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The First and Only National Radio Weekly

621st Consecutive Issue—Twelfth Year

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Feb. 17th 1934

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THE POWERTONE ALL-WAVE KIT SET, See Pages 4 and 5

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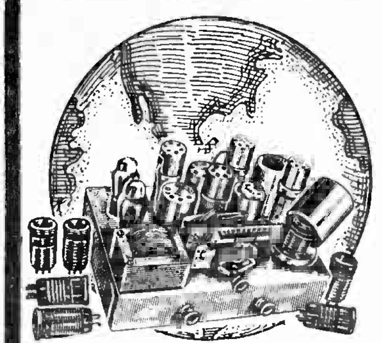

Described in this issue of Radio World
by EMANUEL MITTLEMAN

THE world at your finger tips with the Powertone "SH-6." London, Rome, Paris, Moscow, Berlin are all heard by the mere turn of the dial. The thrills of short waves are not limited only to the reception of foreign signals—hundreds of amateurs, airplanes, ship-to-shore, police signals will provide many thrills to the listener.

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15 to 550 Meters

Note these features:

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- Bruno Coils
- Improved Super-het Circuit
- Automatic Regeneration Control

INTRODUCTORY PRICE
SH-6—Complete kit of parts for construction, including two sets of Bruno plug-in coils and blueprints.......... **$24.50**
Wired and tested with 2 sets of BRUNO Coils ....$5.00 extra.
Set of BRUNO broadcast coils to cover the 200 to 550 meter bands $1.78

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SHORT-WAVE
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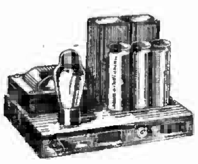

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Circuits include Bosch 54 D. C. screen grid; Balkite Model F Crosley 20, 21, 22 screen grid; Eveready series 50 screen grid; Erla 224 A.C. screen grid; Peerless Electrostatic series; Philco 76 screen grid.

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"RADIO TROUBLE SHOOTING," E. R. Haan. 361 pages. 300 illustrations. $3. RADIO WORLD, 145 W. 45th., N. Y. City.

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The battery operated short-wave set which won the Hoover Cup for premier short-wave design and performance; well designed both electrically and mechanically. Built of the finest precision parts, each operating at maximum efficiency at all times; the Wallace has many features to recommend it to all interested in short-wave reception. Among these features are:

1. Band spread tuning for the crowded bands, controlled by a single panel switch. 2. Ultra Low-Loss coils wound with silver ribbon. 3. Each circuit individually controlled. 4. Highly efficient tuned antenna system. 5. Zero body capacity. 6. 15-200 meter tuning range.

The set is for earphone operation, using two 230 tubes, which require a 2-volt filament supply and 45-90 volts of "B" battery.

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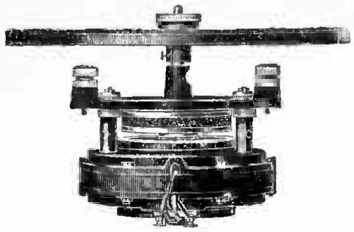

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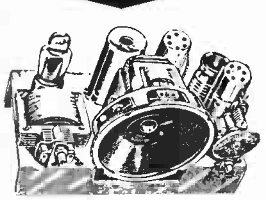

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IN PREPARATION!

12TH ANNIVERSARY NUMBER OF RADIO WORLD

It is probably quite as true today as it was a century ago, that "Life is short and time is fleeting." At any rate, it does not seem twelve years since the first issue of RADIO WORLD was placed before the public—but our **Twelfth Anniversary Number** is now on the way. It will be dated March 17, 1934, and the last advertising forms will close March 6.

Take advantage of this opportunity to reach a larger number of readers than usual, as the publishers plan to celebrate the event by endeavoring to increase the edition and sales substantially. Our regular advertising rates will be in force.

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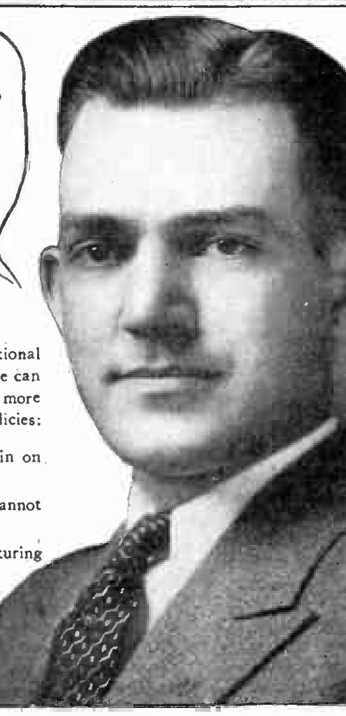

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RADIO WORLD

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The First and Only National Radio Weekly
TWELFTH YEAR

J. E. Anderson
Technical Editor

J. Murray Barron
Advertising Manager

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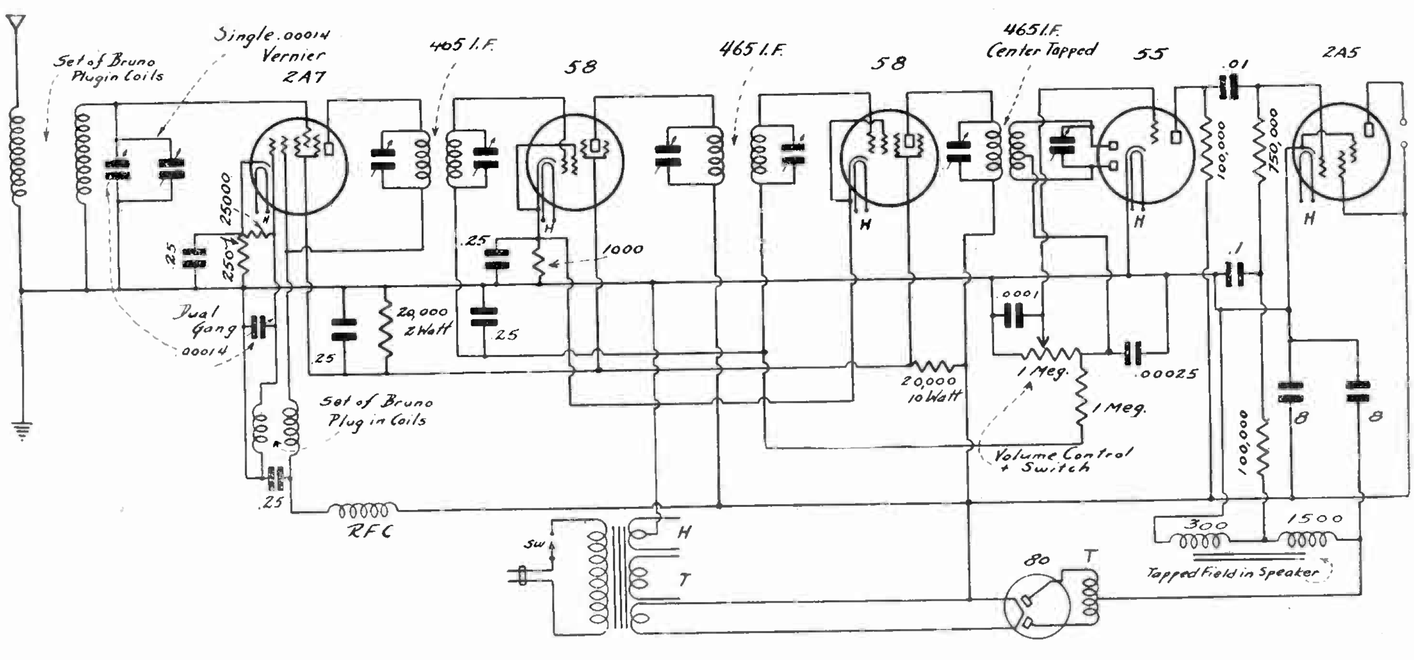
SIX TUBES, ALL WAVES

STANDARD CIRCUIT, WITH PLUG-IN COILS, GIVES EXCELLENT RESULTS ON SHORT WAVES PARTICULARLY

By Emanuel Mittleman
Try-Mo Radio Corporation



Designed to afford high excellence of performance on short waves, using a standard circuit built of quality parts, this six-tube superheterodyne, using plug-in coils, also covers the broadcast band.

THE radio style of today calls for all-wave superheterodynes. No set is quite up to the minute unless it covers the broadcast band as well as the short wave band from 200 meters to about 10 or 15 meters. No set is strictly in style unless it is of the superheterodyne type.

Besides these requirements, there should be electron coupling between the oscillator and the modulator. In other words, no set is in class unless it employs a tube like the 2A7 to perform the functions of oscillation and mixing. In addition, the intermediate frequency should be 465 kc, not because it is the best possible frequency, but because coils and condensers have been designed so as to give best possible all-around results when this frequency is used. This intermediate frequency has been found to be especially suitable for short-wave sets, and it is just as good as any similar frequency for the broadcast band.

An all-wave receiver must have much amplification in the intermediate level, and a great deal of selectivity. Experience has shown that two stages of 58 amplification with doubly-tuned transformers are highly desirable in an all-wave set. Detection may be of the full-wave, diode type, and the most suitable tube for this purpose, that is, for full-wave diode detection and audio amplification in addition where the prior amplification is high, is the 55.

An up-to-the-minute all-wave set should have a high audio gain, with as few tubes and stages as practicable. This calls for an output tube of the 2A5 type.

That there should be automatic volume control goes without saying. An all-wave receiver that has any pretense of high gain must have automatic volume control.

The six-tube, all-wave superheterodyne presented here has all these desirable features, and the circuit is the result of much experimental work by the engineering department of the Try-Mo Radio Corporation. Every feature of the circuit has received the most careful attention by the specialists who have been working on it, and the result is something of which we are justly proud.

Plug-in Coils Employed

In regards to the coil system, we had the choice of using switches or plug-in coils. We tried both and the consensus of the engineering staff was that at this stage the plug-in system was by far the better when results were the basis of comparison and not merely convenience. Hence plug-in coils are used in this circuit, but the coils decided on were those that brought in the best results. The set selected covers the entire short-wave and broadcast bands with tuning condensers having maximum capacities of 140 mmfd. Condensers of this capacity are really necessary in the short-wave region if the stations are not to be crowded so closely together as to make it impossible to separate them and also to make the sensitivity at these waves high. These condensers also have the advantage that the sensitivity in the broadcast band is considerably higher than it would be with the usual large condensers.

There are three 465 kc intermediate transformers in the circuit, each doubly tuned. They provide a high order of selectivity as well as a high order of voltage gain, for the coupling between the two tuned coils in each transformer has been adjusted to the critical value, that is, to the value that gives the highest gain without appreciably reducing the selectivity.

The third intermediate coil has a center tapped secondary for feeding into the diodes of the 55. In all other respects the three transformers are the same.

The Oscillator and Mixer

The 2A7 is used for oscillator and mixer for this combines in one tube the two functions and employs electron coupling between the two parts of the tube. The circuit is conventional, since there is no reason here for introducing any variations, for this type of mixer is highly efficient.

In the tuner are two 140 mmfd. condensers ganged to the same shaft, one tuning the oscillator and the other the radio frequency circuit. In the radio frequency circuit there is an additional 140 mmfd. condenser, connected in parallel with the first, which is used as a vernier tuner. The primary function of this condenser is to make the oscillator and the radio frequency circuit track. The coils have been designed so that when the condensers are wide open, the tracking is right on all the coils. As the capacity is increased by turning the gang condenser, the oscillator pulls away from the r-f circuit, and this is compensated for by the 140 mmfd. vernier condenser. A little experience with the circuit will show just how to set the trimmer condenser for any setting of the gang in order to give the highest sensitivity of which the circuit is capable.

Volume Control

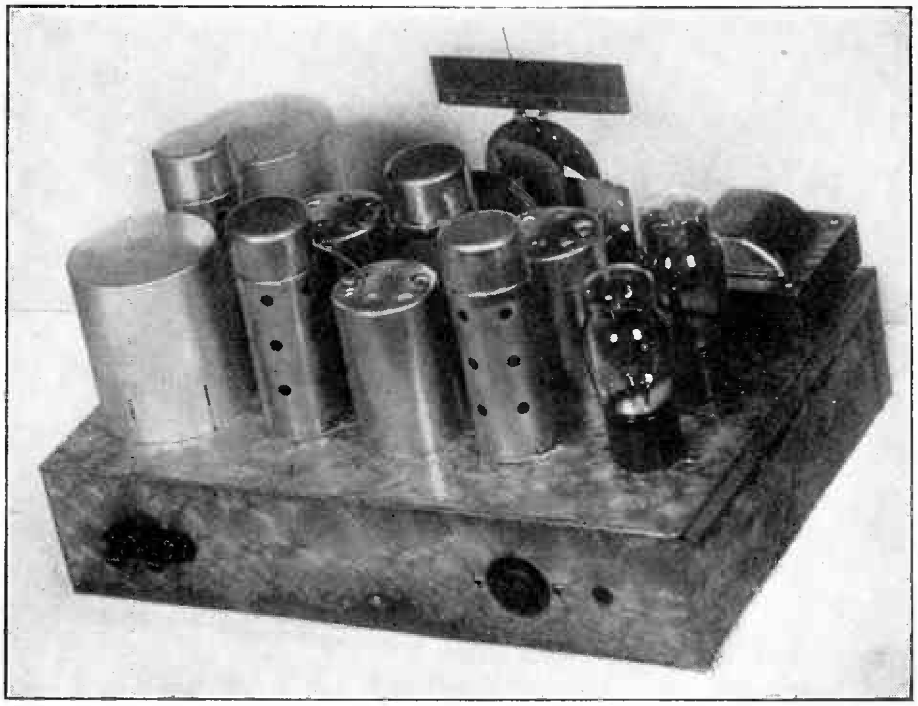
Incidentally, the trimmer condenser also may be used as a volume control, although this is not recommended, for any control of volume by this condenser will lower the signal-image ratio, which should be avoided. There is a good volume control provided where no undesirable effects are produced by it.

The radio-frequency signal is impressed on the top control grid while the oscillator control grid is the innermost grid of the tube. The second grid is employed as anode for the oscillator. The plate, which is electron coupled to the rest of the mixer tube elements, is used for taking off the product of the mixing. The plate is returned to the second grid so that any oscillation current that may exist in plate will flow through the tickler coil and thus aid in producing oscillation.

Slow Taper

The volume is controlled in the grid circuit of the 55 triode. The load resistance on the diode rectifier is a one-megohm potentiometer and the slider of this is connected to the grid. The amplifier is therefore diode biased. This is entirely satisfactory because there is a high resistance in the plate circuit of the triode. A slow taper at the ground end of the potentiometer insures a close control of the output even on the strongest signals that may be encountered.

The automatic volume control voltage is also taken from the load resistance. The grid returns of the two 58 intermediate amplifiers which are automatically controlled are made to the negative end of the potentiometer resistance, or to the center tap of the secondary of the third transformer. The return leads are filtered by means of a one-megohm resistor and a condenser of 0.25 mfd. Filtering of the load resistance is done by means of a 0.00025 mfd. condenser across the entire load and a condenser of 0.0001 mfd. across that portion of the resistor which at any time is in the grid circuit of the triode.



Rear view of the six-tube superheterodyne. Other illustration (front view) is on the front cover.

TAX COLLECTIONS

The U. S. Internal Revenue Bureau collections of the 5 per cent. excise tax on radio and phonograph apparatus during the month of November, 1933, were $246,526.75, compared with $298,577.86 in November, 1932. The excise tax collections on mechanical refrigerators during November, 1933, totaled $172,541.85 as against $113,963.78 in November, 1932.

Most Popular Programs, Per Requests for Seats

If the demand for seats at Broadcasting studio performances of various programs is any criterion, here is how the air performers stand, in the matter of popularity:

N. B. C.

1. Eddie Cantor.
2. Rudy Vallee.
3. Ed Wynn.
4. Show Boat.
5. Joe Penner and Paul Whiteman Orchestra.

C. B. S.

1. Ted Waring's Pennsylvanians.
2. Stoopnagle and Budd.
3. The March of Time.
4. Seven Star Review (with Nino Martini).
5. Albert Spalding, violinist.

How do these lists fit in with your preferences?

A THOUGHT FOR THE WEEK

STATION WOR isn't afraid of the big bad wolf. It has taken on a liquor account and, before the sponsored program goes on the air, this announcement is made:

"Those listening in from dry States may now tune out this station, for the next program is not intended to offer alcoholic beverages for sale or delivery in any State or community wherein the advertising, sale or use thereof is unlawful."

