up to 18 more, without duplicating any letter of the alphabet, whereas letters could be doubled up thereafter, if any such necessity should ever arise.

## New Use for Letter Designators

The second illustration shows the number of pins, accounting for the present conditions of four, five, six, and seven pins.

The third consideration, location of the pins, alphabetical, is illustrated in the third engraving, socket or tube base deemed viewed from the bottom, that is, with pins upward, and heater or filament pins nearest you, with tube parallel to your body.

This is entirely new and causes letters to denote the elements, being additional to the present numerical values of elements, where positive filament or equivalent heater outlet has designation 1, and, the rotation being from right to left, plate is almost invariably 2, the rest of the numbers changing in significance depending on the type of tube, but not chang




enotation of relative position. This is the same what now prevails, but the alphabetical classification is carried forward to a greater point of service, where the last letter discloses the actual element disposition as regards to terminals. The overhead grid outlets are given recognition as to presence, although not being ascribed any number, as none is necessary. The position of such an outlet, where it is present, is always the same, with tubes as they exist to-day.

The existing range for the pin sequence comprises a tube with two outlets, whether these represent one element or two elements, to the tube with eight outlets, where seven are represented by pins and the eighth element or connection is the overhead grid. In general there exist elements numbering one fewer than the numerical designations, because a single element, the heater or filament, requires two connections, two pins, two numbers.

## Seventy Tubes Already

No addition has been made to the existing 1-to-7 listing for an eight-pin type tube. At present no such tube exists. There was some talk last year about one being imminent, but since then no new tube has been generally announced, except the 955, which is a short-wave specialty tube, and besides does not fall into the prophesied classification, being a triode of the heater type. Since the members of the committee are closely in touch with industrial aspects of tube companies, and since no 8-pin base is provided for, although it could be by simple extension of the system, it is believed that there is no impending likelihood whatever of such a tube being announced.

At present there are seventy standard tubes for receivers, not including the 955, which is for short-wave use only, and especially is for experimental use and in that sense not regarded as standard. The trade and experimenters have found it difficult to remember all the tubes, even as to identities, much more so as to purposes and pins. Perhaps it is to aid both that the bases have been given numerical and alphabetical designations in the past, and the present effort is to introduce a majority-rule system that is all-inclusive, rather than the plan of one manufacturer

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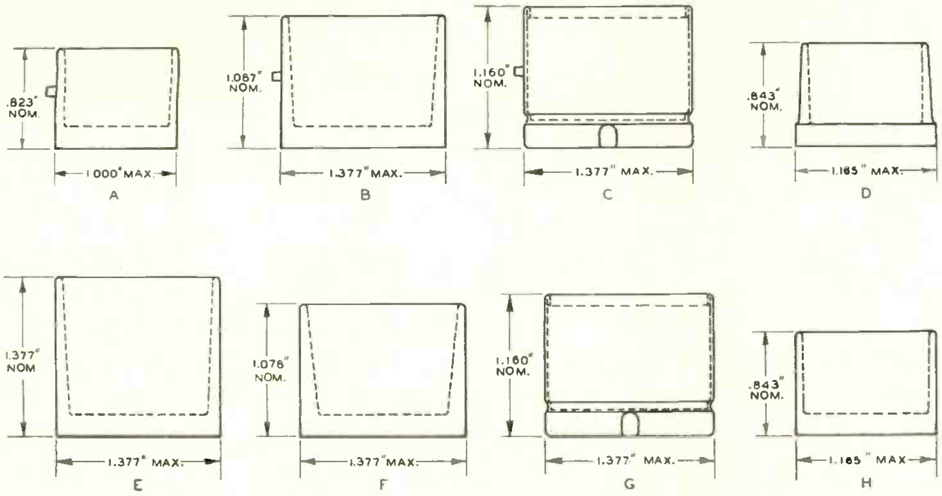
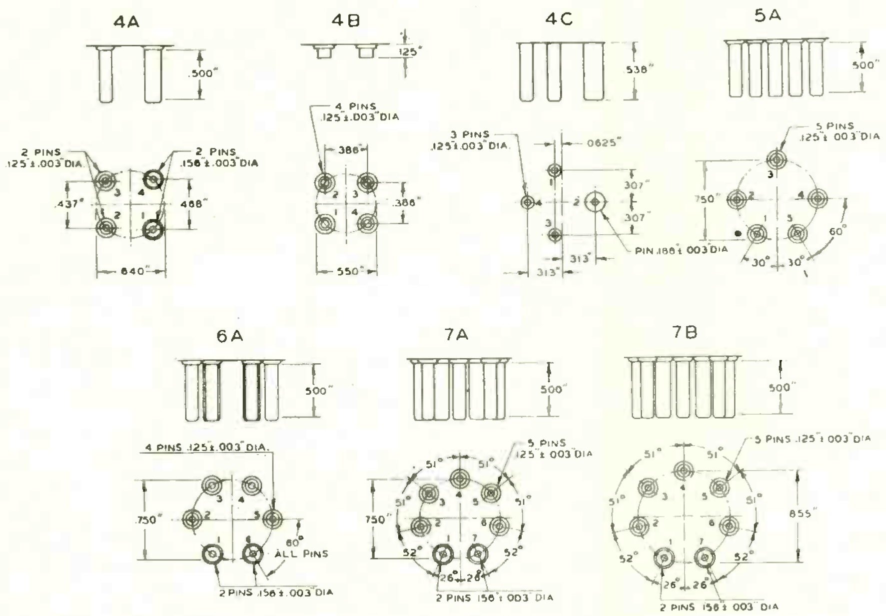
**The third designation, a letter, is entirely new and identifies the relative position of the terminals of elements. This in a sense introduces purpose for the first time in general tube designation.**

# New Tube Designations




**A digit, consisting of a letter, is used to designate the size and type of base shell of tubes in the new set of standards approved by a committee of Radio Manufacturers Association. The eight different types of bases are thus accommodated to this standard as shown in the illustration.**




**The designation selected concerning the number of pins is of course a number, used as a suffix. Thus we have, as shown in the illustration, four-pin, five-pin bases, etc., and the angular disposition thereof within the specified diameters. Selection of right socket is simplified, where different type tubes having the same number of pins but requiring different diameters for pin assembly are concerned.**

*(Continued from preceding page)*
that has to be duplicated by other manufacturers for retention of consistency, due to the peculiarly precarious condition of the tube industry in point of standards.

### "End Letters" Important

The adoption of a simple set of standards therefore was considered advisable, in that the designations would reveal considerable about the tube, other than the full details of purpose of the tube itself.

Numerical designation of the pins, not changed by the new proposals, is most important to most persons who wire sets and experiment with tubes generally, so that the elements may be allocated by their numbers, as well as the socket requirements being revealed.

However, there are some instances where the number of holes does not reveal the desired information, as at least two different types of sockets are required for different tubes having the same number of pins. For instance, the 99 and the 80, the 59 and the 2A7. In such instances the base designation added to the pin information gives the principal data for socket selection.

It is but a step from numerical designations for pin positions to alphabetical designations for given pin locations. Thus if a tube has five pins the first digit is 5. The socket required is found in the next digit, a letter. So 5A acquires significance. However, the five pins may be disposed exactly the same, yet the purposes differ. Hence the "end letter" clears up this point. The arrangement for the 56 would be: 1, heater; 2, plate; 3, grid; 4, cathode; 5, heater. The arrangement for the 35 would be: 1, heater; 2, plate; 3, screen; 4, cathode; 5, heater (no number for overhead grid). The end letter distinguishes these two: A for the 56, E for the 35. So for the first time there will be purpose disclosure as to elements in the tube designations, 5AA, 5AE, etc.



# Bone Conduction Device for Hearing Made by W. E.

A bone conduction type of receiver has been added to the hearing aid equipment produced by the Western Electric Company and designed by Bell Telephone Laboratories. The entire receiver weighs slightly over half an ounce and is 11/16 inches wide, 1-5/16 inches long and a maximum of 9/16 inches deep. The case is made of phenol plastic material.

The receiver, worn just back of the ear against the mastoid process, has been designed to give a large area of contact with the head at that point. The contour of the contact surface is based upon scores of impressions taken from different heads.

The receiver employs an armature fixed to the contact surface and a bi-polar magnet of high efficiency. As the magnetic field fluctuates with the flow of current through the microphone, the inertia of the magnet causes the receiver to vibrate and the contact surface transmits the vibrations to the bones of the head. The vibrations are picked up directly by the cochlea of the inner ear, thus by-passing certain organs of hearing through which sound normally enters. In cases where these organs have been impaired by illness or accident, the bone conduction receiver is of particular assistance. In other instances of impaired hearing, it has the advantage of leaving the ear open to function together with the receiver.

The bone conduction receiver transmits virtually the entire audible range of sound. It fits onto a tiny plug at the end of the transmission cord and can be used interchangeably with the air conduction type of receiver.

### MORE JERSEY POLICE RADIO

The police activities of the city of Jersey City, N. J., are to be materially enhanced by new licenses to operate twelve mobile transmitter units with a power of 4½ watts on the frequencies, 30100, 33100, 37100, 40100, 86000 to 400000, and 401000 and above. By this means their police radio cars may be equipped with transmitters in addition to receivers.

# The Comparison of Receivers

## Overall Measurements of Sensitivity Form a Definite Comparative Figure

*By H. F. Traymore*

IN all the measurements of the various aspects of radio receivers, the aim is ultimately to obtain a characteristic which is representative of the behavior of the entire set. Such an ultimate measurement is the most important of all the analyses that can be made of a receiver. At the same time this investigation is the most difficult of the many tests that may be applied to a receiver in a determination of its qualities and quantities. The difficulty is incurred by the fact that the output quantities are practically always very large compared to the input quantities. This involves the danger of the slightest form of coupling between these stages introduced by the measuring equipment which will tend to alter the behavior of the receiver.

Since the early days of radio, receiver performance has always been a moot point. Many a fan has stated that his receiver would do such and such—statements that have had as much foundation in fact as the most ficticious of fiction. The only really acceptable quantitative statements as regarded receiver performance that were made were based upon actual measurement of this performance.

### Not a Cumulative Matter

All early attempts to obtain the overall characteristics of a receiver made use of the assumption that the overall performance could be designated in terms of the product of the performances of the separate parts of the equipment. If it were assumed that this were true, the problem would be simple. However, it is an unfortunate fact that the effects duc to the input impedance of an amplifier stage and due to various forms of regeneration render this assumption unjustifiable except in the very simplest cases.

Because the frequency at the antenna end of a receiver is quite different from the frequency at the output end, and because of the large stop-up ratio and the regenerative effects, no form of substitution, bridge or comparison method is admissible. It is accordingly necessary that the input be supplied with an artificially generated signal, the form of which is identical with the actual signals with which the receiver might be supplied under ordinary conditions of usage. The relatively large output must be measured by a method which in no way disturbs the normal operating functions of the receiver.

### Input Voltage Methods

In the performance of this investigation the problem of applying a known voltage to the antenna stage of the receiver may be solved in any one of four ways that have been compiled by the Radio Research Board of the Department of Scientific and Industrial Research, London, England:

(1) By inducing the known voltage into the main tuning inductance while permitting this inductance to act as the secondary circuit of a known mutual inductance, and in which the primary current is known.

(2) By passing a known current through a condenser of known value which forms part of the tuning capacity.

(3) By inserting a small non-inductive resistance or a small known inductance in series with the tuned circuit, carrying a known current, by which means a known voltage is applied.

(4) By using a current transformer and potentiometer such as a Dye transformer, or an attenuator having known properties.

It is further stated that the first of these methods has been used to some extent and that it involves the measurement of a mutual inductance of large amount at radio frequencies. Since it is not easily possible to obtain this information with any accuracy, this method becomes unsatisfactory from this aspect. Another difficulty is incurred by the fact that the tuning circuit of the receiver must always include, or consist of, this secondary circuit of the calibrated mutual inductance. Accordingly, this method becomes inapplicable as a general method of testing receivers in which the tuned circuit forms part of the complete receiver.

### Output Range Limited

The second method utilizes a condenser in the tuning circuit. The size of this condenser is dictated by the frequency range of the receiver and since the voltage that is introduced into the set can be controlled only by the current passing through this condenser, the possible range of input voltage is limited. For the smallest measurable radio frequency current, the size of this condenser must be quite large in order that the voltage developed across it be of the suitable amount.

In the third method, a small resistance or inductance is inserted into the tuned circuit of the receiver whereby the known voltage may be impressed upon the circuit. This method has been adopted to a greater extent than the previous methods due to its greater applicability and its comparative freedom from frequency limitations. Small non-inductance resistances can be made within fairly wide limits with a good degree of accuracy and together with a reasonable range of current, so the method becomes applicable to most practical cases. This method, which has given the most consistent results, adopts the potentiometer idea for feeding the input circuit with a known voltage, while measurement of the output of the set is accomplished through a vacuu mtube voltmeter.

A radio-frequency voltage that is modulated at a percentage that is known, by a known audio frequency, is supplied to the input potentiometer. The aspects of this voltage at the output end are then measured to determine the effect upon it as it passed through the various stages of the receiver.

In this analysis it is imperative that the direct magnetic and electric fields from the oscillator be very carefully screened in order that unwanted effects be not introduced. This will involve screening of the leads even up to the potentiometer itself. Usually this procedure is further protected by means of its practice in a completely shielded room. It is also important that the amplifier be shielded to prevent induction from unknown soudces. Refinements in this measurement are dependent upon the perfection of these screens and nothing very far from complete shielding will be found worth-while. In the best design, even the potentiometer itself is shielded. This takes the form of a straight resistance wire with a concentric return, by means of which complete shielding is available. If the resistance wire is tapped at various points, known voltages of various amounts may be obtained. At very high frequencies, it is important that the current through the potentiometer wire be measured at a point as near to the tapping point as possible, from which it would appear that this apparatus has an upper frequency limitation.

Another precaution involves the connection of amplifier filaments. It should be stated here that if these filaments are connected to the junction of the potentiometer resistance wire, and the concentric return, the batteries will be virtually at ground potential, which condition is required for normal operation of the receiver. It is quite important that this condition be adhered to, since the capacities to earth might otherwise be such as to modify the receiver's performance. If the amplification in the receiver is very large, the length of even a short piece of resistance wire becomes too great and it is then necessary to replace this wire by a copper wire whose inductance may be computed. A. W. Hull has succeeded in producing such arrangements for amplifications up to 2,000,000 at a frequency of 1000 kc.

### Current Reduction

The fourth method makes use of some means of reducing the current applied to the input potentiometer by a known amount. The current transformer designed by D. W. Dye is suitable for this purpose. The method involves a current transformer in conjunction with a potentiometer to obtain small known voltages at radio frequencies. By suitably designing the iron path of the transformer, the ratio is accurate at these frequencies, provided the resistance load across the secondary obeys certain conditions A current reduction of 100:1 is easily obtained by this instrument and by suitable turn ratios, a large range of voltage can be given with a limited primary current range.

Efforts to ascertain the dependability of the various methods outlined above have indicated that the last two methods are most likely to yield consistent results.

In the adaptation of these methods to actual practice, it has been found that the factors that limit accuracy are:

(1) It is quite impossible to measure the effective impedance of the input potentiometer. Accordingly, this value has to be conjectured theoretically. However, the possibilities of error in this determination are small.

(2) It is difficult to measure the current existing in the potentiometer at very high radio frequencies. At present, a non-contact thermo-junction ammeter is used, and the assumption is made that its direct current calibration is valid at all frequencies. A better method of measuring the very high frequency currents would naturally improve the accuracy of measurements at such frequencies.

# New Plant De Luxe at WOR

## 50,000-Watt Transmitter About to Take Air

*By G. W. Johnstone*

WITH the soundproof building completed, sixty per cent of the antenna installed and eight per cent of the transformers ready for use, WOR's giant 50,000-watt transmitter now being erected in the East Rahway section of Carteret, N. J., will be ready for use in a few days. Installation of power apparatus in the basement and completion of the setting up of transmitter panels on the main floor is practically all that remains to be done.

It is expected that the new station, which is housed in a windowless building, soundproof and waterproof, will be the last word in construction. It will include every station improvement that has been developed by the Bell Laboratories. The cost of the plant will exceed $200,000.

The principal transmitter, which will broadcast programs sent by special telephone wires from the New York and Newark studios, is completely installed. Later a special short-wave transmitter will be installed, especially capable of sending to or receiving from Europe and South America.

### Theories Get a Jolt

Many innovations have been planned—innovations to prove or disprove theories or sophistries that have cropped up since broadcasting began. These have to do with the effects of high-frequency radiation on atmospheric conditions. Apparatus will be installed to keep complete records of humidity and rainfall on the transmitter site, as well as in the surrounding area, over a long period of time, to make possible an adequate comparison with the available records for the country.

It is pointed out that while little credence is given the arguments advanced in periods of unusual weather conditions that broadcasting causes droughts or cloudbursts depending upon which the complaint or amateur theorist has been suffering from, no tabulations have been made over extended periods to provide bases for refutation.

### An Agricultural Experiment

Personnel at the transmitter will be periodically weighed and will be examined as to eyesight and hearing with a view to determining the effects of high-frequency radiation.

Plans have been discussed with faculty members of the New Jersey College of Agriculture to study the effects on plant growth as well as plant and animal parasites. The area under the antenna system is to be planted with decorative and edible plants.

Similar crops are to sown outside the influence of the radiation and will be given exactly the same treatment. This will be in the nature of an experiment to determine if there are any beneficial effects.

The transmitter building when all installations are completed will house not only the 50,000-watt transmitter but also the present 5,000-watt unit now being heard from Kearny, which will be used as an auxiliary. In addition there will be the set that will flash radio beacons of warning to airplanes flying in the vicinity and a short wave transmitter.

The antenna system consists of twin towers, 385 feet high and some 750 feet apart. Nearly 40 miles of copper wire forming the ground system have been placed in trenches and covered with earth. One of the towers is located in Woodridge and the other in Carteret.

WOR's holdings amount to 35 acres.

### $12,000 Worth of Tubes

Everything in the way of power about the plant will be on a dual basis, automatically connected so that if one fails the other goes into operation instantly. This insures no delay from power failures, such as was recently occasioned when a ship's anchor tore a cable apart in the river near the present transmitter. There are two main power supply cables, each carrying 4,150 volts. One emanates from Carteret the other from Rahway. If the Public Service Carteret line should go dead the Rahway line will instantly be switched into service.

The main transmitter itself will have $12,000 worth of vacuum tubes cooled by a water circulatory system. Though somewhat similar to tubes used in receiving sets, each tube costs $300 to $450 more.

Eight radio experts will be stationed in the control room at all times, all of them behind glass partitions.

There are no windows in the transmitter building and in addition to being scientifically illuminated, it will have the latest in air conditioning systems. Other scientific equipment will be "cold" cooking; that is the engineers will be able to place an egg in a high frequency field and "boil" it to the queen's taste. Electric stoves will be available for those who will take their meals in the more prosaic manner. Moisture creates havoc in transmitter plants and to avoid any possibility of trouble from this sort, the building has extra thick walls with four inches of rock wool, a sound deadening material, as additional factors of safety.

### Tri-Vertical Array

Broadcasts that have heretofore originated at Newark under the auspices of Rutgers University or the New Jersey College of Agriculture will be put on the air from Carteret where a studio designed especially for broadcasts from that point has been constructed.

Visiting will be permitted at the plant when broadcasting starts, which station executives believe will be some time in January.

WOR's antenna system embodies latest engineering principles for getting maximum efficiency in coverage. Although in appearance, it is like the conventional antenna having two towers, a "flat top" section and a lead-in, this in reality is an array of three vertical antennas which concentrate the signal in the areas where good coverage is essential and decrease it toward the ocean and the sparsely populated areas in the opposite direction. Engineered into this arrangement is the new and efficient concentric transmission line and a novel set of antenna coupling units.

### Novel Features

Having studios at both Newark and New York, WOR is equipped with duplicate station speech input equipment which is composed of the latest high quality Western Electric apparatus and which incorporates elaborate and novel control features. It has a tremendous advantage in that the two channels are interchangeable and this means that WOR will have a spare speech input channel in the event trouble develops on one.

## 10,000,000-Volt Crash Now "Voice" of W2XAF

Schenectady, N. Y.

The most powerful voice in the world made its radio debut when W2XAF, the experimental short-wave station of the General Electric Company, took the air with a new signature. The "voice" was that of 10,000,000 volts of artificial lightning. It will sing three crashing bars at the beginning and end of every short-wave broadcast hereafter, signifying that Schenectady, where the late Charles P. Steinmetz competed with nature by manufacturing his own thunderbolts, is on the air.

Although the high-voltage laboratories of General Electric are now located at Pittsfield, Mass., Schenectady with its research laboratory is still the focal point of the company's scientific endeavors, and it was thought fitting that the "voice of electricity" should in the future greet short-wave radio listeners who think they have heard about every conceivable kind of theme song. Therefore the characteristic crash of the recorded high-voltage arc will announce W2XAF in Australia, Little America, South America, and other far-flung listening points.

## Subscribers! Important!

**Note subscription expiration date on wrapper containing your copy of RADIO WORLD. If nearing expiration date, please send in renewal so that you will not miss any copies. Subscription Dept., RADIO WORLD, 145 W. 45th St., New York City.**

## A THOUGHT FOR THE WEEK

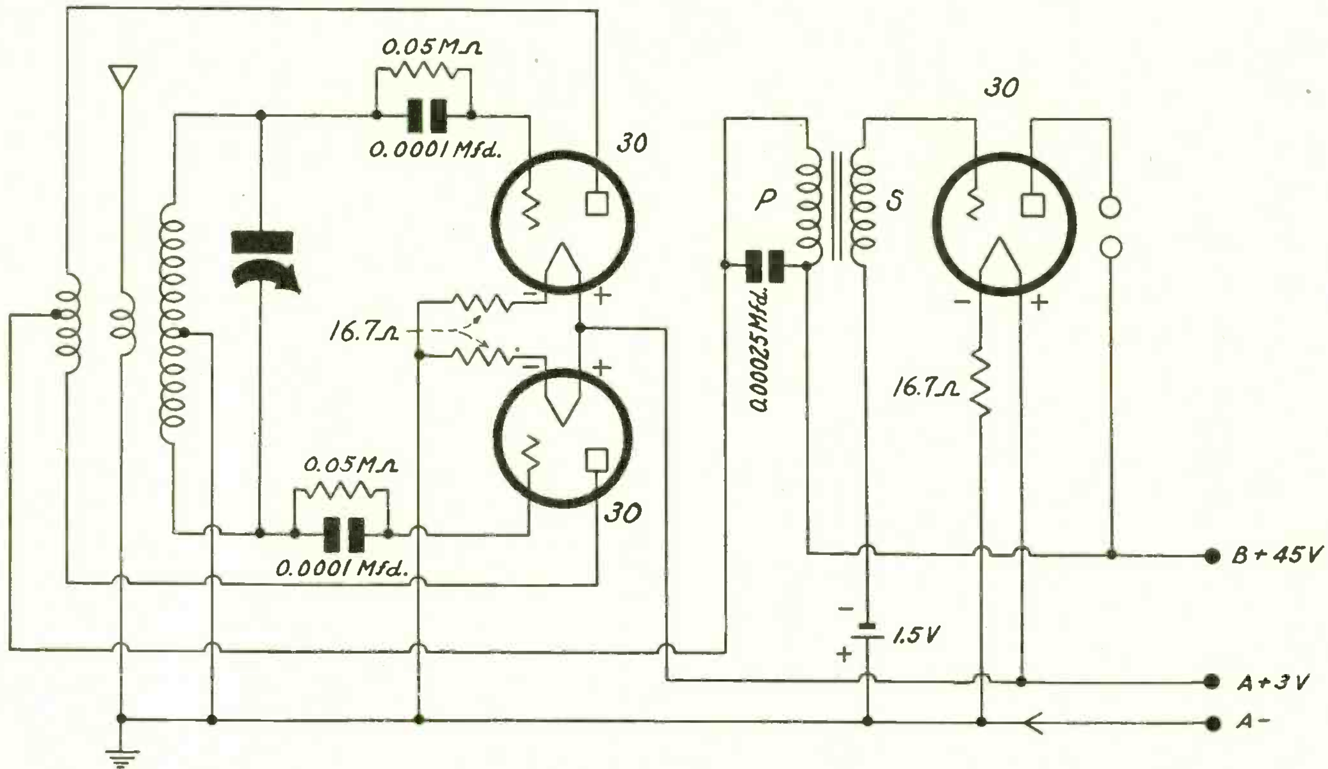
*NOBODY EVER HAS HAD TO APOLOGIZE FOR JOHN McCORMACK. This tenor with the richly Irish voice and the equally rich Irish manner has always made good on any program to which he has lent his name. That was fine news when NBC told a willing public that Mr. McCormack would start a new series of broadcasts over WJZ. There's one thing that the music world and that even larger world of listeners-in seem always to remember—Mr. McCormack never attempts anything he cannot do superlatively well, never cheapens himself or his art by doing anything that is open to criticism of those who believe in good taste, and never, never by any chance forgets that he is a native-born Irishman, no matter in what language he may think or sing.*

*It's good to know that John McCormack still sings true to the scale and gives promise of delighting his great public for years and years to come.*

# Push-Pull Quality Detection

## Hams Can Receive Cleaner Signal by Symmetry

*By L. J. Woodman*




**A novel arrangement of three tubes produces this circuit which contains a push-pull regenerative detector.**

IN the more than 50,000 hams in the country various ingenious schemes have been applied to the equipment in use by the individual owners. These innovations have included the simplest one-tube receivers to the largest 1,000-watt transmitters that some hams proudly boast. The range of these brain-children is great and their description is interesting to the extent that they serve to show little innovations that form the basis of more important developments from which the radio industry's marvelous growth is sprung.

One such scheme is depicted in the sketch. Even a casual glance will reveal that this is nothing more than a regenerative push-pull detector circuit with one stage of orthodox transformer coupled audio amplification. However, such a scheme is not in use at any location that has revealed its presence for publishing. Accordingly, it shall be assumed to be a new scheme that some intrepid hams may try. Perhaps it posseses some kinks that are not generally appreciated.

It is widely understood that a push-pull circuit will not transmit the even frequency harmonics that may be present in its internal circuit to an output circuit. Accordingly, one attribute of this design is readily seen. Also, the power capacity of our detector circuit becomes quite large in comparison to the ordinary one tube detector generally used heretofore.

This results in a receiver that is quite capable of taking care of itself when subjected to radio signals of great intensity. Further, the use of the '30 type tube allows the equipment to be made portable, with its attendant increasing of the receiving scope.

Ordinarily, a three-tube receiver in the past has comprised a detector and a two-stage audio amplifier which successfully operated a loud speaker.

Here it is suggested that one stage of audio amplification be given up so that the detector may be composed of two tubes in push-pull. Though some audio volume is lost in this process, the quality equipment in quality is such that we are not taking a backward step. It is believed that this suggestion offers interesting possibilities which can be fruitful of valuable results in the hands of the inquisitive minded.

