RADIO WORLD

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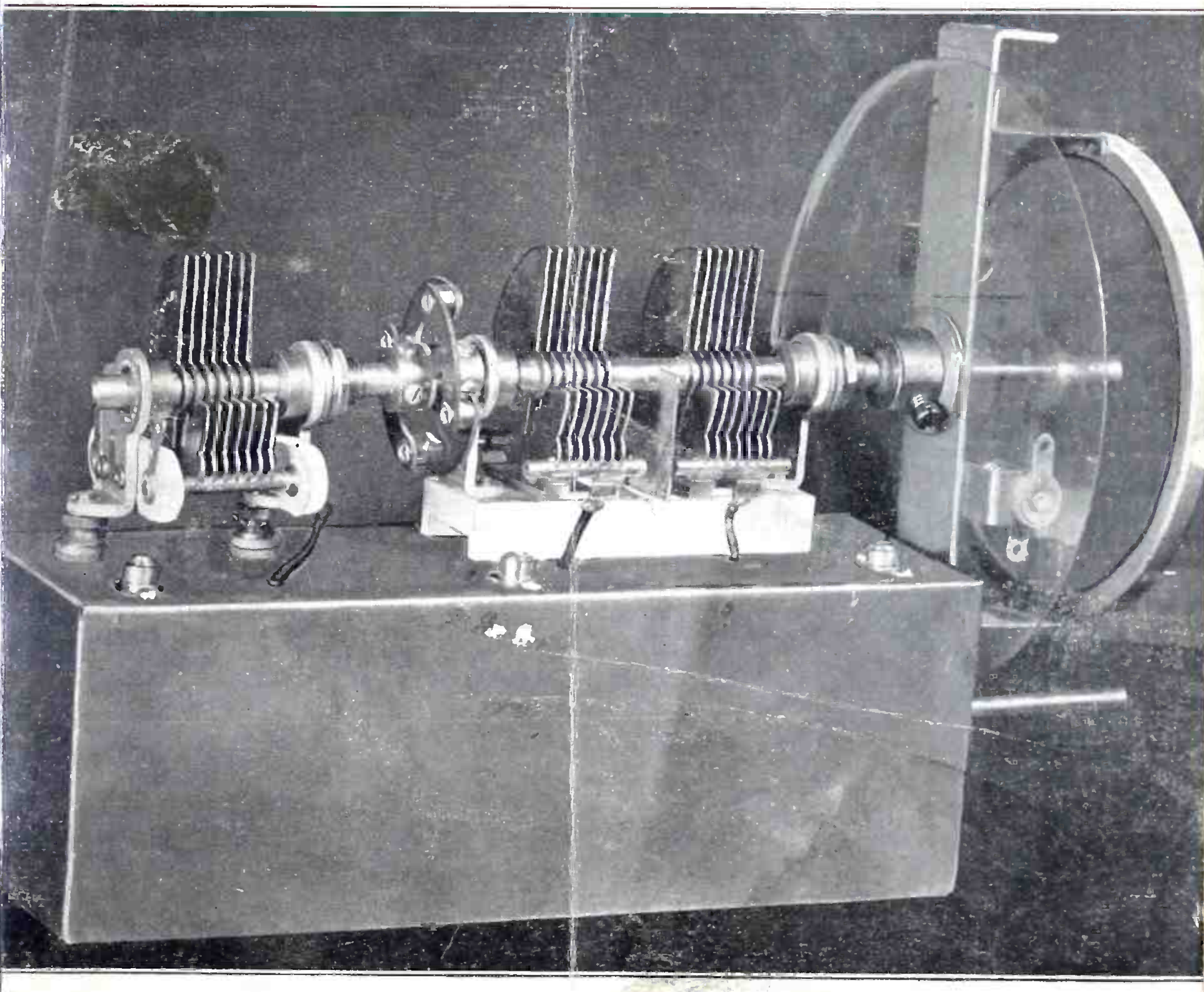
THE HOW-TO-MAKE-IT MONTHLY—*14th Year*

125 EXCLUSIVE ILLUSTRATIONS

INSTALLING AUTO SETS

June 1935
25c per copy

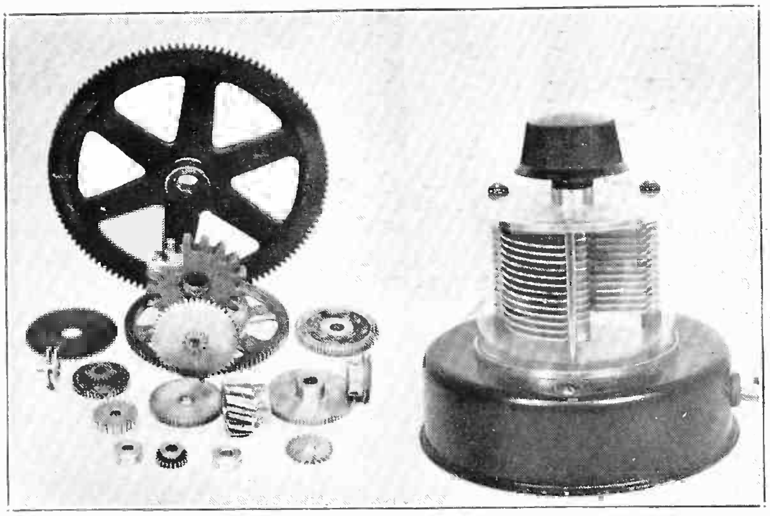
Straight Frequency 'Liner'



PERFECTION

This three gang condenser arrangement, with air dielectric trimmers, produces a perfectly straight frequency line, one of the few such examples in radio. See page 49.

LEOTONE'S STOREHOUSE of Radio Treasures



GEAR KIT

OFTEN the experimenter wants a certain gear—needs one for a specific reduction ratio, dial experiment or inventive drive. Here is an opportunity to obtain a choice variety of brass and phosphor bronze gears. Kit of 20 assorted pieces **$1.89**

WAVE TRAP

INTERFERENCE on the broadcast band is easily eliminated by use of a wave trap. Powerful locals trapped out completely. Full broadcast range covered with precision condenser and spider-web coil. In dust-roof case on solid base. Ready to use **$1.35**

Solution!

We have a stock of more than 120,000 separate pieces—all radio—filling four floors and basement of building exclusively occupied by us. Whatever you want in radio you will no doubt find we have it in our vast storehouse of radio treasures. Dealing with us is the solution of your problems.

PORTABLE FOR SHORT WAVES

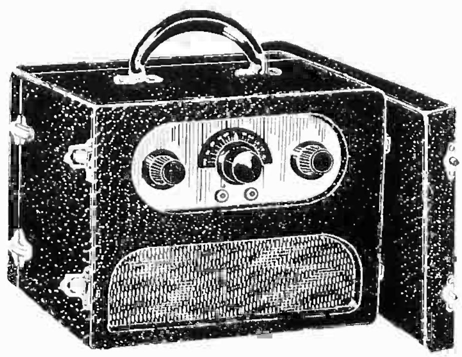
FOR earphone reception of short waves we have a splendid portable for every indoor and outdoor use. It has a 34 r.f. tube, a 32 regenerative detector, a 32 audio driver and a 30 output. Four tubes, fine performance, easy operation.

Complete kit (less tubes, earphones) but including cabinet and batteries **$9.25**

Extra for wiring the kit **2.50**

Extra for tubes **2.00**

Four plug-in coils are included, in short waves only. Set of two broadcast coils, **$1.25** extra.



For that Summer jaunt, vacation at shore or mountain side, or for week-end trips, enjoy our portable short-wave set. Broadcast band coils obtainable also.

LEOTONE RADIO COMPANY

Occupying the Entire Building at

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RADIO WORLD

The How-to-Make-It Monthly—Fourteenth Year

ROLAND BURKE HENNESSY
Editor

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HERBERT E. HAYDEN
Advertising Manager

Table of Contents for JUNE, 1935

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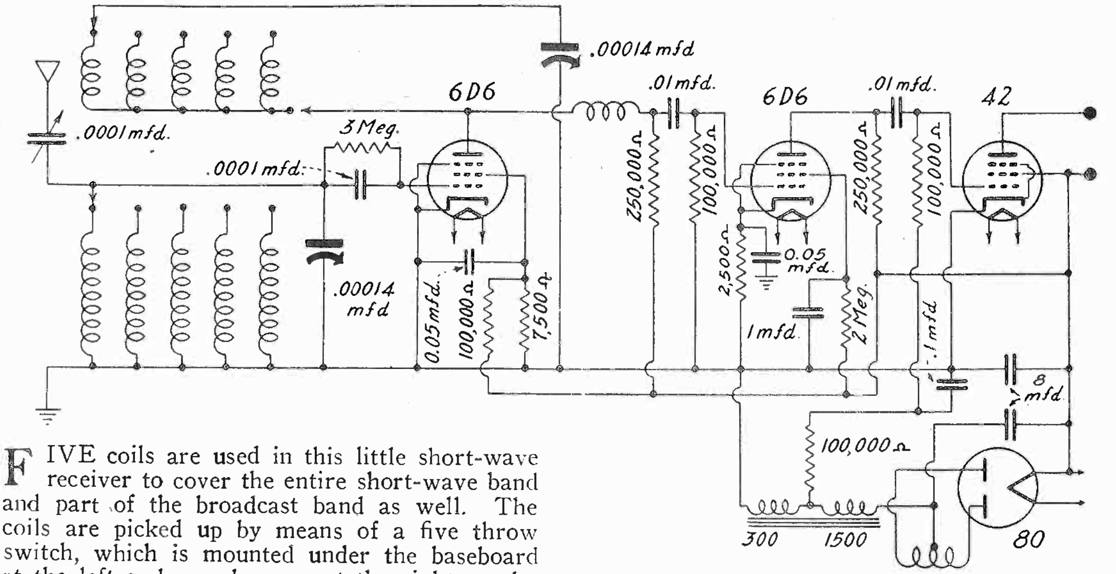
Coil Switch Assembly

In Regenerative S. W. Detector

By Max Steir

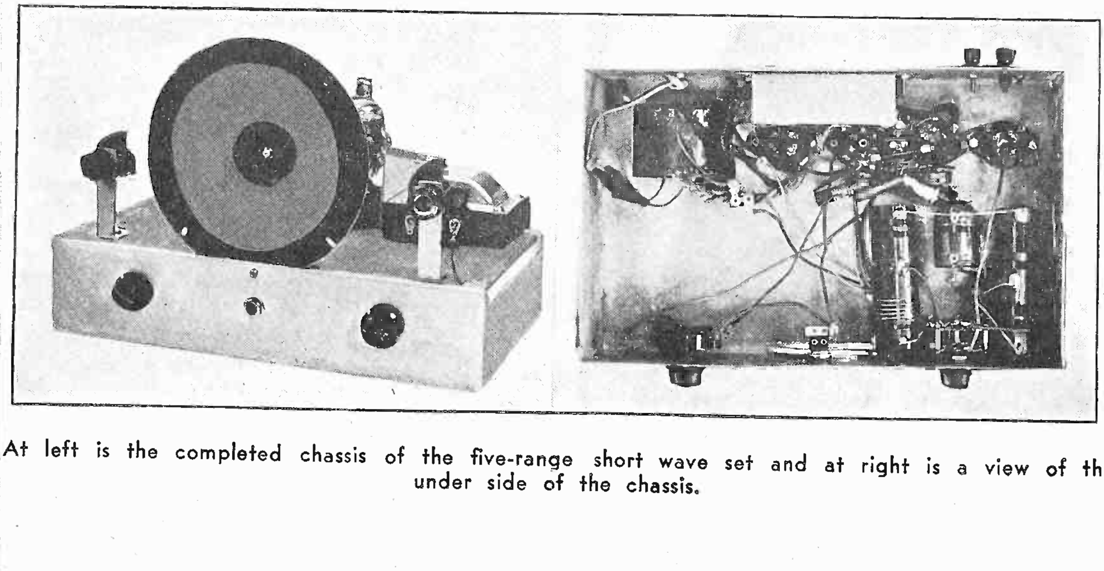


Five coils are used for covering the entire sho wave band in this four-tube, a.c. receiver. The output is sufficient for a loudspeaker.

FIVE coils are used in this little short-wave receiver to cover the entire short-wave band and part of the broadcast band as well. The coils are picked up by means of a five throw switch, which is mounted under the baseboard at the left and may be seen at the right on the photograph of the underside of the chassis. Either three pole, as shown, or two pole switches will do the trick. The tuning and regeneration control condensers are mounted on brackets and are clearly seen on the picture of the chassis, one on each side of the loudspeaker. The capacity of each of these is 140 mmfd. A small adjustable condenser of 100 mmfd. maximum capacity is put in the antenna circuit to make the circuit more selective and to accommodate the antenna to the various wavelengths that may be tuned in. Its setting has a great deal to do with the control of the regeneration and with the presence of dead spots in the tuning ranges. To avoid dead spots and to insure oscillation the condenser should be small.

Outside the coils all the parts are specified. The radio frequency choke in the plate circuit of the oscillator should be pie wound.

SETUP OF THE SWITCH TYPE SET

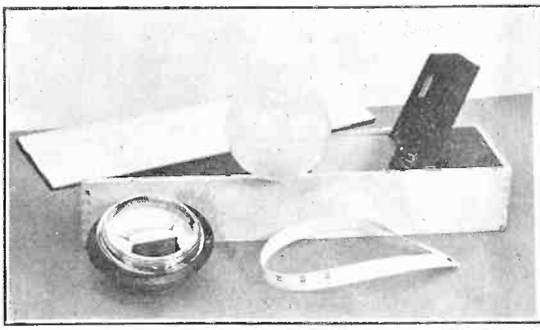


At left is the completed chassis of the five-range short wave set and at right is a view of the under side of the chassis.

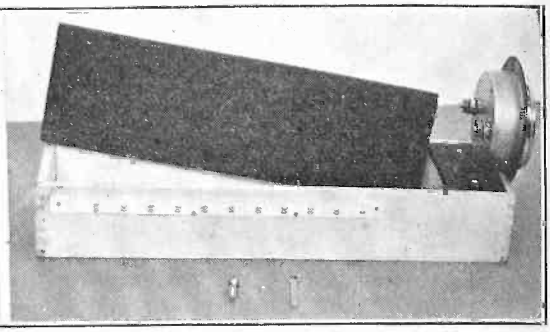
Ultra Frequency Power

Measured with Photocell and Lamp

By Brunsten Brunn



Strip at right is no collar for toy horse but a scale from an old drum dial, 0-100. Meter stares you in face. Box contains slide panel, 50 watt lamp and photoelectric cell, all ready to be boondoggled.



Meter is fastened to one end of the box the scale is affixed to side. The slide cover somehow has undergone a color metamorphosis, which please disregard.

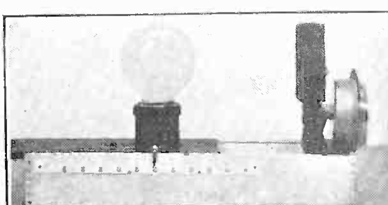
THE measurement of power at ultra high frequencies presents a difficult problem. Ordinary meters do not work at all or they work so poorly that the indicated power is only a small fraction of the power involved. One of the main reasons is capacity. Even minute distributed capacities are sufficient to by-pass the high frequency currents so that they do not reach the element in which the power is to be dissipated. The most successful means for measuring ultra high as well as lower radio frequencies are those based on the heating of an element, usually a small resistor.

One method that has been applied recently for measuring ultra high frequency power of considerable magnitude utilizes a lamp and a photoelectric cell. The power to be measured is used for heating the filament of the lamp to incandescence and the photoelectric cell to measure the intensity of the light. This, of course, is done with a d.c. meter, since the photoelectric current is direct.

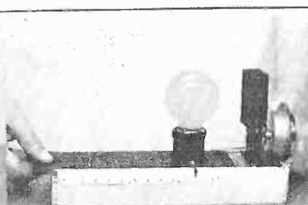
LAMP MAY BE MOVED

The arrangement is illustrated in the photographs herewith. The photoelectric cell and the meter with which its output is measured are mounted at one end of an arrangement similar to that of an optical bench. The lamp is also mounted on this bench but in such a manner that it can be moved to different distances from the photocell. For a given power dissipated in the incandescent filament the photocell current will depend on the distance of the lamp from the cell.

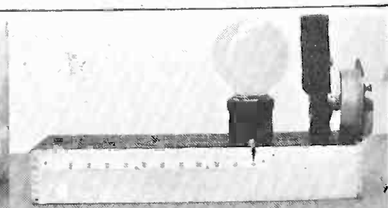
Assuming that the photocell current is directly proportional to the amount of light flux entering the cell, which is true, the amount of



Index is attached to the slide cover that fits into grooved sides of the box, so as lamp is attached to the cover the lamp is moved with the slide and the position indicated relatively by the index.



Now watch closely and you will see the lamp is closer to the photoelectric cell. The relative index previously indicated 50 now indicates 13. Select a distance that gives a convenient deflection.



An end stop is provided so that the lamp can not be moved to produce an index of less than zero, because fellows don't know what to do with less than nothing even during a depression.

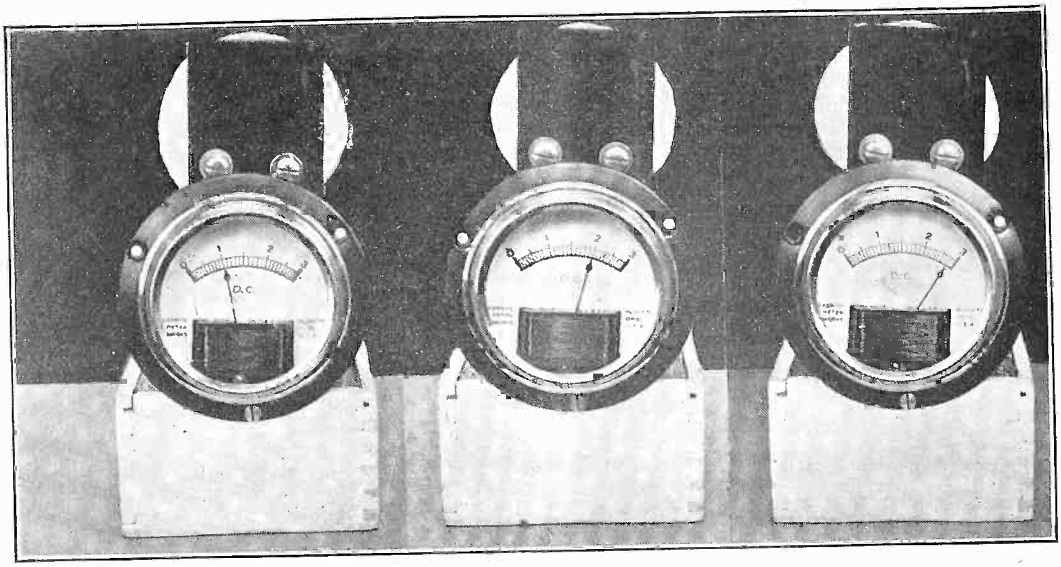
light entering is inversely proportional to the square of the distance between the lamp and the cell. For example, if the current is 25 microamperes when the distance is 5 inches, it will be 6.25 microamperes when the distance is 10 inches.

HEATED BY ULTRA FREQUENCY

The three milliammeters in a row on this page show three different deflections. The first indicates a current of one milliampere, the second two, and the third nearly three. The lamp is nearest for the third reading and farthest away for the first. If the intensity of the light is the same in the first two cases, the lamp is 1.41 times as far away for the first as for the second.

is of interest. If the lamp is connected in series with the antenna, the lamp will glow with an intensity depending on the value of that current. This current can be measured by the substitution method just explained. This current can be taken as a measure of the radiated power, for the power is the product of the square of the current and the radiation resistance.

The lamp has some resistance and this may be of nearly the same magnitude as the radiation resistance. Therefore the measured current will be less than the current would be if the lamp were not in the circuit. Therefore there is a considerable error. This error is less the greater the radiation resistance and also the lower the lamp resistance. This error is compensated for, in part, by the fact that not all the



Keep your eye on the needle. The first deflection denotes 1, the second 2 and the third 2.8. This is what happens to the needle, in general, when the lamp is moved nearer to the cell. More illumination on cell causes more current to flow.

The lamp can be heated by ultra high frequency current as well as with low frequency or direct current. One way of measuring the high frequency current is to send it through the lamp and note the deflection. Then, without making any change in the distances, the lamp can be heated with low frequency or direct current and that current adjusted until the deflection is the same as before. The power can be measured with ordinary meters. This is a substitution method, which is always considered to be the most accurate. Thus we have a means of measuring the ultra high frequency current or power. This substitution method is simple because it does not involve the light radiation efficiency of the lamp as it varies with the current. When the substitution method is used, the lamp can be moved along the scale until, for a given light intensity, the deflection has any desired value.

ANTENNA CURRENT

In a high frequency transmitter current flows in the antenna and it is this current usually that current is measured due to distributed capacity in the lamp leads.

RADIATION RESISTANCE

The method suggests a way of measuring the radiation resistance. Suppose the circuit be arranged so that there is no radiation. If then a high frequency resistance standard be substituted and varied until the photocell current is the same as it was when the antenna radiated, then it is known that the radiation resistance is the same as the value of the adjusted standard. But this still leaves the problem of determining the current through the radiation resistance when the lamp is not in series with the antenna. If the radiation resistance turns out to be high compared with the lamp resistance the error can be neglected. When the radiation resistance is known the current in the antenna can be computed in terms of the measured current, the lamp resistance, and the antenna resistance provided we make sure that the voltage induced in the antenna remains the same.

(Continued on next page)

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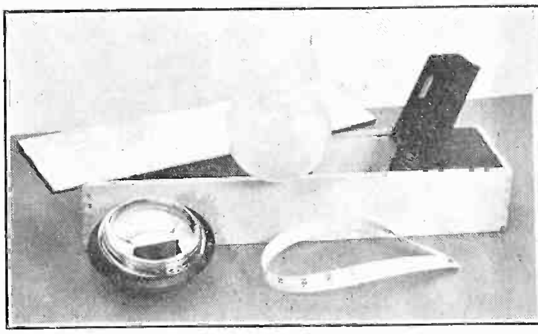

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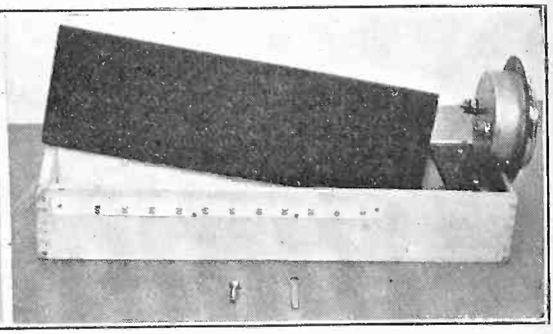

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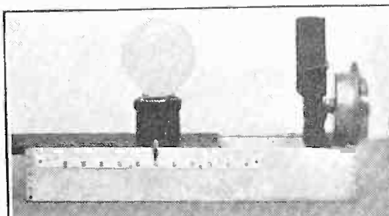

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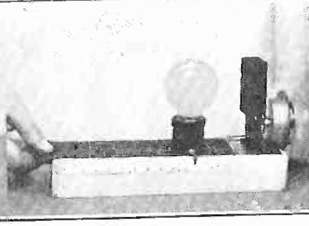

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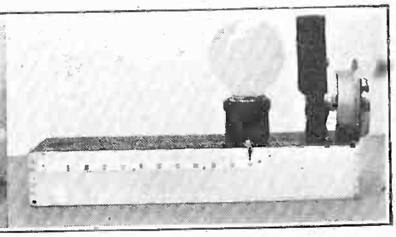

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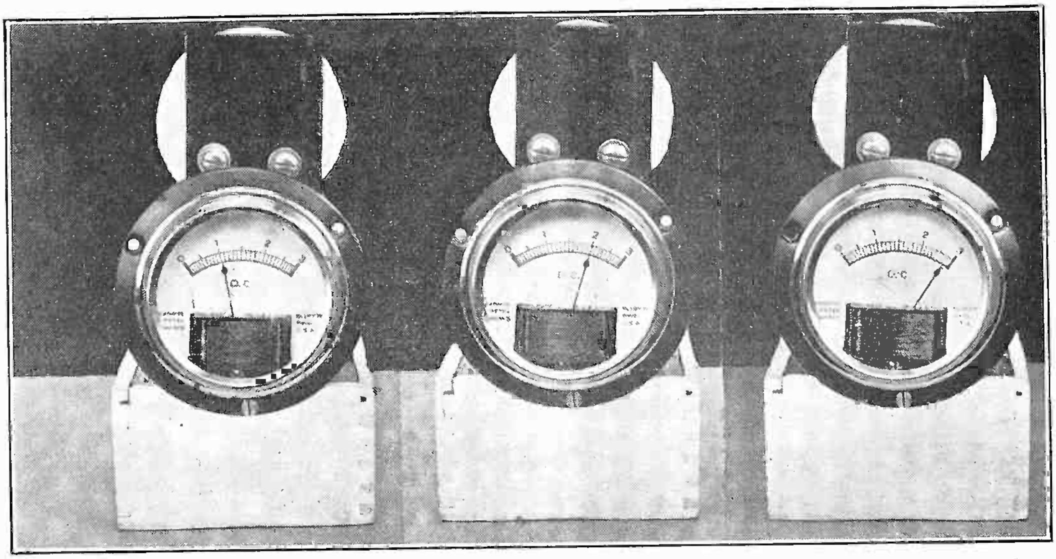

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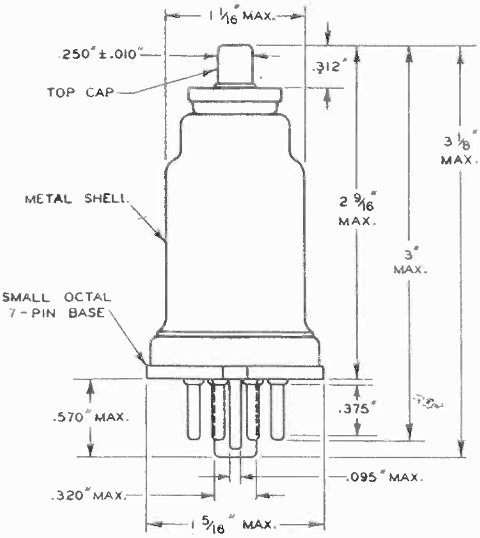
(*Continued on next page*)

Seventh Metal Shell Tube

6L7 is Pentagrid Mixer Amplifier



Dimensions of new tube.

Tentative Data on 6L7

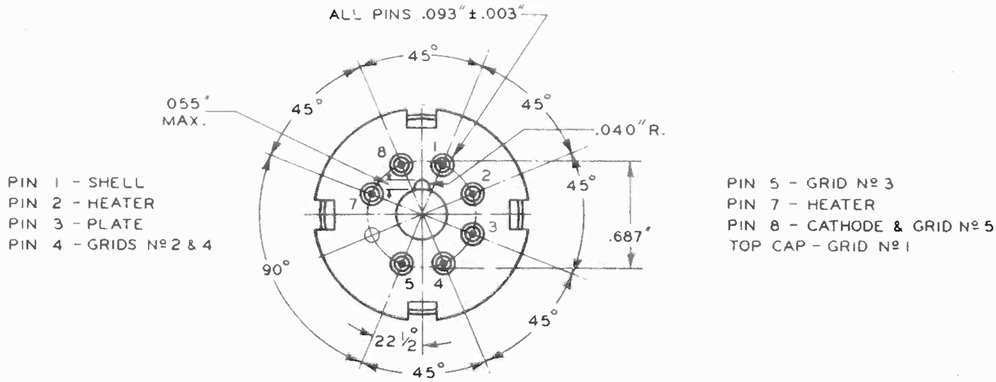
Heater Voltage (A.C. or D.C.)	6.3	Volts
Heater Current	0.3	Ampere
Maximum Overall Length		3⅛"
Maximum Diameter		1 5/16"
Cap		Miniature
Base		Small Octal 7-Pin

MIXER OPERATION

Plate Voltage	250 max.	Volts
Screen (Grids No. 2 & 4) Voltage	150 max.	Volts
Typical Operation:		
Heater Voltage	6.3	Volts
Plate Voltage	250	Volts
Screen Voltage	150	Volts
Control Grid (Grid No. 1) Voltage	-6 min.	Volts
Control Grid (Grid No. 3) Voltage	-20 approx.	Volts
	25 approx.	Volts
Peak Oscillator Voltage applied to Grid No. 3		
Plate Current	3.5	Milliamperes
Screen Current	8.0	Milliamperes
Plate Resistance	Greater than 2	Megohms
Conversion Conductance	325	Micromhos
Conversion Conductance at -45 volts bias on Grid No. 3	2	Micromhos

AMPLIFIER OPERATION

Heater Voltage	6.3	Volts
Plate Voltage	250 max.	Volts
Screen (Grids No. 2 & 4) Voltage	100 max.	Volts
Control Grid (Grid No. 1) Voltage	-3 min.	Volts
Control Grid (Grid No. 3) Voltage	-3	Volts
Plate Current	5.3	Milliamperes
Screen Current	5.5	Milliamperes
Plate Resistance	0.8	Megohm
Mutual Conductance	1100	Micromhos
Mutual Conductance at { -21 volts bias on Grid No. 1 } { -12 volts bias on Grid No. 3 }	10	Micromhos



Base connections, bottom view of socket, for the 6L7.

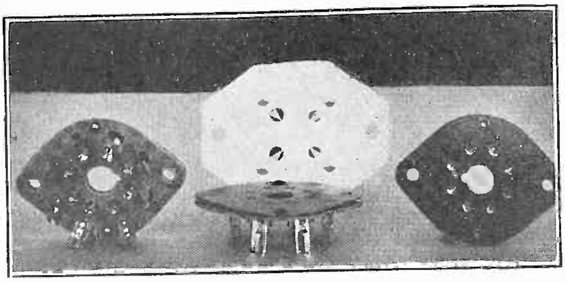
(Continued from preceding page)

If the transmitter is to be adjusted to radiate some particular power, e.g., 50 watts, a 50-watt lamp should be used and the specified voltage should be applied across its terminals. The lamp is then moved along the scale until a suitable reading is obtained on the meter. Then the lamp is substituted for the antenna and the transmitter is adjusted until the meter reads the same as before. Assuming lamp resistance equals radiation resistance, it is then known that the transmitter delivers 50 watts to the antenna.

