HIGH FIDELITY 12 TUBE SUPERHETERODYNE

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OCTOBER 1935

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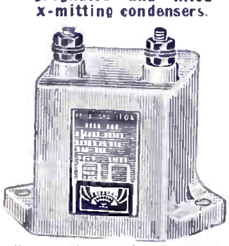

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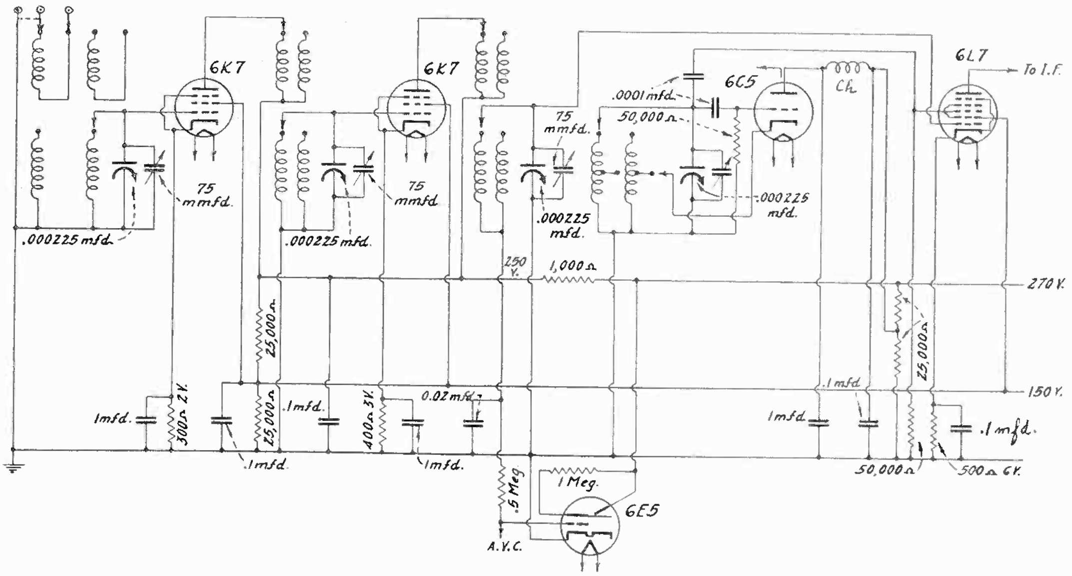
Full Data on All the Metal Tubes

Characteristics, Connections, Voltages and Circuit Information

By Capt. Peter V. O'Rourke



Four of the new tubes are used in this "front end" of a superheterodyne, intended to cover only the broadcast band, using a 2 to 1 frequency ratio and straight frequency line tuning, which is beginning to acquire considerable popularity. The fifth tube is of the glass type, the new 6E5, a cathode ray indicator tube for resonance denotation. The arrow indication to A.V.C. is presumed to be connected to resistance looking toward the second detector equalling 1.5 meg. or somewhat more

AS the metal tubes are now being widely distributed and soon will be in consider-able use, and as constructors of circuits must be familiar with the tubes either to select them properly for their own circuit designs or to connect and voltage them correctly in following wiring diagrams, basic information on these tubes should be at hand, moreover should be studied so that the facts are familiar without reference later on.

The following are significant general facts about the new metal tubes:

(1) There are ten of them at present and no additional ones are in immediate prospect.

(2) All the tubes are heater type and fit into the same socket, known as the small octal, but as not all the tubes have the same number of elements, a different quantity of pins is brought out at the base. Therefore care should be exercised not to insert a tube in a socket circuited for another metal tube, as serious damage to tube and set may result. This danger was at a minimum with glass envelope tubes, as there was a variety of sockets to fit the various numbers of pins.

(3) Due to the vacuum tight close metal shell, the new tubes get warm in operation, and suitable external ventilation must be provided. This is particularly true of the rectifier, where the heat is necessarily larger, due to much greater dissipation requirements, and seriously true also of any tubes used as oscillators because the development of excessive heat produces a commensurate mistuning, or drifting, due to the expansion of the tube elements under heat increasing the capacities among these elements, and also the heat's effect on the emission

(*Continued on next page*)

THE characteristics of the metal tubes as set forth in the article and the tabulated condensation are tentative. This is true of all new tubes. Changes, if any, will be promptly reported in these columns.—Editor.

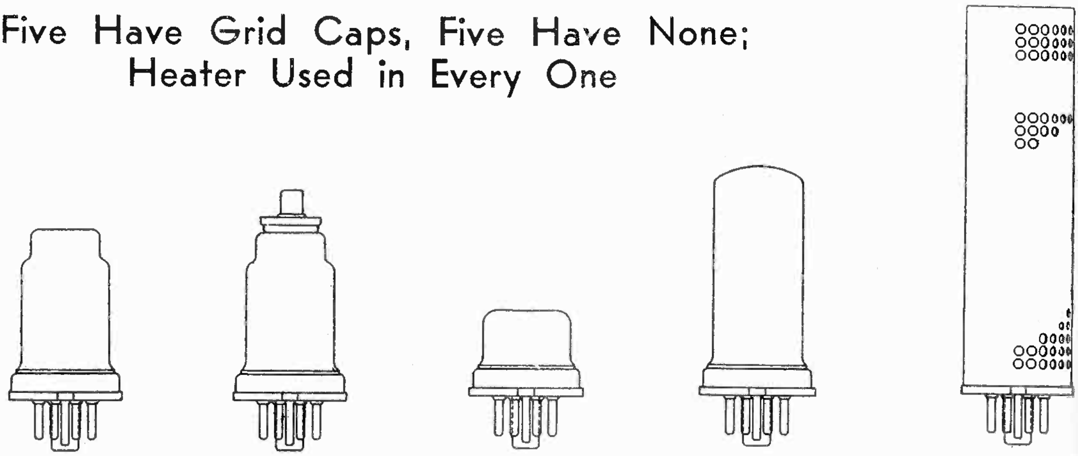
Metal Tubes Classified as to Appearance, Type, Use and Comparative Sizes

(*Continued from preceding page*)
and the plate resistance, indirectly related to frequency.

(4) The tube designation follows a regular system. The numerical prefix (first number) is indicative of the voltage to be applied to the heater, and is either 5 or 6. Where the numerical prefix is 5 the applied voltage is to be just 5. There is only one such tube as yet, the 5Z4 rectifier, also of course of the indirectly heated cathode type. Where the numerical prefix is 6 the preferred heater voltage is actually 6.3 volts, and never should be exceeded by more than 10 per cent., though it may be diminished to 6 volts with small difference in performance. Voltages a little lower than 6.3 may be expected in storage battery operation of the tubes. The letter is a characteristic designation or distinction permitting a wide variety of combinations with numerical prefixes and suffixes, so each tube will have a different designation. The suffix is numerical (second number) and refers to the number of separate terminals. These terminals are always base pins, except that where the tube has a top cap that is counted as a terminal. Sometimes two elements are brought out to one terminal, counted as one in the suffixing (second number). If the tabulation on page 8 shows registration of one fewer number of pins than disclosed on the suffix (second number) then the "missing" one is a grid cap. Shell (S) is not included in the count.

(5) Since all tubes fit in the same socket a universal numbering system is applicable. Each tube has a locating lug corresponding to a keyway in the socket, thus insuring rapid and correct correspondence between socket holes and tube base pins, all of which pins have the same diameter. Numbers are assigned to each of the eight possible pin positions, starting with the shell (S), which is always the first pin position (1). When bottom of tube or socket is viewed, locating lug of tube or keyway or socket toward the observer, starting the shell, 1, the numbers increase in steps of 1 in a clockwise direction, e.g., 2, 3, 4, 5, 6, 7 and 8. So far, heater is always numbers 2 and 7, except in the case of the rectifier tube, where, because the cathode is connected to the heater, the second heater terminal connection is 8. Wherever the cathode is brought out, alone or with associated element, the number is 8. No. 3 is always a plate, or if there are more than one plate, No. 3 is one of the two. No. 4 accounts for various elements, No. 5 accounts for grids,

Five Have Grid Caps, Five Have None; Heater Used in Every One



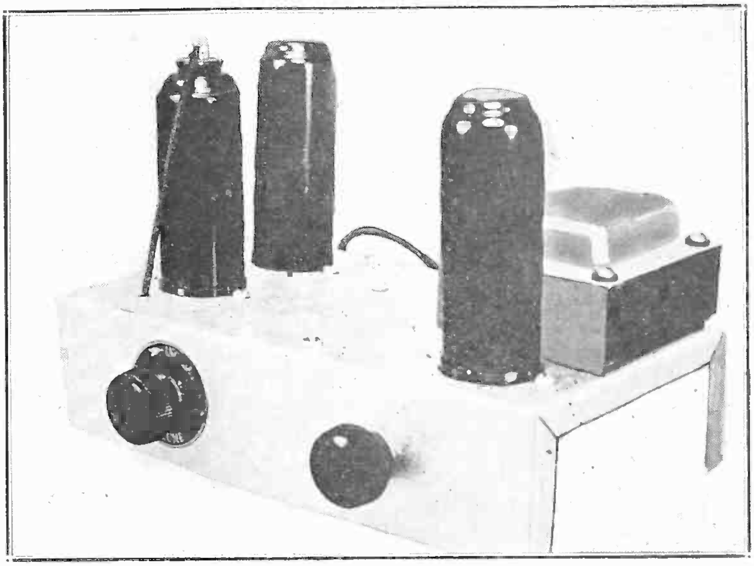
6C5 — 6A8, 6J7, 6K7, 6L7, 6F5 — 6H6 — 6D5, 6F6 — 5Z4

Recent Scientific Advances Made Possible the All-Metal Tube, Says R. C. A.

with one exception (6H6), and No. 6 is used only in the case of two tubes, being a plate of the 5Z4 and Grid No. 2 of the 6A8.

(6) Of the ten tubes, only one bears no relationship to any glass tube, and that is the 6L7 pentagrid mixer amplifier, one tube, not two tubes in one envelope, with very low capacity between the grids of the two tubes, permitting each control grid to act independently on the electron stream, useful in superheterodynes that have a separate local oscillator, as well as for general dual control in an amplifier stage.

(7) The new tubes are smaller in physical size than the glass tube equivalents, upper part not over 1 1/16 inches diameter, and in general have much lower grid-plate capacity, although higher input capacity than glass tubes, and about the same output capacity (around 12 mmfd.)



Besides all metal tubes there are also tubes of substantially the same characteristics, actually in glass envelopes, but surrounded by an integral metal covering, as illustrated in this amplifier. Competitive claims have been voiced by manufacturers of the two types, one stressing that their tubes are "all metal," the others that experimental preliminaries are avoided by using the established glass processes.

Advantages Listed

The new metal tubes were designed by the General Electric Company. Of outstanding significance is the fact the vacuum tight metal shell serves both as container and as an almost perfect shield, thereby permitting the very low capacity between grid and plate, which helps performance on short waves particularly.

"Metal bulb radio tubes," says RCA Division of RCA Manufacturing Company, "have been made practical by the recent great advancements in welding procedure brought about by the use of electronic tubes to provide accurate control of welding operations. In these new metal tubes vacuum tight welds requiring a current flow of as much as 75,000 amperes are made to a precise fraction of a second.

"Another important factor in the design of these tubes is the use of Fernico metal, a new alloy which seals readily to certain special kinds of glass. The use of Fernico eyelets and glass bead seals permits of many advantageous innovations in tube assembly. Some of these are: (1) elimination of need of the usual glass stem structure; (2) reduction in overall length without reducing size of electrode structure; (3) small distance between mount base with resultant rigidity of the mount; (4) short and direct connection of each electrode to its pin terminal.

"Further features of these new metal tubes are the very low grid-plate capacitance due to almost perfect shielding of the metal shell, the strong mechanical joint between header [metal disc that seals shell at bottom] and base, as well as between cap and metal shell, and the use of the new octal base which because of its self aligning design can be easily and quickly inserted in its socket.

"Because of the octal base and the general difference in electrical characteristics these metal tubes are not directly interchangeable with glass type tubes."

(Continued on next page)

Directions for Identifying Terminals By New Universal System

(Continued from preceding page)

The ten tubes, their use and their glass tubes equivalents are in the recognized order of their listing:

Type	*Use*	*Glass Equivalent*
5Z4	Full wave rectifier.........	80
6A8	Converter	6A7
6C5	Amplifier Triode	76
6D5	Power Amplifier Triode...	45
6F5	Amplifier Triode (High mu)	*
6F6	Power Amplifier Pentode...	42
6H6	Twin Diode	†
6J7	Triple Grid Detector, Amplifier	77
6K7	Triple Grid Amplifier	78
6L7	Pentagrid Mixer Amplifier	None

* *The* 6F5 *is similar to the triode section of the* 75.

† *The* 6H6 *is similar to the diode section of the* 75.

The 6F6, similar to the 42, is therefore similar in operating characteristics to the 2A5, the only difference between the two glass type tubes being the heater voltage, 2.5, for the 2A5 and 6.3 for the 42. The 6A7, compared to the new 6A8, is like the 2A7, with the same heater voltage difference. The 76 and 56 are alike, with the heater voltage as only difference, hence both compare with the 6C5, while the 77 is something like the 57 (6J7) and the 78 something like the 58 (6K7).

The circuits used in general for the equivalent glass type tubes may be followed for the ten metal tubes, excepting the 6L7.