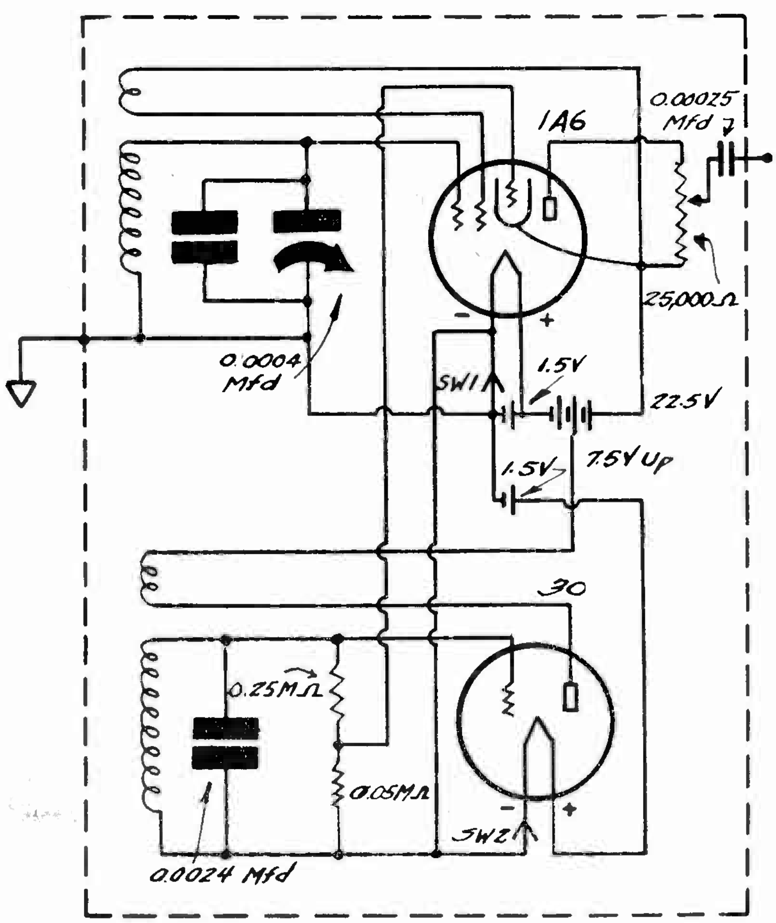
Nevertheless, there's the program and the advertising of a gin distillery and all who will may listen. The Federal Radio Commission has just announced that, while it does not wish to pose as an advocate of air censorship, especially in the matter of liquor advertising, it may have something to say when stations apply for a renewal of their broadcasting licenses.

All of which must make the officials of stations and networks do a little stiff thinking in these days of uncertainty. Can you blame them?

Electron-Coupling in Two Battery Test Oscillators

Output May be Calibrated in Decibels, and Modulation in Percentage, as Well as Frequencies Put Right on Dial

By Herman Bernard



An electron-coupled test oscillator, with separate modulating tube and with output attenuation. The audio modulation may be varied in amplitude by substituting a potentiometer for two resistors.

BATTERY-OPERATED test oscillators share with universal types the advantage of being useful anywhere, but the chief advantage is that transmission can be readily confined exclusively to the output lead. That is, there is no stray radiation of oscillation through an a-c or d-c line. The universal type will feed through the line, as will even a strictly a-c type, unless special precautions, rather costly, are taken to avoid this condition.

For lining up the intermediate channels of superheterodynes the line-feeding condition does not prove troublesome, but if a sensitive receiver is to be lined up at radio frequencies, those not fully conversant with the phenomena of oscillations may become confused due to multiplicity of responses, especially if harmonics are used. Also, no attenuation of the radio-frequency oscillation may be introduced, nor even of the modulation itself, since the modulation is out of reach, so to speak, being the ever-present frequency of either the line current (for a-c use) or grid blocking circuit (for d-c use).

Electron Coupling Used

The battery-operated test oscillator shown above has a separate oscillator, the 1A6 tube, with electron-coupled output, also a separate modulator, the 30 tube, electron coupled to the oscillator.

Not only is it possible to attenuate the radio-frequency output, as shown (potentiometer at upper right), but if desired the audio-frequency introduced into the 1A6 from the 30 may be attenuated by using a potentiometer instead of the two separate resistors, total resistance not less than 100,000 ohms.

The audio-frequency oscillation in the total circuit shown may be larger than desired, and if so a limiting resistor may be put between the 30 grid and one side of the potentiometer that will control modulation percentage. A general method of reaching the right proportion is to introduce no more audio modulation than will permit zero beating with standards (say, broadcasting stations) at exclusively one point for any given harmonic of the test oscillator, not one zero beat just on one side of a given dial position and another zero beat a division or so away. This would prove the presence of more than 100 per cent modulation, a form of distortion.

Constant Amplitude Possible

Those who desire still more advanced service may have the benefit of constant amplitude of radio-frequency oscillation by using an unbypassed leak in series with the control grid of the oscillator section of the 1A6 (Grid No. 1). A milliammeter in the feedback grid of this tube (Grid No. 2) should scarcely change in plate current reading over the entire tuning range. For frequencies of 135 to 405 kc fundamental, a 3 to 1 ratio, a series resistance of 10,000 ohms is suggested as a first experiment.

When the amplitude is stabilized, then the output, unless controlled, is constant. When the tube output itself is constant, the attenuation is a constant percentage, hence the potentiometer may be calibrated in decibels.

Decibel Rating

Assuming dual attenuation, one component relates to the amount of audio-frequency put into the radio-frequency oscillator, the other the amount of the radio-frequency output utilized which has nothing to do with the quantity of modulation. In both instances the results are expressed in ratios. For r-f attenuation this rating is in decibels. The calibration may be made, on the basis of constant tube output, without knowing the actual amplitude of the output. The expression, on the power basis, is

$$db = 20 \log_{10} \left(\frac{Rx}{R}\right)$$

where db is the attenuation in decibels, Rx then is the utilized resistance looking into the load circuit, and R is the total resistance.

For even decibels, in steps of 2 decibels, always down, the calibration may be made from 2 to 20 decibels on the adjoining apportionment of a 10,000-ohm resistor, which may be used in place of the one marked 25,000 ohms.

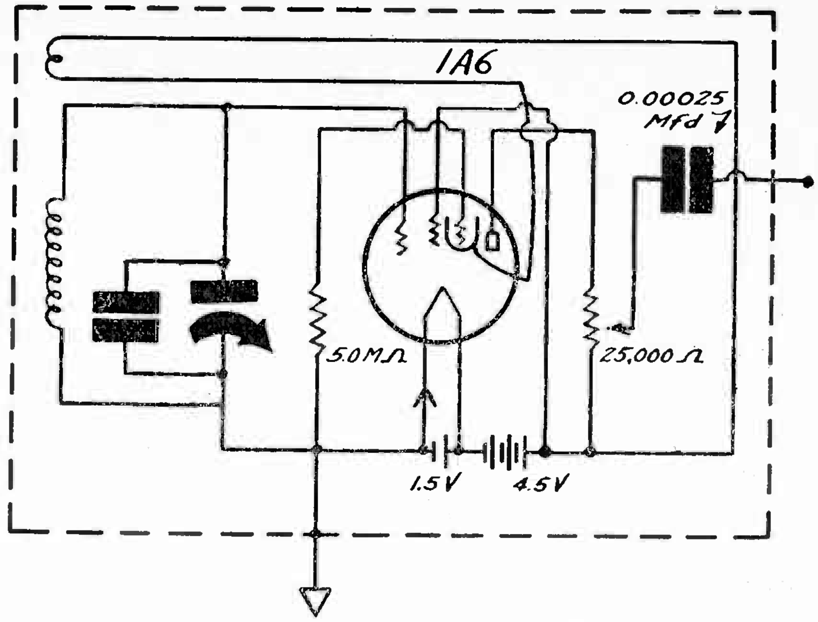
Percentage Modulation

Thus the calibration may be made on the basis of the resistance values alone, and without actual knowledge of the output, since the attenuation is proportionate to the resistance associated with the actual output utilized, and this proportion is merely given in decibels. The measurement may be made for the total values between arm and B plus or for the integral values between adjoining values, the reason for giving the data both ways in the table being to enable closer measurement if one has a low-resistance-reading ohmmeter and makes coincided contacts with the potentiometer arm.

So much for the attenuation in decibels, which refers to the radio-frequency oscilla-

Decibel Attenuation

Attenuation in Decibels (Down)	Resistance Between Arm and B Plus, in Ohms	Differential Between the Adjoining Values
0	10,000	
		2,055
2	7,945	
		1,635
4	6,310	
		1,300
6	5,010	
		1,030
8	3,980	
		820
10	3,160	
		650
12	2,510	
		515
14	1,995	
		412
16	1,583	
		323
18	1,260	
		260
20	1,000	



An unmodulated oscillator, using only 4.5 volts B supply, actually works, due to the use of the 1A6 tube in an unusual way, to improve greatly the mutual conductance. By raising the B voltage to 9 volts assurance of r-f oscillation is gained, even if the grid-blocking method is used for modulation. Details for the constructional alterations to introduce modulation will be found in the text.

tion. Now for the percentage modulation calibration.

If the audio oscillator delivers more than 100 per cent modulation, reduce the amount to 100 per cent. The effective percentage modulation is the expression used when a single tone is considered. The equation follows:

$$M\ \% = \frac{100\,E}{e}$$

where E is the increase in voltage when modulation is applied, and e is the radio-frequency voltage without modulation. A vacuum tube voltmeter, calibrated in r-m-s or peak volts, should be used.

Getting Even Percentages

First the measurement of the oscillation voltage is made by putting the VTVM across the grid circuit, then with the modulation applied, the voltage is measured again, and the difference noted. This difference is E. The modulation is 100 per cent when the difference figure is equal to the r-f oscillation itself. For 10 per cent modulation, the modulating voltage should be one-tenth of the r-f voltage, for 20 per cent modulation the modulating voltage should be one-fifth of the r-f voltage alone, etc.

As for the oscillator circuit proper, the arrangement shown will give satisfactory results. The oscillation intensity will be somewhat greater if the plate of the 1A6, now going to B plus, is returned to negative filament. Such an arrangement might be preferable if the test oscillator is to be put into a shielded box.

The r-f oscillator uses a coil specially wound to cover the specified frequencies, while the dial may be frequency-calibrated, so that the fundamentals are read directly, the broadcast band, with frequencies also imprinted, equalling the fourth harmonic of the fundamental. The fourth is a low enough order of harmonic to avoid confusion on the broadcast band.

A-F Oscillation Transformer

The transformer in the 30 tube circuit is a small audio transformer, the smallest you can get. The core symbols are not shown on that particular transformer in the diagram.

The switching method for the filaments is as near a safeguard as can be atttained using two separate switches, such as would be attached to the two attenuators. If the upper switch is closed the 1A6 tube will light, and if the lower one is closed when the other is, both will light. Suppose the 1A6 switch is opened. Then the 30 tube can not light, which is a safeguard, in that the audio tube would not be left going unwittingly. However, with the 1A6 switch off, and the other on, there is still a filament continuity for the 30, but the two separate A cells are in series opposing, and there will be no current flowing unless the resistances of the cells are unequal. Of course, with special type switches even this slight consideration may be met.

The audio oscillation voltage is given as 7.5 volts minimum. The usual small 22.5-volt battery has no such tap, but 16.5 or 18 volts or some other voltage higher than 7.5 volts may be used. The full 22.5 volts are not at all necessary for the a-f oscillator, but are for the r-f oscillator.

Unmodulated Oscillator

Where no modulation is required, one may use much smaller B voltage, and actually get good oscillation even on 4.5 volts of B battery. Of course negative of B is tied to positive of A, to make the battery voltages cumulative, so if negative filament is taken as datum, the B voltage is the sum of the A and B voltages, i.e., 6 volts. Even this is very slight, and the plate current drain will be in the neighborhood of 20 microamperes (0.00002 ampere). Under such a condition the B battery life is practically equal to the shelf life, even if the tiny cells are used. However, the filament supply should be at least the small 1.5-volt cell of which the cylindrical can is about 1.5 inches diameter.

Here the 1A6 tube is used, also, if one is to go by the designation on the base, but since the elements are used unorthodoxly it is hard to say what kind of a tube it is electrically. Reading around the tube diagram, above, to the right, we have Grid No. 1, or triode control grid, next the grid (No. 2) ordinarily used for positive voltage or equivalent plate of the triode, then the control grid of the pentode (No. 4), while the screen is between that control grid and companion plate as well as between control grid of pentode and positive grid of triode.

Increased Mutual Conductance

The foregoing description applies to the conventional use of the tube, but in the present instance the use is entirely unconventional, being the one that establishes the highest mutual conductance. Since the mutual conductance is practically the figure of merit of an oscillator, and particularly since the plate voltage is so extremely low, we have to use such connections as will insure oscillation of a satisfactory amplitude. Playing deuces wild with the elements, we establish this, after considerable experimenting, finding that mutual conductance is highest (plate current greatest) when the screen is used as the feedback winding, in conjunction with No. 1 grid as control.

Naturally we have some grids to spare. Grid No. 2, conventional plate-type grid as to direction of applied d-c potential, is free, so is returned to positive B. Grid No. 4, third grid from left, is shown connected through a 5.0-meg. resistor to negative filament, but might be returned directly to positive B as an alternative. The conventional plate is used for output.

It will be found by the assiduous experimenter that even if no load is put on the plate, save that of the measured circuit, that there will be coupling. This is due to the capacity between the elements, and the capacity is present no matter if the tube is used conventionally or spectacularly. This means that the coupling in any of these instances cannot be exclusively electronic, but must be also capacitative, and the higher the frequency, the greater this non-electronic coupling. This is true because electron coupling itself is practically constant, independent of frequency, whereas with capacity coupling, granting a fixed capacity, the coupling increases with frequency. It can be imagined that in short-wave sets so-called electron-coupled circuits are principally non-electron coupled at practically all of the short waves, being mostly capacitatively-coupled.

Provision for Modulation

The circuit above might be used as a monitor, or for any other zero-beating purpose, but it is not a certainty that with the load imposition of a grid leak that there will be sufficient r-f oscillation, if any, so some changes would have to be made to introduce modulation. Should modulation be a requisite, as in a test oscillator, the changes would be: Insert a grid condenser of 0.0024 mfd. between stator of tuning condenser and control grid of the oscillator (Grid No. 1 in the tube notation). Connect the overhead grid (No. 4) to positive B, omitting the 5.0-meg. resistor. Return the plate to negative filament. Increase the B battery to 9 volts. Use an 8.0-meg. grid leak, ap-

(Continued on next page)

(*Continued from preceding page*)

proximately, the exact value being selected on the basis of providing a low-pitched audio-frequency oscillation frequency, due to grid blocking. Thus is the tube made to oscillate at two frequencies at once. One engineer told me he made a simple vacuum tube oscillate at five different frequencies at once. This is theoretically possible, and no doubt he did just as he says.

In establishing the modulation by the grid-blocking method just outlined, especial care should be taken to test for its presence at all generated radio frequencies. The test is sufficiently made if notice is taken of the pitch, so that in its change during the tuning process its lowest frequency is still not so low in pitch as to be inaudible, and of course is not zero. It may be zero in a practical instance, meaning no modulation over a small span of the dial, and in either direction from this point the pitch would rise, and after rising possibly decline a bit. The variations thus introduced are due to the effect of the tuning condenser in respect to the grid resistor and grid condenser, so any absence over part of the way may be remedied by lowering the leak a bit if the intended audio oscillation approaches zero frequency, or reducing the grid condenser capacity, or doing both. The choice is somewhat critical, but once made will lead to no further trouble.

Needs Only 2-to-1 Ratio

With the screen used as feedback winding the internal capacity of the tube runs high, around 80 mmfd., so with miscellaneous capacity minima, the total minimum may be around 100 mmfd. Thus to establish even a 2-to-1 frequency ratio the maximum would have to be at least 400 mmfd. With a 350 mmfd. condenser the maximum would be 440 mmfd., and with a 406 mmfd. condenser, the type used in commercial oscillators I manufacture, the maximum would be 486 mmfd., a capacity ratio of 4.86 to 1, or a frequency ratio of approximately 2.2 to 1.