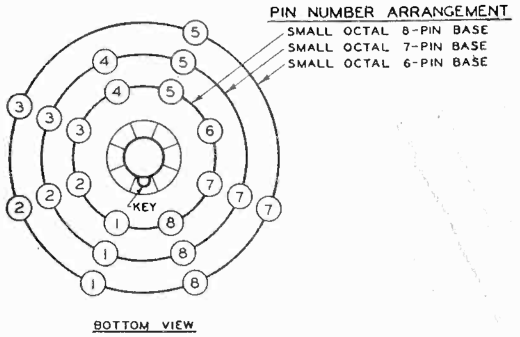
Once the position of the lamp has been set when 50 watts are dissipated in it, the lamp should not be moved.

It should be noted that this is also a substitution method, but instead of measuring the power in the lamp, its rated value is taken, and the power delivered to the antenna is varied until it matches the predetermined value. This method of adjustment is applicable to any radio frequency and is not limited to ultra high frequencies. In one form or another it has been in use for many years.

Revision Notice on Pin Numbering of Octal Bases



The metal shell tubes all fit the same socket, eight holes. Pins not required on tubes for lesser number of connections are omitted. Left and right, views of new sockets for the metal tubes, compared to sockets (center) with which we are more familiar.



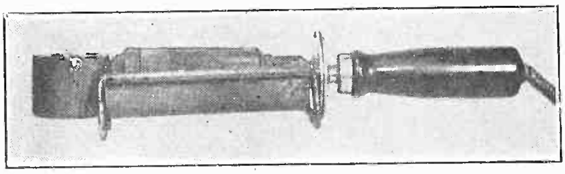
The maximum base diameter of the octals is 1 5/16". This new dimension applies also to the outline drawings of the metal shell tubes printed in the May issue and represents a change introduced by the manufacturers.

Comparison of metal shell and glass envelope being made by Al Mollinger, service executive.

THE data on the metal shell tubes published in the May issue identified pin numbers for the 6, 7 and 8 pin octal bases according to the standardized recommendations of the Radio Manufacturers Association, that is, No. 1 pin corresponded to a heater terminal and successive pins appeared in clockwise rotation when the base was viewed from the bottom.

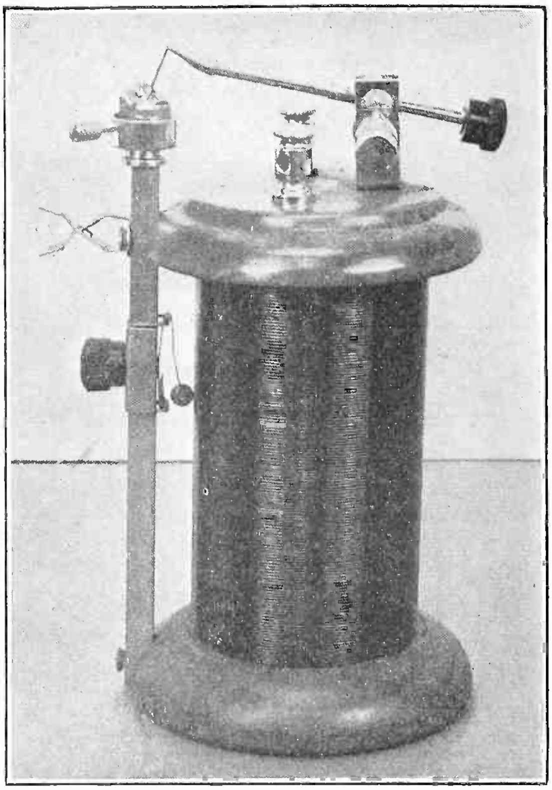
The fact that the octal bases differ from previous base designs in being suitable for a universal socket makes it possible to set up a universal numbering system which is believed to offer advantages in simplicity. In this new system, numbers are assigned to each of the eight possible pin positions. Numbering starts from the shell connection which is always the first pin to the left of the locating lug when the base is viewed from the bottom with the lug toward the observer. Numbering is clockwise on the basis of possible pin positions. Thus, the pin numbers for a 6-pin base are 1, 2, 3, 5, 7, and 8.

The following table gives the revised pin numbers for seven of the metal tubes. The outline of the 6L7 is on the new basis.

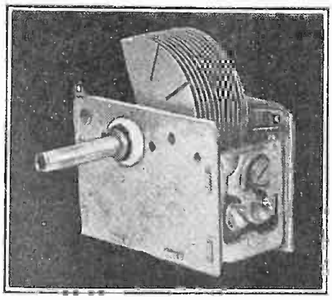


Some type of soldering is best done by dipping. Therefore solder has to be kept fluid in a pot. One experimenter made a pot with a heavy duty soldering iron, tip threaded into an iron cup and extending to the opposite inside circumference. Pot of solid solder took 11 minutes to turn 100 per cent. fluid. Dipping prongs of plug in coils is recommended way for rounded finish.

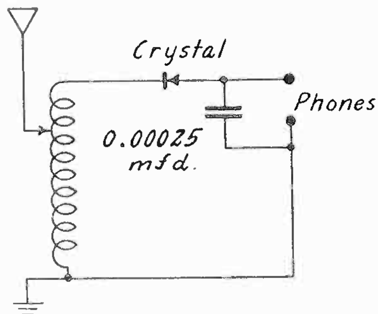
Tube Type No.	*Pin Positions and Numbers* 1	2	3	4	5	6	7	8
6A8	S	H	P	G_3 & G_5	G_1	G_2	H	K
6C5	S	H	P	—	G_1	—	H	K
6D5	S	H	P	—	G_1	—	H	K
6H7	S	H	P_2	K_2	P_1	—	H	K_1
6J7	S	H	P	G_2	G_3	—	H	K
6K7	S	H	P	G_2	G_3	—	H	K
6L7	S	H	P	G_2 & G_4	G_3	—	H	K & G_5



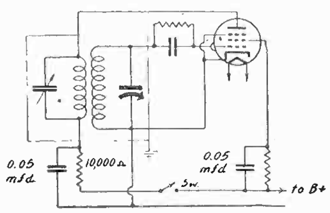
Televisionists are getting busy. William Hoyt Peck (left) has Canadian telecaster on air as RCA moves its electrical system from laboratory to field. (Wide World.)



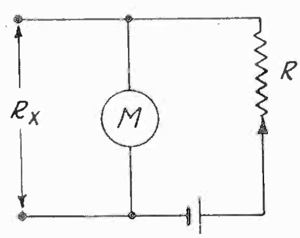
Dissolve celluloid strips or photo film in acetone and you have fine cement for speaker cone repair. At right, condenser plates cut for "matching", but don't bend 'em.



Don't believe it when persons tell you that you can't get stations on a crystal set. Earphone service, of course, but you may get more stations than you expect. Diagram and construction shown.



Simple beat oscillator, wired from an i.f. transformer, one condenser used as variable for pitch changer.



What is meant by shunting the meter to read low resistance. Rx is th unknown, R the meter limiting resistor.

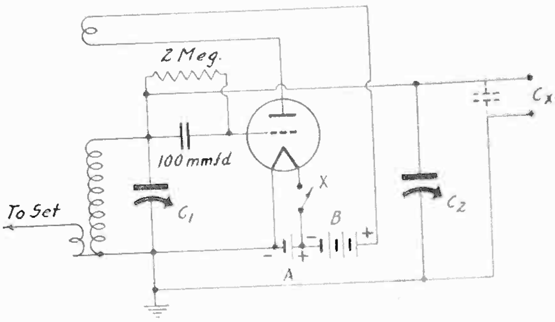
Finding Cx Easily

Substitution Method, Using Oscillator

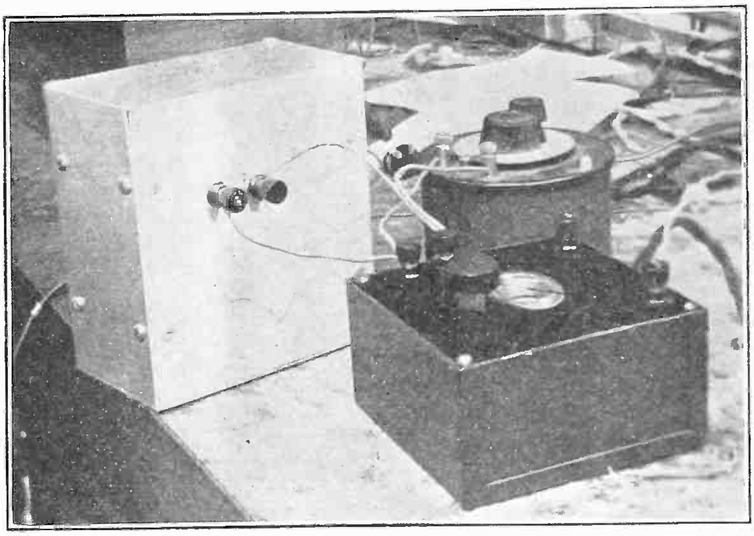
By Jonathan Burrows

HERE is an easy way of utilizing the substitution method for capacity measurement. It is necessary to have a calibrated condenser. Also an oscillator is required. This may be one of the small inexpensive ones, preferably covering the broadcast band fundamentally, if broadcasting stations in that band are to be used. It is just as well to use instead another oscillator, also of the broadcast band type, provided earphones can be put in. The requirements then, are: calibrated condenser, oscillator and receiver. Some means of coupling is provided between oscillator and set.

The oscillator tuning condenser is used at a low capacity setting, the calibrated condenser across it at high capacity, and a beat with a broadcasting station struck. Then insert the unknown condenser (if within the calibration range) and having read the first setting of the calibrated model, turn that model to lower capacity reading sof the calibrated condenser is of the value of Cx. Be careful not to be fooled by harmonics.



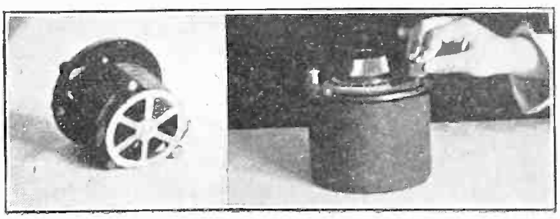
This oscillator is set going, connected to a receiver, and caused to zero beat with the fundamental of a station, by using small capacity of C1 and large capacity of C2, which is a calibrated external condenser. Now Cx is inserted and C2 turned back until zero beat is restored. Difference between two known settings of C2 is the capacity of Cx.



Setup used for working the capacity measurement method, using a small oscillator, this one of the a.c. operated type. The calibrated condenser is behind the oscillator, while the condenser to be measured, really to be calibrated over its span, is in the aluminum

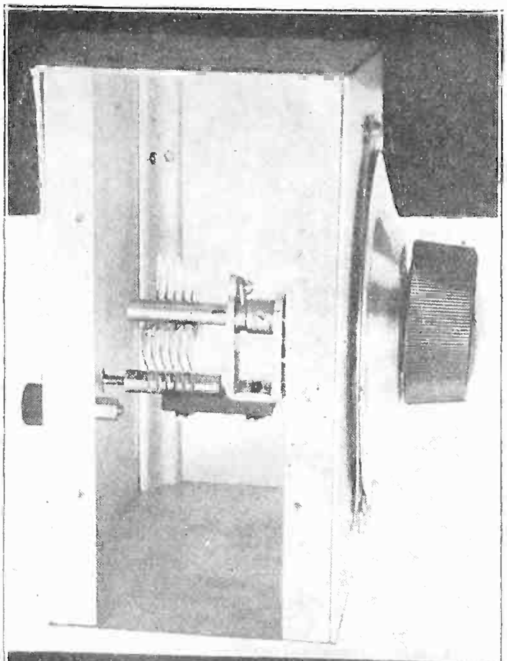
Calibration for usual so-called 0.0005 mfd. condenser:

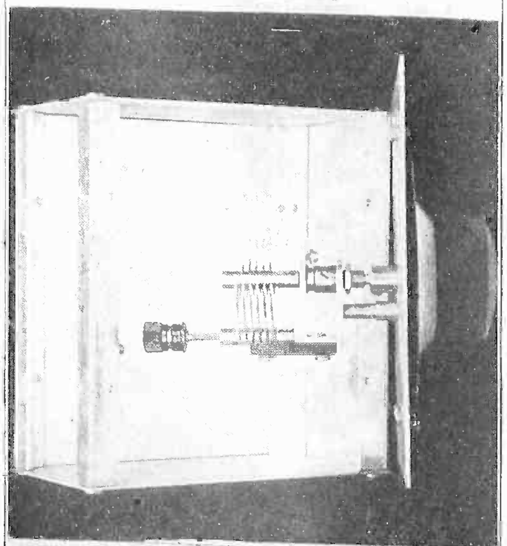
Dial	*Mmfd.*
7	50
12	75
17	100
21.5	125
26.5	150
36	200
45.5	250
54.5	300
64	350
73.25	400
82.5	450
92	500

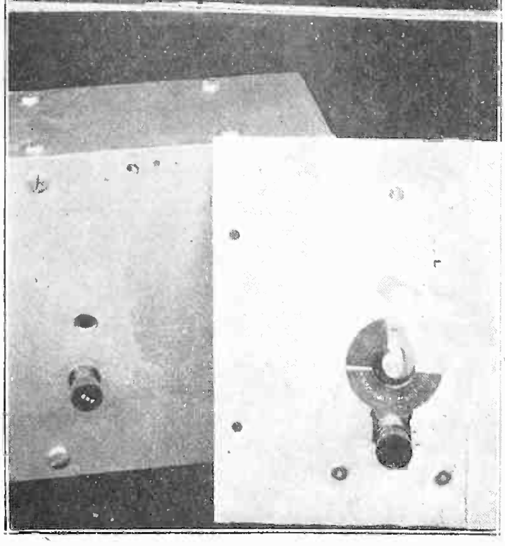


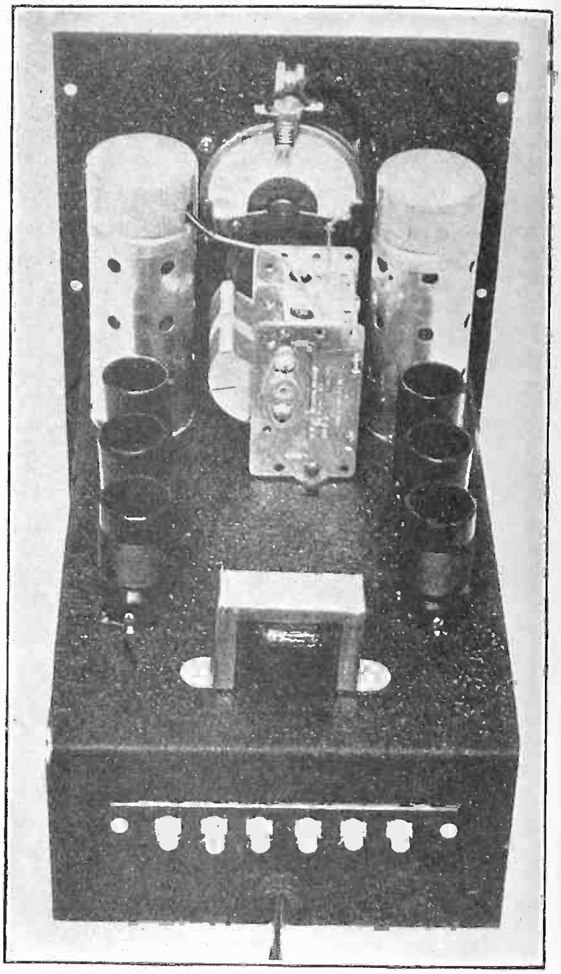
Values tabulated at left are for condenser shown in two views.

PRE-SELECTOR

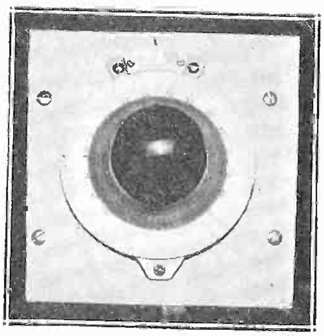






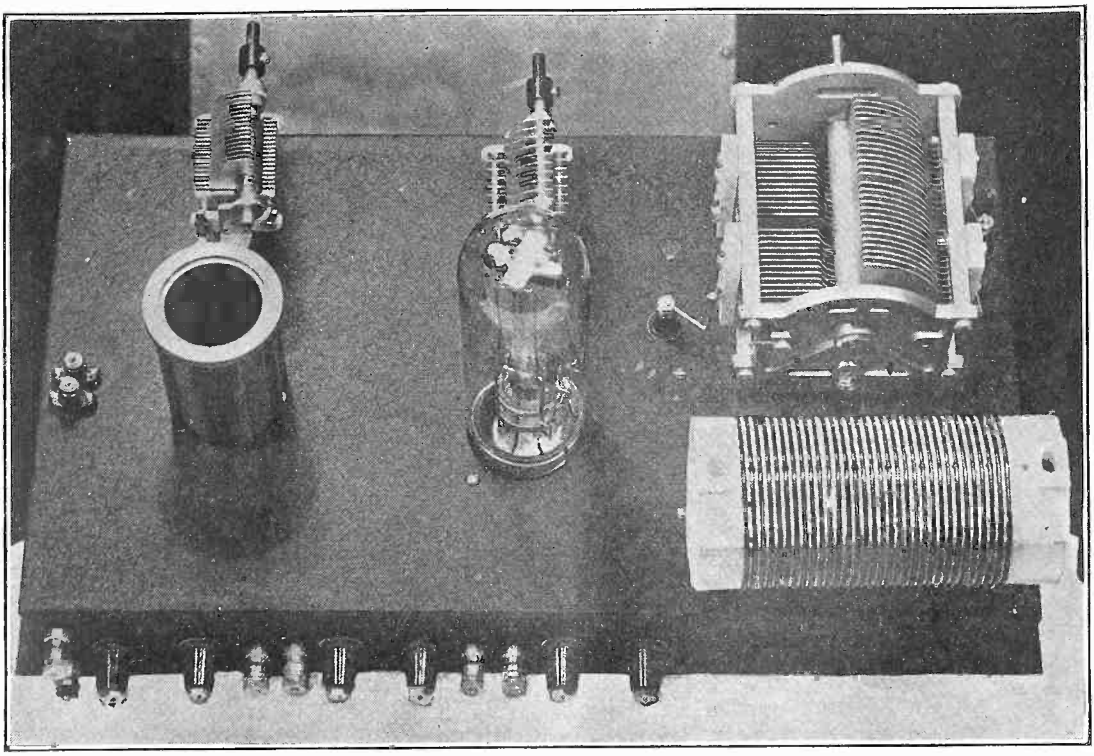


Pre-selector improves selectivity and sensitivity of shortwave tuning. Measurements made showed signal strengths way up and more stations received.



Details in left column show mounting of a small condenser in aluminum box for service as calibrated device, precision dial (above) being used on front. Calibration is made at a laboratory and curve furnished.

W2IJL'S DE LUXE "FINAL"



Transmitter's final stage. The only tube in this outfit is the 242A, a 50 watt triode. The condenser at left is for tuning the grid coil. At center is a 50 mmfd. condenser for tube neutralization. At right is a split stator tank condenser, for tuning the tube plate. The two posts at left center are for link coupling from the buffer.

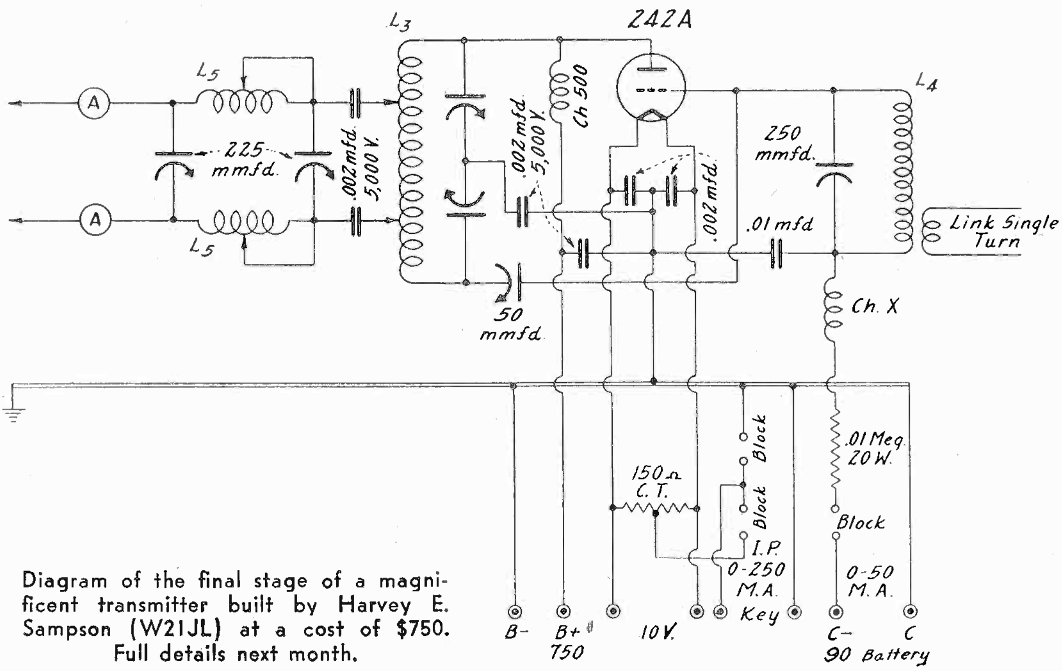
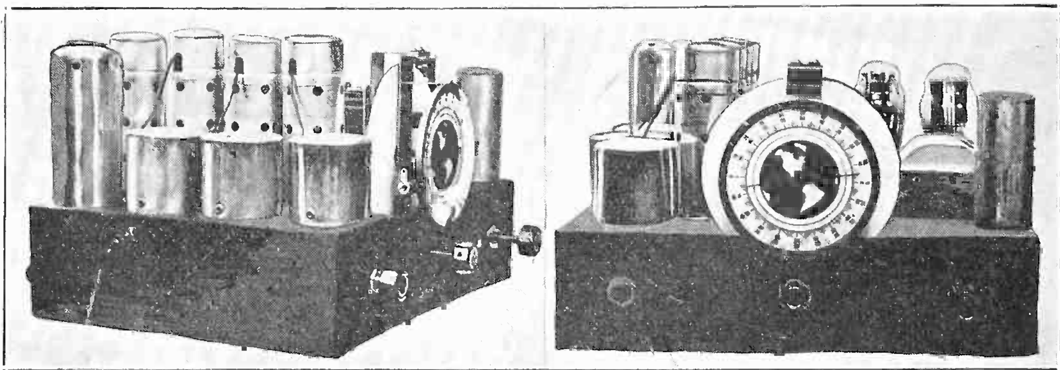


Diagram of the final stage of a magnificent transmitter built by Harvey E. Sampson (W2IJL) at a cost of $750. Full details next month.

Equal Gain on T.R.F.

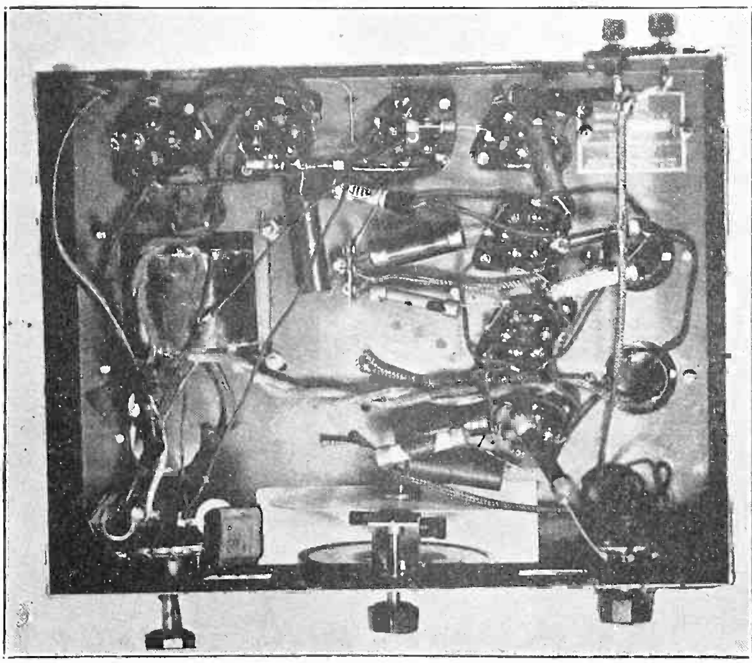
Untuned Stage Boosts High Wavelength Response

By Clark Meadows



Views of the t.r.f. chassis.

A TUNED radio frequency receiver is still the choice of some who want high fidelity reproduction. One reason assigned for the better quality is that these receivers are not as selective as superheterodynes. Of course, either type may be made broad or sharp as desired. Perhaps the one thing that is in favor of a tuned radio frequency receiver is that there are no squeals present, assuming that it is working perfectly, without oscillation. In the super-



The usual chassis hole was present under the untuned coil (or i.f. coil with trimmers wide out), but a plate was put on to ascertain if there resulted any change at all. None could be discovered.

heterodyne there are all kinds of squeals even when it is working normally. It is more difficult to eliminate squeals from a superheterodyne than from a tuned radio frequency set, and even when they have been eliminated, as far as the ear can tell, there are heterodynes present that contribute to background noises.

The circuit depicted here is of the tuned radio frequency type. It employs three tuned circuits, which are adjusted with a three-gang condenser. When all these are lined up, the selectivity is all that is required in even the most difficult locations, and it is not at all difficult to line them up.

There is a unique feature about this circuit, and that is the untuned transformer preceding the diode detector. It does several desirable things. As everybody knows, a tuned radio frequency receiver is much more sensitive on the high broadcast frequencies than on the low. This fact often makes sets oscillate at the higher frequencies while they are still relatively insensitive on the lower.

COMPENSATION INTRODUCED

Then something has to be done about the oscillation, and that something usually kills the selectivity at the very frequencies where higher selectivity is required. Now in this circuit the untuned transformer is used to build up the gain on the low frequencies. It is an intermediate frequency transformer although the usual condensers are not shown. They are left in the circuit, though, but they are opened up wide. Therefore the natural frequencies of the two circuits in the transformer come close to the low frequency end of the broadcast scale. Without this i.f. transformer signals from a 570 kc station are weak, scarcely audible, although the station is local, but with it, those signals are as strong as those from higher frequency statoins. While the transformer is not effective at the high frequencies, it does not unduly cut down the gain. In fact, it cuts down just enough to eliminate oscillation at the higher end. It gains this end without the addition of gadgets that cut down the selectivity.

The coupling between the two coils in the intermediate frequency transformer is left as loose as it is for superheterodyne amplifiers tuned to a fixed frequency. It would seem that this coupling is too loose for an untuned transformer, but this is not the case. The reason for

(*Continued on next page*)

LIST OF PARTS

Coils

Three shielded radio frequency transformers
One 456 kc intermediate frequency transformer
One push-pull input transformer, ratio primary to one-half secondary, 1 to 3
One power transformer, primary, 115 volts, 50-60 cycles; secondaries, 6.3 volts, 3.5 amperes; high voltage, 300-0-300 a.c.; rectifier filament, 5 volts

Condensers

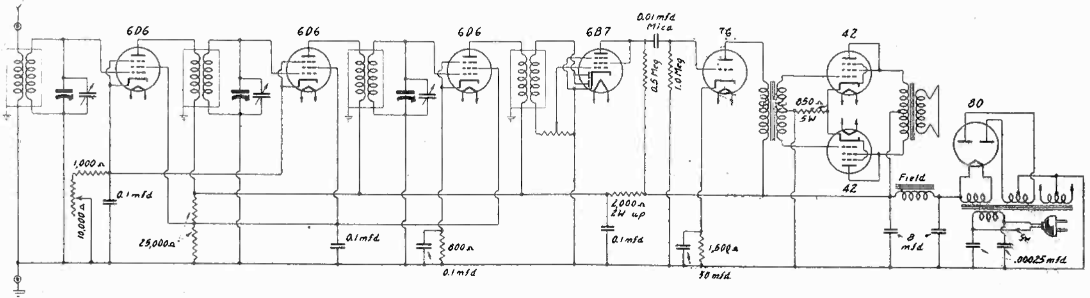
One three-gang tuning condenser with trimmers (capacity at maximum may be 350 to 400 mmfd.)
Two 0.00025 mfd. tubular condensers, 200 volts
Four 0.1 mfd. tubular condensers, 200 volts or more
One 0.01 mfd. mica condenser
Two 8 mfd. electrolytic condensers, 500 volts rating
One 30 mfd. electrolytic condenser, 35 volts rating
One 1,000 ohm pigtail resistor

Resistors

One 1,000 ohm pigtail resistor
One 800-ohm pigtail resistor
One 1,500-ohm pigtail resistors
Two 0.025 meg. (25,000 ohm) pigtail resistors
One 0.5 meg. pigtail resistor (¼ watt sufficient)
One 1 meg. potentiometer
One 10,000 ohm variable resistor with a.c. switch attached
One 850 ohm, 5 watt resistor
One 2,000 ohm, 2 watts up, resistor
One 1 meg. pigtail resistor

Other Requirements

One dynamic speaker with output transformer for push-pull 42 tubes, 1,800 ohm field
One speaker plug and four lead cable
One chassis for eight tubes
Four tube shields and bases
Two four-hole sockets, one five-hole, five six-hole, and one seven-hole. (Extra 4-hole for speaker)
One airplane dial with two pilot brackets
Two pilot lamps (6-volt type)
Four grid clips
Antenna-ground twin assembly post
Phonograph twin jack assembly
Two stand-off insulators



The untuned transformer is shown without condensers, ahead of 6B7.

