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# RADIO WORLD

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The First National Radio Weekly  
70th Consecutive Issue—Thirteenth Year

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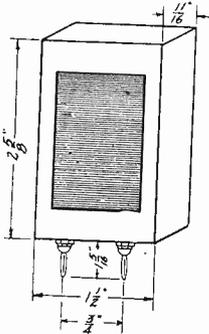
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700 ohms.... 9c	10,000 ohms.. 10c	1.0 meg..... 12c
800 ohms.... 9c	12,000 ohms.. 11c	1.5 meg..... 12c
1,000 ohms.. 10c	15,000 ohms.. 11c	2.0 meg..... 12c
1,500 ohms.. 10c	17,000 ohms.. 11c	3.0 meg..... 12c
2,000 ohms.. 10c	20,000 ohms.. 11c	4.0 meg..... 12c
2,500 ohms.. 10c	25,000 ohms.. 11c	5.0 meg..... 12c
3,000 ohms.. 10c	30,000 ohms.. 11c	6.0 meg..... 12c
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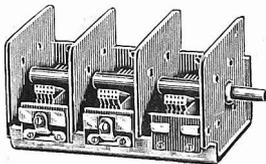
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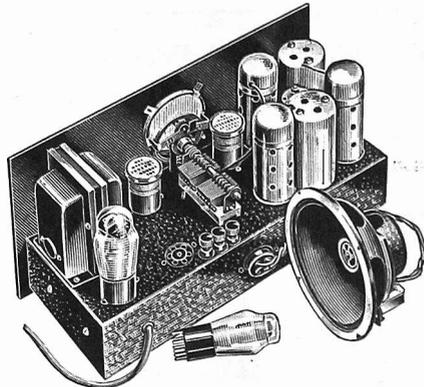
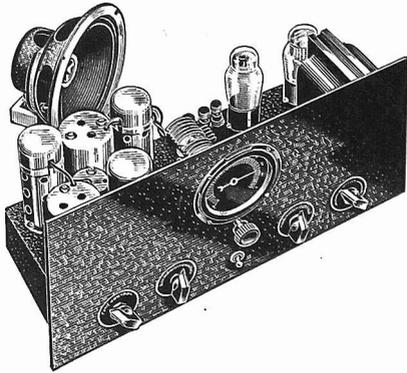
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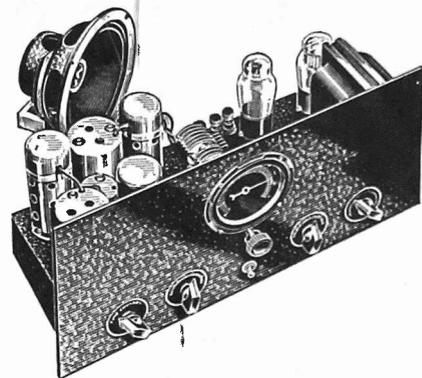
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*The First National Radio Weekly*

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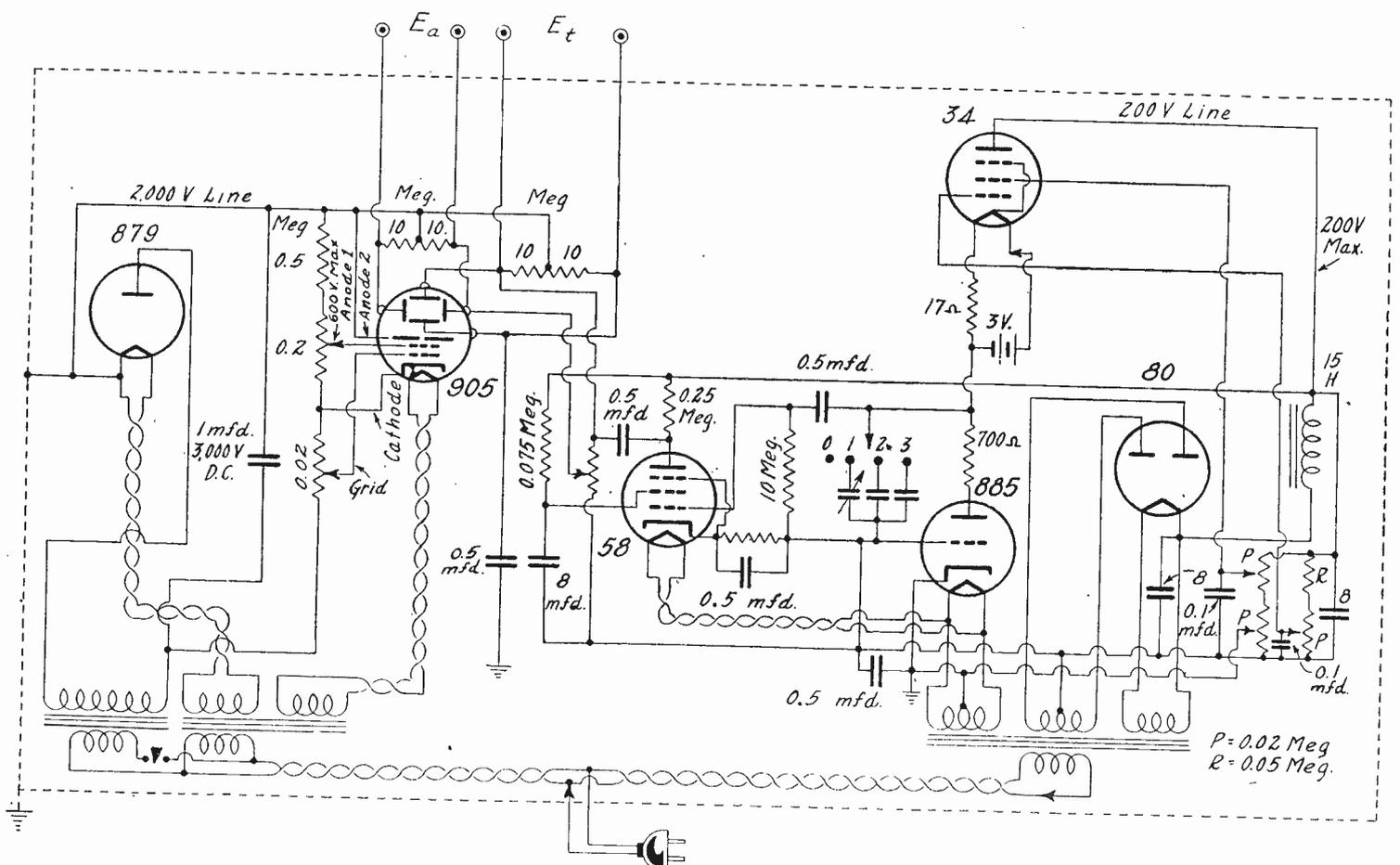
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# How an Oscilloscope Works

## Course of Ray Traced from Origin to Viewing Screen

By Herman Bernard



A cathode-ray oscilloscope with sweep oscillator. At left is the 879 high-voltage rectifier, a new tube. The cathode-ray tube is the 905. The sweep oscillator is the 885, which has a current-limiting tube (34) and an amplifier (58). The 80 is the low-voltage rectifier for the B supply of the 885, 34 and 58.  $E_a$  is the voltage to be analyzed and  $E_t$  is the timing voltage.

VERY extensive use of the cathode ray oscillograph tube is impending, especially for service work, while in the offing looms the use of the tube for television. To the more immediate purpose of testing, the present discussion applies.

It is the outstanding test instrument. Generally speaking, service men may regard the oscilloscope as something in a class with bridges and interferometers, things apart from any necessity of full understanding by them, hence they defer ac-

quaintance with the principles governing the operation.

While a diagram is shown of a device including an oscillograph tube, and to some extent standard specifications are followed, actually the author has not built the device, but is contemplating making something like it in a few months, and meanwhile offers some theory, so that a person need not be compelled to admit: "I don't know anything about oscilloscopes." In a few years all radio and allied service work will be motorized and

oscilloscope equipment for peaking and other measurements and comparisons will be in general use.

This is true because so much of the "invisible" is important, and this way is put on exhibition.

The diagram shows the second tube from left as the 905, one of the new series of oscillograph tubes. We shall examine the conditions that make the tube function as well as the purpose served.

The tube is of the heater type and cathode is connected to heater inside the

tube. Therefore if any bias to be applied to the grid of this tube, and the bias never must be positive, the bias voltage must be between heater (cathode) and B minus. In the diagram the bias will be negative to zero, never positive, and arises from positioning the arm of the 0.02-meg. potentiometer. Through this total resistance of 0.02 meg. the anode currents and the bleeder current of the voltage divider flow.

When 2.5 volts a.c. or d.c. are applied to the heater, the heater warms up, and the cathode is thereby excited by heat and emits electrons. This is the familiar vacuum tube procedure.

The triangular line inside the tube circle at bottom represents the heater, the next higher heavy line represents the cathode. Next above is a dashed line, the grid. This is a control electrode, similar in purpose to the grid in other tubes. Next higher up is another grid, but one that is given a positive potential, not exceeding 600 volts, and classed as an anode.

### Objects of Anodes

Two heavy parallel horizontal lines represent another anode. We shall refer to the lower positive-voltage anode as No. 1 and the higher-voltaged element as Anode No. 2. No. 1 is the focusing electrode, normally operated at 400 volts for this particular tube, while No. 2 is the sensitivity electrode.

No. 2 Anode is really one element, and what looks like a break in the connection is meant to represent a small hole in this element, actually a pinhole in a disc. When we consider the heater, cathode, grid and two anodes, we are considering what is called an electron gun because the cathode-ray stream, shot toward the anodes, controlled by the grid bias, passes through the pinhole in the direction of more plates and a viewing screen. These extra plates are shown as heavy parallel lines representing pairs, and are called deflecting plates because they deflect the stream after it has passed through the pinhole.

We can consider, therefore, a standard tube duplicated as to the origin of electrons, the control of their number in transit at any given period, due to grid bias or Anode No. 2 potential, the confinement of the useful part of the emission to a beam, and then some later action in the tubes caused by the presence and application of other plates with which we might not be so familiar.

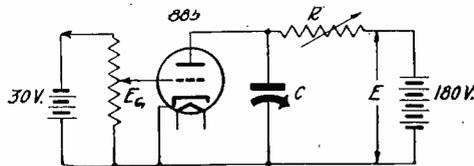
### The Deflecting Plates

Two controls are shown as potentiometers, the lower one, 0.02 meg., affecting the grid bias, the upper one varying the positive potential on Anode No. 1 from 0, when the arm is down at cathode position, to maximum, 600 volts. These controls affect the sensitivity, and naturally it is advisable to keep the brilliance within limits, and only in exceptional necessity, as for rapid photography, should one permit any great brilliance.

The pairs of extra plates are at right angles to each other. A high resistance is connected between the two plates of one set, center to highest voltage, and another high resistance between the two members of the other pair of plates, again center to high voltage. In practice these resistors are separate ones of 10 meg. each, making the total from plate to plate 20 meg. This arrangement assures absence of distortion otherwise likely because of d-c potentials built up on the deflecting plates.

Into either set of plates the voltage to be studied is introduced. Into the other set of plates a timing voltage is put. The voltage to be studied will deflect the beam at the analyzed frequency if it is a.c., as is nearly always the case. The beam strikes a fluorescent screen, being deflected at the frequency of the studied voltage. It would not be possible to see the

## FUNDAMENTAL SWEEP CIRCUIT



**Simple sweep oscillator.  $E_g$  is the grid voltage or bias,  $R$  is the load resistor,  $C$  is the charging condenser and  $E$  is the plate voltage, which should not exceed 200 volts.**

wave pattern, even if the frequency were not high.

### Observing High Frequencies

Practically always it is too high for pulse observation, say the frequency is greater than 40 cycles per second, and therefore the timing control serves to repeat the visibility of the pattern on the screen only often enough for observation, although the frequency to be studied is itself much higher. It has been found that only a saw-tooth wave form satisfies the requirement for the timing or sweep frequency in regard to an undistorted representation of the analyzed voltage. The fluorescence, or illumination due to the influence of rays, arises from the special constitution of the viewing screen.

Thus we have the analyzed voltage and the timing voltage. We would introduce the analyzed voltage at  $E_a$  in the first illustration, whereas the timing circuit could be permanently connected to the other set of plates, to prevent burnout of the screen or puncture of the glass envelope due to excessive heat generated when the ray is permitted the stand still. In fact, it is recommended that the timing voltage be introduced before the other, to assure instantly moving the analyzed beam across the field.

### Grounding

To power the 905 we have a B supply, using a special rectifier, the 879, which will stand the high voltage. (The current is small). The 5-volt or filament winding must be able to stand the 2,000 volts of d.c. between cathode and anode, and if the positive B voltage is used for grounding to shield cabinet then the filament winding for the 905 also must have as much insulation safeguard. The object of grounding the positive is to reduce danger of accidental contact of the body between zero-voltage shield cabinet and high voltage. For frequencies above 500 kc the sweep oscillator cathode should be grounded. In any case a "disconnect" switch that automatically stops this B voltage when the set is removed from cabinet, should be used.

We have now established a means of observing transient and recurrent phenomena. The number of applications is practically unlimited. We can introduce one frequency and then adjust the timing circuit to have a frequency exactly equal to the other, or related to it by any multiple or submultiple, can observe wave forms, distortion, measure percentage modulation or decibel attenuation, line up any channels and do any number of other things, obtaining all results visually, some of them in the form of special patterns which, when compared to published figures, enable us rapidly to come to simple, accurate determination of complex values.

An oscillator used for timing voltage produces the sweep frequency. As intimated, the voltage to be analyzed is swept by another or stopping voltage,

and we can now ascribe the function of rectification to the cathode-ray oscillograph tube.

### Uniform Spacing

We have said there was modulation, and of course this is a form of rectification, when we consider rectification as the attainment of some other frequency than the one originally introduced. Here we do not rectify to d-c values but to lower a-c values that permit visual observation. And it is this combination of visual observation, plus accuracy, rapidity of results and inertialess performance, that renders the system so extremely valuable.

If we want to look at a wave pattern on a fluorescent screen we would want the recurrences to be uniformly spaced, that is, if there are to be four repetitions in a row, we would want the distance between any two repetitions to be the same. Ordinarily the spaces would be unequal, and the wave shape would seem to be declining in width, so that at one end of the screen the distance between repetitions might be twice what it is at the other end. This condition is called a non-linear timing axis. A most successful method of getting rid of this difficulty is to use a vacuum tube as an inversely reactive load on the timing oscillator.

### What the 885 Is

A special tube is used as the timing oscillator or sweep oscillator, the 885. This is a heater type gaseous-discharge tube, and has a negative resistance characteristic, like other gaseous-discharge tubes, such as neon, argon and helium types. This designation is applied to a tube wherein current increases with decrease of voltage, and current decreases with increase of voltage, the condition that makes oscillation possible.

The simple circuit is that of a resistor, with condenser across it, or across the lamp, in series with a voltage source. As stated, the timing axis is not linear. The wave shape is saw-toothed, however, which aids utility, as the ascension is slower than the declination. There are quick recovery, practical elimination of the return sweep from visibility, and the scanning is without the distortion that a sine-wave timer would introduce due to small displacements of the components of the observed patterns from their true positions.

Not only must the timing voltage or sweep circuit be introduced into one pair of electrodes of the cathode-ray oscillograph tube, but a small part of the analyzed voltage should be put into the 885. As little as 1 volt may be put in.

### Use at 20 kc Up

Another fact to consider is that for frequencies above 20 kc the timing voltage amplitude may be altogether too small, hence amplification of the sweep voltage is necessary. Besides, if there were no amplifier tube, it might be necessary to include a pickup coil in the grid circuit of the 885, and provide a means of coupling between this coil and some coil associated with the analyzed voltage, for purposes of locking the two frequencies. For wide ranges of frequencies the impedance characteristics would have to be considered, hence different coils used, some perhaps with iron cores, others very small coils. Inclusion of an amplifier stage, with the use of a tube, that is practically non-discriminatory as to frequencies, seems to offer an advisable addition. It is the 58 tube in the first diagram.

For a timing circuit, therefore, we consider any relaxation oscillator. For more appropriate use we select a relaxation oscillator that has grid control. So if we

(Continued on next page)

(Continued from preceding page)

use a potentiometer of 0.02 meg. or so across a battery of 30 volts, connecting grid to arm, we can control the oscillator circuit as to stopping and starting (on and off switch effect). Also, if we use a resistor and a condenser in the load circuit we can make both variable and get a very wide range of frequencies. C would be the condenser, E the relaxation oscillation voltage, or timing voltage, or sweep voltage, in the simple diagram.

### Grid Action of 855

Briefly, the 885 is a grid-controlled gaseous-discharge tube of the heater-cathode type. When the grid voltage is negative either plate-current cutoff results, or the grid loses control entirely, that it, ceases to function as a grid, depending on the plate potential. To restore the grid control the plate oscillation voltage must be reduced to below the ionization potential of the gas in the tube. The ionization potential is that voltage value at which the gas breaks down. The control of this potential may be made by means of variation of the value of a condenser shunted across the plate circuit and charged through a current-limiting resistor. The condenser is C and the resistor is R in the simple diagram.

When the plate voltage a.c. reaches breakdown potential the condenser discharges through the tube, the plate voltage drops, the grid resumes control and a new-cycle starts.

The plate voltage considered is the oscillation voltage, which builds up beyond the d-c voltage obtained from the exciting battery, the purpose of which battery is to break down the gas, which ignition is influenced by the a.c.

Greater stability is ascribed to the 855 than to other gaseous-discharge tubes, provided the condenser C is not too small. This of course relates to frequency, and some given capacity might be large for one frequency and small for another. For instance, if the frequency is far above 20 kc the capacity of the tube might be sufficient, hence in the diagram of the total unit, where different capacities are shown for C (0, 1, 2, 3), C<sub>0</sub> would be the minimum capacity, or that of the tube alone, and the other values would be additive.

### Locking Method

Having obtained oscillations for sweep purposes, and considering that high frequencies may be put into Ea of the total circuit we have sufficient sweep output to get to high frequencies.

A little of the analyzed voltage is put into the 855 so that exact synchronization is readily obtained. The pattern will lock and hold stationary with several complete cycles of the ray visible on the viewing screen. The timing voltage's frequency is often the same as the frequency of the analyzed voltage, which permits observation of one cycle on the screen. To see two cycles the timing frequency is one-half the other, etc.

The load resistor, R, in the simple diagram, was not entirely satisfactory, we found, because the charging supply to the condenser was inconstant, whereas if a pentode is used as a current-limiting device replacing the pure resistor, exceptional sweep uniformity may be obtained for output voltages up to about 85 per cent. of the supply voltage.

Battery voltage should supply the filament of the pentode, in the present instance a 34. The screen voltage variation method is used for plate-current control, as the plate current depends almost exclusively on the screen voltage in the circuit. The resistor marked 700 ohms, leading from the 885 to the 3, 4, is maximum and keeps the discharge current to a safe value.

# How to Apply Table for All-Wave Coils

Last week's issue of RADIO WORLD told how to determine the inductance data of superheterodyne receiver coils and herein is given a table of values for the bands covered by the frequency limits of 540 kc to 30000 kc. These values have been obtained from a series of curves that are included in the pages of "The Inductance Authority," a book by Edward M. Shiepe.

The home constructor finds that the greatest difficulty he meets in the building of his home made radio equipment is the construction of coils that will act as the formula indicates. More times than less he finds it necessary to either add turns to his finished product or subtract turns, which is obviously not a handy thing to do. Accordingly, when he finds the number of turns, diameter of the coil form and size of wire given to him directly, he has been saved a great deal of trouble.