# Right View of Stability

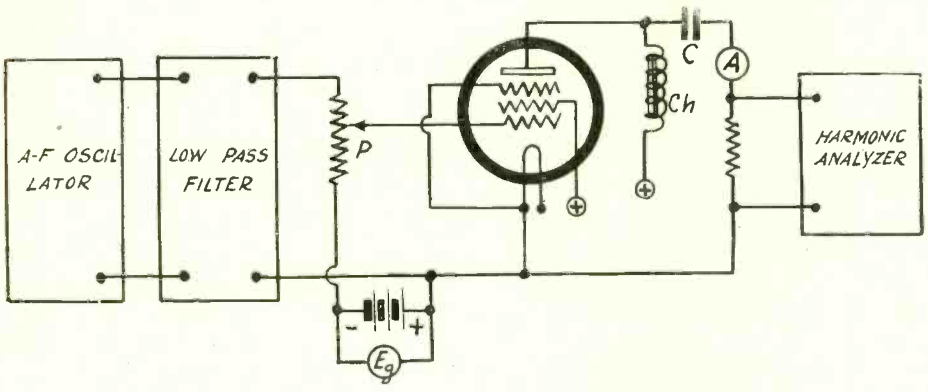
It is characteristic of the dynatron, and all other so-called relaxation oscillators, that stability is poor. This is a fact indeed, although the dynatron has been described in the technical press of the amateur field as very stable. This incorrent report no doubt was due to something printed in Circular 74 of the Bureau of Standards, where it was reported, as a piece of praise for the vacuum tube in general as an oscillator, that a constancy of a certain high order could be maintained, and a dynatron circuit was shown. The conditions for the attainment of this constancy were that the terminal voltages be kept absolutely constant during the period of test. Then the measured accuracy was something of the order of 1 part in 1,000,000.

This was merely the recording of an experimental fact, and the technique of the Bureau of Standards on experimental facts is beyond question. However, the report was made some ten years ago. Anybody not reading closely what was reported in Circular 74 regarding the constancy of a tube oscillator easily could be misled. One could be tempted to say perhaps that the frequency stability of the dynatron oscillator was something remarkable, which is about what has been said. But the conclusion is due to the interpretation and not to the plain reading of the Circular. The interpretation on which the false conclusion is based is that when the terminal voltages are kept constant the generator is stable.

That does not fit in with the definition of frequency staility at all. In practice it is almost impractical to maintain the terminal voltages constant over periods of use. Therefore in practice is it almost impossible to institute a stable oscillator? By no means. Any oscillator can be stabilized, even a dynatron, relaxation gas-tube oscillator or multivibrator. Stabilization means introducing some means of maintaining the frequency relatively constant *despite wide fluctuations in the terminal voltages,* and the very method of measuring the frequency stability consists of purposely altering these terminal voltages and then noting the difference in the generated frequencies.

# Radio University

***ANSWERS to Questions of General Interest to Readers. Only Selected Questions Are Answered and Only by Publication in These Columns.***




**Example of a total harmonic analyzing system.**

### Auditory Perspective

WHAT IS this new-fangled gadget called "audio perspective" that I heard about recently?—P. L.

Auditory perspective involves the spatial aspects of the reproduction of sound and as such finds little application in the ham game as constituted at present. To understand this gadget more vividly, let us consider the broadcasting of an orchestra. Usually this is done by means of one microphone at the transmitting end and one loudspeaker at the receiver end. By such means it is not possible to tell on which side of the transmitting studio the string section or the brass section may be. This may seem to be a useless attribute of the broadcast. But it should be realized that perspective in sound is quite as valuable as perspective in sight. And so it is desirable in a fine sound system to reproduce this perspective, enabling the auditor to be able to sense the violins on one side of the room and the brass on the other. This is especially useful in the broadcast of dramatic plays where action is involved. By this means, it is possible to reproduce a moving sound and thus add reality to the receiver's output. Now that we appreciate the utility of auditory perspective, it can be stated briefly that this is accomplished by the use of several microphones at the transmitter in different locations in the studio and an equal amount of loudspeakers at the receiver spaced in like arrangement. This will also involve several transmitting and receiving channels of equal number with the microphones and speakers. By this method it is possible to convey the illusion of moving sound to produce "auditory perspective."

* * *

### Short-Wave Coils

WILL YOU PLEASE give me some help on the cut-and-try method of winding short-wave coils, so that there will be a little overlap? As a matter of fact, I find that some commercial coils I have provide too much overlap, therefore I do not get quite to the highest frequency desired, although using a commercially-rated condenser of the capacity intended for such coils.—P. W. D.

Take the lowest-frequency coil as example, and remove enough turns from the secondary until the lowest frequency desired to be received, say, 1,600 kc, is tuned in at around 98 on a dial that increases numerically with decrease in frequency. Then ascertain the frequency struck near the opposite end, say, at 2 or 3 on the dial, and have this come in at 98 or so on the next coil. If you have no means of measuring, then duplicate the set, and, adjusting the largest coil as directed, put the second largest coil in the other set, with duplicate condenser used, and adjust the secondary until the frequency generated by the first set, when oscillating at 2 or 3 degrees setting, is registered, in the later set at 98 on the dial. Then put the second coil into the original set and the third coil into the new set, and repeat the process. In this way the overlap will be practically on a capacity basis, which is all right, since the frequency overlap becomes greater with ascending frequency orders, which it should. Moreover, as you suggest, you will be able to reach a higher frequency than formerly, in fact, the new extreme may be surprisingly higher than the old one. The practice is well worth following. Also a single tuning curve for one band will practically apply to the three other short-wave bands, requiring only the multiplication of the low-frequency scale by factors experience will disclose.

* * *

### Audio Harmonic Measurement

I HEAR A LOT of talk and read a lot of texts about the harmonics of an audio system and I would greatly appreciate a short exposition of a method of measuring them.—O. L. C.

There are several ways of determining the harmonic content, but perhaps the simplest one to apply is the indirect or comparative method, whereby an audio oscillator is used for the generation of a particular frequency, a low-pass filter is connected to the oscillator to let that frequency of oscillation through, but suppress higher frequencies, that is, harmonics, and the influenced voltage is put into a vacuum tube. The output circuit of this vacuum tube should be such as to be as free as possible of frequency discrimination, which would require a very high inductance choke, Ch in the diagram, a high capacity C, and a meter A, sensitive to alternating current. The load resistor is that recommended for the plate load of the tube for the voltage operating conditions and is found in charts of tube characteristics. This resistor should be non-inductive. The current meter is included to enable computation of the output power under operating conditions, which would be valuable when treating of power tubes. The power is $I^2R$, where $I^2$ is the square of the current read, and R is the resistance of the load. For certain power levels for output tubes the harmonic distortion permissible is stated, i.e., usually 5 per cent. and in some special instances (45's Class AB or 2A3's Class AB) 2 per cent. A voltage-measuring device is connected across the load resistor, and may be a vacuum tube voltmeter or other static voltmeter. Two measurements are made: (1) of the voltage across R when the low-pass filter is cut out, so that the harmonics are put in, as well as fundamental; (2), when the filter is cut in, so that only the voltage due to the fundamental is measured. The difference is the total harmonic distortion. This method does not enable distinguishing the intensities of the various harmonics, but special filters could be introduced to permit only certain harmonics, one harmonic at a time, to get into the tube, and to be measured alone. The fundamental then would be suppressed, too, until it alone is to be measured.

* * *

### Philco High-Fidelity Set

THE ANALYSIS of the high-fidelity receiver described in the December 1st, 1934, issue of RADIO WORLD causes me to ask some questions regarding this receiver. I should like to know the functions of the antenna transformer, the band-pass filter, the special type of i-f transformer; whether the second detector is at all biased; and the functioning of the tone control circuit.—H. H.

The antenna transformer and the band-pass filter in the Philco set are one and the same thing. The constants have been specially designed so that optimum selectivity and fidelity characteristics are obtained. This band-pass filter is constituted of the first three coils and the first two sections of the ganged condenser. This arrangement creates a design that gives a sharp cut-off rather than a gradual one. The i-f transformers are designed to function the same way and it has been found that the three-coil arrangement does this well. If you will refer to the voltage table at the bottom of the article you will note that the voltage between cathode and ground for the second detector is zero, in other words, there is no cathode bias on this tube. The tone control circuit comprises a fan-shaped switch blade that shorts out an entire section of resistor-condenser combinations in one position and places a .03 mfd. condenser in series with this combination in another position. In a third position the arrangement is connected in the circuit intact. If you will follow through the three positions that are possible for this fan blade switch, you can easily see the combinations obtainable.

* * *

### Audio Coupling

WHAT IS the advantage of resistance-coupled push-pull over transformer coupling? How can sound perspective be sent and received? When will television make its advent on a national scale?—A. H. L.

A discussion of different audio couplings appeared in RADIO WORLD for December 29, 1934. Regarding the specific case you mention, it might be stated that the feature of resistance coupling is the quality obtainable from this system, whereas the transformer coupling gives a bigger step-up with less quality. Therefore, you have to choose between quantity and quality. Sound perspective or "auditory perspective," involves the so-called third dimension in sound. By its use it is possible to tell direction from which a sound originates. For example, let us consider the broadcasting of a scene where an automobile is moving and the sound of its exhaust is audible, as it passes by. In an ordinary broadcast, using one microphone at the transmitter and one loudspeaker at the receiver, no marked effect of special rela-

*(Continued on next page)*

## These Voltages for RCA Communication Receiver

The following voltages are normal at the tube sockets when the receiver is operating at 115 volts a-c line, with no incoming r-f signal, with the volume and sensitivity controls at "maximum" (both turned fully clockwise), and with the automatic volume control switch turned to the "on" position. Such voltages, of course, were measured with high-resistance meters. If low-resistance meters are used in checking, therefore, allowances must be made for meter-current drain.

| Tube | Cathode to Ground (Volts) | Screen Grid to Ground (Volts) | Plate to Ground (Volts) | Plate Current (M. A.) | Heater Volts |
|---|---|---|---|---|---|
| 6D6 (R-F Amplifier) | 6.0 | 105 | 265 | 9.0 | 6.3 |
| 6A7 (1st Detector) | 6.0 | 105 | 265 | 3.5 | 6.3 |
| 6A7 (Oscillator) | — | — | 220 | 4.5 | 6.3 |
| 6D6 (I-F Amplifier) | 6.0 | 105 | 265 | 9.0 | 6.3 |
| 6D6 (Beat Oscillator) | — | 50* | 40* | — | 6.3 |
| 6B7 (2nd Detector) | 3.0 | 50 | 90* | 0.7 | 6.3 |
| 41 (Ouput) | 16.5 | 265 | 245 | 30.0 | 6.3 |
| 80 (Rectifier) | — | — | 690 (r-m-s) Plate to Plate | 70.0 Total | 5.0 |

*Difficult to measure—Calculated from 265 Volts (+B).

*(Continued from preceding page)*

tion is evident. On the other hand, when three microphones, three channels, and three loudspeakers are used, as is the case in auditory perspective, the listener can actually feel that the automobile is moving from one side of the room to the other. Thus, realism is added to the program. As has been intimated, this process involves the use of several microphones, and a like number of transmitting channels and receiving loudspeakers. Otherwise, the technique is the same as for ordinary broadcasts. Television transmission requires a broad band of frequencies. Since the only available space that has this requisite range is in the ultra-short wave region, it is probable that television will be transmitted on those waves when it becomes a practicality. However, these waves have a distance range that is limited to local areas and so for television to become national in scope, it is necessaary that the chain system be used. This will involve telephone transmission lines of high quality with the requisite frequency range. Since such lines are still in process of development, this constitutes one retarding force for the national broadcasting of television programs. It is further claimed by the television interests that the public cannot afford to purchase television equipment at this time because of the depression and because of the necessarily high cost of such apparatus when first introduced. It is a difficult matter to forecast the debut of television since these two serious objections are part of many other deterring influences that are at work to delay television's national scale. But—to give you some definite answer, we would say television ought to be fairly widely accepted within 5 years—and that is a fairly wild guess, hi!

* * *

### Some Causes of Hum

PLEASE STATE some sources of hum in an a-c receiver.—L.C.V.

Interaction between power supply and audio transformer or amplifier.
Long grid and plate leads.
A-c wires are not twisted or adequately neutralized for stray external fields.
Faulty rectifier tube.
Faulty radio tubes.
Speaker too close to the set.
Faulty power supply condensers.
Shorted or grounded choke.
Undersized choke.
Loose laminations in power transformer.
Loose laminations in filter choke.

* * *

### The 864 Tube

I SHOULD LIKE to use the 864 tube in a condenser microphone amplifier that I am building but cannot find the technical data on this tube. Please indicate these points.—N. A. S.

Filament: 1.1 volts, 0.25 amperes
Plate: 90 volts, 2.5 m.a. at —4.5 volts grid bias
Plate resistance: 15,500 ohms
Amplification factor: 6.6
Maximum length: 4 inches
Maximum diameter: 1 3-16 inches.

In addition to these points, it is quite important to realize that the 864 tube is especially suited for performance in places that require a tube to be free from microphonic disturbances, since it is designed so that it is free from this defect. On this count, the 864 has the edge over other tubes for condenser head amplifiers. The commercial forms of condenser microphone pre-amplifiers have taken this fact into account since their design includes the 864.

### HAMMARLUND MANUAL

The 1935 edition of the Hammarlund Short-Wave Manual makes its bow, replete with dope on the construction of short-wave receiving sets. The full constructional details with photographs are given for twelve short-wave receivers and power packs.

A perusal of these instructional articles reveals that the ham with the lean pocketbook has been the subject of the manual editor's thought. This can be appreciated from the fact that the receivers consist of two one-tube sets, seven two-tube sets, and two three-tube sets. Surely among such an array of simple receivers any one may find a suitable subject for his beginning efforts.

Among these sets there appear in consecutive order: (1) Boy Scout's Short Wave Receiver with the 30 type tube; (2) Sporting Twin, two-tube regenerative outfit with 30 and 33 tubes; (3) Dragnet, two-tube regenerator with 34 and 19 tubes; (4) Argonaut, two-tuber with 30 type tubes; (5) power pack for s-w sets using the 80 tube; (6) Gainer, two tuber, 6D6 and 76; (7) Ham A-C Set, two 58's and one 56; (8) Five-Meter Set, Using two 37's and one 38; (9) Doerle with two 30 tubes; (10) the Pentaflex, with one 6A7; (11) the Dual Regenerator, with a 32 and a 33, and (12) the ARRL Ham, with a 30 and a 33.

R. A. Hutchins, of Auburn, Wash., reports that he is very much interested in the treasure seeker described in Radio World of December 1, 1934. His interest is incurred by the fact that he has a great deal of experience in this sort of endeavor and is at present engaged in discovering the whereabouts of a buried cache of about $10,000. Based upon his experiences in this field, Mr. Hutchins gives a few pointers that should be of interest to our treasure seeker readers.

"The one trouble with these machines is that they do not have the capacity for very great depth and also the buzz that I get in my phones seems to creep and so far I have not been able to keep it tuned down to a correct degree where in my experience I find that it produces best results, that is, most sensitive, but the creeping hinders the efficiency of the machine, which is supposed to attract to about 20 feet. . . . Now, your machine looks as if it may be capable of attracting to quite a depth."

The device outlined in the December 1st issue did not use a buzzer modulator, and also provided for good depth plumbing.

# THE AMATEUR ORACLE

***Address Questions Concerning Amateur Regulations and Technique to M. K. Kunins (W2DPS), Technical Editor, Radio World, 145 West 45th Street, New York, N. Y.***

### Effect of Antenna Spacing

IT IS MY intention to erect two vertical antenna wires for the purpose of directional transmission. I understand that these wires should be one half wavelength long but am not completely clear on the point of spacing of these two wires. Please advise.—M. B. C.

The sketch on this page shows the effect of various spacings of the antenna wires. For best directivity, you will notice that the wires should be spaced one half wavelength apart. This will result in a figure 8 pattern that will give maximum radiation along one axis and zero radiation at the axis that is at right angles to this direction.

* * *

### Wire Sizes

HOW MANY TURNS per inch of coil are obtainable with the following wire sizes when insulated with enamel: 8, 10, 12, 14, 16, 18, and 20?—M. N. C.

The number of turns per linear inch of coil that can be had from the various wire sizes you indicate are tabulated below:

| | |
|---|---|
| No. 8 | 7.7 |
| No. 10 | 9.6 |
| No. 12 | 12.1 |
| No. 14 | 15.2 |
| No. 16 | 19.1 |
| No. 18 | 23.9 |
| No. 20 | 30.1 |

* * *

### Pronunciation of Unit

HOW IS THE term "mho" pronounced?—H. G.

In some quarters, this unit of conductance is pronounced: reciprocal ohm and, it is believed, represents the classical pronounciation. However, the vast majority of radio enthusiasts pronounce this term similar to moe, and so we infer that that is the pronunciation.

* * *

### Greater Meter Range

HOW MAY THE range of an a-c voltmeter be extended?—N. V. C.

An a-c voltmeter's range may be extended in the same fashion that the range of a d-c instrument is enhanced, by means of a series resistance. However, in the a-c case, it is essential that this resistance be non-inductive. Since these meters are usually used at power frequencies only, the skin effect resistance may be neglected.

* * *

### Quasi-Optical Waves

WHY ARE THE very short waves called the "quasi-optical" range?— O. M. N.

The wavelengths below about ten meters behave in a fashion similar to light waves in that they apparently only travel in straight lines and thus do not return to the earth. They do not bend around the earth like the longer waves do. Since they thus behave like light, which is treated by the science of optics, these waves have been labelled the "quasi-optical" rays.

* * *

### Schrot Effect

WHAT IS THE Schrot Effect?—J. J. M.

Considerable experimental work has been devoted to the determination of the Schrot or shot effect or voltage that is produced across a tuned circuit in the plate circuit of a single stage amplifier when no input is applied. This effect produces a noise in the circuit that represents one constituent of the background noise in a receiving circuit. It has been theorized that it is caused by the individual electrons that are shot off the filament or cathode in a vacuum tube. Owing to the fundamental physical nature of the Schrot effect, the method has been used to determine the electromagnetic value of the charge on an electron, it being claimed that if sufficient care is taken, this method rivals the former standard method of measuring this quantity. This effect, in company with several others, limits the minimum of noise that a set may be designed to maintain.

* * *

### Fringe Howl

WHAT IS FRINGE howl and how is it corrected?—M. N.

Fringe howl is a terrific audio disturbance that is set up when a tube goes into or out of oscillation. This condition may sometimes be improved by adjusting the antenna or plate by-pass condensers. A more effective remedy, however, usually is had by shunting the detector plate output impedance with a high resistance on the order of 100,000 ohms or higher.

* * *

### Best Receiver

WHICH TYPE OF receiver is best for short waves amateur reception?—F. D. N.

There is considerable controversy as to the better type of receiver among the super-heterodyne or regenerative types. There are many who swear by the modern superheterodyne while many others boost the regenerative receiver. There is much to be said for both types. Where a single receiver is required to cover both the short wave and broadcast bands, the super-heterodyne is decidedly superior because of its better selectivity in the broadcast band. For short wave work only, both types of receivers are about equally as well when properly designed and installed. Among those that build their own, however, the regenerative type is more popular because of its lower cost. It is less costly to build and to maintain, and it is more readily understood by the novice. Its selectivity is not as great as for the superheterodyne but it is ample for most locations.

* * *

### Pentode Properties

WHAT ARE THE essential properties of the pentode tube?—B. X. S.

The pentode is a tube that has the essential properties of the four element tube except that it has an additional electrode for minimizing the secondary emission effects. It possesses a high voltage factor, a high impedance and a high mutual conductance. The kink in the normal characteristic of a tetrode, due to secondary emission from the anode is eliminated by an additional screen that is earthed through the center point of the cathode and is physically located between the plate and the tetrode screen. It tends to prevent secondary emission from plate to tetrode screen.

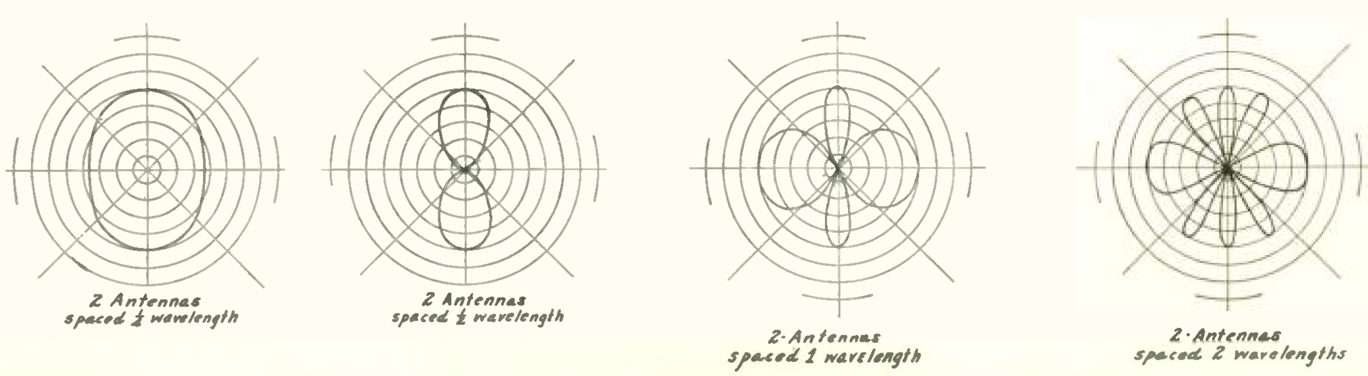
It is claimed that the pentode can replace an ordinary amplification stage and the output stage if the output load is designed to suit the high internal impedance of the tube. Better output stage performance can thus be obtained. However, great care must be taken over the input lead connections since the high amplification factor gives a large input impedance which thrown as a load on the preceding stage may nullify the advantages obtained by the use of the pentode.

* * *

### Drilling Glass

WHAT IS the most effective way of drilling a hole in glass, including an enumeration of the tools involved? I desire to put a hole in a pane to bring a leadin through.—L. C. O'B.

For drilling glass you'll need a drill into the chuck of which you insert a three-cornered file that has been ground down to a very sharpt point at the end. For the lubrication, some turpentine is necessary. When the location of the hole has been decided upon, start drilling with medium pressure. It is imperative that the glass be placed on an absolutely level bench with no dirt or grit between the work and the bench, since these will induce an uneven stress which will break the glass. Drops of turpentine should be periodically applied to the hole which improves the biting ability of the file and also seems to soften the glass so that its fragility is minimized.




**Four patterns of radiation depending on antenna spacing.**

# 1934 A RECORD AS 5,000,000 SETS ARE SOLD

The beginning of the fifteenth year of radio-broadcasting finds the "era of ether" entrenched so deeply in all the ramifications of modern life that few pause to realize that it was only on November 2, 1920, that the opening of the first station started a movement which has revolutionized the thought and action of the entire world. In its development, the production and distribution of radio-receiving sets have founded an industry, the rapid progress of which is without parallel in contemporary commercial achievements. Even from the last few years of economic difficulties the industry has emerged with the interest in its products at a new high pitch, manufacturers having proven their versatility and resourcefulness by rising above the adverse circumstances encountered.

During 1934 there was an almost uninterrupted month-to-month gain in sales, with demand impervious to the usual period of Summer dullness, due to the extended popularity of automobile and portable sets.

The introduction of the all-wave set at a price within the reach of the multitude has been one of the outstanding contributions to the new peak levels set by distribution.

### Stations Fare Well

Broadcasting stations also have furnished bolstering support to the wider use of the radio, as never in the history of the industry have programs of such comprehensive variety and recognized quality been provided to hold the listeners' interest at all hours of the day and night and to bring additional followers into the growing "audience of the air."

Although all previous records were outdistanced during 1934, current indications reveal a stronger uptrend of demand during the first quarter of 1935, with some new peaks to be established during the last six months of that year, according to a survey of the radio industry, which has just been completed by Dun & Bradstreet, Inc.

In spite of the encouraging progress made during the first six months of the current year, the increase in sales has been abrupt since the new models were displayed early in the Fall. In the comparison with the totals for the corresponding period of 1933, losses were reported in no parts of the country, while the increases ranged from 25 to 100 per cent. The cheaper sets have been bought freely, but the proportion is not so large as it was last season, as there has been a decided shift to the higher-priced all-wave sets during the last three months.

### 5,000,000-Set Year

Based on the returns for elapsed eleven months it is estimated that sales for the country, as a whole, average 40 per cent larger than for the comparative period of 1933. This would bring total sales for 1934 around 5,350,000 sets, as compared with the previous peak of 4,438,000 units set down for 1929.

From 60 to 65 per cent of the units sold represented replacements, which is about the same ratio as in 1933, as new enthusiasts are being added daily to the country's radio audience. Considerable replacement business has been received from agricultural districts, where sales had been few more than three years, owners now turning in their old sets for the new all-wave models. The many pay-offs during the year, which gave consumers money which had been considered lost, the higher prices for cotton, tobacco and the general run of farm products, which placed more cash in agricultural districts than in five years, and the steadier trend of employment have permitted deferred desires for radio ownership to be satisfied to the freest extent possible since 1929.

### Wider Interest in Broadcasts

The increased hours of leisure, the perfection of the all-wave receivers, and especially the improvement and extension of broadcasting programs have been responsible for the unprecendented expansion which interest in the radio has attained this year. Unquestioned proof of the growing popularity of this form of entertainment and instruction is provided by the record sums of money being spent for time on the major networks of the country.

In October, the highest sales in broadcast history were reached at $4,527,000, a gain of 59.0 per cent over the 1933 comparative figures, and 49.1 per cent higher than in October, 1932. For the ten months of 1934, these sales amounted to $33,780,000, or 38.8 per cent ahead of the 1933 comparative figures, and 2.2 per cent in excess of the 1932 total, which represented the all-time high. This increase has enabled some of the broadcasting companies to declare extra dividends, while others are planning to take care of accumulated dividends, as profits now generally have replaced the losses of 1932 and a part of 1933.

# Victor and Radiotron United in RCA Mfg. Co.

Consolidation of RCA Radiotron Company with the RCA Victor Company, the single organization to be known as the RCA Manufacturing Company, Inc., has been expected. It entails no changes in any of the sales, advertising or management policies of either of the two former companies, nor any change whatever in the products or trademarks heretofore used, according to E. T. Cunningham, president of the new RCA Manufacturing Company.

"The formation of the new company is the final step in the process of centralization which has been going on for more than a year in the interests of greater operating economy and efficiency," Mr. Cunningham said. "As in the past, the RCA Victor Division and the RCA Radiotron Division will operate independently of each other as their different problems warrant. The separate sales organizations and advertising programs will be maintained. The RCA Victor, the RCA Radiotron, the RCA Photophone and other widely-known RCA trademarks which have through the years accumulated a vast amount of public good-will and acceptance will continue to be featured in the new company's advertising and labelling. RCA Victor products will continue to be developed and manufactured at Radio Headquarters, in Camden, N. J.; and RCA tubes will continue to be developed and manufactured in the Harrison, N. J.

Mr. Cunningham also made public the complete list of board of directors and officers of the new company, as follows:

David Sarnoff, chairman of the board; E. T. Cunningham, president and director; G. K. Throckmorton, executive vice-president and director; W. R. G. Baker, vice-president in charge of the RCA Victor Division and director; J. C. Warner, vice-president in charge of the RCA Radiotron Division and director; Gen. James G. Harbord, director; M. H. Aylesworth, director; Edward M. Harden, director; DeWitt Millhauser, director; Frederick Straus, director; James R. Sheffield, director; Cornelius N. Bliss, director; E. J. Nally, director.

Lawrence B. Morris has been appointed vice-president and general counsel of the RCA Manufacturing Company; J. D. Cook, treasurer; P. G. McCollum, comptroller; F. H. Corregan, secretary; J. W. Burnison, vice-president in charge of manufacturing for the RCA Victor Division; J. M. Smith, vice-president in charge of manufacturing for the RCA Radiotron Division; Maj. J. T. Clement, vice-president in charge of the Washington, D. C., office; F. S. Kane, assistant secretary; David Macay, assistant secretary; C. B. Meyers, assistant secretary; E. F. Haines, assistant treasurer; F. J. Troup, assistant treasurer and assistant secretary.

RCA and Cunningham tube setups have for some time been combined.

## Britishers' French Station Aims Air Ads to Isle

The Imperial Broadcasting Corporation of London, with offices in the R.C.A. Building, intends to establish an American type broadcasting station in France 50 miles across the Channel from England and use the same programs for advertising as used in America by means of transcriptions, as there is no commercial broadcasting permitted from British stations. The company will offer the services of the station, "Radio Normandie," in France, to American advertisers. Many American advertisers have already used this station, including the Philco Radio Co.