(*Continued from preceding page*)

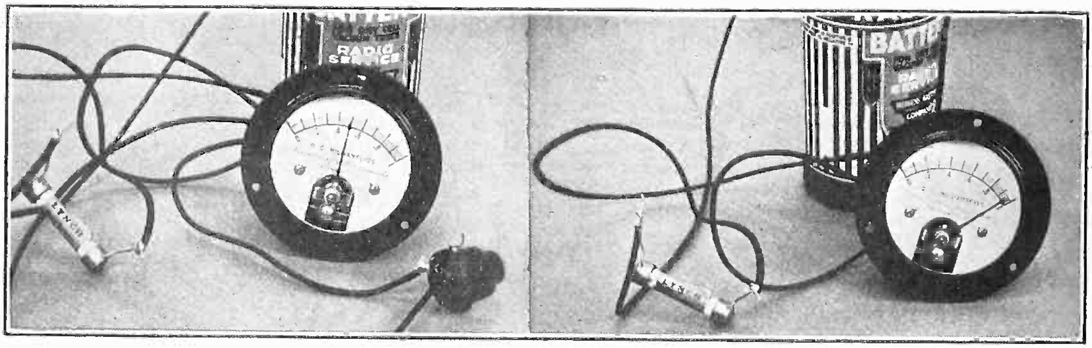
A high audio gain is obtained from the pentode of the 6B7. The signal is still further amplified by means of a 76, which is triode of low voltage gain but suitable for coupling to a transformer. This is a push-pull input transformer that divides the secondary voltage equally between a pair of matched 42 pentodes. The output of these two power tubes, when a suitable loudspeaker is used, is sufficient for all ordinary home requirements.

this is that for a given coupling, the transfer of voltage from one winding to the other is directly proportional to the frequency. Thus the transfer is greater for the higher frequency signals that it would be for the frequency for which it was originally itnended. At the low broadcast frequencies it is also effective because they are near the frequency to which the circuits are tuned in this case.

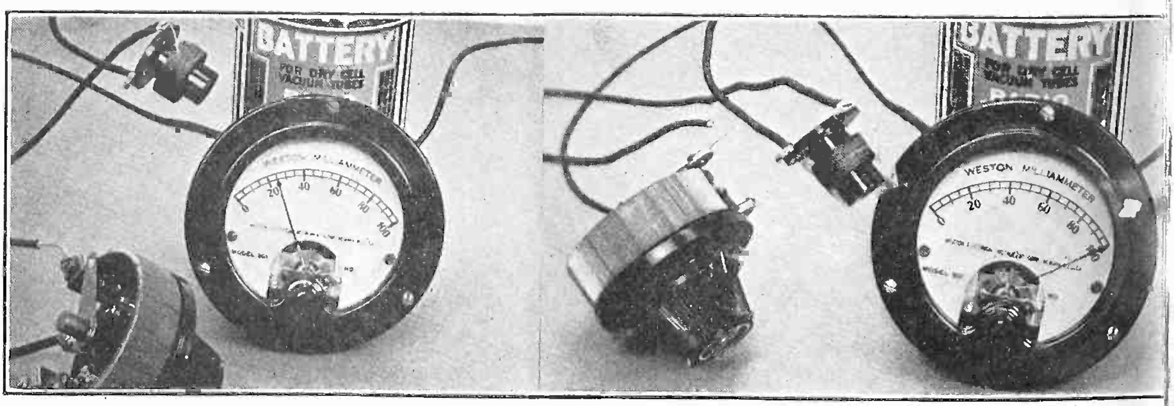
Another advantage of the untuned transformer is that it enables the use of diode detection with the usual simple arrangement. One winding is connected in the rectifier circuit just as it would be connected in a superheterodyne.

In this circuit the detector is a 6B7. The two anodes are tined together to form a half wave rectifier. This is not only simpler than full wave rectifications but it is also about twice as sensitive. The suppressor of the pentode part of the tube is connected to the cathode as usual, but the screen is tied to the plate. The grid is diode biased, being connected to the slider of a high resistance potentiometer, which constitutes the load on the diode circuit. It will be noticed that no condenser is used across the potentiometer. This does not mean that detection is effective without a by-pass condenser. It simply means that theer is enough capacity in the circuit, about 10 mmfd., to filter out the ripple and let the radio frequency current to the rectifier.

EXAMPLE OF METER RESISTANCE MEASUREMENT



Series resistor and battery are used for getting the full scale deflection shown at right, and coil has turns removed in picture at left until meter reads half way. Then coil resistance equals meter resistance and may be measured with large current.

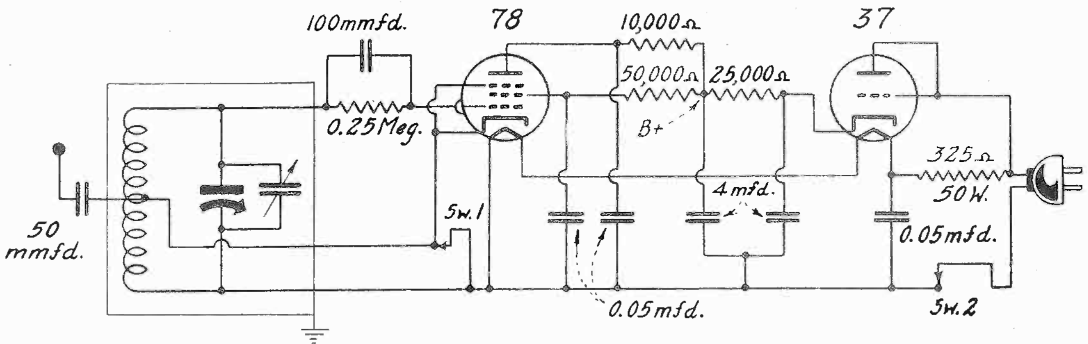


Series rheostat is used so as not to push needle too far, when setting up for resistance measurement with large current. Then rheostat is turned until full scale deflection prevails. The coil is in circuit both times. Now measure voltage drop across the coil and for 100 ma the coil resistance is 10 times the voltage reading. See article on page 32.

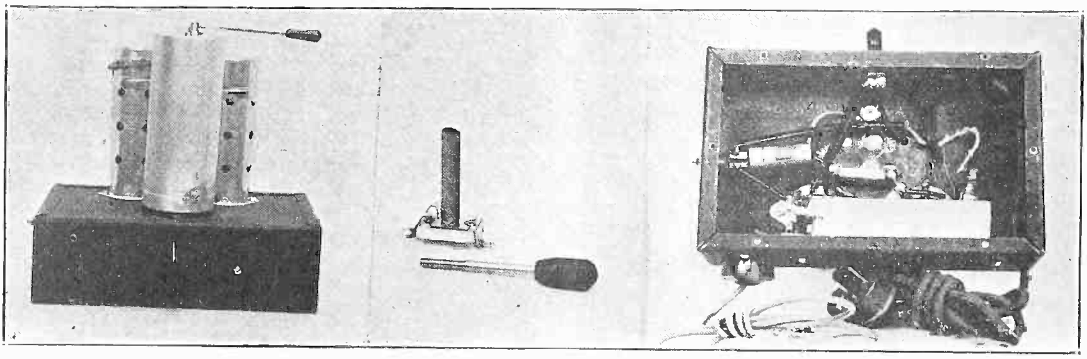
A Beat Oscillator

CW Adjunct and Station Finder

By Lloyd Earl Sampson



This is the circuit of a beat oscillator for making C.W. audible on a superheterodyne and for finding stations. The circuit is universal in that it may be used for either a.c. or d.c.



Left shows the complete beat oscillator with the tuning adjustment at the top. In the middle is shown the detail of adjusting the tuning condenser. At right is shown the inside view of the circuit.

HERE is a simple little gadget that is useful as a station finder and as an auxiliary in the reception of unmodulated continuous waves. It is an oscillator that operates at the intermediate frequency of a superheterodyne. When its frequency is adjusted to the intermediate frequency and the output is coupled to the receiver, a squeal will be heard whenever any station beats with the regular circuit oscillator to produce the intermediate frequency. That is, there are now two independent intermediate frequencies in the circuit and the beating of these two produces a squeal. The value of this is adjusted to have any desired value, say 1,000 cycles per second. The adjustment may be made by either adjusting the tuning of the broadcast or short wave receiver or by adjusting the setting of the beat oscillator. In practice it is most convenient to adjust the tuning of the receiver and leave the beat oscillator fixed after its first adjustment.

A switch Sw1 is provided in the circuit for cutting out the beat oscillator. When modulated signals are to be received the beat oscillator is not desirable after the station has been located on the dial, but unmodulated continuous waves it is needed all the time, for they can not be received without it. When an oscillator of this type is used in conjunction with a superheterodyne, there are squeals everywhere on the tuning dial. Nearly all of them represent separate stations, most of which could not be heard without the beat oscillator. The coupling between the beat oscillator and the set is done by means of a 50 mmfd. condenser connected between the midtap of the oscillator coil and the antenna post on the receiver.

As is plain from the diagram of the circuit, the oscillator tube is supplied plate voltage from a 37 rectifier. The circuit is universal, that is, it can be plugged into either an a.c or d.c line. The filtering is sufficient in either case although there is no filter choke in the supply line. The condenser-resistor filter is satisfactory because the current requirement for this purpose is very small.

High Fidelity Tuning

Sidebands Must Be Passed Without Clipping

By Robert G. Herzog, E.E., B.S.

WITH the advent of high fidelity receivers the experimenter should not only learn how to make such a receiver, but should also consider just why these receivers are high fidelity, and in what they differ from other receivers.

High fidelity receivers differ not only in the audio system, which must be designed to amplify evenly every frequency from 25 to 12,000 cycles, but also in the tuner. Sidebands as well as the carrier, the tuner must be passed with equal intensity.

The normal series or parallel tuned circuit would resonate at any given frequency presenting a relatively sharp peak.

If two resonant circuits tuned to the same frequency are suitably coupled, the secondary current will be substantially constant over a band of frequencies.

BAND WIDTH DETERMINANT

The width of the band depends largely on the coefficient of coupling, although the Q of both circuits also enters into the computations.

The design of these band pass circuits can be carried out simply and with enough accuracy for practical purposes by using the following formula:

Width of pass band = k times the resonant frequency of the circuits.

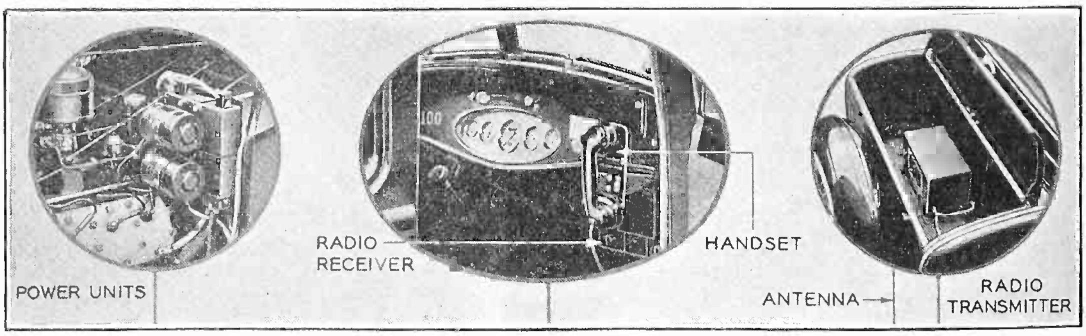
For approximately constant response throughout the pass band the following relation should obtain.

$$k\sqrt{Q^p\ Q^s} = 1.5$$

Where Q^p and Q^s are the Q of primary and secondary, respectively.

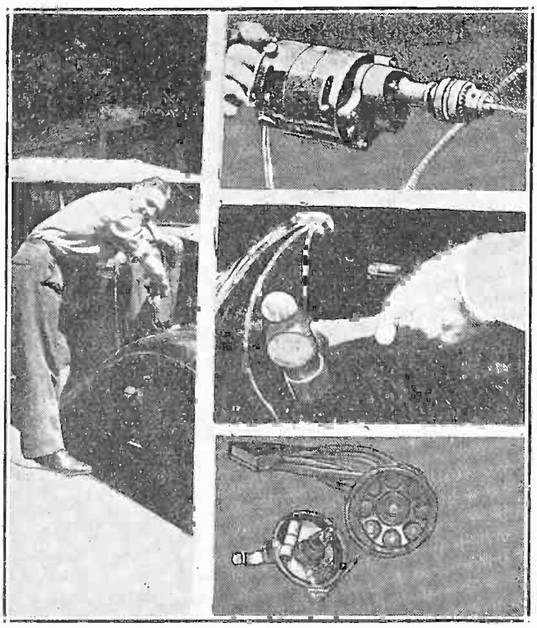
When the condition for uniform response to the pass frequencies is realized, the resonant rise of voltage is just half of that given by one circuit having the same effective Q and considered alone. This is the price that must be paid for the result a flat top tuning curve with somewhat steeper sides than those obtainable with a single resonant circuit. The loss of voltage can easily be remedied by the addition of another stage.

New Police Radio Works Two-Way, Has Audio Relay



Bell Telephone Laboratories

A development in police communication enables the motor patrolman to carry on a two-way conversation with headquarters. In addition to receiving orders, he can report instantly without leaving the car. The system operates on ultra-high frequency channels. The transmitter weighs 20 pounds and has a power of 5-watts. It is held to its frequency by a crystal. To talk from the car, the patrolman merely lifts the telephone from the instrument board and the first sound of his voice automatically puts the car's transmitter on the air. The instant he ceases talking the transmitter automatically switches off. The system is in operation in Evansville, Ind. It will soon be installed also in Nashville, Tenn.



IT'S THE SET, NOT THE CAR

as Seat of Motor Noises

By Jack Schechter

It's a shame to take the money, or words to that effect, are written on the face of an auto set service man preparing to install a receiver in a car at the curbstone. To pierce the plating he will use an electric drill (top right) only if there is a double thickness, otherwise heavy hammer and punch do the trick nicely. Also he will inspect distributor to see that the condenser is not shorted and that contacts are clean.

SUFFICIENT shielding of an automobile receiver is the principal requirement for quietness of operation and freedom from the disturbing effects of the motor. Much improvement has been made recently in auto receiver design to accomplish this end, so that in general it may be stated that spark plug suppressors may be dispensed with, although there are occasional exceptions, due to peculiarities of the car. As a rule, however, it may be said that when there is motor noise it is due not to the car but to the set, because practically all of it can be eliminated by proper design of the set. And close shielding is the basis of much of this design.

When noise is present it is introduced either by way of the antenna or the chassis. A simple expedient is to remove the antenna. If the noise then disappears, the antenna was pickin up the noise. If the noise persists, the set chassis is picking up the noise, and therefore the car has to be put to those grounding precautions that are so numerous that it is hardly likely that they can be tabulated, since special cases crop up now and again that nobody seems to have thought of before.

YEAR ROUND DELIGHT

When a set picks up antenna noise it is characteristic that if a noisy car is passing the trouble appears with increased vigor, so it behooves everybody to keep his car in good condition, not only as a matter of proper care for the car and due regard for safety, but also to improve auto set reception, as most likely the offender will have a set in his car, too.

All through the depression there has been an increase in the building and installation of auto receivers, and the popularity of the car set is increasing, with every indication that this season will be the peak one. It is not as true as many imagine that the car set is itself so very seasonal, that is, a mad rush takes place in Spring and Summer because cars are used more in that time of the year, but there is a steady business in this line, with a mild weather accentuation. That attests to the importance of the car set to the user and the industry and also indicates that home constructors the year round are interested in the car set.

Such sets can be built by the individual, but there is a comparatively smaller percentage of this done than with other types of receivers because of the exactions of car set practice. The chassis construction requires special tooling and chasses are not generally available. Also the information about the intimate details of successful construction is not as widely disseminated. However, much of what may be regarded as standard practice may be followed by the constructor, and if he is handy at metal working he can construct his own chassis, even to accommodate the speaker.

Everyone is aware, of course, that the car set business, from the factory viewpoint, is pretty much standardized and concentrated, so that most of the business is in the hands of a few companies that have all but specialized in this line of work, and one of the leading manufacturers actually makes nothing but auto sets.

It is well therefore to look to what they are doing and to copy the practice based on their own experience.

Very early it was recognized that the con-

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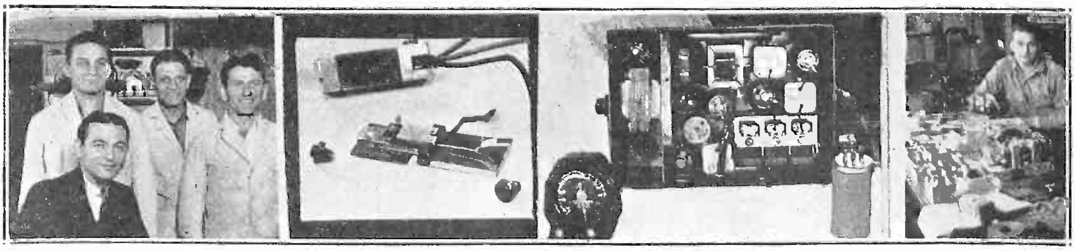


The author (foreground) ana, left to right, Sol Merles, William Fenel and Harry Schechter. Next is shown replacement vibrator with armature and contacts in foreground. Compact auto set is third illustration, vibrator at right, removed. Next is a glimpse of an auto set repair bench

(*Continued from preceding page*)

venience attaching to B power supply from the car A battery was important, and two types of instruments were used, one the vibrator, the other the motor generator. In the beginning the motor generator was far superior, and some makes of vibrators did not stand up very well. Without meaning to favor one method against the other, but merely to report what is happening, I might state that the vibrator has been improved, and is the reigning favorite. The price is less, which is one point, unimportant if performance is inferior, but the performance of the new vibrators is good, and there have been numerous instances even of old vibrators standing up for two years or so. In general a vibrator may be rated at a life of 1,000 hours, the same as a vacuum tube, but there is some uncertainty about any particular vibrator, and some vibrators go bad in a few weeks, while others last as long as I have mentioned, and longer.

TWO VIBRATOR TYPES

The vibrator may be of the type feeding a rectifier tube or of the self-rectifying type. The tube model in general is favored, but there are self-rectifying vibrators that are excellent, too, and included in splendid sets. The principle of the self-rectifying type is the use of a push-pull circuit, with the feed from the common return line, in which the filter is inserted. There is no alternating current in this common branch, since the current at any instance is equal but opposite in phase, hence there is zero difference.

The superheterodyne circuit is used in the receiver without exception. The tuned radio frequency circuit is not suited for the car set, and, except for special uses of persons requiring very high quality at minimum expense, and not requiring great selectivity at all, the t.r.f. set has little place in car or home. The number of tubes will depend on how much sensitivity and selectivity are required and on the power output. An extra tube of course is needed for push pull output, which is popular in the higher grade car sets.

Where to put the set in a car will depend on the car more than on the driver's preference. For instance, cars with heaters require that the set be put on the driver's side. The mounting of car sets should be as simple as possible. Some sets require only one bolt. Others require more. Whatever the number of holes, it is easily made with a heavy hammer and a punch. This method works all right if there is only one thickness of plate on the body, but if there are two layers, then an electric drill should be used.

SPEAKER PLACEMENTS DIFFER

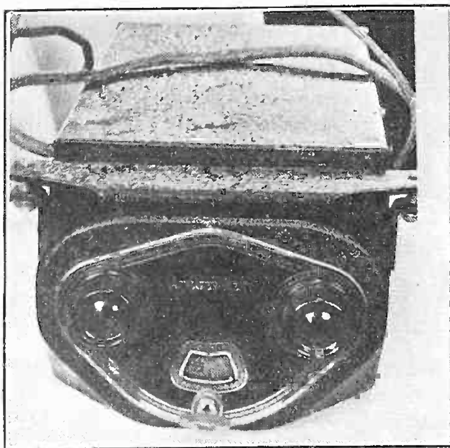
Newer automobiles generally have provision for installing the set in a compartment, and a tie-up exists between automobile manufacturer and set manufacturer, so that there is a particular commercial model set for that very car, that fits in it naturally, but it is possible to put other sets in, of course, and indeed resort to other placement than in one of the small compartments. There are very compact auto sets with speaker enclosed, all in one unit, that fit behind the fireboard, with controls on the car instrument panel, also car sets that are portable, as well as sets with receiver and speaker separate. If the set is of the portable type of course the tuning is done right on the cabinet, but the instrument panel type tuning unit may be used in other instances, while the steering column type is the most popular. The remote control tuning control, the on-off switch and the volume control are attached to a unit that fits on the steering column.

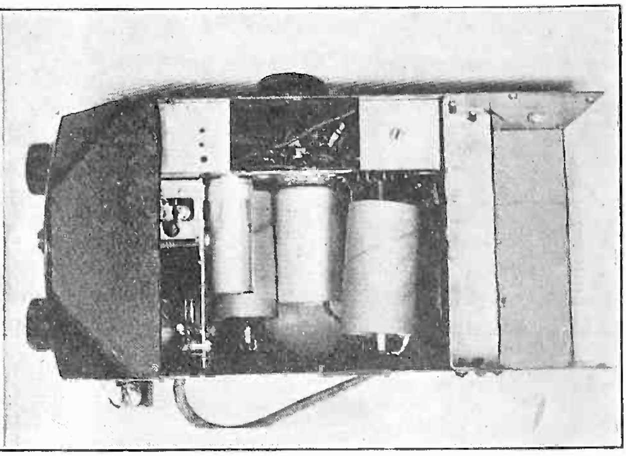
Some sets have separate speaker intended to be mounted inside the car, directly under the roof, like a dome lamp, while others permit placement of the speaker in a rear corner of the car, above the passenger's head, although most speakers are in the driver's compartment.

Assuming that one has built or bought a car set, and has placed the receiver where circumstances require, modified as much as may be by personal taste, his next consideration is an aerial. The car sets are so sensitive that not much antenna pickup is required, and this high sensitivity is accompanied by high stability, which combination is easily practical only in a superheterodyne.

WHERE THE AERIAL GOES

The most natural place to locate the aerial is under the running board. The farther the aerial is from the running board, the better. Of course it could not be put above the board, hence is mounted on upside down standoff in-





Some car sets have speaker built in, true of this model, one of the most compact ever produced.

sulators, under the board, as far down as road clearance permits, in view of danger of bumps. Instead of being just a plain wire, however, the antenna had better consist of a plate, or mesh, so that in a sense an inverted counterpoise exists. The pickup will be adequate at all frequencies, if the antenna primary of the coil in the set is of the high impedance type and the set sensitive.

The ground is the motor casing, and even the cars that are supposed to have bodies floating on rubber have enough bolts and nuts connecting the chassis and thence making conductive run to the motor frame to enable a good ground, but if the set is not sufficiently shielded this shows up by requiring extraordinary precautions for grounding by bonding. This consists of running thick braided wire, well soldered at the two ends, between the points that are to register complete short circuit. Even in the sets themselves, in the interest of full grounding and shielding, binding is used.

The lead from the aerial to the set should be of heavy wire with a serving of rubber and a shield braid, so that the antenna shield may be grounded at the car battery. Either positive or negative of the battery may be grounded, that is, connected to motor frame, this circumstance differing with different makes of cars, even with different models of the same make. This may be determined experimentally by connecting a voltmeter between one side of the A battery and car chassis. If there is no reading the side of the battery to which connection is made is ground, or the battery or meter or both are dead. Assuming good instruments, if the battery voltage is read between battery terminal and chassis, the battery terminal being used is not ground but "hot."

The antenna shield may not be sufficiently grounded if connected to the hot side of the battery, and besides there is introduced the possibility of shorting the battery by inadvertently connecting to car chassis at some other point, as where the antenna enters the receiver. It is not actually necessary to use the thickly cotton serviced type wire that causes the shield braid to be almost an inch in diameter. While it is true that this thick insulation keeps the shield braid so far from the conductor as to minimize the loss to ground due to capacity, it is also true that the car sets are so sensitive nowadays that the precaution so important in prior years need not be observed.

INDOORS AND OUTDOORS

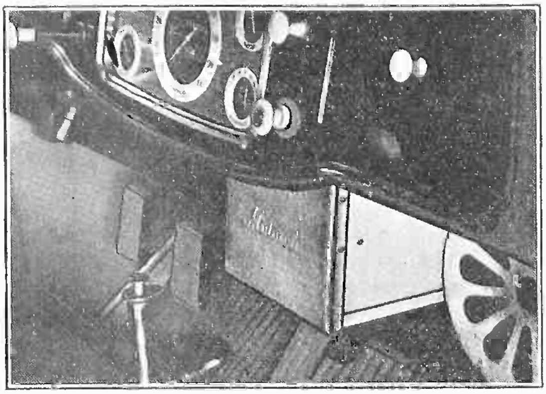
The construction and repair of the car set of course take place indoors. The installation most likely takes place outdoors, and the set is tried out with motor idling, and then with the car given a, or really the set, given a road test. In general, if the test proves a success, and the general rule today is that such actually takes place, in fact almost without exception, the likelihood is that the set owner will obtain long service. However, car sets are subject to ills the same as home sets, and a vibrator may stick, a tube go bad, a wire get disconnected, or some unusual mishap cause trouble. The tubes do not give any more trouble in car sets than in home sets, in fact it is probably true there is less tube trouble in car sets, possibly because the voltaging of the tubes is more strictly limited.

If a vibrator goes bad, it may merely be sticking, and the set should be turned on, tubes permitted to heat fully, and then the vibrator given a solid rap with a hammer, or kicked, whereupon it may be restored to service, otherwise a replacement is in order. The vibrator may be pulled out and another one inserted, just as in the case of tubes. In the picture adjoining the one of three of my associates and myself there are shown replacement vibrator parts, the armature in the foreground, on either side of it replacement tips contacts. Next is shown a car set with remote control at left and the vibrator, removed from the set, at right, prongs up.

This set follows the usual practice of compactness. In the left compartment is the B choke, above it the rectifier tube, in this case an 84, while the socket below the B choke is the one from which the vibrator was removed.

How to Keep Car Sets on Peak Road

By Capt. Peter V. O'Rourke



Set installed by an auto receiver expert in his own car.

AUTO radio is popular the year round, but gets most attention this time of the year. And as each year arrives reception is better, because of progressive solution of problems.

The newest aspects of auto sets include the elimination of spark plug suppressors, because sets themselves are completely shielded; the popularization of unit construction and simplicity of connection; the improvement of B supplies, and the vast improvement in antenna systems.

The antenna is practically as important as the set. Both the underslung and overslung types work well. Some antennas are stretched under the chassis, possibly with criss-cross support; others simply under the running board. In the overslung group come the wiring in the car top, and around the moulding. The stretch above the top is practically passe.

THE INVERSION PROCESS

Since the antenna is physically and electrically short, compensation is required to lengthen it electrically, so that the response is made keener at the low broadcast frequencies, where otherwise it would drop severely. This is particularly true of tuned radio frequency sets, but has application also to superheterodynes. To bring about this equalization of response, or even inversion, so that the lower frequencies, with usually the better stations, are favored, coils are constructed broadly peaked in this region. Some sets are provided internally with compensation, most sets not, so automobile antenna matching transformers are used. Their inclusion produces a striking difference. The attainment of just the right inductance, both self and mutual, and respective values of primaries and secondaries, is a delicate engineering problem, well mastered commercially.

Whenever a transformer is used in this way—and it may be rightly called an impedance mismatching transformer with the mismatch making desired results—it should be preferably in connection with a specific type of antenna for which it was designed. However, there will be improvement in the general direction noted even if a casual auto antenna is used, but not so pronounced a result, unless accidentally.

ANTENNA TRIMMER ADJUSTMENT

The car antenna at best is not likely to be much of a collecting agency. The best must be made of what little is picked up, and the most possible picked up, at that. So if an under-chassis antenna is used, it should be as close to the road as practical, but road obstacles and the bouncing of the car impress a limit in this direction.

Whatever type antenna is used, and especially if an antenna coupling transformer is introduced, the set's antenna trimmer should be readjusted. In fact, in the absence of specific reproduction of installation conditions, as with sets made specifically for certain cars, this antenna trimmer should always be adjusted for maximum response near the high frequency terminal of tuning.

The aim is to make auto sets specially sensitive, since they are given little input. All adjustments should produce peak sensitivity for the system. Naturally, if one drives about a great deal the set may get out of alignment due to bumps and jars, and every few months' attention should be paid to this.

Some cars have wire mesh in the top, and this may be used as aerial, if not grounded. Anything is considered grounded that is connected electrically to the motor frame. This may be a conductive connection for d. c., or may be even a connection through a capacity, since the antenna voltage is a. c. A grounded antenna in a car is just as dead as a grounded antenna anywhere else.

AERIALS INSIDE AND OUT

A test for grounded condition can be made only statically by the d. c. continuity method, by running a wire from the antenna to one side of the continuity tester, other side of tester to motor frame. If the reading is equivalent to that of a short the antenna certainly is grounded. If the reading denotes an open, the strong likelihood is that the antenna is not grounded; still, a condenser may have been put between motor frame and wire screen, some owners' unlikely experiment.

Aerials are being used inside of cars nowadays, and a type of aerial wire that can be stuck on the under side of the top is sometimes used in emergencies. Car construction has much to do with whether such an antenna system works at all. Steel bodies do not aid in exposing such wires to radio waves.

When the aerial of the wire-in-the-top type is used, sometimes scratchy reception results. This is due often to grounding and ungrounding, a part of the wiring being thus exposed. In fact, this making and breaking may take place with any type of an antenna in a car.

TUNING OUT TURNING CORNERS

Naturally the horizontal antennas are somewhat directional, and as the car is driven around corners, volume will change, unless there is compensation. Also, when driving under concrete bridges or through tunnels, waning of signals may be suffered. Automatic volume control succeeds in atoning sufficiently for the variations of input, although of course the shielding of the antenna against radio waves by steel in overhead structures at times may be too much even for the automatic volume control system.

With the set working properly, and the antenna well constructed and its energy put into the set most desirably, the next consideration is to have quiet reception. This is not so easy as it sounds. There have been instances where noise has developed that a dozen service men could not cure, but they did not rebuild the set. It is therefore apparent the set has much to do with the situation. Shielding must be complete. Such completeness is a recent introduction. If there are strays from the motor, interference that is present at an assortment of radio frequencies due to the sparking nature of the disturbance and almost shapeless wave form, will the set pick them up of its own accord? Try it. Disconnect antenna from the set and ground the antenna. Now, if there is disturbance in the set from the motor, the waves get right through the box. The set should be so well shielded that no pickup of this kind takes place.

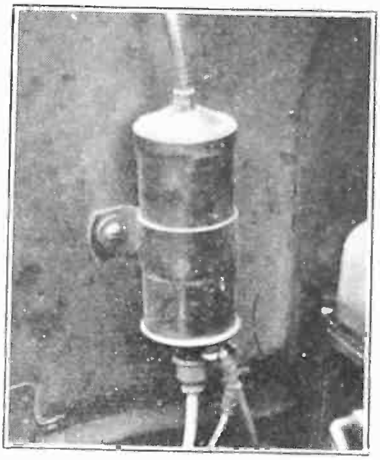
ONE RESISTOR IMPERATIVE

Suppose that with antenna thus grounded there is no sound in the set. Then the shielding is adequate in the receiver, but inadequate elsewhere. There are so many places and conditions under which interference of this type may occur that it is impossible (for me) to list all of them from memory.