This type of oscillator is inexpensive, dependable and relatively trouble-free, except that the A battery has to be renewed every fortnight, assuming average use, since 50 milliamperes are drawn at 1.5 volts applied, which current is in excess of the conservative rating of these flashlight type cells. As for the B battery, however, chain store 3-volt types, 10 cents each, three in series, total 30 cents, serve abundantly. As the A cell costs a dime also, the total battery cost is only 40 cents. And the B chain lasts months without renewal.

So if the frequency limitation can be found to be nothing serious we can get good use out of such an oscillator. Since intermediate frequencies are to be lined up, and broadcast frequencies taken care of as well, and since harmonics are to be used to a considerable extent, we are absolutely safe if we have a ratio of 2-to-1 for the frequencies generated. Anything ever in excess of a 2-to-1 ratio causes some duplication, anyway, as 2-to-1 takes care of any harmonic system fully and completely.

Selecting Fundamental Range

We have, therefore, only to select the fundamental frequency range. With a secondary inductance of 12 millihenries, and identical tickler, we can strike 200 kc. as the highest frequency, so that the lowest frequency would be well below 100 kc., in fact, close to 91 kc. It is well to allow sufficient leeway for adjusting the trimmer that is across the tuning condenser, so if we remove three or four turns from the coil we shall have no difficulty whatever in striking 200 kc., and still will go below 100 kc. at the other extreme. In fact, we could remove a dozen to twenty turns from the coil, and then calibrate for 100 to 200 kc., for sufficient range, since anything in excess of a 2-to-1 ratio is, as already intimated, in the nature of mere surplusage.

As for using such a scale, if we are to adjust an intermediate channel we certainly know approximately what the intermediate frequency is to be. Suppose it is 110 kc., 150 kc., 185 kc or 200 kc. We then select simply the frequency of the fundamental, as all these are within that range. Suppose the frequency is to be 400, 456 or 465 kc. Since 400 is the second harmonic of 200 kc, we would set the test oscillator at 200 kc, and could not make any mistake, either, for the i-f transformers would not tune to 200 kc. or 600 kc. Both 456 and 465 kc. are more than second harmonics of the highest fundamental, that is, are higher than 400 kc., so we use the third harmonic, and again without danger of being misled. The third harmonic of 152 kc. is 456 kc. and the third harmonic of 155 kc. is 465 kc., so we select 152 and 155 kc. for these purposes.

Scale Divisions

As for the scale, it may read 100 to 200 kc., divided into 1 kc. bars or divisions, since practically the whole dial span is used for this coverage alone. The high minimum capacity also spreads out the tuning, making the curve closer to straight frequency line tuning, although to produce an actually straight frequency line, with necessarily smaller frequency ratio, the author had to insert 390 mmfd. extra parallel capacity. The curve was actually closer to straight frequency line than that of any so-called straight frequency line condenser that the author ever tested.

The next tier could be calibrated merely with bars as extensions of the previous ones, imprinted, however, as 200 to 400 kc., with 2 kc. separation; the next tier, 400 to 800 kc., with 4 kc. separation, and the final one 800 to 1,600 kc., with 8 kc. separation. If this does not suit the constructor, since he may prefer 5 and 10 kc. separation, respectively, for the divided broadcast band, then the second tier could have bars 2.5 kc. apart and the first tier bars 1.25 kc apart.

The commercial model now about to go into production has 1 kc separation for the lowest frequency calibration (fundamental), 2 kc. for the next tier (second harmonic), 5 kc. for the next tier (third harmonic) and 10 kc. for the final tier (fourth harmonic).

Covers Everything Intended

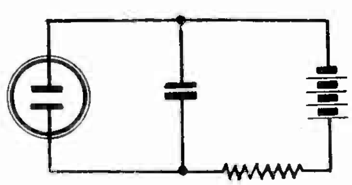
It can be seen that all commercial intermediate frequencies as well as the broadcast band are taken care of, and the reason for raising the plate voltage to 9 volts was to assure sufficient oscillation amplitude for the fourth harmonic range, or high end of the broadcast band.

During the engineering work on this model a little humor was introduced when one of the professional experimenters said he was nervous. His boss asked him why. Here was the reply:

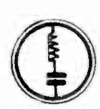
"I'm afraid to be working around such high voltages."

However, 9-volt B supply is utterly practical, despite the joke, and the oscillator is well worth while.

Neon Tube Oscillator



At left is a neon tube audio oscillator, tube without built-in resistor. At right is the built-in resistor type.



If high enough voltage is at hand, the neon tube may be used as an audio-frequency oscillator, and its output may be used for modulating a radio-frequency oscillator. To establish the audio-frequency oscillation it is necessary to use a series resistor and a parallel condenser. The condenser is across the lamp.

The capacity of the condenser largely, almost exclusively, determines the frequency of the oscillating circuit.

The type of tube that has no built-in resistor permits of unlimited choice, within the oscillating voltage range. The amplitude of oscillation is equal to the difference between the extinguishing and the igniting voltages of the lamp.

The more usual type of neon tube, the small bulb that fits in a candelabara base, or the somewhat larger one that fits in an Edison base, has the resistor built in. for use of specified applied voltages, generally around 110 volts. For the present use the voltage would be well-filtered d.c. Otherwise the a.c. would be the ever-present and dominating frequency heard. The lamp with built-in series resistor is at right. The oscillator at left has external resistor only and is commercially obtainable. A suitable combination of values would be 100,000 ohms and 0.002 mfd. for around 100 volts applied, although the voltage concerns the amplitude and not the frequency.

Literature Wanted

Readers desiring radio literature from manufacturers and jobbers should send a request for publication of their name and address. Address Literature Editor, **RADIO WORLD, 145** ***West 45th Street, New York, N. Y.***

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OSCILLOGRAPH USES

INCLUDE VISUALIZATION OF MODULATION PERCENTAGE AND OF SENSITIVITY RESPONSE OF R-F AND A-F CHANNELS

By J. E. Anderson

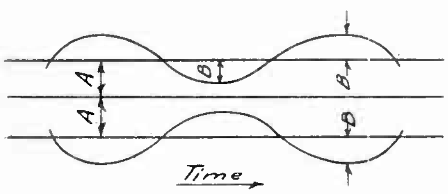


FIG. 1
This represents a modulated wave as it appears on the oscilloscope screen. The heavy wavy lines are the turning points of the electron beam and they are termed the envelope.

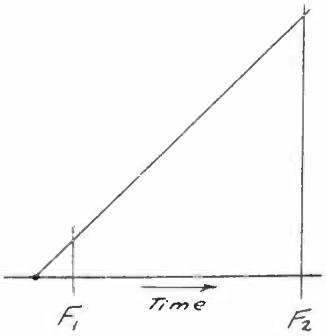


FIG. 2
This curve shows how a timing or sweeping wave should vary to give a linear time axis. The wave is produced by a discharge type of oscillator using constant rate of condenser charge.

FIG. 3
The characteristic curve of an audio transformer or amplifier can be taken on an oscillograph by properly arranging the sweep voltage so that it is proportional to the frequency.

ONE of the most useful devices around a radio laboratory is the cathode ray oscillograph, or oscilloscope. By means of this instrument many phenomena may be viewed which could not be viewed by any other means. Many observations can be made quickly with it which either could not be made at all with any other instrument or which would require a very long time to make. Consider modulation, for example. There are many methods of measuring the percentage of modulation, but there is only one way if viewing it, and that is by the cathode ray oscilloscope. It is even possible to measure the modulation by means of the oscillograph, not, perhaps, to a very high degree of accuracy, but very quickly, at any rate.

Just what is modulation? It is the regular rising and falling of the amplitude of a radio wave according to some definite law. If the modulation represents a tone, the amplitude of the wave rises and falls in sinusoidal manner as time goes on, as illustrated in Fig. 1. Here A is the amplitude of the unmodulated wave, the individual waves of which having been omitted because they are supposed to be so close together that it would be impossible to show them clearly. When the wave is modulated its amplitude does not remain constant, but rises periodically to a value A + B and falls just as often to a value A — B. That is, the amplitude of the radio wave varies between these two limits. Now the amplitude is greater than the unmodulated amplitude by the amount B; now it is less by the same amount.

Seeing the Modulation

If we had no means of seeing this variation in the amplitude we would have to be content with imagining a composite wave form, or we would have to construct it mathematically. If we did this there would always be an uncertainty as to whether or not the mathematically constructed wave actually represented the facts. After all, there could be an error in the assumptions used in arriving at the mathematical result. But if we can see the modulated wave and if we find that it is exactly of the form predicted by the mathematics, then we are certain we are right.

But how can we see the modulated wave by means of the oscilloscope? In the oscillograph or scope, there are two sets of deflection plates which control the direction of the electron beam. If one set of plates is used for producing a deflection in one direction, and the other in the direction at right angles, we have a means of drawing a curve in the same manner as we draw a curve on cross-section paper. Instead of the paper we use the fluorescent screen of the oscilloscope and instead of a pencil we use a beam of electrons. Instead of muscles for controlling the direction of the "pencil" we use two sets of forces, one of the wave we are to delineate and the other a timing force. If we bring about the right conditions we can actually see the modulated wave on the fluorescent screen.

Timing Wave

Let us first consider only the timing force, that is, the propelling type force that is to cause the beam to move horizontally—to establish the abscissas, so to speak. In order that this should produce the proper scale, the beam should move across the screen equal distances in equal times. In other words. the time wave should be linear in respect to time. What this means is illustrated in Fig. 2. Time is laid off horizontally and the force vertically. The straight sloping line represents the positions of the end of the electron beam for every instant of time. The line is straight and therefore the end of the beam moves equal distances in equal times. For example, if the beam moves one inch in 0.001 second. it moves two inches in 0.002 second, three inches in 0.003 second, and so on.

Various schemes have been devised for producing a linear timing, or sweeping, wave but the best of all is the latest, that using a gaseous discharge tube oscillator in which the rate of charging a condenser is kept constant by means of a saturated vacuum tube. We have already described such oscillators in detail. An essential feature of the timing wave, besides linearity when linearity is desired, is that it repeats itself at regular intervals, and that it repeats itself exactly. The oscillator just mentioned produces just such a repeating wave. The rate at which the repetition occurs is also of first importance, but this rate is controllable over extremely wide limits and within narrow limits of accuracy.

Signal Deflection

When we have established a timing wave of the desired frequency and law of variation, we have to provide a means for deflecting the electron beam at right angles to the former deflection. This is done by impressing the signal to be studied across the other set of deflecting plates in the oscilloscope.

When only the timing wave is impressed on its deflecting plates, the electron beam will trace a straight line across the screen in the horizontal direction. When only the signal wave is impressed on its deflecting plates, the electron beam will trace a straight line vertically. These straight lines are the coordinate axes.

When the two waves are impressed simultaneously the electron beam will trace a curve of complex pattern generally, depending, of course, on what is being impressed on the vertical deflecting plates. Suppose that the signal impressed on these plates is that of a modulated radio wave. The curve traced will then lie inside the heavy lines in Fig. 1. It will not only trace the limiting heavy curves, but these will only be the turning points of the beam. Since the beam will linger longer at these points than at any

(Continued on page 22)

KIRCHHOFF'S LAWS APPLIED

Extension of Ohm's Law Enables Solution of Any Network, Regardless of Distribution or Impedances

By Robert G. Hertzog, E. E.
Thor Radio Company

Why Current Can Not Accumulate

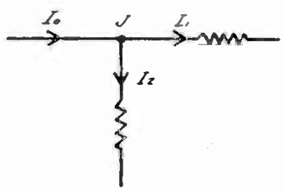


Fig. 1
This illustrates Kirchhoff's first law relating to the summation of currents at a junction of two or more conductors

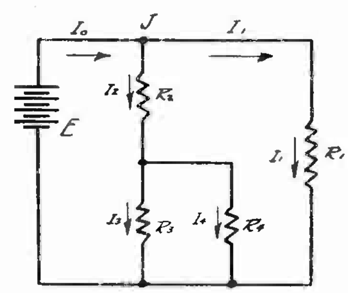


Fig. 2
This illustrates Kirchhoff's second law relating to the summation of electromotive forces and electric potential drops in a loop, or mesh

THE average radio enthusiast learns Ohm's law during the early part of his experimental adventures and uses it often, but more often he finds that it is insufficient to cope with many of the problems which he encounters.

A more thorough understanding of the law in all its forms might help him to solve more problems, but there are still many other problems which cannot be brought under this law. In order that the experimenter should be able to solve more complicated circuits it is essential that he know Kirchhoff's laws as well. These laws are really an extension of Ohm's law. They apply to any network of many meshes whereas Ohm's law applies to a single mesh, that is, to the simplest kind of circuit. Kirchhoff's laws can be stated as follows:

(1) If two or more conductors meet at a point, the sum of the currents coming up to the junction at any instant is equal to the sum of all the currents leaving the junction at that instant. Or, if the currents flowing toward the point are positive and those flowing away are negative, the law is that the algebraic sum of all the currents flowing toward the point is zero.

(2) The total drop of electric potential in a given direction around any closed loop, or mesh, in a conducting network is equal to the electromotive force acting in that loop.

First Law Explained

The first law, the one concerning the summation of the currents, is nothing more than a statement of the fact that electricity cannot accumulate at any point. The law is illustrated in Fig. 1, where three conductors meet at a junction, J, each conductor carrying a current. The currents I_0, I_1 and I_2, are known to flow in the directions indicated by the arrows, or they are merely assumed to flow in those directions for the purpose of analysis. Now, I_0 flows toward the junction, and is, by agreement, positive. Currents I_1 and I_2 flow away from the junction and they must necessarily be negative. When Kirchhoff's first law is applied to the junction, J, we have, $I_0 - I_1 - I_2 = 0$, that is, the algebraic sum of all the currents flowing to the junction is zero.

When applying the second law we go around a loop or mesh in either direction, and as we come to a resistance we multiply that resistance by the current flowing through it. If we are going with the current, we can call the potential drop positive, and then if we go against the current, call the drop negative. In going around a mesh we encounter many of these IR drops. The algebraic sum of all of them in the loop is equal to the electromotive force in the loop, or to the sum of the electromotive forces if there are more than one. Here, too, the sign must be taken into account. If there is no electromotive force in the loop, the sum of the potential drops is zero. This is the case in most of the loops in a complex circuit.

Application of Second Law

Fig. 2 is an application of the second law that arises in connection with voltage divider design, but considerably simplified. E is the electromotive force. There are many loops in the network which we can go around summing up the drops of potential, but it is not necessary to go around all. First let us go around the loop containing E, R2 and R3, going in the clockwise direction, since the polarity of E indicates that the current will flow in that direction. First we have the drop I_2R_2, which is positive, and then the drop I_3R_3, also positive. Kirchhoff's second law applied to this loop gives, $E = I_2R_2 + I_3R_3$. Now let us go around the loop containing R_1, R_4, and R_2, proceeding counter clockwise. First we have the drop I_2R_2, then I_4R_4, and finally $-I_1R_1$. The last one is negative, because we go against the current. Summing up we have $I_2R_2 + I_4R_4 - I_1R_1 = 0$. There is no electromotive force in this loop. The next loop is the one containing R_3 and R_4. Going around this mesh we have $I_3R_3 = I_4R_4$. In this case it is not necessary to go around the loop actually, because we see that the resistors are in parallel, and therefore the voltage drops in the two must necessarily be equal. There are four currents in the network, not counting I_0, and therefore we need four relations to solve the circuit. We have three so far. To obtain the fourth we can either apply Kirchhoff's second law to the loop containing R_1 and E or the first law to the junction of R_2, R_3, and R_4. The second law gives $E = I_1R_1$, whence $I_1 = E/R_1$. The first law applied to the junction gives $I_2 = I_3 + I_4$. Now we have enough relations, and more, completely to solve the circuit. The work is just a matter of algebraic manipulation.

Application to Voltage Divider

The design of a voltage divider is a problem involving the use of Kirchhoff's laws. Let us consider a typical example, that of a B supply for an eight-tube radio receiver employing three 58s, one 57 detector, one 56 audio amplifier, two 45s as output tubes, and one 83 rectifier.

The rectifier tube does not obey these laws. Almost regardless of the current, there is a drop of 15 volts in the tube. This is contrary to Ohm's law. Also, on the left of the rectifier the voltage is a-c, while it is d-c on the other side. There is no simple relation between the root mean square a-c voltage, indicated as 375 volts, and the d-c voltage. Hence it is best to avoid everything to the left of the tube and the tube as well.