The Imperial Broadcasting Corporation either owns or represents twelve radio stations in France, Spain and Jugoslavia.

The officers of the company are Leonard F. Plugge, of London, president; Frank Lamping, vice-president and resident manager.

## RCA Considers New Set-up for Its Capital Structure

Gen. J. G. Harbord and David Sarnoff, chairman and president, respectively, of the Radio Corporation of America, stated that a readjustment of the capital structure of the Radio Corporation has from time to time been discussed informally with the Board of Directors. At their request a Committee of the Board has recently been studying the subject more actively.

A plan is expected to be presented to the Board for early consideration. Any proposal would be submitted to the stockholders.

### ASSIGNMENTS

ALAN RADIO CORP., 80 Cortlandt St., N. Y. City, retail dealer in radio; assigned to Mortimer H. Goodmen, 300 Madison Ave., attorney, and Sydney A. Weinstock, 414 E. 52nd St.

STRAND STORES CORP., 146 Second Ave., N. Y. City. retail and wholesale radios and auto supplies, hardware, etc., assigned to Samuel P. Adelman, 1121 Morrison Ave.

# Station Sparks

## By Alice Remsen

### LISTEN FOR THE NEW ONES

THERE is a new program which sounds very attractive on the NBC-WEAF networks, each day except Saturday and Sunday, at noon. It is a serial dramatization of a wife's struggle to hold her husband's love against the attraction of his young and pretty stenographer. "The Story of Mary Marlin" is written by Jane Crusinberry and sponsored by the Kleenex Company. Joan Blaine plays the title role. . . . Another new program over the same network is "Sugar and Bunny," personated by Aleen Bronson and Jay Victor, each Tuesday and Thursday at 5:30 p.m. Miss Bronson plays a dizzy but very-much-in-love young bride, and Victor plays the flustered but equally-in-love bridegroom. Many comedy situations result from the adventures of these young honeymooners. . . . Strange as it may seem, the orchestra conductor of those Lady Peel "Bee" Lillie broadcasts is named Lee Perrin. Evidently Her Ladyship decided she needed a dash of Worcester Sauce to complete the program. Mr. Perrin provides it very nicely; if you don't believe me, tune in on WJ¾ Friday nights at 9:00 p.m. . . . Fred Allen has renewed his contract with the Bristol-Myers Company and is continuing his Town Hall Tonight broadcasts each Wednesday at 9:00 p.m. NBC-WEAF. He celebrated the event with—of all things!—an amateur night contest. Is there no end to these things. Ernest Cutting certainly started something when he put on his "Air-Breaks.". . . Malcolm LaPrade is back before the microphone in a new series of Cook's Travelogues. Mr. LaPrade is always an interesting speaker, and listeners with wanderlust may be highly entertained by this gifted lecturer each Sunday at 5:30 p.m. over an NBC-WJZ network. . . .

### ELSIE JANIS GIGGLED

Elsie Janis passed her first announcing test easily. Heard her do one of the evening news broadcasts recently. She sounded okay, but giggled here and there. . . . Boake Carter, news commentator, who first rose to nationwide prominence through broadcasting news of the Lindbergh kidnapping, will continue his present series of five broadcasts weekly over an enlarged WABC-Columbia network under a new long-time contract, which went into effect on New Year's Day. As in the past, Carter will be heard from Monday to Friday inclusive, at 7:45 p.m. under the sponsorship of the Philco Radio and Television Corporation. This is his third year for the same sponsor. . . . Rosaline Green has added another laurel to the feminine radio contingent. She is the new mistress of ceremonies for the "Hour of Charm," which is featuring radio's first all-girl vocal and instrumental ensemble, over a WABC-Columbia network each Thursday at 8:00 p.m. . . . Julia Sanderson and Frank Crumit, with Jack Shilkret's Orchestra, are now in their fifth year for the General Baking Company. Originally heard on Friday mornings back in 1931, they switched to the Sunday tea-time period in 1933, and they are still warbling their way through your loud speaker at 5:30 each Sunday over the WABC-Columbia network. . . .

### EVERETT MARSHALL WINS IT

Another contract renewal has been won by Everett Marshall for his current "Broadway Varieties." Marshall, who is also featured in the Broadway Revue, "Calling All Stars," will continue in his role of actor, singer and master of ceremonies. He will still be supported by a mixed chorus, Elizabeth Lenox, contralto, and Victor Arden's Orchestra. Each Wednesday at 8:30 p.m. WABC-Columbia. . . . "Easy Aces" returned to the air after a holiday rest. This program is now to be heard every Monday, Tuesday, Wednesday and Thursday at 3.45 p.m. sponsored by the Wyeth Chemical Company. WABC-Columbia. . . . The Fred Waring program, heard each Thursday at 9:30 over the Columbia network, has been extended to a full hour, still under the Ford Dealers sponsorship. . . . And speaking of Ford, his Sunday evening hour, featuring the Ford Symphony Orchestra and Chorus, has been moved to a new time; henceforth it will be heard over the Columbia network each Sunday at 9:00 p.m. . . . Heard the opening show of the new "Open House" series with Donald Novis and Vera Van. Warren Hull was master of ceremonies and Freddy Martin presided over the orchestra. A very entertaining half-hour of nonchalant chatter and popular music. Sundays at 5:00 p.m. over the WABC-Columbia network under the sponsorship of Vicks. . . . The Mills Brothers are being heard over the air-waves again with the Bing Crosby show each Tuesday at 9:00 p.m. from KHJ, the Columbia outlet in Los Angeles. . . . And now, over Station WOR you can hear that old favorite, Singing Sam, the Barbasol Man, but only once a week, on Fridays, at 9:45 p.m. The broadcasts will emanate from WLW in Cincinnati, and will also be heard over Station WGN, in Chicago. This will be good news for a great many of Harry Frankel's (Singing Sam) fans including myself. . . .

### WLW IN THE NEWS

The old Crosley Follies, on which I appeared many times during my stay in Cincy, may also be heard over WOR on Tuesday nights at 8:30, with Bill Stoess conducting. . . . And I also understand that the Flying Dutchman, another WLW standby, has been sold commercially, but will be heard just locally, I believe. . . . "The Life of Mary Sothern," another WLW production, very popular in the Mid-West, has grown to network proportions and so is now heard over the Mutual Broadcasting System, of which WOR is the New York outlet; Monday to Friday, inclusive, at 4:45 p.m. . . . I am very sorry to announce the death of Edward J. Powell, one of WOR's most brilliant and popular production men. He was ill for six weeks of acute uremic poisoning. Ed was only thirty-one years old, a graduate of Yale, and a clever actor and stage manager. A very able and most likeable chap. . . . Station WBNR, of Memphis, Tennessee, is a new outlet for the WMCA-ABS network. This station will be supplied with sixteen hours of program service from Ne wYork. Still another station to be linked with this up-and-coming network is WJAY of Cleveland, which will take daily program service. And the twenty-fourth member of the WMCA-ABS network is KARK, of Little Rock, Arkansas, known as the Arkansas Farmer Station. Not so very long ago it was thought by many people in and out of the radio business, that another network would not be practical. How mistaken they were is proven by two new networks—the ABS and the MBS. The more the merrier as competition is the life of trade, radio artists will profit thereby. . . . An international authority on beauty, former adviser on cosmetics to the leading film companies in Hollywood, V. E. Meadows, who is also a lecturer and writer, is now being heard thrice weekly over the WMCA-ABS network in a series of programs known as the Meadows Beauty Forum; Monday, Wednesday and Friday, 1:30 p.m. . . .

### WORTH THINKING OVER

*"THE FIRST NEW THING IN TEN YEARS OF RADIO" is the way the announcement of Ray Perkins' latest over-the-air activities reads. Mr. Perkins, whom we admire much and whose idea of comedy is whimsical rather than strong-armed, must admit that a sponsored announcement of that kind is rather hard on any entertainer, stage, radio or otherwise.*

*Feen-A-Mint, whatever that is (we'll find out some night for, in spite of the initial announcement, we continue to like Mr. Perkins since writing the opening paragraph), announces that Mr. Perkins is "the world's funniest Master of Ceremonies." That sponsor evidently insists that its head comedian must be funny even if it takes all the superlatives in Mr. Webster's most popular volume.*

### STUDIO NOTES

Giovanni Martinelli, the operatic tenor, wears large, funny-looking hats with high crowns. They're made of castoro, and designed for him in Italy. . . . Speaking of hats, Ed Wynn's father has never got over the fact that Ed went on the stage instead of taking up his father's business—making hats. . . . Beatrice Lillie is not only a clever comedienne, but a good shot also; she never passes a shooting gallery without popping off a few rounds of ammunition. . . . Francis Langford is in Hollywood where she will take part in a new film, "Vogues of 1935.". . . It is Kay Thompson who heads that latest addition to the Waring broadcast, the Girls Glee Club. . . . Harry Von Zell collects calendars. . . . The WOR engineers won the annual basketball game from that station's musicians this year; the score was twenty to eighteen—pretty good battle at that! . . . The favorite food of Anthony Trini is hot dogs and beer! . . . Madame Schumann-Heink is beginning her fifty-eighth year of singing before the public. . . . It's good news that Marjorie Hannon is starring in her own series; she's a sweet girl. . . . The father of Jane Froman is mayor of Columbia, Mo. . . . Arthur Hale has decided to keep that tiny mustache. . . . Tito Guizar has been signed to star in a movie entitled, "Adios, Argentina.". . . H. V. Kaltenborn has spoken over twenty-one different stations in eleven different countries.

### Tube Voltage Chart

REGARDING the RCA Communication type receiver, diagram and text found in the January 5th issue, can you supply the d-c voltage data?—E. L.

The tabulation at top of page 19 contains the information.

* * *

### Space Charge Detector

IS IT advisable to substitute space-charge detector hookup for more conventional type?—C. L.

No. Advantages are scarce. Easy overload often takes place. If it were better there would be more use of the space-charge detector.

* * *

### Tube Brightness

IS IT NECESSARY to see the tube light before it is safe to assume oscillation?—F. C.

Illumination of the tube by the filament or heater has no connection with presence or absence of oscillation.

## ACCURATE Fixed Mica Condensers

Capacities measured on a bridge.

1,000-VOLT RATING

| | | |
|---|---|---|
| 0.0025 mfd... 12c | 0.0008 mfd... 13c | 0.0004 mfd... 15c |
| 0.002 mfd... 12c | 0.0007 mfd... 13c | 0.0003 mfd... 15c |
| 0.0015 mfd... 12c | 0.0006 mfd... 13c | 0.0002 mfd... 15c |
| 0.0009 mfd... 13c | 0.0005 mfd... 15c | 0.0001 mfd... 15c |

Any six of above, 60c; any 12 of above, $1.10. Any assortment permitted.

## ACCURATE PIGTAIL RESISTORS

¼-WATT RATING

Bridge Measured

| | | |
|---|---|---|
| 100 ohms..... 9c | 4,000 ohms.. 10c | 40,000 ohms.. 11c |
| 200 ohms..... 9c | 5.000 ohms.. 10c | 50,000 ohms.. 11c |
| 300 ohms..... 9c | 6,000 ohms.. 10c | 60,000 ohms.. 11c |
| 400 ohms..... 9c | 7,000 ohms.. 10c | 80,000 ohms.. 11c |
| 500 ohms..... 9c | 8,000 ohms.. 10c | .1 meg....... 12c |
| 600 ohms..... 9c | 9,000 ohms.. 10c | .15 meg...... 12c |
| 700 ohms..... 9c | 10,000 ohms.. 10c | .2 meg....... 12c |
| 800 ohms..... 9c | 12,000 ohms.. 11c | .5 meg....... 12c |
| 1,000 ohms.. 10c | 15,000 ohms.. 11c | .6 meg....... 12c |
| 1,500 ohms.. 10c | 17,000 ohms.. 11c | .7 meg....... 12c |
| 2,000 ohms.. 10c | 20,000 ohms.. 11c | .8 meg....... 12c |
| 2,500 ohms.. 10c | 25,000 ohms.. 11c | .9 meg....... 12c |
| 3,000 ohms.. 10c | 30,000 ohms.. 11c | 1.0 meg...... 13c |
| 3,500 ohms.. 10c | 35,000 ohms.. 11c | 1.5 meg...... 13c |
| | | 2.0 meg...... 13c |

Any six of above resistors, 50c; any 12 resistors, 90c.

Each condenser and each resistor is specially tested and calibrated, and a personally written notation of the resistance or capacity value is furnished. We pay postage sending out these condensers or resistors if you remit purchase price with order.

**DIRECT RADIO CO.**
**145 W. 45th Street, New York, N. Y.**

### COMBINING THE TECHNICAL AND EDUCATIONAL

"RADIO AND EDUCATION, 1933," edited by Levering Tyson. Proceedings of the Third Annual Assembly of the National Advisory Council on Radio and Education.$2.50

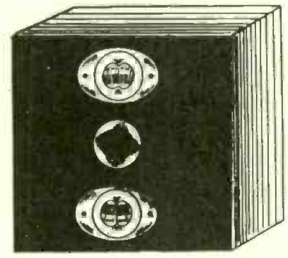
"EDUCATIONAL BROADCASTING." A Bibliography by Robert Lingel. The best and most complete on the subject....$1.50

"A DECADE OF RADIO ADVERTISING," by Herman S. Hettinger. From nothing to $90,000,000 in ten years......$3.00

**Book Dept., RADIO WORLD**
**145 West 45th Street**

# New Signal Generator Free
## *with* $6 (One Year) Subscription

NOW for the first time you can get a wired and tested Signal Generator free as a premium with a $6 subscription for Radio World (52 issues, one each week). Imagine getting Radio World for a year, and also a splendid Signal Generator! Never before have we made so generous an offer as this. Moreover, the offer is revocable without notice. So you'd better act now.



**The Signal Generator, PRE-6, has practically straight - frequency - line tuning. It works on 90-125 volts, a.c. or d.c., and is modulated on a.c.**

The Signal Generator offered as a premium with a one-year subscription is a serviceable instrument, of durable and accurate construction, and enables the peaking of intermediate frequencies, as well as broadcast frequencies. Moreover, short-wave frequencies can be determined. Determinations in frequencies in kilocycles and wavelengths in meters are made by use of this splendid instrument.

## SCALE READS DIRECTLY IN FREQUENCIES AND WAVELENGTHS

MANY experimenters and service men want a really good Signal Generator that serves their purposes abundantly and that costs little. Here it is. Model PRE-6 Signal Generator is given free with a one-year subscription for RADIO WORLD, a most amazing offer, nothing like it ever having been made before in the radio field. And this generator is obtainable in no other way.

The scale reads directly in frequencies of the fundamental (109 to 200 kc, with bars 1 kc apart), and wavelengths of the fundamental (2,700 to 1,500 meters, with bars 10 meters apart). Besides the intermediate frequencies on the fundamental scale, others are on the scale on the next tier from top, including the following imprinted twice: 400, 450, 465 and 480 kc. The reason for these imprints appearing twice is that an automatic check-up on whether the channel measured is tuned exactly to the right i.f. is obtained, when using harmonics, for there is a response in the receiver channel when the generator is turned to one and then another of these two points. Hence no harmonic confusion is possible. Also, 250 and 260 kc are imprinted once on the second tier, for no confusion can result, as second harmonics are used.

## GUARANTEED ACCURACY IS 1%

THE upper tier, at the edge, is 109-200 kc, the lower corresponding tier at the edge is for wavelengths. One inside tier has the registrations for the popular intermediate frequencies not on the fundamental. The other inside scale reads 0-180, so that any odd frequency one is interested in may be recorded elsewhere in respect to a calibration in degrees of a semi-circle. The 335 dial scale is used.

The guaranteed accuracy is 1 per cent. This is checked twice in a precision laboratory. The accuracy is not changed when a tube is inserted. The wired, calibrated, tested Signal Generator is supplied less tube. All you have to do is to insert a 30 tube and start making precision measurements.

Send $6.00 for one-year subscription, and ask for PRE-6. Present subscribers may renew on this basis. Shipping weight, 3 lbs. Enclose postage if prepaid shipment is desired. It's cheaper.

**Foundation Unit for this Signal Generator can be obtained by sending $3 for six-months subscription (26 issues, one each week). The Foundation Unit consists of frequency-calibrated scale, two escutcheons, knob, coil, tuning condenser, and wiring diagram. Order PRE-3. Shipping weight, 1 lb.**

**RADIO WORLD, 145 West 45th Street, New York, N. Y.**
**OUT WEEKLY — 15c a copy at News-stands.**

### BAND SPREAD RECEIVER AND PACK

The Supertone Bandspread Receiver is a five-tube set, 15 to 200 meters, and requires a power pack. There are three 8 mfd. condensers in the pack's filter, also husky B chokes.

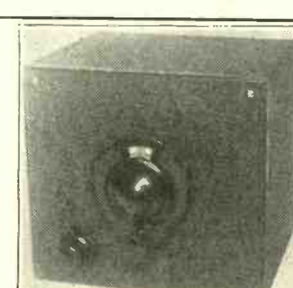
*All Supertone products are laboratory-tested and come up to highest engineering requirements.*

A large number of short-wave enthusiasts like the separate tuner and power pack. This method we have developed with bandspread tuning. The five-tube outfit covers 15 to 200 meters and provides most exceptional results.

| | |
|---|---|
| The wired chassis, with front panel, with coils, less the five tubes | $10.00 |
| Power pack, wired, less tube ........... | 4.98 |
| Five tubes and speaker ............ | 5.25 |
| Complete kit, with tubes, speaker and diagram ............ | 18.00 |

**DIRECT RADIO COMPANY**
**145 WEST 45TH STREET**
**New York, N. Y.**

### EFFICIENT BOOSTER



The performance of any short-wave receiver can be improved by using the Supertone Booster. No wiring changes required in the set. The booster has its own power supply for 90-125 volt a.c. or d.c. operation. Reduces image interference to a minimum.

| | |
|---|---|
| Wired Booster, with plug-in coils for 15-200 meters, hinged-top cabinet (less tubes)............ | $8.95 |
| Two tubes for either of above (25Z5 and 6D6).................. | 1.95 |
| Booster kit, complete, less tubes ............................ | 7.95 |

# SPECIALS YOU MUST NOT MISS

LEOTONE 11" Permanent Magnet Dynamic, supplied with any output transformer ........ $6.95
Farrand 11" Inductor Dynamic Speaker... $2.75
Atwater-Kent 9" Magnetic Speaker Chassis ........ $1.29
Stromberg-Carlson Magnetic Speaker Chassis ........ $1.39
Atwater-Kent El Magnetic Unit........... 89c
Dubilier Shielded 2 mfd. condenser........ 19c
RCA Victor Brunswick Pick-up Heads, left or right side attachment........... $1.35
High-Frequency Section-wound ½2mh RF chokes ........ 19c
Hammarlund Double IF Trimming Condensers, isolontite base........ 17c
50-watt xmitting sockets........ 69c
Freid-Eisman variometers ........ 49c

And Last But Not Least

MICAMOLD RMA COLOR-CODED FIXED CONDENSERS

in following capacities: .001; .0015; .002; .0001; .0002; .00025; .0003; .00035 ........6 for 25c
Tube base short-wave coils—set of 4........35c

LEOTONE RADIO CO. 63 Dey St. New York City

# WIDE SELECTION of PREMIUMS with SUBSCRIPTIONS

OFFER A—Free with $1.00 subscription, 8 weeks.
OFFER B—Free with $1.50 subscription, 13 weeks.
OFFER C—Free with $3.00 subscription, 26 weeks.
OFFER D—Free with $6.00 subscription, 52 weeks.

## COILS

Aerial eliminator. Dispenses with necessity of an aerial erection. Order P-1400. Offer A.
Police thriller short-wave adapter plugs into set for police calls. For '27 detectors only. Order P-1402. Offer B.
Silver-Marshall output transpower, 1 to 1 ratio for single-sided circuit, magnetic speaker. Order P-1403. Offer B.
Silver-Marshall output transformer, push-pull pentode (7,000 ohm load) to 8-ohm secondary. Order P-1403. Offer B.
Kit of three doubly-tuned, aluminum-shielded, 175 kc. i-f transformers. Order P-1408. Offer D.
Set of four 6-prong plug-in oils, 200-15 meters, for use with 0.00014 mfd. Three windings. Order P-1426. Offer C.
Power transformer for 5-tube set (2.5v., 5v., b-v), 60 ma. Order P-1428. Offer C.
Power transformer for 8-tube set (2.5v, 5v., h-v.), 90 ma. Order P-1429. Offer D.

## CONDENSERS

Three-gang 0.00014 mfd. tuning condensers for short waves. Order P 1031. Offer C.
Selection of 15 fixed mica moulded condensers, .0001 mfd. to .001 mfd. State capacities and quantities. Order P-1415. Offer B.
Hammarlund Star Midget condenser. 0.00014 mfd. Order P-1417. Offer B.
De-Jur Amsco dual 0.00014 mfd. Order P-1418. Offer C.
Three 100 mmfd. compression type trimmer condensers. Order P-1419. Offer A.
Eight tubular condensers, 600 volts. Capacities, .002, .006, .01, .02. State quantity and capacities, your selection. Order P-1420. Offer A.
Three tubular condensers, 600 volts, .01, 0.25 mfd. Your selection. State quantities and capacities. Order P-1421. Offer B.
8 mfd. electrolytic. 500v. d.c. Order P-1422. Offer B.
16 mfd. electrolytic, 500v. d.c. Order P-1423. Offer C.
Two 8 mfd. eletrolytic in one case. Order P-1424. Offer C.
Three-gang 0.00035 mfd. ⅜-inch shaft diam. Order P-1425. Offer B.

## RESISTORS

Kit of 12 assorted volume controls (our selection). Order P-1401. Offer A.
Kit of 25 fixed assorted resistors (our selection). Order P-1404. Offer A.
Kit of 50 fixed assorted resistors (our selection). Order P-1404. Offer B.
Volume control portentiometers with a-c switch attached:
5,000 ohms. Order P-1409. Offer B.
10,000 ohms. Order P-1410. Offer B.
20,000 ohms. Order P-1411. Offer B.
50,000 ohms. Order P-1412. Offer B.
500,000 ohms. Order P-1413. Offer B.
Selection of 15 pigtail fixed resistors, ¼ watt. State values and quantities desired. Order P-1414. Offer B.

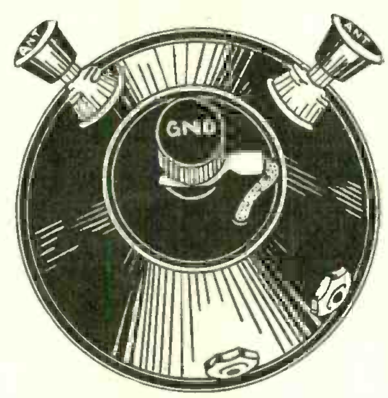
## MISCELLANEOUS

Two 45 tubes. Order P-1405. Offer B.
Two 26 tubes. Order P-1406. Offer B.
Assortment of screws and nuts. Order P-1407. Offer A.
Twelve tube shields and bases. Order P-1416. Offer A.
Set of 12 wafer type sockets, four, five, six, seven-medium holes. State quantity and holes. Your selection. Order P-1426. Offer B.
Set of 6 three-piece aluminum shields. Order P-1427. Offer A.

[NOTE: We pay transportation on any and all of above premiums. This offer to pay transportation is revocable at any time, so act now.]

RADIO WORLD
145 West 45th Street New York, N. Y.

# *NEW* ALL-PURPOSE ANTENNA COUPLER




THE Bernard All-Purpose Antenna Coupler provides a noise-reducing method of connecting any type antenna to any type receiver.

The popular noise-reducing antenna systems, using transmission lines from doublet, can not be connected to most receivers, because most receivers have only one antenna post, the other post being ground, while the doublet's transmission line requires two antenna posts. The Bernard All-Purpose Antenna Coupler provides the necessary link between twisted pair, transposed dual leads, or other transmission lines of doublets, so that a noise-reducing antenna system can be used on the set you have.

Besides, the Bernard All-Purpose Antenna Coupler is in itself a noise-reducing device, enabling quieter operation of the receiver, due to larger ratio of signal to noise.

The Bernard Coupler may be used with broadcast, short-wave and all-wave receivers, and requires no molestation of its connections.

The Bernard Coupler is built into a Bakelite moulded conical container.

The Coupler provides the necessary flexibility of connection to serve four purposes as follows:

**(1)—Use of dual transmission leads from a doublet to a receiver equipped for doublet connection, that is, having two antenna posts.** Connect doublet leads to the two press posts marked "Ant." Connect two tipped flexible leads supplied with the Coupler to the Coupler's two tip jacks, other ends of these leads to the two antenna posts. Disconnect the spade lug from the Ground post and ignore that post of the Coupler. **A measurable reduction in noise** will result.

**(2)—Use of two transmission leads from a doublet to a receiver not equipped with two antenna posts (having only usual antenna and ground posts).** Connect doublet leads to the two press posts marked "Ant." Connect one of the flexible leads from one Coupler tip jack to antenna post of set and other flexible lead from other Coupler tip jack to set's ground post. Connect ground to the ground post of the Coupler and tighten the spade lug in the ground post. If no signals are heard the connections at the receiver are reversed, so interchange them. This use opens the whole field of noise-reducing antennas to sets otherwise denied this advantage.

**(3)—Use of standard antenna, of the inverted L, or T type, with a receiver with only antenna and ground posts.** Connect single antenna leadin to either press post marked "Ant." Connect flexible leads from Coupler tip jacks to the respective antenna and ground posts of the receiver. Connect ground to the ground post of the Coupler, tighten the spade lug in the ground post, and run a wire from ground post to otherwise unused "Ant." press post of the Coupler. Reverse connections at receiver if signals are absent.

**(4)—Use of a standard antenna with a receiver equipped for doublet connection (having two antenna posts).** Connect the single antenna leadin wire to one of the "Ant." press posts of the Coupler. Connect flexible leads from the Coupler tip jacks to the two antenna posts of the receiver. Connect ground to the ground post of the coupler and tighten the spade lug under the ground post of the Coupler.

The Bernard All-Purpose Antenna Coupler is an effective and ready means of improving reception by the use of a small, inexpensive device, one based on sound engineering principles, and built for many years of service. The Coupler may be placed at any convenient point indoors, but the closer it is to the receiver, the better the noise-reduing properties.

Bernard All-Purpose Antenna Coupler, list price, $2.50
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Vol. XXVI JANUARY 5, 1935 No. 17. Whole No. 667

*Published Weekly by* **Hennessy Radio Publications Corporation,** 145 West 45th Street, New York, N. Y.
Editorial and Executive Offices: 145 West 45th Street, New York
*Telephone:* BR-yant 9-0558

# Methods of Using Standard-Frequency Radio Transmission

**[Circular LC404, National Bureau of Standards.]**

THIS pamphlet gives methods of frequency measurement for utilizing standard frequencies transmitted by radio by the National Bureau of Standards. It is in three parts.

Part 1 gives methods of using the 5000-kc/s transmissions for the calibration of standard oscillators in simple cases where the frequencies have such numerical values as to be readily checked directly in terms of the transmissions.

Part 2 gives specific information for the use of the transmissions to check with great accuracy the frequency standard used in any broadcasting station (e.g., the monitor required by F.R.C. Rule 145). The discussion is divided into three sections, A, B, and C, progressing in difficulty of measurement. Section A deals with two frequencies, 1000 and 1250 kc/s; very little apparatus is required for measurements at these frequencies. Section B gives the method of measurement, using an auxiliary generator, for frequencies which are multiples of 50 kilocycles per second. Section C gives the method of measurement for any broadcast frequency (multiples of ten).