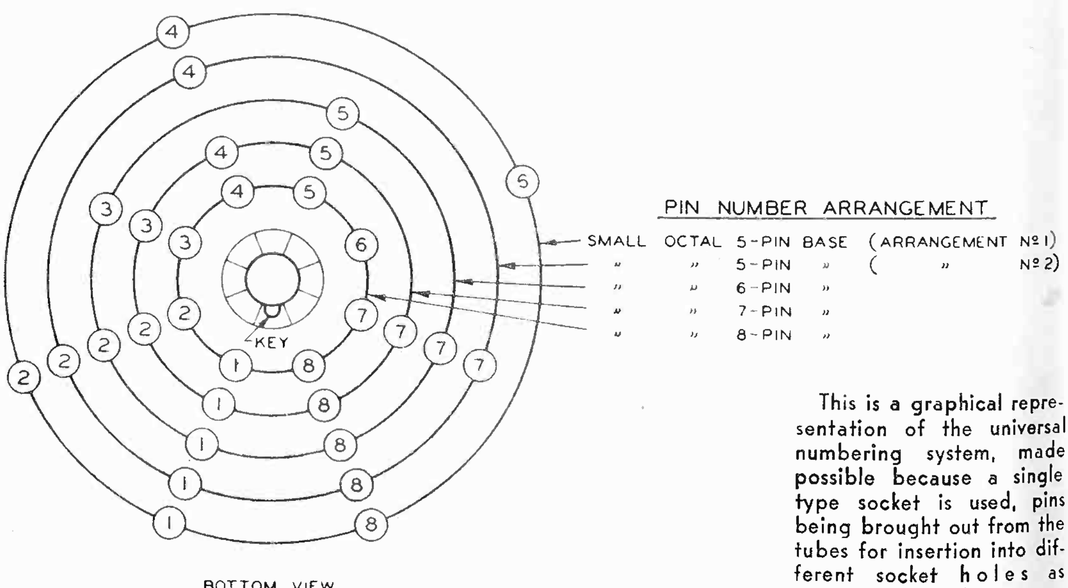
TERMINAL IDENTIFICATION OF METAL TUBES

Pin Numbers and Connections

	1	2	3	4	5	6	7	8	Cap
5Z4	S	H	—	P_2	—	P_1	—	K, H	—
6A8	S	H	P	G_3, G_5	G_1	G_2	H	K	G_4
6C5	S	H	P	—	G	—	H	K	—
6D5	S	H	P	—	G	—	H	K	—
6F5	S	H	—	P	—	—	H	K	G
6F6	S	H	P	G_2	G_1	—	H	K, G_3	—
6H6	S	H	P_2	K_2	P_1	—	H	K_1	—
6J7	S	H	P	G_2	G_3	—	H	K	G_1
6K7	S	H	P	G_2	G_3	—	H	K	G_1
6L7	S	H	P	G_2, G_4	G_3	—	H	K, G_5	G_1

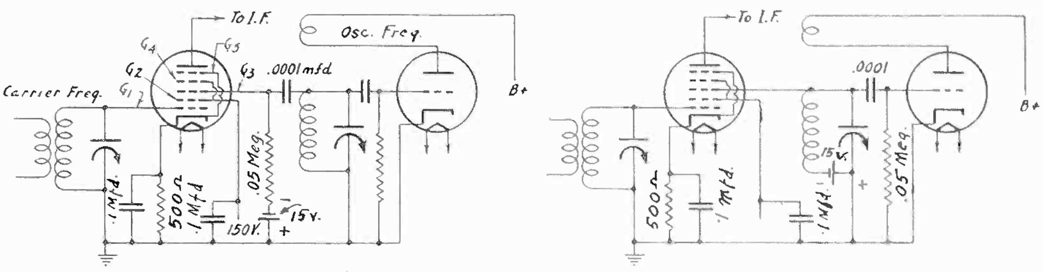
S = shell; H = heater; G = grid; P = plate; K = cathode.

Subscripts give plate and grid numerical identities. Dash under classification means "none."



This is a graphical representation of the universal numbering system, made possible because a single type socket is used, pins being brought out from the tubes for insertion into different socket holes as needed.

First Complete Details of the 6L7, Most Interesting of the Metal Tubes



'o methods of introducing the oscillation voltage into the 6L7. One of them consists of direct ›upling, the other of capacity coupling. There is somewhat greater sensitivity by the capacity coupl- g method. It is suggested that experimental connection of G3 of the 6L7 direct to grid of the independent oscillator be tried as a means of maintaining the G3 element constantly negative.

Two unusual features about the tubes that ‹ve grid caps are that the high mu 6F5, ›ough a triode, has such a cap, and all tubes ›quiring cap connections, since the cap is ›aller than on glass tubes, preferably should ›ve the smaller sized grid clips which are ›ended for the metal tubes.

6L7 Offers Much

Much interest attaches to the possibility of ›ll newer metal tubes. The ten that were ›gineered as one program have been com- ›ted and there is no present program for im- ›diate augmentation of the list. For instance, ›has been learned on good authority that no ›plex type tubes are in view, that is, metal ›mpanions of the 6B7, 75 and 6F7, but it is › be expected that in time, after field ex- ›iences with the ten existing metal tubes, › metal line will be augmented as needs re- ›ire. As all ten are of the indirectly heated ›hode type, all successors are expected to be ›ewise, unless battery type tubes, equal to the ›olt series, are intended, and there is no in- ›mation about any such intention.

)f the ten metal shell tubes now in produc- ›n the 6L7 is the most interesting because it ›s what no other tube does, besides offers ›e possibilities of uses in special directions › attacks a problem admittedly serious. The ›elty consists of the limitation of space charge ›cts on the element into which the carrier ›quently is put. The wide possibilities relate ›uses other than as a mixer tube in a super- ›erodyne. The problem it attacks is the sup- ›t of gain at the higher frequencies of all- ›e or short-wave sets.

The Five Grids

'he 6L7 is a pentagrid tube, that is, it has › grids. At center there is a cathode, and considering the grids as circles of increasing diameter, and citing the numerical pin location and cap, they are, in the order of their position away from the cathode:

G1, into which the station carrier frequency is put, and which may be called the signal grid .... (Cap)

G2, which is a screen for G1 and G3....(4)

G3, the extra grid that supplies the novelty, and to which grid external oscillator voltage is applied, hence G3 may be called the oscillator grid, *though there is no generation produced in the tube at all*..........................(5)

G4, which is the second screen, positioned between G3 and G5.....................(4)

G5, between G4 and plate, and constituting the suppressor ....(8)

In two instances there is internal connection of two elements: (a) the suppressor, G5, is connected to the cathode; (b) G2 is connected to G4.

The previously untabulated elements are:

Cathode .... (8)
Heater ....(2) and (7)
Plate .... (3)

An Investigation of Unfamiliarity

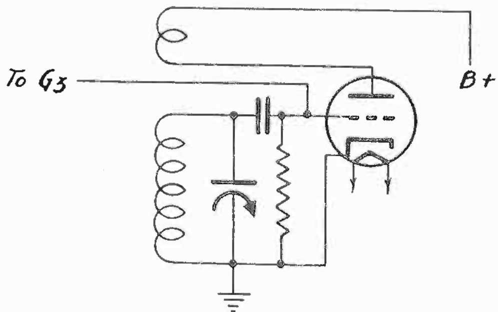
The five grids account for four pins, because of the interconnection inside the tube of Grids Nos. 2 and 4, and the five connections include the cathode. Two more for the heater make seven and one for the plate makes the total eight. Only seven base pins are used, since the signal grid is brought out to the metal cap. The blank in the numerical system is No. 6.

We now understand that the tube is a pentagrid converter for use as mixer in a superheterodyne, that there are five grids, and that one of these grids, called the oscillator grid,

Some Short Wave Troubles Remedied by 6L7, Including Frequency Instability

(*Continued from preceding page*)
is unfamiliar. It is that unfamiliarity and the reason for its presence that will be investigated.

Due to the popularity of short wave reception and the important stations above 15 megacycles it was necessary to add to the list of tubes one that would be free of the vices attendant on the usual pentagrid converter tube at these frequencies. These vices all had to do with lowering of the gain. Help instead of harm from the tube was important because the circuit losses accumulated fast enough (too fast, indeed) at the higher frequencies without any contributing evils from the tube.



Connection of the pickup grid (G3) of the 6L7 to the grid proper of a leak biased independent oscillator. Under these circumstances, which are presented as merely experimental, the two other methods being standard, the leak may require a lower value than ordinarily, so that not too great a negative bias be put on G3. The average negative value applies even on the negative oscillation alternation.

Results Wanted on Higher Frequencies

Of course at lower frequencies the 6A7 and similar tubes were all right. But the high frequencies, those above 15 mgc. (below 30 meters) needed attention, and particularly those frequencies above 20 mgc. (below 15 meters), partly because there is a tendency to have sets tune even somewhat above 20 mgc., the standard limit at present, to the 25 mgc region (12 meters) and possibly later on have sets accommodate also the frequencies of television transmission, 40 to 50 mgc. (7 to 6 meters).

The pentagrid converter tube that we have become used to develops quite a space charge on the single grid. This space charge is an accumulation of electrons and limits the plate efficiency. Also this charge acts as a coupling medium, and if any of the oscillator frequency gets into the signal grid circuit, especially when the two frequencies are only slightly different in percentage, the intended electron coupling is augmented by the space charge coupling, and the coupling becomes too tight.

An investigation of the added effect of the space charge coupling of oscillator to signal grid shows that since the two frequencies are not substantially different, the signal frequency tuned input circuit presents a sizeable impedance to the oscillator frequency, and a large oscillator voltage is built up on the signal grid, which is supposed not to receive any oscillation voltage.

It Is a Single Tube

Also, this extra voltage is 180 degrees out of phase, hence the combining and transfer activities of the tube (conversion conductance) are reduced. The higher the frequency, the greater the reduction of conversion conductance.

Since this condition is present in the tube it exists so long as there is mixing of signal and oscillator frequencies in the regions of frequencies noted, so it would be to no advantage to use a separate oscillator tube merely to attempt a cure, because the trouble is in the converting tube and that tube is there just the same.

The familiar pentagrid converter tube we have been comparing, represented by the 2A7, 6A7 and 1C6, has the oscillator tube in the same envelope as the modulator tube, with intentional electron coupling between them and also unintentional and objectionable space charge current. There is no oscillator tube in the new 6L7, but a grid to which the external oscillation is to be applied so it is not a dual but a single tube.

The reason for not including an oscillator tube in the same envelope or shell is the improvement of frequency stability though the bias on the signal grid is varied. The change of frequency accompanying change of bias in the older tubes is due to the transconductance between the oscillator anode and the signal grid, although there is a screen between them.

Simple Cure: "Cut It Out"

Hence the simple cure for this was to omit the oscillator tube from the assembly, and the separate oscillator tube therefore is required. This is an example where a separate oscillator tube provides a remedy, compared to the space charge vice that could not be cured by the independent tube.

Somewhat the results that are attained by the new tube conceivably could result from using a 6C6, 6D6, 57, 58, 77, 78, etc., as modulator, with voltage from a separate oscillator fed to the independently accessible suppressor grid. However, the plate impedance would be

Unusual Grid (G3) of 6L7 for Pickup; May Be Given an Independent Bias

low, the conversion gain low, and an extraordinarily large oscillation voltage put into the suppressor to modulate the pentode properly. The system could be used, it does work, but it scarcely would be put to wide use, especially since something like a power tube for the oscillation voltage supply would be necessary.

In the new tube the necessity for extremely high oscillation voltage is avoided by making the suppressor high mu. Then, to hold up the plate resistance, a screen is interposed between suppressor and oscillator grid to be electrically effective on the common plate.

Nature of Coupling Changes

The signal grid of the 6L7 is of the remote cutoff type, to minimize distortion due to high negative bias arising occasionally from automatic volume control, and also minimize cross modulation. Grid No. 2, the first screen, accelerates the electrons on their way to the plate and reduces the capacity between the signal grid and the oscillator grid.

This capacity is .12 mmfd., or small enough to produce little coupling of its own account until the frequencies become high. In general the coupling in normal operation is of the electron type, because an external oscillator's voltage is introduced into the electron stream of the 6L7, so that the coupling takes place in the emission of the 6L7, although one of the voltages arises from the emission of an external tube.

Naturally, the nature of the coupling will change with frequency. As the frequencies become very high, the oscillation voltage becomes less, since the oscillator suffers the same rate of losses as the amplifiers, the capacity between the oscillator grid and the signal grid becomes effective to augment electron coupling, and in general the oscillating voltage on the modulator is more nearly constant, because of this seesaw effect.

Circuits for New Tube

A resistor is placed between oscillator grid of the 6L7 and ground, and the coupling of the external or separate oscillator tube may be either direct or through a condenser. Circuits for both methods are given. There is somewhat greater output for the capacity coupling method when G3 is returned to B minus in both instances.

It is entirely practical, and sometimes necessary, where oscillation voltage is high, to put extra bias on G3, when using the capacity method. With the direct method the d. c. from the oscillator furnishes the extra bias.

Let us now analyze the performance of the tube in a mixing circuit.

An r. f. amplifier feeds the magnified station carrier to the signal grid of the operating 6L7. The cathode is emitting electrons that flow to the plate and through the primary of the i. f. transformer. This current is d. c. except so far as the 6L7 introduces a. c. of the carrier frequency. Since the signal grid is between cathode and plate the plate current is made to swing at the signal frequency. One might say the plate current is pulsated at this frequency.

Plate Current Affected

The condenser across the primary of the i. f. transformer bypasses the signal frequency around the coil, but the a. c. goes on through B supply to the cathode to complete the path.

That is all there is fundamentally to the operation of the tube as an amplifier.

As a mixer, however, it must take two frequencies, unite them and put out a third frequency.

The first frequency we have discussed—it is the station's carrier. The second frequency is that of the local oscillator. A suitable impedance is placed between a pickup grid of the

(Continued on next page)

Front Cover Illustration

It is maintained in favor of the all metal tubes that they are rugged, from the inherent nature of their construction, and therefore if accidentally one is dropped there is no glass envelope to be shattered and scattered. So if a juggler wants to do any tricks, as suggested by the activity of the model on the front cover, if he should select metal tubes and drop one there may not be any particular harm to it. The metal tubes, nevertheless, were not brought out to reduce the hazards of the juggling industry but to improve short wave performance.

While there may be no special harm in accidentally dropping an all metal tube, nevertheless care should be exercised, and it is not to be taken as a serious technical advice that the tubes are improved by dropping them on the floor. Indeed, a waxed floor may suffer harm, as there will be a mark left by the hard tube that hits it. Hardwood floors are hard but all metal tubes are harder.

The question of frying eggs on the new tubes will have to be left to experts in the culinary science. All that can be said by a radio technician is that care should be taken not to let the yoke break, as the fry then begins to look scrambled, and the technique for scrambled eggs is different. Besides, there's little to worry about on the heat score. The power spent that way is no greater than with glass tubes.

How to Prevent Unwanted Coupling By Proper 6L7 Voltaging

(*Continued from preceding page*)

6L7 and ground, and across this impedance or load the oscillation voltage is introduced.

Other Frequencies

The same plate is affected, for there is only one plate. The r. f. component of the plate current is the signal frequency. The oscillation voltage introduced at the pickup grid (G3) varies the transconductance between minimum and maximum. Hence there is now a second and additional component of the 6L7 plate current, i. e., the oscillation component, because the pickup grid influences the electron stream in the same general manner G1 did.

The third frequencies arises from something that happens inside the tube. The generic word for that something is detection. In a mixer it is called modulation because it is a combining rather than segregating function. The third component then is the difference between the two other components and this difference is the intermediate frequency.

When we keep in mind there is a separate oscillator, the 6L7 grid to which this oscillation is fed may be called the oscillator grid.

Should Use A.V.C.

The characteristics of the 6L7 as a mixer enable operation at a low plate voltage, because the suppressor severely limits the space charge, and therefore the plate swing is widened. However, for all wave use it is advisable to have 250 volts on the plate and 150 volts on the screen, biasing the signal grid 6 volts negative, so that during the negative cycle of the oscillator grid none of the electrons that this grid repels will get near enough to the signal grid to cause displacement current flow at oscillator frequency in the modulator circuit. Maintaining the minimum bias sufficiently negative (6 volts) substantially prevents such current flow, but since the increased bias decreases the conversion conductance, the screen voltage is raised to 150 volts to supply the deficiency. Moreover, a v. c. must be used for this precaution, otherwise the grid would be driven in the positive direction during half of the signal carrier cycle.