Spark plug suppressors, resistors specially made for retarding the effect of the ignition on radiation, are not required for the latest closely shielded type sets, but are required for all others. Even these latest sets require a suppressor on the distributor, and a 1 mfd. condenser across the generator brushes. It is well to use a 600 volt condenser, for voltage transients may run high. The suppressor is usually 5,000 ohms or so.

The general trend is to use suppressors of around this ohmage even on the spark plugs themselves, where spark suppressors are required, because with the lower resistance the drag on the motor is less. Some 10 to 15 per cent. drop in motor efficiency may be expected when spark plug suppressors are introduced, and one of the main reasons for now resorting to extra shielding of a specially precautionary nature was to avoid this penalty.

One of the tests that shows up the fact is to let a motor idle, then introduce the suppressors, and attempt idling. It may be found necessary practically to race the motor to insure it turning over. The difference may be attributed to the suppressors. And yet, of course, for quiet reception, under circumstances that require such suppression, the resistors must be included, even though on tough hills the motor may balk a bit, and now and again under a trying condition a cylinder may miss.



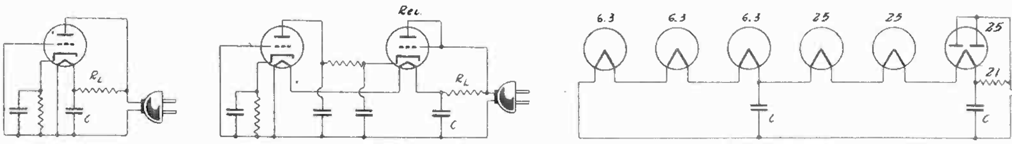
Ignition coil in an automobile, fastened to motor casing. The lead at top to the firing chambers is shielded, the one on bottom is not, so it may be advisable to shield the lower lead some rainy day.

DO NOT LAST FOREVER

The suppressors need not be deemed to have infinite life. They are usually carbon. The continuity between spark plug and distributor is established through the suppressor. Therefore, if a suppressor should open now and again, cylinder miss may be due to that, or if a set formerly quiet seems to be noise ridden, the suppressors may be practically shorted, due to dirt and grime and oil-soaking. The suppressors are not in an atmosphere of utmost purity. Every six months or so new suppressors should be installed.

FALSE ALARMS With Universal Sets

By Lee Waters



Basic circuit at left, RL the limiting heater resistor. Center shows rectifier and extra tube, C aiding r.f. action. For larger sets two such condensers are preferable (right).

IN universal receivers, meaning those that work on a. c. or d. c. line voltage, the limiting resistor often is a part of the a. c. cable assembly. The limiting resistor is the one that reduces the line voltage to the low voltage required for the heaters.

Such a cabling requires three leads. Two of them go directly from the set to the line and are conductive, that is, of very low resistance, and what resistance is there is unintentional. The third one also goes to the line, but through an intended resistor, enabling attainment of the right heater voltage. For correct voltage to prevail the resistance must be of the proper value, not critical, however.

Thus a common side of the a. c. line serves as return for high voltage and for the heater circuit, the line being led indirectly through rectifier to the plates of receiver tubes to be served, and indirectly through the limiting resistor to the heaters, which are in series.

NOT CAUSE FOR ALARM

Instead of the limiting resistor being a long curl of wire built into the line cord assembly, it may be entirely independent, physically, and be placed in the receiver. But the power dissipation in this resistor, especially in small sets, is considerable, and the heat is better radiated in the line cord.

However, some persons not famliar with this condition, on feeling the cord get warm, pull the plug out of the wall socket and consider that the receiver is dangerously defective. This warmth in the line cord is not dangerous and the condition should create no alarm.

COMPUTATION OF LIMITER

Sometimes persons unaware of the line cord resistor method, and desiring to use a longer cord, to enable putting the set farther from the outlet, simply cut off the cord and substitute another. The new cord is of the standard two-wire type, no built-in resistor, and the result is that the full line voltage is applied across the heater series, and zipp go the tubes or a fuse.

What the limiting resistance should be may be computed from Ohm's law, the unknown resistance equalling the voltage divided by the current. The resistance is in ohms. The voltage is in volts and here represents the potential to the dropped, that is, equals the line voltage less the voltage required for the heaters. What the line voltage is will not be precisely known, unless a measurement is made, and even so the voltage may not be the same time and again, but an ascribed value may be used, usually a bit higher than the average. For the case of 110 volt rating of the line the value 115 volts is normally used; for 220 volt rating, 230 is the value for computation. The current is one of the known quantities, since when the voltage is what it should be across the heater, the current will be what the manufacturer's specification states. Normally the current is 0.3 ampere, and the only exception for the 6.3 volt type tubes is that of a current of 0.4 ampere, requiring a special limiting circuit.

It can be seen that in the unlikely instance of a single tube the voltage drop in the limiting resistor would be maximum, the wattage dissipated in the limiting resistor nearly 33 watts, a total waste. As the number of tubes used becomes larger the wasted wattage becomes less, for if the heaters required the full 115 volts there would be no waste, except for power put into any heater beyond reasonable emission required of the tube.

RESISTANCE 21 TO 83.3 OHMS

Take the example of the single tube. This is practically never used, but the resistance R_L should be 362 ohms, the wattage dissipated being 52.6, and as usually the resistor is selected of rating about double the actual dissipation, or a 100 watt resistor.

For the two tube example, the limiting resistor R_L should be 341 ohms, and the actual wattage dissipated is a bit under 31.

The voltage is to be dropped differ, but that is merely saying that different type tubes may have different resistance in heaters. For instance, most tubes drop 6.3 volts at 0.3 amperes, some drop 12 volts, others 25 volts, and one 30 volts. The resistance of the heater may be computed by the same method used for the limiting resistor. For instance, the 6.3 volt heater, 0.3 ampere, has a resistance of 63/3 or 21 ohms. The tubes with filaments dropping higher voltage have higher resistance, the current being the same. Thus the 12 volt tube has a heater with 40 ohms resistance, the 25 volt tube has heater of 83.3 ohms, and the 0.4 ampere 30 volt heater a resistance of 75 ohms.

The fact that the voltage drops across the heaters are to be different is of no consequence, since the current will be the same through all heaters in the same series, and the voltage drop merely expresses the heater resistance. More power goes into the heater when the voltage across the heater is larger; hence, power tubes and rectifiers would be expected to have higher voltage drops, as they do, compared to 6.3 volts, if there is to be any voltage increase.

USE OF MORE TUBES

For a small set of the universal type, operating economy can not exist. The economical method of lowering voltage for few tubes is by transformation; in fact, it is practically a lossless method; but the universal sets are transformerless, since a transformer would restrict the set to a. c. operation.

As soon as the receiver becomes more sizeable, say, has six tubes, the distribution of heater voltage may be on the basis of that diagramed, the voltage dropped in each heater being imprinted above the tube symbol, the limiting resistor dropping 21 volts. Here the wattage dissipation in the resistor is only 6.3 watts, or a resistor rated at 10 to 15 watts would be used, or any other resistor of correct resistance value, of higher than 10 watt rating. What the rating wattage of the resistor is above practical requirement does not matter, simply designating that the resistor operates more cooly.

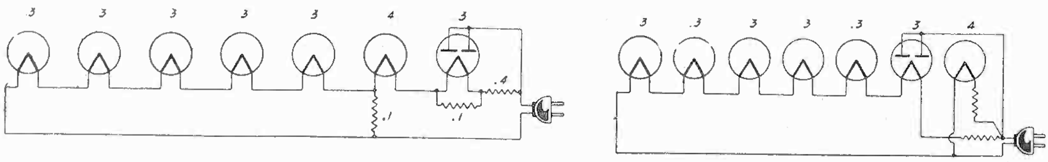
We have considered the example of the current being the same, 0.3 ampere. However, suppose a tube is to be used, drawing 0.4 ampere, along with tubes requiring 0.3 ampere. Suppose we try to use one current or the other, to simplify matters. Thus if the current is at 0.3 ampere, the tube requiring 0.4 ampere will be underfed one seventh, and in the case of a power tube this might result in the reduction of the power handling capability by 30 or 40 per cent. Should we put 0.4 ampere through the series chain, the 0.4 ampere tube would be treated all right, but the other tubes would be overfed, resulting in severe reduction of tube life, and even in poor performance.

THE 48 A SPECIAL CASE

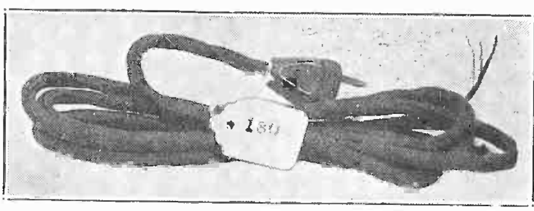
A diagram shows the current carried by each heater in a chain, where five tubes in consecutive series take 0.3 ampere, a bleeder resistor across this much of the series taking 0.1 ampere, so the required total of 0.4 ampere flows. And it flows completely through the one tube that requires it. The last tube has heater that takes 0.3 ampere, but there is a parallel bleeder for this tube alone, so again 0.4 ampere prevails, and of course through the limiting resistor this full current passes.

The diagram shows two methods, one of paralleling a chain, and the other of paralleling a single tube. A precaution observed is that the rectifier is put next to the line, thus reducing the voltage drop between cathode and heaters of other tubes, which is sound practice. Also, a power tube would be put in the chain, as done, as near as practical to the high voltage end (right). But use of the two bleeder resistors is awkward. Also, the 0.4 ampere 48 power tube does not heat up as quickly as the 0.3 ampere tubes, the 48 being one of the three 0.4 ampere tubes. Its resistance is so low at the start that the current is large and the voltage across the other tubes too high. This endangers all tubes except the 48.

Only the 48 of the three 0.4 ampere tubes has a large voltage drop across its heater, that is, has relatively large resistance heater, this being a 30 volt tube, the other tubes of the 0.4 ampere series, the 89 and the 41, being in the 6.3 volt class. So the 48 alone has to be treated so that it has its independent resistance network connected with line, so as to remove the other tubes from its influence. So for a seven-tube set, as suggested, the resistor is chosen for six similar heater tubes, and another resistor for the 48 alone.



Division of current in amperes at left for diverse tubes (0.3 and 0.4 amp.). The 0.4 ampere tube at right has separate limiting resistor, using up much extra power.

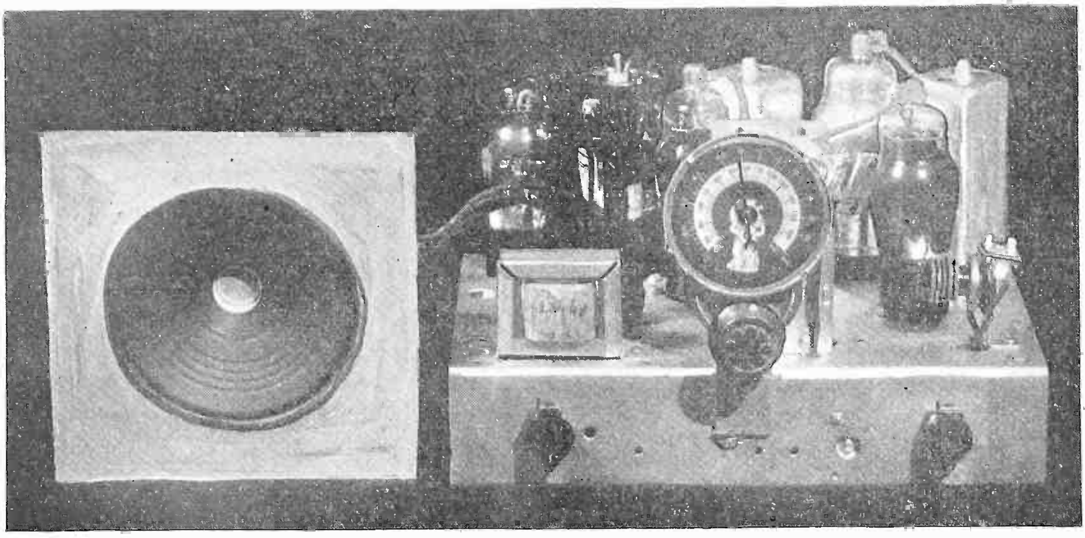


Line cord with 180 ohm limiting resistor built in.

A Dual Range Super

For Universal Operation, with Band Switch

By J. E. Anderson and Jack Goldstein



Front view of the chassis and loudspeaker.

THIS dual-range, universal type superheterodyne of exceptional selectivity and sensitivity. It employs a 25Z5 rectifier, a 43 power amplifier, a 75 diode detector and audio voltage amplifier, a 6D6 intermediate frequency amplifier, and a 6A7 pentagrid converter. The heaters of all these tubes are connected in series, and also in series with a 145 ohm, 30-watt ballast resistor and a 6 volt pilot light, which is shunted by a 20 ohm resistor.

The receiver has been thoroughly tested in the radio-congested area of New York for selectivity and sensitivity, both on the short wave and broadcast bands. With a 50 foot antenna, it easily cuts through the local 50 kilowatt transmitters and brings in low-power distant stations with satisfactory volume and without crosstalk.

On the short wave band, stations in England, Germany, Spain, Central and South America are like locals when these stations come in at all, and, of course, it brings in a multitude of other short wave stations both in this and foreign countries. To bring in these short wave stations it is not really necessary to use the length of antenna specified, for even with a wire ten feet long it does bring the stations in.

THE HIGH-FREQUENCY TUNERS

The high selectivity of the circuit is obtained primarily by the use of two doubly tuned intermediate frequency transformers, each of the four circuits being tuned to 456 kilocycles. These high-gain coils are tuned by small trimmer condensers having a narrow range of coverage so that they may be adjusted to 456 kc without the use of a signal generator. This is a great advantage to those who have no access to a generator.

The high gain of the transformers used is due to correct design of the windings, proper coupling between the coils, and especially to the use of Litz wire on the spools. Coil construction is of the pie type. Litz wire and pie winding have been found especially efficient at 456 kc. They not only enhance the gain but also the selectivity.

The selectivity, of course, is also greatly increased by the radio-frequency tuners. There are two of these, one for the 530-1,600 kc band and another for the 52-17 meter band. The broadcast band coil is wound with Litz, as are the intermediates, for in the broadcast band also Litz is superior to solid wire. The coil has a large primary to insure high gain, but it is rather loosely coupled to the secondary in order not to impair the selectivity.

The high frequency coils are wound with silver plated wire of heavy gauge, with spaced turns, and on small diameters. The object of the silver plating is to provide low resistance on the surface of the wire where most of the high frequency current flows, hence to increase both the selectivity and the gain. The small diameters and space winding are for the purpose of reducing distributed capacity, an important feature in a short-wave circuit.

PADDING OF OSCILLATORS

The trimmer condenser has been removed from the tuning condenser and placed across the broadcast coil, and a similar trimmer has been put across the high-frequency coil. This arrangement has a two-fold purpose. First, it enables the trimming of the two circuits separately, and second, it reduces the minimum capacity, thus greatly extending the tuning range.

The oscillator circuits for the two ranges are padded separately. A trimmer having a range of from 3 to 30 mmfd is placed across the secondary of the broadcast coil and in series with this combination is a padding condenser of 400 to 600 mmfd. range. No parallel condenser is used with the high frequency coil, for none is

(*Continued on next page*)

LIST OF PARTS

Coils

One special high-frequency oscillator transformer
One special high-frequency antenna coil, with trimmer
One special broadcast oscillator transformer
One special broadcast antenna coil, with trimmer
One 456 kc antenna wave trap
Two special 456 kc intermediate frequency transformers, doubly tuned
One 375 ohm filter choke
One six inch dynamic speaker with 3,000 ohm field coil

Condensers

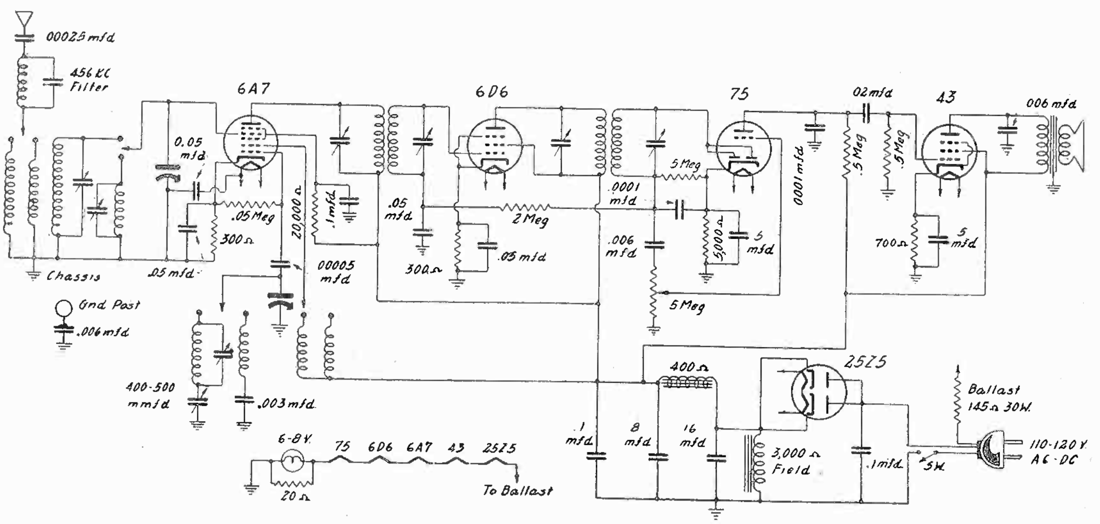
One two gang, 0.00037 mfd. tuning condenser
One adjustable, 400-600 mmfd. padding condenser
Two 0.0001 mfd. fixed condensers
One 0.00025 mfd. fixed condenser
One 0.00005 mfd. fixed condenser
One 0.003 mfd. fixed padding condenser
Three 0.006 mfd. condensers
One 0.02 fixed condenser
Three 0.05 mfd. condensers
Three 0.1 mfd. condensers
One block electrolytic filter condensers: one 16 mfd., one 8 mfd., and two 5 mfd.

Resistors

Two 300 ohm bias resistors
One 700 ohm resistor
One 145 ohm, 30-watt ballast resistor
One 20 ohm resistor
One 20,000 ohm resistor
One 0.05 meg. resistor
Three 0.5 meg. resistors
One 2 meg. resistor
One 0.5 meg. potentiometer with line switch attached.

Other Requirements

One airplane dial
Two bar handles
One cord and plug
Three grid clips
One 6-8 volt pilot light with socket
Four six contact sockets
One seven contact socket
One four pole, two throw, low capacity switch
One steel chassis, 11 inch x 6 inch x 2.125 inch
One tube shield.



The circuit diagram of a universal type, 456-kc, two-range superheterodyne.

(*Continued from preceding page*)

needed to obtained satisfactory alignment, but a fixed condenser of 0.003 mfd. is put in series with the coil to effect tracking at the lower frequency end of the 52-17 meter range.

A two-gang condenser is used to tune the oscillator and the radio-frequency circuits.

BIASING OF MIXER

A mica type condenser of 50 mmfd. is connected in the grid lead of the oscillator and a 0.05 megohm grid lead is connected directly from the grid to the cathode. Thus there is no bias on the oscillator grid except that which is obtained from the drop in the grid leak due to grid current.

A bias resistor of 300 ohms, shunted by a 0.05 megohm condenser, is used for the pentode part of the 6A7, for this not only improves the converting efficiency but it also increases the selectivity of the tuned circuits, since it prevents grid current from flowing in the pentode grid circuit.

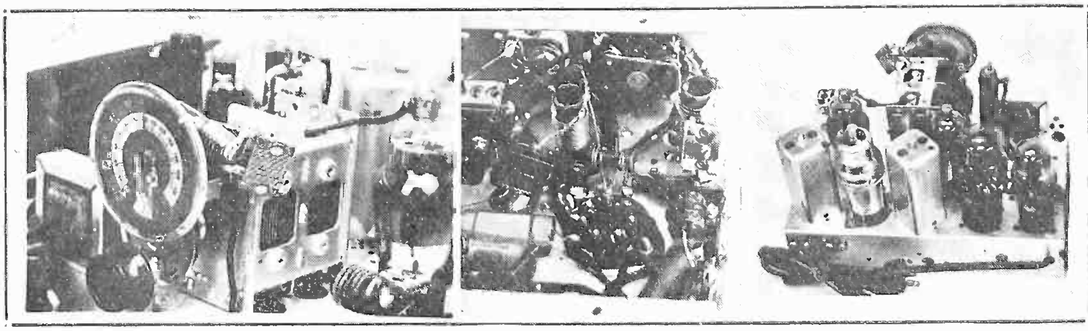
Since this receiver is of the universal type, two protective condensers are put in the antenna circuit. One of these is of 0.006 mfd. capacity and is placed between the external ground and the chassis. The other is of 0.00025 mfd. capacity and is put between the antenna post and the trap circuit.

This trap circuit, which is not often found in 5-tube receivers, is of great advantage. There are certain code stations operating in the vicinity of the intermediate frequency, namely, 456 kc. These stations would cause interference with reeption in certain localities if it were not for the wave trap, which is employed as a rejector. It simply prevents currents of the interfering frequencies from flowing in the antenna circuit and from reaching the intermediate amplifier. The efficacy of the trap has been tested near the harbor in New York, where many boats employ interfering frequencies, and the tests have been entirely satisfactory.

SWITCHING OF COILS

It should be noted that a switching arrangement is used in preference to plug-in coils. This is a great convenience for the swtiching may be done from the panel merely by turning a knob. There is no danger of losing any of the coils, and particularly there is no danger of changing the values of the inductances by handling the coils and moving the turns about.

The switching is accomplished by means of a four pole, two position switch of the low capacity type. This feature is of special importance in connection with the high frequency circuit where a slight addition of distributed capacity will greatly narrow the range of the tuner. The mechanical construction is such that the rotor shaft is not "hot" at any time and at all times a firm, two-point contact is made.



The filament type resistor of 20 ohms is plainly shown across pilot lamp. Short wave coils revealed next. Rear view at right.

Since diode detection is used, the circuit is well adapted to grid voltage control both in the audio and intermediate frequency amplifiers. The control in the intermediate is automatic, for the negative end of the load resistor of the diode rectifier is connected to the grid return of the 6D6 amplifier through a 2 meg. resistor. A 0.05 mfd. condenser is connected from the grid return to the chassis to complete the filtering of the intermediate frequency, that is, to prevent all feedback of the signal frequency.

SELF BIAS FOR TRIODE

The detector load resistance, which has a value of 0.5 megohm, is shunted by a 0.0001 mfd. condenser, and the resistor is connected directly to the cathode, thus eliminating the handicap that would be put on the detector if it were returned to the chassis. Instead of diode bias on the triode, self bias is used, which is obtained from a 5,000 ohm resistor between the cathode and the chassis. This resistor is shunted by a 5 mfd. electrolytic condenser in order to eliminate audio-frequency, reverse feedback. A stopping condenser of 0.006 mfd. is put between the negative end of the load resistor and the high side of the 0.5 meg. volume control. One side of this is connected to the chassis and the slider is connected to the grid of the 75 amplifier. This adjustable provides satisfactory manual volume control.

The coupling between the 75 triode and the power tube grid is designed for high gain and the retention of first rate quality. High gain is insured by the use of 0.5 megohm plate resistor and grid leak. Low note retention is secured by the use of a large stopping condenser, 0.02 mfd., and also by the use of a high value grid leak. High note retention is secured by the use of a small shunt condenser, 0.0001 mfd., from the plate to the chassis. The object of this condenser is to filter out the intermediate frequency signal that remains in the plate circuit.

THE POWER STAGE

The power tube, a 43, is biased by means of a 700-ohm resistor in its cathode lead. This resistor is shunted by a 5 mfd. electrolytic condenser as a means of preventing reverse feedback. This condenser is large enough to be effective on the lowest audio notes, and hence to insure good bass note reproduction.

Notwithstanding the thorough filtering that has been done in the grid circuits of the 75 and 43 to remove the intermediate frequency, some remains in the plate circuit of the power tube. Hence a shunt condenser of 0.006 mfd. is connected from the plate to the chassis. This condenser is necessary to insure good results. While the filtering could be done thoroughly enough ahead of this point to eliminate the i.f., it could not be done otherwise and still retain the quality. As the design stands the high notes are satisfactorily strong; indeed, the hissing sounds are normal.

A six inch dynamic speaker, properly matched to the 43 power tube, is employed.

THE POWER SUPPLY

The line switch, which is mounted on the 0.5 meg. volume control, is put in the chassis side of the line, the safer of the two possible positions. The positive side of the line (in the case of d.c. supply) is connected directly to the combined plates of the 25Z5 rectifier and to one side of the filament ballast resistor. Thus there is no chance of a short here.

A by-pass condenser of 0.1 mfd. is put across the line just ahead of the rectifier for the purpose of eliminating high-frequency noises that may come in on the line.

The 3,000 ohm speaker field is connected between the joined cathodes of the rectifier and the chassis. Thus it is in parallel with the voltage supply of the set. This connection is satisfactory because the speaker draws only a small amount of current and the rectifier is capable of delivering sufficient current for both the amplifiers and the speaker field.

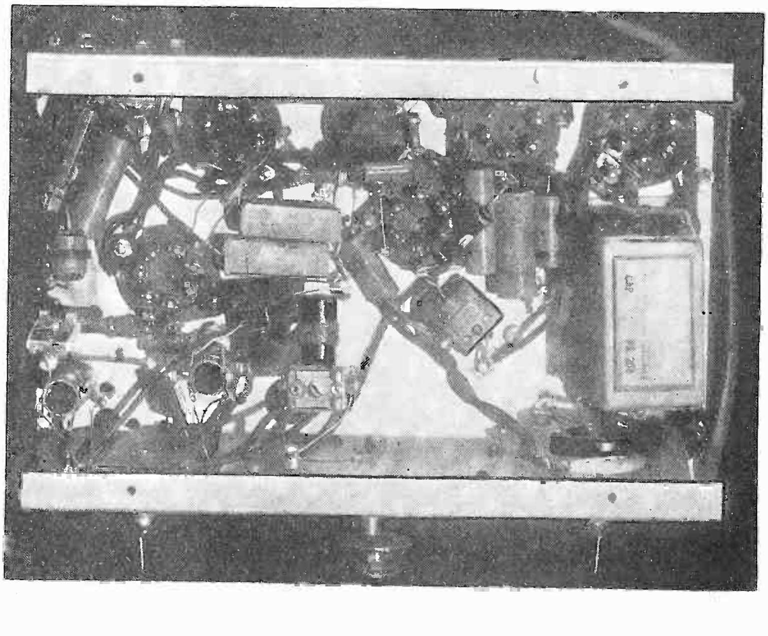
Across the speaker field, and hence across the voltage supply, is a 16 mfd. electrolytic condenser of 200 volt working rating. Then, in series, is a 375 ohm filter choke, and this is followed by another electrolytic condenser, of 8 mfd. capacity. The 0.1 mfd. paper dielectric condenser across the 8 mfd. condenser serves the purpose of bypassing radio and intermediate frequency currents, for which the electrolytic is not effective.

EXAMPLES OF A.C. AND D.C.

The filtering is entirely satisfactory. When the line voltage is d.c. there is no hum as far as the human ear can tell; and when the line voltage is a.c. it is so low that it can be heard only by a keen ear placed within a few inches of the speaker diaphragm.

The screen of the power tube is connected to the high voltage, as is the universal practice. The screen of the 6D6 is connected similarly, for it has been found that exceptionally high sensitivity is obtained by giving it a high voltage. The screen of the pentagrid converter,

(*Continued on next page*)



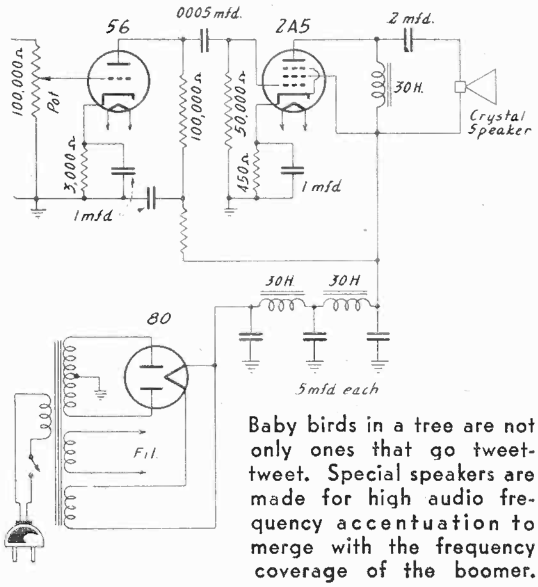
Position of parts shown in underneath view of the wired dual range receiver.

TWEETER AMPLIFIER

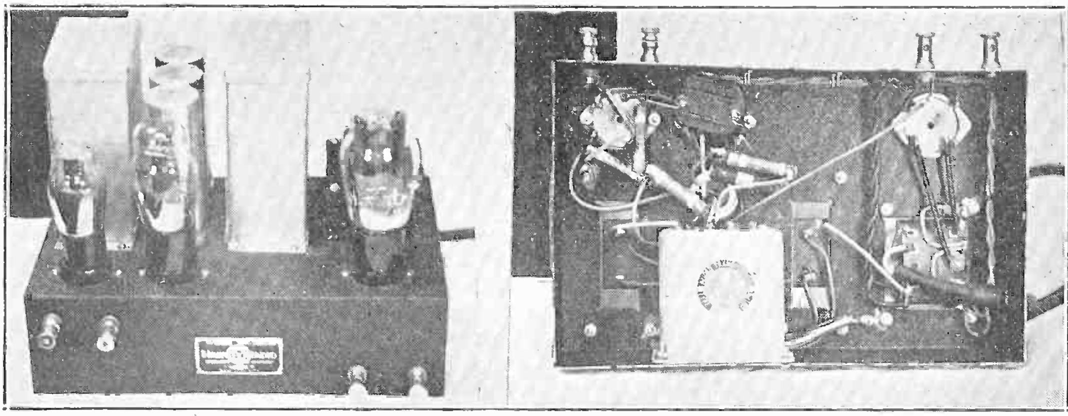
By Louis G. Passavanti

HERE is a tweeter amplifier. Its purpose is to provide accentuation of high audio frequencies to make up for the deficiency of the boomer type of speaker. The combination together make for high fidelity. Not so much power is needed for the high audio frequencies. The 100,000 ohm input of the diagram herewith may be connected in parallel with the output of a pre-amplifier, if a crystal microphone is used, or for the carbon type the present amplifier input may be in parallel with the secondary of the microphone transformer.