Part 3 is a bibliography. [Omitted from this article.—Editor]

### When to Listen In

**The Standard Frequency Transmissions.**—The National Bureau of Standards transmits standard frequencies from its station WWV, Beltsville, Md., near Washington, D. C., every Tuesday. The transmissions are on 5000 kilocycles per second, and are given continuously for two hours during the day and two hours at night. (At this date, the schedule is from 12 noon to 2 p. m., and from 10 p. m. to midnight, Eastern Standard Time). The transmissions can be heard and utilized by stations equipped for continuous-wave reception throughout the United States, although not with certainty in some places. The accuracy of the frequency is at all times better than one cycle per second (one in 5,000,000).

The transmissions consist mainly of continuous, unkeyed carrier frequency, giving a continuous whistle in the phones when received with an oscillatory receiving set. For the first five minutes the general call (CQ de WWV) and announcement of the frequency are transmitted. The frequency and the call letters of the station (WWV) are given every ten minutes thereafter.

## PART 1. CHECKING STANDARD OSCILLATORS

While the standard frequency transmissions may be used for many standardization purposes, the most common use is to determine accurately the frequency of a piezo oscillator. The apparatus necessary is (1) the piezo oscillator, (2) a continuously variable radio-frequency generator which is approximately calibrated: (3) a variable audio-frequency generator: and (4) a radio receiving set. A frequency meter of resonance type is also useful but is not essential.

The fundamental frequency of a piezo oscillator is fixed by the dimensions of the quartz plate used. The vacuum-tube circuit arrangement in which the quartz plate is connected gives numerous harmonics for each fundamental frequency. The radio-frequency generator, which is continuously variable, can be adjusted to any frequency, and likewise gives a series of harmonics for each fundamental frequency to which it is adjusted. If the frequency of the radio-frequency generator is varied over a wide range, beat notes are produced at a number of settings of the generator by the interaction of various harmonics of the fundamental frequency of the piezo oscillator with a harmonic of the fundamental frequency of the generator. The beat notes may be heard in a pair of telephones suitably connected to the generator or to the piezo oscillator. Any frequency present in the piezo oscillator can beat with a corresponding frequency present in the radio-frequency generator, which makes it possible to set the generator at a number of frequencies which have a simple relation to the fundamental frequency of the piezo oscillator. Providing the harmonic relationship is known, measurements can be made at a great number of frequencies in terms of a single standard frequency.

If f is the fundamental frequency of the piezo oscillator which is being used and F the fundamental frequency of the auxiliary generator which gives zero beat, then

$$af = bF$$

where a and b are integers (1, 2, 3, 4, etc.).

The procedure is simplest when the ration of 5000 kc to the nominal frequency of the piezo oscillator to be standardized is a fairly small integer, less than 100. For instance, secondary standards whose fundamental frequencies are 50, 100, 200, 500, or 1000 kc can be measured very simply in terms of the 5000-kc transmissions, and these secondary standards may be advantageously used in turn to calibrate other apparatus. It is, however, possible to use the 5000-kc signals to establish accurately any desired frequency.

Suppose it is required to measure the frequency of a piezo oscillator, the approximate frequency of which is 700 kc, in terms of the 5000-kc standard frequency signals.

If the radio-frequency generator is set at 100 kc, the 50th harmonic (5000 kc) will beat with the 5000-kc transmission, and the 7th harmonic (700 kc) will beat with the fundamental of the piezo oscillator.

The 5000-kc standard frequency signal is received first and identified with the receiving set in the generating condition. The radio-frequency generator is then turned on and adjusted to near 100 kc. This should give a beat note with the frequency generated by the receiving set. The regeneration of the receiving set is then reduced until the set just stops generating. A beat note should then be heard which will in general be of less intensity than that previously heard. This is the beat between the 50th harmonic of the radio-frequency generator and the frequency of the incoming wave. This beat note should be reduced to zero frequency by adjusting the radio-frequency generator. For most precise work, this adjustment should be made by using a beat frequency indicator or other means of indicating exact zero beat. A simpler and equally accurate substitute is to bring in a tuning fork as described below. However, for a simple discussion of the steps involved in the measurement, it will be assumed that an accurate zero-beat setting is obtained.

The radio-frequency generator is therefore precisely adjusted so that it has a frequency of 100 kc. Without changing its adjustment, couple the piezo oscillator to it loosely. A beat note should be heard in the telephones in the output of the piezo oscillator unless the frequency given by the piezo oscillator is an exact

(*Continued on next page*)

FIG. 1

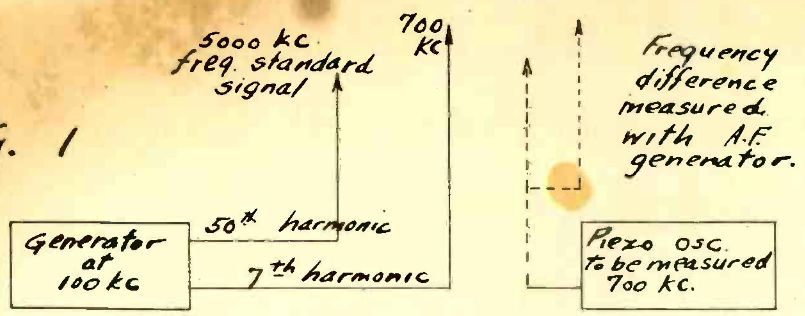
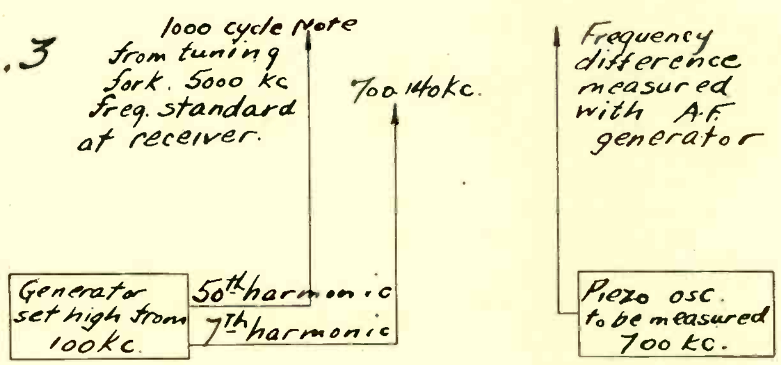



FIG. 2


FIG. 3



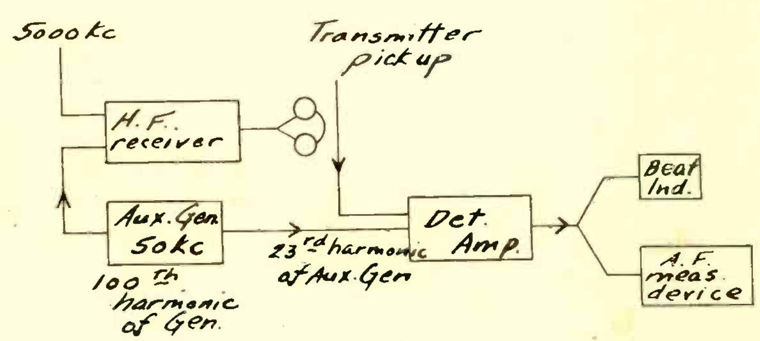




FIG. 4

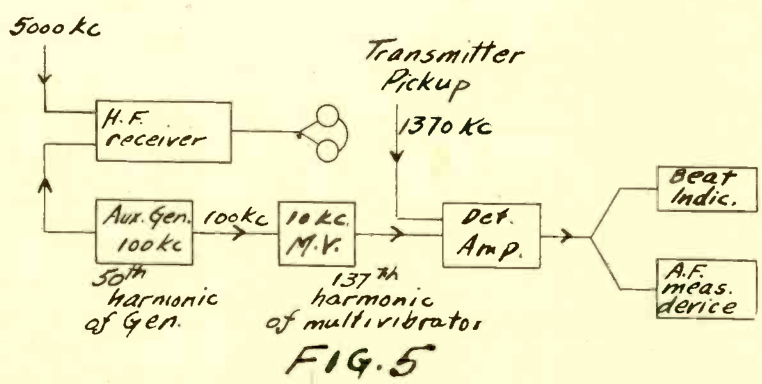



FIG. 5

(*Continued from preceding page*)
multiple of 100 kc. Suppose, for example, it is 700.520 kc. In this case a beat of 520 cycles per second will be heard. To determine the value of this note, the audio-frequency generator must be used.

The frequency of the beat note and the frequency of the audio-frequency generator may be compared by using single phone units from each source and rapidly interchanging them at the ear. If sufficient intensity is available from the two sources then the two audio frequencies will combine and beats may be heard by the ear when the audio-frequency generator is closely adjusted. For exact zero beat the frequency of the adjustable audio-frequency generator gives the difference in frequency between the 7th harmonic (700 kc) of the generator adjusted to 100 kc and the fundamental of the piezo oscillator.

Fig. 1 gives a diagramatic representation of the frequencies used. It is necessary to determine whether the piezo oscillator is higher or lower than 700 kc. This can be done by varying the frequency of the radio-frequency generator. If increasing the frequency of this generator results in decreasing the beat note, then the piezo oscillator is higher than the reference frequency, that is, the audio frequency is to be added to 700 kc. If the reverse is true, then the audio frequency is to be subtracted.

## Use of Audio-Frequency Note

A change in the method described above, which does not require a beat indicator, is to adjust the radio-frequency generator to have a known frequency difference with the incoming wave by means of matching with that of a tuning fork of known frequency such as 1000 cycles per second. This method is more complicated in calculation because a record must be made of four factors, (1) as to whether the radio-frequency generator was adjusted higher or lower than zero beat, (2) the frequency difference, (3) the harmonic relation between the standard signal and the radio-frequency generator, and (4) the harmonic relation between the radio-frequency generator and the piezo oscillator. The harmonic relations, however, come in to any method of measurement of this kind. The measurements involving the use of the tuning fork for adjusting the generator to give a beat note 1000 cycles per second below the 5000-kc signal would be made as follows, and are shown diagramatically in Fig. 2. Set generator from approximate zero beat at 100 kc to 99.98 kc. The 50th harmonic is 99.98 x 50 = 4999.0 kc (beats with 5000 kc in receiver which is not oscillating and gives a 1000-cycle note). The 7th harmonic of the generator (99.98 x 7 = 699.86 kc) may now be heard beating in the telephones of the piezo oscillator which is known to be approximately 700 kc/s. If this value were exactly 700 kc, a note of 700.000 — 699.860 kc or 140 cycles would be heard. However, the beat note produced is matched with a corresponding note from the audio-frequency generator. If the piezo oscillator had the frequency of 700.520 as assumed previously, the audio-frequency note measured would have been 700.520 — 699.860 = 0.660 kc or 660 cycles per second.

Whether to add or subtract the audio-frequency note of 660 cycles to the known frequency of 699.860 kc would be decided as follows when the radio-frequency generator was set lower than the standard frequency signal. If lowering the frequency of the radio-frequency generator increases the beat note (650 cycles in this case), add the beat note frequency, or if increasing the frequency of the radio-frequency generator decreases the beat note, add the beat note frequency.

The measurement could also be made by adjusting the generator to 100.020 kc using the thousand-cycle tuning fork, as in Fig. 3. The 50th harmonic is 100.020 x 50 = 5001 kc, which beats with the standard frequency signal of 5000 kc and produces a 1000-cycle note. A certain audio-frequency note is produced in the telephones of the piezo oscillator, which is matched with a similar note from the audio-frequency oscillator as before. If lowering the frequency of the radio-frequency generator reduces the audio-frequency note heard, subtract it from the known frequency of 700.140 kc.

(*Continued on page 21*)

# The Electron Radiation Theory

## Energy Released by Potential Causing Dislodgement

*By M. K. Kunins*

THE frequency and wavelength of radio waves constitute one of the fundamental concepts. Ask the most recently interested radio fan about his new hobby and he will hurl the terms kilocycles and meters at you, whether or not he has a vivid appreciation of what he speaks. Because of their fundamental nature these terms should not be slighted in the fan's efforts to understand radio.

The fan has become accustomed to realize that he may differentiate between radio stations by means of frequency discrimination. This is a habit that grew out of his first efforts to tune in a station. He therefore realizes that the frequency will broadly determine the type of signal he will receive. He has found that the frequencies between 550 and 1,500 kilocycles will bring him entertainment of various kinds. He has found that the frequencies just above 1,500 kc will allow him to listen in on the police calls, the amateurs and various experimental stations. He has also found that the frequencies below 550 kc will allow him to break in on the ships at sea. He accordingly has a most vivid appreciation of the importance of frequency as far as a radio signal is concerned.

### Small Part of Spectrum

But frequency does not affect radio signals alone. It has been found that radio signals constitute just one small part of a spectrum of frequencies which constitute all electromagnetic radiations in the universe. These frequencies extend from a few kilocycles up to the quintillions and more of kilocycles.

It will be seen in the first sketch that the electromagnetic spectrum has been divided into a number of different types of radiation, each with its own special characteristics and functions. Thus, from a frequency of about 10 kilocycles up to about 30,000 kilocycles, there is the ordinary band that is used in radio communication—10 kc to 550 kc, the long waves; 550 kc to 1,500 kc, the broadcast waves; 1,500 kc to 30,000 kc, the short waves. From 30,000 kc to 1,250,000,000 kc, the new ultra short wave band has just been opened up to the minds of many experimenters and the many strange and useful characteristics of this portion of the spectrum have opened the eyes of many fans with interest. Due to the similarity in action between these frequencies and ordinary light waves this wave is often alluded to as the quasi-optical band. Above this band, from 1,250,000,000 kc to 375,000,000,000 kc, there exist the infra-red rays which constitute many of the waves that create the sensation of heat to the touch sense. We then strike the region that affects the visual apparatus of man, the frequencies from 375,000,000,000 kc to 750,000,000,000 kc. The narowness of this band is striking.

### Still Higher Frequencies

Above the visual band of frequencies there lies the band of ultra-violet rays between 750,000,000,000 kc to 22,000,000,000,000 kc, then the X-Rays from this limit to 50,000,000,000,000,000 kc, then the cosmic rays from this point to 30,000,000,000,000,000,000 kc. At this point, the limit of human resourcefulness stops for the present, for it is not known whether waves above this limit exist. However, it is obvious that this gamut of frequencies is more than enough with which to play.

The fact that all these radiations are of the same nature, except in frequency, makes it interesting to investigate the manner in which all these rays are generated and avail themselves for the services of man. Let us therefore attempt a beginner's symposium.

An understanding of the manner in which radiation occurs will involve a knowledge of the structure of matter as evolved at the

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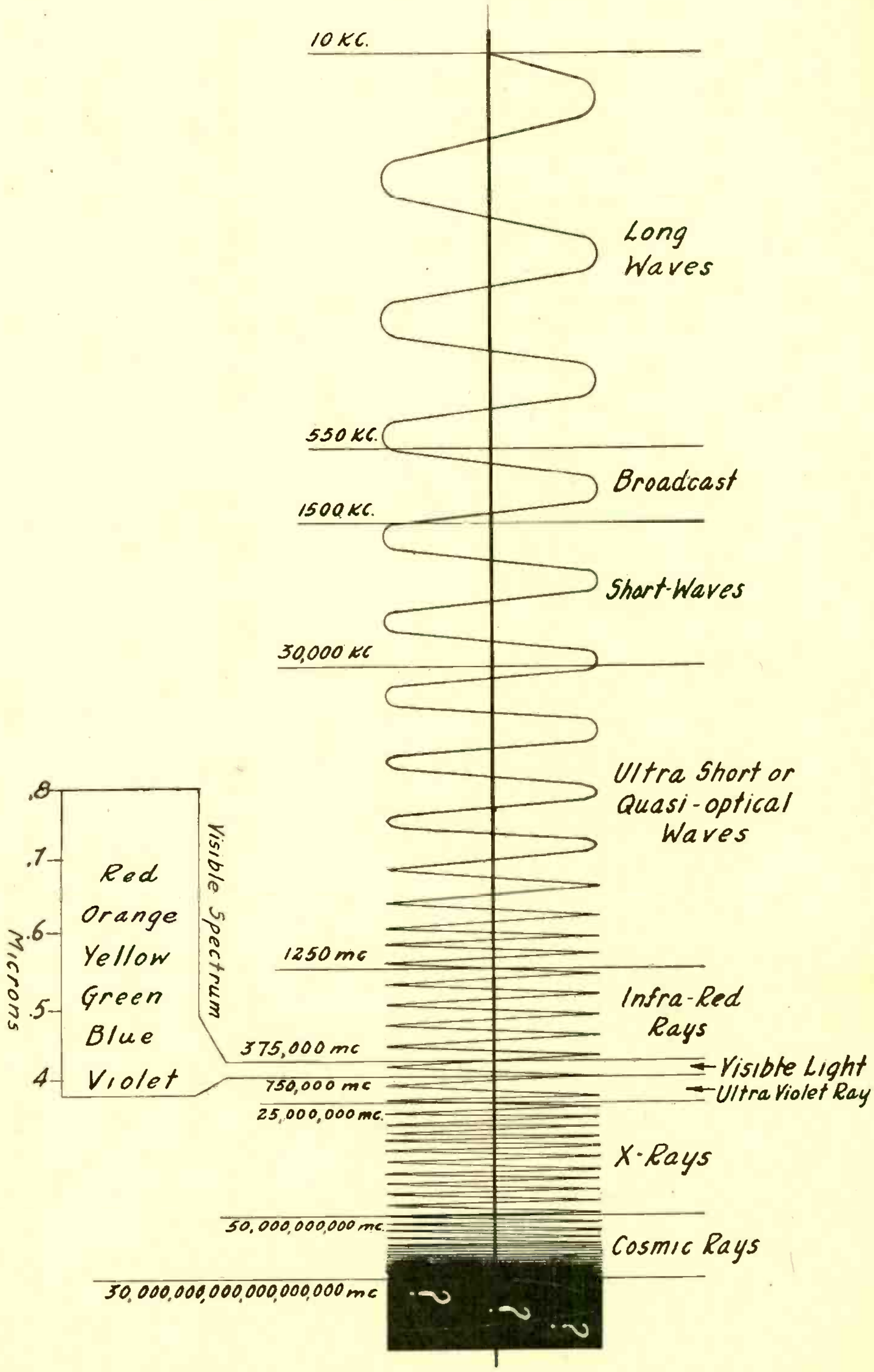
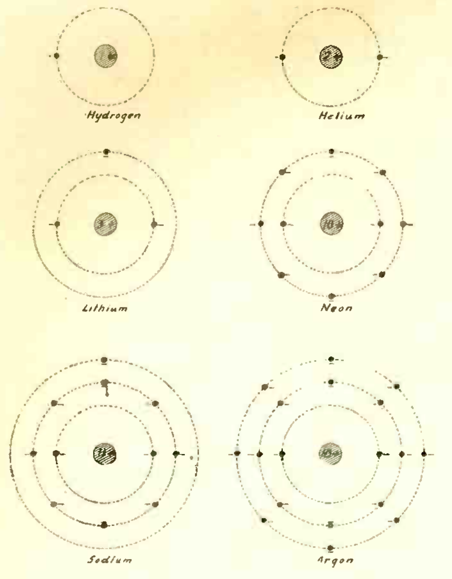



**The electromagnetic radiation spectrum is now taken to extend from about 10 kilocycles of vibrations to more than 30,000,000,000,000,000,000,000,000 kilocycles and still we wonder whether the limit has been reached.**




**The Bohr atom is in effect a miniature solar system. Though the paths of the electrons are really ellipsoidal rather than circular. They are drawn thus for simplicity. Also, these paths occur in all planes and not only in the plane of the paper.**

(*Continued from preceding page*)

present time from the brilliant work of the many physicists who have been engaged in this endeavor. Past work has fairly definitely established the point that all matter (and that means anything you see and many things you don't see that have weight, volume or other physical characteristics) consists of individual arrangements of small entities. The term "molecule" has been given to that smallest amount of matter that still retains the characteristics of the mass of matter from which it derives.

## The Atom Defined

Matter consists of elementary substances (which cannot be further divided) such as hydrogen, oxygen, sodium, etc., called "elements" and combinations of these elements are known as "compounds," such as ordinary table salt, which is a combination of the elements sodium and chlorine, or water which is the pairing of hydrogen and oxygen, etc. The term molecule has then been referred to the smallest piece of a compound and similarly the term "atom" has been ascribed to the smallest piece of an element that still retains the characteristics of the element.

Since compounds are divisible into elements, the term of molecule may be neglected for the somewhat similar term atom. This is our starting point for an understanding of electromagnetic radiation. In the finality of all this analysis, it will be understood that all matter is constructed from individual peculiarities of its atomic structure. An atom is so small that it is invisible to the smallest microscope, accordingly it has been necessary to theorize upon its make-up.

There have been many such theories advanced, but the one propounded by Bohr seems most plausible and it will accordingly be considered. The fact that this theory has been advanced a mere twenty years ago will indicate its recency. It states that the atom consists of a positive and negative charge, the positive one being concentrated in the nucleus which constitutes most of the atom's mass, and the negative charge being concentrated among a number of negative charges known as electrons. It is theorized here that these electrons travel at high speed in somewhat elliptical orbits around the centrally located nucleus, in similar fashion to the manner in which the planets of the solar system traverse the skies around the sun.

## Concentration in Layers

These electrons do not necessarily all travel in the same plane but rather in all planes and in various layers. The diagrams roughly indicate this idea for six different atoms. (Note: The circular paths should be elliptical in reality.) An extension of this theory, known as Langmuir's Octet theory, explains that the concentration of electrons in these layers or shells will vary as 2/8/8/18/18/32/32. In other words, in the shell closest to the nucleus, there can exist only two electrons at a maximum. The next two shells can contain eight electrons each as a maximum; the next two, eighteen as a maximum, etc. Thus we see in the diagram that the helium, neon and argon atoms contain the maximum number of electrons in their shells. On the other hand, the hyrogen, lithium and sodium atoms are not completely filled. It will be noted that the outermost shell contains only one electron where eight might exist at a maximum. Since it is the everlasting function in Nature that forces equalize each other, there is an ever-present attraction for the neutralization of these incomplete outer shells, and it is because of this incomplete outer shell in some atoms that some chemicals display greater chemical activity than others. Thus, the well-known tendency of hydrogen, sodium and lithium, etc., to engage violently in chemical reactions is understandable. On the other hand, the lethargy of the rare gases, such as helium, neon, argon, etc., in the matter of chemical affinity is also vividly appreciated on this basis.

## Table of Composition

The following table indicates the electron composition of all the different atoms:

| Atom | Number of electrons | Arrangement of electrons into shells | Number of shells |
|---|---|---|---|
| Hydrogen | 1 | 1 | 1 |
| Helium | 2 | 2 | 1 |
| Lithium | 3 | 2-1 | 2 |
| Beryllium | 4 | 2-2 | 2 |
| Boron | 5 | 2-3 | 2 |
| Carbon | 6 | 2-4 | 2 |
| Nitrogen | 7 | 2-5 | 2 |
| Oxygen | 8 | 2-6 | 2 |
| Fluorine | 9 | 2-7 | 2 |
| Neon | 10 | 2-8 | 2 |
| Sodium | 11 | 2-8-1 | 3 |
| Magnesium | 12 | 2-8-2 | 3 |
| Aluminum | 13 | 2-8-3 | 3 |
| Silicon | 14 | 2-8-4 | 3 |
| Phosphorus | 15 | 2-8-5 | 3 |
| Sulphur | 16 | 2-8-6 | 3 |
| Chlorine | 17 | 2-8-7 | 3 |
| Argon | 18 | 2-8-8 | 3 |
| Potassium | 19 | 2-8-8-1 | 4 |
| Calcium | 20 | 2-8-8-2 | 4 |
| Scandium | 21 | 2-8-8-3 | 4 |
| Titanium | 22 | 2-8-8-4 | 4 |
| Vanadium | 23 | 2-8-8-5 | 4 |
| Chromium | 24 | 2-8-8-6 | 4 |
| Manganese | 25 | 2-8-8-7 | 4 |
| Iron | 26 | 2-8-8-8 | 4 |
| Cobalt | 27 | 2-8-8-9 | 4 |
| Nickel | 28 | 2-8-8-10 | 4 |
| Copper | 29 | 2-8-8-11 | 4 |
| Zinc | 30 | 2-8-8-12 | 4 |
| Gallium | 31 | 2-8-8-13 | 4 |
| Germanium | 32 | 2-8-8-14 | 4 |
| Arsenic | 33 | 2-8-8-15 | 4 |
| Selenium | 34 | 2-8-8-16 | 4 |
| Bromine | 35 | 2-8-8-17 | 4 |
| Krypton | 36 | 2-8-8-18 | 4 |
| Rubidium | 37 | 2-8-8-18-1 | 5 |
| Strontium | 38 | 2-8-8-18-2 | 5 |
| Yttrium | 39 | 2-8-8-18-3 | 5 |
| Zirconium | 40 | 2-8-8-18-4 | 5 |
| Columbium | 41 | 2-8-8-18-5 | 5 |
| Molybdenum | 42 | 2-8-8-18-6 | 5 |
| Masurium | 43 | 2-8-8-18-7 | 5 |
| Ruthenium | 44 | 2-8-8-18-8 | 5 |
| Rhodium | 45 | 2-8-8-18-9 | 5 |
| Palladium | 46 | 2-8-8-18-10 | 5 |
| Silver | 47 | 2-8-8-18-11 | 5 |
| Cadmium | 48 | 2-8-8-18-12 | 5 |
| Indium | 49 | 2-8-8-18-13 | 5 |
| Tin | 50 | 2-8-8-18-14 | 5 |
| Antimony | 51 | 2-8-8-18-15 | 5 |
| Tellurium | 52 | 2-8-8-18-16 | 5 |
| Iodine | 53 | 2-8-8-18-17 | 5 |
| Xenon | 54 | 2-8-8-18-18 | 5 |
| Caesium | 55 | 2-8-8-18-18-1 | 6 |
| Barium | 56 | 2-8-8-18-18-2 | 6 |
| Lanthanum | 57 | 2-8-8-18-18-3 | 6 |
| Cerium | 58 | 2-8-8-18-18-4 | 6 |
| Praseodymium | 59 | 2-8-8-18-18-5 | 6 |
| Neodymium | 60 | 2-8-8-18-18-6 | 6 |
| Illinium | 61 | 2-8-8-18-18-7 | 6 |
| Samarium | 62 | 2-8-8-18-18-8 | 6 |
| Europium | 63 | 2-8-8-18-18-9 | 6 |
| Gadolinium | 64 | 2-8-8-18-18-10 | 6 |
| Terbium | 65 | 2-8-8-18-18-11 | 6 |
| Dysprosium | 66 | 2-8-8-18-18-12 | 6 |
| Holmium | 67 | 2-8-8-18-18-13 | 6 |
| Erbium | 68 | 2-8-8-18-18-14 | 6 |
| Thulium | 69 | 2-8-8-18-18-15 | 6 |
| Ytterbium | 70 | 2-8-8-18-18-16 | 6 |
| Lutecium | 71 | 2-8-8-18-18-17 | 6 |
| Hafnium | 72 | 2-8-8-18-18-18 | 6 |
| Tantalum | 73 | 2-8-8-18-18-19 | 6 |
| Tungstein | 74 | 2-8-8-18-18-20 | 6 |
| Rhenium | 75 | 2-8-8-18-18-21 | 6 |
| Osmium | 76 | 2-8-8-18-18-22 | 6 |
| Iridium | 77 | 2-8-8-18-18-23 | 6 |
| Platinum | 78 | 2-8-8-18-18-24 | 6 |
| Gold | 79 | 2-8-8-18-18-25 | 6 |
| Mercury | 80 | 2-8-8-18-18-26 | 6 |
| Thallium | 81 | 2-8-8-18-18-27 | 6 |
| Lead | 82 | 2-8-8-18-18-28 | 6 |
| Bismuth | 83 | 2-8-8-18-18-29 | 6 |
| Polonium | 84 | 2-8-8-18-18-30 | 6 |
| Alabamine | 85 | 2-8-8-18-18-31 | 6 |
| Radon | 86 | 2-8-8-18-18-32 | 6 |
| Virginium | 87 | 2-8-8-18-18-32-1 | 7 |
| Radium | 88 | 2-8-8-18-18-32-2 | 7 |
| Actinium | 89 | 2-8-8-18-18-32-3 | 7 |
| Thorium | 90 | 2-8-8-18-18-32-4 | 7 |
| Protactinium | 91 | 2-8-8-18-18-32-5 | 7 |
| Uranium | 92 | 2-8-8-18-18-32-6 | 7 |

## Dislodgement by Potential

Normally, the planetary electrons are rotating around the nucleus of each atom in their proper orbits and no external manifestations of energy are indicated. Each electron possesses a certain amount of potential energy depending upon its distance from the nucleus. The greater this distance, the greater the potential energy. In order to move any electron from its normal path the application of a force is required which would then cause the existence of an unbalanced positive influence at the nucleus. Therefore, if a force causes such dislodgment of one or more of the electrons, an emission or absorption of energy occurs dependent upon whether the electron is dislodged toward or away from the center positive nucleus of the atom.