In the tabulation given below, it will be seen that two separate and distinct sets of data are presented. In the first instance, it is assumed that the coils are to be used in conjunction with a 0.00035 mfd. condenser while in the second case, the condenser that is used is of the 0.00014 mfd. size. The coil data are presented for an r-f coil and an oscillator coil in both instances, the oscillator coil being so proportioned as to produce an intermediate frequency of 465 kc from the modulator.

### Form Diameters

The home constructor is also offered the opportunity to use a coil form of either one inch or one and a quarter inches in diameter. It is important that all data be strictly followed, if the results that are desired shall be obtained. It is not at all permissible to change even a wire size since this will affect the value of the coils inductance and thus change

the ranges indicated, which will result in another mix-up that this tabulation was designed to obviate.

The use of this tabulation is understandable from a discussion of one of the possibilities. Suppose we decide to use a 0.00035 mfd. condenser in conjunction with one-inch coil forms. Reference to the table then indicated that for the frequency band, 540 to 1600 kilocycles, the necessary inductance of 230 microhenries is furnished by a coil that is made of 127 closely packed turns of No. 32 enamelled wire on a one-inch diameter coil form. The oscillator coil that is necessary to track at this band is then found to require an inductance of 110 microhenries which can be obtained from a solenoid of 68 turns of closely packed wire of No. 32 gauge enamelled on a one-inch form

### The Padding Condenser

It is also seen from the table that a series padding condenser is necessary with this oscillator coil that has a value between 350 and 450 mmfd. This condenser is necessary for tracking the oscillator with the r-f stage. Adjustment of this padder is made near the low frequency end of any band, not at the end.

Should the individual constructor prefer the 0.00014 mfd. condenser to the 0.00035 mfd. variety or should he decide that he'd rather use coils that are one and a quarter inches in diameter in preference to the one inch form, he may pursue the same tactics as outlined above in reaching his determinations for this purpose. At any rate, regardless of the choice of constants, much of the unhappiness associated with the construction of a superheterodyne receiver should be obviated by the foregoing table and we again take the opportunity to caution you that any digression from the values shown above will defeat the purpose of the table as presented.

## Short-Wave Coil-Winding Data

Frequencies	Inductance	R-F coil (with 0.00035 mfd.)		Number of turns	
		1-in. form	1¼-in. form	1-in. form	1¼-in. form
540-1600 kc.	230	127 t. #32 en.	108 t. #32 en.		
1500-4500 kc.	28	30 t. #32 en.	23 t. #32 en.		
4000-12000 kc.	4.5	16 t. #16 en.	12 t. #16 en.		
10000-30000 kc.	0.72	4½ t. #16 en.	3¾ t. #16 en.		
<b>465 kc. Osc. coil (with 0.00035 mfd.)</b>					
1005-2065 kc.	110 (C <sub>p</sub> = 350/450)	68 t. #32 en.	54 t. #32 en.		
1965-4965 kc.	20 (C <sub>p</sub> = 1100/1400)	22 t. #32 en.	18 t. #32 en.		
4465-12465 kc.	3.3 (C <sub>p</sub> = 6000)	12½ t. #16 en.	10 t. #16 en.		
10465-30465 kc.	0.53	3¾ t. #16 en.	3¼ t. #16 en.		
<b>R-F coil (with 0.00014 mfd.)</b>					
540-1400 kc.	600	250 t. #32 en.	180 t. #32 en.		
1300-3500 kc.	110	70 t. #32 en.	54 t. #32 en.		
3400-9000 kc.	16	19 t. #32 en.	16 t. #32 en.		
8000-20000 kc.	2.9	11 t. #16 en.	9 t. #16 en.		
12000-30000 kc.	1.4	7 t. #16 en.	5½ t. #16 en.		
<b>465 kc. Osc. coil (with 0.00014 mfd.)</b>					
1005-1865 kc.	230 (C <sub>p</sub> = 450/550)	118 t. #32 en.	90 t. #32 en.		
1765-3965 kc.	52 (C <sub>p</sub> = 0)	41 t. #32 en.	36 t. #32 en.		
3865-9465 kc.	8.5 (C <sub>p</sub> = 0)	20 t. #20 en.	16 t. #20 en.		
8,465-20465 kc.	2 (C <sub>p</sub> = 0)	7½ t. #20 en.	6½ t. #20 en.		
12465-30465 kc.	0.9 (C <sub>p</sub> = 0)	5½ t. #16 en.	4½ t. #16 en.		

Note: The designation C<sub>p</sub> applies to the series padding condenser for tracking the oscillator with the r-f level. Adjustment is made near the low frequency of a band, not at the end, however.

# A Classification of Aerials

## Why Some Systems are Noisy—Remedies Proposed

By Carl L. Wander

THE aerial and the receiver are equally important. Without an aerial nothing can be received. Without a receiver nothing can be received. So one must have both and they are like the heart and lungs of the body, equally essential to life. Therefore, although the receiver may be what a manufacturer or home constructor has made it, the performance will depend considerably on the aerial. At present there is an increased interest in aerials, especially since so many persons are interested in short waves and standard broadcast waves, and want antenna systems that best suit their purpose. Many are surprised at the improvement in reception resulting from an excellent antenna installation.

The antenna is the collector of energy. Some may suppose it has to be a wire, or system of wires, remote from the receiver. This is not so. Some state that their sets pick up local stations "without any aerial at all," and mention this with pride, as attesting to the remarkable sensitivity of the receiver. This is not completely so, either. Any collector constitutes the aerial, and if the set is not adequately shielded, then the coils and wiring themselves will pick up radiation, and comprise an antenna system of small dimensions. If the set is sensitive the locals will be heard indeed, but not "without any aerial," instead with the adventitious aerial self-contained in the receiver. This is not a compliment to the set as a whole, though reception of locals attests to sensitivity. It is a declaration of inadequateness of shielding.

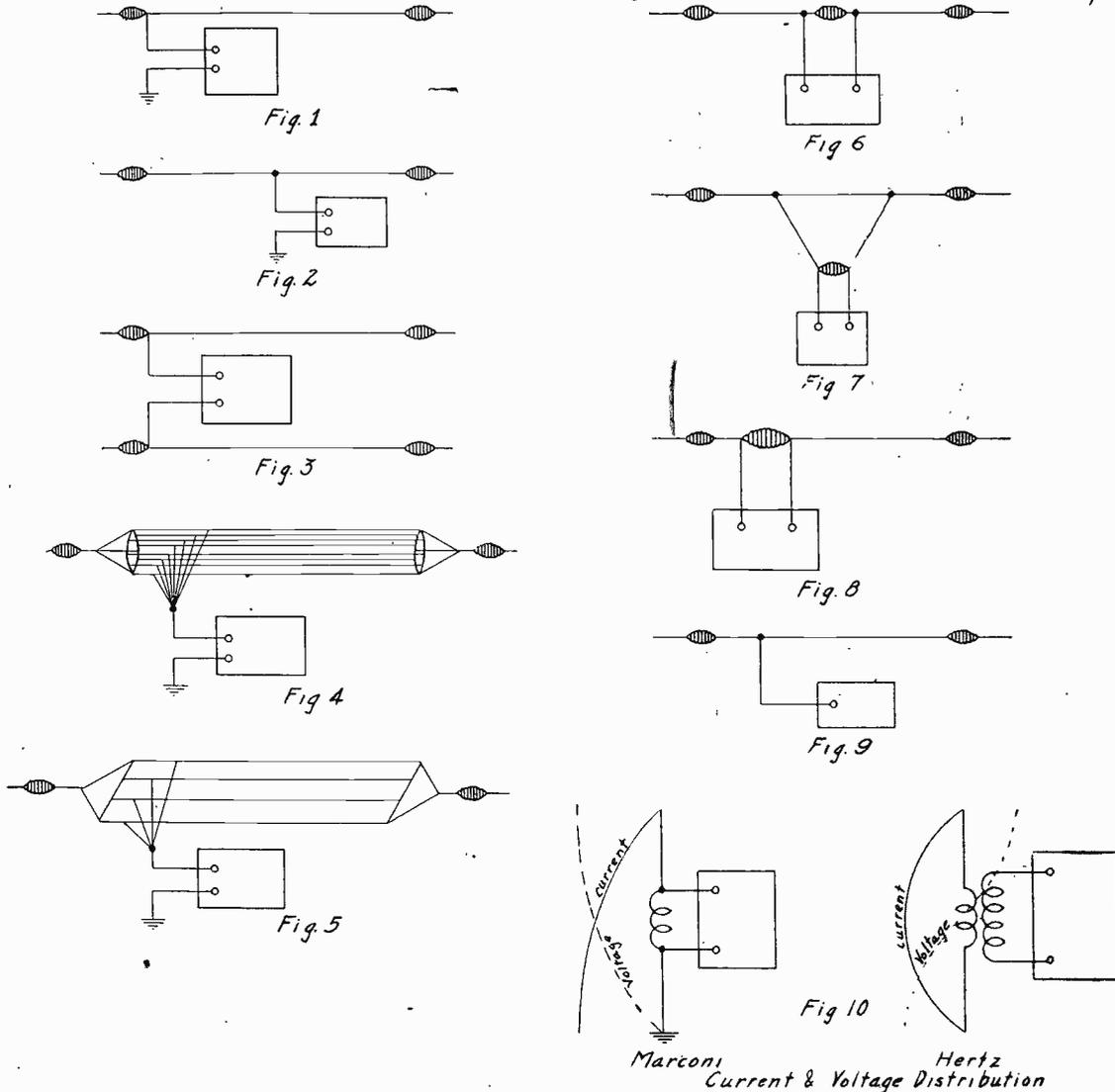
### Inverted L Most Popular

Aerials are of many varieties, the most popular being the one shown in Fig. 1. This is a Marconi antenna of the inverted L type. The designation Marconi is given to it because a grounded system is used, Marconi having been the first one to discover the earth return properties, later confirmed as to method by the measurement and analysis of ground-wave intensity and properties. The "L" designation arises from the fact that if the representation in Fig. 1 is turned around 45 degrees the antenna length will be the upright stroke of a printed L, and the leadin wire will be the base stroke. The turning around gives rise to the "inverted" part of the designation.

Besides the L there is the T type, also Marconi variety, as shown in Fig. 2. This method isn't used so much, and is resorted to mainly because the handiest for some installations or locations, and is not as good a collector. Since voltage is desired, and is halved by the T method, the results cannot be expected to equal those of the other type, for equal effective height and total wire length.

This consideration is modified in practice by the use of a long leadin. Under any circumstances the leadin itself is a ratable aerial, and indeed it may be a better collector of energy than the horizontal portion of the aerial. Better in this sense means it picks up more energy, but does not mean that better results obtain, for a noisy locality practically precludes the use of such a leadin, long or short, since the principal sources of local noise, finally appearing as radio-frequency radiation, are most intense near the ground, hence the quieter pickup is from the horizontal portion, and the best practice would be to move the set up to the aerial.

Physically this cannot be done in comfort. A cold night on the roof offers no



Nine different antenna systems, with a diagram of current and voltage distributions applicable to the Marconi and Hertz antennas. All ungrounded antenna systems may be classified as Hertz types, including the doublet.

attractions, though the stations come in splendidly. A warm room and some noise would be preferable. However, the electrical counterpart of moving the aerial to the roof may be achieved in a reasonable measure.

Fig. 3 shows a special type of aerial, known as the cage antenna, which is also of the Marconi type, because grounded, this being an inverted L cage, although of course a T type cage could be used also. Numerous parallel wires are spaced as if for building a squirrel cage, and each is connected to a common leadin wire. The cage aerial has not won the admiration of experts, although kind words have been said about it by manufacturers of such devices.

A flat-top aerial is shown in Fig. 4, this consisting of several wires, all on the same horizontal plane, however, hence producing the distinction between this and the cage antenna. Again taps are taken to a common leadin and grounding is present. About the same may be said for the flat top as for the cage.

The first example of the Hertz or ungrounded antenna is Fig. 6, representing the doublet. Instead of the antenna wire being a single stretch it is interrupted as such at

center by an insulator, and the leadin consists of two wires, emerging from the mid-section insulator terminals. Although the down wires are shown as straight it is common practice to transpose them, using either twisted pair cord, or insulated pieces called transposition blocks, spaced every few feet or so, the down wires being transposed at each block to neutralize the pickup. Manufacturers of such blocks recommend that the space between blocks be a matter of inches. If that advice is followed, no doubt more blocks are sold, and perhaps somewhat better neutralization prevails. Neutralization of pickup by the leadin is the same electrically as moving the set to the roof.

It can be seen that the input posts of the receiver must be open at both ends, that is, neither terminal must be grounded, for the potential is high on both wires.

### Matched Impedance Tapping

Fig. 7 represents the same type of antenna, a doublet, but introduces a system of apportionment which, when accurately fol-

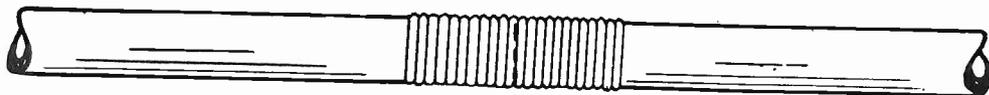
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# Wiring is the Key Task

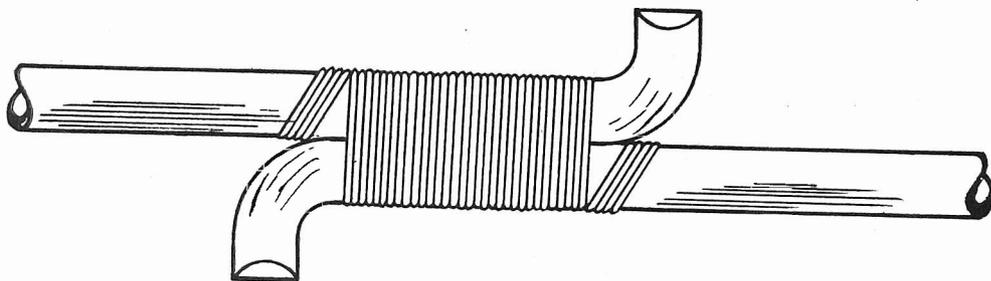
## How to Make Joints and Solder Them—

### Discussion of Wire Factors

By M. K. Kunins



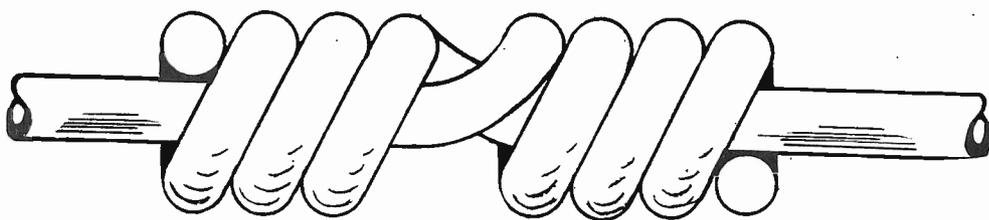
Butt Joint



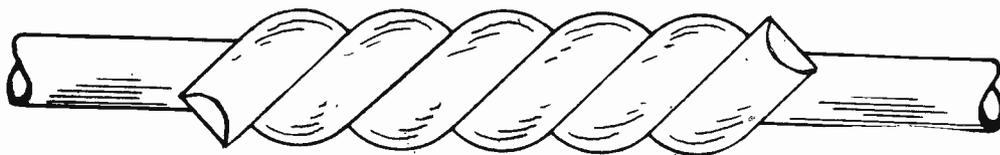
Brittannia Joint



Scarf Joint



Bellhangers' Joint



Telegraph Joint

THE development of radio has taken such a pace that new devices appear on the market almost daily. This requires considerable alertness on the part of the radio fan insofar as progress with the art

is concerned. And the fan maintains his vigil earnestly. He studies the various published results, listens to talks on the latest discoveries and delves into the art on his own experimental hook. All this

research tends to make him well acquainted with the most intricate aspects of a difficult science.

Though he has thus advanced himself, one of the simple branches of radio is usually neglected by the fan. That branch concerns itself with the very important item of wiring. Though we are likely to look upon radio as a means of communication that does not use wires, we should not lose sight of the fact that the various instruments in a piece of radio apparatus require wiring together in order that the ensemble may work as it should. Just as in other systems where we need wire to distribute electricity to give heat, light or power in a building, we must provide a system of conductors in a radio set in order to carry the various currents that are required.

#### Metals Used

In this network of wires necessary in a radio set, it has become customary to utilize copper. This metal is used in preference to others because of its high electrical conductivity, it is surpassed only by silver, the cost of which precludes its use for wiring purposes. Hard-drawn copper wires are ductile and have a high tensile strength. These properties allow copper wires to be bent sharply and drawn through tubes without serious injury. It is thus possible to furnish copper wires in a great variety of sizes, the choice of which is determined by cost, current and resistance.