The 2A5 is used as a pentode because this use aids the high audio frequency accentuation, and besides the small stopping condenser, 0.0005 mfd., reduces low notes considerably.



Baby birds in a tree are not only ones that go tweet-tweet. Special speakers are made for high audio frequency accentuation to merge with the frequency coverage of the boomer.



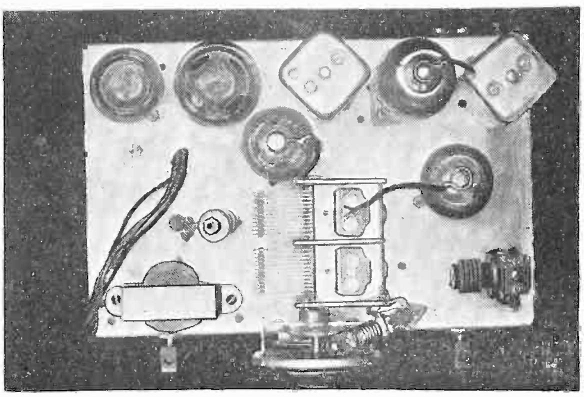
Rear and bottom views of tweeter amplifier.

Screen Connections for Dual Ranges

(*Continued from preceding page*)

however, has been given a lower voltage, but it is obtained by connecting a 20,000 ohm resistor between the screen and the high voltage tap. A condenser of 0.1 mfd. is used to by-pass the high frequency currents to ground and thus to eliminate voltage fluctuations on the screen.

The receiver is built on a steel chassis measuring 11 inches in length, 6 inches in width, and 2,125 inches in height



Bottom view of the dual band set.

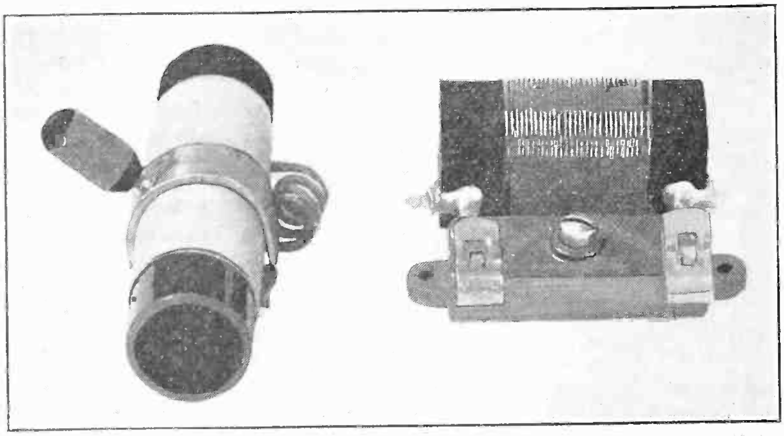
Sometimes blocking occurs in an oscillator. This is remedied easiest by lowering the grid leak between the grid and the cathode. Similar blocking occasionally occurs in the audio amplifier when the grid leak is too high. This is usually indicative of a defective tube following the resistor. There is too much gas current from the grid to ground.

Wave Trap Does the Trick

Out Goes Interference, Joyful Reception Resumed

By A. M. Roth

The slider on the coil is used for its capacity effect, and thus tunes the coil. The setting is selected that eliminates interference. The range is small, so the winding has to be accommodated to the requirements. A low broadcast frequency trap is shown (710 kc). The trap at right, with 0.0001 mfd. variable across, was for 1,450 kc.



THOSE who have had no experience with wave traps have a surprise in store for them—the effectiveness with which interference is trapped out. Recently this fact was brought to light anew in the metropolitan district when WOR increased its power to 50 watts. Many listeners were troubled with cross-modulation and intermodution. While the complaint was exaggerated, it was expressed something like this: "WOR comes in all over the dial and I can't get any other stations."

There was some trouble, of course, and as the station lays down a very husky signal in the part of Brooklyn where we have our shop we were called upon by customers to set them right. This we did with wave traps of the two types illustrated. The same methods were used for getting rid of interference where customers farther removed from the shop were very close to some station.

The traps are used in series with the antenna. The device shown at left in the photographs consists of an open brass ring, slid along the winding, and used as a variable condenser, being left at the setting that does the trick. At right is simply a coil with compression type condenser across it, likewise adjusted once.

The diagrams show the use of the traps for Marconi and doublet antennas.

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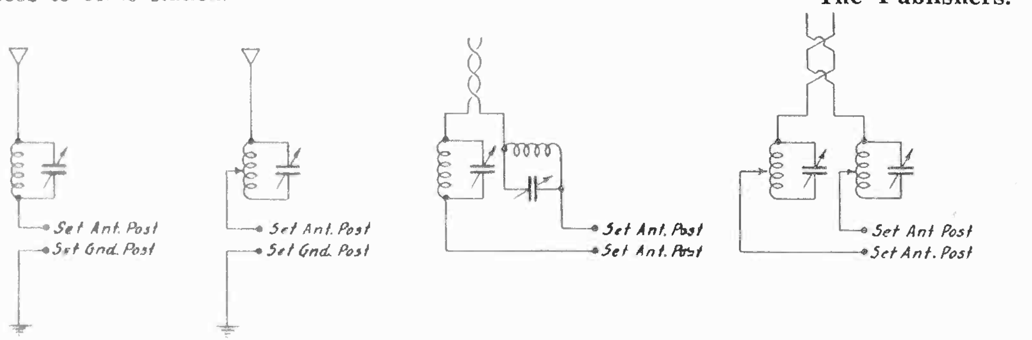
The Publishers.



The two illustrations to the left are for a grounded type of antenna, one for the compression type condenser, the other for the brass ring slider type. The arrow is intended to indicate the movement of the ring along the coil exterior, without denoting conductive connection. The two illustrations at right apply the devices to doublet antenna installations.

Measuring Low Resistance

Without Any Ohmage Calibration

By Herman Bernard

MEASUREMENT of low resistance usually requires high current and calibration or longhand computation. If a small sized cell or battery is used at high current the resistance of the voltage source increases rapidly due to the current drain being far in excess of the rated value. If the No. 6 dry cell or its new oblong equivalent is selected, for 1.5 volts, naturally much current may be drawn, say, 0.25 ampere, with well preserved cell life. If the flashlight type of cell (1.5 volts) or battery (3 volts, etc.) is used, it would be well to restrict the drain to 10 milliamperes.

The voltage source is called a cell when it consists of a single unit, 1.5 volts, and a battery when it consists of two or more units, that is, 3, 4.5, 6 volts, etc.

Diagrams herewith show a way of measuring low resistance without requiring any calibration. The method consists of regulating the amount of current, until it is a decimal fraction of an ampere, or milliampere multiplied decimally, measuring the voltage drop across the unknown resistance, and applying the decimal factor as a multiplier.

100 MILLIAMPERE CIRCUIT

Thus, the first circuit shows 100 milliamperes flowing. For every volt dropped in the unknown resistor, connected between the two posts and identified as Rx, the resistance Rx is equal to the voltage read multiplied by 10. This is true because the current is 0.1 ampere, and every ohm of Rx drops 0.1 volt. So if the voltmeter E (with multiplier R) reads 1 volt, Rx equals 1 × 10 or 10 ohms, and if the meter E reads 1.5 volts the unknown resistance is 15 ohms, assuming the voltmeter circuit does not draw any current. But, of course, it does draw current.

For instance, suppose the current flowing was 100 millamperes, an unknown resistor was connected at the Rx terminals, and the meter voltmeter E, with its limiting resistor R, were connected across the unknown to measure the voltage drop. Suppose the voltmeter circuit had a resistance of 100 ohms per volt and that the voltage reading was 1 volt across Rx, on a 5-volt scale. The current flowing through the voltmeter circuit would be one-fifth of full-scale deflection current, or 10/5 milliamperes. So of he 100 milliamperes flowing, 2 milliamperes flow through the voltmeter circuit and 98 milliamperes through the Rx. This difference, however, is small enough to be neglected.

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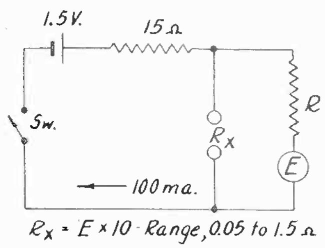
THE BASIC CIRCUIT



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CAN BE WORKED WTHOUT METER

If one has a fresh dry cell of the high current type (No. 6) and connects an accurate 15 ohm resistance in the circuit the current will be 100 milliamperes, or near enough to it for all present purposes, so that no meter will be needed. Therefore some experimenters lacking the meter and desiring to make resistance measurements may use a voltmeter as shown and multiply the reading by 10 to determine the unknown resistance.

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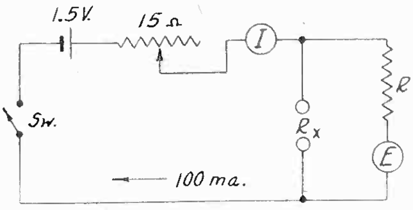

$R_x = E \times 10$ Range, 0.05 to 15 Ω

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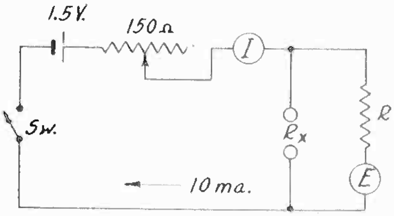
THIS IS USEFUL



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To measure higher resistance would cause a greater percentage of current to flow through Rx, for instance at 15 ohms for Rx the total current flowing is not 100 milliamperes but half that, because a total of 30 ohms (15 ohm limiting resistor plus equal unknown) is in series with the cell.

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(*Continued on page 36*)

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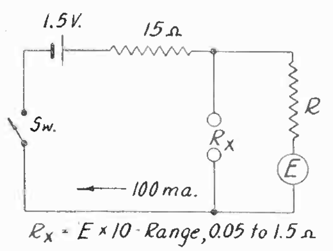

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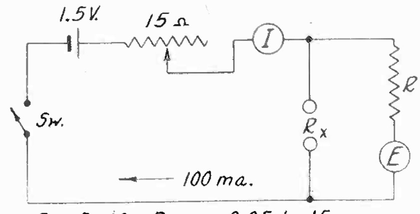

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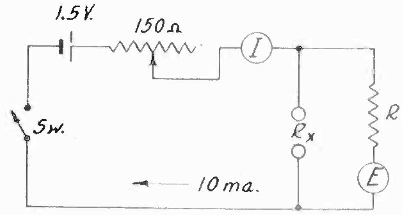

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(*Continued on page* 36)

Three Tube Speak

By Albert

HERE is a layout adaptable to short wave reception on a loudspeaker, using three tubes. This is possible because the large tube at left consists of two tubes in one envelope: a half wave rectifier and a pentode power tube. It is the 12A7. Some manufacturers, but not all, make it. The rest of the tubes are standard, a 6C6 detector and a 76 driver.

The speaker is of the magnetic type and will not require an output filter if the bias on the power tube is raised high enough to keep the plate current through the magnet winding at somewhat less than 40 milliamperes.

DETECTOR TUBE SHIELDED

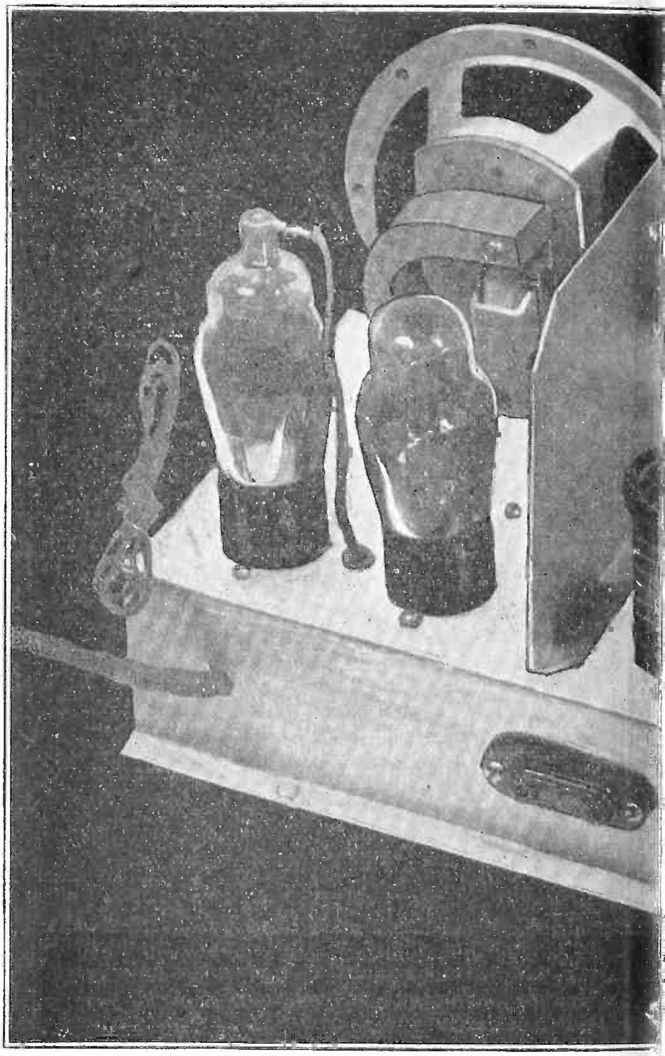
A shield is advisable on the detector tube. The coil socket is placed near the rear, so that there will be convenient access if the chassis is put into an open back cabinet. It is not necessary for stable operation that a cabinet be used, although the small speaker gets some baffle assistance when the cabinet is included.

The partition in the center is there because of mechanical support requirements and not for any electrical purpose. It will be noted that the airplane type dial is fastened to this large bracket at front, thus causing the tuning knob to be elevated above the other controls, also centering that knob in a horizontal direction, and avoiding the necessity of a high chassis, otherwise required for conventional mounting of the dial.

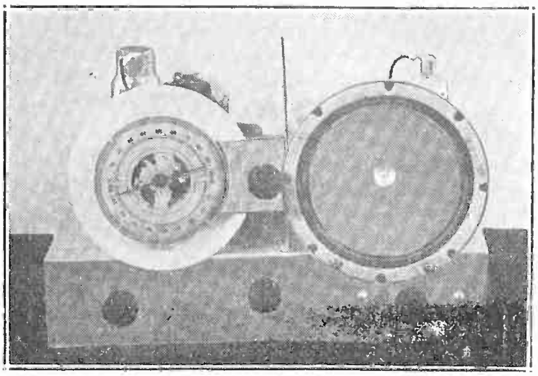
SERIES ANTENNA CONDENSER

The circuit may be whatever the builder prefers, as the circuits are pretty well standardized now. The antenna is connected to the secondary and grid through a variable series condenser of 50 mmfd. capacity. Such a condenser insures oscillation, particularly at the high frequencies, because the effective antenna resistance may be reduced to the point where regeneration is practical, by reduction of the capacity in this series circuit. For any one band a particular setting of this control gives improved results, of the nature of those attendant on impedance matching. The position is not critical and need not be changed until the band is shifted by the insertion of a different coil.

The detector plate is resistance loaded, but more than 100,000 ohms might imperil regener-



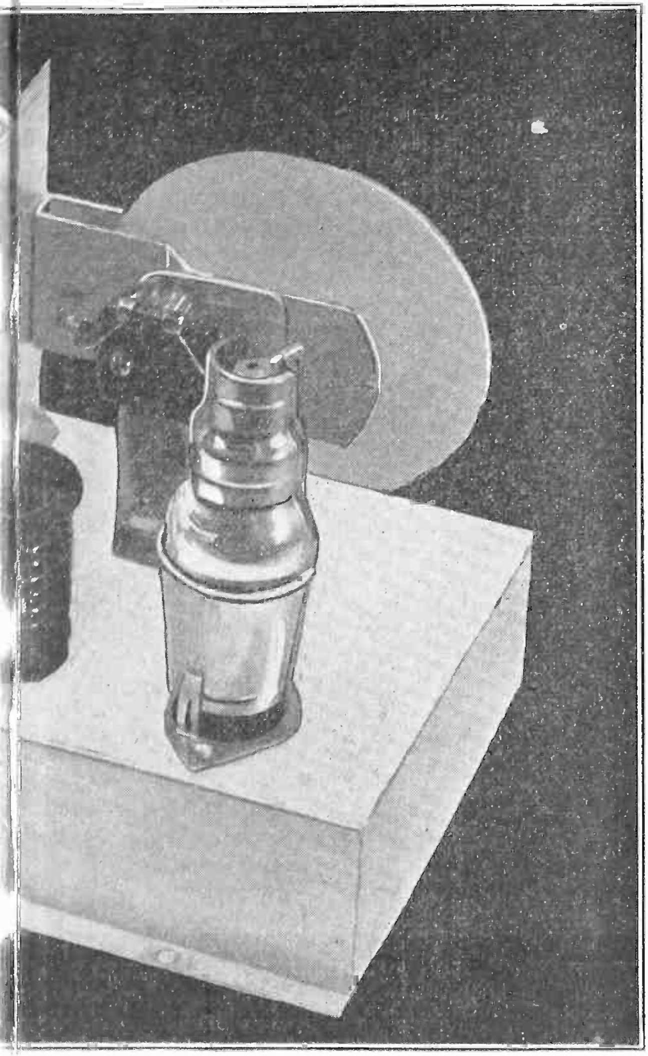
The plugin coil is so placed that the rear of the quick and convenient changing. The cabinet is speaker a bit by sup



The airplane dial is mounted unusually.

er Short Wave Set

Reynolds



et, which is open, renders ready access for essential for stable operation, but helps the g some baffling.

ation. Often 50,000 ohms will do nicely in this case. Besides the main tuning condenser, here 140 mmfd., there may as well be a 15 mmfd. condenser across it, for bandspread. With only one tuned circuit, bandspreading in this way is simplified.

REGENERATION CONTROL

The set shown had control of the screen voltage affect regeneration. From the main B plus lead a resistor of 20,000 ohms was connected to oen side of a 30,000 ohm potentiometer, the other end of which was grounded. The screen was connected to the slider of the potentiometer and bypassed by 0.25 mfd. Thus the smaller windings on the coils were used for feedback, two winding coils made practical for the circuit, and smooth regeneration control achieved.

THROTTLE METHOD

Of course those who prefer the throttle capacity method may use that. It consists of putting an r.f. choke coil between the return of the plate winding and the load resistor, a throttle condenser of 200 mmfd. between plate return and ground, so that varying the capacity varies the choking effect.

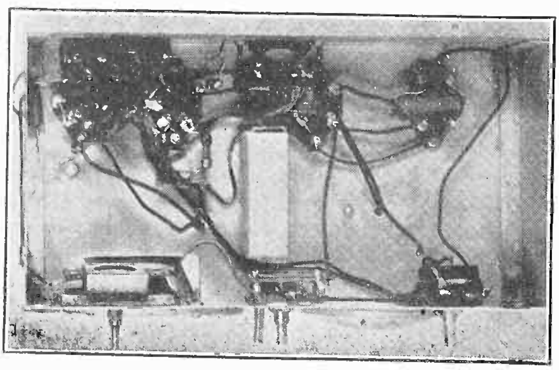
The layout may be used with regeneration control knob at left, bandspread condenser knob next, above it the main tuning knob, and at right the antenna series condenser.

The design of the receiver shown is, of course, universal, that is a.c.-d.c. This is obvious because there is now power transformer. The line cord has a resistance built in.

UNIVERSAL PRECAUTIONS

One of the precautions to be observed with universal sets is that if used on d.c. the right polarity must be strictly observed when connecting to the line, otherwise the electrolytic condensers are endangered. Also, on a.c. use, if the rectifier tube goes, the electrolytics will blow, as then there is nothing but a.c. across the electrolytics, and they do not normally stand up under such a severe condition.

There are bipolar electrolytics made, however, where this danger is eliminated. In general, for a given physical size the capacity is half that of the more usual condenser, and for a given capacity the price is twice as much.



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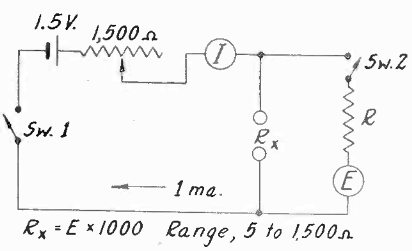

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This method was applied to a 0-0.5 d.c. galvanometer, the resistance of which was determined to be 17.6 ohms, and measured on a decade box later, for verification, to be 17.67 ohms. For any present purpose, however, such meter resistance would be taken as the nearest whole number of ohms, e.g., 18 ohms.

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Since full scale deflection is 0.5 milliampere in the example of galvanometer, the full scale voltage reading is 0.0005 ampere × 18 ohms, or 0.009 volt. It should be emphasized that the meter is used without limiting resistor as for current readings, yet as voltmeter and therefore should not be applied to this purpose until there has been most adequate verification of the extremely low nature of the voltage.

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Weston 0-0.5 galvanometer, Model 375, scale 30-0-30. Rm = 18 ohms; Ro = 3,000 ohms; E = 1.5 volts.

Im Microamperes	*Rx Ohms*	*Im Microamperes*	*Rx Ohms*
(1) 16.7	0.6	(12) 200	12
(2) 33.4	1.3	(15) 250	18
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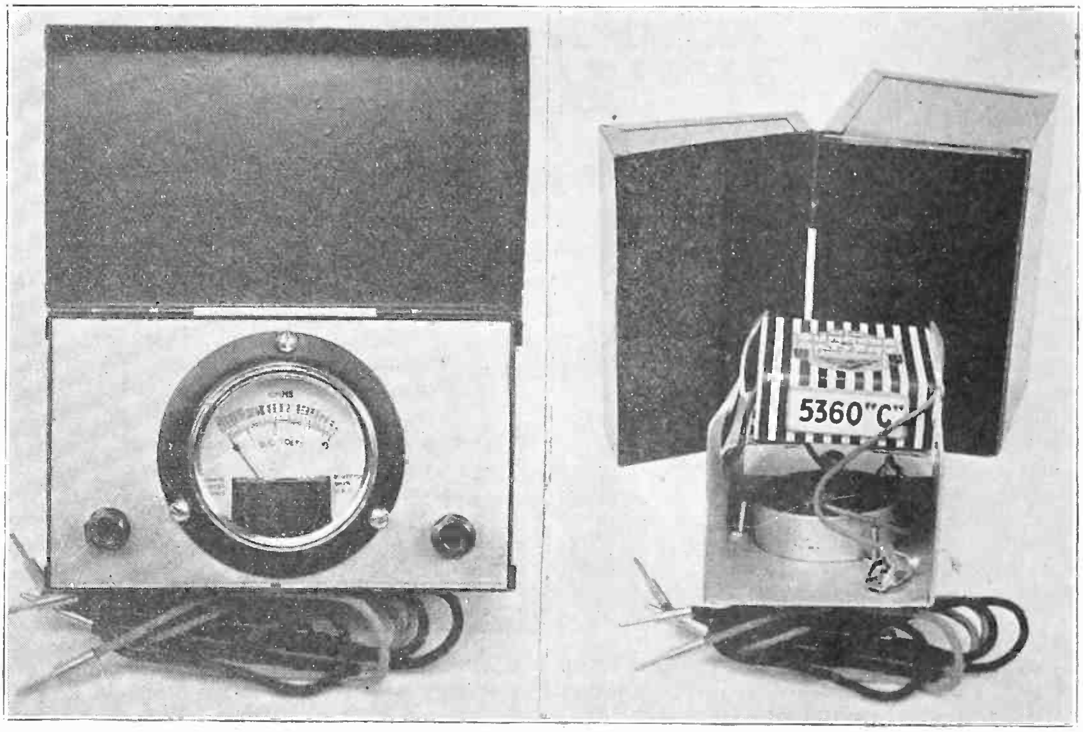

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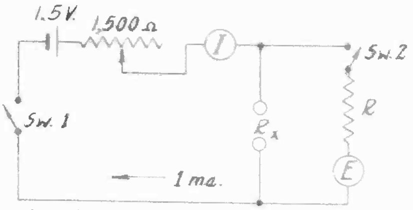

$R_x = E \times 1000$ Range, 5 to 1,500Ω

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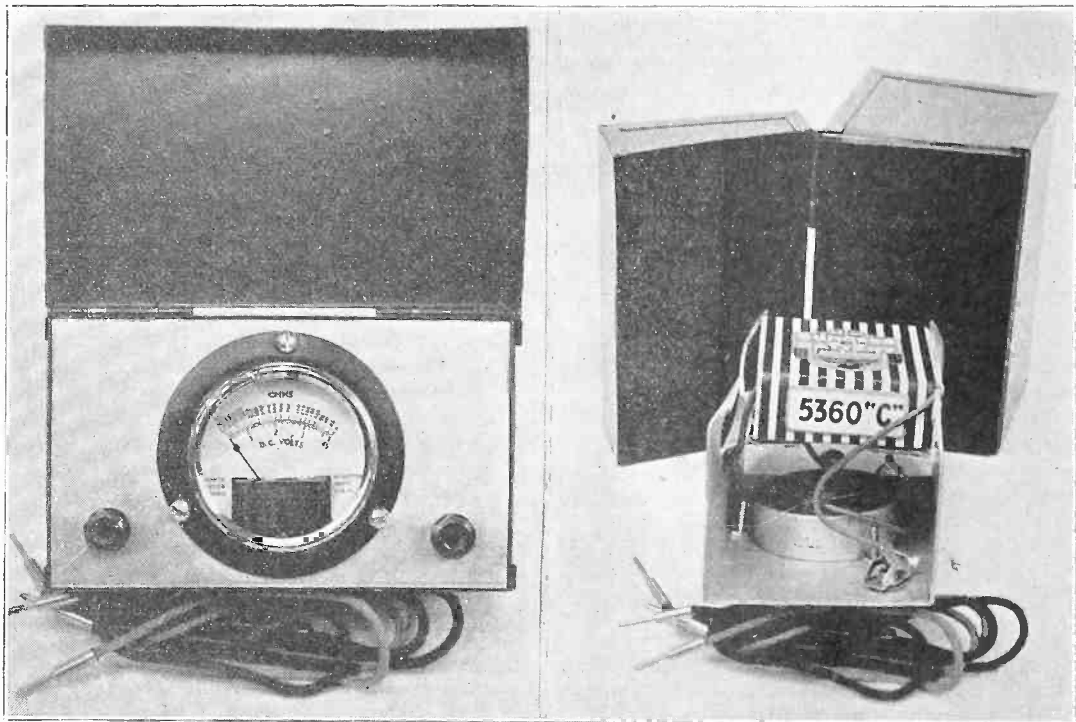

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(*Continued on next page*)

Three Tube Speak

By Albert

HERE is a layout adaptable to short wave reception on a loudspeaker, using three tubes. This is possible because the large tube at left consists of two tubes in one envelope: a half wave rectifier and a pentode power tube. It is the 12A7. Some manufacturers, but not all, make it. The rest of the tubes are standard, a 6C6 detector and a 76 driver.

The speaker is of the magnetic type and will not require an output filter if the bias on the power tube is raised high enough to keep the plate current through the magnet winding at somewhat less than 40 milliamperes.

DETECTOR TUBE SHIELDED

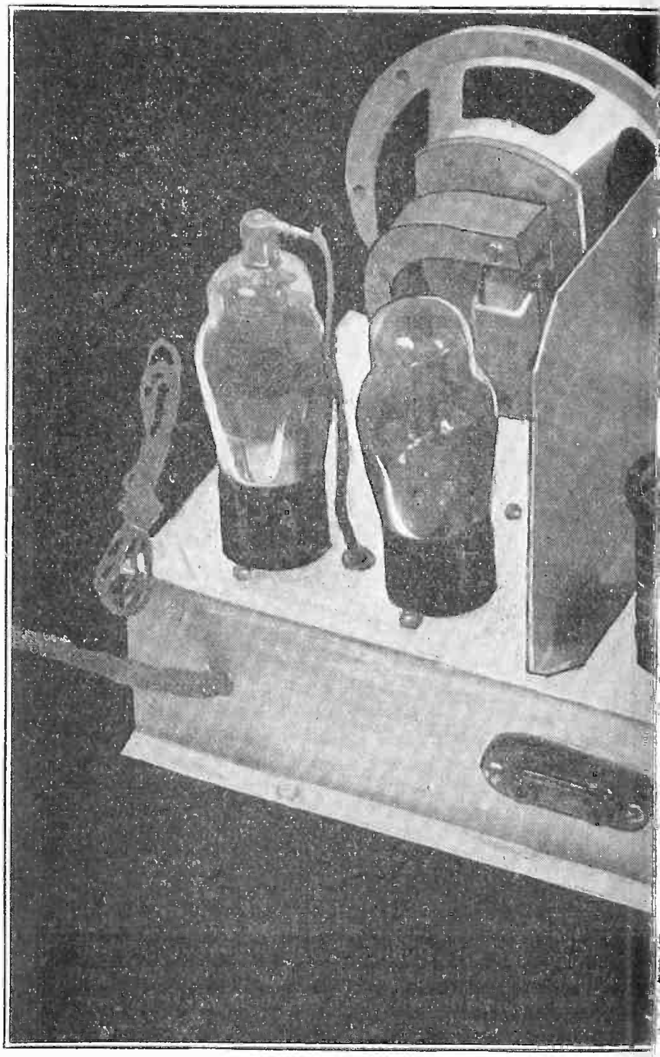
A shield is advisable on the detector tube. The coil socket is placed near the rear, so that there will be convenient access if the chassis is put into an open back cabinet. It is not necessary for stable operation that a cabinet be used, although the small speaker gets some baffle assistance when the cabinet is included.

The partition in the center is there because of mechanical support requirements and not for any electrical purpose. It will be noted that the airplane type dial is fastened to this large bracket at front, thus causing the tuning knob to be elevated above the other controls, also centering that knob in a horizontal direction, and avoiding the necessity of a high chassis, otherwise required for conventional mounting of the dial.