If the electron is dislocated toward the nucleus, the difference in energy represented by the change in potential level will be evidenced in the form of an external manifestation by the radiation of energy. This energy radiated from the atom as a result of the electron or electrons having been dislodged from normal, form electromagnetic radiations and for each electron that is moved, a certain amount of energy will be released.

## The Quantum Theory

The amount of this energy is constant per electron per potential level and is known as a quantum. This energy then shoots out from the atom, according to latest measurements, at a velocity of 299,820,000 meters per second or somewhat more than 184,000 miles per second. A theory propounded by Prof. Albert Einstein sets forth that it is the scattering of these quanta of energy through space that constitutes the radiations that are emitted by any radiating matter. Our present knowledge does not indicate the exact nature of this energy nor does it ex-

(*Continued on next page*)

(*Continued from preceding page*)
plain the manner in which it travels through space.

A knowledge of the theorv involved in these radiations by itself is not very useful. It is of greater utility to know how these rays may be generated. Accordingly, the sketch showing some of the sources of these rays is of interest. It will be noted that electrical devices have in the main been illustrated. However, it should be understood that other agencies can also produce radiations. Illustrative of this fact is gas heat, coal heat, etc., for infra-red rays; and, any source of white light in which will usually be found some ultra-violet light rays.

### New Tube Helps

In the radio communication range, we of course have the various types of vacuum tubes that can generate most capably any frequency within this range of this band. For the ultra-short waves the new acorn tube extends the possibilities of this region most completely. Formerly, the technique of this band utilied the Barkhausen-Kurz and Magnetron oscillators. In the inra-red or heat region, the electric coil heater within a parabolic bowl reflector furnishes the most easily handled form of this source of radiation. Other agencies make use of the gas flame, the heat from coal and other burning matter, etc.

Light waves, or those that affect the eye, are derived primarily from incandescent electric lamps. In the past, however, the sources constituted the candle, the kerosene lamp, the gas mantle and jet, etc. For ultra-violet light, we usually are dependent on any source of intense white light since the violet rays that make a light source more white. The best source of white light is the electric arc.

### X-Rays and Cosmic Rays

The X-rays of Roentgen are universally generated by vacuum tubes of a design that is especially suited for the purpose. The theory in this connection is that when certain high-speed electrons strike a metal target, they are caused to rebound and form X-rays that have highly penetrative powers. If this target is inclined to the axis of the tube's electrodes, these rays may be made available outside the tube.

In the field of cosmic rays, we find that the scientists are still involved in hungry pursuit of the secrets of this region.

During the past year we have read in the daily press of many intrepid individuals who have ventured into the stratosphere where these rays exist in profusion, for the purpose of measuring the properties and thus acquiring a larger appreciation of the characteristics. This field is most exciting because of its celestial nature.

Some of the interesting properties of some of these waves have been tabulated by the Smithsonian Institution at bottom of this page.

### Terms Used

In conclusion, it might be well to indicate the units that are used in the various branches of radiation study. In the foregoing, all these rays have been treated on the basis of frequency and of course when so treated the term kilocycles can be used. However, it is sometimes useful to describe these waves in terms of wave-length in which case, a number of different units are available, indicated below in tabulated form:

| *Waves* | *unit* | *Symbol* | *Size with respect to meter* |
|---|---|---|---|
| radio communication | meter | m | 1 |
| Ultra-short waves | centimeter | cm. | $10^{-2}$ |
| Infra-red rays | micron | $\mu$ | $10^{-6}$ |
| Light waves | Angstrom unit | A | $10^{-10}$ |
| Ultra-violet | Milli-Angstrom | mA | $10^{-13}$ |
| X-rays | Micro-Angstrom | $\mu$A | $10^{-16}$ |

### Tempting Field

The recent advent of the ultra-short waves has served to reawaken the pulses of dormant experimenters whose discoveries in the radio communication bands have served to advance the science and art of radio a great deal. However, the day will come when the ultra short waves will also hold no secrets for us and will be a commonplace utility. Then, the experimenters might again say there is nothing new to discover. BUT, THEY ARE WRONG! The gamut of frequencies above the ultra-high frequencies presents a field that is tremendous in its immensity of possible investigations. It, perhaps, even holds the secret to eternal life itself! Come on, you curious ones, try the infra-red rays, as a start. Get yourself one of these electrical heater coil units with the parabolic reflector behind it and see what you can find out. We are intensely interested and would be glad to hear of your results.

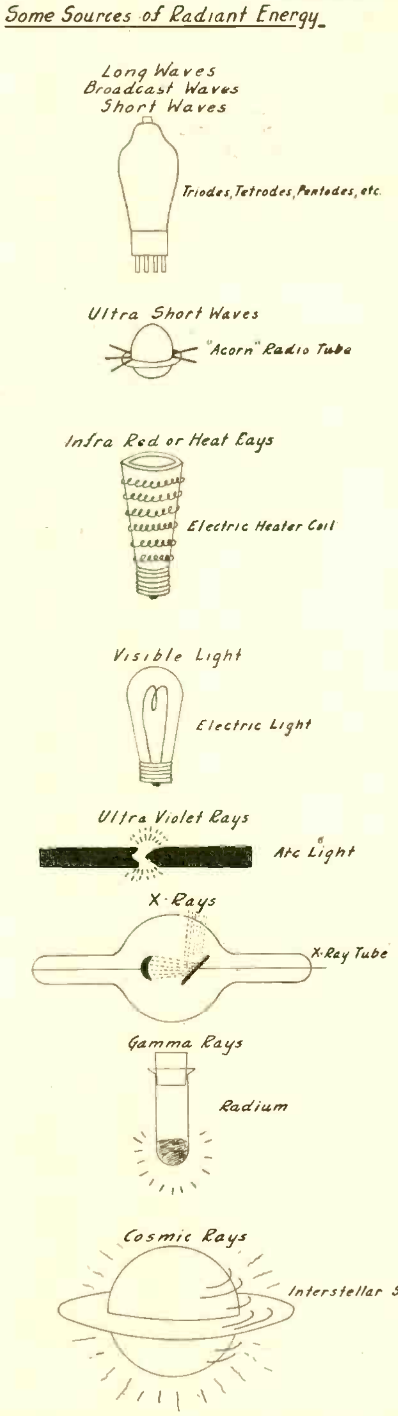
| *Wavelength (cm.)* | *Nature of Radiation* | *Effect on Atom* | *Temperature Absolute* | *Where found* |
|---|---|---|---|---|
| $7500 \times 10^{-8}$ $3750 \times 10^{-8}$ | visible light | disturbs outmost electrons | 3880 to 7700 | stellar atmosphere |
| $250 \times 10^{-8}$ $10^{-8}$ | X-rays | disturbs inner lectrons | 115,000 to 2900000 | stellar interiors |
| $5 \times 10^{-9}$ $10^{-9}$ | Soft gamma rays | strips off nearly all electrons | 58000000 to 290000000 | Central regions of dense stars |
| $4 \times 10^{-10}$ | Gamma rays of radium | Disturbs nucleus | 720000000 | .... |
| $5 \times 10^{-11}$ | Hardest gamma rays | .... | 5800000000 | .... |
| $4.5 \times 10^{-12}$ | .... | Hydrogen atom becomes helium atom | 64000000000 | .... |
| $2 \times 10^{-12}$ | Highly penetrating death rays | disintegrates nucleus | 150000000000 | ... |

# Minimizing the Harmonics

There is one kind of static shield that is intended to lessen the crackling sounds one hears when trying to get distant stations. Another kind is designed to reduce the whistle often heard when the harmonics of a local station signal get mixed up with the fundamental signal of a weaker distant station. Distortion that is ever present in the generation and amplification of radio waves for broadcasting causes many unwanted harmonic frequencies to appear and a new simple device designed by Westinghouse engineers, to cure the harmonic trouble, do so by preventing the harmonics from getting into the ether. A static shield is used. A wire lattice-work is suspended between the coils that connect the transmitter to the antenna.

Legislation under the Federal Communications Commission has required strict observance of the percentage of harmonic radiation of all broadcast stations, so serious is the effect of these stray signals from super-power stations. When KYW started broadcasting, careful measurements and adjustments were made on harmonic radiation. With aid of the new static shield, it is estimated that the reduction of harmonics was hundreds of times better than the law requires.

The simplicity and effectiveness of the static shield and its coming popularity are evidenced by the fact that a miniature one is built into the new Westinghouse 50-watt police broadcast transmitter installed recently in Charleston, W. Va.

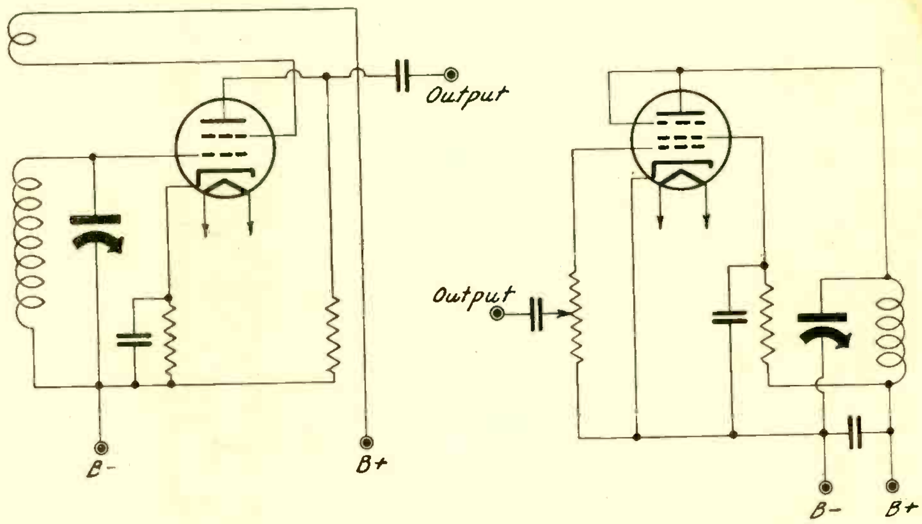



**The various forms of electromagnetic radiation are manifested by the various examples shown here. Though some of them generate several different radiations, the indicated types preponderate.**

# Special Uses of Tubes

## Two Oscillators, One Stable, Other Unstable

*By Frederick L. Carter*




**A pentode used effectively as a triode with conventional plate for pickup purposes, to provide electron-coupled output, so the work circuit will not influence the frequency of the generator. Another special use of a vacuum tube in a generator is that of a pentode converted into a tetrode, by tying the suppressor to plate or screen, so that dynatron characteristics may be maintained.**

TWO unusual tube uses are shown in the diagram. Both apply to oscillators. In the one instance a pentode is operated practically as a triode with suppressor. But as the suppressor action is nullified the triode appellation may be allowed to rest. Otherwise the tube as used would be called a tetrode.

This use was originated in these columns and the sole purpose is to provide electron coupling of the output. In that way the frequency of generation in the oscillator is not affected by the circuit into which the oscillation is put. The coupling is weak, besides. It is so weak that when the conventional plate circuit, here used as a pickup element, had a pair of phones in series with it, the generator hooked up for detection, practically nothing could be heard, despite good antenna input.

The freedom of influence of the work circuit on the generator circuit nevertheless has much to commend it, although other means, for stronger coupling, may be provided readily, and still the frequency influence of the work circuit on the tank circuit is small enough to disregard.

### Feedback Through "Screen"

Not much is generally known about this special use of the tube. A few experimental facts are obvious. The effective plate to cathode resistance is higher this way than by the normal method. This would follow from the absence of the screening effect. The grounded screen of conventional practice, considering radio or audio frequencies, makes for a low output capacity. Still, low is a relative term. For the 24 tube it is indeed a small capacity, but for the suppressor type tubes the capacity at best runs to around 12 mmfd., and by the illustrated method is considerably higher.

Feedback being through the "screen," used as effective plate, the plate resistance is high, the relative change of plate current through the feedback circuit is small, hence stability is good, but difficulty may be experienced in maintaining oscillations at high frequencies, say, much above 10 mgc. Thus, within its limits, the method had excellent advantages, and for frequencies of 10 mgc and lower the smaller conductance is of little consequence.

An interesting consideration, this part being theoretical, applies to the current through the total resistance of the potentiometer. It is plain from the fact that there is output coupling that there is current through this resistance. Also it is true that the resistance must not be very high, otherwise the voltage across the resistance will be too much, or coupling too tight, and anything like a neon tube connected there for modulation purposes might not strike.

### The Electron Effect

The current through the resistor has been measured and is of the order of a few microamperes. Now, why should current flow through a grounded resistor? In the first place, only one end of the resistor is grounded. The same is true of a grid leak in an audio circuit and in some radio-frequency circuits. We should not be surprised, then, to find current through the load resistance, for the element of the tube is itself not grounded, but at a positive potential.

The question is, how does the pickup element acquire its potential? This element is in the electron field. The electrons are moving. Whenever a conductor is placed in a field of moving electrons there is a potential acquired by the conductor. So there is a potential on the pickup element, because this element is surrounded by agitated electrons. If a resistor is connected between this element and ground, the electrons will be caused to flow through the resistance, to ground, through the B supply, and perhaps back to the cathode. So far as radio frequencies are concerned, the electrons of the generation frequency come to rest at ground and are not renewed. Very low frequency electrons, if present, might keep on going through. At radio frequencies renewal must come from the cathode, the source of all electrons in the vacuum tube, that is, the sole emitter.

### The Dynatron

There is a condition known as secondary emission, but it is not emission in a strict sense, that is, one of origin. The cathode is the exclusive originator. Secondary emission consists of electrons that are emitted from the cathode only to strike some other element, say, the plate, to be bounced off, and some of them sent back in the direction of the cathode, thus to oppose the main flow of electrons. This opposition is a limiting factor on the performance of all tubes that possess the possibility of secondary emission. Suppressors intended to prevent such secondary emission therefore enable high plate efficiency, as much more can be gotten out of the tubes at relatively low voltages, a fact that domintes the performance of some power tubes.

The other circuit is that of a dynatron, where the tube used is not such as originally intended for dynatron purposes. A dynatron is an oscillator so circuited that the slope of the plate resistance, and also of the screen resistance, is negative. That is, when the voltage is increased for any reason, either a-c or d-c voltage, the current is less, instead of greater. Now, the suppressor is intended to render this practically impossible, except for certain occasional and scarcely controllable circumstances. If the presence of the suppressor is denied to the tube, as by combining the suppressor with the plate or screen, whereby the suppression no longer exists, the secondary emission has practically full sway, the dynatron conditions are satisfied, provided of course the d-c potentials are properly applied. This proper application consists of a certain critical apportionment of the d-c voltages, whereby the plate must be less positive than the screen. In general, the screen voltage may be around 60 per cent. of the total B voltage and the plate voltage around 40 per cent.

### Dynatron Unstable

No doubt the dynatron makes the simplest oscillator. The plate circuit alone has to be tuned. There is no grid circuit affected by radio frequencies in any sense related to the tube performance. The grid may be left open-circuited, and still there will be oscillation. But the grid circuit alone may not be tuned, for then there would be no oscillation. All that can be said of the grid circuit is that a negative bias may be introduced to limit the plate and screen currents, with the precaution noted that if the bias is too high there will be no oscillation no matter what the proportion of the B voltage to screen and plate, assuming no potential increase of the total B voltage supply commensurate with the negative bias increase.

# Technique of the New KYW

## Philadelphia Transmitter Introduces Important Improvements

*By Charles P. Worcester*

EXEMPLIFYING the technical perfection of modern radio engineering, the new transmitting facilities of KYW went on the air from Philadelphia.

The original KYW, Chicago, transmitted its first program in 1921. It was the pioneer broadcasting station in the Middle-West. In moving the station to Philadelphia, Westinghouse engineers provided it with completely new transmitting equipment, which in its technical perfection more forcibly brings to mind the pioneering beginning and long years of operation that are behind the call letters KYW.

### Directional Antenna Used

The style of architecture is Pennsylvania Colonial. This is the first time in broadcasting history that a transmitter of 50 kilowatt maximum rating has been so designed that its size is suitable for a building of this style. Two innovations that resulted in saving much space were the use of extremely compact nitrogen-filled radio condensers and a new design of high-voltage rectifier.

This new station will use four 245 foot vertical antennas each connected separately to the transmitter. The power of the transmitter will be divided into these four units. By controlling the phase relationship of the current delivered to the four vertical masts, it will be possible to accurately adjust the direction of the radio beam so that maximum signal will be delivered into Philadelphia. At the same time a minimum signal will be delivered in other directions where, if a signal were present, interference would result with other radio stations.

The control over this phase relationship is accomplished from the control room of the station.

### Power Capacity 50 kw

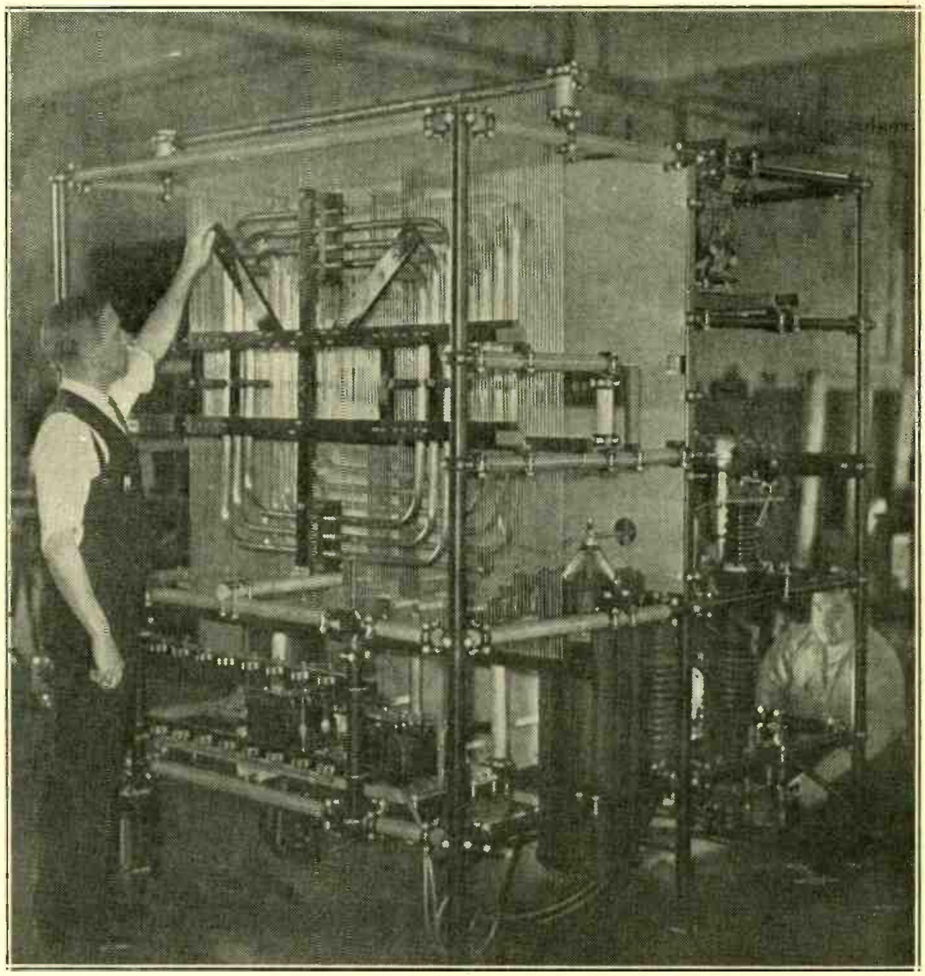
The KYW transmitter is designed as a 50 kilowatt transmitter but modified for operation at 10 kilowatts. The power supply to the station is 4150 volts, 3 phase, 60 cycles.

Like other broadcasting stations, KYW is required to maintain its frequency (1020 kc) within plus or minus 50 cycles. To accomplish this, quartz crystal plate measuring about 1 inch square is used to generate the radio-frequency oscillations. The feeble oscillations of this crystal are amplified in the transmitter and connected to the antenna system. Up to this point, this system is not different than most modern broadcast stations.

However, the oscillation unit in which the quartz plate is held is a new development by Westinghouse containing many refinements after years of experimental work. Actual tests in which one of these crystal oscillator units was used to generate the frequency at WBZ, the variation of the assigned frequency was not more than 5 cycles. The quartz plate is held at a constant temperature through the use of mercury thermostats and the complete oven is contained in an aluminum casting making the circuit free of all interference from external circuits.

As a matter of precaution and to assure continuity of program service, a duplicate quartz crystal oscillator unit will be maintained in operation at all times.

## STATIC SHIELD STAYS HARMONICS



**The static shield used at new KYW, Philadelphia, for preventing the transmission of harmonics.**

### Distortion Checked Visually

Another device, also containing a quartz crystal plate held at constant temperature, will be used as a means of checking the stability of frequency of the station. This frequency checking or monitoring device contains a meter, the pointer of which remains at the center position when the station is on its correct frequency. Any deviation above or below the assigned frequency is accompanied by a movement of this meter pointer to the right or left of center. The unit is kept in operation at all times as a guard against any accidental shifting of the station frequency.

The control room of the station will contain an oscilloscope, using a cathode-ray tube similar to that used in the latest television developments. By connecting various circuits to this tube, the operator can observe distortion and percentage of modulation in the program and in various parts of the transmitter.

High-level Class B modulation is used at this station using equipment similar to that designed by Westinghouse engineers for the 500 kw transmitter at WLW. One hundred percent modulation will be possible over the musical scale, including frequencies between 30 and 10,000 cycles.

### Enormous Audio Transformers

The ability to achieve this perfection is the result of the development by Westinghouse engineers of enormous audio transformers, free of the usual distortion.

When modulation exceeds 100 per cent, serious distortion results. As a safeguard against this occurence, engineers have devised an over-modulation indicator which operates in connection with the radio power amplifier at the transmitter. On the panel in the station control room, a

(*Continued on next page*)

# Rectifiers for D-C Meters

## Several Ways of Establishing Instrument as "Universal"

*By William Akerron*

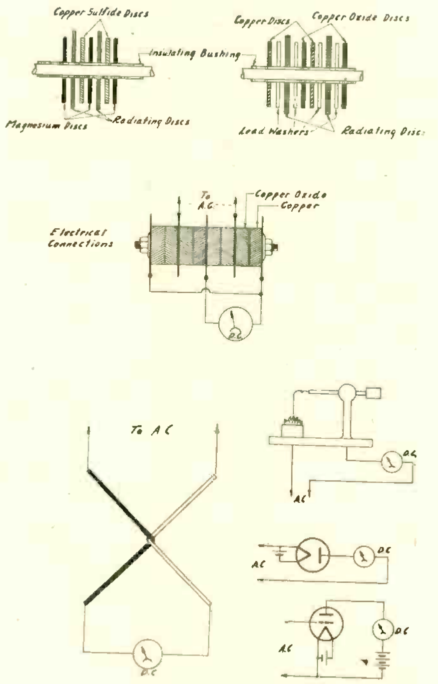
THE less fortunate ham who hasn't wads of money with which to purchase the many luxuries of a more nearly ideal existence finds himself spending a great deal of time (if not money) thinking up economical ways of doing things that his more fortunate confrere finds of no moment at all. In this process, many new uses for old devices have been discovered and this difficulty becomes in reality a blessing. You've heard the old adage, "Necessity is the mother of invention."

One of the most common luxuries for the thus disposed ham are meters and other instruments. We call them luxuries since radio equipment can work without them (though usually out of adjustment) and because of the comparatively large cost. Though one meter may cost $5, several meters are necessary. It is accordingly economic to take steps that will reduce the number of instruments required to perform the necessary measurements in a radio circuit.

### Rectifier for D-C Instrument

Thus, through economic pressure, meters have become associated with sets of shunts and multipliers whereby one instrument could perform the function of many meters through a variety of ranges thus furnished. In this way, one meter many times performs the functions of ten or twenty meters. However, a restriction is usually involved. The meter may be a d-c instrument which can only be used for such currents. If it is desired to measure an alternating current, this combination is not applicable in its form as mentioned. However, this instrument may be rendered capable of furnishing this service by the expedient of a rectifier which will change the alternating current into direct current that is measurable by the meter.

There are several ways of accomplishing this end with the various types of rectifiers that are available. It is proposed to treat a few of these possibilities: (1) the thermopile; (2) the thermocouple; (3) the crystal rectifier; (4) the diode rectifier, and (5) the triode rectifier.




**The construction of two types of dry disc copper rectifiers. The thermocouple, consisting of two dissimilar metals joined at a "point," a very simple type of rectifier, is shown at left. The old crystal detector with its "cat's whisker" can be returned from oblivion for rectifying purposes. Also the diode and triode vacuum tubes are useful.**

The work of various physicists of the past evolved the fact that a series arrangement of two dissimilar metals in contact with each other had the useful property of conducting an electric current in only one direction. This is of course the process of rectification, whereby an alternating current that reverses its polarity or direction periodically in an input circuit to the thermopile may be made to function in only one direction in the output circuit to constitute a direct current.

The first two sketches illustrate two types of such a rectifier. In the first one, the active elements are two alternate discs of copper sulfide and magnesium. In the second one, the active discs are made of copper in the pure state and copper oxide. In both of these thermopiles the discs are mounted in alternating sequence upon an insulated threaded rod between successive radiating discs for the dissipation of the heat that is generated within the units.

### Danger of Nullification

The purpose of the threaded rod is to furnish a convenient means for clamping the units tightly together. This latter requirement is especially important in the copper oxide type since this type of rectifier will quickly lose its value if the air can get at the copper disc to oxidize it to copper oxide. If this should happen, there would be two copper oxide discs in juncture which would nullify this action. Therefore when the copper oxide disc is very tightly squeezed against the copper disc so that no air may enter in between, the life of this unit is materially increased.

The copper oxide rectifier is quite the more universal type of dry disc rectifier and is readily obtainable in the open market.

In the third sketch, the manner of connecting it up electrically is readily seen. It is apparent therefrom that the alternating current under consideration is connected between the two middle sections of a four-section rectifier while the rectified direct current is taken off the middle point and the outsides.

In this manner, the multiple purpose meter may be made to measure alternating current in addition to direct current. for the measurement of alternating current makes use of the thermocouple. This

Another way of utilizing a d-c meter

(Continued on page 20)

# KYW Minimizes Harmonic Radiation

(Continued from preceding page)

red light flashes each time the modulation exceeds a predetermined value and warns the operator so that the volume will be reduced.

The main rectifier is of new design and considerably smaller than previous rectifier designs for 50 kw stations. It is capable of delivering 12,000 volts, 17 amperes d.c. This voltage is adjustable and will be used at considerably lower rating at KYW.