The following statement concerning the metal tubes is taken from "General Electric Short Wave News," an organ of the company that developed the tubes:

Probably the most important advance made during the past two years is the perfection of the metal tubes. In 1933 a survey made by the General Electric Company indicated that the radio receiver, as far as standard domestic broadcast reception was concerned, was highly developed. But in connection with short wave reception the story was different.

The "tools" of radio then used by radio engineers were capable of doing a good job of standard broadcast reception, but at the extremely high frequencies used in short wave work they lost their "edge" or became inefficient, unreliable and dull. For instance, a tube which we call one of the "tools" of radio, would behave in a quite different manner when responding to a broadcast signal than when attempting

(*Continued on next page*)

Precautions for Use of Metal Tubes

In connection with sets using the new metal tubes a few precautionary methods should be followed. Always member that the tubes may be operating, although the receiver appears to be dead, and that precautions should be taken in removing or working around the tubes with bare hands as they develop considerable heat. Since it is impossible to see the internal elements of the tube it is advisable always to check the tubes for shorts and remember that these tubes should not be misused just because the outer shell is of metal construction. If any receivers are encountered using wafer type sockets the tubes should be carefully inserted, making sure that the locating key is not forced through the thin material, thereby cutting a new key-way in the socket. It is always best to instruct set owners not to remove tubes as they are liable to replace the tubes in the wrong sockets since the pin arrangement makes this error possible. In no case are standard glass tubes and metal tubes to be considered interchangeable. —*Sylvania News.*

High Frequency Sensitivity Increased Ten Fold by New Tubes

to bring in a short wave signal at a frequency twenty times higher. Short waves demand skillful handling, and the tools employed must be those of a master artisan.

Conservation of Energy

There was a crying need for a compact, self shielded tube, with no internal leads that might dissipate the energy of the short wave signal between the tube elements and the base pins. Better shielding was needed so that full advantage could be taken of the amplifying properties of the tube.

Both these objectives, it was found, could be attained by making the tube of metal. Metal-working technique made the short leads possible; the fact that the metal envelope was the shield conquered the shielding problem.

What does this mean to the short-wave listener, you say? It means increased reliability of short-wave reception—more consistent logging of distant short-wave stations. Thanks to the new metal tubes, an increase in sensivity in the ultra high-frequency band of about ten times over that of previous receivers is now possible, with proportionately better performance down into the broadcast band.

More Pep

What else? Better tone quality. Because of more efficient shielding and shorter internal leads in the tube, greater amplification can be utilized in the intermediate frequency amplifier, feeding the detector tube with a sufficient volume of signal so that that tube need not "strain its ears" to detect the signal. With an adequate flow of signal into the detector tube, the reproduced sound from the loudspeaker is natural and undistorted even when the volume control is turned down to a whisper.

Rugged Construction

One look is all that is needed to realize how compact are these sturdy new tubes. Because they are compact, it is no longer necessary to make one tube perform several functions except where desirable for other reasons than to conserve space. Each tube can concentrate on its own job, and the result is better quality and reliability.

In utilizing a new principle of construction, full advantage has been taken of the opportunity for better mechanical design. The steel shell is not subject to breakage. The tube elements have short, sturdy supports welded to the header, resulting in less mechanical vibration of the elements. (The header is the round metal disc welded into the end of the shell and supporting the elements.)

Metal-working technique allows the leads to enter at the proper points in the header to achieve the shortest, most direct paths. The leads enter the header through a glass bead which in turn is fused to a special eyelet of "Fernico" alloy. This alloy has the same expansion characteristics as the glass bead, and preserves a perfect seal at all operating temperatures. Accurate control of the vital welding processes is accomplished through a system of Thyratron control developed by the General Electric Company. All these details make for an extremely rugged tube that will retain its vacuum and its normal operating characteristics for a long period of time.

Convenient Handling

The metal tube is made convenient to handle. A new type of octal base has been developed that makes installation of tubes easy even under difficult circumstances, such as in poor light or

(*Continued on next page*)

How to Obtain Answers to Metal Tube Questions

Questions on the metal tubes may be adressed to Tube Editor, RADIO WORLD, *145 West 45th Street, New York, N. Y. If several questions are put, they should be tabulated and space left for the answer to be written on the original letter of inquiry.*

Miniature Grid Caps for New Metal Tubes

The metal tubes have a smaller cap (if one is used) than the glass tubes have. The smaller type is called the "miniature" cap, and is ¼ inch in diameter ± .01 inch (one one-hundredth of an inch). The height is .312 inch. A miniature clip is used for connecting input lead to the tube cap.

Tubes with 8 pin biases connect to all socket contacts.

Tubes with 7 pin bases omit No. 6.

Tubes with 6 pin bases omit Nos. 4 and 6.

Tubes with 5 pin bases are in two arrangements: (a), omitting 3, 5 and 7; (b), omitting 3, 5 and 6. In class (a) is the 524 and in class (b) fall the 6D5 and 6F5.

The shell is always brought out to a base pin, always No. 1, and it is usually grounded to chassis.

Tubes Getting Hot Cited as Advantage Due to Good Dissipation

(*Continued from preceding page*)

in sockets not easily accessible. The octal base has a central keyed locating pin that is slightly longer than the contact pins. By placing the locating pin in a hole centrally located in the socket and rotating the tube until the key slips into its groove, the tube is quickly and easily inserted.

A distinctive feature of the new metal tube is its exterior finish. There is another reason besides appearance for choosing a black finish—that of most efficient heat radiation. The superiority of a black surface as a heat radiator is strikingly shown by the classical experiment of placing two pieces of cloth, identical except that one is black and one white, on top of a layer of snow or a piece of ice.

Temperature of Elements

When placed in the sunlight the snow or ice beneath the black cloth will melt first. A certain amount of heat, no more than necessary, is liberated within the tube by the heater element. The heater element raises the temperature of the cathode element to the point where electrons are emitted, a basic principle of the vacuum tube. It is well, however, to keep the temperature of all other elements as low as possible. This is done by using the efficiently radiating shield, whose fairly high operating temperature merely indicates that it is doing a good job of conducting heat away from the interior of the tube to the outside atmosphere.

Advantages Summarized

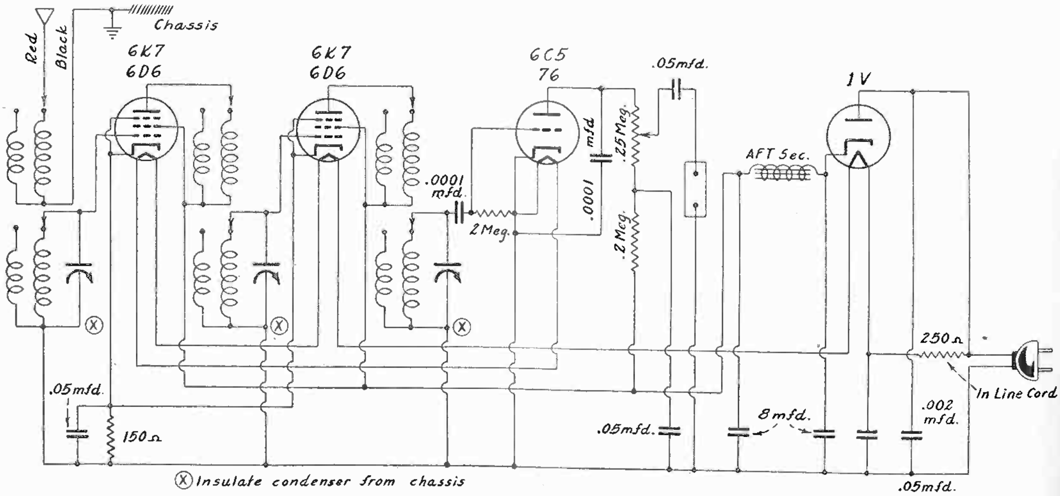
One possible comment on the use of a metal shell is that the lighted filament in the tube is not visible. However, it is indeed seldom that tubes fail due to burned out filaments. On the other hand, the filament of a worn-out tube may light just as brightly as that of a new tube. To tell whether any tube, past or present, is in good operating condition, it must be tested on a reliable tube checker or in a receiver known to be operating properly.

Without going too far into technical details, then, these are some of the advantages offered by the new metal tubes:

1. Better sensitivity (more distance) especially on short waves.
2. Better tone quality, especially at low volume.
3. Rugged construction, capable of withstanding severe mechanical shocks.
4. Permanent vacuum sealed in steel, insuring long life.
5. Ease of installation with new octal base.
6. Efficient heat radiation, further enhancing long useful life.

NEW TUBES GOOD OSCILLATORS

The metal tubes perform well as oscillators. The 6C5 is especially intended for this purpose, as separate local oscillator in conjunction with the 6L7. However, the pentode of the 6L7 was tried as oscillator, and it worked very well. In fact, it was possible to generate a wave, though a feeble one, of a wavelength just a bit below one meter. The low grid to plate capacity of the metal tubes makes possible better control of the external circuit, though the output capacity is still rather high.

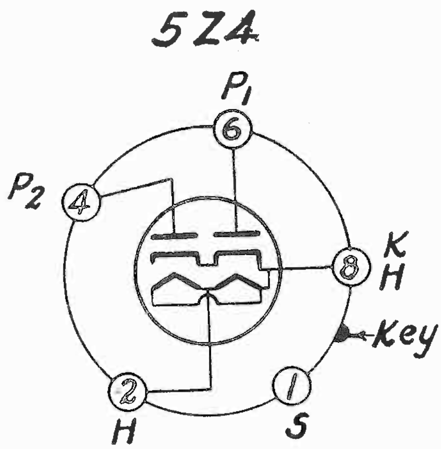


Circuit diagram for a four-tube receiver for earphone reception. A three-gang condenser is used. The 1V is a half wave rectifier of the glass type. For the other tubes either the metal ones or their glass equivalents (both inscribed on the diagram) may be used.

5Z4 Maximum Current 125 Ma; Conventional Coils Suit 6A8

The following data were compiled mainly from the RCA Radiotron bulletin, "The New All-Metal Tubes."

5Z4 FULL WAVE HIGH VACUUM RECTIFIER



Bottom view of socket.

The 5Z4 is a full-wave rectifying tube of the metal type intended for use in d.c. power-supply devices which operate from the a.c. supply line.

Tentative Characteristics

Heater Voltage	5.0	Volts
Heater Current	2.0	Amperes
A-C Plate Voltage per Plate (RMS)	400 max.	Volts
Peak Inverse Voltage	1100 max.	Volts
D-C Output Current	125 max.	Milliamperes
Maximum Overall Length	5-1/8"	
Maximum Diameter	1-5/16"	
Base	Small Octal 5-Pin	

Installation

The *base* pins of the 5Z4 fit the five contact octal base socket for this pin arrangement (or the universal eight-contact socket) which should be installed to hold the tube in a vertical position with the base down. Provision should be made for free circulation of air around the tube since it becomes quite hot during operation.

The *heater* of the 5Z4 is designed to operate from the a.c. line through a stepdown transformer. The voltage applied to the heater should be the rated value of 5.0 volts under operating conditions and average line voltage.

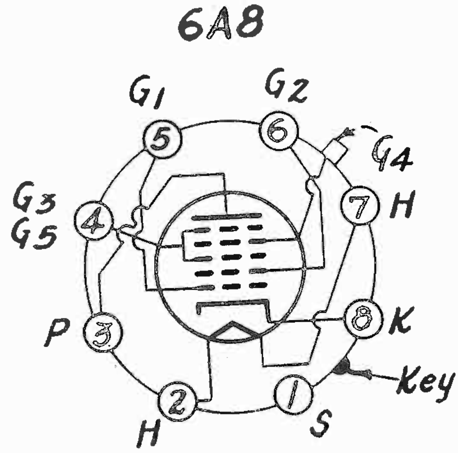
Application

As a *full wave rectifier*, the 5Z4 may be operated with condenser input or choke input filter under conditions not to exceed the ratings given under Characteristics.

As a *half wave rectifier,* two 5Z4's may be operated in a full-wave circuit with reasonable serviceability to deliver more d.c. output current than can be obtained from one tube. For this use, the plates of each 5Z4 are tied together at the socket. The allowable voltage and load conditions per tube are the same as for full wave service.

The *filter* may be of either the condenser input or choke input type. If an input condenser is used, consideration must be given to the instantaneous peak value of the a.c. input voltage. The peak value is about 1.4 times the rms value as measured by most a.c. voltmeters. Filter condensers, therefore, especially the input condenser, should have a rating high enough to withstand the instantaneous peak value, if breakdown is to be avoided. When the input choke method is used, the available d.c. output voltage will be somewhat lower than for the input condenser method for a given a.c. plate voltage. However, improved regulation, together with lower peak current, will be obtained.

6A8 PENTAGRID CONVERTER



Bottom view of socket.

The 6A8 is a multi electrode vacuum tube of the metal type designed to perform simultaneously the functions of a mixer (first detector) tube and of an oscillator tube in superheterodyne circuits. Through the use of this type, the in-

The 6A8 is a companionate tube, in that is greatly resembles in performance characteristics the 6A7 pentagrid converter tube for mixing purposes in a superheterodyne, although it can be adopted to other uses. The coupling is electronic.

Conventional Coil Design Suitable for 6A8 Frequency Converter

(Continued from preceding page)

dependent control of each function is made possible within a single tube.

Tentative Characteristics

Heater Voltage (A.C. or D.C.)	6.3	Volts
Heater Current	0.3	Ampere
Direct Interelectrode Capacitances (Approx.):*		
Grid No. 4 to Plate	0.03	Mmfd.
Grid No. 4 to Grid No. 2	0.1	Mmfd.
Grid No. 4 to Grid No. 1	0.09	Mmfd.
Grid No. 1 to Grid No. 2	0.8	Mmfd.
Grid No. 4 to All Other Electrodes (R-F Input)	12.5	Mmfd.
Grid No. 2 to All Other Electrodes (Osc. Output)	5	Mmfd.
Grid No. 1 to All Other Electrodes (Osc. Input)	6.5	Mmfd.
Plate to All Other Electrodes (Mixer Output)	12.5	Mmfd.
Maximum Overall Length	3-1/8″	
Maximum Diameter	1-5/16″	
Cap	Miniature	
Base	Small Octal 8 Pin	

*With shell connected to cathode.

As Frequency Converter

Plate Voltage		250 max.	Volts
Screen (Grids No. 3 and No. 5) Voltage		100 max.	Volts
Anode-Grid (Grid No. 2) Voltage		200 max.	Volts
Anode-Grid (Grid No. 2) Voltage Supply**		250 max.	Volts
Control Grid (Grid No. 4 Voltage		—3 min.	Volts
Total Cathode Current		14 max.	Milliamperes
Typical Operation:			
Plate Voltage	100	250	Volts
Screen Voltage	50	100	Volts
Anode-Grid Voltage	100	250‡	Volts
Control Grid Voltage (Minimum)	—1.5	—3	Volts
Oscillator Grid (Grid No. 1) Resistor	50000	50000	Ohms
Plate Current	1.2	3.3	Milliamperes
Screen Current	1.5	3.2	Milliamperes
Anode-Grid Current	1.6	4.0	Milliamperes
Oscillator Grid Current	0.25	0.5	Milliamperes
Conversion Conductance	350	500	Micromhos
Control Grid Voltage, Approximate (Conversion conductance = 2 mmfd.)	—20	—45	Volts

‡This is an anode grid supply voltage applied through 20000 ohm voltage dropping resistor.