Sometimes, in special cases, when wires of high resistance are desirable, wires made of other metals are used because of their lower conductivity. In this connection, were copper wires used for resistance purposes, excessive lengths of copper wire would be required. Hence wires of high resistance material are employed, which materially decreases the wire length for a given resistance. For this purpose, the wires are usually made of iron, nickel, chromium or manganese in various combinations with copper to form various alloys that possess different resistance properties. Illustrative of these resistance wires are:

Alloy	Components
Nichrome.....	nickel, chromium
No. 95 Alloy.....	copper, nickel
Advance.....	copper, nickel
Manganin.....	copper, manganese, nickel
Comet.....	nickel, copper, chromium
Tophet.....	nickel, chromium
Cupron.....	copper, nickel
Constantin.....	copper, nickel

#### Wire Gauge Sizes

Wires are generally made of circular cross section. The process of manufacturing consists of drawing the metal through steel dies, when it has the requisite ductility. The size of the wire that results from this process is given in terms of a number that is defined by the particular gauge system that is used. Among the various gauges are the Browne and Sharpe, Birmingham, U. S. standard, British standard, Washburn & Moen, etc. In the United States, the one that has been accepted as standard is the Browne and

**BROWNE & SHARPE WIRE TABLE**

Gauge No.	Diameter		Cross Section Area			Resistance (ohms/1000 ft.)		Current Capacity of Copper Wire
	Mils	Mm.	Cir. Mils	Sq. In.	Sq. Mm.	Copper	Advance	
0000....	460.0	11.68	211600	.1662	107.2	.0499	....	211.6
000....	409.6	10.40	167800	.1318	85.03	.0629	....	167.8
00....	364.8	9.266	133100	.1045	67.43	.0793	....	133.1
0....	325.9	8.252	105500	.08289	53.48	.1000	....	105.5
1....	289.3	7.348	83690	.06573	42.41	.1260	....	83.7
2....	257.6	6.544	66370	.05213	33.63	.1592	....	66.4
3....	229.4	5.827	52640	.04134	26.67	.2004	....	52.6
4....	204.3	5.189	41740	.03278	21.15	.2536	....	41.7
5....	181.9	4.621	33100	.02600	16.77	.3192	8.88	33.1
6....	162.0	4.115	26250	.02062	13.3	.4028	11.21	26.3
7....	144.3	3.665	20820	.01635	10.55	.5080	14.19	20.8
8....	128.5	3.264	16510	.01297	8.36	.6405	17.9	16.5
9....	114.4	2.906	13090	.01028	6.63	.8077	22.6	13.1
10....	101.9	2.588	10380	.008155	5.26	1.018	28.0	10.4
11....	90.74	2.305	8234	.006467	4.17	1.284	35.4	8.2
12....	80.81	2.053	6530	.005129	3.31	1.619	44.8	6.5
13....	71.96	1.828	5178	.004067	2.62	2.042	56.7	5.2
14....	64.08	1.628	4107	.003225	2.08	2.575	71.7	4.1
15....	57.07	1.450	3257	.002558	1.65	3.247	90.4	3.3
16....	50.82	1.291	2583	.002028	1.31	4.094	113.0	2.6
17....	45.26	1.150	2048	.001609	1.04	5.163	145.0	2.0
18....	40.30	1.024	1624	.001276	.82	6.510	184.0	1.6
19....	35.89	0.9116	1288	.001012	.65	8.210	226.0	1.3
20....	31.96	0.8118	1022	.0008023	.52	10.35	287.0	1.0
21....	28.46	0.7230	810.0	.0006363	.41	13.05	362.0	.81
22....	25.35	0.6438	642.4	.0005246	.33	16.46	460.0	.64
23....	22.57	0.5733	509.5	.0004002	.26	20.76	575.0	.51
24....	20.10	0.5106	404.0	.0003173	.20	26.17	725.0	.41
25....	17.90	0.4547	320.4	.0002517	.16	33.00	919.0	.32
26....	15.94	0.4049	254.1	.0001996	.13	41.62	1162	.25
27....	14.20	0.3606	201.5	.0001583	.10	52.48	1455	.20
28....	12.64	0.3211	159.8	.0001255	.08	66.17	1850	.16
29....	11.26	0.2859	126.7	.00009953	.064	83.44	2300	.13
30....	10.03	0.2546	100.5	.00007894	.051	105.20	2940	.10
31....	8.928	0.2268	79.70	.00006260	.040	132.70	3680	.079
32....	7.950	0.2019	63.21	.00004964	.032	167.30	4600	.063
33....	7.080	0.1798	50.13	.00003937	.0254	211.00	5830	.050
34....	6.305	0.1601	39.75	.00003122	.0201	266.00	7400	.039
35....	5.615	0.1426	31.52	.00002476	.0159	335.00	9360	.032
36....	5.000	0.1270	25.00	.00001964	.0127	423.00	11760	.025
37....	4.453	0.1131	19.83	.00001557	.0100	533.40	14550	.020
38....	3.965	0.1007	15.72	.00001235	.0079	672.60	18395	.016
39....	3.531	0.0897	12.47	.000009793	.0063	848.10	24100	.012
40....	3.145	0.0799	9.888	.000007766	.0050	1069.00	32660	.009
41....	2.800	0.0711	7.841	.000006160	.0040	1323.00	....	.008
42....	2.494	0.0633	6.220	.000004885	.0032	1667.00	....	.006
43....	2.221	0.0564	4.933	.000003873	.0025	2105.00	....	.005
44....	1.978	0.0502	3.910	.000003073	.0020	2655.00	....	.004

the wiring. In spite of all precautions, however, an occasional poor joint is inevitable and when wiring, the greatest care must be taken to make the joint as nearly equal as possible to the original wire in all its qualities. The operation of making a joint between two wires is of greatest importance since it is the weakest point in the entire chain of wiring. The following qualities may be represented as evaluating the efficiency of a joint:

- (1) High conductivity.
- (2) High mechanical strength.
- (3) Durability.

It is important to note that all these considerations are materially improved by soldering all joints. In this connection, it should not be out of place to consider the two kinds of solder that are in common use: fine solder and plumbers' solder.

Fine solder is always used in soldering joints in copper conductors and for soldering lead sleeves on lead-covered wires. This solder is an alloy consisting of equal parts of pure tin and pure lead. A good solder that is rich in tin emits a crackling sound while it is being bent, which can be heard if the stick is held near the ear. This is a fairly good test of the quality of solder. Plumbers' solder, occasionally used in electrical work where wiped joints are required, is an alloy of one part of pure tin to two parts of pure lead.

**Function of Flux**

In the process of soldering, another element beside the soldering stick and iron is necessary, that is the flux. It is the function of this agent to allow the solder to flow more readily into the joint. This is accomplished by the flux's action of cleaning the joint's surfaces and reducing any oxide on the surface to a metallic state. If a copper wire is carefully cleaned by means of emery cloth and heated over a gas flame, the surface will be seen to tarnish rapidly and assume a dark brown appearance. A small piece of resin dropped on this wire will melt and it will be noticed that the wire will regain its original lustre. A stick of fine solder lightly pressed against the wire surface that has been cleansed as above and strongly heated will melt, and the molten solder will spread over the surface and cover it with a thin permanent film. The surface is then said to be tinned.

Several patent fluxes on the market do a better job of this purifying process than the pure resin alone. In this connection, it should be well to look out for corrosive fluxes, which, if left on the joint, will eventually eat away the metal resulting in a poor mechanical job. Because of this, pure amber resin is undoubtedly the safest flux to use.

There are several types of joints that may be used in the wiring operations that a radio man will run across. Each has its own merits and its own peculiarities. Prominent among these joints are:

- (1) Butt joint.
- (2) Britannia joint.
- (3) Scarf joint.
- (4) Bellhangers' joint.
- (5) Telegraph joint.

**How to Make Joints**

The diagram illustrates these. The butt and scarf joints have the advantage of simplicity and the disadvantage of poor mechanical strength, whereas the Britannia, the Bellhangers' and Telegraph joints are quite strong, but require additional care. The following is a classification of the directions for making these joints:

**Butt and Scarf Joints:**

Though these joints may be unable to withstand tensile strains, they are of value where appearance is the main consideration, or where there is lack of space.

(Continued on next page)

Sharpe gauge. An indication of its definitions are given in the table above.

The resistance and the current carrying capacity of a copper or other type of wire is dependent upon the cross sectional area of the wire, among other things. When the conductor is thus of circular cross section, its area is obtainable from the formula that the area of a circle is equal to the product of 3.1416 and the radius squared, viz., area =  $\pi r^2$ . However, since the wire tables give the diameter of wires rather than the radius and also since the diameter is more readily measurable, it is desirable to transform this formula into terms of the diameter:

$$r = \frac{d}{2} \therefore \text{Area} = \pi \frac{d^2}{4} = 0.7854 d^2$$

Thus, we are enabled to calculate the cross sectional area of a wire when its diameter is known. From this information we are then in a position to ascertain the amount of current that a wire will safely carry, based on the assumption that satisfactory conditions consist of one ampere per 1,000 circular mils.

**What a Mil Is**

In this connection it is apropos to indicate that a mil is one thousandth of an inch and a circular mil is the square of the diameter in mils. In other words, if the diameter is 10 mils, the area will be 100 circular mils. And since this area is one-tenth of 1,000 circular mils, this wire can carry one-tenth of an ampere capably.

The resistance of a wire is directly proportional to its length and inversely proportional to its cross sectional area. For given equal lengths of different wires,

then, the resistance will vary inversely as the area. Another factor has to be introduced to take account of the different capabilities of different metals to conduct electric current, known as the "resistivity." This constant is shown for various metals in the following table in terms of ohms per circular mil foot:

Metal	Resistivity
Silver .....	9.75
Copper .....	10.55
Aluminum .....	17.30
Zinc .....	38.00
Nickel .....	58.0
Iron .....	61.1
Platinum .....	72.0
Lead .....	114.7
Monel .....	256.
Manganin .....	290.
Cupron .....	294.
Cromin .....	570.
Tophet .....	650.
Nichrome .....	650.

Thus, in order to determine the resistance of a piece of wire, we multiply its length in feet, by its resistivity and divide this product by the cross sectional area in circular mils.

This will furnish us with the derived data appearing in the last three columns of the wire table.

Now that we understand the two major attributes of electric wiring (resistance and current-carrying capacity), we can proceed to a practical problem that is present when wiring of electrical parts is required. This is the problem of joining wires.

When possible, joints should be avoided since however well a joint is made, it must be regarded as a possible weak point in

(Continued from preceding page)

- (1) Clean one-half inch from both ends with emery cloth.
- (2) Square or bevel the ends with a fine file, according to type of joint, so that when fitted together the ends appear as one continuous wire.
- (3) Tin these ends thoroughly and wipe superfluous solder off with a clean rag.
- (4) Bind joint tightly with No. 24 bare copper wire beyond the ends of the scarf.
- (5) Solder joint solidly, leaving it bright and free from roughness.

#### Britannia Joint:

This joint is useful for application where great tensile strength is required.

- (1) Clean the ends of the wires with emery cloth for a distance of about  $1\frac{1}{2}$  inches.
- (2) Bend  $\frac{3}{8}$  inch of the ends at right angles to the wire itself by holding the wire in a pair of pliers and hammering the ends down against the jaws.
- (3) Tin the ends, including the bent portion, and remove superfluous solder with clean rag.
- (4) Fit the ends together as shown in the sketch so that the wires are in snug contact.
- (5) Bind the wires together tightly by means of No. 24 bare copper wire.
- (6) Solder up solid, leaving the joint bright and free of roughness.

These three joints are specially applicable to large wires on the order of those larger than about No. 8 or so, since such wires are not readily bent back and forth as is required in the following joints. However, in cases of smaller wire on the order of No. 12 or smaller, this difficulty is not present and the Bellhangers' or Telegraph joints are recommended because of their greater intimacy of contact between the wires.

#### Bellhangers' Joint:

This joint is a very strong one in tension, however, it has the disadvantage of trebling the wire diameter at the joint. The procedure in its construction is as follows:

- (1) Clean the wire ends for a distance of about three inches with emery cloth.
- (2) Tin these ends with a thin layer of solder, wiping away excess solder.
- (3) Cross the wires, two inches from the end, keeping the wire coming from the left in front.
- (4) Grip the crossed wires together just on the left of the crossing point with a pair of pliers.
- (5) With the thumb and forefinger of the right hand, give the main wire a bend, in this way bringing the two wires practically in line with each other.
- (6) Twist the end of the left wire round the right wire for six or eight turns and repeat this on the other side of the joint.
- (7) Clip the excessive lengths with a pair of pliers.
- (8) Solder the joint solid.

#### Telegraph Joint:

This joint is not quite as strong as the Bellhangers' joint in tension, however, it has the advantage of only doubling the wire diameter at the joint. The following steps are indicative of the process involved in building up this joint.

- (1) Clean the wire ends for a distance of about three inches with fine emery cloth.
- (2) Cross the wire ends at about one and one-half inches from the ends, keeping the left wire in front.
- (3) Grip the wires together just to the left of the junction with a pair of pliers.
- (4) With thumb and forefinger of the right hand twist the main wires and the projecting ends equally around a

# How Voltage and Current Are Distributed in Two Main Antenna Systems

(Continued from page 7)

lowed, results in the matching of impedances, and best transfer to the set, although this is a single-frequency system, and therefore applicable not to reception but to transmission.

The favorite antenna system of the transmitting amateurs is the Zepp of Fig. 8, also a Hertz type, and rather peculiar in that the full length of the antenna proper is utilized, as represented by the line between the right-hand insulator and the large common insulator, while the small left-hand wire between insulators amounts to practically nothing, but has a lead-in just like the long wire.

In practice the two wires are tuned, either to the same frequency or, as some have found to better result, one just a bit different in frequency than the other. The left-hand down-lead then acts as a neutralizing agency and a transmission line is produced,

although again the efficiency is high only for single-frequency service.

Each of the two types, Marconi and Hertz antennas, has its own characteristic. In the Marconi type the voltage is zero at ground, hence current is maximum there. This is shown in Fig. 10, if the straight perpendicular line is considered as running through the coil and taken as the zero axis, by turning the diagram around 45 degrees. Current is least, voltage maximum at the antenna post of the set. Therefore this is a voltage-fed system.

The Hertz type, with absence of ground, input fed to terminals of primary of antenna coupler, has voltage maxima at terminals, though voltages are out of phase by 180 degrees, and has current minima naturally where voltage maxima exist. The current curve is an arc of a circle, approximately, but the voltage curve is roughly a squat S. Fig. 9 represents a voltage-fed type of Hertz antenna.

## STUDIO NOTES

NBC's Pickens Sisters, Jane, Helen and Patti, are currently appearing in the smash hit, "Thumbs Up" . . . and Beatrice Lillie is making personal appearances in the Rainbow Room on the Rockefeller Center Roof. . . . James Melton is studying languages, German, Italian and French. . . . Dorothy Page won the school cup for running during a track meet at Penn Hall School for Girls at Chambersburg, Pa. She and Lanny Ross should have a lot in common; Lanny was a track star, too. . . . Freddie Rich is one of thirteen children; his six brothers are all musicians, but his six sisters are not musical in the least. . . . Jerry Cooper started as a trombone player, then a guitarist, a night club baritone and now a radio tenor. . . . Both Vera Van and Donald Novis are natives of California. . . . Kate McComb, who plays "Ma O'Neill," is also a native of the motion picture state. . . . Lucille Glenn was formerly a telephone operator. . . . Mme. Schumann-Heink received six dollars for her first concert appearance sixty years ago. She sang the alto part in Beethoven's Ninth Symphony. . . .

common axis, on both sides of the joint.

- (5) Clip the excessive lengths with a pair of pliers.
- (6) Solder the joint solid.

If the radio constructor will keep these factors in mind in his efforts at wiring a piece of radio apparatus, he will produce a result that will speak well of his labor and provide him with a unit that will be free of the troubles that are induced through aged, poorly made joints.

The best example of the utility of the foregoing statements is in the antenna system. Usually, splices are necessary in the antenna wire itself or in the feeder wires. If the care and process indicated herein is followed in this work, the antenna should most certainly provide the service that is expected of it. In the event that this is not so, the blame can be probably laid at the doorstep of incorrect design rather than installation.

Summarizing the statements in this article, we might state that the weakest point in the radio chain is the individual

link represented by the connection joints. If sufficient care is taken at these points, a workmanlike job should result that will not cause trouble.

## Survey of Engineering Employment Under Way

The United States Department of Labor is cooperating with the American Engineering Council by preparing a confidential questionnaire to be sent to all the engineers in the United States. This will constitute a survey that will give such data as salary trends, types of employers, duties over the past several years, educational background, and other facts that will give a good picture of the engineer's status. It is believed that this is the first comprehensive nation-wide study ever made of a professional group and it is expected that the results will be of immediate practical application to the problem of engineering employment.

## A THOUGHT FOR THE WEEK

JOHN HOWARD TASKER, CLAUDE F. MacARTHUR AND OUR OWN ALICE REMSEN have been adventuring in the field of television—though, let us hasten to remark, not from a scientific or technical standpoint. They have devoted a lot of time to the task of bringing the progress of communication up to the minute via lyrics, music and vocal and instrumental calisthenics—or should we say gymnastics? The result is a number entitled, "Nothing is Safe Any More." This number was heard last week on the "America in Music" program over the NBC-WJZ network.

There's one thing you must admit is true about radio—it calls for a lot of thinking and experimenting, because after all you can't dash off a comprehensive, worth-while musical number about television—just like that! If you don't agree with us try it out yourself—and be sure to have some nerve remedy at hand.

## LITZ FOR WIRING

The use of Litz wire for connecting radio equipment together is foolhardy because its numerous insulated strands cause difficulty of connection.

# Series-Parallel Heaters

## Application of Ohm's Law Gives Resistance and Wattage of Limiting Devices

By Harold C. Burden

WHEN a radio enthusiast has delved into the science for some time he acquires a *savior faire* that permeates his attitude such that elementary or fundamental axioms seemingly become trite and non-essential. His early contact with Ohm's law has caused this law to suffer from the ravages induced by the necessity of keeping up with the art. However, this does not minimize the importance of such a fundamental consideration as Ohm's law. One of its special applications in the matter of series-parallel connection of the filaments or heaters of a number of modern multi-electrode tubes confirms its usefulness.

The radio receivers of today utilize combinations of several tubes, the heater voltage and current ratings of which differ considerably. To connect these tubes together across the 110-volt power line in a manner that is most efficient, it is necessary to apply the principles dictated by Ohm's law. Reference to a chart showing the characteristics of the various tubes on the market reveals that some of the tubes require heater voltages of 2.0 volts, others 2.5, 3.3, 5.0, 6.3, 7.5, etc. Not only do the voltages differ in the various tubes, but also the current differs. This factor may be the very small amount of .06 ampere or the fairly large value of 2.5 amperes. Connection of tubes that have different filament ratings thus requires special consideration.

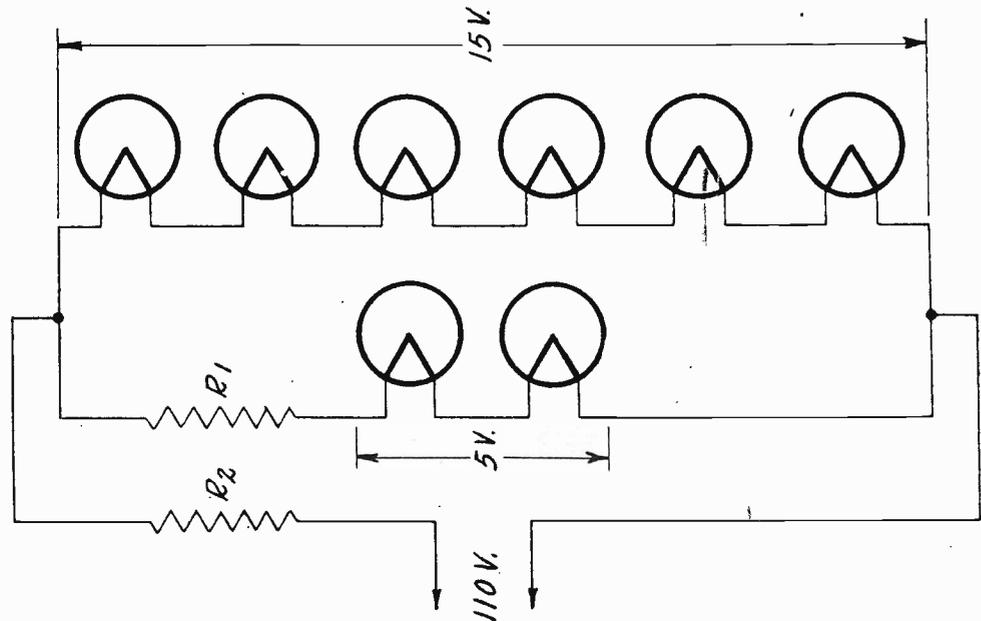
### Ohm's Law

The sole tool necessary in this process is Ohm's law. This law is probably the number one rule of electricity and accordingly of radio and was first enunciated by a German physicist, George Ohm, in 1826. At that time Ohm discovered that the greater the difference of potential across the ends of a wire, the greater will be the current that flows. This was a very remarkable discovery in itself, since nobody until that time had given any such a definite statement regarding the quantitative side of electricity. However, still more remarkable was the discovery that something within the wire itself tended to hinder the current from flowing. This thing, whatever it was, which tended to oppose or resist a current from flowing, was called *resistance*. In mechanics, it is a well-known fact that friction exists between two bodies that move with respect to each other, as a result of which heat is induced. Reasoning by analogy, early experimenters regarded electrical resistance to be similar to friction of mechanics.

By numerous experiments and extended reasoning it has been shown that in reality resistance is quite different from the friction of mechanics. The present theories of conduction in electricity indicate that resistance is determined by the spaces between the electrons within the conductor.

It has been theorized that an electric current consists of the flow or transfer of charge of electrons within a conductor. These electrons are infinitesimally small compared with the spaces between the conductor's atoms and there exist large numbers of electrons that are either entirely outside the individual atoms or are

### PRACTICAL SOLUTION OF ONE PROBLEM



Series-parallel connections of the filaments of a number of radio tubes presents a problem adapting the principles set forth by Ohm.

easily detachable through the application of very small external electric fields.