For a given current drawn by the load there will be a certain d-c voltage across the entire load. This is assumed to be 235 volts. Now there is a choke having a resistance of 1,250 ohms between the rectifier and the load. If we knew the total current, that is, I_0, it would be possible to determine what the voltage across the line on the rectifier side of the line should be in order to give 235 volts on the other side, but so far we do not know it.

The Load Resistance

The load resistance R_1 in this case is the resistance of all the plate circuits in the receiver, all connected in parallel. Now each of the 58s takes a current of 8 milliamperes, normally, or a total of 24 milliamperes. The 57 takes 0.1 milliampere, the two 45s together 60 milliamperes, and the 56, 5 milliamperes. Therefore the total value of I_1 is 89.1 milliamperes, or just 89 for short. Although we need not know the effective value of R_1 we can now determine it, for it is 235/-0.089, or 2,640 ohms.

Now let us assume that when the slider on R_4 is at the top, that is, at 140 volts, the total screen current is 6 milliamperes. We can also assume that the value of I_3 is 5 milliamperes, for this is entirely arbitrary and the choice is only based on judgment. If the voltage drop I_3R_3 is to be 140 volts, the value of R_3 must be 28,000 ohms in order for the current to be 5 milliamperes.

We now know that the value of I_2 is 5 plus 6, or 11 milliamperes, which is an application of Kirchhoff's first law. If the voltage at high end of R_2 is 235 volts and 140 volts at the low end, the drop in it is 95 volts. Therefore R_2 should have a value of 8,630 ohms.

Choice of Potentiometer

The choice of R_4 is also more or less arbitrary, but the resistance must be high enough not to change appreciably the current distribution we have assumed. If we make it 100,000 ohms, 1.4 milliampere will flow through it. That is a considerable part of the 5 milliamperes that flowed through R_3. Hence, even if we use as high a value as 100,000 ohms for R_4 it is necessary to make allowance for it. This is best done by changing R_3. If there is to be no change in the current distribution, R_3 and R_4 must be chosen so that when they are in parallel, the total resistance will be 28,000 ohms. Therefore, if R_4 is 100,000 ohms, R_3 should be 38,900 ohms. We might also make R_4 250,-000 ohms. In that case R_3 should be changed to 31,500 ohms.

We now know the total current I_o and therefore we can compute the drop in the choke. Since I_1 is 89 and I_2 is 11 milliamperes, I_o is 100 milliamperes. Therefore, the drop in the 1,250-ohm choke is 125 volts. Therefore the voltage across the line next to the output of the rectifier should be 360 volts.

The first thing that should be done when starting the design of a voltage divider is to estimate the plate and screen currents that will flow when the desired voltages are impressed on the elements. The currents can be obtained from tube characteristics covering the tubes used in the circuit. Then the equivalent network should be drawn up, indicating the directions and distributions of the various currents. These currents can then be used in conjunction with the desired voltages for determining the various resistances. It should be remembered that the amount of bleeder current may be taken at pleasure, but one should be guided by the total current that may be taken from the rectifier. It is better to have a large bleeder current for voltage constancy, but as the bleeder is increased the voltage will drop. Moreover, if the bleeder current is high, higher wattage resistances are required. A bleeder between 5 and 10 milliamperes is reasonable.

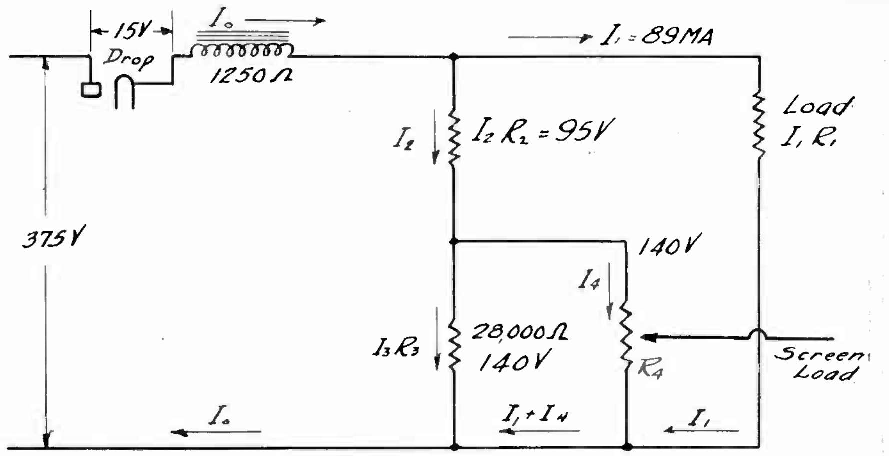


FIG. 3

The design of a voltage divider such as this is a problem involving Kirchhoff's laws.

Prices Announced for Oscillograph Tubes

The prices of the new cathode ray oscillograph tubes and the sweep control tube have just been announced:

906 (3-inch screen, electrostatic deflection)	$18.00
905 (5-inch screen, electrostatic deflection)	40.00
904 (5-inch screen, electrostatic deflection)	50.00
903 (9-inch screen, electromagnetic deflection)	120.00
885 (gaseous type triode for sweep control)	2.00

The high-voltage companion rectifier, 878, for use with the oscillograph tubes is priced at $11.00.

Television Called Ready; Prosperity the Trigger

(Topical Press Photo)

London radio stores are sending technicians and sales representatives to Borough Polytechnic School to learn about television, on the theory that commercial television is impending. A gas discharge tube is being demonstrated.

While representatives of the leading television experimental laboratory in the United States are admitting that the development of television transmission and reception has reached a stage that renders commercialization practical from the scientific viewpoint, the timidity of executives regarding whether the public has enough money to pay the necessarily high prices the sets would cost is holding back the start. There is more optimism in England. For instance, London radio stores are sending technical and sales employes to Borough Polytechnic School to learn something about television, to be prepared for the expected start of sales of television receivers. No date is mentioned!

The executives in the United States have been careful not to repeat the mistake of offering something before it was good enough and before the public was ready to buy it. Due to the plane to which sound broadcasting has been raised, in respect to electrical technique, and with a public accustomed to such quality, it is realized that anything much less than equivalent quality in television might prove a boomerang. Right now the development is not quite up to the illumination and definition of a home movie showing 16 millimeter film, but the difference is not very substantial, especially if 240-line transmission is used.

NEW DIAL SYSTEMS FO

Mechanical and Optical Index M
of Scales with Coil

By Edward

DIALING and switching systems have become vastly important since all-wave reception won serious interest on the part of the general public. While those experimentally inclined could get along with a simple numerically-scaled dial, and would know from experience the bands in which they were working, especially when plug-in coils were used, the general public can not be expected to gain such familiarity simply, and besides prefers a switching system.

Whatever may be the advantages of a plug-in system, it is nevertheless true that excellent results can be obtained from an excellent switch, and suitable types of switches are now on the market, with contact resistance and self-capacity not much different from what obtains when using plug-in coils.

Two new ideas are presented herewith, one the invention of J. E. Anderson, applying to a circular drum dial, with or without provision for automatic coincidence of switch position with frequency scale for the particular band, and using an optical system, the other the invention of Herman Bernard, using a mechanical system entirely.

Bernard's Method

A system of having the coil switch revolve a multi-faced frequency-calibrated drum, and a mechanical system move the dial pointer over the exposed calibration, is the one devised by Mr. Bernard and is illustrated in Fig. 1.

The two main objects of any such system would be (1) to correlate the frequency scales automatically with the switch position and (2) to provide a high degree of legibility or definition.

The correlation is important because under many systems now used in switch-type all-wave receivers, the vice is obviously revealed, for though frequency calibration may exist, there is nothing to show which band is being tuned in, and a casual radioist could be confused. One remedy in use is to have a different colored pilot lamp for each band, the coil switch also switching on the colored correlated lamp, and the switch points being similarly colored. However, numerous lamps, such as six or more as would be required in a well-engineered receiver that provided adequate linear separation on the frequency scale, are cumbersome and also numerous wire leads may have inductive and capacity effects that introduce instability.

Good Linear Separation

If the switch shaft and the drum shaft were in the same plane the same operation would suffice without gearing, but in general this is impractical because the scale is then a long piece at right angles to the front panel and hardly within view, unless the panel is a top panel, and you would look down on it, in a purely directional sense, when establishing the frequency setting.

The second consideration, a high degree of legibility, must be preserved, and virtually all systems that have frequency-calibration fail in this respect. The reason is that the scale is circular, and that the frequencies are calibrated in semi-circular tiers, hence the system is concentric, and some span must occupy the position nearest the hub, where the circumference is smallest, hence crowding greatest. Moreover, this other than choice position is usually awarded to the highest band of frequencies, so that the so-called calibration is in jumps of megacycles, and the width of the indicator may account for some thousands of kilocycles, meaning, of course, that frequency calibration becomes rather meaningless to this extent.

The Hexagonal Model

The drum that rotates with the turning of the coil switch to various band positions, and which has one face for each switch throw, would be a hexagon for a six-position switch, as illustrated. Although the drum revolves with the switch action, it does not move to left or right, but the pointer travels along the front, and the correct scale is always the one that appears in front, due to coincidence in gearing, the others being hidden either because other than perpendicular, or at rear, or because of the occlusion determined by the escutcheon.

The illustration shows plainly that the front scale is calibrated, and there is a suggestion of equivalent bars on the next upper face, but no suggestion as to the face next lower to the one exposed, although it must be understood that each of the six faces or planes are calibrated in frequencies.

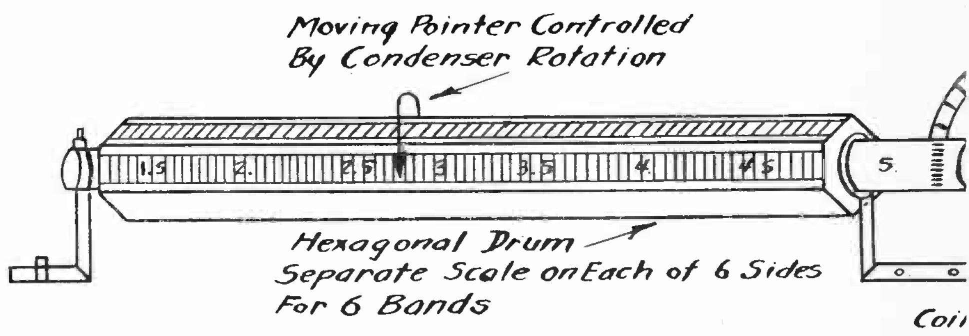
Total Scale Width Used

For any band the total width of the scale is used for accommodating the calibration, and the actual linear distance is always the same for all bands, since even the frequency overlap, one band to another, should be calibrated as part of any one scale.

The indicating system is not of the best, being a mechanical one, with some possibility of parallax, but a projection type could be used, or even an optical system, where a beam of light is made to travel over the exposed scale due to reflection from an angled mirrored surface on the back of the front panel, the light source being farther back and controlled by the condenser action.

Some of the popular systems of full-vision dialling, with long, horizontal scale, are mechanically constructed so that due to cam action the indicator is exactly perpendicular only when close to the center, or approximately in line with the dial shaft, and as the movement is away from this point in either direction the index begins toppling over, so to speak. Such a method is of scant help in a system as now being discussed, as it prevents the use of a straight surface,

Full Scale Width for



FI

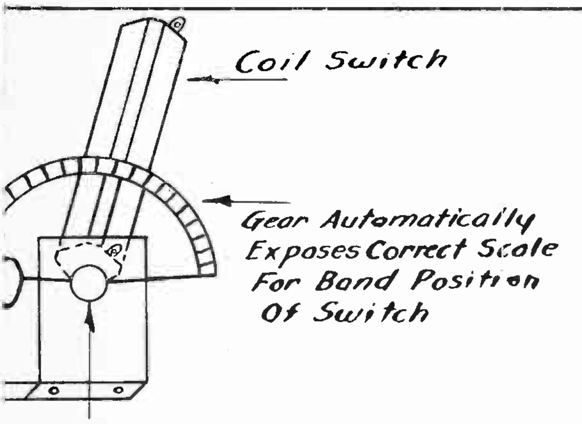
A dialing system devised by Herman Bernard, whereby the frequency- automatically and exclusively exposed to view, being selected by the same connected to a system controlled through the condenser shaft indicates "diminishing legibility

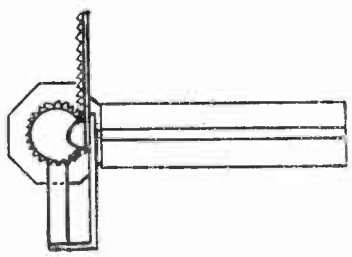
)R MULTI-RANGE SETS

/lethods; Automatic Coincidence Switch Points

M. Shiepe

Each Frequency Band





G. I

·alibrated scale that applies to the band in which one is working is ocess as applies to the switch selection of the coils. A moving pointer the frequency. Note that there is no crowding, as the concentric vice of " is totally avoided.

hence a polygon. Another such dial has the proper constantly-upright indicator, using a system of belt and pulleys. This is serviceable in the present instance.

Reflection of Index

So simple an arangement as gear and rack, gear attached to the condenser shaft. rack to the indicator, would move the index also.

The parallax problem may be solved in any instance by having a polished urface on which the field is blackened, leaving the bars and printing exposed brilliantly, and serving as a mirror for the index. Thus if the pointer is knife-edged its reflection could be used as index, and this would provide high accuracy.

Consulting the illustration, let us imagine now that we are going through the operation of using the device, although the description in words hardly brings out the simplicity of the operation.

The coil switch is identified on the drawing. The switch is turned to the desired position, say, to tune in the first short-wave band above the broadcast band in frequencies. The scales are so disposed on the drum that they coincide with the switch settings for the various bands. Thus the particular frequency band would be perhaps from 1.5 to something more than 4.5 megacycles (1,500 to plus 4,500 kc). If the condenser closes to the left, and since turning the condenser to the left will drive the pointer to the left, the direction is consistent and lower frequencies are to the left.

Correct Exposure Automatic

A vernier mechanism drives the condenser. A knob for purposes of dial actuation is on the front panel. Turning this knob moves the pointer. The relationship between the capacity of the condenser, represented by the pointer position on the exposed scale of the drum, and the inductance selected by the switch, determines the frequency, and this determination constitutes the calibration.

The reason that the coil switch exposes the correct scale is that the switch has attached to it a gear with teeth sticking forward, and these teeth engage the identations or extrusions of the shaft of the drum. Thus the gear automatically exposes the correct scale for the band position of the switch.

Something must support the coil switch. A bracket is used. Something should hold the gear in mesh. Another bracket serves the purpose, or the two objects are obtained by a single bracket.

The side view of the gear mechanism is illustrated at right in the figure. Whether the shaft of the knob is indented or extruded for gearing purposes is merely a detail.

Since the drum must revolve, it is necessary that it be free of impediment from the bracket. A slotted circle around the shaft, with sleeve tight enough to prevent the shaft from moving up or down or left or right, and yet not so tight as to prevent turning the drum, is used.

This is the first exposition of the automatic dial system as devised by Mr. Bernard.

J. E. Anderson's Contribution

Now as to Mr. Anderson's system:

If oscillators, radio receivers, calibrated condensers, and other devices used in measurement are to be read accurately some means must be provided for reading small angular displacements accurately. The simplest device used that can be called precision is the ordinary vernier scale attached to the main scale. But this is quite limited because the scale cannot be made very long. The largest dial available for radio purposes has a diameter of 6 inches, making the circumference approximately 19 inches long. If this scale is divided into 100 equal divisions and the vernier has 10 divisions equal to nine on the dial, it is possible to read directly to one part in one thousand, and since the divisions are fairly large in this case it is easy to estimate closely to one part in 2,000. If the scale is divided into 180 equal divisions and the vernier still reads 1-10 of the smallest division, it is possible to estimate closely to one part in 3,600. It should be remarked that the length of the scale is not equal to the circumference, but only to one-half the circumference, or at most, to three-quarters. The actual length of the scale has little to do with the accuracy of the reading if there is a vernier, but it has much to do with the ease of estimating between divisions. The longer the scale, the longer each division, both on the main dial and on the vernier, and the easier it is to estimate.