An intermediate and bias rectifier are contained on the same unit as the main rectifier.

All high voltages are shielded behind doors in the transmitting room. When it becomes necessary for the operator to enter the transmitting room, the high voltages are automatically turned off and grounded through the operation of interlocks. Similar methods are employed by nearly all high power broadcasting stations.

### A.C. on Sending Tubes

The filaments of all of the transmitting tubes operate directly from alternating current. All other high-power broadcasting stations thus far have required the use of large motor generators to convert the alternating current into direct current for the transmitting tube filaments. The use of alternating current on filaments of tubes introduces noise on the carrier wave radiated by the station. To neutralize this, Westinghouse engineers have developed a "magnetron suppressor" which introduces a current of the right phase and amplititude into the power amplifier circuit to neutralize the noise current produced by the use of a.c. on the filaments.

All of the power tubes of the station are cooled with distilled water which is circulated through the tubes and through cooling radiators. Large blowers force the cool air through the radiators extracting the heat from the distilled water.

Thermostats and water flow meters are used as a guard against failure of the water system to cool the radio tubes properly. Automatic regulators are used to maintain the filament voltages at their correct operating value. Short circuits or flash overs in the radio equipment which might overload and ruin the expensive tubes cause other automatic devices to operate which reduce the high voltage direct current from the rectifier to half value. If the trouble which occurred was only momentarily and clears itself up, the

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type of rectifier has the advantage of extreme economy since all that is required are two short lengths (about 2 or 3 inches long) of dissimilar wire—one might be iron and the other advance resistance wire.

The procedure involved in this type of rectifier constitutes joining these two wires together in the form of an "X" so that they have a common junction point. The efficiency of this couple is directly affected by the size of this juncture. For best results it is essential that this point be as small as possible and it is for that reason that soldering the two wires together is not good procedure, since the layer of solder shorts the joint into a large area.

## Method of Connection

As will be seen in the sketch, the alternating current under consideration in this case is fed to two dissimilar ends of this couple while the output side to the d-c meter is taken from the two remaining ends. Thus, the correct hook-up involves two dissimilar wires in the input side and two dissimilar wires in the output side to the meter.

The thermoelectric effect that allows this couple to act as a rectifier depends upon the fact that two dissimilar metals in contact have the reciprocal property of generating an electric current from heat. The alternating current flowing in the input side of the couple thus generates heat at the junction which heat generates a direct current in the output side.

The good old crystal detector was the standby in the days of yore as far as radio is concerned. It performed its function of detection against great odds until the advent of the vacuum tube caused its abandonment. The infinitely greater capabilities of the vacuum tube dropped the crystal detector from the radio scene for reception but the crystal still is useful as a rectifier for relative measurement purposes in a pinch when no other rectifier is available.

## The Crystal Rectifier

Certain minerals, such as galena, magnetite, pyrites, carborundum, etc., have the natural property of allowing an electric current to flow through them in only one direction. This ability of certain crystals has never been satisfactorily explained but nevertheless that does not prevent us from utilizing this curious phenomenon. Therefore, to avail ourselves of this property all that is necessary is that we find that "sensitive spot" with a cat's whisker when the crystal is connected in series with the meter for the measurement purposes outlined heretofore.

Of course, the use of a cat's whisker, with its annoying ability of jumping, is quite a nuisance. Because of this fact, the sensitive spot often is lost, and the circuit's effectiveness jeopardized. Therefore, in mitigation of this failing, the less sensitive carborundum crystal in series with an energizing battery may be substituted for the crystal with the cat's whisker. With the carborundum crystal, it is possible to make a permanent contact with pressure which is not easily jarred.

Though Edison noticed the Edison effect many years ago, he did not appreciate the utility of two electrodes in a vacuum tube being able to rectify an alternating current. It was not until Fleming envisioned this use that the diode vacuum tube became applicable to the purpose of rectifying alternating current into direct current. An extension of this application may be adopted for our purpose and according to the connections shown in the sketch, our d-c meter may be used in the measurement of alternating current voltages. No worry about sensitive spot troubles, which most certainly is a decided advantage.

## The Triode Rectifier

The triode vacuum tube is seen so often in the guise of an amplifier that its rectification possibilities are not fully realized. However, the triode is an even better rectifier than the diode—since it also amplifies in addition to its rectification action, and may be made to rectify without itself drawing current from the measured source, which is never true of a diode. It is this function of rectification that is applied in the vacuum tube voltmeter. A fundamental connection for this purpose is shown in the final sketch. It will be noted here that the alternating current is fed into the grid-filament circuit of the tube while the meter in the plate-filament circuit measures the direct current increments or decrements that flow as a result of the a. c. in the grid circuit. Through the amplifying action of the triode tube, the a. c. after rectification is amplified to d. c. of a greater comparative magnitude.

It should be obvious to the experimenter that there are many ways of "skinning a cat" and it is to the everlasting credit of the ham with the limited pocketbook that he has been able to function under adversity incurred by a capital of practically no dimensions.

## Resistance of Rectifier

Rectification is commonly regarded as changing alternating current to direct current. In connection with d-c meters, to constitute them of the rectifier type, the definition holds strictly, because something is done to produce a direct current where the input was an alternating current, and this direct current the d-c meter of course will read. By suitable shunts the current range may be extended. By suitable series resistors the voltage range may be extended, a voltmeter simply being a current meter where the equivalent voltage values to produce definite currents are calibrated in volts.

A fact to consider in connection with the rectifier is the resistance thereof. Likely this will run high in some instances. The thermopile type may be included in this group. Special rectifiers, consisting of plates, as used in rectifier type "universal" instruments, have a relatively high resistance. In one instance this resistance is 4,950 ohms. The rectifier evidently was specially made to have this resistance, for the meter resistance itself is 50 ohms, and the sum of the two resistances is 5,000 ohms, or just right for the 0-5 scale of voltage on the meter, which is of the 1-milliampere full-scale deflection type.

## Avoiding Multiplicity

Since the rectifier may have appreciable resistance, it is well to measure this resistance, and to treat the other series resistances accordingly. Therefore for a 50-volt scale, the limiting resistance would have to be 49,950 ohms, since the meter has the other 50 ohms resistance, but the rectifier has 4,950 ohms, so the resistor to use would be 45,000 ohms. Meter and rectifier make up the difference.

This would be true for use of the a-c scale. For the d-c purpose, then, a resistance would have to be cut in, equal to the rectifier resistance, or 4,950 ohms, and when this is done, the resistors used for higher voltage ranges on a.c. also would be applicable to the same ranges on d.c. That is, two sets of resistors would not be needed.

However, the two scales do not track. That is, there must be an a.c. scale, or calibration, and a d-c scale, or calibration. The difference is rather pronounced over a portion of the scales, but there is practically always some difference. This is principally due to the impedance factor, that is, the capacity and inductance effects of the resistor or rectifier at the frequencies considered. The capacity may be rather high.

Also, the frequencies themselves are not unlimited. In general, frequencies for the types of rectifier units used in conjunction with meters, using the dissimilar plates closely held together, are not serviceable above 30 kc. It isn't that current fails to flow, but that it fails to flow according to the calibration of the scale. The absolute values becomes worthless, practically, at higher frequencies, although a meter manufacturer might supply data wherefrom the true voltage could be calculated, in respect to frequencies higher than 30 kc. In general, of course, measurements are made of low frequencies, say, not above 10 kc. These frequencies are in the audio realm.

## Other Rectification Aspects

Aside from the use of rectifiers with d-c meters, it is interesting to note that real rectification exists whenever there is a substantial change of frequency. In the more familiar instances to which the word rectification is applied the change is from a-c values to d-c values. There may be a ripple of a.c. present, but a filter would be used to wipe that out. In a superheterodyne, the mixer tube, or modulator, is a rectifier in a very real sense. Are not two frequencies put into it, and is not one lower frequency taken out? Hence has there not beeen a change of frequency? There has. Rectification has taken place.

In the same sense the cathode-ray oscilloscope may be regarded as a rectifier, because a.c. may be put in, of a very high frequency, a timing circuit used to cause reduction in the number of pulses, while maintaining their relative amplitudes and other proportions, hence there has been a change of frequency for visual purposes, or rectification.

# KYW

(*Continued from preceding page*)

transmitter will return at once to full power. If the trouble is not cleared up, the station automatically shuts down and requires attention of the operator.

## Air Envelope for Condensers

The tuning condensers for most transmitters are large plates carefully insulated and spaced from each other and suspended in the transmitting frame with free circulation of air around. In the new station, the tuning condensers are mounted in cylindrical tanks measuring not over a foot in diameter and 3 feet high. These tanks are sealed and nitrogen is introduced under high pressure. Although greatly reduced in size from former types of condensers, these nitrogen filled condensers are able to withstand even higher operating voltages. Even though the parts of the condenser are sealed inside, it is possible to tune them from the front panel of the transmitter control board just as one would turn a dial on an ordinary radio receiver.

To minimize the generation of harmonic frequencies in the radio equipment, special attention is given to the balancing of all circuits. Furthermore in the power amplifier, where the generation of harmonic frequencies is of serious consequence, the use of shielded nitrogen filled condensers is used. Other parts of the power amplifier are carefully shielded and balanced.

## The Static Shield

Also, there is a static shield consisting of a sheet of vertical wires suspended between the two coils which connect the output of the radio amplifier to the antenna system. This static shield is grounded, thereby, preventing the transmission of harmonic frequencies by capacity reaction between these two coils.

# THE RCA COMMUN

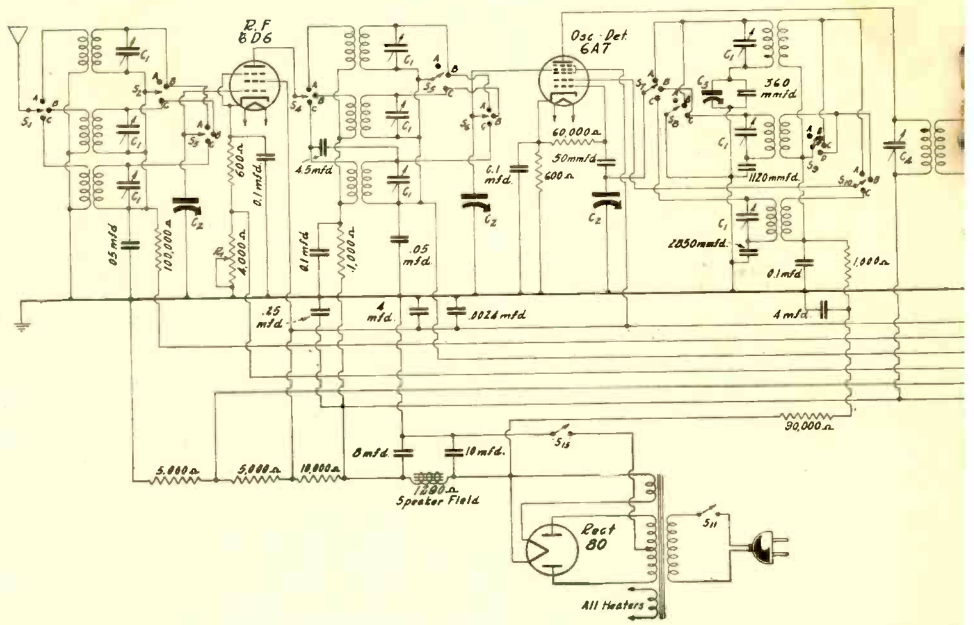
## Model ACR-136 Suitable Especially for Ar

*By Leroy*

A NEWLY announced radio receiver is the RCA Amateur Communications receiver Model ACR-136. This receiver utilizes the super-heterodyne circuit with an i.f. of 460 kc and an additional oscillator for beating against c-w signals. It also contains automatic volume control and a pentode output stage. Its tuning range occurs in three bands as follows:

A 540— 1720 kc—Broadcast, police
B 1720— 5400 kc — Amateur, police, aviation
C 5400—18000 kc — Amateur, S. W. broadcast, aviation.

Integral with the equipment are the power supply and a dynamic loudspeaker operating from the pentode output stage which delivers 1.9 watts of undistorted power. In other words, the whole works is in one box.



The circuit of the ACR-1

### A.V.C. May Be Cut Out

The tuner part has one tuned r-f stage, for low image-frequency response and high signal-to-noise ratio. The set has sufficient sensitivity to go well below the noise level in almost any location. The selectivity is such that stations can be copied through the QRM. The audio system of this receiver is equal in quality with that of a good broadcast receiver, bringing a new pleasure to phone work.

The controls have been arranged for maximum convenience and ease of operation. No plug-in coils are required, the desired band being selected by a switch next to the main tuning control. The use of both a sensitivity control and an audio-gain control permit the operator unusual flexibility in controlling background noise. A jack, which mutes the speaker when phones are plugged in, is provided on the front panel. An easily operated toggle "stand-by" switch removes the plate voltage from the tubes during periods of transmission, but leaves the heaters lighted and ready for instant operation. A switch to cut out the a.v.c. permits the clarification of slow-speed telegraph signals. An adjustment of the beat oscillator control allows the selection of the desired beat frequency for c-w reception. A tone control is provided and is particularly useful in reducing background noises.

Ease of tuning is provided mechanically by a two-speed reduction drive. The low ratio (10 to 1) permits any band to be covered rapidly, while pulling out the main tuning knob increases the ratio to 50 to 1 for fine tuning.

A unique dial permits the positive logging of stations of any frequency without re-setting to a reference point. Band spreading is provided by the vernier pointer which travels approximately nineteen times as fast as the main pointer. The main dial, accurately calibrated in megacycles, facilitates the location of stations.

### Operation Detailed

By the agency of this dial, tuning is of course accomplished. This controls by means of a single knob the tuning of the r-f amplifier, oscillator and first detector circuits through a three-gang variable capacitor. The procedure in tuning this set for broadcast or amateur phone stations involves the following steps:

1. Turn the power switch on and advance the sensitivity control for maximum sensitivity.
2. Select the position of the band switch at which the band letter that is visible through the small opening in the dial corresponds to the frequency scale that includes the station desired.
3. Set standby and a-v controls on and the beat frequency oscillator control off.
4. Advance volume control until background noise is heard.
5. Push in tuning knob on dial and rotate short pointer to approximate setting of desired station then pull knob out and adjust to exact center of carrier.
6. Decrease volume as necessary and adjust tone control for preferred quality of reproduction.

If several moderately strong stations are available, silent tuning between station settings may be obtained by turning sensitivity control counterlockwise until background noise (at any point on the dial where no signal is heard) just disappears. Obviously, weak or distant stations below the noise level will not be received after this adjustment.

### Use of Beat Oscillator

In the efforts to locat eweak, odulated signals, the beat oscillator may be used to advantage. It should be tuned for this purpose exactly to the intermediate frequency of the receiver so that an audio frequency note of ascending pitch will be obtained on each side of every incoming carrier. To adjust the beat oscillator in this manner, simply tune the receiver accurately to any carrier of suitable strength, then turn the beat oscillator switch on and swing the small horizontal rod inside the case in either direction until zero beat is obtained. It follows then that any carrier will be tuned to exact resonance when the tuning capacities are adjusted to zero beat and that the presence of weak signals will be heard almost as well as that of signals of greater strength because of the heterodyne whistle produced while passing through resonance.

For c-w code reception, the tuning procedure is the same as for modulated signals except that the beat oscillator performs a definite rather than incidental function. It is set not at the intermediate frequency but slightly above or below so as to provide an audio frequency beat note when the receiver is tuned to resonance with any carrier. The tuning capacities then should be adjusted to the center of the carrier by listening to the switch or key clicks before turning on the beat oscilla or switch. Always adjust the pitch with the horizontal rod never by means of the tuning control knob.

### Data on Circuit

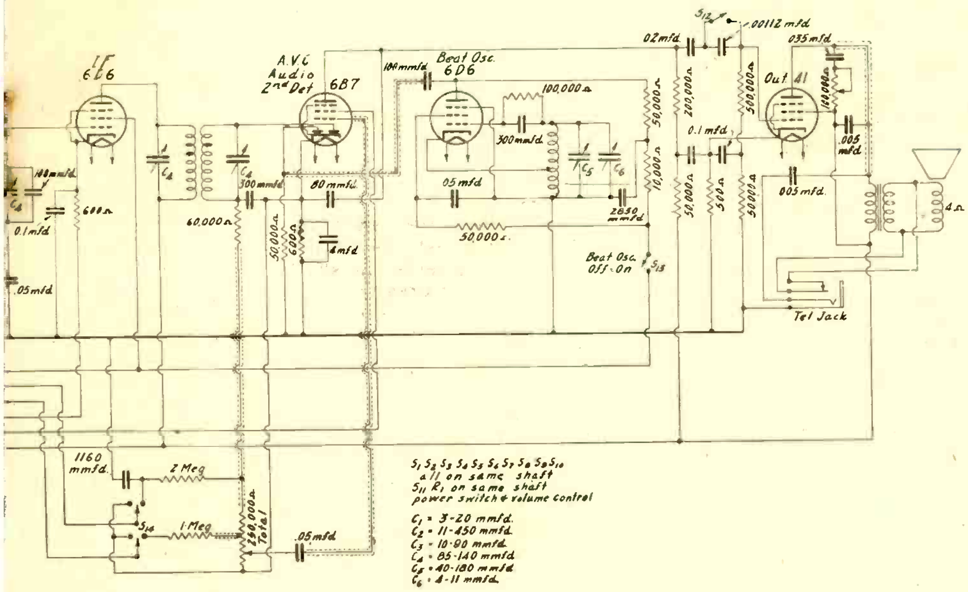
Upon entering the receiver a signal passes through a shielded lead to the antenna coupling transformer, the secondary of which is tuned by one section of the three-gang variable capacitor, and is thence impressed upon the grid of the r-f amplifier—a stage of pre-selection used primarily for reducing image-frequency interference to a negligible value. The output of this stage is transformer coupled to the grid circuit of the first detector which also is tuned to the signal frequency by the second unit of the gang capacitor.

As in all superheterodynes, the first detector is actually a mixer stage, combining

# ICATION RECEIVER

## nateurs, Though for General All-Wave Use

*Mastick*




**36 communication receiver.**

for fluctuations in field strength (fading) and for extreme changes of r-f input when tuning. The switch in this circuit permits elimination of the automatic volume control feature by removing all variable bias from the afore-mentioned tubes.

The audio-frequency component of the rectified signal is capacitance-coupled from the arm of the volume control to the pentode section wherein amplification occurs. Resistance coupling is used between this amplifier section and the power output stage which also is connected as a pentode for high-power sensitivity. The plate circuit of the output stage is matched to the cone coil of the electro-dynamic loudspeaker through a step-down (output) transformer.

A tone control circuit consisting of a variable resistor and a fixed capacitor in series is connected across the primary of the output transformer. The sensitivity control is a variable resistor common to the cathode circuits of the r-f and i-f amplifiers for alteration of self-bias produced by the combined plate currents for those tubes.

All power voltages are obtained from a full-wave rectifier and filter system connected to the a-c line. The loudspeaker field coil is excited from this system and serves therein as a filter reactor.

the incoming r-f carrier with an unmodulated sinusoidal voltage produced by a local oscillator. The oscillator plate circuit, being tuned by the third section of the gang capacitor, maintains a constant frequency difference from the transmitted signal throughout the entire tuning range. Thus, a difference or *beat* frequency is developed when any signal is received which is the same at each position of exact resonance. In this receiver, the functions of the first detector and oscillator are performed by a single tube.

### Alignment Coils Shorted

It should be noted at this point that the three tuning ranges are obtained through a coil-selector system in conjunction with the one three-gang variable capacitor. Three sets of coils, each set consisting of three coils, are employed and with each shift of the range switch, a different and complete coil set is substituted. In addition to selecting the desired coil set, other contacts are provided on the range switch to short-circuit the coil set for band A when operating in band B and the coil set for band B together with the oscillator coil for band A when operating in band C. This practice prevents the occurence of "dead spots" in bands B and C because of absorption effects in coil sets A and B which (when untuned) have natural periods within the range of the next higher-frequency band.

The beat frequency that is set up in the first detector carries the same modulation as the original r-f signal and is commonly termed the *intermediate* frequency. Since this intermediate frequency is constant for all r-f carriers, the next (i-f amplifier) stage utilizes fixed tuning. Its grid circuit is coupled to the first detector through a transformer, both windings of which are tuned to the intermediate frequency (460 kilocycles) by means of independent adjustable capacitors. A similarly-tuned transformer is used to couple the output of this amplifier to the second detector, making a total of four capacitors for adjustment during alignment.

The i-f signal generated by the beat oscillator for c-w reception also is applied to the input of the second detector. As mentioned, the variable capacitor operated by the horizontal rod inside the case is actually a *vernier* control which permits adjustment of the oscillator output frequency over a very limited range on either side of the receiver intermediate frequency. The little condenser is connected in parallel with the main tuning capacitor for the oscillator stage—also a variable air-dielectric unit accessible for adjustment by means of a screw-driver through an opening in bottom of case. Both capacitors together with the oscillator tuning coil are contained inside a single shield.

### A.V.C. in This Stages

In addition to detection, the succeeding stage also performs functions of automatic volume control and audio-frequency amplification. Diode detection is employed to avoid distortion and provide automatic volume control. The i-f signal is applied between the cathode and diode plate elements of the tube and the volume control, which is in series with this circuit, assumes a negative d-c potential of an amplitude that varies directly in accordance with the strength of the original r-f carrier. By returning this potential or portions thereof to the grids of the r-f amplifier, first detector and i-f amplifier, these tubes are biased in varying degree to compensate

### Controls

All controls except the beat oscillator frequency adjustment are located upon the front panel and identified insofar as necessary by adjacent markings.

**Power Switch and Sensitivity Control**—The POWER switch is combined with a SENSITIVITY control and operates at the counter-clockwise end of rotation. When the knob is turned clockwise from latter extremity, the switch closes initially to supply power to receiver and continued rotation increases the sensitivity of receiver gradually to a maximum. Sensitivity is controlled by variation of the grid-bias voltage applied to the r-f and i-f amplifiers. In operation, this control may be employed to provide "silent tuning" between station settings. It is particularly advantageous, however, as an auxiliary volume control when the automatic volume control action of the receiver is removed.

**Tone Control**—Next in order to the right is a TONE control for attenuation of the higher frequencies, *full-range* reproduction being obtained with the knob turned fully clockwise. Under adverse weather conditions, static interference generally will be reduced to an appreciable extent by restricting the audio-response range. The control circuit consists of a variable resistor in series with a fixed capacitor and is connected across the primary of the output transformer.

**Beat Oscillator Switch**—The C. W. OSC. switch, located immediately to the right of the tone control, serves to interrupt plate and screen grid supply voltages to the beat-frequency oscillator stage. Thus, that stage can be rendered inoperative at any time, but, since the filament remains

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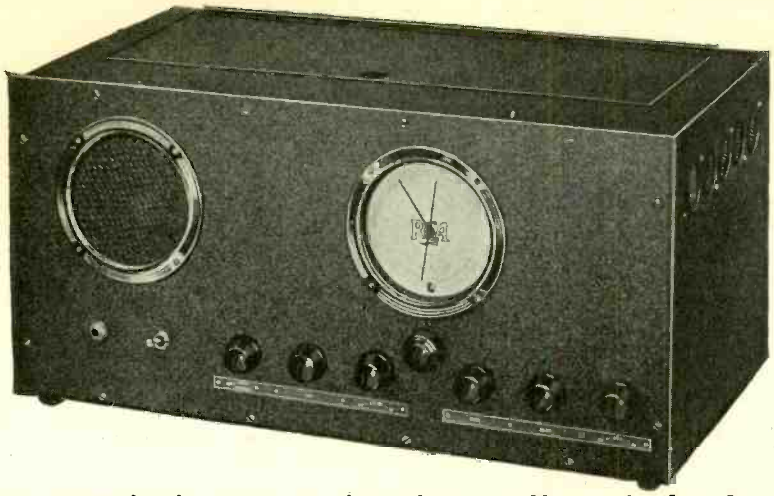

**A new communication type receiver that is self-contained and operates between the frequencies of 540 kc. to 18000 kc.**

(*Continued from preceding page*)

heated continuously, is ready for instantaneous operation.

**Beat Oscillator Frequency Control**—To provide manual control of the output frequency over a limited range on each side of the "zero-beat' position, a midget variable air capacitor is connected across the main tuning capacitor for the beat oscillator stage. Such adjustment is made inside the case upon lifting the lid, the small capacitor being located inside a shield at the rear left-hand corner of the chassis and operated by means of a horizontal rod pivoted from the top of that shield.

**Tuning Control**—The knob directly beneath the dial is the main tuning control. This knob when set inward affords a drive ratio of 10:1 for rapid adjustment and. when pulled out, engages a secondary drive with a ratio of 50:1 for precise tuning—a valuable feature for short-wave work.

**Range Switch**—The following knob to the right is a RANGE switch for selecting any of the three bands whose frequency limits are tabulated under "Electrical Specifications." A visual band indicator operates in conjunction with this knob, the band letters corresponding to the various switch positions appearing in sequence through a small opening in the lower half of the dial.

**Volume-Control**—The VOLUME control is connected in the audio-frequency circuit and increases the output level with clockwise rotation.

**Automatic Volume Control Switch**—On the extreme right-hand end of the front panel is the a.v.c. control—a switch for eliminating automatic volume control action to obtain best reception of slow-speed code transmission.

**Stand-by Switch**—The toggle switch located on the front panel is connected in the plate circuit of the rectifier stage. When thrown to the left, all plate and screen grid voltages are removed, but the filament supply is unaffected, leaving the receiver "warmed-up" so that operation can be resumed instantaneously. Amateurs will find this switch highly advantageous for silencing the receiver during "sending" periods.

**Phone Jack**—The phone jack on the panel at the extreme left-hand end permits quick substitution of headphones for reception of extremely weak signals. When a phone plug is inserted in this jack, it simultaneously short-circuits the voice coil of the electrodynamic loudspeaker and connects the phones through a small capacitor across the plate circuit of the power output stage. Since the loudspeaker field is employed as a filter for the rectifier stage, that unit still forms an active part of the circuit when using headphones.

## Dial

The dial of this instrument incorporates a mechanical band-spread system particularly suited to amateur or other work where a fine degree of resetability is required. In addition to the three main scales calibrated directly in frequency (kilocycles or megacycles), two arbitrary scales are available for precision logging. These are known as the *vernier* and *vernier index* scales, the former being fully circular at the outside of the dial and the latter semi-circular at the center of the dial.

It will be observed that the *vernier* scale is graduated from "0" to "100" and traversed by the long single-ended pointer. On the other hand, the *vernier index* scale is graduated from "0" to "9" and traversed by the short double-ended pointer used for the main frequency scales. The longer pointer makes one complete revolution for each unit of travel of the shorter pointer on the *vernier index* scale. Thus, any station may be logged accurately with three digits; for example, if the *vernier index* reading is between "3" and "4" and the *vernier* reading is "72," then the log number is "372." The index number is always the lower of the two numbers between which the pointer is located.

In logging stations by this method, the band *letter* also must be named. For the above example, therefore, the full log number would be "A-372," "B-372," or "C-372," depending upon the setting of the range switch. As mentioned under "Controls," the band letter is visible through a small opening near the bottom of the dial.

In circuits where the tuning capacitor covers a relatively wide frequency range, the advantage of mechanical band spreading over the well-known electrical method lies in the greater uniformity of separation obtainable throughout that range and in the convenience of single-control tuning. With electrical band spreading, it is general practice to connect small variable capacitors in parallel with the main tuning (tank) capacitors. If such a system were employed, the various "amateur" channels could not be spread as uniformly since for a given frequency change, the travel of the band-spreading capacitors would be far less at the high-frequency end of the scale than at the low-frequency end; in other words, band-spreading action would be very effective for the "amateur" channels at 40 meters (band C) and 160 meters (band B) but relatively poor for the two remaining channels at 20 meters (band C) and 80 meters (band B). In addition to this fundamental defect, there would be required at least one additional dial and the probability of error in reading or resetting would be greatly increased. The direct-reading frequency scale of this receiver obviously is possible only with a single tuning control and should be found very convenient.