**Anode grid voltages in excess of 200 volts require use of 20000 ohm voltage dropping resistor.

Installation

The *base* pins of the 6A8 fit the eight contact octal base socket, which may be installed to hold the tube in any position.

The *heater* of the 6A8 is designed to operate on either d.c. or a.c. For operation on a.c. with a transformer, the winding which supplies the heater circuit should operate the heater at its recommended value for full load operating conditions at average line voltage. For service in automobile receivers, the heater terminals of the 6A8 should be connected directly across a 6 volt battery. In receivers that employ a series-heater connection, the heater of the 6A8 may be operated in series with the heater of other types having a 0.3 ampere rating. The current in the heater circuit should be adjusted to 0.3 ampere for the normal supply line voltage.

The *cathode* of the 6A8, when operated from a transformer, should preferably be connected directly to the electrical midpoint of the heater circuit. When it is operated in receivers employing a 6 volt storage battery for the heater supply, the cathode circuit is tied in either directly or through bias resistors to the negative side of the d.c. plate supply which is furnished either by the d.c. power line or the a.c. line through a rectifier. In circuits where the cathode is not directly connected to the heater, the potential difference between them should be kept as low as possible. If the use of a large resistor is necessary between the heater and cathode of the 6A8 in some circuit designs, it should be bypassed by a suitable filter network or objectionable hum may develop.

Application

As a *frequency converter* in superheterodyne circuits, the 6A8 can supply the local oscillator frequency and at the same time mix it with radio input frequency to provide the desired intermediate frequency. For this service, design information is given under Characteristics.

For the *oscillator* circuit, the coils may be constructed according to conventional design, since the tube is not particularly critical. The supply voltage applied to the anode grid No. 2 should not exceed the maximum value of 250 volts. In fact, from a performance viewpoint, a lower value is to be preferred, because it will be adequate to provide for optimum translation gain. Under no condition of adjustment should the cathode current exceed a recommended maximum value of 14 milliamperes.

The bias voltage applied to grid No. 4 can be varied from —3 volts to cutoff to control the translation gain of the tube. With lower screen voltages, the cutoff point is less remote. The extended cutoff feature of this tube in combination with the similar characteristic of super control tubes can be utilized advantageously to adjust receiver sensitivity.

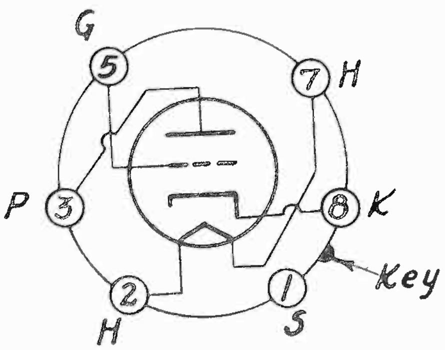
A. V. C. FOR MODULATOR

It is usually desirable in high powered sets to introduce automatic volume control in the modulator tube of a superheterodyne. The signal grid therefore is connected through a resistor to the rectified diode output (high side), and this resistor is bypassed by a condenser of .02 mfd. or higher. The product of resistance in megohms and capacity in mfd. should lie between .04 and .09.

6C5 Mutual Conductance 2,000; Mu of 100 Marks 6F5

6C5 DETECTOR AMPLIFIER TRIODE

6C5



Bottom view of socket.

The 6C5 is a three electrode tube of the metal type recommended for use as a detector, amplifier, or oscillator. This tube has a high mutual conductance together with a comparatively high amplification factor.

Tentative Characteristics

Heater Voltage (A.C. or D.C.)	6.3	Volts
Heater Current	0.3	Ampere
Plate Voltage	250 max.	Volts
Grid Voltage°	—8	Volts
Plate Current	8	Milliamperes
Plate Resistance	10000	Ohms
Amplification Factor	20	
Mutual Conductance	2000	Micromhos
Grid-Plate Capacitance*	1.8	Mmfd.
Grid-Cathode Capacitance*	4	Mmfd.
Plate-Cathode Capacitance*	13	Mmfd.
Maximum Overall Length	2-5/8"	
Maximum Diameter	1-5/16"	
Base	Small Octal 6-Pin	

°If a grid coupling resistor is used, its maximum value should not exceed 1.0 megohm.
*With shell connected to cathode.

Installation

The *base* pins of the 6C5 fit the six contact octal base socket (or the universal eight contact socket) which may be installed to hold the tube in any position.

For *heater* operation and *cathode* connection, refer to Installation for type 6A8.

Application

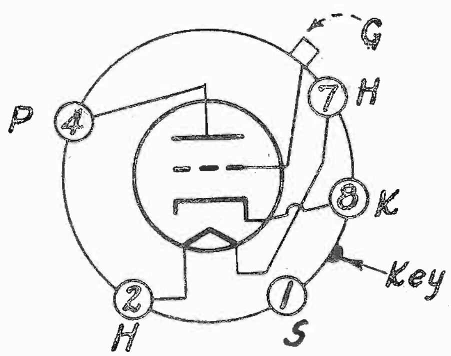
As an *amplifier,* the 6C5 is applicable to radio-frequency or audio-frequency circuits. Recommended operating conditions for service using transformer coupling are given under Characteristics. For circuits utilizing resistance coupling, typical operating conditions are as follows:

Plate-Supply Voltage	250	Volts
Grid-Bias Voltage (Approx.)	—5	Volts
Plate Load Resistor	50000 to 100000	Ohms
Plate Current	1 to 2	Milliamperes
Voltage Amplification	14	
Voltage Output (5% second harmonic)	42	Volts (RMS)

As a detector, the 6C5 may be of the grid leak and condenser or grid bias type. The plate voltage for the grid leak and condenser method should be 45 to 100 volts. A grid leak from 0.1 to 1.0 megohm with a grid condenser of 0.00005 to 0.0005 mfd. is satisfactory. For the grid bias method of detection, a plate supply voltage of 250 volts may be used together with a negative grid bias voltage of approximately 17 volts. The plate current should be adjusted to 0.2 milliampere with no input signal voltage. The grid bias voltage may be supplied from the voltage drop in a resistor between cathode and ground.

6F5 HIGH MU TRIODE

6F5



Bottom view of socket.

The 6F5 is a high mu triode of the metal type. It is particularly suitable for use in resistance coupled amplifier circuits.

Tentative Characteristics

Heater Voltage (A.C. or D.C.)	6.3	Volts
Heater Current	0.3	Ampere
Plate Voltage	250 max.	Volts
Grid Voltage	—2	Volts
Plate Current	0.9	Milliampere
Plate Resistance	66000	Ohms
Amplification Factor	100	
Mutual Conductance	1500	Micromhos
Grid-Plate Capacitance*	2	Mmfd.
Grid-Cathode Capacitance*	6	Mmfd.
Plate-Cathode Capacitance*	12	Mmfd.
Maximum Overall Length	3-1/8"	
Maximum Diameter	1-5/16"	
Cap	Miniature	
Base	Small Octal 5-Pin	

*With shell connected to cathode.

Up to 19 Watts from 6F6 Tubes in Push Pull Output

(*Continued from preceding page*)

Installation

The *base* pins of the 6F5 fit the five contact octal base socket for this pin arrangement (or the universal eight contact socket) which may be mounted to hold the tube in any position.

When a 6F5 is used to amplify the output of the 6H6 diode, it is recommended that fixed grid bias be employed. Diode biasing of the 6F5 is not suitable because of the probability of plate current cutoff, even with relatively small value of signal voltages applied to the diode circuit.

For *heater* operation and *cathode* connection, refer to Installation for type 6A8.

Application

As an *amplifier* in resistance coupled a.f. circuits, the 6F5 may be operated under the following conditions:

Plate Supply Voltage	250	250	Volts
Grid Bias Voltage..	—1.3	—1.3	Volts
Plate Load Resistor	0.25 to 1.0	0.25 to 1.0	Megohm
Grid Resistor**	0.25	0.5	Megohm
Plate Current	0.2 to 0.0	0.2 to 0.4	Milliampere
Voltage Amplification	52 to 56	51 to 60	
Voltage Output	11 to 20	14.5 to 25.5	Volts (RMS)

**For the following amplifier tube.

Single-Tube Class A Amplifier (6F6)

	Pentode Connection		*Triode Connection* Screen tied to plate	
Plate Voltage	250	315 max.	250 max.	Volts
Screen Voltage	250	315 max.	—	Volts
Grid Voltage	—16.5	—22	—20	Volts
Plate Current	34	42	31	Milliamperes
Screen Current	6.5	8	—	Milliamperes
Plate Resistance	80000°	75000°	2600	Ohms
Amplification Factor	200°	200°	7	
Mutual Conductance	2500	2650	2700	Micromhos
Load Resistance	7000	7000	4000	Ohms
Total Harmonic Distortion	7	7	5	Per cent
Power Output	3	5	0.85	Watts

°Approximate.

Push-Pull Class AB Amplifier (Pentode Connection)

	Fixed Bias	*Self-Bias*	
Plate Voltage	375 max.	375 max.	Volts
Screen Voltage	250 max.	250 max.	Volts
Grid Voltage	—26 min.	—	Volts
Self-Bias Resistor	—	340 min.	Ohms
Zero-Signal Plate Current (Per tube)	17	27	Milliamperes
Zero-Signal Screen Current (Per tube)	2.5	4	Milliamperes
Effective Load Resistance	2500	2500	Ohms
Load Resistance (Plate-to-plate)	10000	10000	Ohms
Total Harmonic Distortion	5	5	Per cent
Power Output	19 approx.*	19 approx.‡	Watts

*With one triode-connected 6F6 as driver operated at plate volts of 250, grid volts of —20, and with a minimum plate load of approximately 10000 ohms: input transformer ratio, primary to one-half secondary, is 3.32. The plate, screen and grid supply have negligible resistance.

‡With one triode- connected 6F6 as driver operated at plate volts of 250, grid volts of —20, and with a minimum plate load of approximately 10000 ohms: input transformer ratio, primary to one-half secondary, is 2.5. The plate and screen supply have negligible resistance. The value given for the self-bias resistor is determined for the minimum grid bias of —21 volts.

Push-Pull Class AB Amplifier (Triode Connection)

Screen tied to plate

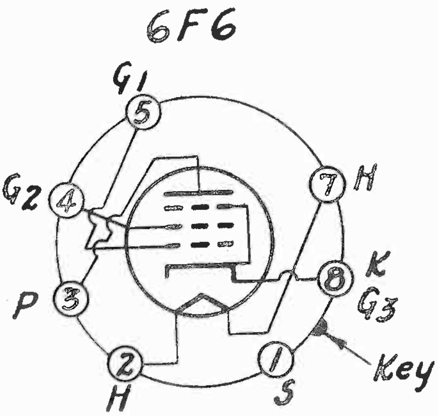
	Fixed Bias	*Self-Bias*	
Plate Voltage	350 max.	350 max.	Volts
Grid Voltage	—38	—	Volts
Self-Bias Resistor	—	730 min.	Ohms
Zero-Signal Plate Current (Per tube)	22.5	25	Milliamperes
Effective Load Resistance	1500	2500	Ohms
Load Resistance (Plate-to-plate)	6000	10000	Ohms
Total Harmonic Distortion	7	7	Per cent
Power Output (2 tubes)	18 approx.*	14 approx‡	Watts

*With one triode-connected 6F6 as driver operated at plate volts of 250. grid volts of —20, and with a minimum plate load of approximately 10000 ohms: input transformer ratio, primary to one-half secondary, is 1.67. The plate and grid supply have negligible resistance.

‡With one triode-connected 6F6 as driver operated at plate volts of 250, grid volts of —20, and with a minimum plate load of approximately 10000 ohms: input transformer ratio, primary to one-half secondary, is 1.29. The plate supply has negligible resistance. The value given for the self-bias resistor is determined for the minimum grid bias of —36.5 volts.

.5 Meg. Limits Grid 6F6 Resistor; Self Bias Then Advisable

6F6 POWER AMPLIFIER PENTODE



The 6F6 is a heater cathod power amplifiei pentode of the metal type for use in the audio output stage of a.c. receivers. It is capable of giving large power output with a relatively small input voltage. Because of the heater cathode construction, a uniformly low hum level is attainable in power amplifier design.

Tentative Characteristics

Heater Voltage (A.C. or D.C.)	6.3	Volts
Heater Current	0.7	Volts
Maximum Overall Length		3-1/4"
Maximum Diameter		1-5/16"
Base		Small Octal 7-Pin

Under the above maximum voltage conditions, transformer or impedance input coupling devices must be used.

Installation

The *base* pins of the 6F6 fit the seven contact octal base socket (or the universal eight contact socket) which may be installed to hold the tube in any position.

The *heater* is designed to operate at 6.3 polts. The transformer supplying this voltage should be designed to operate the heater at this recommended value for full-load operating conditions at average line voltage.

The *cathode* should preferably be connected directly to a midtap on the heater winding or to a center-tapped resistor across the heater winding. If this practice is not followed, the potential difference between heater and cathode should be kept as low as possible.

As a *Class A power amplifier pentode,* the 6F6 may be used either singly or in push-pull. Recommended operating conditions are given under Characteristics. If a single 6F6 is operated at a plate voltage of 250 volts, the self-bias resistor should have a value of approximately 410 ohms; at 315 volts, 440 ohms. For two tubes in the same stage, the value of the self-bias resistor should be approximately one-half that for a single tube.

Class A

As a *Class A power amplifier triode,* the 6F6 may be used either singly or in push-pull. For this service the screen is connected to the plate. Recommended operating conditions are given under Characteristics. If a single 6F6 is operated as a Class A triode at a plate voltage of 250 volts, the self-bias resistor should have a value of approximately 650 ohms. For two tubes in the same stage, the value of the self-bias resistor should be approximately one-half that for a single stage.

Class AB

As a *Class AB power amplifier triode or pentode,* the 6F6 should be operated as shown under the Characteristics. The values shown cover operation with fixed-bias and with self-bias, and have been determined on the basis of some grid-current flow during the most positive swing of the input signal and of cancellation of second-harmonic distortion by virtue of the push-pull circuit.

Self-bias resistors should be shunted by a filter network to avoid degeneration at the low audio frequencies. The filter network may be omitted for push-pull Class A pentode and Class A triode service.

The type of input coupling used should not introduce too much resistance in the grid circuit. Transformer or impedance coupling devices are recommended. If, however, resistance coupling is employed, the grid circuit may have a resistance as high as 0.5 megohm, provided self-bias is used and the heater voltage does not rise more than 10% above rated value under any conditions of operation; without self-bias, the value should be limited to 0.05 megohm.