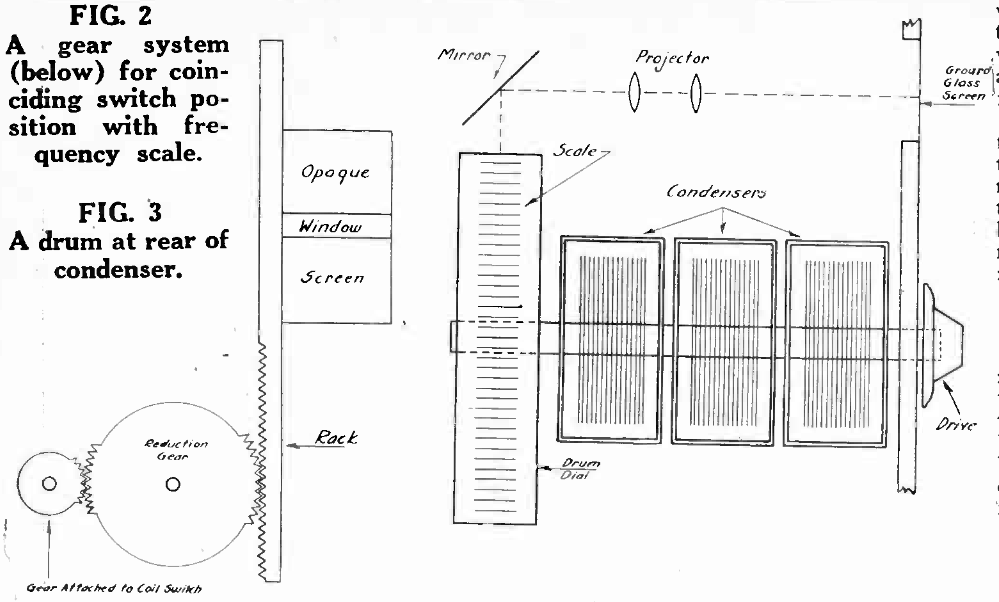
Gearing and Worms

It is, of course, always possible to attach some gear arrangement to multiply the angular displacement, that is, to multiply the ratio between the angle to be measured, and that with which it is measured. But gears always introduce lost motion, and the greater the multiplication the greater the effect of the lost motion. There is therefore no assurance that a gear arrangement, however great the magnifications may be, will help the accuracy. One of the methods often used in "gearing up" employs a micrometer screw in place of gears. This offers some advantage in that it is possible to obtain a high multiplication with a given amount of lost motion. The ordinary micrometer caliper employs this method for reading small distances accurately, and it is more accurate than the vernier caliper. Yet there is considerable lost motion. Another example in which the screw, or worm, is used is a com-

(Continued on next page)

FIG. 2
A gear system (below) for coinciding switch position with frequency scale.

FIG. 3
A drum at rear of condenser.



(*Continued from preceding page*)

mercial high precision condenser. This has a main scale of 26 divisions and a micrometer screw on the drum, of which there are 100 divisions, one hundred of these divisions being equivalent to one division on the main dial. By means of this arrangement it is possible to read directly one part in 2,600 of the main dial at maximum. The divisions on the micrometer scale are so large that it is easy to estimate to one tenth of a division, thus making readings of one part in 26,000 possible, at full scale. The screw is accurately made and the lost motion is small, yet there is sufficient to prevent duplicating settings within the accuracy with which the scale can be read.

It may be stated generally that for precision work there should be no mechanical magnification by means of gears and screws, and, moreover, there should be no end stops on the device turned.

Open Magnification

One method which offers possibilities is shown in Fig. 3. A large drum dial is attached to the condenser shaft at the rear of the condenser. The diameter of this drum can be made quite large so that the divisions may be large, or so that many divisions can be engraved with legibility. Directly over the drum is a mirror mounted so that it makes an angle of 45 degrees with the axis of the condenser. The spot on the dial directly under the mirror is brightly illuminated. The mirror reflects the portion of the dial directly under it through a system of lenses to a ground glass screen on the panel. The lenses can be adjusted so that the image of the scale is brought to a focus on the screen.

If the elements involved in this system are rigidly mounted there will be no lost motion and the magnification of the image of the scale may be made considerable, depending on the focal length of the lens and the distances involved.

How does this help in reading the scale accurately? In the first place the scale may be large, permitting a large number of divisions. These may be very close together on the scale, yet when they have been thrown on the screen they will be quite far apart, making it easy to read them. It is not only important that the divisions be close together but that the lines be fine so that when they have been magnified they will not be a considerable proportion of the distance between them.

An indicator must be provided in this case, and it is best that this be not a part of the image projected, for then its image will be magnified also. It is best placed on the ground glass, where it may be a fine vertical line, such as an extremely fine wire, a fine ink line, a silk thread, or a spider filament.

As the dial is turned the divisions on the file in review passed the indicating line on the dial. Reading accurately is a simple matter, for the divisions will be large, and the division lines and the indicating line will be fine. It is even possible to mount a vernier on the ground glass, but this must be made for a given scale and optical system.

Multiple Scales

When the arrangement is to be used on a multi-range tuner, either receiver or oscillator, it is desirable to have several scales on the drum. These can also be placed parallel, and they can be placed so that they can be shifted independently in respect to the drum. Thus it is possible to calibrate each range to be direct reading.

But which scale should be read on the dial. Perhaps there will be six of them, arranged in tiers. If they are all visible at the same time, it will be confusing, and the wrong scale might be read. This can be avoided by any one of several arrangements. The mirror can be shifted a little for each change of tuning range. It would require a comparatively small change in the angle to shift the desired part of the image on the screen, or on a given portion of the screen. Another way is to provide a curtain with a narrow window in it and then move the curtain each time the tuning range is changed. This window would be just wide enough to show the scale desired and to eclipse all the others.

Mirror Shifting

This shifting of the mirror or of the curtain should be done automatically. Suppose, for example, that a switch is used for selecting different coils to change the wave range. The operation of turning the coil switch should either turn the mirror by the right amount or pull the curtain up or down by the right amount. A possible way of moving the curtain automatically is indicated in Fig. 2. A small gear is attached to the shaft of the switch. This engages another gear of larger diameter, which in turn engages a rack. The rack moves up and down, thus moving the window in the same direction. The vertical length of the curtain must be equal, approximately, to twice the vertical dimension of the window.

Curtain Control

In order to move the curtain the right amount each time, it is only necessary to select the correct gear ratio. It is necessary, of course, that in turning the coil switch, the same angle is turned every time. Otherwise there would be no ratio possible. Guiding of the rack and mounting of the intermediate gear are mechanical details.

Such a scheme as this is rather complex, but there are occasions where it is highly desirable, and the trouble involved in rigging it up is well repaid. Incidentally, the cost of the lenses and of the mirror need not be more than a quarter.

WNEW Instals Vertical Aerial 430 Feet High

WNEW's new vertical radiator type antenna at Carlstadt, N. J., has been completed.

The former system of using two towers to support the antenna wires will be obviated by the new antenna which rises 430 feet above the Jersey meadows. This single tower of symmetrical design houses the aerial which will be fed by a transmitter capable of amplifying evenly the entire audible range of sounds.

An aviation beacon has been installed atop the tower as a landmark and guide for passing planes. The beacon in operation flashes 36 times a minute and will be noticeable throughout the entire metropolitan area.

The tower is built on a salt marsh. It is supported by 80 piles driven into the marsh eighty feet. A special insulating base of high tensile strength porcelain separates the concrete base, which weighs 120 tons, from the single metal latticework tower.

20,000,000 Sets in 4 Years Is New Plan of Soviet

The Soviet organ, "Pravda," details Soviet plans being developed by the Commissariat for Communications to develop broadcasting in Russia and also receiving set manufacture. It outlines a four-year Soviet program for production of 20,000,000 receiving sets with present and enlarged manufacturing facilities of the Soviet and with twenty scientific research institutes of Russia now engaged thereon. By the end of 1937, the "Pravda" article states, it is hoped to develop a large radio manufacturing industry to work present plants at full capacity and complete ten new plants, to cost 130,000,000 rubles, for manufacture of sets, tubes, amplifiers and batteries. Immediate construction of the new plants "at full speed" is advocated.

In Russia there are now only sixty-two radio stations, according to the "Pravda" article, but twenty-nine new stations are now building and Soviet authorities are planning development of excellent broadcast programs.

Three Channels Above 1,500 kc Are Alloted

Washington.

Stations soon will be broadcasting programs between 1,500 and 1,600 kc, due to the extension of the band as voted at the radio conference in Mexico City.

The Federal Radio Commission has assigned 1,530, 1,550 and 1,570 kc, limited power to 1 kw, permitted sponsored programs, and decided on 20 kc separation for quality modulation. It is expected experiments with high-fidelity transmitters and receivers will be conducted on the three channels.

100 WATTS OUTPUT

IT CAN BE OBTAINED WITH 2A3 PUSH-PULL DRIVING 800 PUSH-PULL OUTPUT

THE 800 is a triode designed for use as a radio-frequency power amplifier or oscillator. It may also be used to advantage as a Class B audio-frequency amplifier where large power output is required. When two of these tubes are used in this way, 100 watts of audio power can be obtained.

In this application note, data are given for Class B operation of the 800 with plate potentials of 750, 1,000 and 1,250 volts. The optimum plate-to-plate loads and transformer ratios for each condition of operating voltage are also shown. A pair of 2A3 or 45 tubes will supply maximum driver signal.

Typical operating conditions for two 800's in a Class B output stage are as shown:

TABLE I FOR THE 800'S

Driver Tubes, Two 2A3's; Plate Volts, 250; Grid Volts, —45

Plate Volts	Grid-Bias Volts	Driver Transformer Ratio* Pri. to ½ Sec.	Plate-to-Plate Load Ohms	Plate Input Power Watts	Total Power Output Watts (2 Tubes)	Total Distortion Per Cent
750	—50	1.75:1.0	6400	160	90	7.3
1000	—55	2.0:1.0	12500	160	100	7.0
1250	—70	1.0:2.0	21000	160	106	7.0

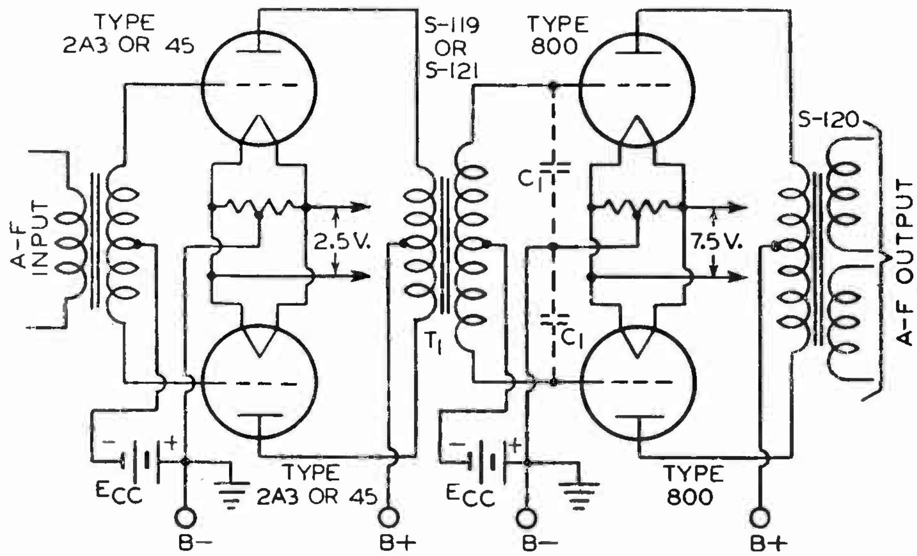
TABLE II FOR THE 800'S

Driver Tubes, Two 45's; Plate Volts, 275; Grid Volts, —56

1000	—55	2.16:1.0	12500	160	100	7.9

*For approximately 80% peak-power efficiency.

Fig. 1 is a circuit diagram of a typical Class B audio amplifier. Grid bias should be supplied from a source having good voltage regulation, say RCA Radiotron Co., Inc., and E. T. Cunningham, Inc. A small-capacity storage battery is excellent for supplying this bias, since the action of this type of amplifier is usually such as to keep the battery charged. In general, a dry battery should not be used since it may polarize when grid current is drawn or it may have too high an internal resistance.



Typical Class B output, 100 watts, using the 800 tubes to feed the speaker. C1 and C2 would be 0.0001 mfd. to prevent r-f oscillation. S-119 and S-121 represent transformers, data on which RCA Radiotron Company supplies.

The Three Biases

Self-bias means bias due to voltage drop in a resistor through which flows the B current of the biased tube. Semi-fixed bias means currents of other tubes also flow through the biasing resistor. Fixed bias means independence of the current changes in the biased tubes, hence totally external application.

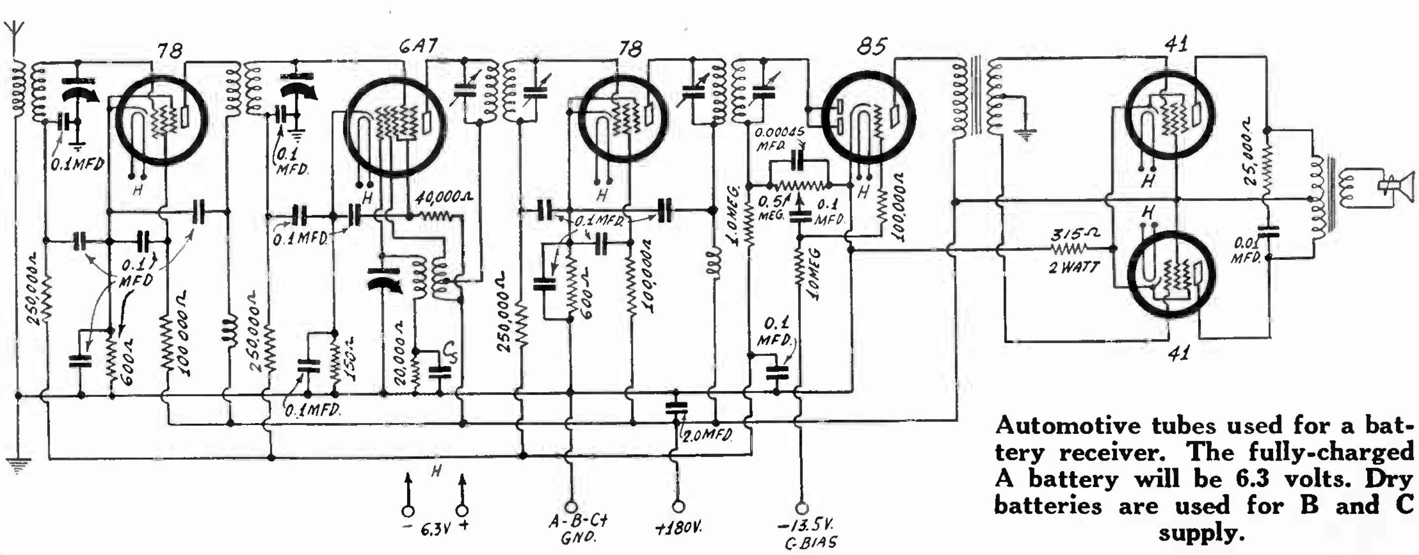
Lewis Winner Father of an 8¾ lb. Boy

On January 30th, the President's birthday, Roosevelt, Lewis Winner, advertising writer, became a father of an 8¾-lb. boy. Both baby and mother are doing exceptionally well.

Mr. Winner expected to go to Washington to see the President and incidentally spread the glad tidings.

A reporter asked Mr. Winner: "Will it be advertising or publicity for your son?"

"Anything his heart desires," Mr. Winner replied, "but I hope it is not advertising or publicity."



Automotive tubes used for a battery receiver. The fully-charged A battery will be 6.3 volts. Dry batteries are used for B and C supply.

Characteristics Tabulated for New 6C6 and 6D6

The 6C6, the 6.3-volt equivalent of the 57, and the 6D6, similar to the 58, have the following tentative characteristics, according to RCA Radiotron Co., Inc., and E. T. Cunningham, Inc., who supplied the copyrighted tables:

6C6
Triple-Grid Detector Amplifier

Heater Voltage (A.C. or D.C.)	6.3	Volts
Heater Current	0.3	Ampere
Plate Voltage	250 max.	Volts
Screen Voltage	100 max.	Volts
Grid Voltage	—3	Volts
Suppressor	Connected to cathode at socket	
Plate Current	2.0	Milliamperes
Screen Current	0.5	Milliamperes
Plate Resistance	Greater than 1.5	Megohms
Amplification Factor	Greater than 1500	
Mutual Conductance	1225	Micromhos
Grid Voltage*	—7 approx.	Volts
Grid-Plate Capacitance (With shield-can)	0.010 max.	μμf
Input Capacitance	4.7	μμf
†Output Capacitance	6.5	μμf
†Overall Length	4-11/16" to 4-15/16"	
Maximum Diameter	1-9/16"	
Bulb	ST-12	
Cap	Small Metal	
Base	Small 6-Pin	

*For cathode current cut-off.