## Beat Oscillator

The beat-frequency oscillator embodied in this receiver is of the electron-coupled type, known to afford excellent frequency stability. Its primary purpose, of course, is to enable the reception of c-w (continuous-wave) telegraph signals, but it also may be used to advantage in locating regular broadcast or other modulated forms of transmission by the "birdie" method. Although the latter practice usually will be unnecessary because of the high sensitivity of this receiver, it may be found expedient in cases where the signal strength is very low or the carrier is not modulated continuously.

For c-w reception, it is customary to adjust the oscillator frequency to a value 1 or 2 kc above or below the intermediate frequency of the receiver. Thus, all carriers to which the receiver can be tuned will be heard at *exact* resonance as notes of the same pitch since the beat or separation frequency will be constant throughout the entire tuning range. The pitch, of course, may be varied at will by changing the output frequency of the oscillator, either to satisfy personal preference or to eliminate interfering signals. Best intelligibility and greater apparent volume due to the inherent sensitivity characteristic of the human ear will result using a moderately low-pitch or beat frequency in the order of 500 to 1,000 cycles, but *audio-image* interference will decrease with ascending pitch.

Audio-image interference is an effect entirely distinct from that commonly referred to in superheterodynes by the term "image-frequency response." By the latter is meant interference set up by an incoming carrier on the same side of the desired carrier as the *radio-frequency* oscillator but removed by *exactly* twice the receiver intermediate frequency. Such interference in this receiver is rendered negligible through the use of a pre-selector or radio-frequency amplifier stage.

### Data on Beats

When using the beat oscillator, interference of the same pitch as the desired signal can be produced by any continuous-wave signal which upon passing through the receiver is converted to an intermediate frequency on the same side of the receiver intermediate frequency as the beat oscillator but removed by *exactly* twice the separation of the beat oscillator. In this case, the interfering signal would be a *true* audio image. If one merely visualizes the sharp selectivity curve of the superheterodyne, he will observe at once that the attenuation offered by the tuned circuits of the receiver to such *image* responses will increase very rapidly as the oscillator separation is widened.

It should be appreciated in relation to the preceding paragraph that interference signals can be encountered not only at the *audio-image* frequency but at any frequency above or below the beat oscillator frequency at a separation within the audio range. Such beat notes ordinarily will be distinguishable from the pitch of the desired signal because of the dissimilarity of pitch. In cases where both sound almost alike, confusion between the desired and undesired signals can be practically always eliminated by shifting the setting of the beat oscillator.

If a beat note of approximately the same pitch as the desired signal is heard, the interfering signal must be either near the frequency of resonance or near the *audio-image* frequency. For the first condition, best discrimination will be obtained using a fairly low pitch frequency on the opposite side of zero beat from the interfering frequency. Use of a relatively low pitch is recommended since for a given small frequency separation, say 100 cycles, two notes will be much more discernible in the region of 500 cycles than at 1,500 cycles. When the interfering signal is at or near the audio-image frequency, however, two alternatives are possible. The

(*Continued on next page*)

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oscillator frequency either can be adjusted to zero beat with the frequency of interferences or swung through zero beat with the desired signal to some value on the opposite side of i-f resonance.

### Difference Frequency

As an example, to illustrate the latter alternatives, suppose that with the receiver tuned to a station, the beat oscillator is adjusted to one kilocycle above the intermediate frequency and that an interfering signal is present at 1,900 cycles above i-f resonance (100 cycles below the audio-image frequency). Thus, the desired frequency will produce a 1 kilocycle note and the interfering signal a note of 900 cycles, these tones being sufficiently close that the former probably would not be discernible readily. By increasing the oscillator frequency by 900 cycles, however, the desired signal would be as a 1,900 cycle note and the undesired signal heterodyned to zero frequency. On the other hand, the oscillator frequency could be changed to a point on the opposite side of the i-f resonance so that the desired signal would again be heard as a one kilocycle note. The interfering signal then would produce a note of 2,900 cycles and so should cause no confusion.

Quite a great percentage of the kick derived from the ham game involves the reception of distant stations and to improve this phase of the game, a good receiver is a big asset. Also, a transmitter will reach no further than the distance which can be reliably heard on the receiver. Thus, we are enabled to say that with the use of such a sensitive receiver as described herein, the range of a ham station transmission is increased without touching the adjustments of the transmitter.

## EDDY IS NEW WBZA OPERATOR

J. C. Eddy, former ship to shore operator for the United Fruit Line, has become station operator at WBZA in Springfield, Massachusetts. Mr. Eddy was associated with WEAF in 1926 and 1927 and since that time has been with the United Fruit Line.

# Radio Demolishes Frontiers for Farmers

## By Powel Crosley, Jr.

AT one time it was thought that each farmer lived in a world by himself, independent of all other forces. That never was true, but many farmers and others thought it was. In recent years farmers have awakened to the fact that perhaps more than any other group of people they are most vitally affected not only by local, state and national conditions, but by the affairs of the world, especially those that have a bearing on world markets. No, none of us, not even the farmer, lives by himself.

Four factors have played an outstanding part in bringing farmers in closer contact with the world, much to their advantage. First came rural free delivery that made possible daily newspapers on the farm. About the same time came the telephone, making communication quick between farmers and their neighbors, as well as their local markets. Next came the automobile, which gave farmers the personal transportation advantage. Then came radio, and the farmer's range of contacts was extended over a state or several states. Now with radios for American and foreign reception, his sphere has extended beyond the boundaries of a single country to all the world.

### Barriers Broken Down

What has all this meant to farmers? For one thing, it has broken down the last barriers of isolation. It has put farmers in close, first-hand touch with the world, with markets and all the things that govern farm prices, with state, national and even international events and developments. It has made it possible for them to be informed about everything that has a bearing on their economic, social and political welfare. It has brought about a better knowledge of conditions and therefore greater opportunity for farmers to act with as much information and foresight about their business as business men and other groups. By hearing discussions of business, economic and political questions farmers are in a better position to formulate their own plans and policies and take better advised action in their own interest. No longer is it necessary for them to grope uninformed about vital issues and conditions that in the past have been unseen and unknown forces that controlled their destiny, and seemingly were insurmountable and uncontrollable.

Aside from these practical advantages, there is brought to farmers a whole world of entertainment. Programs in distant cities that would be unavailable and that would be exceedingly costly were it possible to attend them, are brought right into the home on the farm.

### Sphere Is Widened

The farm family can sit by the fireside on cold wintry nights and in unfavorable weather and have the best enjoyment that the wide world affords, for with American and foreign radio receiving sets, all one has to do is to turn the dial to get programs from any part of the country or the world. Through radio, news is available to farmers as well as to others right while it is happening. Every educational and cultural advantage is theirs for they can listen to plays, musicals and lectures on all kinds of subjects, which but for radio would be impossible. The work of the womenfolk on the farm is made lighter and brighter by programs that bring music, plays and other entertainment, as well as helpful suggestions about homework, cooking and the many things women have to do. During the noon hour as well as in the evening recreation is brought to the men, also.

Battery sets, as well as sets operated by home power plants, are available at low cost so that if the farm is away from power lines, a radio may be enjoyed regardless of location. Radios have been so perfected that it is easy to instal any type.

### Location Is Best

Moreover, farmers get the best reception because they are away from the sources of man-made interference or the disturbances of industrial centers. There are no steel structures, electric lines, street railways, nor power plants to cause interference in reception. They not only have greater range, but much better quality of reception.

A radio will pay for itself many times over on the farm by bringing up-to-the-minute market quotations and weather reports that let farmers know when to plant crops or harvest them, and when to sell grain, stock, poultry and produce. It warns them of frosts and other factors that have a bearing on farmers' profits. With a radio the farmer knows what to expect and what to do. And good radios are to be had from twenty dollars up!

## PERSONAL NOTES

E. H. Gager has been appointed plant manager of KYW. For several months he was in charge of the construction of the Philadelphia station. Mr. Gager for nineteen years was assistant superintendent of the Commonwealth Edison Company, Chicago. From 1922 to 1925 he was associated with KYW, Chicago. For four years he was chief engineer of WEMR, Chicago, later becoming staff engineer with the National Broadcasting Company. Mr. Gager's duties will include technical supervision of the studio and station of KYW.

A. C. Goodnow, formerly studio supervisor at KDKA, holds the same position at KYW. The control operators include F. M. Sloan, from KDKA; I. N. Eney and C. E. Donaldson, from WBZ.

J. J. Michaels, formerly chief operator of KYW, chicago, is chief operator at the Philadelphia transmitter. His operating staff includes Bryan Cole, Bernard Clark and W. C. Ellsworth. Mr. Clark was formerly of the Radio Broadcasting Headquarters staff and Mr. Ellsworth of the Radio Engineering Department of the Radio Division of Westinghouse in Chicopee Falls, Mass.

## NEW SOLAR CATALOGUE

The Solar Manufacturing Corporation, 599-601 Broadway, New York City, manufacturer of Fixed Capacitors for radio use, announces the issuance of the latest Special Service Catalog No. 6-S.

Features of interest to the service trade include ultra-compact dry electrolytics in various voltage ratings, special self-healing type wet electrolytic condensers, auto vibrator and suppressor condensers, together with a wide assortment of paper, mica, trimmer and padding condensers.

These catalogs may be obtained direct from the Solar Manufacturing Corporation.

## FASTER HOMCHARGER

Originally introduced in 1920 by the Automatic Electrical Devices Co., of 324 East Third Street, Cincinnati, Ohio, the Homcharger for recharging automobile batteries in your own garage proved so successful that nearly a million were sold within a few years. Now the same company announces a new and improved model known as the Hi-Rate Homcharger.

The use of larger and higher compression engines, dual electric horns, more powerful lights, auto radios, etc. has imposed such a drain upon the car battery that a much faster charging rate was deemed necessary.

## A THOUGHT FOR THE WEEK

*TO BE OR NOT TO BE—POPULAR OR CLASSIC? The wiseacres of the music world are racking their brains in an effort to discover whether the public as a whole prefers popular music or the music of the masters. Of course, when the ransacking of brains and the balancing of percentages is all over they still won't know very much more than they do now. There are so many people in the world and so little standardization, how can guessers settle a question which has been debated for centuries? And whose decision will be accepted as final? And who has figures that are convincing—and what the dickens is it all about, anyhow?*

# Photo Cell Terminology

## Standard Definitions Covering Fascinating Field

*By Samuel Wein*

IN the previous issue, December 29th, we discussed the underlying principles dealing with light. In the present issue we discuss those facts that deal with the phototube. An intelligent understanding of light and the photo cell is necessary in order properly to design devices associated with both.

The phototube has been the subject of considerable investigation by careful scientists as well as electrical engineers with a view of refining the apparatus used in connection with the cell, in the hope of getting the best and most consistent results. After all, like all phases of scientific endeavor, it is based upon an intelligent understanding of the elements used in a "set up."

The definitions given herewith were taken from the report of the Standards Committee of the Institute of Radio Engineers.

**Terminology**

The Standards Committee of the Institute of Radio Engineers have accepted the expression "phototube" which is more or less extensively used.

**High Vacuum Phototube**

A high vacuum phototube is one which is evacuated to a degree that its electrical characteristics are essentially unaffected by gaseous ionization.

**Gas Phototube**

A gas phototube is one into which a quantity of gas has been introduced, usually for the purpose of increasing sensitivity.

**Sensitivity of a Phototube**

The sensitivity of a phototube is the ratio of the short-circuit current through the tube to the incident radiant flux. It is usually expressed in terms of current per unit radiant or luminous flux. In general, the sensitivity depends upon the voltage applied to the tube and upon the intensity and the spectral distribution of the flux.

In the special case of a simple vacuum phototube, the relation between the current and radiant flux is linear. Also, in this case the specified voltage may be taken as any voltage sufficient for saturation current.

**Static Sensitivity**

Static sensitivity is the ratio of the direct current through a phototube operated at a specified voltage to the incident radiant flux of specified value.

**Dynamic Sensitivity**

Dynamic sensitivity is the ratio of the alternating component of current through a phototube operated at a specified voltage to the incident pulsating radiant flux of specified mean intensity, frequency of pulsation, and degree of modulation.

**Monochromatic Sensitivity**

Monochromatic sensitivity is the ratio of the short-circuit current through the phototube to the incident radiant flux of a given frequency or very narrow frequency range.

### Total Sensitivity

Total sensitivity is the ratio of the current which flows through a phototube at a specified steady voltage to the total radiant flu- (in watts) of specified spectral energy distribution entering the tube. The total sensitivity depends on the spectral distribution of energy of the radiation and is related to the monochromatic sensitivity.

In the special case of a simple vacuum phototube, this sensitivity is independent of the radiant flux and equals the variational sensitivity. Also in this case the specified voltage may be taken to be a voltage sufficient for saturation current.

**Total Luminous Sensitivity**

Total luminous sensitivity is the ratio of the direct current through a phototube operated at a specified voltage to the total luminous flux in lumens.

**Luminous Tungsten Sensitivity**

Luminous tungsten sensitivity is the ratio of the current which flows through the tube at a specified steady voltage to the total luminous flux in lumens entering the tube from a tungsten filament lamp at a specified temperature.

**2870 Tungsten Sensitivity**

This is the ratio of the current which flows through the tube at a specified steady voltage to the total lumens entering the tube from a tungsten filament lamp at a color temperature 2,870 degrees Absolute.

**Variational Sensitivity**

Variational sensitivity is the ratio of the change in current which flows through the tube at a specified voltage to the change in the total flux entering the tube. As most precisely used, the term refers to infinitesimal changes.

**Variational Sensitivity Amplitude Relation**

The variational sensitivity amplitude relation is the relation between variational sensitivity of a phototube and the amplitude of the total steady radiant flux entering the tube.

**Current-Wavelength Characteristic**

Current-wavelength characteristic is a relation usually shown by a graph, between the direct current through a phototube and the wavelength of a steady radiant flux.

**Conductance of a Phototube**

The conductance of a phototube is the ratio of the current through a phototube at a specified radiant flux to the voltage at its terminals.

**Variational Conductance of a Phototube**

The variational conductance of a photo tube is the ratio of the change in current through a phototube at a specified radiant flux to the change of voltage at its terminals.

**Resistance of a Phototube**

Resistance of a phototube is the reciprocal of the conductance.

**Variational Resistance of a Phototube**

Variational resistance of a phototube is the reciprocal of the variational conductance.

**Photo-Voltage Coefficient**

The photo-voltage coefficient is an expression of the open circuit voltage generated by a phototube in response to a unit variation in radiant flux when the tube is regarded as a constant voltage generator. It is the ratio of the variational sensitivity to the variational tube conductance at specified values of operating direct voltages at the terminals of the tube, and of radiant flux.

For a simple phototube and with voltage sufficient to draw saturation current, this quantity becomes infinite. In this case the tube is more conveniently regarded as a constant current generator. The tube is likewise more conveniently regarded as a constant current generator when the impedance is very high.

**Photo Current Coefficient**

This is an expression of the short circuit current generated by a phototube in response to a unit variation in radiant flux when the tube is regarded as a constant current generator. It is numerically equal to the variational sensitivity.

**Gas Amplification**

This is the ratio of the sensitivity of a phototube, measured at a voltage greater than the ionization potential of the gas, to the sensitivity measured at a voltage less than the ionization potential of the gas.

# Antenna Called Key to 5-Meter Range

The successful operation of the ultra shortwave transmitter located in the heart of New York City on the roof of the Hotel New Yorker has interested metropolitan amateur radio circles. The transmitter itself is of comparatively low power but it is supplying a signal which covers the entire metropolitan area, with an intensity which is at least equal to any other New York Sstation, although several are operating on from 5 to 10 times the amount of power.

Members of the Club attribute most of their success to the height of the antenna itself, the efficiency of the transmission line, which is used to connect the transmitter to the antenna and the extremely high efficiency of the "long lines oscillator" which is employed.

### Tuned to Antenna Wave

Very definite proof has been established, indicating that the transmitter is most efficient when it is tuned to the exact wavelength of the antenna itself. Special telescopic antennas, made of aircraft duralumin, enable the operators to change the length of the antenna at will. Tests conducted between this station and a portable station located in an airplane have shown that this same type of antenna and a National Portable transceiver, operated with dry cells, can be utilized satisfactorily for two-way radio telephone conversation up to a distance of 40 miles.

Smilar tests conducted with transceivers in automobiles have shown that it was possible for two-way communication to be established between the Hotel and cars as far distant as Eagle Rock, N. J., a distance of approximately 25 miles.

### Transmission Line Used

The advantage of the telescopic type of antenna and a newly developed high frequency transmission line cable, has greatly simplified the work of installing the transceiver in the aeroplanes and automobiles.

# Characteristics of Resistors

## Some Change Value Considerably Under Load

*By Morris N. Beitman*

*Supreme Resistor Company*

FIXED resistors find extensive application in modern radio design. Their uses are numerous, with their resistances varying anywhere between a few ohms to grid leaks of several megohms. One has only to look under a radio chasis to realize that resistors are the most extensively used radio parts.

Usually carbon composition resistors are employed where little current is concerned and when cost is an important factor. Wire-wound resistors must be used when power dissipated is more than about one watt or when a fair degree of precision is needed.

### Methods of Manufacture

In the composition type resistor the conductor is mixed with a binder of insulated material in a proportion to produce resistors of the desired size. Carbon and graphite are usually used for the conductor. Clay, rubber, and various chemical plastics are used for the filler and binder. The solid body type of resistors are either extruded or molded similarly to other ceramic products. Sometimes this mixture instead of being made in rods with connecting leads is coated on ceramic forms, baked, and covered over with another ceramic material.

Nickel-chromium alloys are usually employed for wire-wound resistors. But nickel-iron and nickelcopper have also found application. This wire is used bare, enameled, or oxidized. The latter form is used when the units are close wound and the voltage difference between turns is very small. Sizes range all the way down to .001 of an inch in diameter. It is interesting to note that an average wire (.00175) used for this purpose has the resistance of 220 ohms per running foot.

### Wire Wound Units

Wire-wound resistors are wound on porcelain or other ceramic forms. Terminals are attached at the ends. The entire assembly, except the extreme ends of the terminals or the pigtails, if used, is coated with vitreous enamel or refractory cement. This coating serves as a protective covering for the fine wire and also keeps out the moisture. The characteristics of wire-wound resistors are slight or negligible positive temperature coefficient and no voltage coefficient.

On the other hand, the resistance of a composition resistor is closely correlated to the applied voltage. In other words, the resistance of a composition resistor varies with the applied voltage. The increase in voltage has a tendency to reduce the resistance; and this drop, in poor resistors, may be as high as 25% of the total resistance. This variation, of course, is not a desirable effect and compels the use of the wire-wound type where a greater degree of accuracy is required.

Composition type resistors further shows considerable variation of resistance with applied load. The resistance here changes positively or negatively, depending on constituents of the resistor. Under a slight overload in extreme cases the change may be as high as 30%. The poorest wire-wound resistor, in comparison, when overloaded 100% will not show a greater variation than about eight percent.

With the advent of high-fidelity receivers, noises that arise in the parts must be reduced to an absolute minimum. Wire-wound resistors create almost no noise. Composition resistors do show the presence of microphonic noise which is somewhat dependent on the load.

The rating of wire-wound resistors is based on the wattage they will dissipate continuously for an unlimited time in free air without passing° C. temperature in an ambient temperature of 40° C. Of course when these units are mounted inside of radio sets the condition existing is very far away from the open air requirement.

Also the heat from adjacent parts, such as power transformers and tubes, makes the ambient temperature of higher value than specified. Because of these limitations wire-wound resistors should be used at a fraction of their nominal rating when mounted inside of a chasis. However, many wire-wound resistors may be greatly overloaded if mounted in free air or away from any parts that may be harmed by extreme temperatures of about 450° C.

In rating composition resistors greater difficulties are encountered. Since the resistance of this type of resistors is directly dependent on the temperature and applied voltage, it may change its resistance to a degree because of these variable factors where it will no longer be of suitable size. No standard has as yet been worked out to rate composition type resistors, but as a maximum one square inch of radiating surface is considered capable of dissipating one watt.

### The Accuracy

Due to the changing nature of composition resistors it would be hardly worth while to manufacture to more exact resistance than the present plus or minus 10%. Many do not realize what a great variation of resistance this figure represents. As an example, when you purchase a 1,000 ohm resistor you may be getting any size between 900 and 1,100 ohms. When further changes mentioned before occur, no one really knows what resistance you have. For this reason wire-wound resistors also prove their superiority.

Wire-wound resistors may be wound to the exactness of plus or minus 2%, but 5% is the usual figure. Possessing negligible temperature coefficient and no other variable factors, they are suitable to more exact work.

### The Color Code

Composition resistors are color coded according to the R.M.A. specifications. The color of the body of the resistor represents the first figure. One end is colored to represent the second figure. The band or dot in the middle is colored to represent the number of ciphers that follow the first two figures. The figure-color table is below:

0 Black
1 Brown
2 Red
3 Orange
4 Yellow
5 Green
6 Blue
7 Violet
8 Gray
9 White.

Wire-wound resistors are not usually color coded, but are marked with metal or paper tags. The wattage of wire-wound resistors is of great many sizes of which the following are commonly manufactured: 1, 5, 10, 20, 30, 50, 100 and higher.

# A Surprising Difficulty Met

## In Coinciding Calibrated Scale with Signal Generator's Frequencies

*By Herman Bernard*

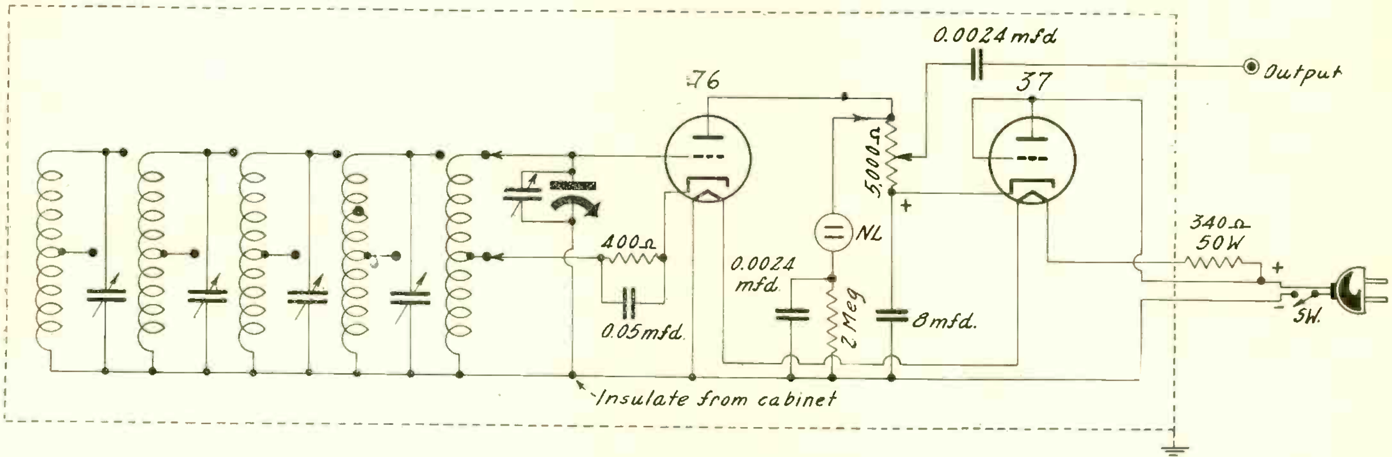



**Diagram of the 339 signal generator, in the adjustment of which a controlling factor in such a Hartley circuit was discovered.**

THE diagram represents a five-band signal generator, 54 to 17,000 kc, for which coils were originally wound, and an airplane dial calibrated, with some capacity added to the condenser's tuning capacity when the calibration was established. Without resort to the original constants an attempt was made to duplicate the circuit and tracking. It proved rather difficult.

What happened was that the frequency range for the band under test, 54 to 170 kc, was not fully covered, in fact, missed out seriously. There seemed to be no good reason for this. There had been no mistake made in the original calibration. A 76 tube had been used in self-bias fashion. The circuit was a Hartley Oscillator. The voltages applied to the plate and to the heater were the same as before. The condenser across the biasing resistor was the same capacity.' In fact, it was the indentical condenser, taken out of the original model.

What do you suppose cause the failure of coincidence between dial scale and generated frequency?

### Mystery Solved

A new coil was made, other one ignored, and the inductance selected was that which caused the generation of 54 kc when the dial reading was 54. But when attempt was made to reach 170 kc there was no success. Not much more than 130 kc could be registered. Surely something was wrong.

The original coil was put in. This was the coil used when the scale was calibrated. Surely there could be nothing wrong with the coil. There wasn't. Still, bad missout.

No, the only possible source of trouble was the bias on the tube. And when that was duplicated, compared to the original setup, the tracking prevailed nicely. In fact, the accuracy happened to be ¼ per cent., which is rather remarkable. Only precision laboratory instruments of high cost achieve such accuracy, as a rule.

The biasing resistor for the generating tube is shown as 400 ohms, just as an indication that it should be a rather low value, but in point of fact will be selected on the basis of enabling one to carry to the high-frequency extreme of any band with fair exactitude, leaving perhaps a little leeway, so that a trimming capacity may be introduced.

This solution of unexpected trouble may prove valuable to many experimenters, not only in building this generator, but any circuit, like it or different from it, generating or non-generating. The point is that the bias changes the resistance of the tube, hence there is a dual effect: first, the effect resistance itself has on frequency; second, that change in resistance has an auxiliary capacity effect.

### Avoid This Modulation

The situation that obtains when the resistor and the capacity related to it are considered becomes rather complex. If the case of a grid leak and condenser is considered it will be found that the larger the resistance the smaller the equivalent parallel capacity effect of the series condenser, considering the tuned circuit. That is, the grid condenser is across the tuned circuit in fact, because the parallel capacity effect would be complete if all resistance were removed, leak and tube alike, but d-c potential source retained.

In the Hartley, as shown, the biasing resistor and condenser across it work in the direction of larger capacity across the tuned circuit, the higher the resistance and the higher the bypass capacity. Also, since the biasing circuit is so closely allied with the tuned circuit, being tied in with the grid circuit from tap to cathode, and with the plate circuit, from cathode to ground, the time constant of the resistor-capacity combination may be high enough to produce low-frequency modulation. This is essentially not desired. Either capacity or resistance or both may be reduced to avoid this retrouble, but there is no danger of it, if the biasing resistor is less than 2,000 ohms, as it must be, and if the bypass condenser is 0.05 mfd. or less.

### The Filtration

The signal generator shown in the diagram, known as the 339, is perhaps the simplest one that can be built for serious all-wave coverage. It has a 76 oscillator, a 37 rectifier, and a neon tube modulator or audio-frequency generator. Wave bands are changed by front-panel switching. There is an attenuator. The modulation may be removed or introduced by switching, and this is true whether the service is a.c. (any commercial frequency) or d.c., 90-125 volts.

The rectifier tube resistance, in conjunction with the 8 mfd. 175-volt electrolytic condenser, constitute a sufficient filter, as the current is low. How the degree of current influences the effect of such filtration may be demonstrated by the fact that there is a slight trace of hum at the higher frequencies of tuning in any band, due to the greater current drawn by the tube, arising from the increased amplitude of oscillation, of course. This may be corrected, if desired, by using a bypassed limiting resistor in the plate leg, between end of volume control and B plus, although the general lowering of the amplitude will result.