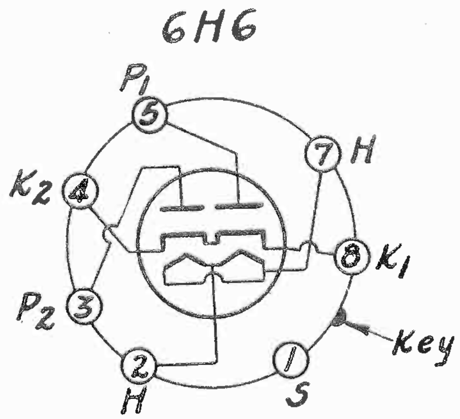
(Continued on next page)

The tabulated data on the 6F6 are printed on the opposite page and show the use of the tube in three different ways: (1) as a single tube for Class A amplifier service; (2), as push pull Class AB pentodes, two tubes; (3), as push pull Class AB triodes, two tubes. The single tube has a power output rating of little less than a watt; the pentode push pull output is 19 watts, while the triode push pull output is 14 to 18watts. Note that the total harmonic distortion for the push pull penodes is 5 per cent., while for the single tube, and the push pull triodes, it is 7 per cent.

Separate Cathode for Each Diode in the 6H6 Dual Detector

(Continued from preceding page)

6H6 TWIN DIODE



Bottom view of socket.

The 6H6 is a heater cathode type of metal tube combining in one shell two diodes. Each diode has its own separate cathode and corresponding base pin. This arrangement offers flexibility in the design of circuits employing the 6H6 as a detector, a low-voltage low-current rectifier, or for the purpose of automatic volume control.

Tentative Characteristics

Heater Voltage	6.3	Volts
Heater Current	0.3	Ampere
Plate No. 1 to Plate No. 2 Capacitance*	0.02 max.	Mmfd.
A-C Plate Voltage Per Plate (RMS)	100 max.	Volts
D-C Output Current	2 max.	Milliamperes
Maximum Overall Length	1-5/8"	
Maximum Diameter	1-5/16"	
Base	Small Octal 7-Pin	

*With shell connected to cathode.

Installation

The *base* pins of the 6H6 fit the seven contact octal base socket (or the universal eight contact socket) which may be installed to hold the tube in any position.

For *heater* operation and *cathode* connection, refer to Installation for type 6A8.

Application

For *detection,* the diodes may be utilized in a full-wave circuit or in a half-wave circuit. In the latter case, one plate only, or the two plates in parallel, may be employed. The use of the half-wave arrangement will provide approximately twice the rectified voltage as compared with the full-wave arrangement.

For *automatic volume control,* the 6H6 may be used in circuits similar to those employed for any of the duplex-diode types of tubes. The only difference is that the 6H6 is more adaptable due to the fact that each diode has its own separate cathode.

Since the diodes by themselves do not provide any amplification, it is usually necessary to provide gain by means of a supplementary tube. Types such as the 6C5, 6F5, 6J7, and 6K7 are very suitable for this purpose. Their use in combination with the 6H6 is similar to that of the amplifier sections of duplex-diode triode or pentode types, such as the 76, 75, 6C6, and 6D6. The amplifier sections of these types have somewhat the same characteristics as the 6C5, 6F5, 6J7, and 6K7, respectively.

KEEPING THE DIODE "STRAIGHT"

It is preferable to work the diodes well within their current rating limits, because the intended linear detection does not apply so strictly when the current is high. Thus for the 6H6, though 2 milliamperes are the limit, operation at no time in excess of 1 milliampere would be preferable.

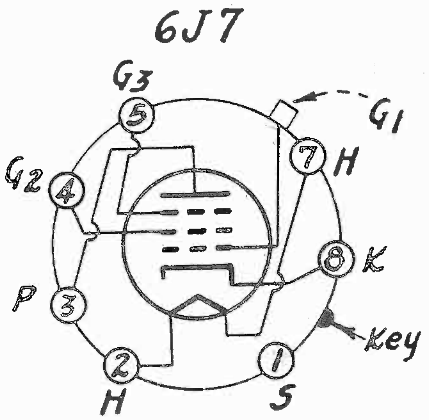
Separate Cathodes Add a Refinement

Presence of two separate cathodes, one serving each separate diode, and only tiny capacity between diodes, enables certain improvements in receivers consistent with tube economy. The principal improvement is that one diode may be fed for regular second detection in a superheterodyne, the other diode fed for separate rectification for automatic volume control voltage supply. Therefore, with no triode or pentode in the same envelope, and with separate cathodes in the 6H6, usual fixed biasing resistors may be used on controlled tubes, without running the unthinking risk of having the controlled grids positive when there is no signal, or not enough signal to overcome the bias on the amplifier. This subject is treated in a special article in this issue. See page 48.

It may be possible also to develop a nonreactive push pull circuit, also a subject treated in these columns. Last month some phases of this topic were covered, this month additional data are given. See page 50. As yet there is no authenticated solution to the problem, so far as we know.

Triple Grid Biased Detector, 6J7, Yields Much from Small Input

6J7 TRIPLE-GRID DETECTOR AMPLIFIER



Bottom view of socket.

The 6J7 is a triple grid type of metal tube recommended especially for service as a biased detector in radio receivers designed for its characteristics. In such service, this tube is capable of delivering a large audio frequency output voltage with relatively small input voltage. Other applications of the 6J7 include its use as a high gain amplifier tube.

Installation

The *base* pins of the 6J7 fit the seven contact octal base socket (or the universal eight contact socket) which may be installed to hold the tube in any position.

For *heater* operation and *cathode* connection, refer to Installation for type 6A8.

The *screen* voltage may be obtained from a potentiometer or bleeder circuit across the B supply source. Due to the screen current characteristics of the 6J7, a resistor in series with the high voltage supply may be employed for obtaining the screen voltage, provided the cathode resistor method of bias control is used. This method, however, is not recommended if the high voltage B supply exceeds 250 volts.

Application

As a *biased detector,* the 6J7 can deliver a large audio frequency output voltage of good quality with a fairly small radio frequency signal input. Typical recommended conditions for the 6J7 as a biased detector are as follows:

As a *radio frequency amplifier pentode,* the 6J7 may be used particularly in applications where the r.f. signal applied to the grid is rela-

(*Continued on next page*)

Tentative Characteristics

Heater Voltage (A.C. or D.C.)		6.3	Volts
Heater Current		0.3	Ampere
Plate Voltage	100	250 max.	Volts
Screen (Grid No. 2) Voltage	100	100**	Volts
Grid (Grid No. 1) Voltage	—3	—3	Volts
Suppressor (Grid No. 3)		Connected to cathode at socket	
Plate Current	2	2	Milliamperes
Screen Current	0.5	0.5	Milliamperes
Plate Resistance	1.0	Greater than 1.5	Megohms
Amplification Factor	1185	Greater than 1500	
Mutual Conductance	1185	1225	Micromhos
Grid Voltage (Approx.)‡	—7	—7	Volts
Grid-Plate Capacitance°		0.005 max.	Mmfd.
Input Capacitance°		7	Mmfd.
Output Capacitance°		12	Mmfd.
Maximum Overall Length		3-1/8"	
Maximum Diameter		1-5/16"	
Cap		Miniature	
Base		Small Octal 7 Pin	

*If a grid-coupling resistor is used, its maximum value should not exceed 1.0 megohm.
**Maximum Screen Volts = 125.
‡For cathode current cutoff.
°With shell connected to cathode.

Plate Supply*	250	250	250	250	Volts
Screen Voltage	50	33	100	100	Volts
Grid Voltage	—2	—1.7	—3.9	—4.3	Volts
Cathode Resistor	3000	8000	4000	10000	Ohms
Suppressor	Connected to cathode at socket				
Cathode Cur. (No signal)	0.65	0.21	0.97	0.43	Milliamperes
Plate Resistor	0.25	0.50	0.25	0.50	Megohm
Blocking Condenser	0.03	0.03	0.03	0.03	Mfd.
Grid Resistor‡	0.25	0.25	0.25	0.25	Megohm
R.F. Signal (RMS)**	1.18	1.21	1.38	1.37	Volts

*Voltage at plate will be Plate-Supply voltage less voltage drop in plate resistor caused by plate current.
‡For the following amplifier tube.
**With these signal voltages modulated 20%, the voltage output under each set of operating conditions is 1 peak volts at the grid of the following amplifier, a value sufficient to insure full audio output from a type 6F6

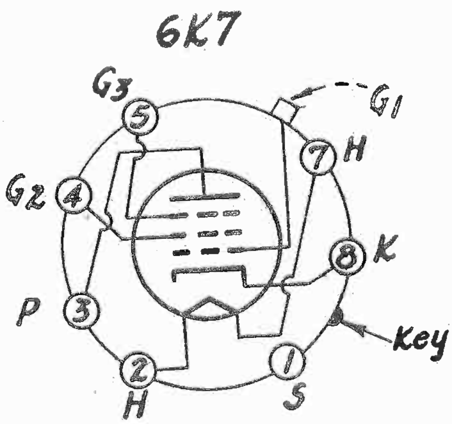
Details on Working Volume Control by 6K7 Bias Alteration

(*Continued from preceding page*)

tively low, that is, of the order of a few volts. In such cases either screen or control grid voltage (or both) may be varied to control the receiver volume. When larger signals are involved, a super-control amplifier tube should be employed to prevent the occurrence of excessive crossmodulation and modulation distortion. Recommended operating conditions for amplifier service are given under Characteristics.

Detector bias may be obtained from a bleeder circuit, from a resistor in the cathode circuit, or from a partial self-biasing circuit. The cathode resistor method permits of higher output at low percentage modulation.

6K7 TRIPLE-GRID SUPER-CONTROL AMPLIFIER



Bottom view of socket.

The 6K7 is a triple grid super control amplifier tube of the metal type recommended for service in the radio frequency and intermediate frequency stages of radio receivers designed for its characteristics. The ability of this tube to handle unusual signal voltages without cross-modulation and modulation distortion makes it adaptable to the r-f and i-f stages of receivers employing automatic volume control.

Installation

The *base* pins of the 6K7 fit the seven contact octal base socket (or the universal eight contact socket) which may be installed to hold the tube in any position.

Heater operation and *cathode* connection are the same as for 6A8.

Control grid bias variation will be found effective in changing the volume of the receiver. In order to obtain adequate volume control, an available grid bias voltage of approximately 50 volts will be required. The exact value will depend upon the circuit design and operating conditions. This voltage may be obtained, depending on the receiver requirements, from a potentiometer across a fixed supply voltage or by the use of a variable self-bias resistor in the cathode circuit.

The *screen* voltage may be obtained from a potentiometer or bleeder circuit across the B supply source. Due to the screen current characteristics of the 6K7, a resistor in series with the high voltage supply may be employed for obtaining the screen voltage provided the cathode resistor method of bias control is used. This method, however, is not recommended if the high voltage B supply exceeds 250 volts. Furthermore, it should be noted that the use of a resistor in the screen circuit will have an effect on the change in plate resistance with

Tentative Characteristics

Heater Voltage (A.C. or D.C.)				6.3	Volts
Heater Current				0.3	Ampere
Plate Voltage	90	180	250 max.	250 max.	Volts
Screen (Grid No. 2) Voltage	90	75	100	125 max.	Volts
Grid (Grid No. 1) Voltage (Minimum)	—3	—3	—3	—3	Volts
Suppressor (Grid No. 3)		Connected to cathode at socket			
Plate Current	5.4	4.0	7.0	10.5	Milliamperes
Screen Current	1.3	1.0	1.7	2.6	Milliamperes
Plate Resistance	0.315	1.0	0.8	0.6	Megohm
Amplification Factor	400	1100	1160	990	
Mutual Conductance	1275	1100	1450	1650	Micromhos
Grid Voltage*	—38.5	—32.5	—42.5	—52.5	Volts
Grid-Plate Capacitance°				0.005 max.	Mmfd.
Input Capacitance°				7	Mmfd.
Output Capacitance°				12	Mmfd.
Maximum Overall Length				3-1/8"	
Maximum Diameter				1-5/16"	
Cap				Miniature	
Base				Small Octal 7-Pin	

*For mutual conductance = 2 micromhos.
°With shell connected to cathode.

Two Separate 6L7 Control Grids Shielded from Each Other

variation in suppressor voltage in case the suppressor is utilized for control purposes.

The *suppressor* may be connected directly to the cathode or it may be made negative with respect to the cathode. For the latter condition, the suppressor voltage may be obtained from a potentiometer or bleeder circuit for manual volume and selectivity control, or from the drop in a resistor in the plate circuit of the automatic volume control tube.

Application

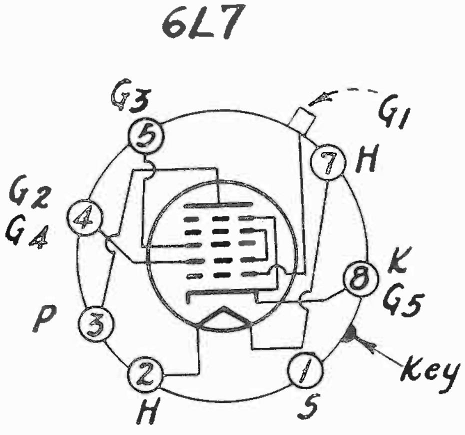
As a *radio frequency amplifier,* the 6K7 is especialy applicable to radio receiver design because of its ability to reduce crossmodulation effects, its remote cutoff feature, and its flexible adaptability to circuit combinations and to receiver design. Recommended conditions for the 6K7 as an amplifier are given under Characteristics.

To realize the maximum benefit of the long cutoff feature of this tube, it is necessary to apply a variable grid bias and to maintain the screen at a constant potential with respect to the cathode. However, good results may be obtained by using a variable cathode resistance which, of course, reduces the screen potential with respect to the cathode by the same amount that the bias is increased, thus hastening the cutoff and reducing the ability of the tube to handle large signals. This undesirable effect may be nullified by means of a series resistor in the screen circuit.

The use of series resistors for obtaining satisfactory control of screen voltage in the case of four electrode tubes is usually impossible because of secondary emission phenomena. In the 6K7, however, the suppressor practically removes these effects and it is therefore possible to obtain satisfactorily the screen voltage from the plate supply or from some high intermediate voltage providing these sources do not exceed 250 volts. With this method, the screen-to-cathode voltage will fall off very little from minimum to maximum value of cathode-control resistor. In some cases, it may actually rise. This rise of screen-to-cathode voltage above the normal maximum value is allowable because the screen and the plate current are reduced simultaneously by a sufficient amount to prevent damage to the tube. It should be recognized in general that the series resistor method of obtaining screen voltage from a higher voltage supply necesitates the use of the variable cathode resistor method of controlling volume. When screen and control grid voltage are obtained in this manner, the remote cutoff advantage of the 6K7 may be fully realized.