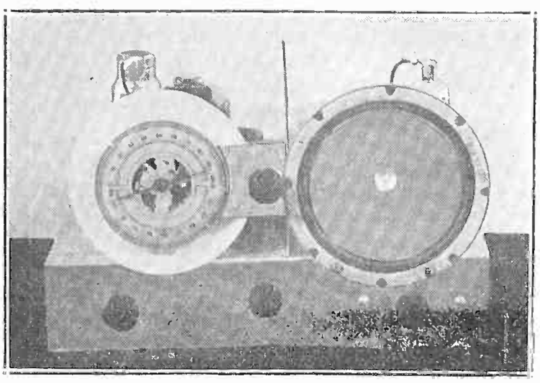
SERIES ANTENNA CONDENSER

The circuit may be whatever the builder prefers, as the circuits are pretty well standardized now. The antenna is connected to the secondary and grid through a variable series condenser of 50 mmfd. capacity. Such a condenser insures oscillation, particularly at the high frequencies, because the effective antenna resistance may be reduced to the point where regeneration is practical, by reduction of the capacity in this series circuit. For any one band a particular setting of this control gives improved results, of the nature of those attendant on impedance matching. The position is not critical and need not be changed until the band is shifted by the insertion of a different coil.

The detector plate is resistance loaded, but more than 100,000 ohms might imperil regener-



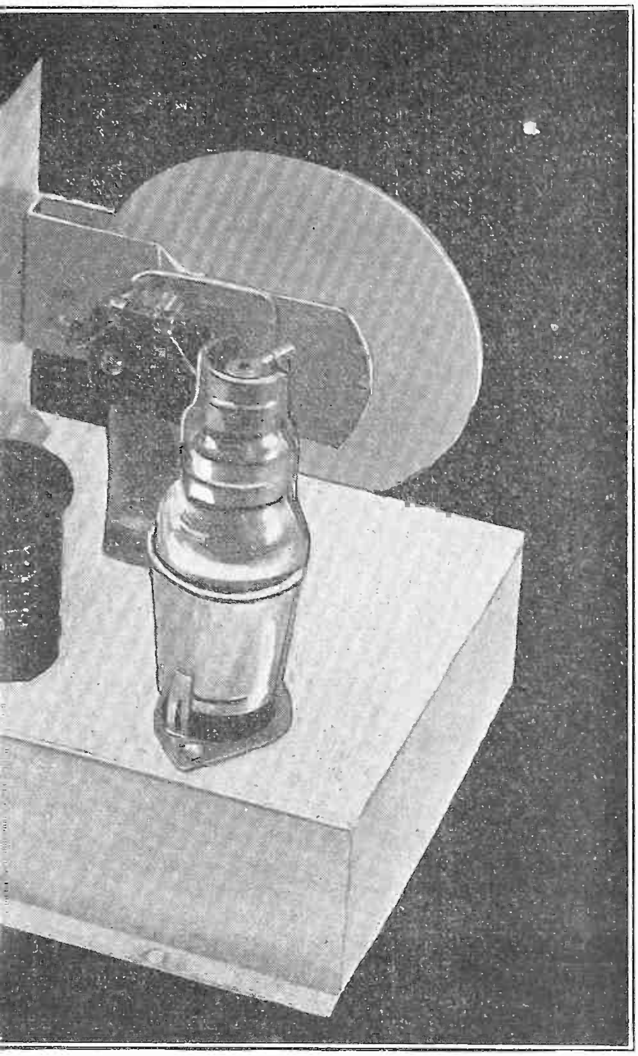
The plugin coil is so placed that the rear of the quick and convenient changing. The cabinet is speaker a bit by su



The airplane dial is mounted unusually.

er Short Wave Set

. *Reynolds*



net, which is open, renders ready access for essential for stable operation, but helps the ng some baffling.

ation. Often 50,000 ohms will do nicely in this case. Besides the main tuning condenser, here 140 mmfd., there may as well be a 15 mmfd. condenser across it, for bandspread. With only one tuned circuit, bandspreading in this way is simplified.

REGENERATION CONTROL

The set shown had control of the screen voltage affect regeneration. From the main B plus lead a resistor of 20,000 ohms was connected to oen side of a 30,000 ohm potentiometer, the other end of which was grounded. The screen was connected to the slider of the potentiometer and bypassed by 0.25 mfd. Thus the smaller windings on the coils were used for feedback, two winding coils made practical for the circuit, and smooth regeneration control achieved.

THROTTLE METHOD

Of course those who prefer the throttle capacity method may use that. It consists of putting an r.f. choke coil between the return of the plate winding and the load resistor, a throttle condenser of 200 mmfd. between plate return and ground, so that varying the capacity varies the choking effect.

The layout may be used with regeneration control knob at left, bandspread condenser knob next, above it the main tuning knob, and at right the antenna series condenser.

The design of the receiver shown is, of course, universal, that is a.c.-d.c. This is obvious because there is now power transformer. The line cord has a resistance built in.

UNIVERSAL PRECAUTIONS

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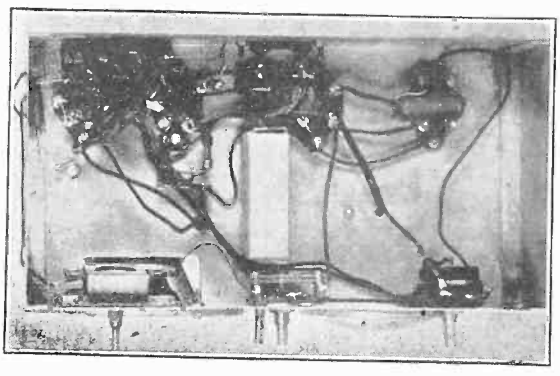

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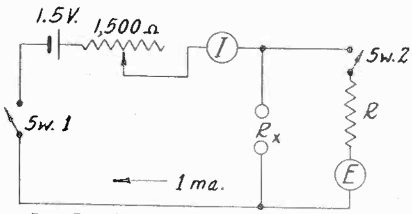

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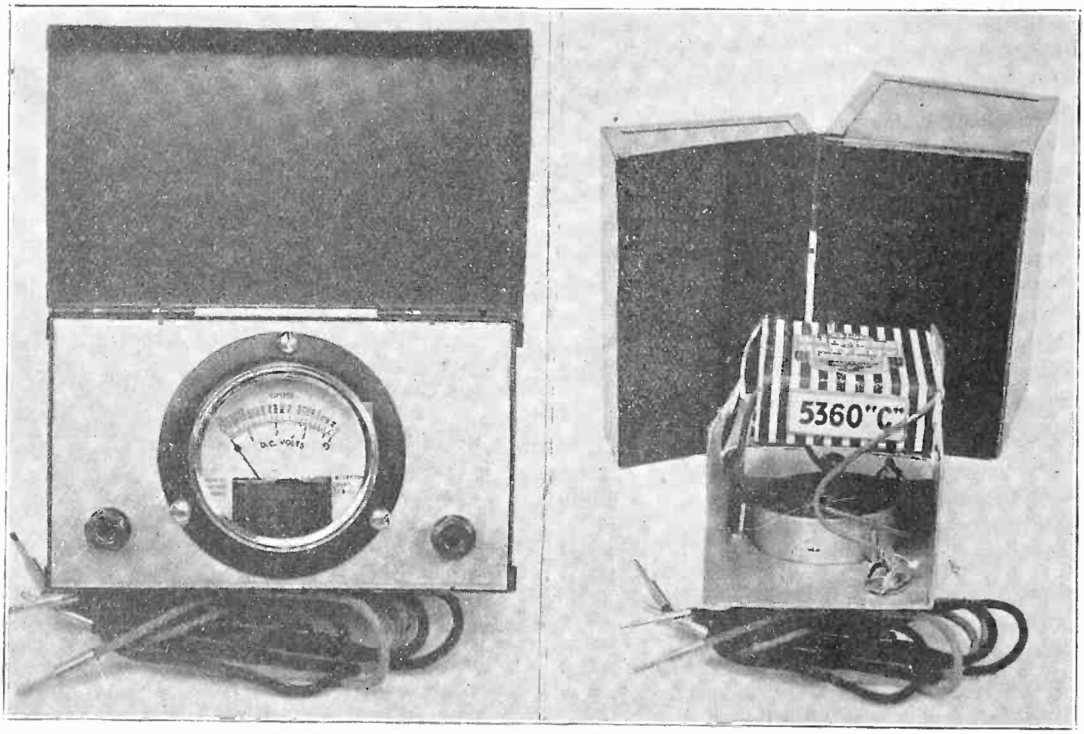
Follow this method: Short the Rx terminals, turn on the switch Sw, adjust the circuit for 100 milliamperes, reading the meter I, open the Rx terminals, whereupon the current will become almost unreadable, put in Rx, readjust the current to 100 milliamperes, read the voltage across Rx, and multiply the voltage reading by



Combined resistance meter and voltmeter housed in a metal card index box. Such a meter normally draws milliamperes, yet may be shunted, although not such low resistances read.

smallest resistance mentioned, the meter may be used with 1,000 ohms in series to follow the scale for a 0-1 milliammeter, 0-1 volts, or 1,500 ohms for 1.5, 3, etc., as terminal reading. This dispenses with the need of computing the voltage.

EXTENSION OF DECIMAL RANGE

Returning to the decimal current system at low resistance measurement, and considering the second diagram, we found range limitation serious, but extension may be accomplished by the inclusion of the current meter I, or 0-100 milliammeter, and a rheostat. The value of the limiting resistance in this rheostat nominally should be 15 ohms, but since a variable is used we may select a 20 or 30 ohm instrument, and 10. The answer is the value of Rx, lying between say 0.05 ohm (depending on how closely low voltage can be read on the meter) and 15 ohms. The voltmeter may be 1.5 volts, 2 volts or 3 volts full scale.

USING HIGHER VOLTAGE

If one hasn't a voltmeter of such low range as recommended for any of these purposes, the voltage of the battery may be increased to the meter maximum meter voltage, or thereabouts. Suppose the meter is of the 6 volt type. Then the battery voltage is increased to 6 volts. This is four times the original 1.5 volts in mind, therefore the limiting resistor also should be four times as great, or 60 ohms. If a variable is used, 100 ohms or so would be satisfactory,

(*Continued on next page*)

(*Continued from preceding page*)

and the adjustments made for 100 milliampere service. The same multiplier of 10 applies to the voltage reading in determining the resistance in ohms.

In view of the use of flashlight cells, and also the practical requirements that do not widely call for measurement of such very low resistances as we have been considering, we may consider the example of 10 milliamperes current flow. Here the cell may be as before, 1.5 volts flashlight type, the limiting resistor nominally required 150 ohms, but a variable of a few hundred ohms will do nicely, and the voltage read is multiplied by the factor 100. Now the voltmeter should be of the 1,000 ohms per volt type, or even more sensitive, so as to not to disturb the accuracy, and the range may be taken as 0.5 to 150 ohms. Also I is a 0-10 milliammeter, instead of 0-100. A battery of 3, 4.5, 6 volts, etc., may be used for matching a voltmeter, if the limiting resistor is increased proportionately, as before, to 300, 450, 600 ohms, etc., variable resistors somewhat higher because adjustable to the correct value.

EXAMPLE NOT TO FOLLOW

The fourth illustration concerns current meter I as a 0-1 milliammeter, ER as a voltmeter of 1,000 ohms per volt or better, limiting resistor 1,500 ohms, or a few thousand ohms if variable, and total current flow adjusted to 1 milliampere. The voltage read is multiplied by 1,000. The voltage may be increased, if the limiting resistor is increased proportionately, as in the previous examples, to accommodate a voltmeter of 0-3, 0-4.5, 0-6 volts, etc. The theoretical resistance range may be taken as 5 to 1,500 ohms.

The fourth example, however, is not practical, because the system loses accuracy the moment that the voltmeter current is an appreciable percentage of the total current. Here if 1 milliampere flowed through I, at 1,500 ohms for Rx, the limiting resistor also of 1,500 ohms then being out of circuit, and ER being a 1,000 ohms per voltmeter of 1.5 volt range, ER would read only 0.75 volt, because ER and Rx would be equal, in parallel, hence the total current through I would be taken half by the ER and half by the Rx circuit, and the voltage of 0.75 multiplied by 1,000 would yield for Rx 750 ohms, instead of 1,500 ohms, a 50 per cent. error. So in the absence of a more senstitive voltmeter we shall leave the system as found in the example shown in the third diagram.

METER SHUNTING METHOD

There is another method of low resistance measurements that may be followed on the basis of determination of the resistance of the meter, though requiring calibration. Take the example of the 0-1 milliammeter and assume the measurement by the coil shounting method yields a value of 30 ohms. We know that the coil had 30 ohms and the meter likewise. If the shunting coil were 15 ohms, the meter still 30 ohms, less current would flow through the meter than through the coil, so setting up a series circuit to deflect the meter needle to full scale, limiting resistor and cell the other components, if the meter reads less than half scale the unknown is less than 30 ohms, if the meter reads more than half scale the unknown is more than 30 ohms. Also, if there is hardly discernible deflection the resistance Rx is greater than 300 ohms. These are rough boundaries handy to know.

By using the decimal method applied to voltage readings for resistance determinations, rheostats of various values may be adjusted to desired standards, and also low fixed resistors measured. Then to encompass 0.5 ohm to 200 ohms for the meter shunting method of resistance readings, on a 0-1 milliammeter, the calibrated resistors may be placed across the meter one at a time, and the current noted.

$$Rx = \frac{Rm\ (Ro + Rm)}{\dfrac{E}{Im} - Ro}$$

in which

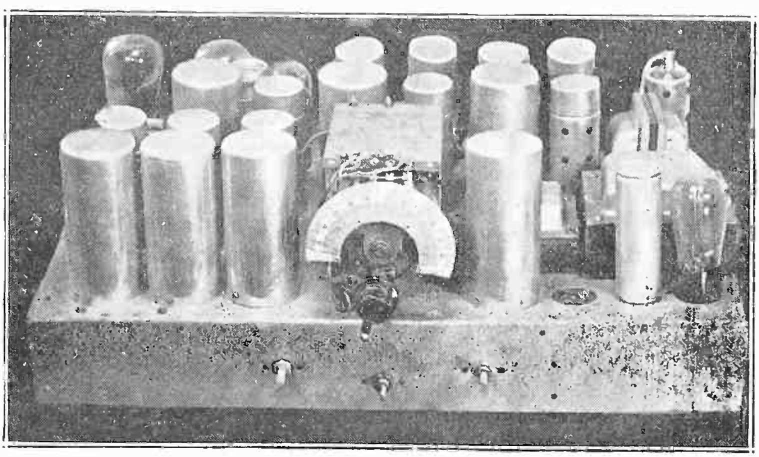
Rx is the unknown resistance.

Rm is the internal resistance of the meter itself.

Ro is the limiting resistor.

E is the battery voltage.

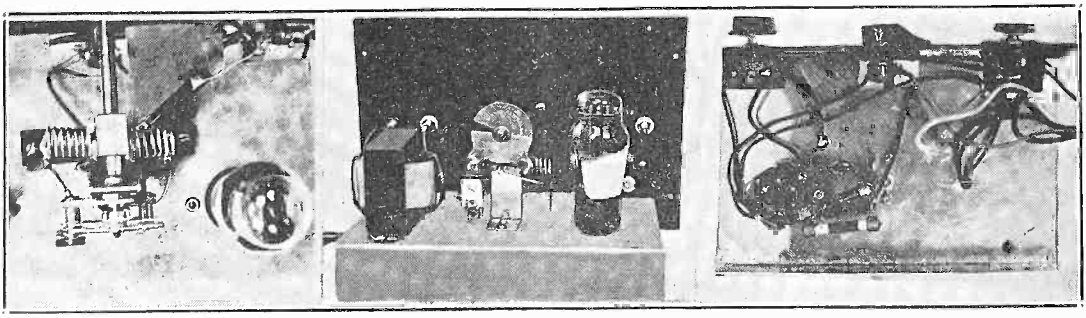
Im is the current through the meter alone.



High powered all wave set of original design includes different colored pilot lamps to reveal identities of the different bands.

An Effective Transceiver

By Maxwell M. Hauben



Three views of the transceiver. The five meter coils are in circuit. The microphone transformer is atop the chassis. The under-chassis view shows volume control at left and receiver-transmitter switch at right.

THIS transceiver uses the 19 tube in a very simple super-regenerative circuit. The coils may be changed for the two bands, 5 meters and 10 meters. Throwing a switch changes the operation from reception to transmission.

The success depends on having plenty of regeneration. The object of introducing super-regeneration is to be able to build up the sensitivity greatly, so that with this single tube the noise level could be reached.

The greater the tube emission, the more certain one is of full regeneration, and so the tube may be operated at full 3 volts, although the recommended voltage in the tube specifications is 2 volts. The 3 volt service considerably reduces the tube life, but any who desire to use 2 volts may introduce a resistor of 8 ohms between A plus and the on-off switch.

The illustrations show the layout. The diagram is easy to follow. Coil information is as follows:

FIVE METERS

L^1 = Seven turns of No. 14 plated wire on 3/8-inch form diameter.

L^2 = Same as L^1.

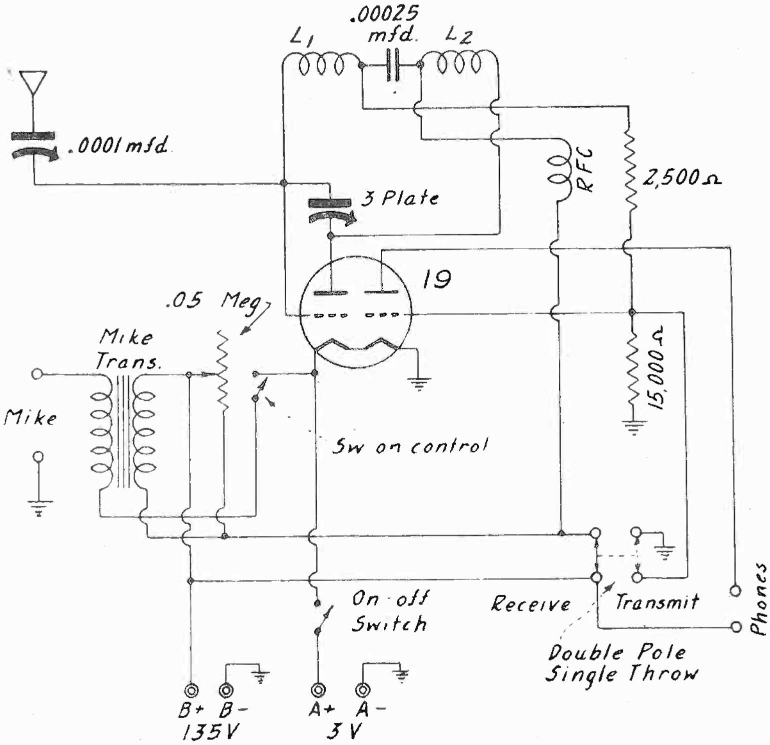
TEN METERS

L^1 = 11 turns of No. 14 plated wire on 5/8-inch form diameter.

L^2 = Same as L^1.

As for the radio frequency choke, RFC, this consists of 65 turns of No. 28 single silk covered wire on 3/8-inch form diameter.

The receiver-transmitter switch is of the type that is moved to either of two positions to short one while leaving the other open.

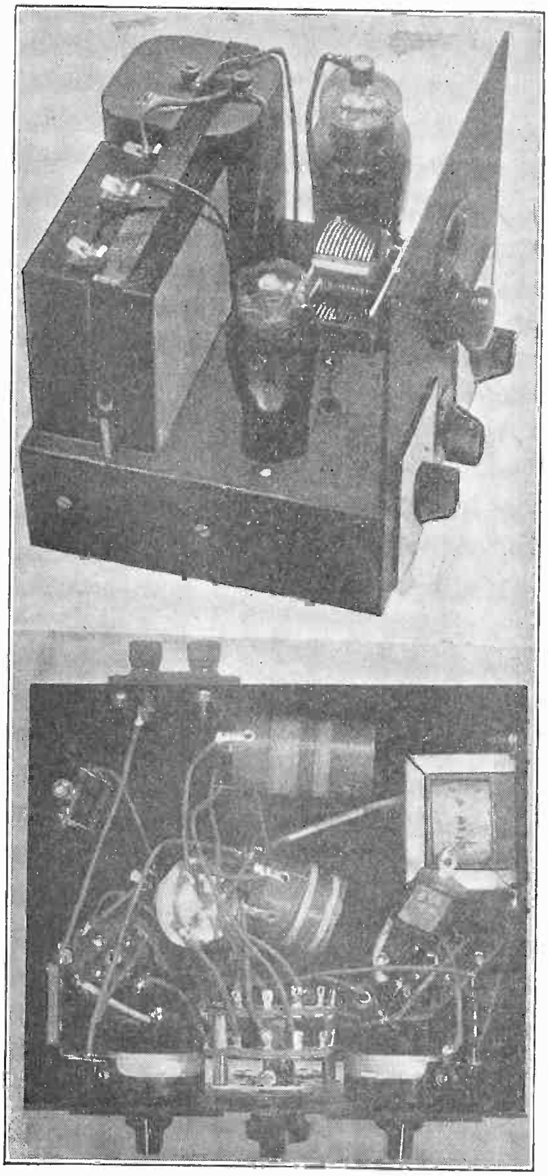


Biggest interest in radio in recent weeks has been in transceivers, enjoying rebirth of popularity as warm weather arrived. (Baffin Bay subscribers please ignore). Throw a switch to one side the thing's a transmitter, to the other side it's a receiver. Coils may be inserted for operation in either 5 meter or 10 meter band.

Battery Signal Generator

132 to 3,800 Kc with Attenuation Calibrated

By Edward M. Shiepe



The new 45 volt small B battery and the new "Little Six" A cell are shown (top), while bottom view reveals parts and wiring.

A BATTERY operated device may be used anywhere, any time. No other type of operation permits this. To be sure, the batteries will run down, and one is put to unexpected expense if the A switch is left closed unwittingly, but these conditions must be accepted along with the advantages.

In the battery type signal generator a very satisfactory result is obtained, a good strong oscillation, with a steady and clean modulation, with no feeding through the line. Grounding may be complete, so that the shielding effect of the metal cabinet is utmost, because the case does not have to be isolated from the a.c. or d.c. line. Moreover, it must be admitted that battery operated signal generators are practically in exclusive use in laboratories, and therefore one may be tempted to copy somewhat laboratory practice.

One such practice is to have the audio intensity that is introduced into the radio frequency oscillator subject to control and graduated on a scale, reading percentage modulation. This is a practically linear scale for a linear potentiometer. Also, the radio frequency output being subject to attenuation, the graduation may be in terms of decibels.

THE GRADUATED PLATES

The front view of the generator shows these two plates, which may be engraved laminated phenolic composition. The percentage modulation is of some importance where prescriptions for adjustments may require a certain percentage be used. The decibel attenuation is approximately calibrated, the scale being according to the formula for power differences, because the measurements are assumed to be made on a receiver or channel that has power output, where the generator rating should be related to the type of receiver output. Therefore to test modulators alone, as in transmitter practice, the scale does not hold, because modulators are on a voltage basis. For the decibel notation to apply of course the current has to be the same at all frequency settings of the radio frequency generator, and while such constancy does not hold absolutely, it does so nearly enough, because of the stability of the radio frequency generator.

Two new battery types make the present design particularly appropriate and useful. The large capacity A supply is the new square type 1.5 volt cell good for many hours of use, while the B battery is the compact 45-volt type, with

22.5 volt tap, the same size as the prior 22.5-volt battery of portable dimensions.

The tubes used are a 34-radio frequency oscillator and a 30-audio frequency oscillator. The term modulator is usually applied to the audio frequency oscillator. By selection of B voltage, grid condenser capacity and grid leak the frequency of the tone may be selected. The values given in the diagram produce a 1,000 cycle note. A larger stopping condenser may be used for lowering the audio frequency pitch, if desired, but 1,000 cycles is preferred by many.

ELECTRON COUPLING

The radio frequency output is electron coupled and so there is little radio frequency change due to the setting of the 10,000 ohm potentiometer's arm, practically none, except on the short wave band, where the change is less than 10 kc out of 3,800 kc. This is no worse than occurs in other precision instruments.

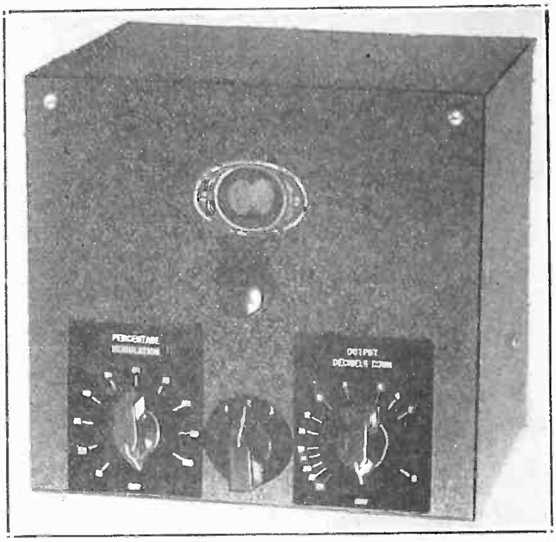
By switch operation, using stationary coils, any of the following three bands is selected:

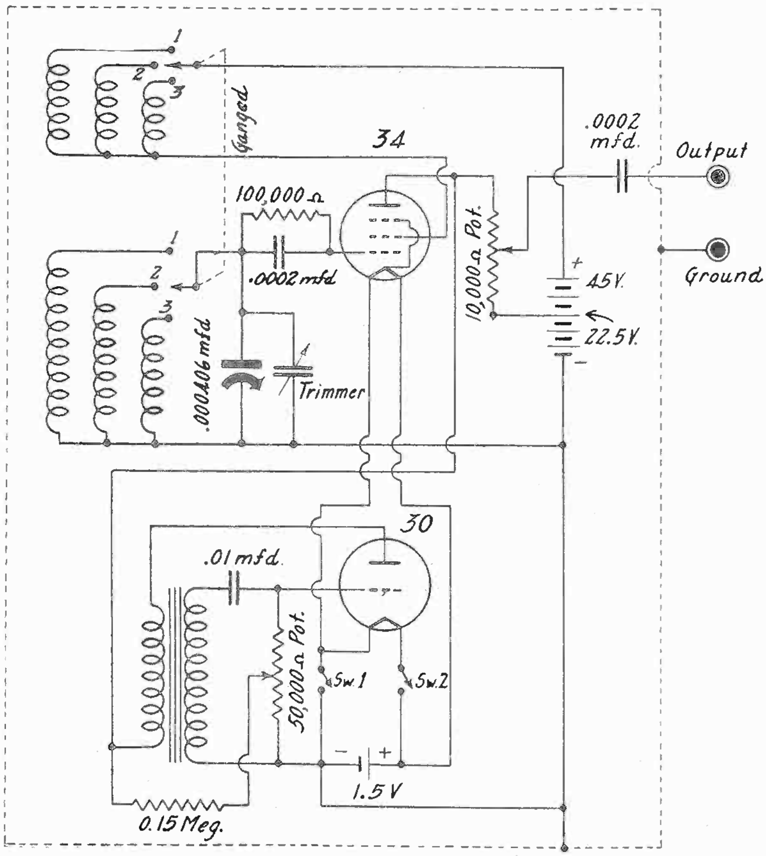
(1)— 132 to 380 kc.
(2)— 540 to 1,520 kc.
(3)—1,320 to 3,800 kc.

The dial scale is frequency calibrated, hence direct reading, and is tracked by a General Instrument ball-bearing condenser, when precision coils are used. The calibration repeated (No. 1 multiplied by 10) is rendered very practical because of large trimmer capacity, the trimmer turned down all the way, a position from which it will not be disturbed, by the way, as there is no play between dielectric and plates.

The low frequency scale and the broadcast scale are separately on the dial, occupying respective rows of the disc. The broadcast band happens to be equal to the low frequency band multiplied by 4, that is, 538 to 1,520 kc, but the broadcast band is registered to begin at 540 kc.

(*Continued on page 43*)



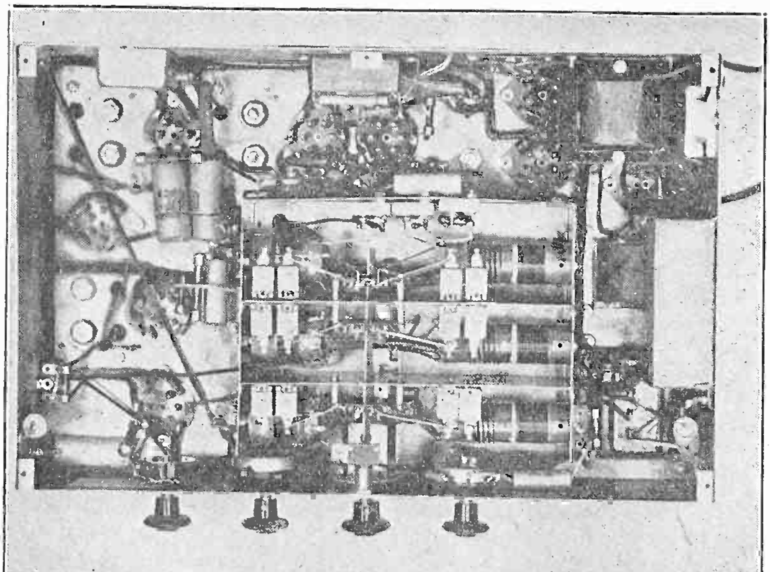


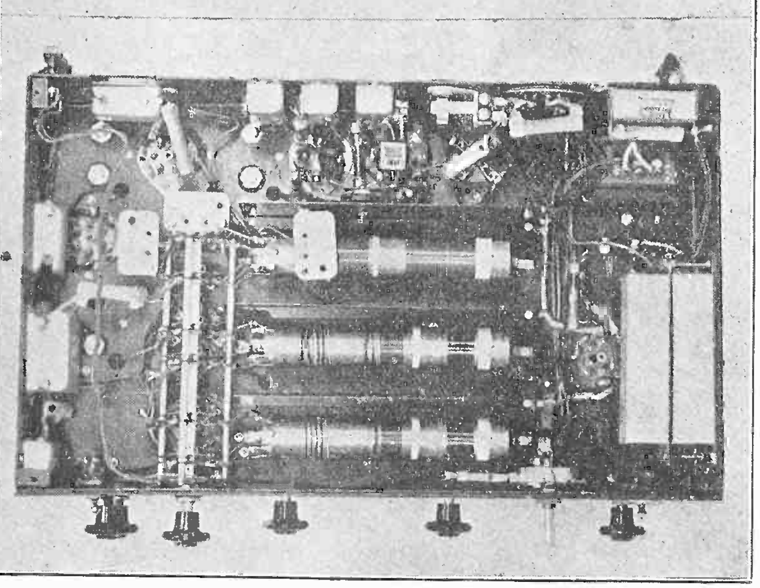
Two different scales, with oratory type signal generator, which is battery operated. The low frequency scale is read directly, the broadcast band directly, and that for the intermediate short wave frequencies the low frequency scale is multiplied by 10.