Note 1: Pin 1—Screen, Pin 2—Plate, Pin 3—Heater, Pin 4—Heater, Pin 5—Cathode, Pin 6—Suppressor, Cap —Grid

Pin numbers are according to RMA Standards Sheet 801-A (M-8-115) and are the same as for Type 57.

Note 2: In circuits where the cathode is not directly connected to the heater, the potential difference between heater and cathode should be kept as low as possible.

Note 3: The internal shield in the dome of the 6C6 is connected to the cathode within the tube.

†Indicates a change.

6D6
Triple-Grid Super-Control Amplifier

Heater Voltage (A.C. or D.C.)	6.3	Volts
Heater Current	0.3	Ampere
Plate Voltage	250 max.	Volts
Screen Voltage	100 max.	Volts
Grid Voltage	—3 min.	Volts
Suppressor	Connected to cathode at socket	
Plate Current	8.2	Milliamperes
Screen Current	2.0	Milliamperes
Plate Resistance	800000	Ohms
Amplification Factor	1280	
Mutual Conductance	1600	Micromhos
Mutual Conductance (At —40 volts bias)	10	Micromhos
Grid-Plate Capacitance (With shield-can)	0.010	μμf
Input Capacitance	5.0	μμf
Output Capacitance	7.5	μμf
Overall Length	4-9/32" to 4-17/32"	
Maximum Diameter	1-9/16"	
Bulb	ST-12	
Cap	Small Metal	
Base	Small 6-Pin	

Note 1: Pin 1—Screen, Pin 2—Plate, Pin 3—Heater, Pin 4—Heater, Pin 5—Cathode, Pin 6—Suppressor, Cap —Grid

Pin numbers are according to RMA Standards Sheet 801-A (M-8-115) and are the same as for Type 58.

Note 2: In circuits where the cathode is not directly connected to the heater, the potential difference between heater and cathode should be kept as low as possible.

Note 3: The internal shield in the dome of the 6D6 is connected to the cathode within the tube.

Constant Plate Current in an R-F Oscillator

Measurement for constancy of d.c. in an oscillator's plate circuit is not without value, since it has been found experimentally that the measurement more easily made gives a good disclosure of the a-c condition in relative terms. A thermo-galvanometer was used as check, for a-c values.

Another fact worth considering, and also shown by Herman Bernard in his experimental notebook, is that the tickler inductance and coupling may be adjusted so that wide variations of amplitude and frequency may be held in check. Thus if the tickler is inordinately large, as for instance a 10-millihenry choke coil, where the secondary inductance is of the order of 3.5 millihenries, there will be low-frequency oscillation, but not high-frequency oscillation, as the choke is not a tickler but a choke at these high frequencies of the tuning (where the range is 3 to 1) and stops the feedback actually. However, this vice has been capitalized by Bernard, who adjusted tickler turns until the response at the low-frequency end was exactly duplicated at the high frequency end, removing some 150 turns from a 900-turn honeycomb coil of small physical dimensions. Then the plate meter needle scarcely moved throughout the span of tuning.

The radio art has been looking for a simple means of introducing frequency stability, an advantage that has not yet appeared in commercial superheterodynes, where the oscillation wobbulation is considerable. Methods of thermostat control of capacity are being used, and these are to be encouraged, although their significance is not much when one realizes that the oscillator circuit in which they are included is not frequency stabilized.

The thermostat control consists of a trimming condenser set once in the oscillator circuit, and having plates of dissimilar metals, so that when temperature changes make one of the metals expand they make the other metal equally contract, so that there is no capacity variation in the trimming due to the temperature changes. However, it must not be forgotten that the stator and rotor plates of the tuning condenser itself would have to be similarly treated, and the oscillator frequency stabilized as well, before the remedy is complete.

230 Stations Abroad Change Wavelengths

London

The wavelengths of 230 European broadcasting stations were switched simultaneously in conformity with a plan evolved at a recent conference in Lucerne, designed to eliminate much of the interference which has troubled listeners in Europe.

The results of the change will be studied by Raymond Braillard, president of the Technical Commission of the International Union of Radio Diffusion, at Brussels. Some forty experts are aiding him in the study. Clearer reception is expected for all listeners.

Pilot Back in Fold

The Pilot organization, which provided the Dragon, Wasp and many other leaders, is once more back in production and from its Long Island City plant has just released a new all-wave receiver.

Radio University

A QUESTION and Answer Department. Only questions from Radio University members are answered. Such membership is obtained by sending subscription order direct to RADIO WORLD for one year (52 issues) at $6 without any other premium.

RADIO WORLD, 145 WEST 45th STREET, NEW YORK, N. Y.

Twisted Pair Transmission Line

IS IT possible to use twisted pair as a transmission line? If it can, would it be necessary to put it inside a metal sheath to protect it from moisture?—J. M. B.

Yes, it is possible to use twisted pair for a transmission line, but if it is to be placed inside a metal sheath, that sheath might as well be used as one side of the conductor and the twisted pair as the other.

* * *

Grid Leak and Stopping Condenser

IT IS a well known fact that the frequency stability of an oscillator is better when a stopping condenser and a grid leak are used than when the grid coil goes directly to the grid. Can you give any reason why this should be so? What makes an oscillator frequency stable?—W. R. Y.

The grid leak and stopping condenser increases the grid resistance for one thing, by limiting the flow of grid current. At the same time the plate resistance is increased. When the grid resistance and the plate resistance are large the frequency stability is better. If both were infinite, if that could be, the frequency stability would be perfect. It is possible, however, to obtain good frequency stability even when no stopping condenser is used, and it is done by tuning the grid and the plate circuits, not in the usual way, but by putting a coil or condenser of right value in either the plate or the grid lead, or in both, preferably both.

* * *

Meaning of Transducer

WHAT is the meaning of the terms transducer? I have seen this term used in articles on radio, but I never have seen any definition of it. It is not defined in the dictionary I have.—W. N. J.

By transducer is meant a device that converts energy from one form to another. Thus, a microphone is a transducer because it converts sound energy into electrical energy. A loudspeaker is also a transducer, for it converts electrical energy into sound energy. Other transducers are phototubes, electrical generators, steam and gasoline engines, lamps of all forms, and electrical batteries. Literally the term means a device that "draws across" or "pulls across." There is an unknown gulf between any form of energy and any other.

* * *

Calibration of a Condenser

HOW can a variable condenser be calibrated accurately? I have secured a good condenser and provided it with a first rate vernier dial and I intended using the combination for measurement of capacity. But the condenser is not calibrated and I have no means of doing it.—W. R. I.

The simplest way is to send the condenser to a laboratory and have it calibrated. This, however, may be quite expensive, especially if many calibration points are to be obtained. Moreover, it is possible that in shipment the calibration may change due to jars. Another way of calibrating is to obtain a small accurately known capacity and then calibrate the condenser in terms of this by the step-by-step method. Suppose, for example, that you have a small condenser having a capacity of 20 mmfd. With this you can calibrate any condenser in steps of 20 mmfd. The process is as follows: You put the condenser to be calibrated in an oscillating circuit, and adjust it to maximum capacity. Make this oscillator zero-beat with another oscillator. Connect the known condenser in shunt with the condenser under measurement. Decrease the capacity of this until zero beat occurs again. You then know that you have changed the capacity by 20 mmfd. Remove the small condenser and readjust the frequency to zero beat. Put the small condenser across the other as before and vary the condenser under measurement until zero beat occurs again. Two points 20 mmfd. apart have now been found. Continue this process as far as possible. Finally the capacity of the larger condenser is known except for the minimum capacity, and this is less than 20 mmfd. Plot a curve of all the points obtained. By means of the curve and any other adjustable condenser you can find the minimum capacity in exactly the same way since you now know the capacity difference between any two settings. It is also possible to start with the minimum setting. If you have a calibrated oscillator it is also possible to find the minimum of the condenser by noting the frequency change caused by adding the condenser, set at minimum.

* * *

Using Tetrode As Triode

WHAT happens to a tetrode or a pentode when the screen is connected to the plate and the tube is used in that manner in an amplifier or oscillator? Does it still have the characteristics of a tetrode or pentode?—R. R. W.

When the screen is tied to the plate, the tube becomes a triode in all respects. It is no longer a pentode or a tetrode. If the plate and the screen are at the same potential, there is only one element in effect. This does not make a power pentode a triode just because the d-c potentials are the same on the two elements, for in this case the screen is maintained at a constant potential while the plate has a variable potential. The plate potential depends on the load impedance. But if the screen were actually connected to the plate, the power pentode would become a triode.

* * *

Hum Elimination

ABOUT how much is the suppression of the hum component in a rectifier-filter such as is used in a B supply? Is there any advantage in using two filter sections over a single section?—E. R. J.

Two filter sections reduce the hum twice as much, measured on a percentage basis. In two sections of the ordinary type, the suppression is such that the remaining hum is about one part in 10,000 of the original hum. It would be about one part in 100 with a single stage. This assumes good matching of the filters. The suppression depends much on the load that is put on the rectifier and on the inductance and capacities.

* * *

Rating of a Microphone

WHEN the sensitivity of a microphone is given in decibels what is the meaning? It has been my understanding that decibels will express the sensitivity only when two quantities are compared? If that is correct, what is the basis of comparison in regard to the microphone?—G. L.

The response of a microphone is the ratio of the voltage generated to the sound pressure on the diaphragm producing that voltage. Twenty times the common logarithm of this ratio is the number of decibels. This compares the output with a standard of one volt per bar, the bar being a unit of pressure equal to one dyne per square centimeter. A pressure of one atmosphere is very nearly equal to 1,000,000 bars.

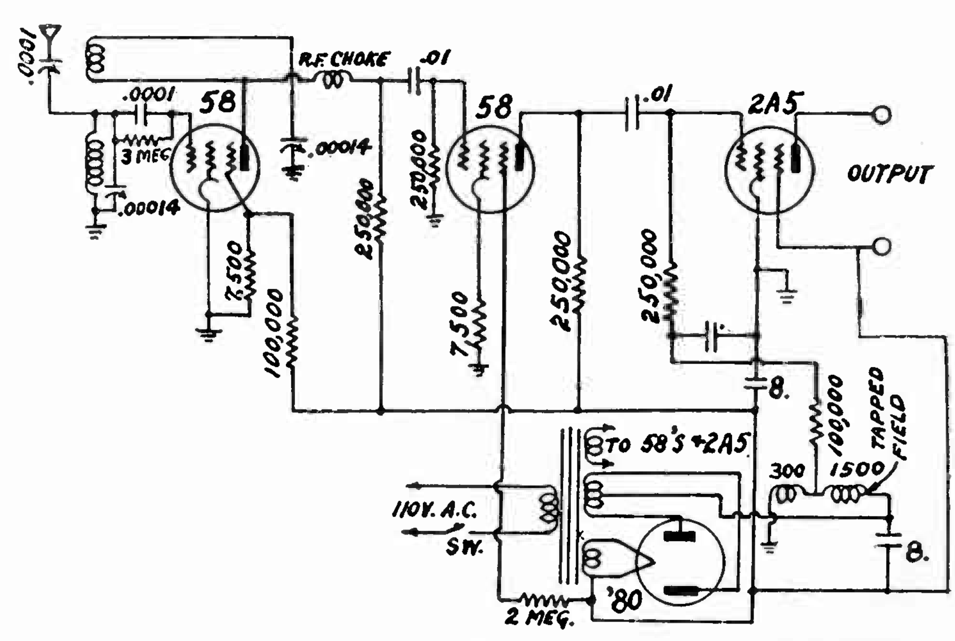
* * *

A Simple Short-Wave Set

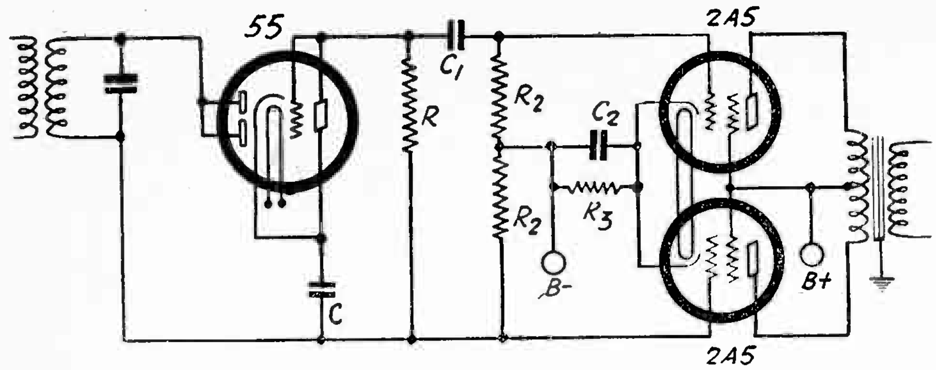
PLEASE show a simple short-wave regenerative set suitable for plug-in coils and give all the values necessary to build the circuit. It should have plenty of audio frequency amplification, built in power supply, but the tuner should be as simple as possible, consistent with good results. —E. W. H.

Below you will find the circuit you request. There is only one tuning condenser but there is an antenna trimmer condenser and a condenser for controlling the regeneration. The bias for the power tube is obtained from the drop in the speaker field coil, the usual 300-ohm tapped section being used. The unmarked condenser in the grid circuit of the power tube may have a value of 0.25 mfd., or any larger value.

(*Continued on next page*)



This diagram can be followed in building a simple, yet efficient, short-wave receiver. Ease of tuning is one of the important features.



The connections necessary for driving a push-pull amplifier by a diode rectifier, the coupling between the two being resistance and capacity.

(*Continued from preceding page*)

Sweep Oscillator Frequency

YOU have given a formula for a neon tube oscillator which seems to work out all right. Will you also give one for the gaseous discharge tube when the charging of the condenser is done through a saturated vacuum tube?—W. C. H.

If there is a charge Q, on a condenser of capacity C, the voltage across the condenser is $V = Q/C$. If the condenser is charged with a constant current I amperes, the quantity increases uniformly with time, and so does the voltage across the condenser. To charge the condenser to a voltage V requires a time t such that $V = It/C$. Therefore the time of charging is $t = VC/I$. If the tube breaks down when the voltage V is reached and it takes an inappreciable time for the discharge, the charging is repeated so that the frequency is I/VC. Thus we can compute the frequency in terms of the capacity of the condenser, the break-down voltage, and the current. Suppose that the current is adjusted so that the current is one milliampere, the break-down voltage so that it is 100 volts, and suppose that the capacity of the condenser is 0.001 mfd. The frequency of oscillation is then 10,000 per second. This assumes the time of discharge as negligible. Actually, the frequency would be a little lower, for the time of discharge is not entirely negligible.

* * *

Motional Impedance

WHAT is meant by motional impedance? I have read this term in radio literature, but I have never seen any indication as to its meaning.—H. E. H.

If you measure the impedance of a loudspeaker voice coil or of the primary of the transformer feeding it, there will be one value when the diaphragm is clamped so that it cannot move and another value when the diaphragm is free to vibrate to emit sound. The impedance obtained when the diaphragm is clamped is called the blocked impedance, and that obtained when the diaphragm is free is called the normal impedance. The difference between the blocked and normal impedances is the motional impedance. It must be the vector difference, however.

* * *

Dynatron Terminology

IF the plate in a dynatron is not the highest potential electrode and if it does not always attract elecrons, is it correct to call it the anode? It seems to me that the screen, or grid, is the anode in this case. Has any name been given to the plate when it is not the electrode of highest potential? —T. L. W.

Perhaps it is not quite correct to call the plate the anode when it is not the highest potential electrode and when it even may be the source of secondary electrons, but there is no special name for it. It can still be called the plate. Or it might be called the second anode. It might also be called the target, for electrons are literally hurled at it.

* * *

Suppression of Images

IS THERE any advantage in having a radio frequency tuner in a short wave superheterodyne for the suppression of image frequencies? In other words, is it worth while from this point of view of adding an extra tuner?—J. M. B.