### Due to Collision

It is estimated that the resistance is thus incurred by the collisions between the atoms and the electrons. The greater the number of collisions, the greater will be the resistance.

### The Formula

As a result of his experiments, Ohm formulated the general law that the electric current depends directly upon the difference of potential across the wire and also varies inversely as the resistance of the wire. Expressed mathematically, this takes the form:

$$I = \frac{E}{R}$$

where  $I$  is the current in amperes,  $E$  is the potential in volts, and  $R$  is the resistance in ohms.

In the use of Ohm's law in connection with the series-multiple connection of the heaters of several tubes, it is necessary to transform this formula to its equivalent form:

$$R = \frac{E}{I}$$

By the use of this derivation we are in a position to determine what the values of limiting resistors should be in order that these tubes may be correctly combined.

### Example Cited

Let us take the case of three 57's, three 56's and two 47's. What is the most economic and most efficient way of connecting the heaters of these tubes together?

These tubes could not be connected together in series since they have different current ratings. The 56 and 57 require one ampere of heater current while the 47 has to be furnished with 1.75 amperes. The difference in these current requirements precludes the possibility of the simple series connection. The parallel connection is not feasible though the tubes require the same heater voltages. This is so since the parallel connection would require quite a large current to flow with its consequent large power loss. In this case, if the parallel connection was restored to, a current of nine amperes would flow.

In all electrical wiring schemes, it is wise to keep the current as low as possible to minimize power loss in the connecting wires. Accordingly, we shall attempt to connect these tube heaters together in series multiple.

### Series-Parallel Connection

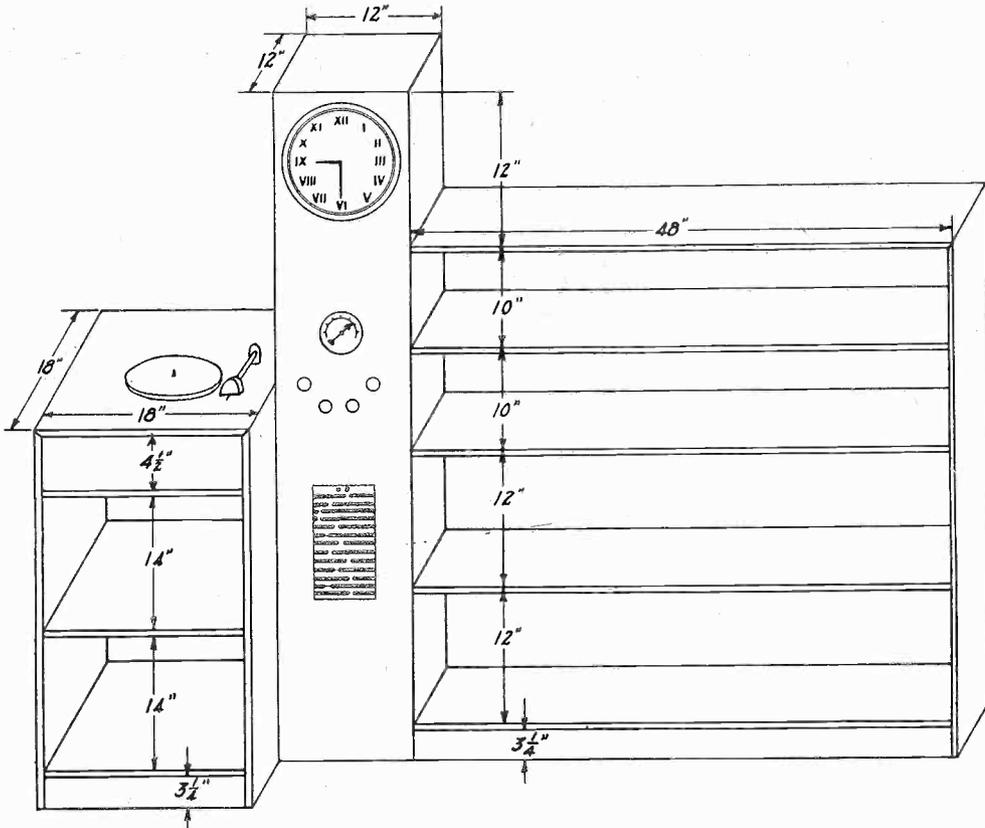
It will be seen from the sketch that the six 56's and 57's are connected in series. Since each tube heater requires 2.5 volts, the total voltage required for this combination is 6 times 2.5 volts or 15 volts. The two 47's are then to be connected in parallel with a series arrangement that has a drop of potential of 15 volts across it. The 47 heater voltage is 2.5 volts so that the necessary drop across two of them in series would be 5 volts. Of course, this 5-volt drop must be the same as the drop across the six tubes in order that the connection may be made to function as it should. Therefore an additional resistance is connected in series with the two 47's to absorb the excess

(Continued on page 17)

# A MODERN RADIO-PHON

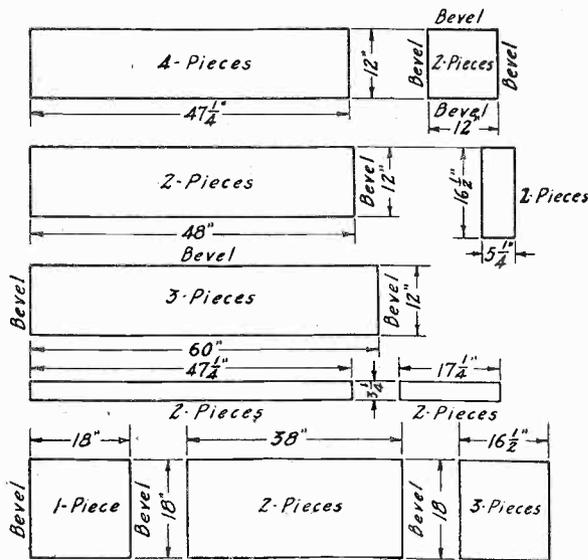
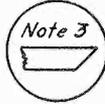
## Automatic Station Selector May B

By A.



— Details —

- Note 1 - All edges, except when otherwise indicated, are square
- Note 2 - All wood, 3/4" thick
- Note 3 - All edges marked "bevel" are bevelled off at 45°



This modern design of a radio installation is very appropriate for the home that is furnished with modern furniture.

THE tremendous range of the designer's skill that has been applied to furniture through the ages provides us with a wide choice in furnishing our homes. The ornateness of one period and the simplicity of another can satisfy

those persons who are inclined either way. Those more conservative are able to use the designs that are in between. Thus the taste of the most fastidious may be satisfied.

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toward what is called "modern" design. This furniture is characterized by its simplicity and unadorned lines and curves. And many persons are falling hard for its appeal. A room, designed in this taste, has a mood linked with it that is indistinguishable. Thus, a living room consisting of a suite finished in two tones of orange with a medium green rug and other incidentals of similar color furnishes a warm and cheery glow. Ordinarily the room contains a console radio receiver designed by an individual who had more idea of the future environment than Columbus had of the existence of a new world.

Such is the action taken by the person that furnishes his home: furnishings are chosen with painstaking care so that harmony is not disturbed and into the surroundings is thrust a most unharmonious radio receiver. Because this is a practice that is quite general we propose to discuss a design for a radio combination that should be well fitted for inclusion in the scheme of a modern home.

### Clock-Controlled Receiver

Modern homes should have modern conveniences according to the most modern practice and, if possible, future practice. Accordingly, it was decided that the design would include a standard radio receiver that is automatically controlled by an electrical clock arrangement. The receiver is mounted in a grandfather clock cabinet arrangement together with automatic control apparatus, while a speaker is not included here.

The reason for not placing the speaker in this cabinet is that when a speaker is mounted in the same cabinet as a radio receiver it may tend to modulate the receiver due to the speaker's vibration. Also a good radio installation requires that the loudspeaker be located in the best acoustical location in any particular room. The location of the radio apparatus proper is not important acoustically. By having the speaker physically independent of the radio equipment, such a choice is readily carried out. Thus, we can position the radio equipment in such a manner that it harmonizes with the furniture and we can see that the speaker is located in its correct acoustic relationship.

The clock face is also of interest. It is constructed of a sheet of thick glass that has the numerals sand-blasted in its rear face which side is silvered as a mirror. Around the periphery of the glass is located a number of lamps whose light plays upon the etched numerals through the glass to make them luminous. This produces a pleasurable effect in a darkened or dimly-lighted room.

### The Switching

Below the clock are the manual controls of the radio equipment, the type of which may sometimes be desired in preference to the automatic control. As may be seen, there are four of the knobs which represent, respectively:

- (1) On and off switch, volume control

# PHONOGRAPH INSTALLATION

## Included—Speaker Remote from Set

Worcester

phonograph switch, automatic control on and off switch.

- (2) Tuning control.
- (3) Band switch.
- (4) Tone control.

The reader will readily recognize these as standard.

The lowest section of the clock unit is devoted to the automatic control mechanism. The portion of this device that is visible is a multiplicity of switch units by means of which pre-selection of a program is possible. This consists of a number of sliding contacts in a horizontal direction that make contact with fixed station points on a selector that is located internally. The number of these horizontally-disposed switches depends upon the period during which automatic control is desired, one switch for each quarter hour. Thus, for control from the period covered from 4 p. m. to 1. a. m. on a quarter-hour basis, 37 such individual switches are necessary. The number of points on each switch will depend on the number of stations desired automatically, plus two or more points for "on" and "off" operations. So much for the radio portion of this equipment.

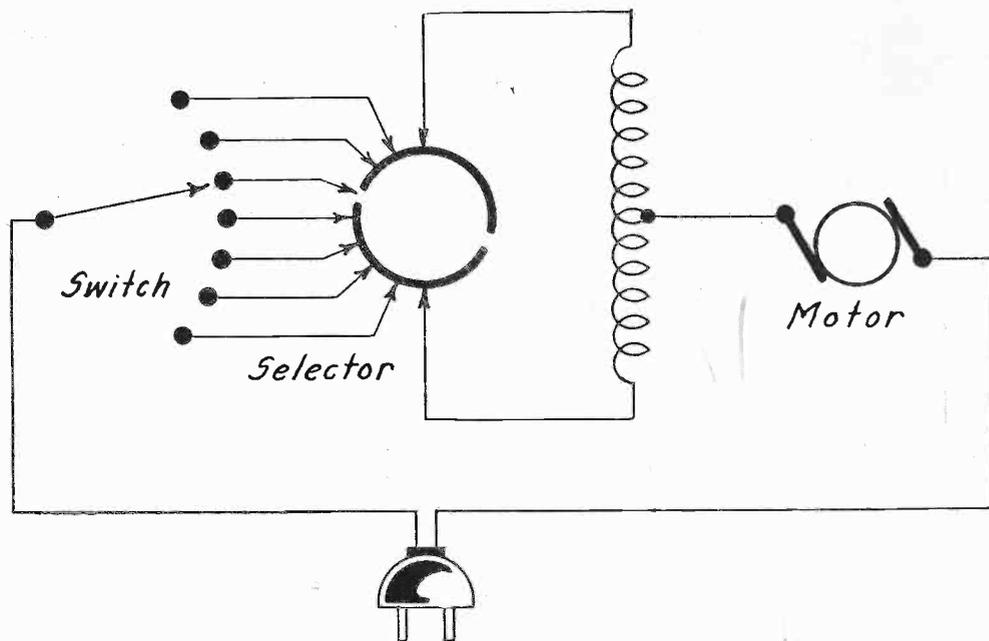
Reference to the sketches of this design will reveal the inclusion of a phonograph unit to the left of the radio section. This phonograph could be so located that it is immediately adjoining a sofa or other chair so that one could sit in the chair at the same time the phonograph is manipulated. The phonograph was included in the arrangement since there are many occasions when radio programs do not cater to the momentary mood of the individual.

### Bookcase for Balance

By a proper selection of suitable recorded music, proper treatment of moods can be readily accomplished. In this connection, there are two shelves below the phonograph unit where record albums may be stored according to the mood of the record such as lullabies, spirited march music, dance music, soothing symphonies, warming rhapsodies, etc. Of course, this is an electrical phonograph so that its output may be fed to the same loudspeaker from which the radio programs exude.

The inclusion of a book case on the right side of the radio equipment serves to balance the design and also to furnish a neat place of refuge for otherwise itinerant books, magazines and other publications. The sixteen feet of available book space should be ample for most conditions.

The constructor of this simple piece of furniture might find it to his advantage to buy the lumber for this project already squared and accurately cut at the proper sizes in the event that he is not properly equipped with carpentry tools. If this procedure is taken he will conserve much wasted energy that is incurred by the lack of suitable tools and he also will produce a neater job, since all that remains for him to do is to assemble the parts that are indicated in the detail sketch.



A simple yet effective method of controlling a radio receiver by remote means.

The quality of the wood that is chosen is deliberately omitted from this discussion since some could afford a much finer wood than others. By proper choice of paints or varnishes, the cheapest wood might almost approach the more costly variety in appearance.

### The Remote Control

There are many ways of achieving remote control for radio receivers. It is the author's belief that none compares in simplicity and effectiveness with the patented device shown in the drawing above. There can be no doubt that this apparatus is simple. Just three parts are necessary: a reversible motor, a selector and a switch or number of push buttons. The number of stations that is controllable by this means is limited solely by the number of push buttons or points on the switch and the corresponding number of points on the selector. Thus, as many as fifty stations can be so controlled, if desired. It is not believed that a greater number than that would be required in any instance. A good average number of stations would be about ten. That would cover most of the stations, if not all, that are consistently heard in the best locations.

#### Switch:

The switch, or as has been shown above, the push buttons, is the means by which the tuning operation is started. If station WLW is desired and the appropriate button pushed or the switch lever is adjusted to the appropriate switch point, connection will be made that will cause the motor to rotate, carrying with it the selector which is tied to it.

#### Selector:

The selector is composed of two semi-circular copper bands that are fastened

to the periphery of an insulating disc of bakelite or other insulator with a small insulated space between the ends. Seated on this periphery and located 180 degrees apart are two brushes that control the limits of rotation of the motor and the main tuning control since this selector is mounted directly on the same shaft as the tuning control. At intermediate points along this disc, are other fixed brushes that are located in positions that are compatible with the locations of the individual stations on the main tuning dial. The current from the switch or push button mentioned above is then transmitted through this selector band to the motor and that portion of the split field that is in contact with the active brush, resulting in immediate rotation of the tuning control in the correct direction.

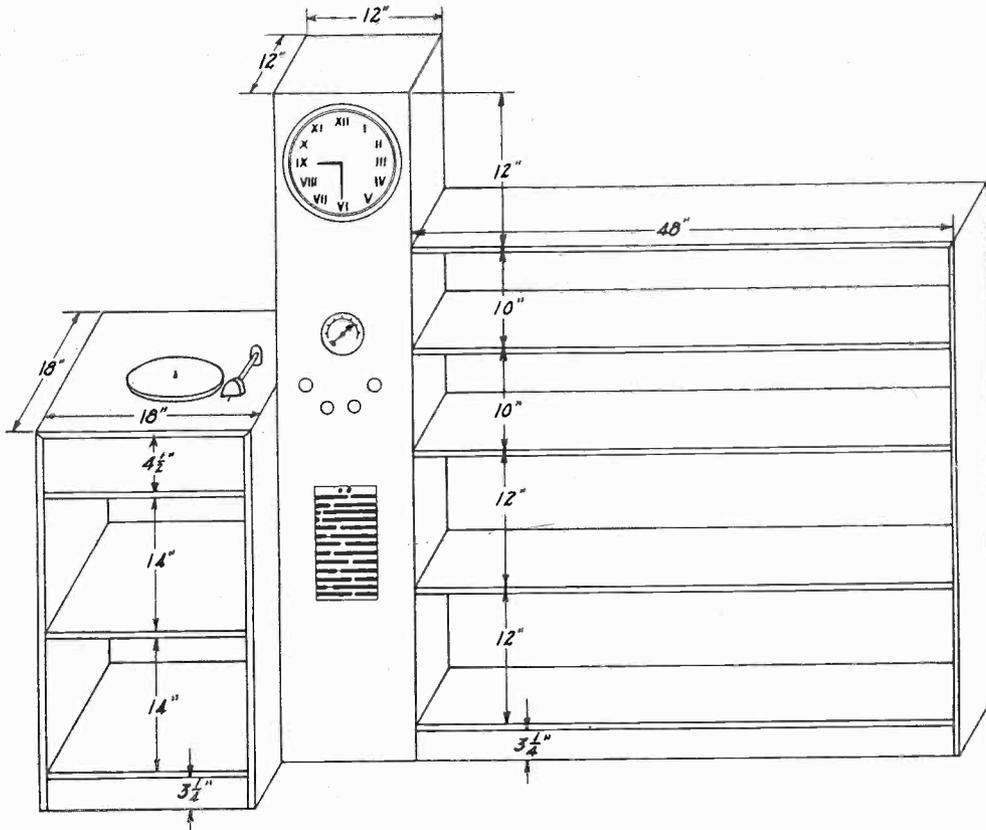
#### Motor:

In order that the motor does not skip by the station after it has been correctly tuned to that point, the motor shaft is made slideable for about  $\frac{1}{4}$  inch, so that when not energized the armature is not in the electrical center of the motor and a clutch arrangement is disengaged. However, when the connection has been made as outlined above, the current continues on its way through the correct field coil to the armature, which causes it to be sucked into the electrical center of the motor, which action also closes the clutch, thus mechanically connecting the motor to the tuning control shaft. As soon as the point of station resonance is achieved, the circuit is broken by the small insulating piece at the end of the semi-circular band which causes the motor armature to return out of the electrical center of the motor and break the mechanical connection to the tuning control, so that the desired station is not passed by and exact resonance is achieved.

# A MODERN RADIO-PHONOGRAPH

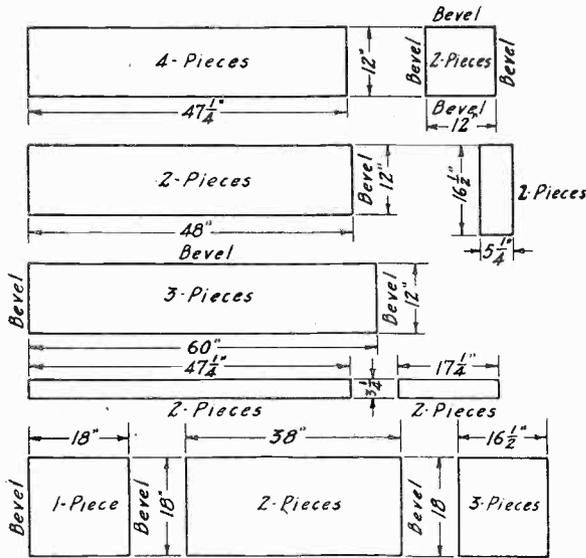
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The lowest section of the clock unit is devoted to the automatic control mechanism. The portion of this device that is visible is a multiplicity of switch units by means of which pre-selection of a program is possible. This consists of a number of sliding contacts in a horizontal direction that make contact with fixed switch points connected to the various station points on a selector that is located internally. The number of these horizontally-disposed switches depends upon the period during which automatic control is desired, one switch for each quarter hour. Thus, for control from the period covered from 4 p. m. to 1. a. m. on a quarter-hour basis, 37 such individual switches are necessary. The number of points on each switch will depend on the number of stations desired automatically, plus two or more points for "on" and "off" operations. So much for the radio portion of this equipment.