Attractive Coil Assemblies

Eye to Art Does Set No Harm

By Perry C. Ainsley





Two different receivers by the same manufacturer. The top illustration shows the coil switch built into the shield assembly, thus making the leads to coils more nearly uniform in length. The trimming condensers are in eye compelling formation. The switch to one side of the coils represents the preceding model.

MUCH improvement is noted in the appearance of the coil assemblies in short wave and all wave receivers. There is some relationship between appearance and performance, probably because a designer who takes enough pains to produce a neat layout also takes enough pains to insure maximum performance.

While a peek underneath the chassis is not conclusive, a set one is asked to buy naturally invites such inspection.

LOVELY TO LOOK AT

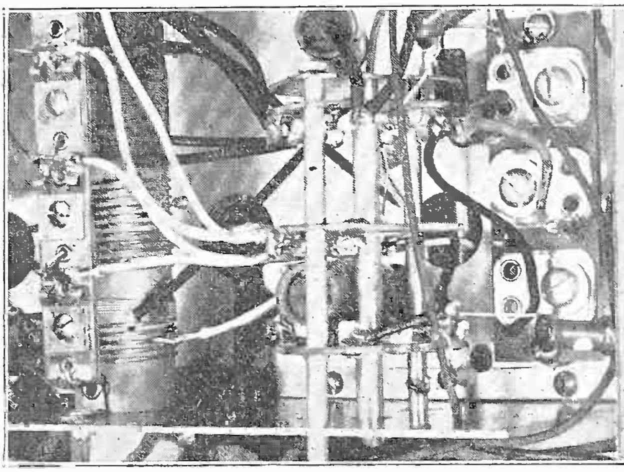
The two illustrations on this page represent excellent achievements in appearance, and the receivers are of recognized performance. They are products of the same manufacturer, two different models, the upper one the later. A switch that was previously at left has been moved nearer the center, thus more nearly equalizing the distance of leads to switch. From the upper photograph it is apparent that the shield compartment had to have the switch built into it, since the switch shaft pierces the walls, and the switch therefore was assembled on the shielding. There are three compartments in each illustration, and nine coils on three forms for three bands, using a three gang condenser. The trimming condensers are neatly arranged in formation, and all told the interior view of the wiring (top photo) is about as attractive as anything that the market now offers.

SWITCHES O. K.

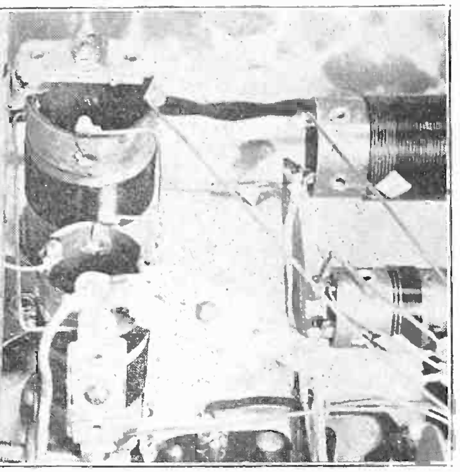
When the general public became interested in short waves the radio industry was hardly prepared for the business that was waiting, and even the switches intended for band shifting were of an inferior type, high capacity, high resistance and vacillating contact. Now switches are excellent, contact capacities of less than a micromicrofarard being encountered, and contact resistances of a few thousandths of an ohm. Positive contact is the rule with switches, as the indeterminate type was impossible.

The trimmer condensers shown on the receivers pictures on this page and the other are of the compression type. These are satisfactory but cannot be said to stay put. under rigors of transit and meteorological changes. Therefore some manufacturers will announce sets for 1935-36 in the higher priced brackets, that have air dielectric condensers for radio frequency trimming, as well as for intermediate frequency adjustment. One of these sets will be announced next month by a manufacturer that holds practically top recognition in radio, and the other by a mid-Western manufacturer whose sets have been particularly attractive to amateurs.

That the placement of coils is a problem that at first was not solved well, but is getting more attention, can be noticed by comparing last year's models with this year's, and next year's with this year's. Some designers put coils fairly close to switches, others distribute coils at right angles, the goal being to avoid objectionable interaction, and especially to hold up the performance above 10 mgc, the region where it is difficult to have receiver performance compare with that on lower frequencies. This is still a problem.



Several coils on one form, form parallel with coil switch, trimmers close to the coils they serve, and on a separate strip.



Coils require much experimentings so that they are properly placed. Right angle location illustrated.

Battery Operated Signal Generator

(Continued from preceding page)

For the short wave band the low frequency band scale is multiplied by 10, and there is an overlap, 1,320 to 1,520 kc, while from the low band to the broadcast band there is a fundamental missout, 380 to 540 kc. The 200-kc overlap affords selection of excellent spreadout from 1,320 to 2,000 kc or so, important in adjusting local oscillators in broadcast superheterodynes. The missout is taken care of, 380 to 540 kc, by the separate calibration marks for intermediate frequencies that would fall in this region, harmonics of lower freqencies being used. Hence with slight harmonic application, and without confusion, there is coverage from 132 to 3,800 kc.

In the construction, the chassis is fastened to the front panel—both being finished metal—and the generator is wired completely on this combination, so that the generator may be inserted right in the box cover, which is closed on five sides.

Adjusting Coils for Short Waves

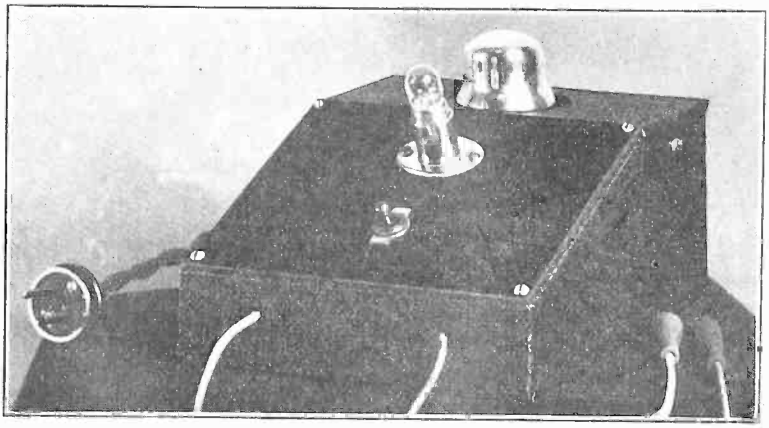
When short waves are to be received in several bands, under conditions where trimmers are not independently used on the individual secondaries of coils, it is practical to adjust the inductance in a simple manner. If the coil is wound in spaced fashion, that is, one turn not hugging the next turn, some small adjustment of the distance between turns may be made even after the coil is wound about as tightly as you can do it by hand. Then if it is required to lower the frequency for any tracking, the inductance may be increased by bringing the turns closer together.

Simply tend to bunch the wires toward the center, especially as the inductance per turn is greatest at about the center, or at least is smallest at the ends. Of course, this method requires that the coil be a bit too small in inductance to start with, as it is not practical to reduce the original axial length of winding, only decrease it.

Condenser Leakage Tester

Neon Lamp Device Uses Pulses as Gauge

By B. C. Lord



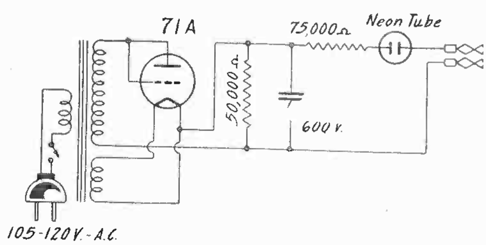
Apparatus for testing the leakage of paper condensers. The fewer the flashes of the neon lamp the less the leakage. As a practical application, condensers were rated as satisfactory when the number of flashes was one or less per second.

A DEVICE for relative testing of leakage of paper condensers was constructed, consisting of a power transformer, a 71A tube used as rectifier, a 50,000 ohm bleeder resistor across which was a 2 mfd. 600 volt condenser, while a 75,000 ohm series resistor and a neon lamp completed the circuit. When the condenser to be tested was connected to the circuit by clips the neon lamp would flash. For practical purposes it was found that one flash per second, or less, would denote a condenser of satisfactorily low leakage, whereas if the flashes were more rapid the condenser would be unacceptable.

Quite a difference was noted, comparing condensers of different manufacture. Naturally, the greater the capacity the greater the expected leakage, but some makes showed much less leakage on 4 mfd. than did others of 0.25 mfd., both condensers of the same voltage rating.

The voltage applied in the test was about 400 dc. The clips were well insulated, to safeguard the fingers from any tingle due to accidental touching.

The neon tube is of the type without limiting resistor built in.



Circuit diagram of the condenser leakage tester. The 600 volt condenser line should be continuous.

NEW METAL TUBES IN OCTOBER

Although the new metal tubes have been distributed to manufacturers they are not expected to be on the general market until October. The tubes are seven in number, and others are to be announced within the next few months, for release after October. They have metal shells, instead of glass envelopes, and all fit the same

NEW TRANSMITTING TRIODE

There is a new transmitting triode, the 838. It is designed primarily for use as a zero-bias Class B audio-frequency power amplifier, but may also be used advantageously as a radio-frequency power amplifier and as an oscillator.

All Circuits We Print Can Be Readily Duplicated

ALL parts for circuits described in RADIO WORLD constructionally are obtainable, most of them stocked by regular supply sources. However, anybody unable to obtain desired parts may obtain information as to where to procure them by writing to Trade Editor, RADIO WORLD, 145 West Forty-fifth Street, New York, and enclosing stamped, addressed envelope.

Moreover, all of the circuits have been constructed and tested, and the photographic illustrations should be followed as closely as possible, as location of parts sometimes plays an important role in determining results, especially on short waves.

—EDITOR.

War on Static Succeeding

Major Armstrong Uses Frequency Modulation to "Defeat Nature"

By J. E. Anderson

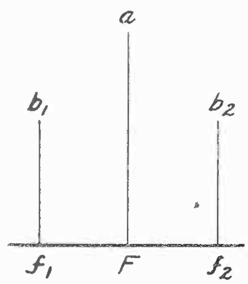


FIG. 1
The carrier and two side frequencies in an amplitude-modulated wave.

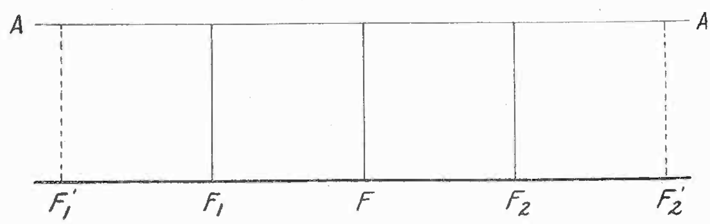


FIG. 2
This represents a frequency modulated wave. The constant intensity is the distance between the two horizontal lines. The greater the modulation, the greater the distances F_1F and FF_2.

THE next major development in radio appears to be frequency modulation. Successful experiments along this line have been announced by Major Edwin H. Armstrong of Columbia University, one of the foremost radio authorities. These experiments have been conducted over a long period in the laboratories of Columbia University and at the experimental station of the National Broadcasting Co., atop the Empire State Building in New York. Receiving stations had been set up at Westhampton, L. I. and at Haddonfield, N. J., at which suitable receiving equipment was set up to listen to the 7½ meter wave of the Empire State building transmitter.

According to Major Armstrong the new system will practically eliminate static and other extraneous noises that disturb radio communication, for example, tube noises arising from non-uniform flow of electrons. Selective fading is another trouble that appears to vanish when the system of communication is used.

EXPLANATION OF FREQUENCY MODULATION

Heretofore waves used in broadcasting have been amplitude modulated. This means that the frequency is held constant at a specified value and the amplitude is varied in accordance with the audio signal that is impressed on the carrier. When the wave is frequency-modulated, on the other hand, the amplitude is held constant and the frequency is varied in accordance with the audio signal.

It cannot be said correctly that frequency modulation is new, for it has existed since the beginning of modulation, but it has existed as a serious vice. The best radio minds the world over have been engaged in overcoming this defect, and several years ago a concerted, international move was started to effect a remedy. The introduction of piezo-electric crystal control of oscillators was the first step in correcting the defect, and it remains the best for elaborate transmitters. Other means have also been discovered for stabilizing the frequency of oscillators in which it is not practical to employ crystal control. It may be said that the problem of frequency stability has been solved satisfactorily. And just as this goal has been attained, the best radio minds turn to frequency modulation in the opposite direction. It is not frequency modulation in itself that is a vice, but only its presence when the wave is supposed to be amplitude modulated. In frequency modulation a variation of the amplitude will be the vice and, presumably, the successful application of frequency modulation depends on a means for suppressing amplitude variation.

WIDTH OF A WAVE

Much has been written about the width of a wave. Most of the time this does not mean anything. Usually it was the circuit that was broad, or lacked selectivity. Sometimes this was because the coupling was too close and sometimes because the tuned circuit had too much resistance. When the wave is modulated, either by amplitude or frequency, it does have a certain width, for more frequencies than one are involved. But an un-modulated wave has no width, provided the frequency remains constant.

The waves generated by spark transmitters

(*Continued on next page*)

(*Continued from preceding page*)

were very broad in themselves, for such generators produced a wave having a fundamental of about 1,000 cycles per second and all the harmonics thereof. When a tuned circuit, say of 600 meters, was excited by the spark, the harmonics in the 600-meter region were very close together, and several of them lay within the tuning curve of the most selective circuit. Moreover, all these harmonics were nearly of the same order of magnitude. When such transmitters were used very loose coupling and selective circuits were required to make the wave sharp, that is, to exclude all the harmonics except one. Very little success was attained and it is for this reason that spark transmitters are being suppressed as fast as tube oscillators can be substituted.

"WOBBULATION"

When frequency modulation was first recognized as a vice it was called "wobbulation." The cause of this was that the plate resistance of the oscillator tube did not remain constant during the modulation cycle. A tone of 100 cycles, say, was transmitted on one frequency and a tone of 10,000 cycles on another. Of course, there was a continuous change, and the process of modulation was very complex. The reason the plate resistance played a part was that in an oscillator not frequency stabilized the frequency depends on the plate resistance. Since in amplitude modulation the plate resistance is intentionally varied, frequency modulation was an unavoidable concomitant. The solution of the problem was to stabilize the frequency, and, as has been said, that was done.

When a wave is modulated in amplitude, the wave may be said to have a width, for more frequencies than one are involved. Thus if a wave of constant frequency is modulated by a tone of 10,000 cycles, three frequencies are involved, the carrier, the upper and the lower side frequencies, one side frequency being 10,000 cycles less than the carrier and the other 10,000 cycles greater. The width of the wave can then be said to be 20,000 cycles. If the carrier is modulated by a combination of audio frequencies ranging from the lowest tone up to the highest, the width of the transmission band is two the value of the highest tone transmitted.

The side frequencies are not independent entities, but may readily be converted into such by a tube or other non-linear device. The side frequencies are mathematical abstractions, and circuits react to a modulated wave just as if those two side frequencies were present together with the carrier. Any circuit that is to be used for the transmission or reception of a modulated wave must be designed so that the side frequencies could be received if they were physically real. If not, they would be tuned out and the modulation would be eliminated. That is what is done, practically, when a quartz crystal is used as one of the tuners. Of course, even a quartz crystal is not so selective that the side frequencies are completely suppressed, but can be restored by suitable circuits.

MICROPHONISM

Frequency modulation exists in receivers in many instances in the form of microphonism. Suppose we have a local oscillator, as in a superheterodyne. By jarring the set there is frequently a howl. This is due, usually, to the vibration of the plates of the oscillator condenser. As the plates vibrate mechanically the capacity of the condenser changes, and at the same time the frequency generated varies. This gives rise to the howl, and it is due to frequency modulation. It is heard, of course, as an amplitude variation, because as the oscillator frequency changes, the intermediate frequency is rapidly changed on and off the i.f. tuning curve. The same effect could be obtained by turning the oscillator condenser back and forth at a rapid rate. When that is done it becomes clear that it is a case of frequency modulation.

Not all cases of microphonism are due to frequency modulation. For instance, when the plates of a radio frequency condenser are jarred there may be a howl. This can only be a case

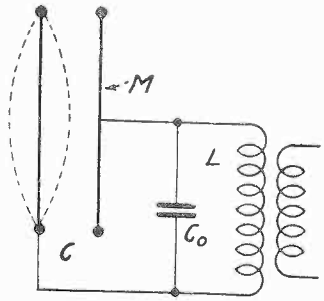


FIG. 3
A simple tuned circuit including a condenser microphone which may be used with a tube for the production of frequency modulated waves.

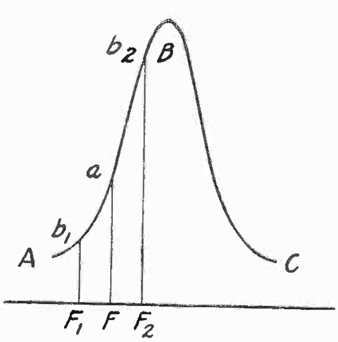


FIG. 4
This shows how a frequency-modulated wave may be impressed on a resonant circuit for producing amplitude modulation. A rectifying detector must be used after this device to make the signals audible. The combination use offers possibilities of retention of some present practices while including the new.

of amplitude variation, due to rapid tuning and detuning. It is the same phenomenon as the frequency modulation spoken of above made audible by rapid tuning and detuning of the signal in the intermediate selector.

Again, microphonism may be due to vibration of the elements of tubes. If the oscillator is not involved, the howl is mainly due to amplitude modulation; but if the oscillator is involved, that is, if the elements of the oscillator tube vibrate, the howl is due to frequency modulation, although amplitude modulation is not absent here either. In fact, the two types of modulation are closely inter-related, and can be segregated only by painstaking design and care.

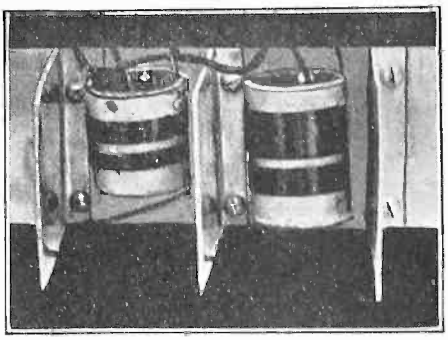
INTENTIONAL FREQUENCY MODULATION

Let us take a condenser microphone and connect it across the coil in the oscillator so that this coil and the condenser form the tuned circuit that determines the frequency. There may be other capacity in the circuit beside that of the microphone, but we shall assume that the microphone contributes the major part. When we talk into the microphone, the capacity changes, and hence the frequency changes. The output of that oscillator is therefore frequency modulated. The frequency will depend on the amplitudes of the sound waves that impinge on the microphone diaphragm. If we shout into the microphone, the frequency variation will be great; if we speak softly into it, the frequency modulation will be feeble. For low frequency tones the frequency variation will be large, for low frequency tones have large amplitudes. Conversely, for high frequency tones the frequency variation will be slight, for high tones have small amplitudes. However, regardless of the intensity of the tone that reaches the microphone, the oscillator will execute periodic changes of frequency and the period will be the same as the period of the tone impressed on the microphone. It is this periodic change in the frequency of the oscillator that constitutes the frequency modulation.

It is clear that the range of frequency change can be altered in two ways. The first is to vary the intensity of the sound that falls on the microphone. The second is to vary the capacity in parallel with the microphone. If this fixed capacity is large, the frequency change caused by a given sound intensity on the microphone will be small, for the percentage change in the capacity produced by the condenser will be small. On the other hand, if the capacity of the microphone is large compared with the rest of the capacity, a sound of given intensity will produce a large change in the frequency. Naturally, it will be economical of the radio spectrum space if the change in the frequency is small, for the smaller the change in the frequency the narrower will be the frequency band occupied by the modulated signal.

HIGHLY SELECTIVE

The fact that the frequency-modulated signal can be squeezed through a very narrow aperture, that is, a highly selective circuit, accounts for the elimination of static and other undesired noises. It is not claimed for the new system, it should be pointed out, that it eliminates all noise, but that it does suppress it in the ratio of about a thousand to one.



Superheterodyne mixer coils as used in present amplitude modulated circuit.

At the receiver the frequency modulated signal is first passed through a current limiting device to remove amplitude modulation. Thus all the frequencies in the band are made of equal intensity. The signal is then led to a selective network for detection. The selectivity curve of this network takes the place of the ordinary detector. The midfrequency, however, cannot be adjusted to fall at the peak of the curve, for this would result in frequency doubling, for the greatest intensity would occur at the peak, and frequencies both lower and higher would be less intense. The optimum adjustment would be such that the midfrequency would fall at a point on the curve where the intensity is about 0.7 of maximum, on either side of the peak. Moreover, the frequency variation would have to be limited so that the peak is never reached in one direction and so that the frequency never encroached too far on the "talus" of the curve in the other direction.

It is clear that the new system requires a new technique of circuit design.

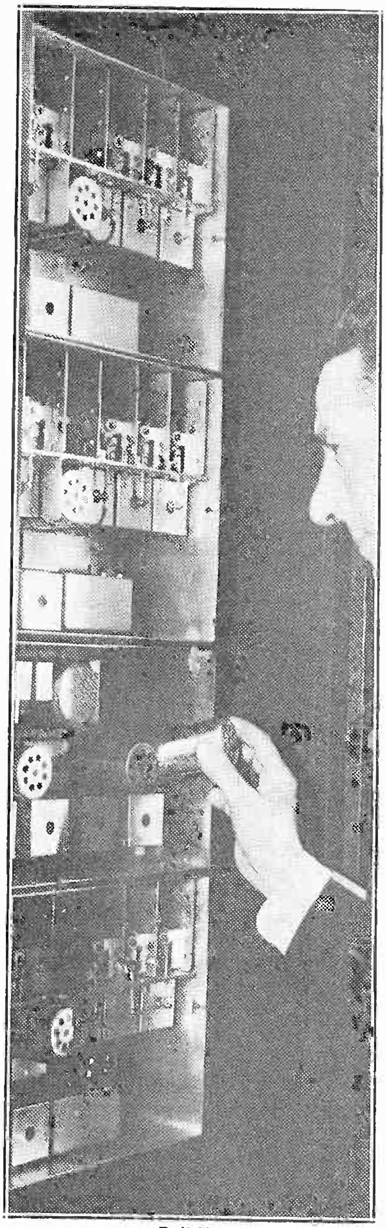
Fig. 1 represents a portion of the frequency scale encompassing the carrier F and the two side frequencies f_1 and f_2 as in amplitude modulation. As long as the transmitted tone does not change in value, the distances f_1F and Ff_2 remain the same. That is, the two side frequencies are fixed. If either f is the highest frequency that is transmitted, say 5,000 cycles per second, f_1f_2, represents the width of the transmission band, or the width of the wave. All other side frequencies lie closer to F, but the distances from F to the two side frequencies are always the same for any given tone.

COMPARISON OF INTENSITIES

The intensity of the modulation is represented by the height of the lines above the frequencies. The intensities of the side frequencies, f_1b_1 and f_2b_2, is always less than the intensity of the carrier, Fa. For weak modulation the b's are barely above the horizontal lines. For 50 per cent modulation either bf is ¼ of aF.

(Continued on next page)

ONE OF FINEST



Bell Telephone Laboratories

The whole system of short wave transmission and reception as practised at present is on the basis of amplitude variation, whereby the potential of the wave is altered by the modulation. The proposed solution for static purposely introduces frequency modulation. Static will be heard even on such an elaborate short wave receiver as the one shown, though minimized by correctives. It is one of the finest short wave receiving installations so far developed.

(Continued from preceding page)

Frequency modulation is represented in Fig. 2. F is the midfrequency and F_1 and F_2 are the extreme limits of the generated frequency as the result of a tone on the condenser microphone of given intensity. This intensity may be represented by F_1F_2. If a more intense tone falls on the microphone, the frequency variation is greater, and may be represented by $F'_1F'_2$. For small variations in frequency, say less than one percent, the distances F_1F and FF_2 are the same.

The intensity of the current at any frequency is the same and may be represented as the distance between the two parallel lines AA and F_1F_2. If the currents are not the same, they are made so by the current-limiting device.

The width of the wave in the case of Fig. 2, as has been said, depends on the intensity, and may be F_1F_2, if these represent the most intense sound impressed on the microphone. Although this maximum distance (between dotted lines) is greater than the distance f_1f_2 in Fig. 1, in actual practice it may be a very much smaller portion of the frequency scale. Indeed, the width of the band in frequency modulation must be narrow if quality and selectivity are to be good.

CIRCUIT CITED

In Fig. 3 is a tuned circuit which may be used in an oscillator for frequency modulation. L is the inductance, C_0 is the fixed capacity across the coil external to the condenser microphone M which has a mean capacity C. When sound falls on the diaphragm (left electrode) this vibrates about as shown by the dotted lines, increasing and decreasing the capacity, and hence decreasing and increasing the frequency generated.

For very small excursions of the diaphragm about its position of equilibrium (solid line), we may write the approximate relation

$$F + f = F [1 + (C/2C_0) \sin qt].$$

In this equation C_0 and C do not have the values given above. Instead C_0 is the total capacity across the coil when the diaphragm is at rest and C represents the amplitude of the capacity change; that is, the maximum increase or decrease in the capacity of the microphone. F is the midfrequency and f the frequency change at a time t, while q is the audio frequency in circular measure, or in radians. The equation is only approximately correct when C is very small compared with C_0. It shows that the frequency of the circuit varies cyclicly about the value F at rate q. The percentage frequency modulation might be defined as $100C/2C_0$.

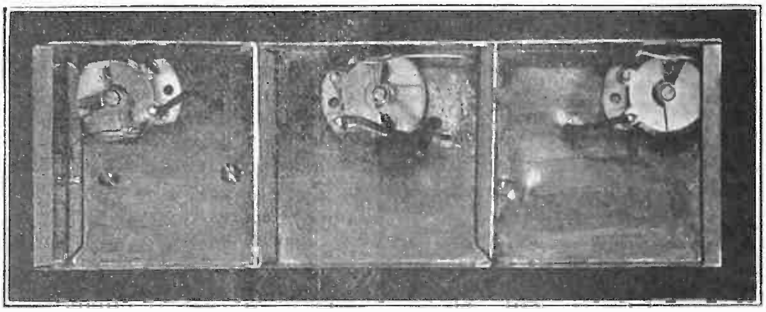
Fig. 4 shows how a frequency-modulated signal can be detected into an amplitude variation. ABC represents a selectivity curve of considerable sharpness. The midfrequency is at "a", the steepest point of the curve. The lowest frequency in the band is F_1, and it is placed so that the resonance is still sensibly straight. The highest frequency is F_2, which is placed just below the peak of the curve. The tuning could also be done so that the transmission band falls on the corresponding part of the other side of the curve. Whereas all the fre-

Straight Frequency Line

Achieved with Junior Midline and an Air Dielectric Trimmer

By Herman Bernard

Straight line frequency tuning has been desirable ever since transmitting stations were placed on a frequency basis. Broadcast stations are placed every 10 kilocycles in the radio spectrum. If the tuning is not S.L.F. the stations at the lower end will occupy much more room on the dial than the high frequency stations will. It is obviously desirable to have them equally spaced on the dial from one end to the other, and this can be done only with a straight line frequency tuner.



Inside view of the copper shield used for mounting the s. f. l. system.

IT is convenient indeed to have straight frequency line tuning, and for those interested in precision tuning it is imperative that the line be absolutely straight. That means that for a given angular displacement of the dial the frequency change is the same at any selected parts of the tuning spectrum. Condensers with plates cut for s.f.l. do not come up to this stiff requirement, as the curve flattens out a bit at the high frequency end due to uncontrollable distributed capacity, which it will differ in different receivers and can't be compensated.

A method has been worked out whereby the line is perfectly straight, using a junior midline condenser of 100 mmfd. capacity, across which is an air dielectric trimmer of 25 mmfd.

BROADCAST BAND IN TWO STEPS

A three gang arrangement has been used, and while the frequency ratio is 2 and a small fraction, the curve flattens out at the low frequency end this time, so where the departure begins the calibration is omitted, and the useful ratio is 1.9. But the line is perfectly straight, no observable deviation, and the trimmer adjustment eliminates any disturbing effect circuit minimum capacities would otherwise have on the tuning characteristic.

The broadcast band, and a bit more, is covered in two steps, and then short waves are tuned in, with the excellent dial spreadout of s.f.l. and with the further advantage that in a superheterodyne it is unnecessary on any band to use series padding condensers, or molest the trimmers. The curve being s.f.l. the padding for the oscillator is done exclusively by inductance, and then of course the same frequency difference is maintained over the full calibrated part of the tuning. The system has been worked actually in a t.r.f. and has been set up tentatively in a superheterodyne now under construction. The mechanical fittings are shown on the front cover.

Multiplex Operation on New System

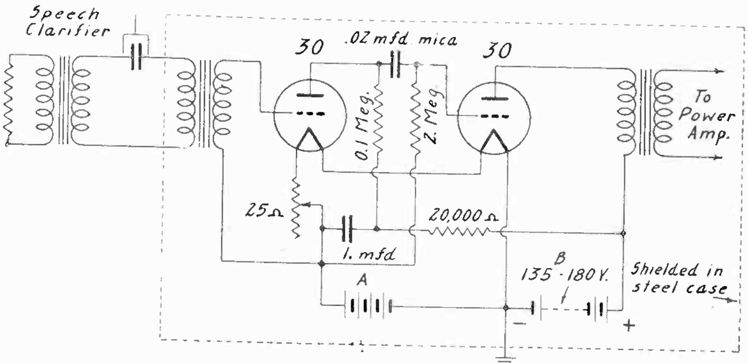
(*Continued from preceding page*)

quencies involved are radio frequencies, the variation in the intensity occurs at an audio rate. Regular detection rectification will be required after the signal has passed this selectivity device.