As a mixer in superheterodyne circuits, the 6K7 may be used to advantage. It is capable of producing, under the proper conditions of grid and local oscillator voltage, a gain in the mixer stage of about one-third that which can be obtained in an intermediate-frequency amplifier stage. In addition, this gain can be controlled as in the case of the radio frequency amplifier by varying the grid bias either from a separate supply or from a variable resistor in the cathode circuit. This is a particularly desirable feature in receivers employing automatic volume control, because it enables a much lower threshold input to be received without loss of amplification and permits the reception of high input voltages without loss of control. Recommended conditions for the 6K7 as a superheterodyne mixer follow: Plate voltage, 250 volts; screen voltage, 100 volts; suppressor connected to cathode at socket; and grid-bias voltage, —10 volts approx. (with 7-volt oscillator peak swing.)

6L7 PENTAGRID MIXER AMPLIFIER



Bottom view of socket.

The 6L7 is a multi-electrode vacuum tube of the metal type designed with two separate control grids shielded from each other. This design permits each control grid to act independently on the electron stream. This tube, therefore, is especially useful as a mixer in superheterodyne circuits having a separate oscillator stage, as well as in other applications where dual control is desirable in a single stage. The design of the tube is such that coupling effects between oscillator and signal circuits are made very small. This feature enables the 6L7 to give high gain in high frequency circuits.

(*Continued on next page*)

Very Small Interelectrode Capacities, Except Output, Found in 6L7

(*Continued from preceding page*)

Installation

The *base* pins of the 6L7 fit the standard seven contact octal base socket (or the universal eight contact socket) which may be installed to hold the tube in any position.

For *heater* operation and *cathode* connection, refer to Installation of type 6A7.

Application

As a *mixer* in superheterodyne circuits, the 6L7 can mix the input from an external oscillator with the radio input frequency to provide the desired intermediate frequency. For this service, design information is given under Characteristics.

As a *radio frequency* or *intermediate frequency amplifier*, the 6L7 should be operated as shown under Characteristics. In general, properly designed radio frequency transformers are preferable to interstage coupling impedances, especially in cases where a high impedance B supply may cause oscillation below radio frequencies. The fact that the grid No. 1 plate capacitance of the 6L7 is extremely small is advantageous in circuits where high attenuation is required.

Tentative Characteristics

Heater Voltage (A.C. or D.C.)	6.3	Volts
Heater Current	0.3	Ampere
Direct Interelectrode Capacitances:*		
Grid No. 1 to Grid No. 3	0.12	Mmfd.
Grid No. 1 to Plate	0.0005 max.	Mmfd.
Grid No. 3 to Plate	0.25	Mmfd.
Grid No. 1 to All Other Electrodes	8.5	Mmfd.
Grid No. 3 to All Other Electrodes	11.5	Mmfd.
Plate to All Other Electrodes	12.5	Mmfd.
Maximum Overall Length	3-1/8"	
Maximum Diameter	1-5/16"	
Cap	Miniature	
Base	Small Octal 7 Pin	

As Amplifier

Heater Voltage	6.3	Volts
Plate Voltage	250 max.	Volts
Screen (Grids No. 2 and No. 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: { —15 volts bias on Grid No. 1; —15 volts bias on Grid No. 3 }	5	Micromhos

As Mixer

Plate Voltage		250 max.	Volts
Screen (Grids No. 2 and No. 4) Voltage		150 max.	Volts
Typical Operation:			
Heater Voltage	6.3	6.3	Volts
Plate Voltage	250	250‡	Volts
Screen Voltage	100	150‡	Volts
Signal-Grid (Grid No. 1) Voltage	—3	—6 Min.‡	Volts
Oscillator-Grid (Grid No. 3) Voltage**	—10	—15	Volts
Peak Oscillator Voltage Applied to Grid No. 3 (Minimum)	12	18	Volts
Plate Current	2.4	3.3	Milliamperes
Screen Current	6.2	8.3	Milliamperes
Plate Resistance	Greater than 1		Megohm
Conversion Conductance	350	350	Micromhos
Signal-Grid (Grid No. 1) Voltage for Conver. Cond. of 5 Micromhos	—30	—45	Volts

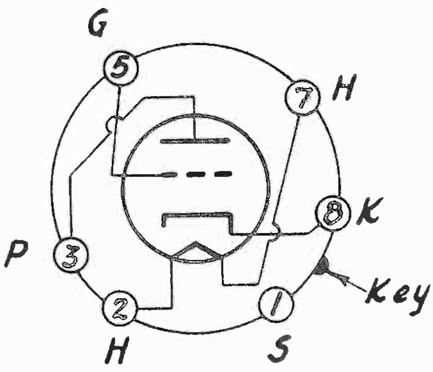
**The dc. resistance in oscillator grid No. 3 circuit should be limited to 50000 ohms.
‡Recommended values for all-wave receivers.
*With shell connected to cathode.

The 6L7 lends itself to many uses, other than the conventional one for which it is primarily intended. Such uses will be covered in articles in subsequent issue. The impedance from G3 to cathode may be used as a load resistor for direct coupling, the difficulties of introducing modulation at audio frequencies into an ultra frequency oscillator or modulated amplifier, and even the introduction of relaxation oscillations are practicalities. Nnot only is the 6L7 the most interesting of the ten tubes but in the sense of its variety of uses and abundance of benefits in ultra frequency practice, it is the most important.

Advance Information on 6D5 Power Amplifier Triode

Power Amplifier Triode

6D5



Bottom View of Socket

The 6D5 is a power amplifier triode fairly closely equivalent to the 45 tube. The characteristics are listed at right and constitute advance notice, as the tube is the last of the series of ten, and most of the manufacturers are not yet ready to release data on this tube. However, the characteristics are sufficiently stated herewith, and the application of the tube to actual construction is not attendant with any difficulty.

Heater Voltage	6.3 volts a.c. or d.c.
Heater Current	0.7 ampere
Direct Interelectrode Capacities:	
Grid Plate	3.5 mmfd.
Input	4.0 mmfd.
Output	7.5 mmfd.

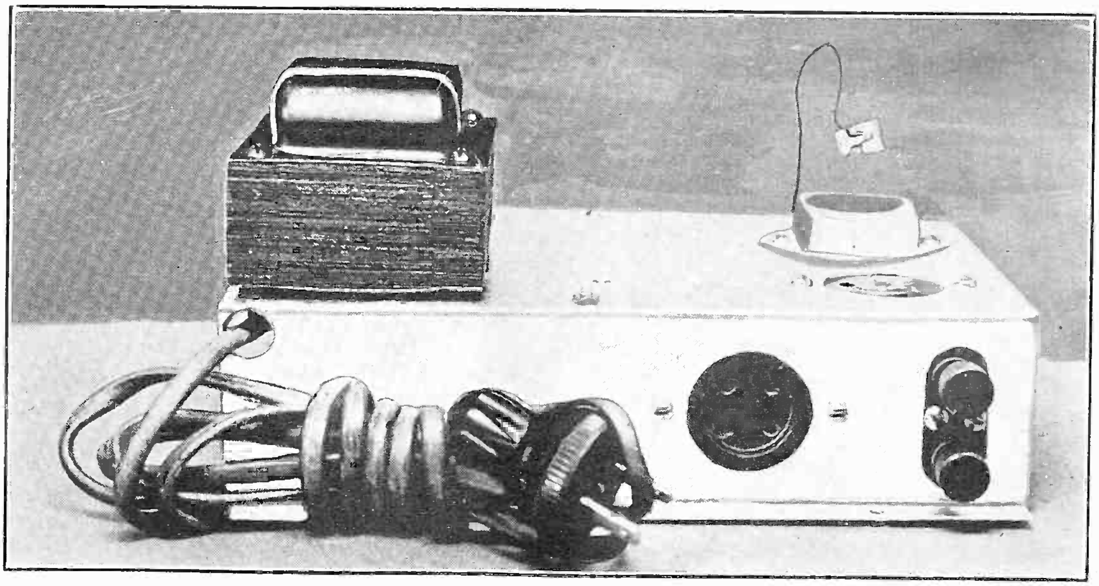
Amplifier (Class A, Single Tube)

Plate Voltage	275 volts max.
Grid Voltage	minus 40 volts
Plate Current	31 milliamperes
Plate Resistance	2250 ohms
Mutual Conductance	2100 micromhos
Load Resistance	7200 ohms
Undistorted Power Output	1.4 watts
Amplification Factor	4.7

Amplifier (Class AB Push Pull; Two Tubes)

Plate Voltage	300 volts max.
Grid Voltage (Fixed Bias)	Minus 50 volts
Plate Current†	23 milliamperes
Load Resistance	5300 ohms (P to P)
Power Output	5 Watts

* With shell connected to cathode.
† Per tube at no signal input.



Behind the transformer is a rectifier tube. Then if there is a high mu driver, or pentode tube, the last tube may be a 6D5 and can be almost loaded up from a carbon microphone. This makes a handy amplifier layout.

COMPARISON CLOSE FOR 6 OF THE 7 TUBES

Of the ten tubes, seven have direct equivalents in the glass envelope type, as shown in the right hand column of the table. While the 6D5 is included among the seven, and compared to the 45, the comparison between these two is not quite as close as between companionate tubes in the six other examples. As stated in the footnote, the 6F5 corresponds to the high mu triode of the 75, and the 6H6 compares to the diodes of the 75, so in effect these two glass type tubes are separated to form the two metal tubes. About the same results are to be expected from the use of the two glass tubes. However, anybody making or buying a metal tube set naturally would want the tubes to be consistent.

There is no glass equivalent of the 6L7, as this tube represents a new development and advance, being the first sign from the tube manufacturers of recognition of drifting as something requiring attention in the manufacture of tubes. The question of frequency stability is beginning to assume considerable importance.

TABULATED CHARACTERISTICS OF THE TEN TUBES

Type	Use	Filament Rating Volts	Filament Rating Amps.	Plate Volts	Negative Grid Volts	Screen Volts	Plate Current ma.	Screen Current ma.	Plate Resistance Ohms	Mutual Conductance Micromhos	Amplification Factor	Load Resistance Ohms	Milliwats Undistorted Output	Similar Glass Type
5Z4	F. W. Rectifier	5.0	2.0	400 RMS	...	...	125	..	.....	....	....	....	....	80
6A8	Converter	6.3	0.3	250	3.0	100	3.3	3.2	500,000	†500	....	....	....	6A7
6C5	Amplifier	6.3	0.3	250	8.0	...	8.0	..	10.000	2,000	14	....	....	76
6D5	Power Amplifier	6.3	0.7	275	40.0	...	31.0	..	2,250	2,100	4.7	7,200	1,400	45
6F5	Amplifier	6.3	0.3	250	2.0	...	0.9	..	66,000	1,500	50-60	....	....	*
6F6	Pentode	6.3	0.7	250	16.5	250	34.0	6.5	80,000	2,500	200	7,000	3,000	42
	Triode¶	6.3	0.7	250	20.0	...	31.0	..	2.600	2,700	7	4,000	850	
6H6	Rectifier	6.3	0.3	100 RMS Max.	...	...	2.0 Max.	..	......	....	....	....	....	*
6J7	Detector, Amplifier	6.3	0.3	250	3.0	100	2.0	0.5	1.500.000	1,225	1,500	....	....	77
6K7	Amplifier	6.3	0.3	250	3.0	100	7.0	1.7	600,000	1,650	1,160	....	....	78
6L7	Mixer	6.3	0.3	250	6.0	150	3.3	8.0	1,000,000	†325	....	....	....	None

*6F5 corresponds to triode of 75 while 6H6 corresponds to diode of 75.
¶Screen tied to plate.
†Conversion conductance.

Answers to Questions That Vex Readers Interested in the Tubes

Shall He Replace Glass Tubes?

PLEASE let me know whether it is advisable to replace the present glass tubes in my radio set, even though I would have to put in the new sockets.—K. W. K.

No, it is inadvisable to attempt this change. Especially if the set is intended to cover only the broadcast band, or even short waves to 15 mgc or so, it would not be advisable. Moreover makeshifts in general have proved unsatisfactory in the past with other radio developments, and your proposal is a makeshift. The new tubes are to be used in new sets and circuits designed and intended for them. An existing set might have to undergo so many changes that it would be cheaper to dispose of the old set and have a new one installed or built. It should be noted that the new tubes are particularly advantageous for the higher frequencies of short waves, and also that these tubes do not mitigate the service rendered by glass tubes.

* * *

How He Got the Impression

IT was my impression that the 6L7 was a pentagrid converter tube with electron coupling between its oscillator and modulator elements, but now I am told it is only a single tube, but I did not make up the impression out of my head.—L. W. S.

What probably happened was that you read early and sketchy announcements about the tube that, for some reason, did not give very informative details, for instance, did not reveal that the tube was a single one and not a dual. At least, is has to be classified as a single tube, a pentode, because the extra element, G3, is a pickup grid, and to this grid the oscillation voltage from an independent oscillator is fed. This fact was not brought out in early announcements, so therefore the impression may have gone around that the 6L7 was like the 6A7, although one of the metal tubes (6A8) is like the 6A7 glass tube, and therefore the 6L7 could not be expected to be like that glass tube, too.

* * *

"I Remember, I Remember"

CAN you give me a good rule for remembering the ten metal tubes? I read about them now and again but I forget which tube is which, and when somebody talks about the 6H6 or the 6D6 I can't for the moment remember what the tube is supposed to do, so would have to write it down secretly, and then look it up in some published authority.—W. S. C.

We have somewhat the same trouble, not quite so bad. We can not think of any one rule that would enable you to remember the ten metal tubes and their functions. However, maybe some rules not quite hopeless can be set forth. The first is that of the ten tubes only one takes 5 volts on the heater, and that is a rectifier, the 5Z4. You can remember that because of the 5 for 5 volts, the Z, which is a rectifier designating letter in tube terminology, and the 4 the only last number of its kind in the list. So, if a fellow says 6K7 and 6A8 at least you will know it is not a B supply rectifier tube. All the rest begin with 6, meaning the heater voltage should be around 6. If the rectifier is listed first, then the rest of the tubes have letters in alphabetical order, as shown in the tabulation on another page. You know the 6A7—the glass type pentagrid converter—and since the equivalent metal tube has an end number simply one higher, you know the 6A8. We now have two possibilities of error eliminated. Now we shall skip to the 6F6 and 6H6, because they alone begin and end with six, and make believe the H stands for high fidelity, because all high fidelity sets have diode detectors, and so the 6H6 is the double diode detector tube. The other is a pentode amplifier, and you'll have to remember that without association. Contining down the alphabetical list we have to find something to associate with 6J7, 6K7 and 6L7. Since 6H6 was a detector, we can remember that the next letter, J, happens to represent a detector, the equivalent of the 77, 57 or 6C6. It is a quadrode of the super control type, and the next in line is the amplifier of the series, 6K7, while the last on the list is the tube unlike any we have had, consisting of a pentode with an additional grid to which external oscillation voltage is to be supplied, the 6L7. Going back, now, we eliminated the first tube by the 5, the Z and the 4, numbers and letters, none of the others have, and the last, the 6L7, because it stands alone in function; the 6A8 because it is next in order to its glass companion 6A7, the 6F6 pentode power tube and 6H6 because of the 6 at beginning and end, the H for diode; the 6J7 because the J adjoins a detector and is itself, a detector, and the 6K7 the companion amplifier. Then also we have to remember "cold" that the 6C5 is an amplifier (like the 76); the 6D5 is a power amplifier (somewhat like the 45) and the 6F5 is a high mu amplifier. Or, if the rules won't work, the list can be memorized from the tabulation.