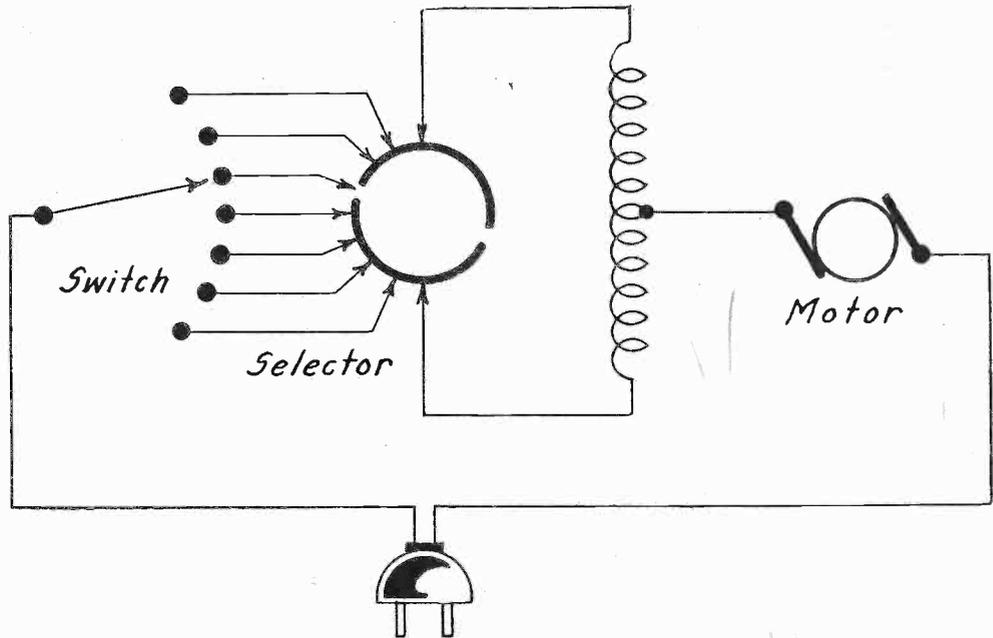
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By a proper selection of suitable recorded music, proper treatment of moods can be readily accomplished. In this connection, there are two shelves below the phonograph unit where record albums may be stored according to the mood of the record such as lullabies, spirited march music, dance music, soothing symphonies, warming rhapsodies, etc. Of course, this is an electrical phonograph so that its output may be fed to the same loudspeaker from which the radio programs exude.

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The constructor of this simple piece of furniture might find it to his advantage to buy the lumber for this project already squared and accurately cut at the proper sizes in the event that he is not properly equipped with carpentry tools. If this procedure is taken he will conserve much wasted energy that is incurred by the lack of suitable tools and he also will produce a neater job, since all that remains for him to do is to assemble the parts that are indicated in the detail sketch.



A simple yet effective method of controlling a radio receiver by remote means.

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The switch, or as has been shown above, the push buttons, is the means by which the tuning operation is started. If station WLW is desired and the appropriate button pushed or the switch lever is adjusted to the appropriate switch point, connection will be made that will cause the motor to rotate, carrying with it the selector which is tied to it.

#### Selector:

The selector is composed of two semi-circular copper bands that are fastened

to the periphery of an insulating disc of bakelite or other insulator with a small insulated space between the ends. Seated on this periphery and located 180 degrees apart are two brushes that control the limits of rotation of the motor and the main tuning control since this selector is mounted directly on the same shaft as the tuning control. At intermediate points along this disc, are other fixed brushes that are located in positions that are compatible with the locations of the individual stations on the main tuning dial. The current from the switch or push button mentioned above is then transmitted through this selector band to the motor and that portion of the split field that is in contact with the active brush, resulting in immediate rotation of the tuning control in the correct direction.

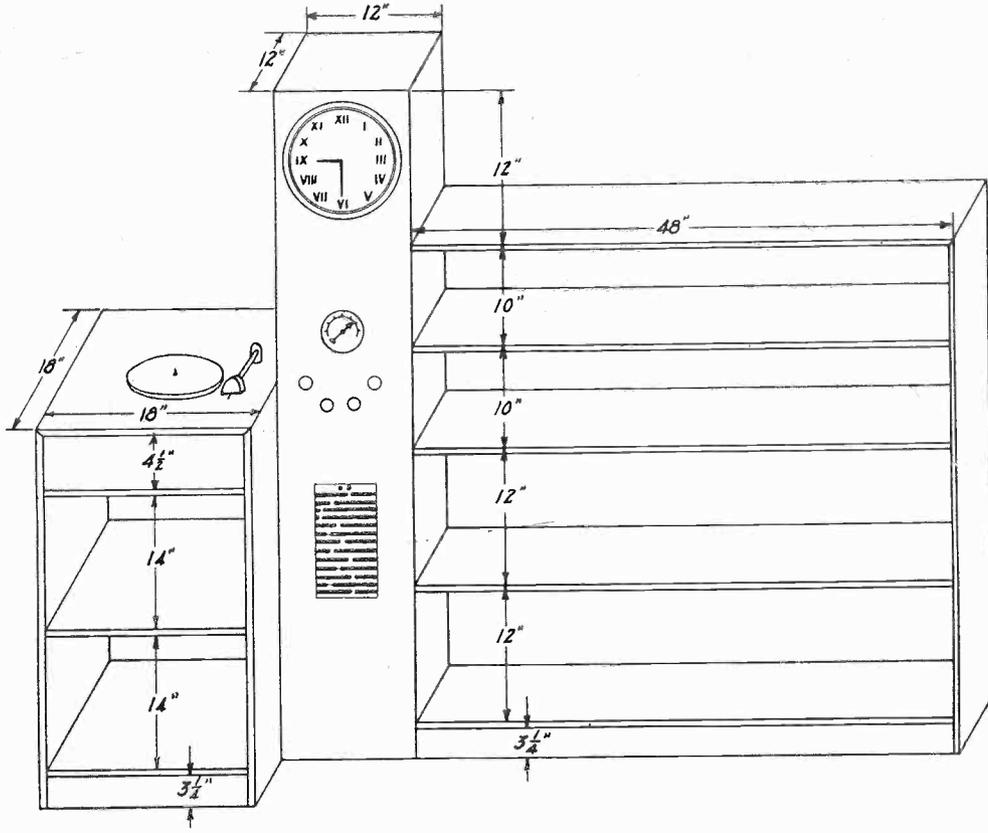
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# A MODERN RADIO-PHONOGRAPH

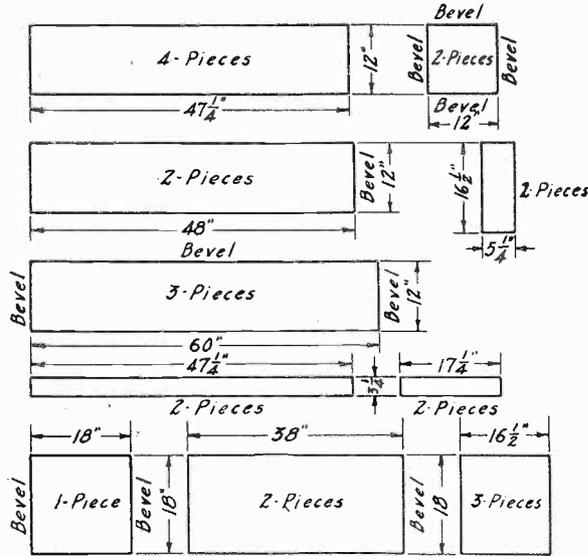
## Automatic Station Selector May Be

By A.



— Details —

- Note 1 - All edges, except when otherwise indicated, are square
- Note 2 - All wood 3/4" thick
- Note 3 - All edges marked "bevel" are bevelled off at 45°



This modern design of a radio installation is very appropriate for the home that is furnished with modern furniture.

THE tremendous range of the designer's skill that has been applied to furniture through the ages provides us with a wide choice in furnishing our homes. The ornateness of one period and the simplicity of another can satisfy

those persons who are inclined either way. Those more conservative are able to use the designs that are in between. Thus the taste of the most fastidious may be satisfied.

Today we see a new trend in furniture

toward what is called "modern" design. This furniture is characterized by its simplicity and unadorned lines and curves. And many persons are falling hard for its appeal. A room, designed in this taste, has a mood linked with it that is indistinguishable. Thus, a living room consisting of a suite finished in two tones of orange with a medium green rug and other incidentals of similar color furnishes a warm and cheery glow. Ordinarily a room contains a console radio receiver designed by an individual who had more idea of the future environment than Columbus had of the existence of a new world.

Such is the action taken by the person that furnishes his home: furnishings are chosen with painstaking care so that harmony is not disturbed and into surroundings is thrust a most unobtrusive radio receiver. Because this is a practice that is quite general we propose to discuss a design for a radio combination that should be well fitted for inclusion in the scheme of a modern home.

### Clock-Controlled Receiver

Modern homes should have modern conveniences according to the most modern practice and, if possible, future practice. Accordingly, it was decided that this design would include a standard radio receiver that is automatically controlled by an electrical clock arrangement. The receiver is mounted in a grandfather clock cabinet arrangement together with automatic control apparatus, while speaker is not included here.

The reason for not placing the speaker in this cabinet is that when a speaker is mounted in the same cabinet as a radio receiver it may tend to modulate the receiver due to the speaker's vibration. Also a good radio installation requires that the loudspeaker be located in the best acoustical location in any particular room. The location of the radio apparatus proper is not important acoustically. By having the speaker physically independent of the radio equipment, such choice is readily carried out. Thus, we can position the radio equipment in such a manner that it harmonizes with the furniture and we can see that the speaker is located in its correct acoustic relationship.

The clock face is also of interest. It is constructed of a sheet of thick glass that has the numerals sand-blasted on its rear face which side is silvered as a mirror. Around the periphery of the glass is located a number of lamps whose light plays upon the etched numerals through the glass to make them luminous. This produces a pleasurable effect in a darkened or dimly-lighted room.

### The Switching

Below the clock are the manual controls of the radio equipment, the operation of which may sometimes be desired in preference to the automatic control. As may be seen, there are four of the knobs which represent, respectively:

(1) On and off switch, volume control

# PHONOGRAPH INSTALLATION

## Included—Speaker Remote from Set

**Worcester**

phonograph switch, automatic control on and off switch.

- (2) Tuning control.
- (3) Band switch.
- (4) Tone control.

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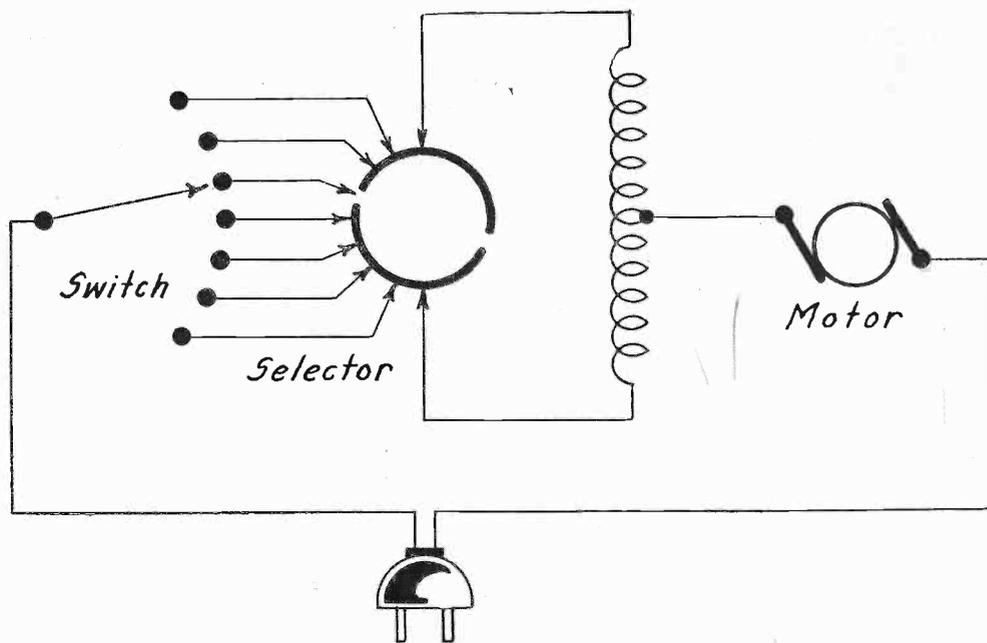
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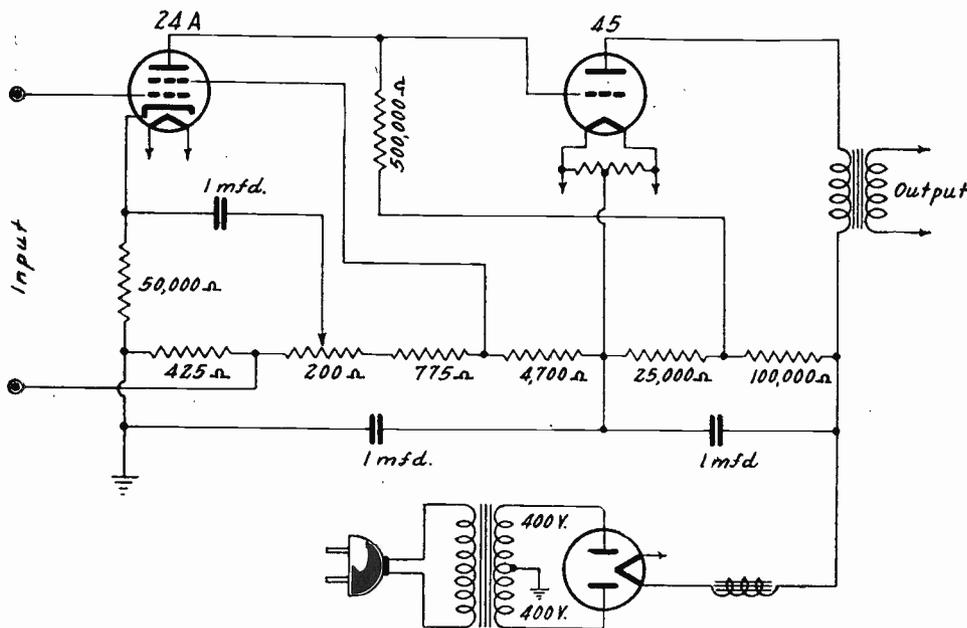
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# A Non-Reactive Amplifier

## Excellent Frequency Characteristic Follows From Absence of Coils and Condensers



The Loftin-White amplifier is an audio frequency amplifier whose frequency is very faithful due to resistance coupling without a distorting coupling condenser between interstage grid and plate.

It has been quite generally agreed that the resistance-coupled amplifier is best when one desires to construct an amplifier that has a minimum of frequency distortion. However, the serious disadvantage of poor amplification properties has reduced the application of this method while the transformer type of amplifier with its superior gain has been steadily improved to the point where it is almost as good as the resistance-coupled amplifier when it comes to fidelity.

Several years ago a type of resistance-coupled amplifier was introduced that had even better fidelity characteristics than the ordinary type of this amplifier and also had the advantage of requiring few

parts which reduced the cost of the amplifier very much. This amplifier was of the direct-coupled type and was introduced by Messrs. Loftin and White along the time that the screen grid tube first came out. This amplifier was immediately accepted by many and built in great numbers. Its frequency characteristic was practically a straight line since it utilized no condensers or inductances, being composed solely of resistances. This amplifier would have a straight line all the way up the frequency scale were it not for the inter-electrode capacity of the tube affecting the higher frequencies. However, it seems that the advent of super-triodes, pentodes, pentagrids, duo-diodes, etc., has

served to take fadom's interest away from this circuit, and also it is not the simplest circuit for a service man to tackle.

### No Positive Grid

A request from a reader to explain this circuit has revived our interest in it and so it is presented here. Reference to the diagram will indicate that two tubes are used, the 24A and the 45. The fact that only resistances are used for coupling the stages is of interest from the viewpoints of low cost of parts and the connection of the plate and grids of the two stages. Obviously, a resistance is a low cost unit. It does not cost as much as a transformer and so by omitting the need for a transformer, a decided saving in investment is attained. The other point of interest is the fact that a positive plate is connected to a grid that is supposed to be maintained at a negative potential. How is this possible, you ask?

Let us consider the diagram. It will be seen that the two tubes are really connected in series across the resistances from which the plate voltages are secured. It will further be noted that the cathode of the 24A is at a lower potential than the filament of the 45. It will thus be appreciated that in reality, though the grid of the 45 is connected to the same point on the voltage divider that the plate of 24A is, the 45 grid does not have the same voltage on itself as the plate of the 24A, since its potential is dependent upon the difference between grid and filament, hence will actually have a negative value. In other words, if 90 volts exists between the left end of the voltage divider and the tap to which the common plate and grid is attached and the filament of the 45 is tapped to the 80 volt point, there actually exists on the grid of the 45 a negative 10 volt bias. Thus, although the interstage plate and grid are connected together directly, the voltage is not the same on both elements since the potential of each electrode depends upon the potential level above its own cathode or filament.

### No Coupling Condenser

Thus, we obviate the need for a coupling condenser even! This distorting influence on the frequency characteristic is then discarded and the performance of the amplifier improved. It is imperative that this circuit utilize a tube in its first stage that has a very high amplification factor because of the fact that the amplification obtainable from this circuit is gotten solely from the tubes themselves. There is no step-up transformer here to help the amplification action. The second tube is really a power stage that converts the voltage amplification to power amplification so that a sufficient sock may be delivered to the speaker apparatus.

For greater amplification, the 45 tube may be replaced by another 24A stage which it then follows. Thus, there will be two voltage stages feeding the power stage. In this case, a 50 type tube was usually substituted for the 45 because of the increased load. However, the 2A3 tube should prove effective, and also spare the necessity for the high voltage required for the 50. It will be noted that the voltages are cumulative, or series fed, compared to the common example of parallel tapping for B voltage.

## Sensitive Relay Turns on Lights as Sun Dims

A selenium cell's internal resistance varies with the light that falls upon it. Therefore, if this device is so set up that the daylight can fall upon it, the cell's resistance will vary with the amount of daylight. For a given setting of the voltage potentiometer which is determined by economic and relay operating considerations, the spring tension knob for adjusting the relay armature is turned until the armature is attracted by the relay in a reliable manner by the amount of daylight that the operator decides needs supplementing by the electric light system. The electric light system is connected to the center and lower terminals of the right-hand terminal strip directly if the circuit uses only a few lamps of low wattage or through a heavy-duty switch, if the lighting system uses many large-wattage lamps. The section that takes place as a result of this connection is such that when there is ample sunlight or daylight present, the selenium cell's resis-

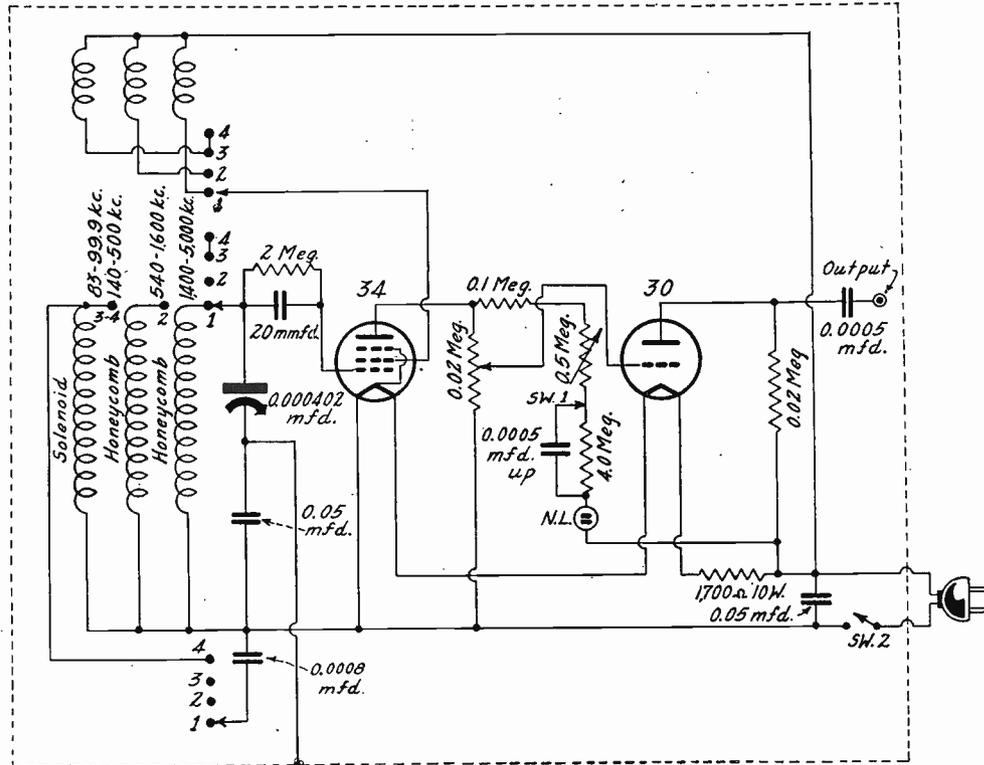
tance is low so that a sufficient current flows to maintain the relay armature in the attracted position so that the contact that is normally closed remains open. However, as soon as the daylight reaches a level that is too low for comfortable vision, the selenium cell's resistance has assumed a higher value which in turn limits the current through the relay coil to a point where the armature is pulled to its unenergized position by the spring and closes the contact which completes the circuit for the electric light system. In this manner, the electric lights will go on and off automatically, according to the variation in resistance of the selenium cell which will be directly controlled by the intensity of daylight that falls upon it.