Whether or not an extra tuned circuit improves the image ratio depends on the frequency, on the selectivity of the extra r-f circuit, and particularly on the intermediate frequency used. For a given intermediate frequency a given selectivity of the r-f circuit, the suppression of the image becomes less and less the higher the signal frequency. For practical values of selectivity and intermediate frequency, it does not require a very high signal frequency before the suppression of the image becomes practically nil. Hence we might say that if the only reason for adding another radio frequency tuner, it might as well be left out. There is an advantage, though, in having the extra tube for radio frequency amplification, for the sensitivity of the receiver can be increased a great deal by this tube. That the image is not suppressed a great deal by the extra tuner is obvious when it is considered that the intermediate frequency may not be greater than 465 kc, when the two frequencies, that is, the desired frequency and its image, differ by only 930 kc. If the signal frequency is 9,300 kc, the image is detuned by only one part in ten. For higher signal frequencies the detuning is still less. However, the detuning for the longer short waves is appreciable, and the extra tuner might be all right for them. Some years ago they used an intermediate frequency of 45 kc in the broadcast band. The image then differed by 90 kc from the desired frequency. At 1,500 kc this represents a detuning of 6 parts in 100. That is six times worse than the case of 465 kc at 9,300 kc. But then there was no appreciable suppression of the image frequency when the intermediate was 45 kc.

* * *

Comparison of Gains

RECENTLY I built a public address system and inserted a stage of resistance coupled amplification and in the grid circuit of the tube I inserted an attenuator consisting of a 500,000 ohm voltage divider. When the added tube was in the circuit I had to set the potentiometer so that the resistance between ground and the grid was 125,000 ohms when the output of the amplifier was the same as it was before, judging by the sound volume. The change was quickly made from one to the other. From this can you compute the gain of the added amplifier in decibels?—R. E. N.

If the total resistance of the potentiometer was 500,000 ohms and the resistance between the slider and ground was 125,000 ohms, you had to introduce an attenuation of 12 db. The voltage gain must have been four, approximately.

* * *

Push-Pull from Diode

I UNDERSTAND that it is possible to couple a push-pull amplifier to a diode detector by means of resistance and capacity. If that is right, please show a circuit and explain how it works.—R. E. L.

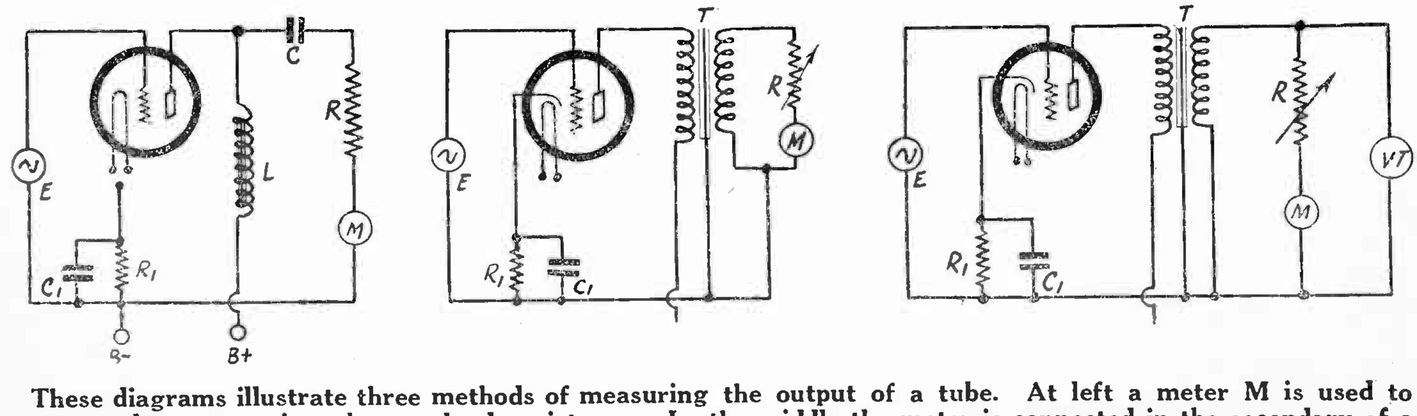
At the top of the page you will find a circuit in which a 55 diode detector feeds a stage of push-pull using two 2A5s. The signal voltage is divided equally between the two power tubes by the resistance R2R2. The arrangement works because no point on the rectifier is grounded.

* * *

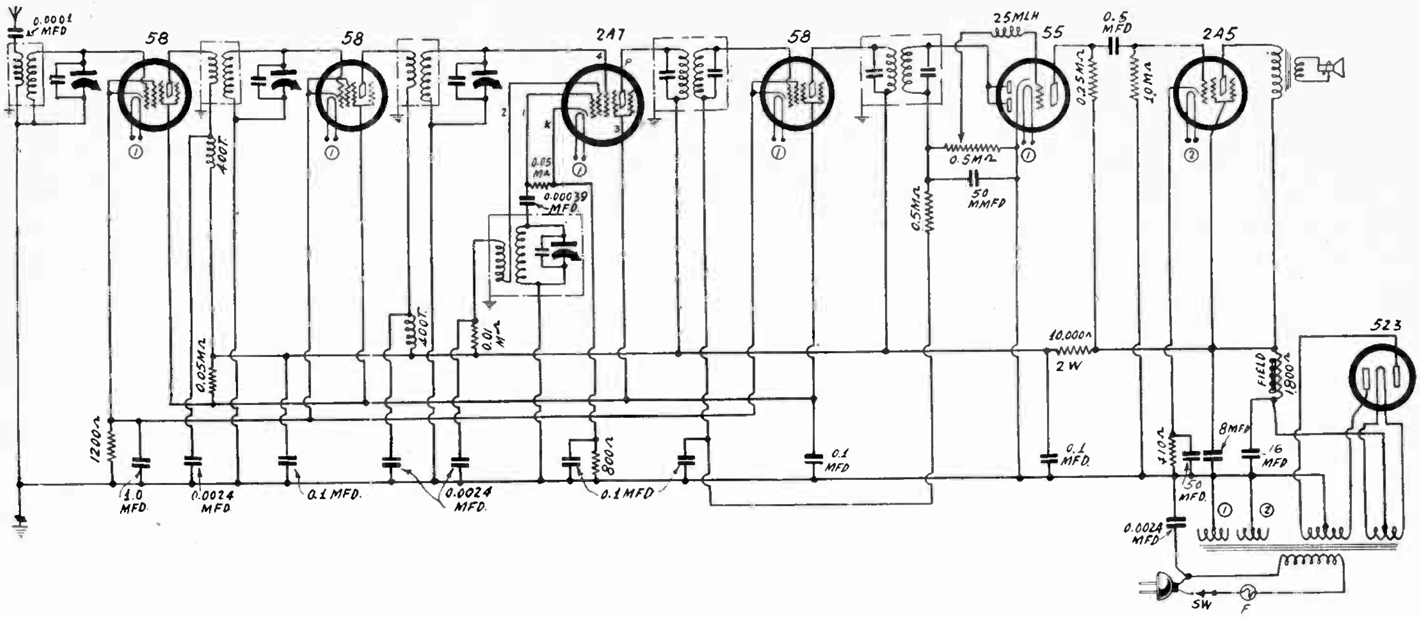
Using 48 as Triode

IS IT permissible to use the 40 power tube as a triode by connecting the screen to the plate? If so, what should the bias be on the grid?—W. B. L.

This use of the 48 tube was explained in the February 3 issue of Radio World. The bias voltage should be 32.5 volts. It is a splendid power tube whether it is used as a triode or as a tetrode, especially when the voltage available is not more than 100 volts.



These diagrams illustrate three methods of measuring the output of a tube. At left a meter M is used to measure the current in a known load resistance. In the middle the meter is connected in the secondary of a transformer, the resistance being known. At right, the current through the resistance and the voltage across it are measured.



In this seven-tube superheterodyne a four-gang condenser is used for tuning the radio frequency signal and for varying the oscillator frequency. A favorable signal to image ratio is the result.

Tuning Out Hum

WHEN the last trace of hum is to be eliminated from the output of a rectifier and filter, I know it can be done by means of a condenser across one of the filter chokes. But to what frequency should the coil be tuned with the condenser, the line frequency or the twice that frequency?—P. C.

If the rectier is of the full wave type, the coil should be tuned to twice the frequency of the line, because the principal ripple is of that frequency. If the rectifier is of the half wave type, the circuit should be tuned to the line frequency. However, if the last trace of hum is to be removed, it is better to avoid the half wave rectifier. It is not sufficient to tune the coil. It is also necessary to balance the input circuit to the rectifier and the two sides of the rectifier so that there is no 60-cycle hum component present. Moreover, the positive lead should not be taken from one side of the filament but from the center. It would be preferable to use a rectifier with an indirectly heated cathode.

* * *

Cause of Noise

WHY is a superheterodyne always noisier than a radio frequency type of receiver? This I have found always to be the case but I cannot see any reason for it.—H. B. L.

Generally the reason is that the superheterodyne is more sensitive so that it will pick up more noise. Then it may be that it is because there are more conductors and more tubes in which noise may originate. Most of the noise, however, comes from the outside and is merely brought in by the super.

* * *

A Seven-tube Superheterodyne

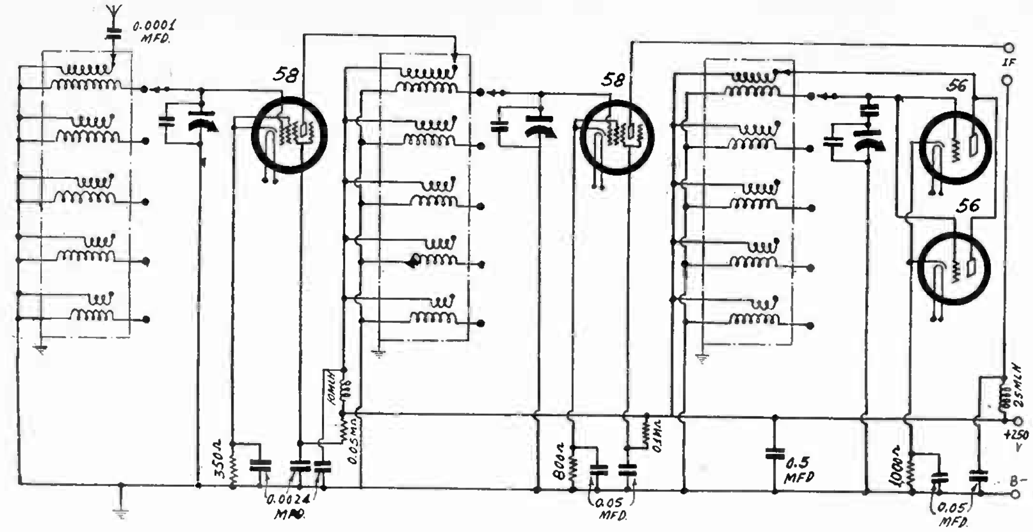
IF YOU have a circuit diagram of a seven or eight tube superheterodyne in which a four gang variable condenser is used for tuning, will you please publish it. I prefer to use many radio frequency tuners to many intermediate because I believe that this will result in better selectivity. They should preferably be one with 2.5-volt tubes, but it will be all right if it is designed for 6.3-volt tubes, for I can easily make the changes necessary.—F. E. W.

You will find just such a circuit above. It contains only seven tubes, but an extra intermediate can be added to make it eight. For mixer and oscillator the 2A7 is used, for this is the latest and most popular at this time.

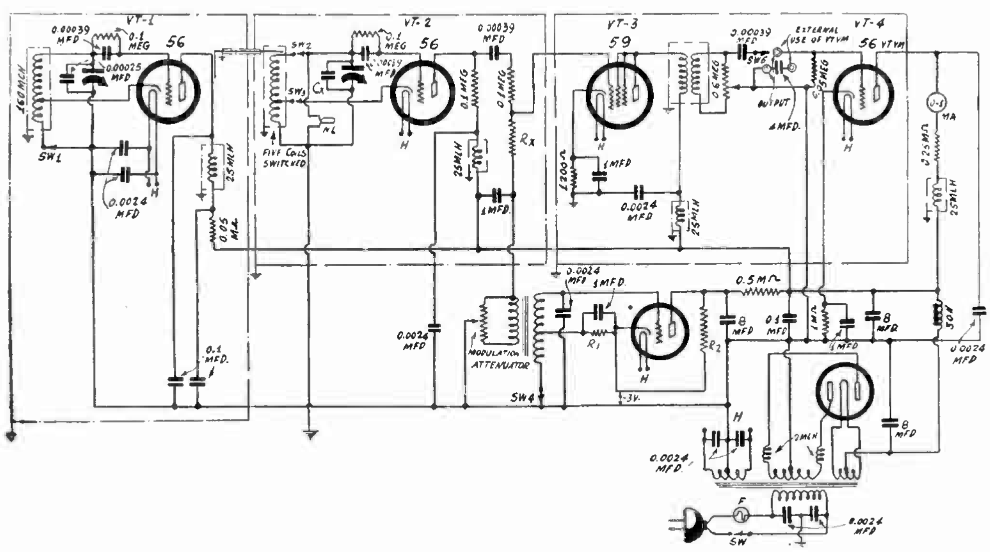
Output Proportional to Frequency

CAN YOU suggest any scheme for making the output of an amplifier proportional to frequency over a considerable range? I have a problem where this is essential.—R. T. M.

Mutual inductance will do the trick provided that you do not tune. If you have a constant current in the primary of a transformer the voltage across the secondary will be directly proportional to the frequency, for the coupling is proportional to the product of the frequency and the mutual inductance. Of course, it is necessary that the mutual inductance be independent of the frequency. The voltage across a coil having inappreciable resistance is also proportional to the frequency, provided that the current through the coil is held constant.



This diagram shows how to wire a three-deck, five-stop switch into an all-wave receiver so that any one set of coils can be thrown into the circuit.



There are three Hartley oscillators in this circuit. It can be used to produce a beat note of any audio frequency, a fixed audio frequency, and a modulated or unmodulated radio frequency.

All-Wave Set

WILL YOU kindly show me a circuit diagram of an all-wave receiver, or the tuner part of a receiver, in which the coils are selected by means of a switch? I have a switch with six positions and three decks which I plan to use in an all-wave superheterodyne. What I want to know particularly is the arrangement of the switch in relation to the coils so that only two moving contacts are required for each coil, for that is all I have on the switch.—W.N.B.

You will find such a diagram on this page. While there are only five coils it is easy to add another according to the same scheme. The idea is to ground one side of each tuned coil and pick up only the "hot" side by means of the switch. Likewise one side of the tickler or primary should be connected permanently to the B supply, picking up only the other side of the coil with the switch. In the diagram one side of the antenna coil is also connected to ground. While there are two 56 tubes in the oscillator, this is not essential, for one tube will give good results.

* * *

Beat Oscillator

I SHOULD like to build a beat-note oscillator which can be used either as such or as a modulated oscillator. That is, there should be an audio oscillator as well as two radio frequency oscillators. Will you kindly show a circuit diagram of such arrangement?—T.W.A.

In the lower figure on this page are three Hartley type oscillators, two working at high frequency and one at audio frequency. If you kill the first oscillator and keep the other two going, a modulated radio frequency wave will be generated. If you kill the audio oscillator and keep the other two going, a beat note oscillator results. To vary the beat note, a small trimmer on either of the high frequency oscillators will suffice. This trimmer should be small compared with the capacity of the condenser used for fixing the frequency.

TRADIOGRAMS

By J. Murray Barron

An announcement comes from the laboratories of Try-Mo Radio Co., Inc., 85 Cortlandt Street, New York City, of a short-wave and an all-wave superheterodyne, which comes in a six-tube kit and also as a wired model.

* * *

Radio fans who are really interested in short waves should join one of the short-wave clubs.

* * *

W. J. M. Lahl, of Chicago, manager of the RMA Traffic Bureau, died recently. The funeral was attended by many RMA members and other radio and railroad friends.

The Review

Questions and Answered Based on Articles Printed in Last Week's Issue

Questions

1. Without using an extra winding, that is, any special tickler, is it possible to introduce regeneration where there are at least two tubes in cascade, and if so, how?

2. If one push-pull tube draws more plate current than its companion push-pull tube, of what is that a sign? Can you suggest a remedy?