* * *

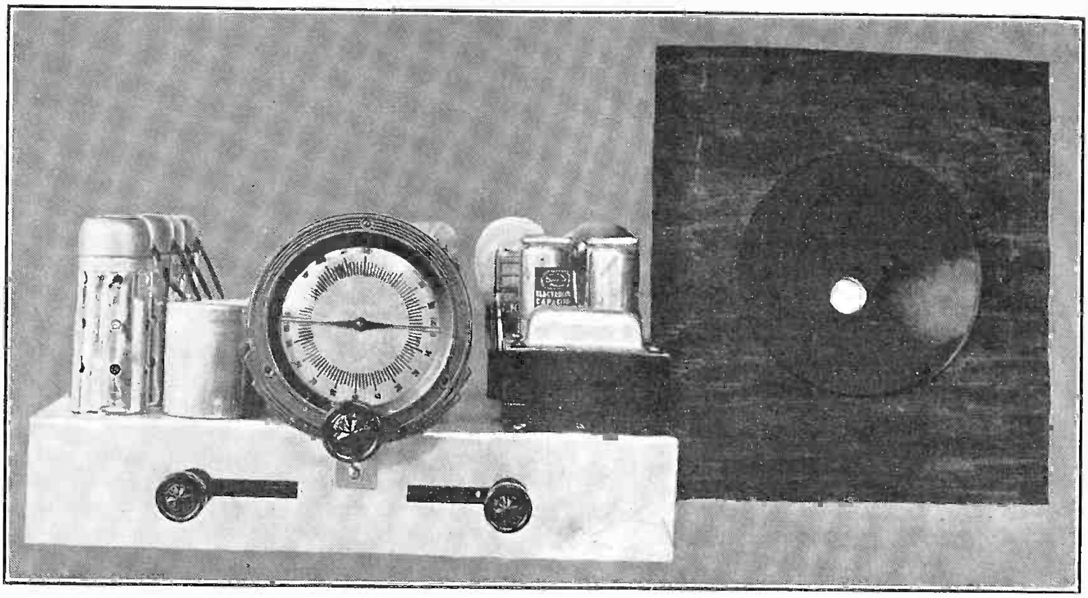
IS the broadcast band reception improved very much by the use of the metal tubes?—L. W.

Not very much. The improvement in general is in the direction of more sensitivity. Indirectly this results in the reduction of noise. The sensitivity is increased much on the high radio frequencies, say, above 10 mgc, compared to performance from glass type tube, but the relative improvement declines as the frequency declines.

A Hum-Banished T. R. F. Set

Quality Reproduction from Push Pull Output

By J. E. Anderson



An ugly hum problem was encountered in a tuned radio frequency receiver, cured easily by connecting the midpoint of the heaters to the positive side of the power tube biasing resistor. This caused a positive bias to be applied to the heater. It is generally considered that the heater is independent of the radio frequency circuits, but this is not a fact, as there may be appreciable heater to tuned circuit coupling, that is, carrier frequency current flow in the heater leg.

A RADIOIST with a keen sense of discernment between the real thing in tone and a close counterfeit required a range of volume from a gentle fireside companionableness to Wagnerian thunder that would stimulate a multitude. Keen edged selectivity that cut out the life and sparkle from the reproduced tones and speech had to be sacrificed for realism, yet sufficient selectivity had to be retained to insure that no undesired signals should interfere with any particular signal selected for the moment.

Such a requirement was met with a tuned radio frequency receiver as diagramed. Four tuners had to be used to get the necessary selectivity, three r.f. amplifier tubes to get the necessary radio-frequency gain, and push-pull output to get the necessary volume without distortion on the greater intensities.

A 57 type grid bias detector, followed by a resistance-capacity coupler, was essential to get high detecting efficiency; and a 56 type audio amplifier was necessary to feed the push-pull amplifier properly.

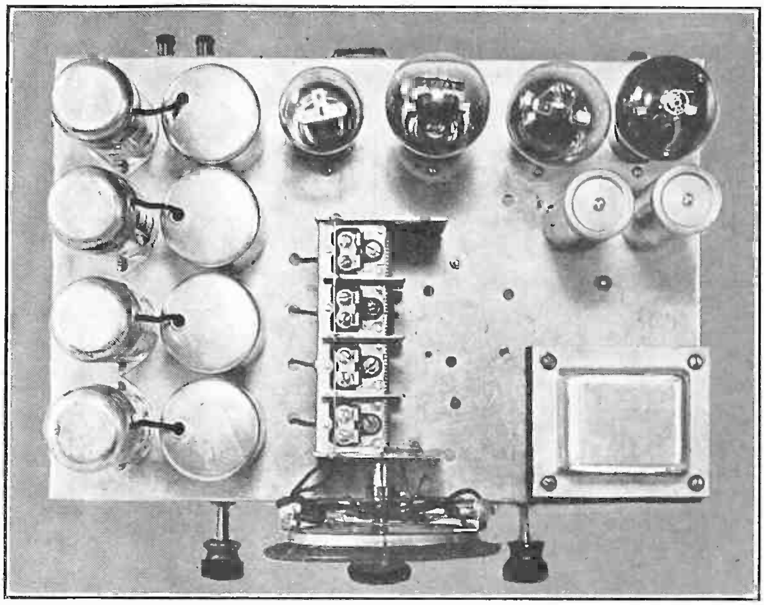
Tried and True Methods

Technically there is little to be said about this receiver. It follows sound and well tried principles throughout. Not even a lead has been run in a "new and novel" manner, and there is not a single untried "trick" in it.

A speaker, 10 inches in diameter and well baffled, was used. This is an essential for faithful reproduction of the tones from the bass viol, the bass drum, and the low tones from the piano and the organ. When the amplifier delivers these low tones to the speaker, that speaker must be large, and the baffle still larger, if the tones are to be radiated into the air actually and not merely by the differences of the harmonics of those tones. (In explanation of this statement it may be well to say that even if the fundamental of a low tone is completely suppressed but if its harmonics are brought out strongly, the fundametal is still audible by virtue of modulation, or detection, in the ear.)

Equalizing Resistors

Attention is called to the two 0.5 megohm resistors connected across the two sides of the secondary of the push-pull transformer. What is their purpose? To improve the tone. When they are not used, the signal voltages on the high audio tones rise to excessive values because there is no load on the secondary, and this rise causes nerve-wracking screeching in the loudspeaker. To a degree these resistances obviate the need of a tone control, yet one is incorporated because it gives the listener a chance to vary the proportion of highs and lows to suit his own pleasure. On soft and sedate music he is likely to wish a preponderance of the lows, but on speech and more lively music he may wish to have the highs a bit more pronounced. Bringing out the highs in their true proportion is especially advantageous in rendering speech distinct, for the highs carry the consonants. This tone control is connected between the two grids of the output stage, and it consists of a 0.5 meg. variable resistor in series with a .002 mfd. condenser.



After having tried out both arrangements, first the tubes nearer the tuning condenser and tubes at the outside (left), the method was adopted as shown in the photograph. This circuit was very completely engineered, even though it is a tuned radio frequency set, and something considered simple, elementary.

There is also a provision for a phonograph connection. The phono jacks are connected between the grid of the 56 and ground. Thus when the pickup unit is connected the 56 tube remains an amplifier as it should, and does not change to something half way between a detector and an amplifier. The gain in the two stages following the phono provision is ample for the usual type of phono pickup.

Radio Silent on "Phono"

The usual pickup has a low resistance or impedance. Therefore when it is connected in parallel with the grid leak and the plate coupling resistance the performance of the pickup is not altered. When the 57 tube is "on" the effective resistance across the phono unit is about 300,000 ohms. This is so high that it cannot have any effect on a 200-ohm pickup unit. Even if the pickup has a much higher resistance, there is still no need of connecting the phono unit to the grid and ground alone.

Will the radio signal interfere with the playing of the phonograph, if the radio frequency amplifier is left on? It will not. The phono unit virtually short circuits the output of the 57 tube. Besides, it is not necessary to tune the r.f. circuits to a strong station while the phonograph is being played, nor to turn up the radio frequency amplification. The r.f. volume control alone has such a wide range that the signal can be cut out entirely on the strongest broadcast station.

How the Problem Was Met

One of the problems that arose in the construction and adjustment of the receiver was audio frequency hum. The filtering was thought to be ample, for there was a good inductance, low resistance filter choke and a husky 1,000 field coil in series with the B supply, and two 8 mfd. and one 2 mfd. condensers in shunt with the field.

Besides the power transformer used was oversized for the number of tubes employed, and many small bypass condensers were placed at strategic points. Yet there was an audible hum of 120 cycles. Additional condensers did no good. Neither did additional choking. As an attempt to remove the last trace of hum, the 20 ohm resistor was placed across the heater winding and its center point was connected to the bias resistor of the 45 tubes. This proved successful. The ear could no longer detect the hum and even sensitive finger tips placed against the speaker diaphragm could not feel vibration.

The two 45 tubes are slightly overbiased by means of an 850 ohm resistor between ground and the center of the heaters. This overbiasing was done in order to make maximum output a little greater. It increases the volume handling capability of the receiver on the low, strong tones, yet it does not impair the quality on the weaker signals. Because of this slight overbias a .5 mfd. condenser is connected across the bias resistor. Its use is not essential but it aids in keeping the tone good in case one of the 45 tubes should become weak.

As a refinement a line filter has been incor-

(Continued on next page)

(*Continued from preceding page*)
porated. It consists of two 0.1 mfd. condensers connected across the primary of the power transformer. They are in series and their junction is grounded.

Shielded Antenna Wire In Set

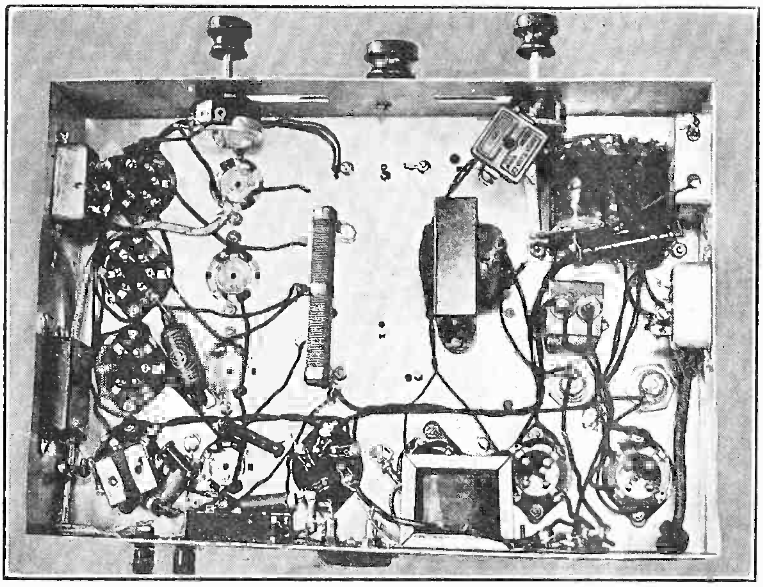
During the adjustment of the receiver only slight difficulty was experienced with oscillation at radio frequency. However, there was a slight tendency toward oscillation at certain settings of the tuning condenser until the lead from the antenna binding post to the first coil was shielded. This lead is necessarily rather long and it runs past three of the coils and the three 58 tubes. Although the distance between the lead to these coils and tubes was several inches, shielding of that lead was found advisable.

All the screens of the radio frequency amplifiers are connected together on a tap of the 25,000 ohm, wirewound voltage divider and a common bypass condenser of .25 mfd. was used. This method of supplying the screen voltage was adopted because it makes the voltage more nearly constant and therefore improves the performance of the tubes. The screen of the 57 detector is connected to the high voltage line through a resistor of .5 meg. This provides the proper screen potential for that tube, and it is kept from varying with the signal by means of a 0.1 mfd. condenser connected between the screen and the cathode. The bias resistance for the detector is 50,000 ohms, shunted by .5 mfd.

Two Receivers Compared

This capacity is large enough when placed across a resistance of such a high value, to prevent degenerative effects. It is five times higher than the capacity ordinarily employed in this position. The limiting bias for the three r.f.

(*Continued on next page*)



There isn't much to do when wiring the set, as the underneath view confirms. The auxiliary choke was placed near the power transformer, but the audio transformer was put on the inside of the rear chassis wall. Do not make the mistake of putting the a.f.t. near the power transformer.

LIST OF PARTS

Coils

Four shielded radio frequency transformers for .000365 mfd. condensers.
One push pull audio input transformer.
One 400 ohm, 100 milliampere filter choke.
One 100 milliampere power transformer.
One 10 inch dynamic speaker with a 1,000 ohm field coil.

Condensers

One four-gang .000365 mfd., with trimmers.
One .00025 mfd. mica. One .002 mfd.
One .02 mfd.
Two .25 mfd.
Three .5 mfd.
One 2 mfd., 600 volt.
Two 8 mfd. electrolytic condensers, 600 volt.
One double 0.1 mfd. condenser, or two singles.
One 0.1 mfd. condenser.

Resistors

One 10,000-ohm tapered potentiometer, bias resistor built in.
One .5 meg. variable resistor with line switch attached.
One 20 ohm, center tapped.
One 850 ohm, 5 watt bias.
One 0.25 megohm.
One 50,000 ohm.
One 2,500 ohm.
Four 0.5 meg.
One 25,000 ohm, wire wound voltage divider (over 10 watts).

Other Requirements

Nine wafer type sockets (one for speaker).
Four grid clips. Four tube shields.
One 4 inch airplane type dial, with dial light sockets.
One twin phono jack. Two binding posts.
One line cord and plug.
Three knobs for the controls. One chassis.
A length of shielded wire for antenna lead.
About 25 feet of hookup wire.
Tubes: Three 58 r-f. amplifiers; one 57 detector; one 56 audio amplifier; two 45 output tubes; one 80 rectifier; two 2.5 volt dial lights.

(*Continued from preceding page*)

amplifiers is obtained from a 150 ohm resistor in their common cathode lead. This is built into the 10,000 ohm manual volume control. The used portion of the total bias resistance is shunted by a .25 mfd. condenser.

The question may arise whether this a-c. receiver is better than the a.c.-d.c. receiver described in the August issue. There need be no difference in the quality on moderately strong signals, but on very strong signals, and especially on strong bass notes, the advantage lies with the a.c. receiver because the voltages available are higher and because of push-pull. The choice may be based on the power available, though the universal job has the advantage that in case the owner moves from one district to another he need not change his receiver. The a.c. receiver has the real advantage of ample reserve power on the bass notes.

New Polish Ocean Liner Fully Radio Equipped

The Pilsudski, first of Poland's new trans-atlantic liners, plying between Gdynia and New York, has a transmitting and receiving short and long wave plant. The antenna will be 0.4 to 0.8 kw. A general receiver tunes from 20 to 20,000 meters. A much smaller set, to transmit and receive, will be used over distances up to 250 miles.