The inverse application of this arrangement would make use of a connection to the two reversed terminals. In this fashion, the device may be made to light a pilot light that would indicate when the daylight has reached the weak level.



# Detuning Precautions Applied to Attenuator of Signal Generator

By Herman Bernard



The use of electron coupling between r-f generator and output removes danger of detuning or shorting the oscillator, while an amplifier tube preserves the safeguard in respect to the measured circuit itself. Diagram is of the 333A Signal Generator.

ONE of the troubles with some signal generators is that they detune or short the circuit being measured. This applies particularly to measurements made on receivers at the station-carrier frequency, when the generator's attenuator is practically in shunt with the antenna coil, so that when the resistance becomes low between the arm and ground, due to attenuation, the primary of the antenna coupler in the set becomes practically shorted, and detuned as well. The attenuator and the incidental capacities arising from it and the coupling to the generator, as well as the alteration of the effective inductance of the primary of the antenna coupler, account largely for the detuning.

For these reasons it is well to have an amplifier tube, because then in effect there is a high resistance between the generator and the measured circuit. This is particularly valuable when the generator covers broadcast and short-wave frequencies. Of course the attenuator then would not be at the output of the generator, for if it were the same vice sought to be cured would be present nevertheless. The control should be associated with the generator proper, and in such a way as to cause no detuning there, either.

## Value of Electron Coupling

It has been found that electron coupling presents an excellent opportunity of freedom from detuning effects. This type of coupling may be referred to as emission coupling. In the emission stream the coupling takes place, hence does not depend directly on external inductance, capacity or resistance.

There are various methods of obtaining electron coupling, although there is a practical restriction that screen-grid tubes must be used for the purpose. One coupling method that has proved very satisfactory is that used in the 333-A Signal Generator, the diagram of which is printed herewith. A screen-grid tube is used, with normal screen acting as the effective plate, and the normal plate serving as a pickup element. The coupling is loose when the conventional plate, now pickup element, is returned to ground. Some current will flow, however, in any load placed on this element, because the conventional plate acquires a small positive voltage at the oscillation frequency due to the presence of that element in a field of moving electrons. Any electrode in a field of moving electrons obtains a potential due to the impact current through the electrode. And whenever current flows through an electrode there is a potential drop across the electrode. Or the pickup element may be considered as a high resistance in parallel with the electron stream. The d-c potential on this pickup element will determine largely the equivalent resistance the element presents to the electron stream. The higher the d-c potential the smaller the equivalent resistance.

## Negative Bias for Amplifier

Thus if the attenuator, a potentiometer of 20,000 ohms (0.02 meg.), is placed across conventional plate and B minus, there will be small current through the resistance, small voltage drop, loose coupling and freedom from frequency disturbance of the generator due to setting of the control. In the particular circuit of the 333-A,

the grid of the 30 amplifier tube is connected to arm of the potentiometer, and a negative bias is maintained on the amplifier tube equal to the potential difference across the filament of the 34 oscillator, or around 2 volts.

The facts of the circuit have been published in these columns before, but a brief summary will be presented now, with new detailed directions for use.

The 34 is used as the oscillator, with a small grid condenser, because of the stabilizing effect of a small condenser on amplitude and frequency, it being a fact that when there is even amplitude of oscillation over any tuning band there is frequency stability, the two being the same electrically and mathematically.

As the small grid condenser, 20 mmfd., is hard to obtain as a commercial fixed capacity, it may be improvised by taking about 10 inches of insulated wire, halving it by bending back into a U, and twisting the resultant two branches around each other, snipping the wire at the curve of the U to constitute the two separate pieces, and coiling the result around a pencil for compactness. Remove the pencil finally. The condenser thus resulting is used across the 2 meg. grid leak. Be sure to connect the ends of separate wires this way, not only wire by mistake, otherwise the lead would be shorted, and the direct-frequency-reading dial could not be tracked. A safeguard is to snip the U apart only after the connections are made to the lead.

## The Relaxation Oscillator

The generator has output, as already stated, coupled to an amplifier tube. Associated with this coupling is an audio oscillator, consisting of a special small neon lamp in series with which is a high resistance, associated with a condenser, and across the series circuit a high voltage. If the condenser is put across the lamp there will be weak audio oscillation, though sufficient for most persons. If the condenser is across the high resistance (shown as 4 meg.) the audio oscillation will be intense, and will overmodulate the r-f oscillator, causing double-hump tuning, so a limiting resistor is used. The value suggested is 0.1 meg. This type of oscillator is called a relaxation oscillator. The percentage modulation from the resultant maximum value down to 20 db less may be controlled on d-c use by a series rheostat of 500,000 ohms.

## Bands of Frequencies

As the generator works on a.c. or d.c., 90-125 volts, and uses the line voltage on filaments and plate, in the case of a.c. there will be hum as the modulation. The neon tube audio oscillator then does not function as such, as a.c. will not produce oscillation at the time-constant frequency of the condenser-limiting-resistor circuit. Also there is no control of the modulation. But on d.c. the modulation may be controlled by the adjustment of the 500,000-ohm resistor, and even removed, by switching out the fixed capacity (0.0005 mfd. up) that makes audio oscillation possible. The higher this capacity the lower the frequency. The values indicated afford oscillation of a few thousand cycles. Sw-1 is on the 500,000-ohm rheostat, or potentiometer used as rheostat with one end free.

(Continued from preceding page)

There are four positions of the band switch:

- (1) 1,400-5,000 kc
- (2) 540-1,600 kc
- (3) 140-500 kc
- (4) 83-99.9 kc, 3,600-3010 meters.

Only three coils are used, as the lowest frequency range is obtained by switching a capacity of 0.0008 mfd. across the coil and tuning condenser used for 140-500 kc.

The dial is direct-reading in frequencies, and for the lowest-frequency range only, is also direct-reading in wavelengths. Hence there are four tiers, two on top for the low-frequency, high-wavelength designations, two on bottom for the intermediate and broadcast frequencies. The short-wave frequencies are read as multiples of 10 of the 140-500 kc band, that is, 1,400 to 5,000.

As a constructional fact, the tiers are placed left and right, rather than top and bottom, hence the two escutcheons, each of which has two indexes, are to left and right of the knob, but on a higher level.

### Directions for Use

The generator is used as follows:

**Connections:** The line plug is connected to the 90-125-volt line. If the line is a.c. the plug may be inserted either way. If the line is d.c. the plug must be inserted a particular way. There is no danger if the plug is reversely connected to d.c., but the Signal Generator will not oscillate then, so reinsert the plug the other way. The antenna post on the Signal Generator marked "Ant," is for connection to the circuit to be measured or peaked. Do not use the post marked "Gnd," as there would be a small resultant frequency change. In aligning all frequencies remove the aerial from the set and connect generator output to plate of the modulator.

**Exploration of Frequencies:** If one has no idea of the frequency being measured, turn the generator's range-selector switch to No. 1 position, 1,400-5,000 kc, and if no response is heard the frequency is lower than 1,400 kc. Turn knob to Position 2, and if still no response is heard the frequency is lower than 540 kc. If no response results on Position 3, either, the frequency is lower than 140 kc. If there is no response at Position 4 the frequency is lower than 83 kc, so can not be read, or generator or receiver isn't working.

**Short Waves (Position 1):** If a response was heard at Position 1, denoting frequency is 1,400 kc or higher, there is only one response in traversing the calibration (scale 140-500 multiplied by 10) the frequency is read directly from the scale (introducing mentally the multiplication factor of 10), and will be 1,400-2,800 kc. For unknown frequencies, 2,800 kc up, there will be two or more responses in traversing the generator dial. For frequencies higher than 2,800 kc the measurements are made by means of a confusion-eliminating harmonic system. The radio frequencies measurable this way are almost without limit, though depending on the sensitivity and frequency range of the system being measured. Taking a certain general low level of receiver sensitivity, measurements to 25 mcg are readily practical. For multiple responses from sweeping the generator dial when band switch is set at Position 1 for 1,400-5,000 kc fundamentals, gain a response in the receiver due to any setting of the generator. Read a generator frequency, an harmonic of which is producing the response. Turn the generator dial slowly until the next succeeding response is heard. It matters not if the generator fundamental frequency is increased or decreased. Note the frequency of this second fundamental. Subtract the lower read frequency from the higher read frequency. Divide this difference into one of the read frequencies and the answer is the harmonic order of

## USE A RESISTOR OF DOUBLE THE COMPUTED WATTAGE OF THE LIMITING CIRCUIT

(Continued from page 11)

the 10-volt drop. What should this resistor be, in size? That is where Ohm's law comes in:

$$R = \frac{E}{I} = \frac{10}{1.75} = 5.7 \text{ ohms.}$$

Which means that in order for a resistance to have a 10-volt drop across it while 1.75 amperes (heater current of 47's) flows through it, it must have a resistance of 5.7 ohms.

This arrangement is then all set to be connected across a potential of 15 volts. But, we desire to connect this across the 110-volt line. And so it is necessary to insert another dropping resistor in series with the entire combination to absorb the excess 95 volts (110 minus 15). This resistance is calculated in the same fashion as the other and so we proceed:

$$R = \frac{E}{I} = \frac{95}{2.75} = 34.9 \text{ ohms or approximately 35 ohms.}$$

### Wattage Difference

This equation stipulates that a series dropping resistor will develop a 95-volt drop across it when it carries 2.75 amperes if it has a resistance value of 35 ohms. It is permissible to disregard frac-

tions of an ohm in these calculations since the voltage sometimes varies quite a bit.

It is well to show the superiority of the series-parallel connections over the straight parallel connection by indicating that the series parallel connection involves a consumption of about 300 watts of power while the parallel connection with the same tubes expends 990 watts. There is a tremendous saving in power, quite obviously.

Once we have determined the required value of resistance we are not finished, for the resistor must be able to stand the current required to be passed through it. Since we know the current, the voltage and the resistance in all cases considered, we need only determine the wattage. This is another form of Ohm's law. In words, the wattage in watts equals the product of the voltage in volts and the current in amperes. Using instead the resistance and the current, wattage equals the product of the resistance and the square of the current. These facts are often written as equations as follows:

$$W = E I$$

$$W = I^2 R$$

When the actual wattage is obtained thus, use a resistor rated at of twice that value, to be conservative.

## DETAILED GENERATOR PROCEDURE

the other read frequency. Multiply this other read frequency by the harmonic order and the answer is the unknown frequency. Two examples: Suppose one dial reading is 200 and the other is 220. Since the scale is to be multiplied by 10 for this range, the actual frequencies generated fundamentally are 2,000 and 2,200 kc. The difference is 200 kc. Divide 200 into 2,000, the answer is 10, so the unknown is the tenth harmonic (not of 2,000 but) of 2,200 kc. Hence 22,000 kc or 22 mcg is the answer. Suppose the difference, 200, were divided into 2,200, also a read fundamental. The answer is 11. So the unknown is the eleventh harmonic (not of 2,200 but) of 2,000, again 22,000 kc or 22 mcg. Always the answer must be the same, of course. Also, when the method is applied to the alternate case, the harmonic order will be one higher or lower than in the first instance, because consecutive harmonics of different fundamentals are used. The readings are more easily taken at low frequencies of the band, because of the greater mechanical separation on the dial, but if response is weak or hard to identify, higher fundamentals must be used. Let us take as the final example readings of 465 and 480, representing 4,650 and 4,800 kc. The difference is 150 kc. Divide 150 into one read frequency, 4,650, answer is 31, which is the harmonic order of 4,800 kc, so the unknown is  $31 \times 4,800$  or 148,800 kc, or 148.8 mcg. If the difference, 150, were divided into 4,800 the harmonic order would be 32, applied to 4,650, yielding also 148,800 kc or 148.8 mcg. The wavelength is around 3 meters. It can be seen therefore that frequencies higher than any that would be required to be measured are taken care of to a degree of accuracy depending solely on the accuracy of the scale's coincidence with the generated fundamentals.

**Broadcast Band (Position 2):** If there was no response at Position 1, but response at Position 2, the unknown is in the broadcast band. If only one response is heard the unknown is 540-1,080 kc, read directly. If there are more than one response the unknown lies between 1,080 and 1,600 kc, and is the second harmonic of the lower read frequency or fundamental of the higher read frequency. It is better to use the lower setting and multiply by 2, while the higher setting, read directly, is used as check. This is again due to the better spread-out at low frequencies, and also for standard broadcasts is due to the 10 kc calibrated differences for more than an octave, or harmonic range, 540-1,100 kc. The factor 2 introduces 20 kc calibrated differences 1,100-1,600 kc, for second harmonics. The dial differences, 1-100-1,600 kc, are 50 kc on fundamentals, another reason for using the low end and multiplying by 2.

**Intermediate Frequencies (Position 3):** For 140-500 kc, if there is only one response the unknown is 140-280 kc, so read it directly. If there are more than one response the unknown is equal to or higher than 280 kc, so, to determine how much higher, or rather, just what the unknown is, move the dial to read higher than 280 kc, and the unknown is now read directly. Elimination of possibility of higher unknown frequencies, by tests at Positions 1 and 2, is assumed.

**Lowest Frequencies (Position 4):** If the first response is at Position 4, none at Positions 1, 2 or 3, the unknown is 83-99.9 kc and read directly in those frequencies, or equivalent wavelengths.

**Special Connection Advice:** Wherever a set manufacturer has given directions for connections contrary to those recommended above, follow the manufacturer's advice.

# Westinghouse P-E Cells

## An Analysis of Sensitivity and Performance

By Samuel Wein

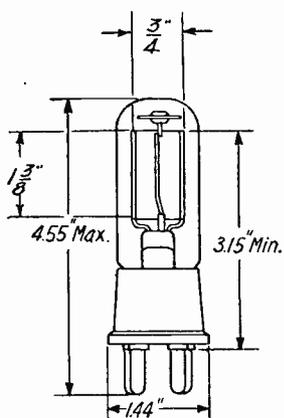


Fig 1

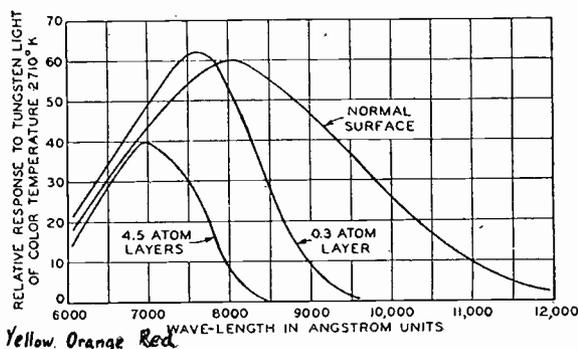


Fig. 2  
Effects on the photoelectric sensitivity of various thickness of the outer layer of caesium

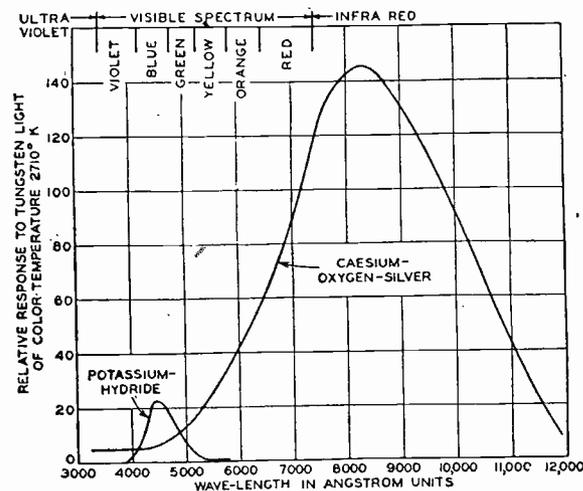


Fig. 3  
Comparison between the older potassium hydride and the modern caesium oxide on silver oxide cells.

Various characteristic curves for some of the Westinghouse phototubes. The standardized Westinghouse base for phototubes is at left.

ONE of the conventional forms of the modern phototube such as is met with on the open market is seen in Fig. 1. The cathode (active surface) is made of a semi-cylinder of silver in its purest form. The anode (collector, or sometimes known as the "grid") is made of a stout nickel wire, and is mounted along the axis of the semi-cylindrical cathode. Both the cathode and anode are mounted on the glass "stem," which is fused onto a glass bulb (usually soda-lime or Pyrex). A small nickel cup or molybdenum strip which is crimped to hold the "caesium pellet" in it, is visible on top of the elements. Of course, modifications of the foregoing constructional form varies with each manufacturer to suit their own manufacturing conveniences. But these modifications do not alter the physical characteristics of the cell, since the end result is more or less highly standardized, matters of which we shall discuss later on.

### Evacuation Process

The next step in the process is to highly evacuate the bulb and to form the active film on the semi-cylindrical form of silver. The process roughly is:

1. Converting the surface of the silver to its corresponding oxide (silver oxide, AgO).
2. Distillation of the metallic caesium (Cs) on the silver oxide.
3. Convert the AgO and the Cs to AgO-CsO.

It is this latter film which is of interest to us, and which is now found to be the most sensitive form of active film.

It is not our intention of discussing the details in the process of manufacturing this AgO-CsO film here, but a summary such as we have already described ought to suffice our readers.

The most sensitive form of cell is one in which the long wavelength limits extends very far into the infra-red region. This is usually obtained by combining the excess caesium oxide with the silver oxide and restricting the sensitive surface within extremely close limits of atomic thick-

ness. Experimental results indicate that a decrease in sensitivity is had if a greater number of atomic layers of CsO are superimposed on the AgO, which is seen in Fig. 2.

### Responses Compared

In Fig. 3 we see the relative response of the older form of phototube using potassium hydride as compared with the AgOCsO film when a tungsten filament is used as the light source (Color temperature 2710° K over the spectral range from 3000 to 11,000 Angstrom units). The remarkable difference between these two cells is obvious.

A few cells, as manufactured by Westinghouse, are discussed below.