3. If a mercury-vapor rectifier tube is used, why is it advisable that the B choke have a low d-c resistance, and that the choke type input be used, without condenser next to the rectifier?

4. How is a fair degree of selectivity obtained from a one-tube regenerative receiver for short waves?

5. What is the accurate usual means of generating a low radio frequency so that harmonics may be used for receiver and test oscillator calibration? State briefly what is the nature of the device.

6. What type of variable condenser is most satisfactory for capacity measurements? Why?

7. What happens to the electrons that reach the fluorescent screen of a cathode-ray oscillograph tube?

8. State a method of making the 1A6 a ready oscillator.

9. If a circuit that should oscillate does not oscillate, should grid leak and condenser be included to induce oscillation, or should they be omitted? Why?

10. State a simple method of attaining amplitude stability, and reveal the simplest measurement for use as check.

11. What does amplitude stability mean? What advantage does it offer? Does it mean the same as frequency stability? Are the two related? How?

12. List ten combination tubes, that is, tubes that are the equivalent of two tubes in one envelope, include the latest one of these, and state its functions.

13. State what Victron is and give an idea of its characteristics.

14. What is the effect of shunt resistance on frequency, and why?

15. Which causes the greater change in capacity due to temperature changes, the variations introduced in the supports or in the plate areas? What shall be done about the spacers to minimize the change in capacity due to temperature?

Answers

1. Where there is cascaded radio-frequency or intermediate-frequency amplification, it is practical to introduce regeneration by connecting a very small variable condenser from the plate of one tube to the plate of the preceding tube. To establish regeneration this way the phases must be right in the coil and if they are not, they can be made so by reversing the connection to plate or grid winding of the transformer. Connection that went to grid is made instead to grid return, and connection that went to grid return is made to grid. That constitutes reversal. The two windings referred to constitute one r-f transformer.

2. Unequal plate currents in the respective push-pull tubes disclose static unbalance, or unequal plate resistances in the tube circuits. A remedy is to increase the negative bias on the tube that draws the more current. A large bypass condenser should be put across the extra resistor that develops this additional bias, but no condenser should be across the common biasing resistor, because there is no signal current through the common resistor when the circuit is symmetrical.

3. The B choke should have a low d-c resistance if a mercury-vapor rectifier tube is used, because a high resistance drops too much voltage, and as current through the rectifier changes considerably during use, due to the effect of modulation and even to differences in carrier amplitudes, the B supply voltage at the end of the choke varies considerably. The object of using the mercury-vapor rectifier is to maintain the output voltage from the filter practically constant. Omitting the condenser next to the rectifier aids this constancy.

4. A one-tube regenerative receiver may be made fairly selective for short waves by using a short aerial, or a small series condenser between the antenna proper and the input to the receiver. Both of these conditions are equivalent to loose coupling.

5. The usual means of generating a low radio frequency of a high order of accuracy, for obtaining harmonics so that calibrations may be made, is a multivibrator. This is a two-tube device, resistance-capacity coupled, in which the output of each tube is fed into the grid of the other. The frequency is determined by the resistances and the capacities, as there is no inductance.

6. A straight-line capacity condenser, because of the uniform change of capacity with dial plate displacement.

7. The same thing as happens to electrons in other thermionic vacuum tube circuits. They return to the cathode through the external circuit.

8. The 1A6 may be made a ready oscillator by using the triode grid as the control grid and the pentode screen as the plate, and having the usual tuned-grid feedback circuit. Oscillation amplitude will be somewhat higher if the pentode control grid is then tied to the triode control grid. The whole general scheme alters the nature of the tube completely and also introduces a very large minimum capacity, some 80 mmfd., due to the tube, and these facts should be taken into consideration.

9. If a circuit will not oscillate, the removal of grid leak and condenser is in the direction of improving the possibilities of oscillation, since the grid leak and condenser draw power from the tube circuit.

10. Amplitude stability in an oscillator may be attained by using a leak outside the tuned circuit, between grid and the high end of the grid coil, of such value that it acts as a damper at the higher frequencies where oscillation tends to be great, and is of small effect at the lower frequencies. A suggested value for usual oscillators is 10,000 ohms. The measurement for such stability may be most simply made by putting a current meter in series with the plate circuit (bypassing the meter with a condenser if the meter itself has appreciable d-c resistance), and selecting the unbypassed series grid resistor on the basis of practically no change in plate current over the entire tuning range of the oscillator.

11. Amplitude stability means that the oscillation voltage does not change, but remains steady over the tuning range. One value of attaining it in a test oscillator is that the sensitivity of a receiver at various frequencies may be measured with a simple output meter, since the input voltage is known in advance to be the same for all frequencies. Frequency stability is steadiness of frequency. The relationship is that without amplitude stability there can be no frequency stability.

12. Ten combination tubes are: 55, 85, 75, 2A6, 2B7, 6B7, 2A7, 6A7, 6F7 and 12A7. The latest of these is the 12A7, a combination power output tube and B rectifier, requiring 12.6 volts on the heater. The power tube is a pentode, the rectifier is a half-wave diode, and the two cathodes are entirely separate.

13. Victron is a new insulating material. One of its most interesting attributes, in the light of the present interest in short waves, is that it discloses no heating effect at high frequencies. Heat is a loss. The loss factor is the lowest so far attained in such materials. The material, which is immune from effects of moisture and oil, can be machined. It is a thermoplastic, that is, solid until heated to a high temperature, hence can be moulded.

14. The effect of a shunt resistance on a tuned circuit is to lower the frequency, as the introduction is equivalent to that of a small parallel capacity.

15. It is difficult to say which causes the greater change in the capacity, the variation in the supports or that in the dimensions of the plates. The changes due to variations in the effective area of the plates must be very small, but changes in the distance between the plates should have a large effect. Whether the distance increases or decreases as the temperature increases depends on the mountings and the spacers. To make a condenser that does not change appreciably the spacers should be made of a material that neither expands nor contracts. Invar is an alloy that remains constant and fused quartz is an insulator that is practically invariable.

Tax Returns Show Better Radio Business

Improvement of the radio industry is strikingly indicated in final 1933 reports of Internal Revenue collections of the five per cent federal excise tax. During December radio tax collections were $570,-629.50, an increase of 45½ per cent over the collections of $392,204.81 for the similar month of 1932. Excise tax collections on mechanical refrigerators last December totaled $127,186.74 against $103,344.23 in December, 1932.

For the six months ending December 31, 1933, the radio excise tax collections were $1,574,358.96, an increase of 32.9 over collections in the similar six months' period of 1932.

Total radio and phonograph excise taxes collected by the Government in 1933 were $2,596,612.29.

Recording and Reproducing Apparatus Is Announced

High-grade motors for phonograph recording, as well as quality recording apparatus, are now being manufactured by Sound Apparatus Co., 400 East Eighty-first Street, New York City.

There is free interesting literature of the latest developments in these types of high-grade equipment for sound engineers, broadcast artists and installation engineers.

FINANCIAL REPORTS

Loews, Inc., which also conducts broadcasting station WHN—Net profit for the 12 weeks ended Nov. 23, 1933, after taxes, depreciation and other deductions, $1,594,608, which, after preferred dividend requirements, equals 94 cents a share on 1,464,205 common shares, compared with $741,910, or 36 cents a common share, for the same period in the preceding year.

Station Sparks

By Alice Remsen

Radio Veterans in Harness Again

Several radio veterans are scheduled to return to the microphone this week, among them one of my old favorites, Malcolm La Prade, the Man From Cook's. Another favorite, Franklyn Bauer, and Al Jolson are also back. Donald Novis is in New York playing vaudeville and will probably be heard over the air shortly, and what pleases me most of all, George Beatty, who made such a hit with his Broken Arms Hotel on the Amco program, is due back on the air very shortly.

A BRAND-NEW ONE

There is a new program on Saturdays, 6:15 p.m. E.S.T. over WABC and the Columbia network sponsored by the Rieser Company, makers of Venida hairnets, featuring a vocalist and an orchestra under the direction of Waldo Mayo, conductor of the Capitol Theatre Orchestra, New York; program has been named "The Voice of Romance." Vocalist not picked at this writing. . . . Lief Erickson, who used to make his living as doorman for a Los Angeles movie house, has been engaged as vocalist by Ted Fiorito for his Old Gold program. That's what you might call a good break. Lief is a baritone, a tall, husky blond, resembling his exploring namesake of the eleventh century (according to all reports). He is a nephew of John P. Medbury. Fiorito met Lief at Medbury's house the night he had been fired by the theatre manager for singing on the job. . . . In the new Gertrude Stein opera "Four Saints in Three Acts," the stage directions are set to music and sung by a mixed chorus, quite in keeping with the rest of the weird proceedings. . . .

DOROTHY PARKER STANDS THE GAFF

Did you hear Dorothy Parker read her humorous "The Waltz" on a recent Alexander Woollcott program? It was a delightful reading, but Dorothy almost broke down several times, for seated in the studio were her friends, James Montgomery Flagg, who insisted upon sketching her while she worked; Oscar Levant, who stared at her no end, and Harpo Marx, who made dreadful faces—all in fun, of course, but very demoralizing to a newly fledged radio artist. . . Kate Smith is now a full-fledged member of the Winnebago tribe of the Sioux. Her Indian name is Homb-o-goo-win-ga, meaning "Glory of the Morn." She is seriously thinking of changing her theme to "When the Morn Comes Over, etc., etc.". . . Evelyn McGregor is continuing her good solo work with the Andre Kostelanetz orchestra; she is listed as a soprano, but is really a contralto. . . . Georgie Jessel will be the special master of ceremonies again on the American Revue. . . . Dramatic guest artists are to be a regular feature of the "Big Show."

THE HARP COMES BACK

The harp is coming into its own on radio; scarcely an orchestra is now without this lovely instrument. Three are used on the Brillo program with Tito Guizar, each harpist an artist—Samuel Amarosi, Imelda Georges and Harriet Joyce. . . . The Ward Baking Company will present a novel style of program on Sundays, a double-header—two distinctly different fifteen-minute periods, featuring the famous musical comedy team, Cecil Lean and Cleo Mayfield, the voice of James Melton, and the Billy Artiz Orchestra. Guest stars of the stage in scenes from famous plays will be used each week. The first act will be at 6:45, a half-hour intermission, and then the second act of this double-header at 7:30. WABC and Columbia network. . . .

JIMMY KEMPER A TRUE ARTIST

Jimmy Kemper continues to please this scribe with his dramatic song presentations on the Tydol program. Jimmy has a rich baritone voice plus plenty of stage experience, which gives him the smooth finish of a true artist. . . . "You're Devastating," from Roberta, is, I believe, one of the best tunes of the season. Not heard too often, either. . . .

COLUMBIA GIVES THEM A CHANCE

Got to give Columbia credit, they do exploit their artists; the latest booking is Gertrude Niesen, in a Warner short; Phil Regan is already in Hollywood for Warner; the Do, Re, Mi Girls, Gypsy Nina, Isham Jones, the Four Eton Boys, Little Jack Little, and Vera Van will be seen in Paramount productions. Which is all very good publicity for Columbia and its artists. Some money, too! . . . Morton Downey reversed the usual proceeding when he arrived in Sioux City and inducted a member of the Winnebago Indian tribe into the Clan O'Downey, with a clay pipe, a shillelah and a shamrock. . . . The first international broadcast from the Opera Comique in Paris was scheduled for February 10th at 3:15 p.m., E.S.T., via WABC and the Columbia network, by special arrangement with the French Government and in cooperation with their station. Massenet's "Manon" was heard, with a distinguished cast, headed by Madame Vina Bovy and Monsieur M. Vergnes. Paul Bastide conducted. . . . "The Lone Wolf"—Al Llewellyn—is back on WABC with a spot of his own Thursdays, at 12:15 p.m. Al is also featured each week on Dancing Echoes, and with two Metropolitan Parade programs. . . . Aldo Ricci, who directs the Phantom Strings over NBC networks, thought he was seeing things the other morning. Following a brief intermission between rehearsal and broadcast, Ricci took his violin out of its case and only after playing for several minutes discovered that a new mute had replaced the old one. The new mute, designed especially for him by Don Hall of the Don Hall Trio, spans five strings instead of three, and has four rubies, Ricci's birthstone, between the spaces, and in between the stones the musical signs, sharp, flat and natural are inlaid in gold. . . . Amos 'n' Andy aren't seeing much of the NBC studios these days. The boys are making a personal appearance tour of Eastern cities and broadcasting from wherever they happen to be. Week of February 16th they appear in the Hippodrome Theatre, Toronto, Canada. . . . Among President Roosevelt's favorite songs are "Anchors Aweigh," "The Halls of Montezuma" and "My Wild Irish Rose," according to a message sent by Stephen Early, the President's secretary, to Jack Denny, NBC orchestra leader. . . .

Oscillograph Tube

(*Continued from page 9*)

other point, the limiting curves will be brighter than any other portion inside the curves. For this reason it will seem as if the electron beam traced the limiting curves only, or the envelopes as they are called.

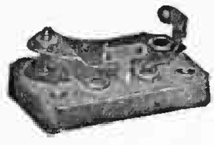
The electron beam will trace the complex curve, say from left to right, in a certain time, depending on the frequency of the timing wave. During this time there may be several cycles of the modulating wave. That is, there may be many maxima and minima. The number of these will depend on the ratio of the timing wave frequency to the modulating frequency, and not on the frequency of the wave that is being modulated. In Fig. 1 a little more than one complete modulating wave is shown. This is sufficient. But if it is desired that more should appear on the screen it is only necessary to make the frequency of the timing wave less, for then the modulating wave will go through its cycles in a relatively shorter time. Just what the ratio between the timing and modulating frequencies should be is a matter of choice. Certainly at least one full modulating wave should appear.

The percentage of modulation can be measured by means of the pattern that appears on the screen. Put a piece of paper on the screen with the edge placed so that it passes through a maximum. With a pencil mark the two extremes, thus getting a measure of $2 (A + B)$. Now place the edge of the paper of a minimum and mark the extremes, thus getting a measure of $2 (A - B)$. Now with any rule measure the distance on the paper. The percentage modulation can then be computed from $(A - B) / (A + B) = (1 - k) / (1 + k)$, in which k is the modulation factor and 100 times that is the percentage modulation.

Just as the modulated wave may be observed on the screen, so may many other phenomena be observed. Suppose, for example, that we wish to observe the characteristic curve of an amplifier, that is, the output versus the frequency. A signal of constant amplitude but of varying frequency is impressed on the input of the amplifier. The output is impressed across the vertical deflection plates of the oscilloscope. The timing wave is now to be determined by the frequency. There are several devices that can be used for producing a voltage that is directly proportional to frequency. The best source of the audio frequency is a beat note oscillator arranged so that as a condenser is turned the frequency of the beat varies over the entire audio band. When we have arranged for a continuously variable frequency and a voltage for the time deflection plates that is directly proportional to the frequency, we are ready to make the observation. If the amplifier is mainly transformer coupled, the resulting pattern will be something like that shown in Fig. 3, where gain is shown delineated vertically and frequency horizontally. Actually the curve traced might be the curve shown as well as its image in the horizontal axis. The deflecting beam will not trace the curve merely, unless it has been so arranged, but it will trace a complex curve in which the curve shown is the envelope.

The pattern appears almost instantaneously. If changes are made in the circuit, the effects of these changes will also appear instantaneously. Therefore the oscillograph can be used for observing the effect of the addition of condensers, chokes, resistors, and other devices, and the result of any change will appear immediately. In that manner as much might be accomplished in an afternoon which might take months to do by other methods.

PADDING CONDENSERS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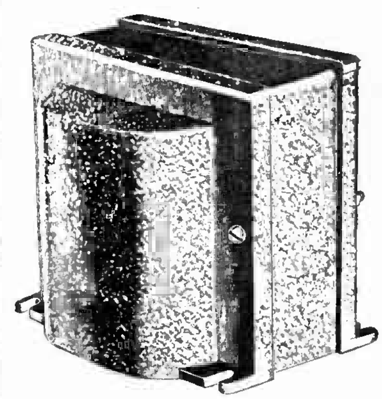

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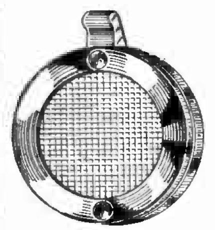

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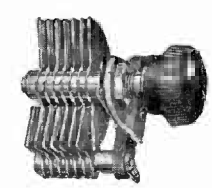

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