The new system is capable of multiplex operation, according to Major Armstrong, as many as four different signals having been sent and received over the experimental circuit at the same time. This appears to be a solution to the serious problem of network broadcasting. The system is more suitable for use with ultra-high frequencies than for the lower frequencies employed now in broadcasting. Therefore it has possibilities in connection with the transmission of radio vision signals. The elimination of static and similar disturbances also makes it suitable for this purpose, for when such disturbances come through in a television setup they cause streaks and splotches which mar the pictures.

The Velocity Microphone

By Einar Andrews



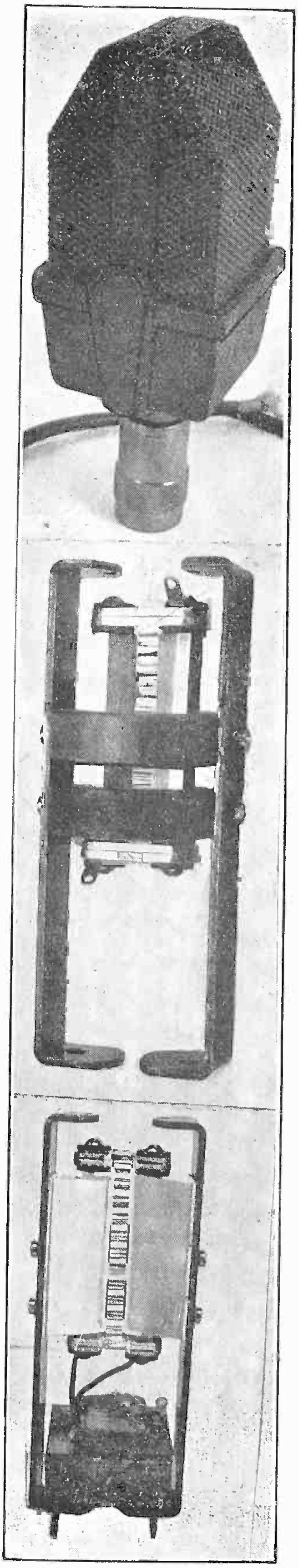
The velocity microphone is represented by the resistor and transformer at left, a fixed condenser serving as speech clarifier. Following is a battery operated two stage pre-amplifier for connection to the power amplifier.

THE ribbon or velocity type microphone, illustrated herewith, depends on careful design and assembly for maximum performance, which means extreme sensitivity to sound waves. They are called ribbon type microphones because the armature is a light corrugated ribbon of aluminum, andt hey are called velocity microphones because the voltage induced in this ribbon is directly proportional to the instantaneous velocity of the air in the sound wave.

The aluminum ribbon is suspended in the field of a permanent magnet. When sound waves fall on the ribbon it vibrates and thus cuts the lines of magnetic force. Whenever this happens, that i, when a conductor cuts lines of magnetc force, an electromotive force is induced in that conductor. Therefore in the case of the ribbon microphone, a small e.m.f. is induced in the ribbon as soon as it vibrates. In principle the velocity microphone does not differ from a megneto or a dynamo except in respect to the force that is used to create the relative motion between the conductor and the magnetic lines of force.

At the otp of the page an assembled microphone is illustrated. The perforated housing is made of steel and is used as a protection for the delicate mechanism within. The perforations are for giving sound waves free and unimpeded access to the ribbon.

In the middle picture the housing has been removed to show the internal structure. The ribbon is plainly visible although it is partly hidden by the permanent magnet structure.

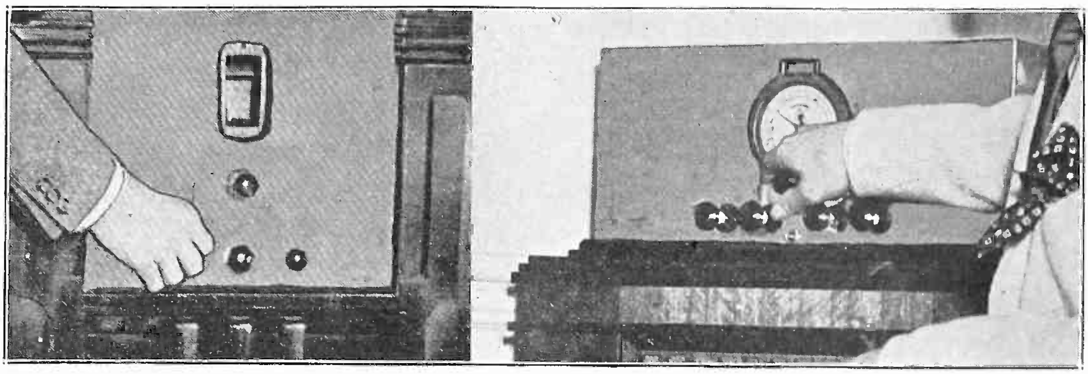


Velocity type microphone, as shown at top, was assembled from a kit. Braces and ribbon assembly are shown in second view, while microphone transformer is shown installed in view at bottom.

Support for Tuning Arm

Housewife's Baffling Fatigue Ended

By Caroline V. Erwin

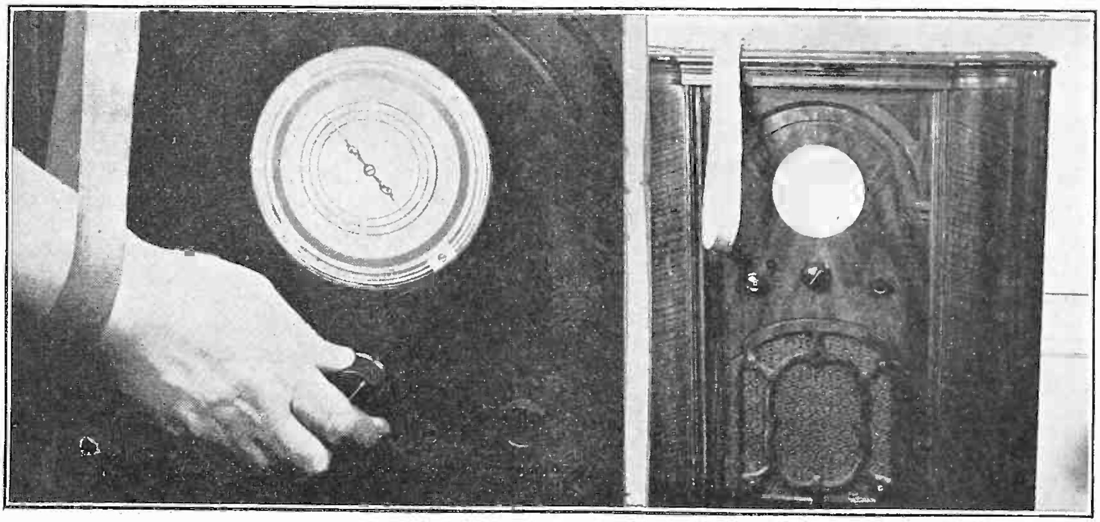


Even persons who do not need any help to hold up their chins may appreciate some assistance when doing a great deal of fine tuning on short waves. In other words, something to support the arm might help.

FUN though it is to tune in European and Asiatic short wave stations, the actual tuning operation is a bit trying at times. One does not notice this while the delightful performance is on, because one is suffused with rapture, but getting up in the morning one may notice that one's tuning arm has that tired feeling. The reason obviously is lack of support while that trying tuning was being done.

Although I am a housewife and not handy at tools, I contrived a support strap and attached it to the rear of our console. The pictures of how this was done tell the story completely. It remains only for me to mention that I was able to tune in more stations using the support strap than before, because I never got tired. Naturally, when fatigue is felt, even if unconsciously, the disposition is to move along very quickly, and I need not remind readers of a radio magazine that this express service on the dial produces many station miss-outs.

It is my firm belief that receivers of the future will be equipped with poise straps or other devices for the comfort and satisfaction of the distance enthusiast, and when this comes to pass I will thank my friends to remember my early suggestion and confident prophecy.

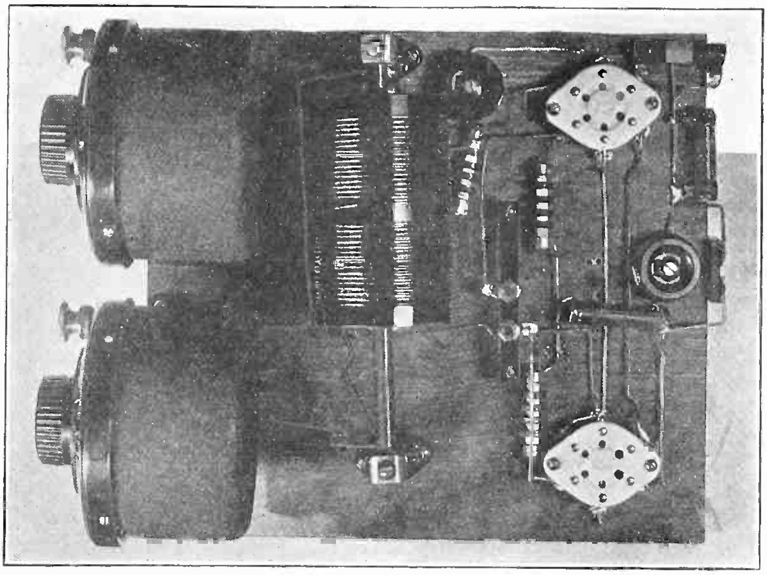


Here is how the author solved this serious problem. Lady's arm did not get tired after an hour's hard work of this kind, although the system was tried without benefit of clergy or bandspread.

A D.C. Transmitter

10 to 15 Watts Easily from Simple Set

By Harry Rosenthal



The modernistic condensers work well nevertheless.

HERE is a simple transmitter that works on direct current. Although the voltage available is low the circui tis capable of putting out a good deal of power. The reason for this is that the 48 tubes draw a lot of plate current even at 110 volts. The power that is converted into high frequency oscillation is derived from high current rather than high voltage.

The use of direct current eliminates the need of a power transformer for supply the filament and plate currents and it also eliminates the need for a rectifier and an elaborate filter. As will be noticed, the two filaments are connected in series and a 135 volt, 25 watt ballast resistor is employed to limit the heater current. No filtering is required in the filament circuit because the 48s are of the heater type.

In the grid circuit of each tube is a 2.5 millihenry choke to prevent shorting the grids at high frequencies. The grid return connects to the junction of these chokes, going through a 50,000-ohm, 2-watt grid leak, which is used for the purpose of establishing a bias on the grids. As will be seen from the illustration at left, a quartz crystal is connected between the two grids. The frequency, therefore, is crystal controlled. The tapped tuned circuit connected between the plates of the tubes is for the purpose of transferring the output to the antenna and to establish a suitably phased impedance. The secondary of the plate circuit is also tuned. To get a signal free from harmonics the coupling between these two circuits should be loose, but it should be adjusted for maximum output. It should be noticed that the condenser that tunes the plate coil is not grounded on either side. This means that it should be insulated from the panel, that is, if the panel is of metal. Body capacity effects do not enter in this case from nothing that is done to the tuning condenser affects the frequency of oscillation, unless the detuning is so great that the circuit stops oscillating. Of course, detuning decreases the output a little but that offers no difficulty because if the plate circuit is approximately in tune the oscillation intensity will be close to maximum.

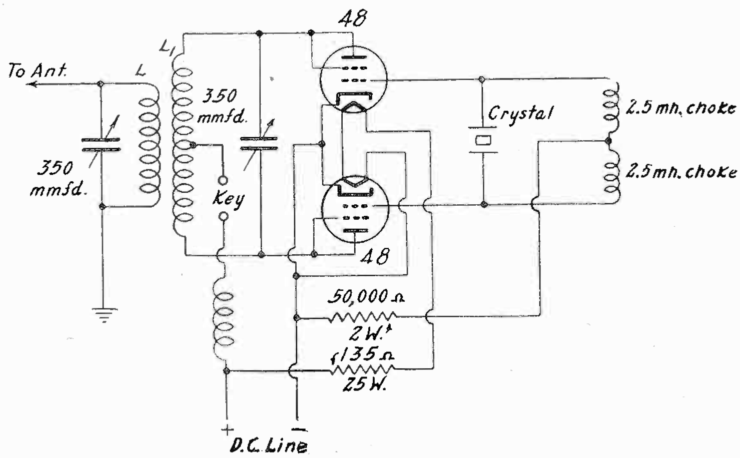
It is more important to tune the antenna circuit and to adjust the coupling. The antenna condenser is grounded and can therefore be adjusted accurately.

Gathering together practically everything from the spares and extras he had about the home workshop, the author built a d.c. transmitter, which he is shown tuning. Clip pencil may be removed from pocket and transmitter still will work.

KEY POSITION

The key is put in the lead between the midtap of the plate coil and the plate supply, that is, the 110-volt line. In series with this line is a radio frequency choke, mainly for the purpose of eliminating or reducing key clicks. Since the

Something unusual in a transmitter, that is, d.c. operation. Hits the ether with a hard smack but is very light on the purse. In fact, the builder managed to pick up the tuning condensers from a benevolent relative in the radio business at 25 cents each. Must be in the wrong business.



transmitter is intended for the sending of code signals, a little hum is of no importance and for that reason there is no audio filter in the plate supply. Anyway, on a d-c line there is very little hum in the first place.

A good idea of the construction of this transmitter may be obtained from the photograph. The two tuning condensers are at the left, and each is inclosed in a metal case. In the middle is the plate transformer LL1, wound on a rather large form with heavy enameled wire. The tubes are at the right and the three radio frequency coils may be seen between the tubes and the tuning coil. Note that the chokes are of the pie-type winding. This type is especially effective at high frequencies because of the low distributed capacity. The location of the resistors is also clear from the photograph.

MOUNTING OF COILS

As is customary in short-wave transmitter construction, the parts are mounted on a wooden baseboard. This is done to eliminate the losses that would result from the use of metal.

The coil system is mounted above the baseboard although this is not clearly seen from the photograph.

The two 48s are used as triodes, the screens being connected to the plates. As such they are capable of even greater output than when they are used as power pentodes. The circuit is also push-pull. The chief advantage of this connection is that the circuit is balanced in respect to the power supply. This should eliminate all noise, but exact balance is not easily attainable and for that reason there will be some line noise mixed with the signal. Especially there are brush noises, which represent actual interruptions of the voltage for very short times. This in no way interferes with the signal for it merely puts a slight modulation on it.

The diameter of the coil L_1 is 3 inches. For the 160-meter band the number of turns is 28 and for the 80-meter band it is 18. Any fairly large size wire may be used, No. 18 enameled being suitable. The coil illustrated in the drawing has a larger number of turns, but the specifications have been changed since the transmitter was photographed. The primary L is on the inside and is adjustable. It may have one-quarter the other turns, but heavy wire (No. 14).

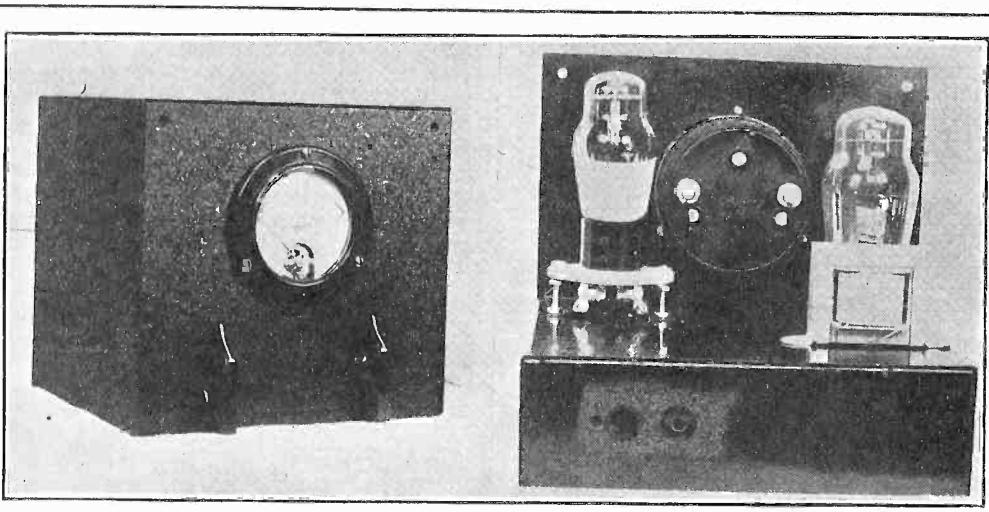
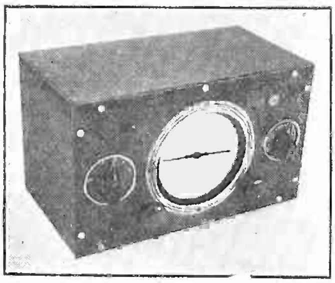


Plate meter, detector tube and a.c. rectifier used for high resistance calibration by using standards as grid leaks.

(*Continued from preceding page*)
thereby using up material they have on hand, and so will find occasion to construct or reconstruct inductances, but may run into serious trouble trying to adjust the coils to the calibration on the scale. In fact, such trouble actually was encountered in commercial production, and therefore the solution found from that experience is set forth here for the benefit of constructors generally.

Assuming that one has such a dial as the one pictured, the problem is to adjust the inductances. Start with the low frequency inductance, because the scale representing the lower set of numbers surely was calibrated with the largest coil, not, for instance, the 5,400-17,000 kc coil. The reason is that a honeycomb coil is used, of about 22 millihenries, and since the number of turns is only a little less than 2,000, the distributed capacity will be higher than that of succeeding coils, especially as some of the succeeding ones will be solenoids.

The first problem to solve is how to set the pointer of the dial. If the condenser plates are totally enmeshed, tested by putting your fingers



Front view of the generator.

on the condenser to feel rotor and stator plates aligned, the intended dial reading must be known. For the instrument pictured this reading is 54. Some dials have calibrations that begin at less than full capacity. Not so of this one, however.

UNEXPECTED DISTRIBUTED CAPACITY

No matter if the coil is somewhat off, just a random approximation of what is needed, though of course not absurdly different, turn the generator dial from lowest to higher frequencies, but not far, until a response is heard in a higher frequency receiver, say a broadcast set. Say the reading is 57. It makes no difference what is the actual frequency generated, there should be another response as the generator dial is turned, at 2 x 57 or 114. There may be intervening responses, in fact would be, for broadcast band receiver. Yet here are two useful references, 57 and 114. Suppose the second reading is 112. There is too much distributed capacity in the circuit. Why? Because the tuning ratio has been cut down. Where 2 to 1 should have prevailed, less than 2 to 1 exists. So reduce the distributed capacity.

There is no trimmer in this particular circuit, so what shall be done to effectuate reduction? First, since a switch is to be used, and may be assumed to be in circuit, remove it and connect directly. If the difference is noticeable, then the switch must be replaced with one of low capacity. But first move connecting wires, especially grid and cathode wires, farther from chassis and particularly farther from each other as a great reducer of distributed capacity, causing a high frequency end change of 8% in a given instance. Even the condenser plates may be inspected, to see that there is uniform spacing, and outside rotor plates not accidentally too close to companion stators. When a check of frequencies at a high capacity condenser setting and a low capacity setting causes twice the low frequency to appear where it should—no matter what the true frequencies are—then the capacity of the circuit is properly adjusted. It is the capacity and its rate of change that determine the most. Capacity and frequency change. The inductance is a constant.

THE COIL PROBLEM

Now with the dial set properly, in respect to the condenser, and the capacity change properly established and checked, the next problem is to get the inductance right. For the present instance an inductance of 25 microhenries may be used, and this will be too large. This can be checked, too. Gain a response in the higher frequency receiver (broadcast band usually), and note the reading on the generator dial. Say it is 55 and that the broadcast station is known to be 660 kc. Divide 55 into 660. The answer is 12. So the fundamental might really be 55, its 12th harmonic beating with 660 kc. Divide by lower numbers than 12, to get the remaining responses: 60, 65, etc. If the dial hits them all just right the inductance is right and the whole system tracks. If the responses come in before the dial is turned as far as it should be, that is, if instead of 60 being the next response after 55, one finds 59 is the next, the inductance is too high. If the condenser has to be turned more than the scale indicates it should be, the inductance is too small. When the inductance is correct the system will track the dial excellently. Any doubt about an unknown low frequency may be referred to a calibrated broadcast receiver, since the generator's low frequency is equal to the difference between the two consecutive frequency settings of the receiver that pick up a response from the unmolested generator.

For the next band the same procedure is followed, using the next scale, and the distributed capacity will not be so far different as to cause any trouble, or if there seems to be a difference, otherwise unaccountable, adjust the inductance, as may be done in the other case, by bringing the coil closer to or farther from metal, e.g., the chassis, testing thus with all or nearly all condenser capacity in circuit. The inductance determines the low frequency setting. The capacity in circuit is the predominant determinant of the frequency for the high frequency end.

For the broadcast band the coil will have less distributed capacity, and seriously less, so that the previous calibration will not hold strictly, unless some capacity is added. So put in a broadcast coil, anything approximately right, and go through the same operation as before, this time having the receiver at 1,080 kc to 1,400 kc. Gain a response due to a setting that produces 1,080/2 to 1,400/2, that is 540 to 700, take the reading at the low frequency position for whatever it is on the dial, and it need not represent the true frequency, but the repeat point should come in at a frequency reading on the generator of twice the previous one. If the pointer must be moved more than this distance not enough capacity has been added. If the pointer does not have to be moved the full distance, too much capacity is present. To add capacity, twisted insulated hookup wire may be used as a trimmer condenser, when tightly twisted equalling about 3 mmfd. per inch.

The two high frequency coils will have about the same distributed capacity as the broadcast coil, because they are solenoids in which the distributed capacity does not depend directly on the number of turns.

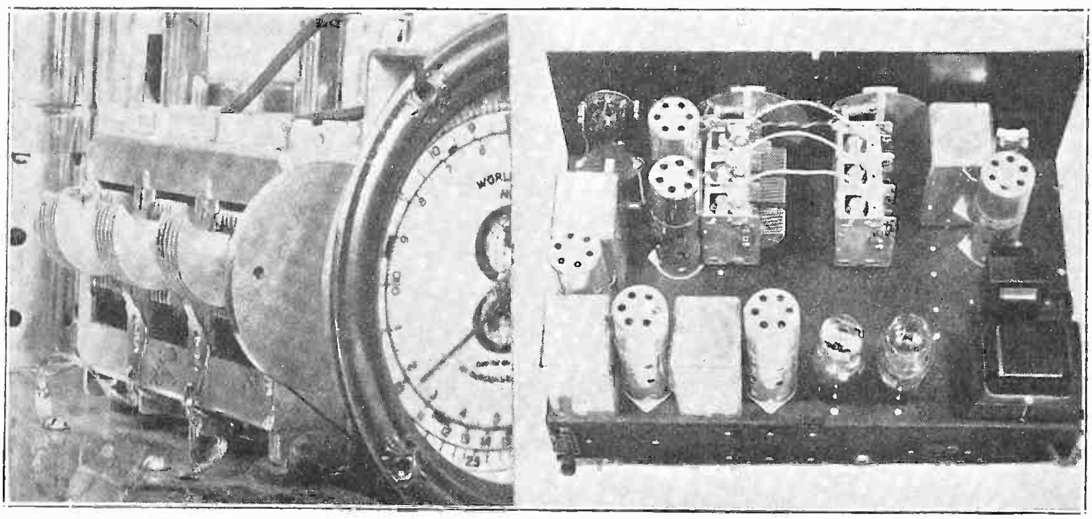
AGAIN THE SWITCH WIRING

As a caution, when running wires to a switch, they contribute considerable capacity and should be spaced as far from one another as practical. Also, the calibrated dial will be correct for one, and only one, set of circumstances, and this must be duplicated. Only the condenser used in the original calibration may be used for tracking the dial, because, as stated, the calibration is really one concerning the capacity alone. The inductance being a constant, the correct frequencies are only incidental to the correct capacity and rate of change of capacity. When the capacity and its change are right, choice of the proper inductance is an easy matter. Otherwise it is never possible to get the "right" inductance, for none is right for a wrong capacity condition.

Coils for such devices also are produced commercially. The lowest frequency coils must be run off in quantity so that the wire comes from the same spool. Otherwise different inductances will result though precisely the same number of turns is used, in fact, for the low frequency coil in mind the inductance difference, using different spools, same number of turns on coils, was equivalent to a difference of 13 turns had the same spool been used. When wire is drawn the die tends to wear, and the wire diameter increases. This increase for the wire on any one spool is negligible, but for random spools may be serious, even ruinous, unless the number of turns is adjusted for the spool from which one is working. This is a manufacturing problem and is mentioned only to give an insight into the degree of accuracy required in coil winding for precision purposes.

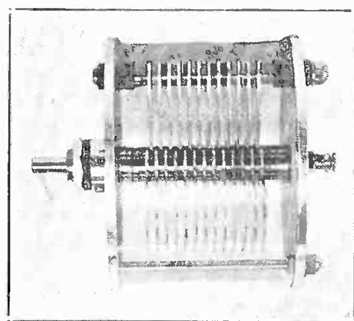
The 6 volt tubes, and other heater tubes, are popular in oscillators, and when used should be recognized as being unstable until they become properly heated. This means that a few minutes should be permitted to elapse before the generator is used, though it is oscillating meanwhile. The calibrations all are made on properly heated tubes, but before the few minutes are up the frequencies read higher than expected, but soon settle down to excellent steadiness. The operating stability is good, therefore, though in the warming up process (when the generator should not be used) the stability is very poor. Check this, if you like, by zero beating with a properly heated tube, then turn off the generator, and hear the frequency of the generator change as the emission is reduced more and more. The frequency may change enough to drive the beat again beyond audibility.

Two Bandspread Mechanisms



At left, gang trimmers are worked by pulling out tuning knob, otherwise main condenser moves. At left, separate actuation of condensers.

Authors of three articles in this issue, after finishing text, seem happy. L. to r., Max Steir, Edwin K. Butler and Maxwell M. Hauben.

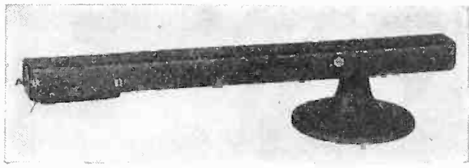


Better grade of condensers for laboratory work are shielded or at least dust protected. This one has celluloid cover.

New Midtown Amateur Headquarters

CRYSTAL PICKUP

$9.00



NEW CRYSTAL PHONES

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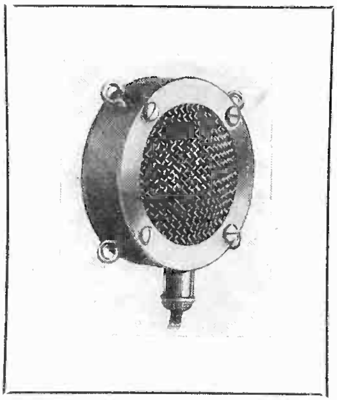

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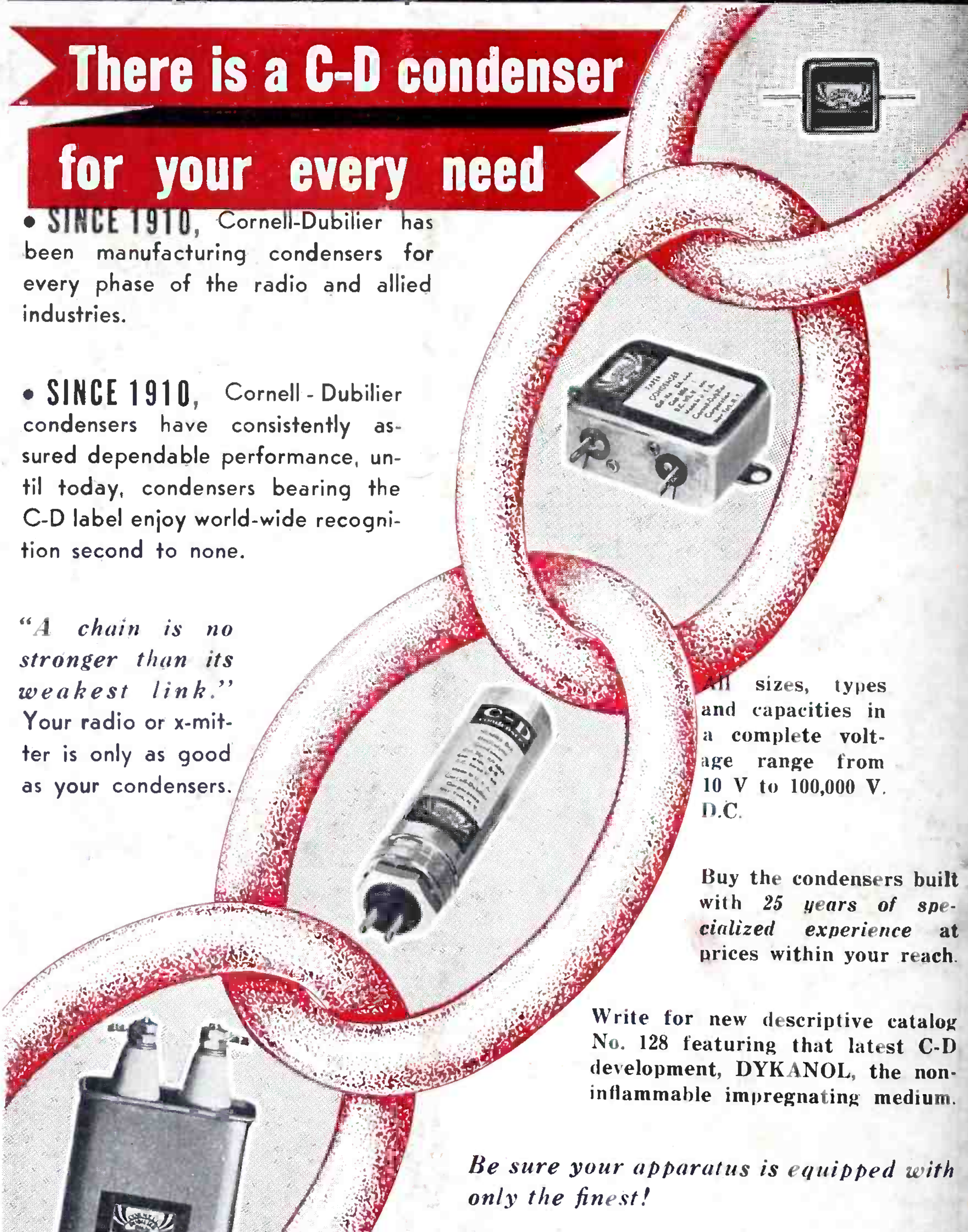

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