Types SR-50 and SK-60 phototubes are alike, excepting that the "50" is a highly evacuated tube and the "60" is filled with argon at low pressures.

A curve would show that the current output of the "50" phototube is exactly proportional to the light flux when saturation voltage is applied.

Curves further indicate that the current output of the "60" is proportional for the light flux for low illuminations and low voltages but not for high illuminations and high voltages. For a given tube, a load resistance can always be chosen so that the current output becomes quite linear with light flux over the permissible range of illumination.

### Output Variation

For a given light flux, the current output of the "50" tube varies to saturation as the applied voltage increases in a manner quite similar to the effect in a triode vacuum tube. Note that at 90 volts the current is practically independent of voltage fluctuations.

For a given light flux, the current output of the "60" tube rises to saturation or approximately 15 volts and then begins to rise again for higher voltages just as in a gas-filled thermionic tube. At 90 volts the current sensitivity is about 5 times the corresponding value for a

vacuum tube. This augmented sensitivity due to gaseous ionization is the chief merit of gas filled phototubes.

From -20° C. (-4° F.) to + 20° C. (+ 70° F.) there is very little dependence of sensitivity on temperature, but from 20° C. to 70° C. (160° F.) a decrease of about 0.4% per degree C. (0.2% per degree F.) may be expected. The phototubes should not be subjected to temperatures higher than 70° C. This temperature of 70° C. is an absolute maximum and should not be approached if it can be avoided.

### 61 Highly Sensitive to Blue

Type SK-61 phototube is in all respects identical with the "60" type tube, except in spectral sensitivity and temperature characteristics.

It should be indicated that the "61" phototube is highly sensitive to blue light to which the "60" phototube is least sensitive. Also the typical temperature coefficient of the former is roughly one-tenth as great.

The SR-51 phototube is in all respects identical with the "50" type cell, except in its spectral sensitivity and temperature characteristics.

The "51" type phototube is highly sensitive to the blue light to which the "50" is least sensitive. Also the typical temperature coefficient of the former is roughly one-tenth as great.

### Base Pin Arrangement

Though the Standards Committee of Institute of Radio Engineers has assigned numbers to each of the pins in the base, making it easier to recognize the pins as to filament, grid, plate, etc., manufacturers of photo-cells have not accepted the pin number assignment. No explanation for this lack of co-operation is offered by the manufacturers. Accordingly, it is of utility to discuss the Westinghouse pin arrangement.

The mechanical design as well as the electrical requirements of photo-tubes are of paramount importance. Cells used in

(Continued on next page)

# Amateurs' Views Broadened

## Cultural Aspect of Ham Activities Far-Reaching

By M. K. Kunins

W2DPS

THE word amateur indicates one who practises certain things for the pleasure or knowledge derived therefrom, without any thought of financial reimbursement. Thus, a radio amateur practises the art of radio for the fun involved. And truly, there is an inconceivable amount of fun to be had.

Another date was added to the already long list of historical events to memorize when in 1899 Marconi first achieved success in transmitting a wireless signal across a distance that was considered great in those days. Marconi started something.

It wasn't very long after the announcement of his success that many individuals in Europe and America started delving into this mysterious realm of wireless whereby it was incredibly possible to converse with someone at a distance without any visible connections. As time went on, more and more persons were drawn to this magical phenomenon. These pioneers were truly amateurs for they spent great amounts of money in perfecting their apparatus without any idea of monetary gain.

Through the experiments of these persons the art of wireless began to attract the attention of the world's governments as a means of safeguarding human life aboard vessels plying the oceans. By means of this agency it would be possible for a ship in danger of sinking or otherwise handicapped to summon aid from great distances.

### Quick Recognition by U. S.

The Government of the United States was no laggard in the recognition of this utility of wireless and accordingly drafted the ship act of 1910, whereby it became compulsory for certain ships to carry wireless equipment for safeguarding the human lives aboard. The Titanic disaster of 1912 is a vivid example of the value of wireless. By means of this agency it was possible to save some of the passengers. Thus wireless entered its second stage with the birth of humanitarian commercialism of its properties.

In spite of this new possibility for early amateurs to derive monetary benefits from their knowledge, many retained their amateur status and continued their experiments. In this way the hoarse spark transmitter and the crude coherer receiver came into wide use. During these days the U. S. Government did not regulate the amateur and accordingly he took his choice of power and wavelength of his transmitter. Of course, power was limited by cost. Consequently, the electric power companies were not troubled much by amateurs overloading lines and transformers. However, considering all things, the amateur of those days had quite a free rein in the matter.

### Fascination Spreads

Gradually, this new plaything fascinated more persons until the amateur fraternity comprised quite a large percentage of the radio populace. Of course, it became incumbent on the government to provide regulations whereby chaotic interference would be averted. Accordingly on August 13th, 1912, Congress approved Public Law No. 264, providing for the regulation of radio communication. The main point of interest to us in this bill is the fact that

the Secretary of Commerce, as head of the U. S. Department of Commerce, was given authority to regulate radio communication. Thereafter, the amateur, as well as other radio services, was held accountable to the United States Government through the Department of Commerce. He was also

### The Westinghouse Cells

(Continued from preceding page)

industrial applications are more likely to be subject to rough handling by individuals than is the case of vacuum tubes in radio sets, in addition to the fact that many phototubes will be mounted on moving or vibrating apparatus. Since the electrical life of industrial cells must be very long, the safety factor of mechanical design must be correspondingly increased.

The electrical requirements involved are: (1) the current carrying capacity of the base pins in conjunction with the socket contacts used; (2) the voltages imposed, requiring greater creepage distances; (3) the molded material must have a very high resistance because phototubes and their amplifiers are high impedance devices.

The Westinghouse Company, bearing these factors in mind, has slightly increased the dimensions and spacings between the pin contacts to offset possible difficulties that might arise.

The size of the pins are 3/16 inch in diameter, in order to carry the heavy currents available in the phototubes. These pins are capable of carrying 25 amperes continuously in a closed type socket, or 32 amperes in air, without overheating.

The layout of pins is on a 1-inch diameter circle with spacing so arranged as to have the greater distances where the high voltage stresses occur, or where a high resistance leakage path is necessary.

These two features of heavier pins and larger creepage distances also lend themselves more readily to larger base shells, resulting in greater flexibility of tube design, since the glass envelope (bulb) need not be restricted to such an extent at the point of sealing.

### Prong Contacts

Both the anode and cathode are brought into the base, and the wires are now soldered with an acid free soldering medium (preferably soldering paste). All phototube manufacturers use different pins for the anode and cathode, and no standard pin has been accepted with respect to the anode and cathode.

True enough this can be easily standardized, but the manufacturers have failed to do so till the present time. As a matter of fact, when the cells are purchased from the manufacturers they will gladly co-operate with the consumer by placing the anode and cathode wires to any of the pins in the base to suit the individual demand or requirement. However, it appears that a specific pin terminal should once and for all times be accepted with respect to the anode and cathode and so avoid possible difficulties and loss of time in checking back with the manufacturer if the phototube is purchased on the open market.

[Table of Westinghouse cells next week, issue Feb. 2d, page 3.]

obliged to obtain a license, issued by the Secretary of Commerce, attesting to his ability as a radio operator. Thus, by July 1st, 1913, the Secretary of Commerce issued licenses to 1224 amateur stations in the United States.

The great inherent value of wireless continued to grow apparent to men all over the country. And, by July 1st, 1916, the Department of Commerce had licensed 4,870 amateur stations, a growth of 400% in three years! The next year saw the advent of the United States into the World War and accordingly all non-Government radio stations were ordered dismantled and closed. The majority of the amateurs who were of age joined the communication branches of the army and navy.

Although all non-Government radio stations were closed during the war, the art of wireless was not at a standstill. It was actually making greater strides than ever before since it was proving to be a valuable means of inter-communication at the front and elsewhere. At the close of the war period, the restriction on radio stations was removed and July 1st, 1920, saw 5,922 licensed amateur stations indicated that wireless was not being neglected. Steadily the number of licensed amateur stations increased by leaps and bounds, at the approximate rate of 5,000 per year for the next two years. Thus, 5,922 amateurs became 15,504 by July 1st, 1922. From then on, the number of licenses issued now amounts to about 50,000.

### Value of Amateur

It should now be apparent how much the art of radio owes the amateur. He has been responsible for many of its great advances.

Often it has been said that a technical training without a cultural background was a deficient education. That is very true. But, I am sure there are many who detest the thought of memorizing Greek or Latin passages to become "cultured," otherwise, there might be no technical students, since a technician's makeup is such that he treats in realities only. I do not condemn these subjects for the technical student. I merely state that the average technical-minded person cannot find interest in Latin and Greek. Where else, then, can this cultural background be obtained? Curiously enough, amateur radio can furnish this background. Associations as a radio amateur will give one experience in law, psychology, geography, and in languages, to say nothing of electrical engineering.

How do you study law by engaging in amateur radio? Well, the amateur has the law at his every turn. Before he can obtain a license to operate a station, he is required to familiarize himself with the radio law, the International Radiotelegraphic convention and the various regulations added from time to time. It is quite interesting and simple. A boy 9 years old has obtained a license. This study of the radio laws and regulations usually awakens an interest in other forms of law and ones views are correspondingly broadened.

### Broadening Effect

How does one study psychology by engaging in amateur radio? No sooner

(Continued on next page)

# Radio University

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

## Rectification Test on D. C.

IS IT POSSIBLE to test the effectiveness of rectifiers, using d. c. instead of a. c.?—K. L.

Yes. This may be done readily. Measure the amount of current that flows in one direction and the amount that flows in the other direction, for a given impressed voltage. This is simply a measure of the resistance in each direction. The higher the ratio of inverse resistance to forward resistance, the better the rectifier. The voltage should be carefully selected to match the rated voltage of the particular rectifier, as rectifiers vary decidedly in their efficiency for various impressed voltages. Of course, this is only a preliminary test for of the rectifying property. One should test the rectifier under actual a-c conditions. Yet the d-c test is a very good indication of the efficiency of a rectifier. The complete circuit for the d-c test would consist merely of a battery of voltage corresponding to the rated voltage of the rectifier, placed in series with the d-c connections of the rectifier, and a resistance to limit the current to values within the rated capacity of the rectifier. A milliammeter is placed in series with the line and current is read with each polarity of the impressed voltages.

\* \* \*

## Watch Repair Amplifier

I DESIRE to construct an outfit that will enable me to see the ticking of a watch on a neon lamp, for comparison with the fluctuations of another neon lamp driven by a standard of frequency (marine chronometer). Will you please express a few ideas about how to accomplish this?—I. W. D.

A ready means of attaining the result is to build a three-stage amplifier, feeding a single output tube, with no less than 150 volts on the plate, more if you like. Into the first amplifying tube grid circuit connect the secondary of a microphone transformer, primary to a small microphone. The plate circuit of the output tube has an audio choke in it. The

neon lamp is connected in parallel with this choke, using a resistor in series with the neon lamp, to limit the current. This limiting resistor is built into lamps purchasable in stores. When the watch ticks, the sound is picked up by the microphone, delivered to the primary of the coupling transformer, and the induction transfers the voltage to the secondary or grid circuit. The gain has to be pretty high, because some watches tick so faintly, for instance thumb-nail size wrist watches, and in some instances a resonant chamber would have to be created, in which such a tiny watch would be placed, to build up the sound quantity around the microphone input. When something more than 65 volts of signal appears across the output audio choke the lamp will strike, while at no signal there will be a dark lamp. You can decide experimentally if the gain is enough to cause lamp striking when the weakest-ticking watch is used. An ordinary watch will give plenty of hop to the output lamp. For comparison purposes two such amplifiers would be built. The standard chronometer would be coupled to one. Synchronism would be judged visually, so that the test watch is made momentarily equal to the other, and for specific test periods the estimated loss or gain of the test watch in seconds per month could be determined. Of course, it depends on the watch itself, its construction, constitution and condition, whether normal changes of temperature, moisture etc. will affect the loss or gain of time. For particular needs such as the judgment of loss or gain in terms of seconds per month, a stroboscopic method of comparison would be advisable, and the ratio could be arranged to permit the reading of loss or gain of seconds for a small period after preliminary synchronism? This of course is the all-important test for watchmakers and repairers.

\* \* \*

## Long-Playing Needles

ARE THERE any particular phonograph needles that play more records,

without becoming useless, than do the average needles?—E. D.

Yes. There is a cadmium needle that is good for playing about 150 records of the 12-inch variety.

\* \* \*

## Suiting Speaker to Set

IN MY RECEIVER there is an 1,800-ohm straight field coil, through which power tube current does not pass, but the resistance is used for dropping the maximum B to the value needed for r-f tubes. I have a much better speaker, 2,500 ohm field, and put that in, but the volume was far less. Could this be due to the inherent difference in the speaker sensitivities or would you suppose the field resistance difference had something to do with it?—L. J. C.

It is of course possible that the speakers have different sensitivities, but it is reasonable to assume that 2,500 ohms dropped the B voltage too much and affected the r-f gain. This could be determined readily by re-inserting the speaker with 2,500 ohm field, and putting across this field a fixed resistor of 2,000 ohms, or a bit more, 10 watts rating. This is permissible as the speaker field is not used for filtration in any important sense, but the r-f tube current through the field is used for excitation of the field. Another expediency would be to connect one side of the 2,500-ohm field to B plus next to rectifier, where the voltage is higher than the present source of feed to the power tubes. Also you could unwind part of the field winding to substitute the new speaker for the old at the same field resistance, but this is not advisable, because the sensitivity of the speaker depends considerably on that field, particularly the ampere turns of the field winding.

\* \* \*

## Cathode-Ray Potentials

IN DIAGRAMS put out by RCA and others I note that cathode-ray oscillograph circuits are shown with timing voltage introduced on one plate only, as the other plate is grounded, and as B plus is grounded, an intended center-tapped resistor between plates is shorted for half of its resistance. That leaves one plate effective, as to the sweep frequency, without the precaution against distortion that the two resistors are supposed to create, due to equalization of d-c potentials.—R. D.

As you state, if B plus is grounded, and  
(Continued on next page)

# Amateurs Hear Own Signals Return to Them

(Continued from preceding page)

has an amateur obtained his licenses than he surprises everybody with the rapidity with which he assembles his equipment. No sooner is his apparatus in order than he is attempting to communicate with someone over the ether. Not only does psychology explain his sudden enthusiasm but it also explains the reason for the various erratic actions and statements of the man at the other end of the conversation.

When you arrive at that day when you start to entrench yourself in the business world, you will find that a knowledge of psychology is a valuable asset in your conversations. For it is only by sizing up the individual you are talking to that you can best accomplish any persuasion necessary. Now, since amateur radio contacts consist mainly of conversations where the other party is invisible, you have to use utmost tact and diplomacy in framing your statements. Further, radio knows no distance limitations. Consequently, you have the power to engage in conversation with a great number of personalities. And, you'll discover the great

diversity extant in human natures—the basis of psychological study.

How do you study geography by engaging in amateur radio? It is apparent to you all that radio bridges all distances. How many times have you boasted of receiving Chicago or New York stations on your broadcast receiver? Even there, in the realm of receiving alone, you are acquainted with remote places in a manner that no geography book can equal. How much more valuable is it to be able to converse with these remote locations? With the present-day amateur, Chicago and New York are as the next room. They deal, instead, with expeditions at the North Pole, or Frenchmen, New Zealanders in their native country or others. To speak half way round the earth is a commonplace occurrence now-a-days. Is this not more potent a means of imbedding geographical knowledge into stubborn craniums? At this point, I am reminded of the many amateurs who have claimed to have heard their own signals come back to them after having traveled round the earth! Here we become engaged in a study of planets and eventually become in-

involved in astronomy. The next question one asks is: How does one study languages by engaging in amateur radio? It has been said that we find it easy to pick up foreign radio stations. What do we talk about when we do? If we are the average, we ask about the weather. Just like the man you all know who has become accustomed to intone "Fine weather, isn't it?" to you, so that he is making that statement in the cloudiest of drab days. After you have spoken about the weather, you will have noted various foreign mannerisms of your new friend. If you are quick to take advantage, here is an opportunity to converse with Frenchmen, Germans, Italians, Cubans, etc. No longer will the man who can converse in seven tongues be the subject of deep and reverential admiration. For, he will have become as the sand on the beach!

Thus, besides the valuable experience obtained in the science of electrical engineering, the radio amateur becomes a highly cultured man and can face the world with a fuller appreciation of its aspects, and, indeed, enhance his possibilities and opportunities of success.

(Continued from preceding page)

a sweep oscillator output has one side grounded, connected to one c-r plate, high side to other plate, one plate then is directly grounded and the resistance apportionment is destroyed, nullifying the intended distortionless effects. The fact B plus was grounded may have been overlooked as to its effect on the voltage-equalization resistance circuit. A condenser for picking up the grounded side of the sweep oscillator would preserve the plate potential equalization in the c-r tube.

\* \* \*

### Photo Cell As Rectifier

WHEN A PHOTO CELL is used, would you say that it operates on a principle of rectification of light? Connected to the cell would be a voltage (unless the cell were self-generating), and the battery has a negligible resistance, or should have. The cell is then made to work a relay directly, that is, provided that the cell is sensitive enough. When an amplifier tube is used there seems to be a better operating condition but I often wonder why this particular type of rectifier (photo cell, provided it is a rectifier) does not have a load resistance in a series, the same as practically all other rectifiers. —R. W. F.

A photo cell may be classified as a rectifier of light, since light is a. c. and constitutes the input, while the current is d. c. and constitutes the output. The change in the direct current is due to the difference in the intensity of the lamp or its proximity to the face of the cell and has nothing to do with the frequency of light, which the cell filters abundantly, as you may well imagine. Though the cell current is small, the resistance is not necessarily high, because the voltage is small, for the ba voltaic type, and much smaller for the self-generating type. In a given instance of a 50-watt lamp 1 foot from a selenium cell, excited by 22.5 volts of battery, the current read was 4.5 milliamperes compared to 2 milliamperes at small illumination. Therefore the resistance of the cell decreases, the greater the light put into it, and when practically no light is put in, the resistance is 10,000 ohms. That would indicate the desirability of a load resistor for any purpose of obtaining differences in terms of voltage, due to the small change through the large resistance creating a ratable voltage difference. In diode rectifiers in radio sets, load resistors often have a ratio of 100 to 1, compared to the conducting resistance of the tube at some ascribed input. If voltage utilization of the output of the cell is desired, the load resistor should be very helpful, and consistent with the general practice of rectification in radio. But somebody once classified the cell as current-operated, and since then it has been dangerous to life to speak in terms of voltage utility, although the terms "current-operated" and "voltage-operated" have scarcely any meaning, as no means of driving current without voltage has yet been devised. Only the voltage causes a neon lamp to ignite, due to the electrons breaking down under the pressure, and yet the neon lamp is called a "current-operated device" because the specific utilization is that of the effect of changes in current values. Of course, the effect of high resistance load on frequency characteristic has to be considered.

## WLW Seeks Permanent License to Use 50 kw.

The Crosley Radio Corporation, owners and operators of station WLW, have filed application with the Federal Communications Commission for permanent license to operate with 500 kilowatts of power.

# Station Sparks

By Alice Remsen

### JACK AND LORETTA SPOTTED

THAT POPULAR TEAM OF SONG AND CHATTER FAME, Jack and Loretta Clemens, who have been doing such good work on "The Gibson Family" programs, now have a commercial spot of their own, each Sunday morning at 11:15 on WEA and the red network. They are sponsored by the makers of the Venida Beauty Aids for the Hair. They are a clever couple; besides singing solos and duets, Jack plays guitar and banjo, and Loretta plays the piano. . . . Another new Sunday program is the "Immortal Dramas" series, sponsored by Montgomery Ward. Drama, music and narration are effectively employed in these presentations. Every Sunday at 2:00 p. m. over coast-to-coast NBC-WEAF network. . . .