At maximum, under conditions shown, the plate current is around 6 milliamperes. At minimum it may be around 3 milliamperes. If a limiting plate resistance of 1 meg. is introduced, bypassed by 0.05 mfd., the current will drop to 250 microamperes (one-quarter of 1 milliampere) and will not change more than 15 microamperes over the tuning range. The only trouble with introducing this limiting device is that its presence must be consistent with oscillations in those regions where oscillations are not so easy to maintain, around 10 to 16 mgc. The limiting resistor, then, should be no higher in value than permits the retention of oscillation.

### 76 a Good Oscillator

The 76 tube, the 6.3-volt equivalent of the 56, though a bit sturdier in construction than the 2.5-volt equivalent, was selected because it is such a good oscillator. Also it is inherently more stable than the 6C6 which was tried out originally, and the substitution was made for that reason. In

(*Continued on page 20*)

# Crosley Has Gadgets Logging Short-Wave Stations

Cincinnati

Applying the principle of the circular slide rule, a Crosley radio engineer has worked out a novel circular short-wave dial log of all the principal short-wave stations in thirty-four countries. The outstanding feature of this dial log is the fact that with a single setting of the rotating arm, the days of the week, hours of broadcasting, call letters, kilocycles, city and country in which each station is located, all appear in a straight line through a cutout in the arm and can be read at a glance.

In the outer circle are listed the kilocycles of the different stations. Inside is another circle in which are given the station call letters, and in the center are listed the cities and countries in which they are located. On the rotating arm are two tables which give the days of the week and the hours of broadcasting. On the reverse side of the dial log the thirty-four countries are listed and the kilocycles for each given, so that all it is necessary to do is to turn the arm to the number of kilocycles listed in the outer circle of the log and all information regarding time of broadcasts, etc., is immediately available. These dials are published by the Crosley Radio Corporation and stocked by Crosley dealers.

# Pick-up and Recorder Announced by Universal

The newest item in the production schedule of the Universal Microphone Co. factory at Inglewood, Cal., is a combination pick-up and recorder, impedance 400 ohms.

The equipment is full annular ball bearing mounted, and thus eliminates side wear of grooves.

The spring adjustment is a special feature. It is so assembled that pressure can be easily and quickly adjusted down to a featherweight on the needle groove, thereby eliminating groove and needle wear.

It matches the input of standard microphone transformers. As a recording cutting head, it matches standard line-to-line mixers, tube-to-line and line-to-line transformers.



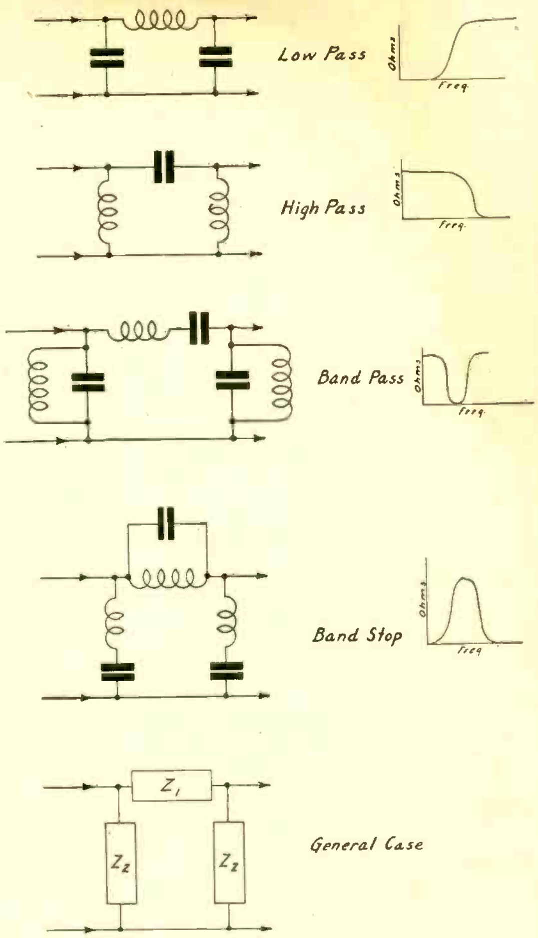


## RCA CREATES INFORMATION DEPARTMENT

The creation of a new department of the Radio Corporation of America, to be known as the Department of Information, was announced by David Sarnoff, president. The department will be headed by Frank E. Mullen, who has been promoted from his previous post as Director of Agriculture of the National Broadcasting Company at its Chicago office. Among the duties of the department will be those which have been handled by the Department of Public Relations, and Mr. Mullen will take over the work of Glenn I. Tucker, formerly manager of that department, who resigned recently.

# THE AMATEUR ORACLE

***Address Questions Concerning Amateur Regulations and Technique to M. K. Kunins (W2DPS), Technical Editor, Radio World, 145 West 45th Street, New York, N. Y.***




**Filters are selected for the purposes to be served and are designated accordingly. A low-pass filter lets lows go through but stops highs. A high-pass filter lets highs go through but stops lows. A band-pass filter allows a small band through and cuts off, more or less, outside that band.**

## Infra-red Rays

CAN YOU GIVE me any information concerning infra-red rays, the so-called black light? Can it be produced at home? And, if so, what kind of glass is used in this connection, since ordinary glass does not transmit ultra-violet light and I assume the same holds true for the infra-red?—J. G.

Infra-red rays are very high frequency electromagnetic radiations that are immediately next to the quasi-optical or ultra short radio waves of the radiation spectrum. The frequency range is approximately between 1250 megacycles and 375,000 megacycles. They are heat waves, approximately and may be most conveniently generated in the home by means of the regular electric heater that utilizes a copper reflector. An automotive product firm makes a small edition for defrosting windshields of automobiles, that can be operated from a 6-volt storage battery. It is advisable not to use any sort of glass with such a unit because of the possibility of its fracture from the heat.

* * *

## Speaker Field Choke

In the October 27th issue there appeared a diagram of an 8-tube super. I fail to note any data regarding the filter choke and would like to ask what is its size.—M. H. R.

This filter choke may be the field coil of a standard dynamic loudspeaker. The d-c resistance may be about 1,500 ohms.

* * *

## Error Corrected

IN YOUR ISSUE of May 5th, I notice in a diagram of a universal short-wave set that there is no return for the a.c. voltage. Please advise whether this is so or not.—W. A. S., Jr.

You are right. To correct this situation, it is recommended that the upper end of the 210-ohm resistor be disconnected and attached to the negative side of the line. The other loose lead is already connected to the other side of the line.

## Filter Design

WHAT ARE the fundamental points involved in filter design? I am interested especially in band-pass filters.—R. L. C.

Filters are merely combinations of condensers, inductances and sometimes resistances. Advantage is taken of the fact that capacity attenuates the low frequencies, that inductance attenuates the high frequencies and that resistances attenuate all frequencies. Therefore to construct a filter that will kill the low frequencies, we shunt the line with capacities; to kill the high frequencies, we shunt the line with inductances; and to kill all frequencies except a certain band, we shunt the line with a shunt arrangement of L and C; and to kill one band of frequencies and pass all others, we shunt the line with a series arrangement of L and C. The sharpness of the points of cut-off is determined by the number of such elementary sections that are used.

* * *

## Field Office Relocations

Several of the district field offices of the Federal Communications Commission have moved to new locations. They are given below with their new addresses:

Sixth district.
411 New Post Office Building, Atlanta, Georgia.

Seventh district.
P. O. Box 150, Miami, Florida.

Thirteenth district.
207 New U. S. Court House Building, Portland, Oregon.

Sixteenth district.
927 New Post Office Building, St. Paul, Minnesota.

Seventeenth district.
410 Federal Building, Kansas City, Missouri.

* * *

## New Rectifier Tube

APROPOS the question of D. N. appearing in this column, December 15th, 1934, issue, Harry D. Dudichum, Jr. of Pitman, N. J., states that Sylvania has a new rectifier tube known as the 25Y5 for 220 volts.

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(*Continued from page* 18)

theory the 6C6 should be quite stable, because it is a suppressor type tube of the r-f pentode variety, and the plate current remains practically constant, regardless of the plate voltage. However, the screen has to be tied somewhere, and in small devices (also in some large ones) a series resistor is used. Hence the change in the amplitude of oscillation will considerably change the voltage drop in the limiting screen resistor, hence alter the effective screen voltage. And since the screen voltage, rather than the plate voltage, determines the plate current, it can be seen that the plate characteristic becomes unstable for indirect reasons.

The 56 and 76 are coming into wider and wider use as oscillators, because of the high mutual conductance. While this high conductance in a sense works against stability, because small changes in oscillation amplitude on the grid side produce relatively large changes in plate voltage drop, the stability may be enhanced by the use of a series limiting resistor in the plate circuit that is large compared to the d-c resistance of that circuit. Besides, the main consideration is that there be oscillation, so a tube that affords oscillation with no difficulty whatever is a wise choice. Refinements may be introduced at any time, consistent with the maintenance of oscillation.

## Currents Given

The stability is improved by the limiting resistor method because a pure resistance is a very large part of the total resistance. The impure resistance is the tube plate circuit. How stable the frequency will be with proper limitation of the plate current by the series resistor method is shown by the comparison of maximum and minimum currents. When the change is only 15 parts out of 250, or roughly 5 per cent., the frequency stability will be as good as 1 part in 10,000, without any special treatment of inductance, temperature, etc. It should be remembered, however, that the usual period of operational use is considered. Over long periods—months or years—changes may take place that would impair the scale-to-generation accuracy, but scarcely the frequency stability. What would be required would be capacity re-adjustments in the trimmer circuits.

For the first band, 54 to 170 kc, the adjustment may be made for a frequency of 140 to 160 kc, by using stations 1,400 to 1,600 kc in the broadcast band, and beating the tenth harmonics of the generator with the station fundamentals. As a check, use some station near the low end of the broadcast band. Say it is WEAF, 660 kc. The tenth harmonic is of 66 is 660, so at 66 there should be coincidence. But the eleventh harmonic of 60 also is 660, so there should be coincidence at 60. And the twelfth harmonic of 55 is 660, which enables comparison of 55 on the scale, zero beat with the station being used. So one station may be used, if preferred, to traverse the dial for several spot frequencies. Take the broadcasting station frequency, one near the low end, and divide it by 13, 12, 11, 10, 9, 8, etc., and note what these frequencies are. If the case is that of 660 kc, we can tie down the circuit inductively when the dial reads 55, check at 60, 65, 73.3, 82.5, nearly 95, 110, 132 and 165. Thus the high-frequency tie-down point of 165 on the dial may be used for capacity adjustment. Actually, the coils are made commercially, so no inductive tie-down is necessary, only the capacity adjustment, which should include the bias resistor reduction if the spot frequencies are not as numerous or as coincidental as required.

(*Continued from page 4*)

or if increasing the frequency of the radio-frequency generator increases the audio note, subtract it. The audio-frequency note heard with a piezo oscillator having the assumed frequency would be 380 cycles, hence 700.140 + 0.380 = 700.520 kc.

## PART 2. CHECKING BROADCAST FREQUENCY STANDARDS

### A. Integral Sub-multiples of 5000 kc.

The frequencies which are integral sub-multiples of 5000 kc are most easily measured. There are only two broadcast frequencies, 1000 and 1250 kc/s, which bear this relation. The fifth harmonic of 1000 kc is 5000 kc. If a 1000-kc oscillator, whether a transmitting set or frequency standard, is coupled to a radio receiver tuned to 5000 kc at a time when the standard signal is being received, a heterodyne note will be produced which is equal to the frequency difference between the 5th harmonic of the 10400-kc oscillator and the standard signal.

Assuming that the nominal value of the 1000-kc oscillator is known, all that remains in order to measure the frequency accurately, is to determine the frequency of the beat note and whether the frequency is higher or lower than the standard signal. This is done when the radio receiver is not in the generating condition. The most convenient method, if the beat note is in the audible range, is to match it with a known audio frequency produced by a calibrated audio-frequency oscillator.

The direction of the deviation is most easily determined by making a slight change of known direction in the unknown frequency. If an increase in the unknown frequency increases the audio-frequency beat note the frequency is high. If an increase in the unknown frequency decreases the audio-frequency beat note, the frequency is low. Conversely, if a decrease in the unknown frequency increases the audio-frequency beat note the frequency is low, and if a decrease in the unknown frequency decreases the audio-frequency beat note, the frequency is high. If the audio-frequency to be measured is between 5 and 200 cycles per second, the audio-frequency arrangement described in a previous Bureau publication by N. P. Case can be used with a very high degree of accuracy. If the audio frequency is still lower and goes below the range of the audio-frequency amplifier, it is necessary to provide a carrier for this audio-frequency note. This is done by making the radio receiver generate and adjusting the resulting beat note so that it is approximately 1000 cycles per second. A fluctuation in the amplitude of this 1000-cycle note, which has a frequency equal to the frequency difference between the two radio frequencies, will then be heard. If it is only desired to readjust the unknown frequency to agreement with the standard signal, it is a simple matter to adjust to zero beat. The same method can be used for a frequency of 1250 kc. Precaution must be taken to make it possible to combine the signals with approximately equal intensity. Some difficulty in this respect may be expected if measurements are made when the transmitter is operating unless the harmonics are very completely suppressed.

### Case of 1000 or 1250 kc.

A station frequency monitor which utilizes a piezo oscillator having a frequency of 1,000 or 1,250 kc can be measured or adjusted to frequency in a similar manner. If the radio transmitter is operating, the measurement can be made indirectly in terms of the transmitter in the following manner. Measure the frequency of the radio transmitter in terms of the 5,000 kc signal and simultaneously read the frequency as indicated by the frequency deviation meter on the monitor. The two frequencies should agree. If they do not, adjust the frequency monitor until the deviation meter indicates the correct frequency deviation. It may be desirable to measure the frequency monitor directly against the standard signal at a time when the radio transmitter is not operating.

If the frequency monitor is of the type which is adjusted to exactly 1,000 or 1,250 kc, the measurement can be made the same as in the case of the radio transmitter. However, if the monitor is set high or low by 500 or 1,000 cycles, it will be necessary to make use of an audio-frequency oscillator to determine the value of the audio beat frequency. In the case of a monitor which has a frequency of 999.500 or 1,000.500 kc, the beat note to be measured would be 2,500 cycles per second. As five cycles variation in the beat note is only 1 part in $10^6$, any audio-frequency oscillator which would be constant to 5 or 10 cycles per second would be adequate. In the case of a monitor which has a frequency of 999.000 or 1,001.000 kc a 5,000-cycle note would be produced. Similarly for 1,250 kc, audio-frequency beat notes of 2,000 and 4,000 cycles per second would have to be measured. The general relation is that the audio-frequency note produced by heterodyning the monitor frequency and the 5,000-kc standard signal is equal to the product of the number of cycles the monitor is set high or low and the ratio of 5,000 to the nominal value of the monitor.

### B. Measurements With Auxiliary Generator for Frequency Multiples of 50.

Measurements of any of these frequencies require the use of an auxiliary generator in addition to the high-frequency receiver. The auxiliary generator may be a piezo oscillator or it may be a manually controlled oscillator. If a piezo oscillator of the desired frequency is available, it is desirable to use one. In this case a distorting amplifier is necessary in order to bring out the harmonics so that the beat against the 5,000-kc standard signal can be easily heard. This piezo oscillator should be provided with a vernier frequency adjustment so that it can be readily adjusted to agreement with the 5,000-kc standard in the manner previously described. After this is done the monitor or radio transmitter can be measured in terms of harmonics of the auxiliary generator. If a manually controlled generator is used, the L/C ratio must be low so that the frequency can be easily adjusted to zero beat with the standard frequency, and readily held on that frequency.

There are two main factors which determine the frequency to which the auxiliary generator should be adjusted. The first is that its frequency must have an integral relationship with the standard frequency and the frequency to be measured. The second is that the harmonic which is heterodyned with the standard frequency must be of sufficient intensity to produce a beat note which is easily recognized.

Taking both factors into account the best result is attained if the frequency of the auxiliary generator is the highest common factor of the standard frequency and the frequency to be measured. There is one other consideration in the case of a manually controlled auxiliary generator and that is, the lower its frequency, the less trouble is experienced in holding it at zero beat against the standard frequency. The following table indicates the broadcast frequencies which can be measured in terms of the 5,000-kc standard frequency transmission by means of a high-frequency radio receiver and an auxiliary generator. It will be understood that the table gives all broadcast frequencies which are multiples of 50, but does not indicate more than one generator frequency for these frequencies except for 1,000 and 1,500 kc.

| 500 kc | 200 kc | 100 kc | 50 kc |
|---|---|---|---|
| 1,000 | 600 | 700 | 550 |
| 1,500 | 800 | 900 | 650 |
| | 1,000 | 1,100 | 750 |
| | 1,200 | 1,300 | 850 |
| | 1,400 | 1,500 | 950 |
| | | | 1,050 |
| | | | 1,150 |
| | | | 1,250 |
| | | | 1,350 |
| | | | 1,450 |

### Example of Auxiliary Method

As an example of this method of measurement, assume the frequency of the radio transmitter to be 1,150 kc. The radio receiver, in the generating condition, is tuned until the 5,000-kc standard frequency signal is heard. The auxiliary generator, set on approximately 50 kc, is then turned on and the frequency varied until a second audio frequency is heard on the output of the high-frequency receiver. If the radio receiver is then adjusted so that it does not generate, the auxiliary generator can be set to zero beat with the standard frequency signal. If the radio receiver is again made to generate, the auxiliary generator can be easily set to agreement with the standard frequency signal as previously explained. The rough adjustment to zero beat must be made when the radio receiver is in the non-generating condition, otherwise there is danger of setting to zero beat between the two audio frequencies of harmonics of the audio frequencies. If a piezo oscillator is used, this precaution is unnecessary. A detector-amplifier is set up so as to receive portions of the outputs of the auxiliary generator and the 1,150-kc radio transmitter, Fig. 4. The output of the amplifier will give the audio beat frequency between the 23d harmonic of the auxiliary generator and the 1,150 kc of the radio transmitter. If this audio-frequency is reduced to zero as indicated on a visual beat indicator the transmitter frequency will be in exact agreement with the standard frequency signal. One person can make this adjustment, as an aural indication may be used for the auxiliary generator and a visual one for the transmitter adjustment.

If a piezo oscillator is used as the auxiliary generator, it need only be checked against the standard frequency signal at intervals.

### C. Measurement of Any Broadcast Frequency

The methods of measurement given in the preceding paragraphs are applicable to twenty of the frequencies in the broadcast band. The highest common factor of 5,000 kc and the remaining broadcast frequencies is 10 kc. The frequency of the auxiliary generator must therefore be 10 kc if the other broadcast frequencies are to be checked readily in terms of the 5,000-kc transmissions. The beat note between the 500th harmonic of the 10-kc generator and the 5,000-kc transmission would not be loud enough to be heard distinctly. The simplest solution, therefore, is to set the auxiliary generator on 100 kc and let it control a 10-kc multivibrator. The beat against the standard frequency signal could then be heard easily and the harmonics of the 10 kc would heterodyne equally well with fre-

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# Station Sparks

*By Alice Remsen*

## NEW ONES FOR 1935

THIS 1935 brings quite a few new programs to the air. Little Jackie Heller, the 61-inch tenor, will inaugurate his first sponsored evening program on Monday, January 14th, over an NBC-WJZ network at 10:00 p. m. EST. Jackie will be heard at that time each Monday under the sponsorship of Chappel Brothers, makers of Ken-L-Ration. . . . Igor Gorin, young Russian baritone, who was "discovered" by Rudy Vallee, began a new series of programs recently over an NBC-WEAF network. Each Monday at noon. He sings in all languages, especially Russian and Spanish. . . . Morton Downey is back on the air at his old stamping ground, the NBC. Under the sponsorship of the makers of Carlsbad Sprudel Salts, Downey is heard twice weekly. Each Sunday for a half hour at 4:30 p. m.; and each Tuesday for fifteen minutes at 7:15 p. m. over an NBC-WJZ network. His contract is an ambitious one, calling for a salary of six thousand dollars weekly. Downey began his radio career about ten years ago via the NBC networks. He has been successful ever since. . . . Anne Jamison, petite lyric soprano from Canada, has signed an exclusive contract with the NBC Artists Service. Miss Jamison was born in Belfast, Ireland. At the age of four she went to India with her family, lived there four years, then returned to Ireland. Her next move was to the little town of Guelph, Ontario; and now—New York, and a nice contract. . . . "The O'Neills," new dramatic serial of American home life, now heard over the CBS-WABC network under the sponsorship of the Gold Dust Corporation, have over two thousand American housewives to thank for their contract. These housewives listened to eight programs and picked the O'Neills as the best. Now you may hear them, Monday, Wednesday and Friday evenings at 7:30 p. m. over WABC and network. . . .

## ORMANDY IN EARLY THIRTIES

The Minneapolis Symphony Orchestra, under the direction of the eminent young Hungarian conductor, Eugene Ormandy, inaugurated a series of weekly concerts over the nationwide WABC-Columbia network on Friday, December 28, from 3:15 to 5:00 p. m., EST. Originating in Minneapolis, the broadcasts are relayed to the Columbia network through the facilities of WCCO. The concerts will be heard on Fridays, January 4, 11, and 18, March 1, 8, 15, 22 and 29, and April 5, 12, 19 and 26.

Numbering 85 members, the Minneapolis Symphony ranks among the leading orchestras of the world. In its 31 seasons in Minneapolis the orchestra has become a northwestern institution and its extensive annual tours and frequent broadcasts have won for it an enviable place in America's musical world. Ormandy plans to offer primarily works which the public knows and loves. He has had wide experience in the theatre, concert hall and radio, and his popular programs will also feature less familiar masterpieces famous for their melodic beauty.

The young conductor, still in his early thirties, was a child prodigy at the Budapest Academy of Music when he gave his first public recital at the age of seven. When only seventeen he was awarded a Professorship of Music. In 1921 Ormandy came to America and immediately embarked upon the versatile career which ultimately carried him to guest conductorship with the New York Philharmonic-Symphony, the Philadelphia Orchestra, and with the Columbia Broadcasting System prior to his Minneapolis engagement.

## THE GUMPS GOING STRONG

The Big Show is continuing the Ex-Lax series with the same stars, Block and Sully, Gertrude Niesen, and Lud Gladkin's Continental Orchestra. David Freeman is still writing the comedy material for the show. Mondays, 9:30 p. m. WABC-Columbia network. . . . Owing to the enthusiastic reception given to "The Gumps," famous cartoon family, as characters of a radio series, the WABC-Columbia network over which they are heard has been increased from twenty stations to forty-eight. They may be heard daily except Saturday and Sunday at 12:15 p. m. The Gumps are sponsored by the Corn Products Refining Company. . . . Kate Smith is sponsored again, this time by the Hudson Motor Car Company, each Monday night at 8:30 p. m. over the nation-wide WABC-Columbia network. But Kate is not relying upon herself alone—she is auditioning ambitious semi-amateur artists, and will use weekly guest entertainers from among those auditioned; Jack Miller's Orchestra, and the Three Ambassadors, male trio, complete the program. Kate is journeying to a different city each Friday night to conduct the hunt for new talent. . . . Lavender and Old Lace won a contract renewal for 1935. The program remains the same, with Frank Munn, tenor; Hazel Glenn, soprano, and Gus Haenschen's Orchestra. Each Tuesday, at 8:00 p. m. Sponsored by Bayer's Aspirin. . . . "Melodiana," which is sponsored by the makers of Phillips Dental Magnesia, also won a new contract, and also keeps its program intact. Featured are Vivienne Segal, prima donnar soprano; Oliver Smith, tenor, and Abe Lyman's Orchestra. Each Tuesday, 8:30 p. m. . . .

## STUFF AND SOME NONSENSE

Taxicab drivers who line up outside the Columbia Radio Playhouse waiting for possible fares at the end of the Caravan program all tune their cab radio in on the show while they wait. . . . Babs Ryan has her luxurious blonde hair done up differently for just about every broadcast. . . . All those cheers heard in the vicinity of West 44th Street the other night were made of the real college stuff. About fifty alumni of Pittsburgh University attended Fred Waring's program at the CBS Playhouse and when it was off the air Fred and the orchestra and all fifty faithfuls yelled themselves hoarse for every college they could think of. Norman Brokenshire, announced on the CBS Headliners program, reports he's spending a lot of spare time now working out the details of his inventions, an all-consuming hobby of Norman's. . . . David Ross claims to have antedated the piano-sitting Helen Morgan by several years. He was quite a tiny lad at school but had a good, big reciting voice so the principal sat him on top of the piano at assemblies and bade him perform. . . . Colonel Lemuel Q. Stoopnagle reports a weird fan letter. It encloses a clipping showing that a husband and wife who were on the verge of parting listened to "Stoopnagle and Bud's" gloom-chasing antics and were made to laugh together so uproariously that they resolved to "live happily ever after." . . . Ray Henricks is the newest star from the Pacific Coast to join the staff of the American Broadcasting System. He is now featured over the ABS-WMCA network on Tuesdays at 7:00 p. m. . . . Station WJW, popular Akron, Ohio, station on 1210 kilocycles, has joined the ABS. "The Voice of Romance" has been moved to an earlier position on the ABS-WMCA schedule. He may be heard, Monday through to Friday, at 8:30 p. m. . . .

## STUDIO NOTES

Jack Denny is always getting letters meant for Jack Benny and vice versa. . . . Phil Hanna, Three Cheers top tenor, has a top tennis rating in California, and won the Canadian Doubles Junior Championship when he was just out of high school. . . . Ben Bernie has grown a mustache since he has been in Hollywood. He's also carrying a cane. What next? . . . Muriel Pollock is busy writing some smart new tunes. . . . George Givot, the "Grik" Ambassador of Good Will, is really a Russian, but was raised in Omaha, Nebraska. . . . Glen Gray's nickname is "Spike." . . . Mario Braggiotti, CBS partner of Jacques Fray, is a sort of walking League of Nations. Born in Florence, Mario was brought up in Boston and is an American citizen. His four grandparents were English, French, German and Italian. . . . And there's Victor Kolar, Ford Symphony conductor, also an American citizen. He was born in Budapest, Hungary—his father a Slovakian and his mother a German. He was educated in Prague, then German, now Czechoslovakian, and populated mainly by Bohemians, and he is equally at home speaking English, German, Bohemian, Hungarian and Slovakian.

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quencies in the broadcast band. It is evident that with this equipment all assigned frequencies in the broadcast band can be checked against the 5,000-kc standard frequency signal, Figure 5.

There are some cases in which a frequency can be measured by more than one of the methods indicated. The question arises as to the advantages and disadvantages of the various possibilities or as to how existing equipment might be brought into use. The first method is applicable to only two frequencies. It provides the most accurate check for frequencies which are very near the harmonic value. For monitors, however, which are set high or low by 500 or 1,000 cycles per second, the audio frequency which must be measured is so high that it is very difficult to determine its value. This method is further handicapped by the fact that if the measurements are made in the transmitting station when the power amplifier is operating, the harreceiver. If that is the case it would be may be so strong that it will block the monic which is picked up on the receiver necessary to locate the receiver at some distance from the transmitter and use a line between transmitter and receiver.

The second method requires an auxiliary generator and detector-amplifier in addition to the equipment used in the first method. A small error may be introduced in this method in the adjustment of the auxiliary generator. If a piezo oscillator is used this error is negligible. The error is much greater if a manually-controlled oscillator is used. In either case, however, it should not be more than a few parts in a million. This method is applicable to 20 of the broadcast frequencies, and is much more satisfactory for checking monitors which are set off-frequency because the audio frequency to be measured equals the amount the monitor is set high or low. If a harmonic amplifier is coupled to the auxiliary generator so that sufficient voltage is procan be read directly on the visual indicator vided, the measurement of the monitor provided with that unit.

It is necessary to use the third method in checking the remaining 76 broadcast frequencies. This method requires a high-frequency receiving set, auxiliary generator, 10-kc multivibrator; detector-amplifier; and audio-frequency measuring equipment.