### FAST AND FURIOUS

I had a rather amusing experience last week; had just finished my Wednesday morning program, when the studio door opened and John Tasker Howard rushed in. Mr. Howard, as you probably know, is the distinguished authority on American music who presents the 10:30 p. m. Monday evening series on WJZ, "America in Music." Mr. Howard was very excited; he asked me if I wrote song lyrics; receiving a reply in the affirmative, he literally dragged me down to the NBC music library, handed me a lead sheet and begged me to write a lyric on television for the music which he had just then composed. He had only the chorus; the music for the verse was being written by Claude MacArthur, one of NBC's crack arrangers. I asked Mr. Howard what it was all about, and he told me he had programed a television song for the following Monday, and at the last moment had discovered that he could not use the song; his continuity was already written and he didn't want to change—so, we just had to write a television song—and we did—in less than half an hour I had written two verses and two choruses, and Mr. MacArthur had composed the music of the verse and made a piano copy of the whole thing, from which he proceeded to make an orchestration. Mr. Howard's continuity was saved. I sang the song on the program, and everybody was pleased all 'round, the possible exception of the listening radio public, although up to the present writing we have received no complaints. . . .

### JACK STILL WHISPERS

Whispering Jack Smith, one of the veterans of radio, has a new series, sponsored by the Ironized Yeast Company, three times weekly, Tuesday, Thursday and Saturday, at 7:15 p. m., over an NBC-WEAF network. He will be accompanied by his own twelve-piece orchestra. Jack dates back to the crystal set and earphone days of radio, and originated the confidential style of singing which earned him his nickname—and that all came about by accident. Jack told me he had a cold one day, didn't want to sing; nobody to take his place—so he whispered, and has been whispering every since. . . . Jimmy Wallington hasn't changed a bit since he was awarded his second medal for diction. Last year Jimmy was singled out for the honor by the American Academy of Arts and Letters; this year it was the Radio Stars Magazine that presented him with a medal. Judgment for the award was based on diction, delivery, microphone personality, adaptability to the mood of the program, and versatility. . . .

Ruth Etting, famous singer of stage, screen and radio, returned to the air for her first regular series in several months as the star of the new Kellogg College Prom, to be inaugurated over an NBC-WJZ network on Thursday, January 24, at 7:45 p. m., E. S. T. Red Nichols and his popular college prom orchestra, including the Red Nichols Songcopaters, well-known male trio, furnish the dance rhythms and vocal choruses for the weekly broadcasts and each week some noted college coach or athlete is presented as a guest speaker at the half hour program from the NBC Radio City studios. . . .

### MOULDING "THE O'FLYNN"

That colorful romantic series "The O'Flynn," heard over WABC on Fridays at 10:30 p. m., is being directed by a very capable and artistic man, William Bacher. It is a pleasure to watch him at work with his actors, practically moulding them with his long, nervous fingers, with arms waving in the air, his reddish hair standing up straight with vital energy, and a disarming grin on his face. No less dynamic is Nat Shilkret, who conducts the orchestra and sings very quietly and efficiently. In addition to numbers from the current Broadway production from which "The O'Flynn" is taken, new songs are written each week by Conductor Shilkret and Henry Neeley, the latter being co-author with William Bacher of the broadcast series. Lucille Wall, Ray Collins and Peggy Allenby are featured in the speaking parts, and Viola Philo and Milton Watson play the singing roles. . . .

### GOOD OLD BILL BRADY

A very interesting CBS series is William Brady's program of colorful reminiscences, heard each Sunday night at 10:30. Mr. Brady tells tales out of school about politics, sports, motion pictures, the theatre and all the other enterprises with which he has been associated throughout his long and honorable career. A very well worth-while program. . . . There are two new late dance orchestras on CBS to enliven evenings at home—Cab Callo-way's, Friday, Saturday and Sunday evenings at twelve midnight from the Cotton Club, and Johnny Green's on Tuesday and Saturday at 11:30 p. m. from New York's fashionable Hotel St. Regis. . . . There is a new series of programs now coming over Station WOR. They are very unique—a sort of modern Arabian Nights; written by Marion Parsonette and entitled "Dark Enchantment"; each Tuesday night at 9:30. . . . Following a vacation from the air-waves, Arthur Tracy, known as The Street Singer, has returned to the air, over WOR and the Mutual Broadcasting System's network of four powerful stations (WOR, Newark; WLW, Cincinnati; WGN, Chicago; and WXYZ, Detroit). Sponsored by the Scholl Manufacturing Company, Tuesdays, Thursdays and Saturdays at 7:30 p. m. . . .

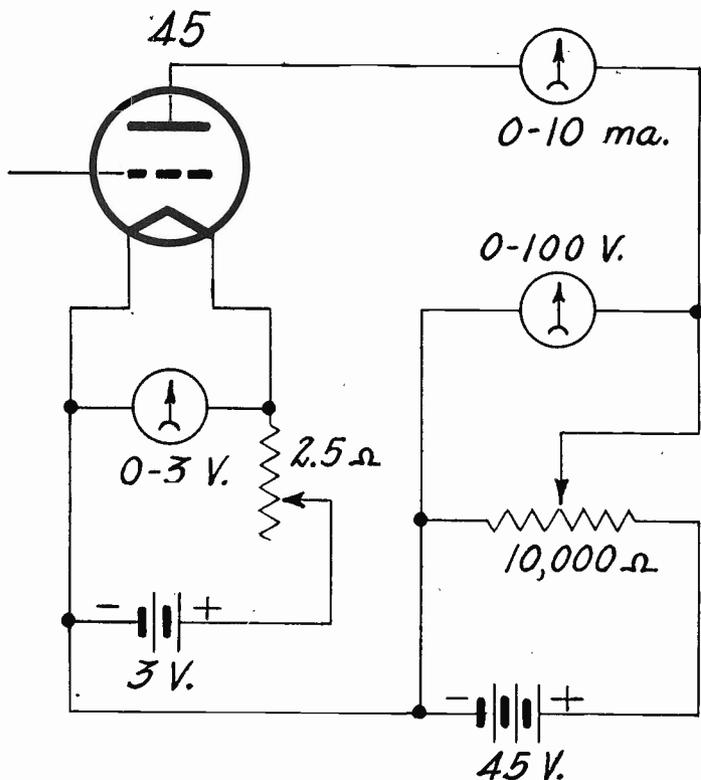
## Three Get Setback in Ham License Quest

Myrle M. Sullivan, Brooklyn, N. Y., William Frock, Eagle Rock, Calif., and Sanford Luftig, New York City, have been barred from examination for radio operator privileges for a six-month period because of having been found guilty of operating unlicensed amateur radio stations without valid operator licenses.

# Regular Tubes Photo-Electric

## Magnesium Inside Envelope Used for Economical "Electric Eye"—Results Shown for a 45 Tube

By Samuel Wein



The measurements of photo-electric action possible with an ordinary 45 type vacuum tube were made with this circuit.

and for complete light. The data then were accumulated for different filament voltages of the following values: 0.75, 1.0, 1.25, 1.5, 1.75, 2.5. The results are indicated below:

Filament Voltage—	DARK	LIGHT
0.75 volts:	Plate current (ma.)	
10 volts $E_p$ .....	.1	.1
20 volts $E_p$ .....	.1	.1
30 volts $E_p$ .....	.1	.1
40 volts $E_p$ .....	.1	.1

Filament Voltage—	DARK	LIGHT
1.0 volts:	Plate current (ma.)	
10 volts $E_p$ .....	.25	.4
20 volts $E_p$ .....	.9	1.0
30 volts $E_p$ .....	1.15	1.2
40 volts $E_p$ .....	1.2	1.25

Filament Voltage—	DARK	LIGHT
1.25 volts:	Plate current (ma.)	
10 volts $E_p$ .....	.35	.6
20 volts $E_p$ .....	1.9	2.05
30 volts $E_p$ .....	3.6	3.65
40 volts $E_p$ .....	4.9	4.9

Filament Voltage—	DARK	LIGHT
1.5 volts:	Plate current (ma.)	
10 volts $E_p$ .....	.4	.7
20 volts $E_p$ .....	2.35	2.75
30 volts $E_p$ .....	4.7	5.2
40 volts $E_p$ .....	6.8	7.7

Filament Voltage—	DARK	LIGHT
1.75 volts:	Plate current (ma.)	
10 volts $E_p$ .....	.37	.65
20 volts $E_p$ .....	2.75	2.9
30 volts $E_p$ .....	6.0	6.05
40 volts $E_p$ .....	9.55	9.55

Filament Voltage—	DARK	LIGHT
2.0 volts:	Plate current (ma.)	
10 volts $E_p$ .....	.3	.7
20 volts $E_p$ .....	2.8	3.0
30 volts $E_p$ .....	6.3	6.9
40 volts $E_p$ .....	10.5	10.5

Filament Voltage—	DARK	LIGHT
2.5 volts:	Plate current (ma.)	
10 volts $E_p$ .....	.4	.64
20 volts $E_p$ .....	2.7	2.95
30 volts $E_p$ .....	6.5	6.6
40 volts $E_p$ .....	off scale	off scale

$E_p$  is designation of plate voltage.

From a consideration of these data it would seem that the most effective photo-electric action that could be obtained from a 45 tube under these conditions of light would be when the filament voltage was 2.0 volts and the plate voltage was 10 volts. Under these circumstances the change from dark to light conditions would cause a change in plate current from 300 microamperes to 700 microamperes, which is a change of 233%. That should be effective enough for any sensitive relay.

### Successful System

In conclusion, it might be stated that if a 45 tube is energized with 2 volts on the filament and 10 volts on the plate (quite an economical power supply) and operated in conjunction with a sensitive relay, an automatic lighting system could be set up that does not burden anyone's pocketbook and could be made to operate most successfully.

MANY a fan has at one time or other wondered why some vacuum tubes that he purchased contained more or less of a silver coating within the bulb than another tube. He has also wondered what its purpose was, since to all appearances it was without any utility. That is partly true. It has no or little utility after the tube is purchased, since it has already served its purpose in the process of manufacture and merely remains as a vestige of that occasion. For, during the manufacturing process, this silver-like film on the interior surface of the glass bulb was deposited as a result of the "flashing" process wherein some magnesium powder was ignited to absorb any residual gases within the bulb after the evacuating pumps had done their best.

In this reaction, the magnesium becomes deposited on the walls of the bulb and appears as a silver-like film.

During the early years of radio, when radio was not advanced to the present degree and vacuum pumps did not do as good a job as at present, the vacuum tube of that day contained instead of the silver-like deposit a rainbow-hued film due to the different compounds formed from the residual gases. Since there is very little residual gas in a modern tube, most of the film on the bulb is pure magnesium and has a mirror-like appearance. This film has always been regarded as not performing any function after manufacture.

### Surprising Results

However, it begins to appear that this film is perhaps a blessing—at least to the experimenter who has a limited pocketbook. For, it has been found that this film has photo-electric properties. True, this film does not function as well as an orthodox phototube,

but serves some experimental purposes. Well, one experimenter discovered that the common, ordinary, everyday garden variety of 45 type of radio vacuum tube could perform this function quite effectively and so a series of tests was run on this tube under different conditions of filament and plate voltages and the resulting data are indeed surprising.

The diagram on this page shows how this tube was connected up for the test. It will be noted that provision has been made for a variability in the plate and filament voltages which could be measured by appropriate voltmeters in addition to a milliammeter to measure the plate current that would be an indication of the photo-electric effect. In this test, the grid was left free, although it could probably be tied to the plate just as well. However, if this is done, the values given that resulted from this test would be different.

In addition to the equipment indicated in the diagram, an automobile headlight bulb of 32 candle power furnished the source of illumination from which the photo-electric effect would be tested. This bulb was located about 52 inches from the 45 tube and was equipped with a focusing lens that fed the light to the 45 in such a way that the beam struck the electrodes of the tube from the top of the bulb, the side opposite the base. Thus, the light permeated the region enclosed by the plate of the tube, and occupied by the filament and the grid.

### Results of Tests

In the test two conditions were enforced, no light and full light. Then for a given filament voltage, the voltage on the plate of the tube was varied in steps of 10 up to 40 volts for conditions of complete darkness

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4	50	600	3000
5	100	700	4000
6	150	800	5000
7	200	1000	6000
10	250	1250	7000
15	300	1500	8000

20 WATT ..... 20¢ EACH

30 WATT ..... 25¢ EACH

50 WATT ..... 29¢ EACH

SIZES IN OHMS

100	1,000	12,500
200	1,500	15,000
250	2,000	20,000
300	3,000	
400	4,000	in 50 watts only
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500	6,000	30,000
600	7,000	40,000
700	8,000	50,000
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## LATHE..

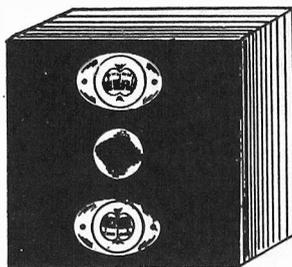


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## SCALE READS DIRECTLY IN FREQUENCIES AND WAVELENGTHS

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

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

## GUARANTEED ACCURACY IS 1%

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

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

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

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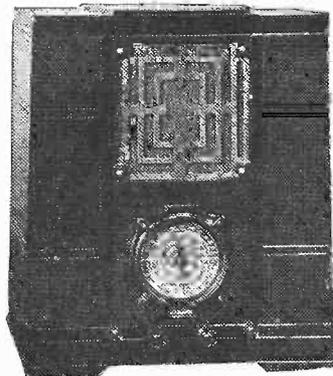
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**DE LUXE TABLE MODEL**  
\$32.70

quality and selectivity are excellent. Sensitivity is remarkably high as far as consistent with low noise level.

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

Cat. 1008-WCH, wired chassis, with eight RCA tubes (one 6A7, two 6D6, one 75, one 76, two 42 and one 80) and heavy-duty dynamic speaker, 50-60 cycles, 110-125 v. Primary power consumption 80 watts. Chassis 13" wide, 7" high, 8 1/4" front to back. Shipping weight 25 lbs.)..... **\$26.10**

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

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

Cat. 1008-WDL, standard chassis in de luxe table model cabinet 14 1/2" wide, 16" high, 9 1/2" front to back (28 lbs.)..... **32.70**

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

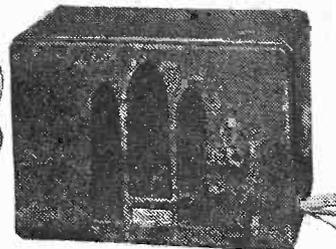
Cat. 1008-WCO, console model, 21" wide, 36 1/2" high, 12" front to back (51 1/2 lbs.)..... **41.70**

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



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



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

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

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

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



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

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

Model 1042-PD, illustrated at left, is the same circuit in a de luxe table cabinet. The two table models have an airplane frequency-calibrated and illuminated dial, and besides can be obtained for battery operation and 32-volt operation. It is a superheterodyne of the switch type, covering the broadcast band and 18 to 55-meter short-wave band. It has automatic volume control and tone control. It is for 105-120 v. 50-60 cycle operation. Primary power consumption 60 watts; shipping weight, 17 1/2 lbs. Net price. **\$20.37**

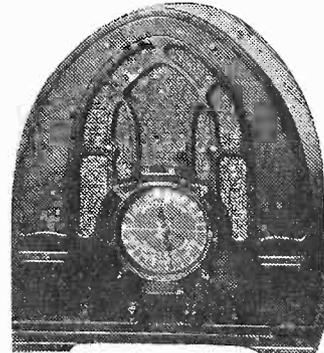
Cat. 1042-PCH, wired chassis, 9" wide, 7" high, 6" front to back; dynamic speaker, five RCA tubes (one 6A7, one 6D6, one 75, one 42 and one 80), 550 to 1,500 kc and 5,500 to 16,000 kc. For 50-60 cycles, 110-125 v. (14 1/2 lbs.) **\$17.10**

Cat. 1042-PG, table model Gothic cabinet. (17 1/2 lbs.)..... **\$19.17**

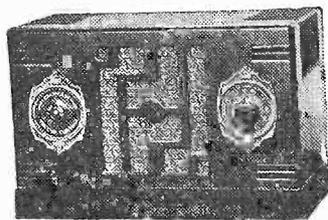
Any of 1042 series, 50-60 cycles, 220 v. @ 60c extra; 110-125 v., 25 cycles @ \$1.50 extra. Cat. 1042-PBCH, battery model chassis for 6-volt storage battery and B battery operation (batteries not supplied); complete with tubes and speaker. (14 1/2 lbs.) **\$21.90**

Cat. 1042-PBG, same as above (battery model) in Gothic cabinet, with tubes, speaker. (17 1/2 lbs.)..... **\$23.97**

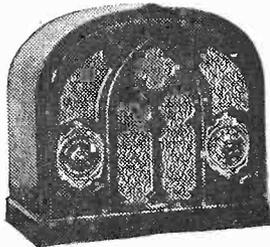
Cat. 1042-PBD, battery model, in de luxe table cabinet. (17 1/2 lbs.)..... **\$24.17**



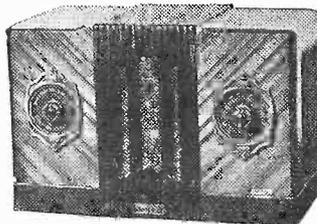
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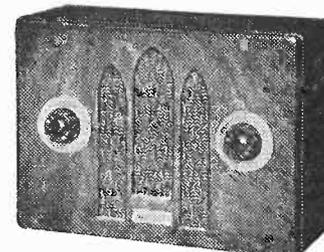
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FOR those interested only in the broadcast band we have a splendid ac t-r-f model DIAMOND OF THE AIR that tunes from 540 to 1,900 kc, and therefore gets some police and amateur calls as well; that has frequency-calibrated and illuminated airplane dial; and that can be bought, complete with tubes, all wired and ready for operation of its self-contained dynamic speaker (left-hand illustration above) at only \$13.17. Order Cat. 1041-XG, for 50-60 cycles a.c., 105-120 volts. The same set is illustrated at right in de luxe cabinet, price \$13.77. Order Cat. 1041-XD. Not only may the receiver be bought already in either cabinet, but separately as a wired chassis, with speaker and tubes (less only cabinet). Besides, there is a model for 25 cycles a.c., 90-120 volts, and another for 220 volts a.c., 50-60 cycles. This is a tuned-radio-frequency receiver, five-tube model, using two 6D6, one 6C6, one 42 and one 80. It will be noticed that the economical and electrically strong 6-volt series tubes are used in the receivers proper. The primary power consumption is 55 watts. Not only is this a fine receiver, but it is made right, and every attention has been paid to detail. The airplane type dial is frequency-calibrated, so that the frequencies are read directly. There is provision for phonograph connection. The wired chassis is Cat. 1041-XCH, complete with speaker, tubes, \$11.97. Shipping weights of 1041 series, 11 1/2 lbs. 25-cycle models, \$1.20 extra. 220-volt models 60c extra.

The above set is a two-band 5-tube ac-dc universal receiver for 50-60 cycles, 110-125 volts, and is Cat. 1042-U, \$17.37 (10 1/2 lbs.). It uses one 6A7, one 6D6, one 75, one 43 and one 25Z5. Sold complete with RCA tubes. Ranges, 550 to 1,500 kc, 5,500 to 16,000 kc. Approximate kilocycle calibration. Band change by switching.

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

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



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

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

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

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