For emergencies an alarm spark transmitter has been provided. This transmitter is entirely supplied from a special storage battery. There is also a direction finder with a revolving frame, installed in the navigation room. It allows an exact definition of the ship's position by means of radio-goniometric measurements.

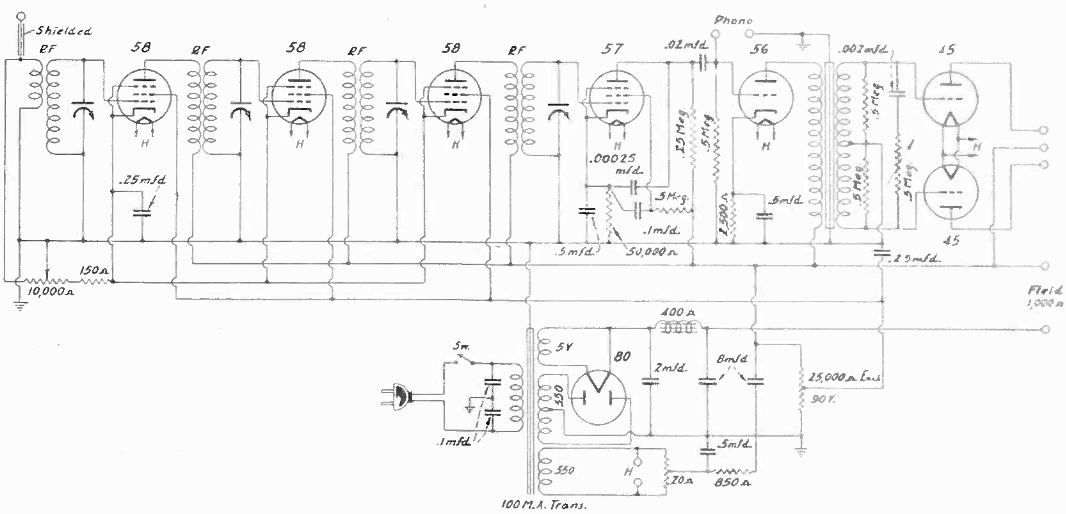
All of the radio equipment is provided with several antennas of different types and dimensions. Power is supplied from four dynamos.

Emphasis Next Month on Constructional Data

The November issue of RADIO WORLD will stress, almost to the point of exclusion of other material, constructional articles on radio and audio devices, with intimate textual details and comprehensive diagrams, including pictorial wiring diagrams based on the literal placement of the parts. These pictorials would be called blueprints but for the fact that the printing will be in black.

All of the circuits that have been or will be printed in the monthly have been fully authenticated, and the bugs have been taken out of them. In the November issue the constructional details will be made more intimate, and the illustrations will deal more closely with the actual information needed for layouts and wiring connections. In line with its policy of being a how-to-make-it monthly, RADIO WORLD will give the constructional data down to the very last detail. The treatment will be such as to enable even the novice to build the devices.

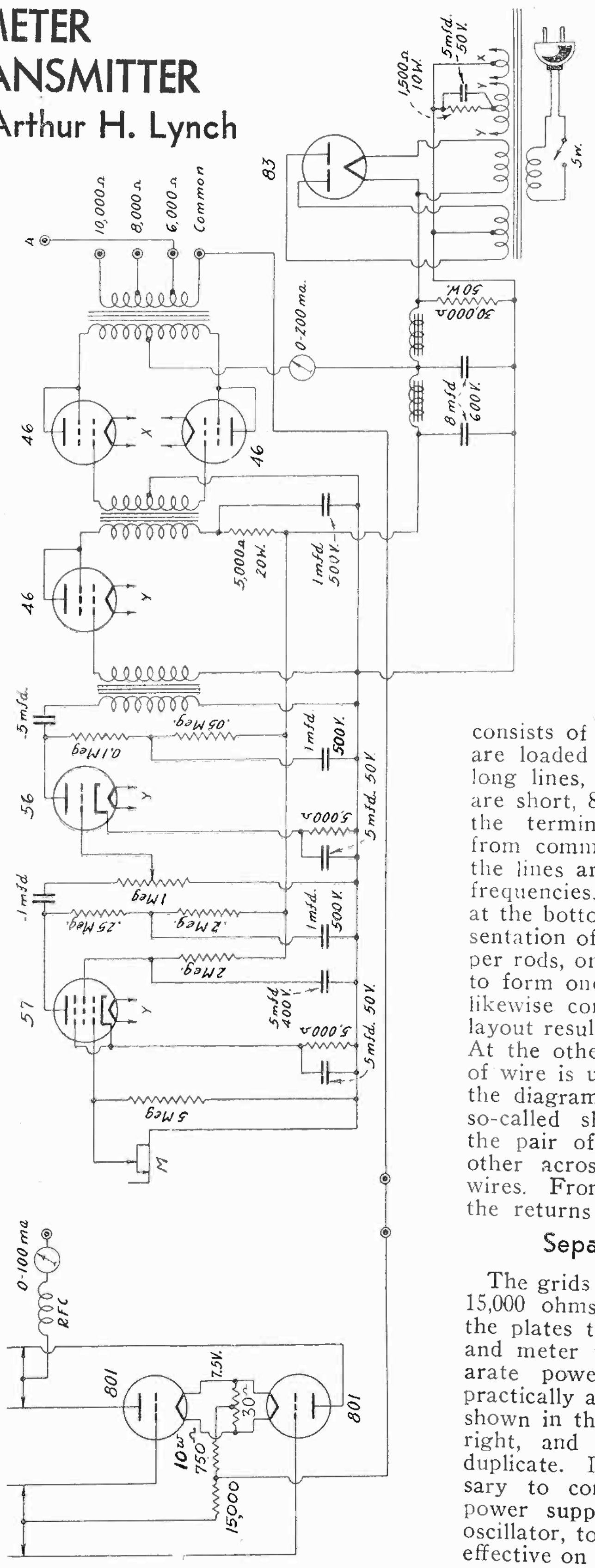
Push Pull 45 T. R. F. Receiver



Wiring connections for the quality tuned radio frequency set.

5-METER TRANSMITTER

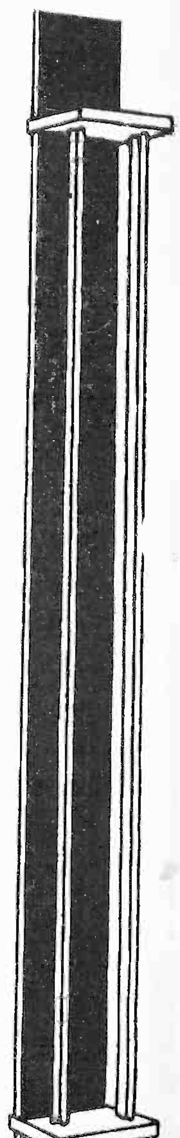
By Arthur H. Lynch



IN the August issue were published data about the 5 meter transmitter operated in the tower of the building of Bank of the Manhattan Trust Company, 40 Wall Street, New York City, almost 1,000 feet above the sidewalk. Last month the historical development of 5 meter activities of the Garden City Radio Club, of which the author is a member, was set forth, and reports of various contacts given, including contacts with other members of the club and with amateurs generally, operating in this range.

The Transmitter Diagram

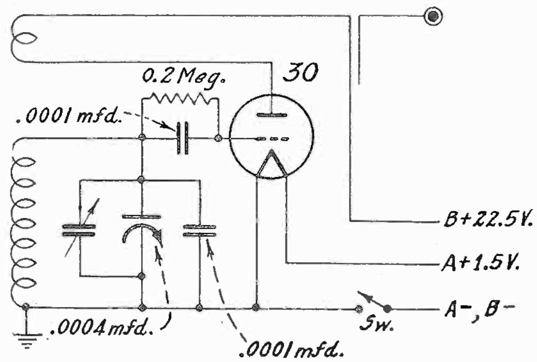
It was promised that the diagram of the transmitter would be given this month, and here it is. If you will turn the page around so you can read it—not a bad idea—you will find that something strange looking is at the left. This is the oscillator. It is a push pull affair and consists of two 801 tubes. They are loaded by what are termed long lines, but in fact the lines are short, 8 feet long or so, and the terminology was acquired from commercial practice where the lines are really long for low frequencies. The blackish object at the bottom is a general representation of the four hollow copper rods, one rod behind another to form one pair, the other pair likewise constituted, the parallel layout resulting. One end is free. At the other end a turn or two of wire is used for coupling. As the diagram suggests, there is a so-called shorting strap across the pair of grid wires and another across the pair of plate wires. From the center of these the returns are made.



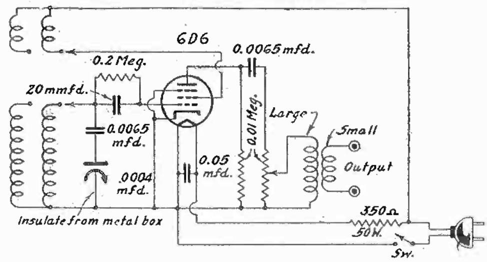
Separate B Supply

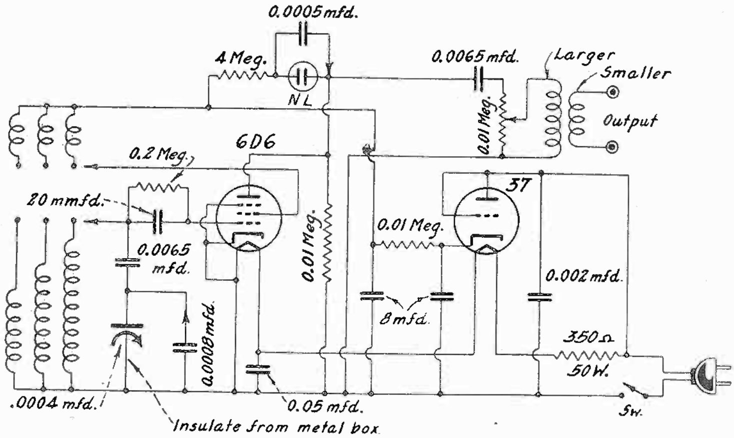
The grids are returned through 15,000 ohms to the minus lead, the plates through an r.f. choke and meter to B plus of a separate power supply, which is practically a duplicate of the one shown in the speech amplifier at right, and may be actually a duplicate. It is, of course, necessary to connect minus of the power supply to minus of the oscillator, to make the B voltage effective on the oscillator.

Signal Generator Circuits



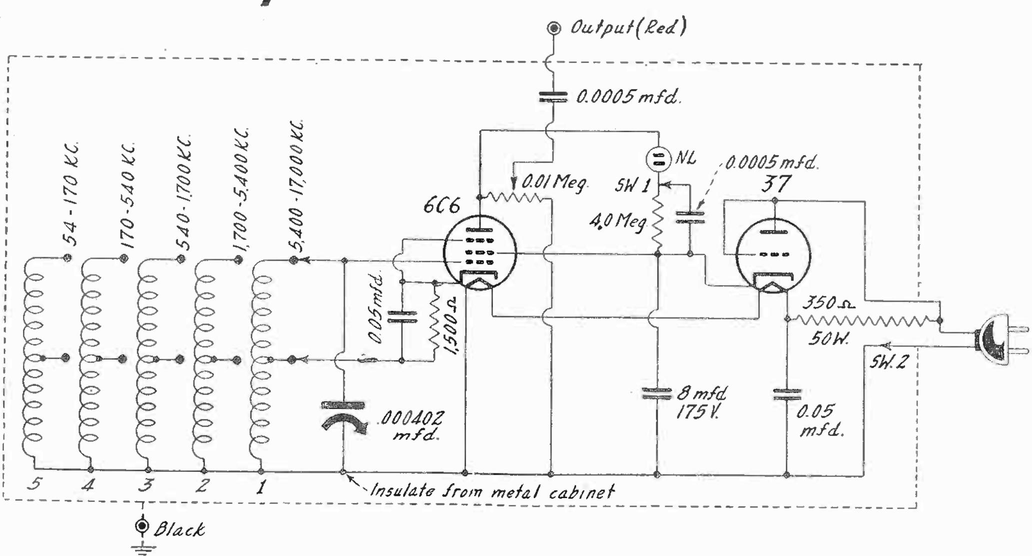
For r.f., 109 to 200 kc, harmonics for 218 to 500 kc.



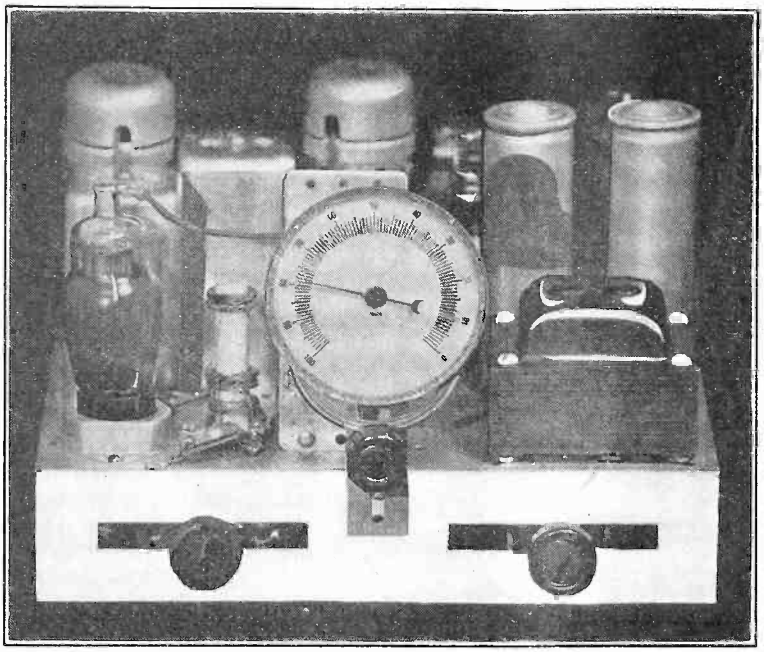


Above is a single tube test oscillator for two fundamental ranges, 140 to 500 kc and 540 to 1,600 kc. There is modulation present on a.c., consisting of the line hum, no modulation on d.c. Electron coupling between generator and output is used, and a coil to protect the receiver from sensitivity control by the generator's attenuator. At left is a three band generator, 1,400 to 5,000 kc added to the previously mentioned ranges, and besides a rectifier tube is included and independent modulation by means of a neon tube relaxation oscillator. This, therefore, has modulation on a.c. or d.c. use.

Hartley Oscillator for Five Bands



The same general ideas as embodied in the two tube generator above are included in this five band model, which uses the Hartley oscillator, identified by the tapped coil, tap to cathode. The frequency calibrated dials applicable to these generators require that there be no capacity added across the tuning condenser in the five band model, none for the one tube a.c. model, none for the two tube model, except the .0008 mfd. switched across for special bandspread purposes, 83 to 200 kc and 830 to 2000 kc.



Note the coil placed atop chassis in view above. At right, underneath view.

Results from Few Parts

Attained in Five Tube, Two Band Receiver

By Jack Goldstein

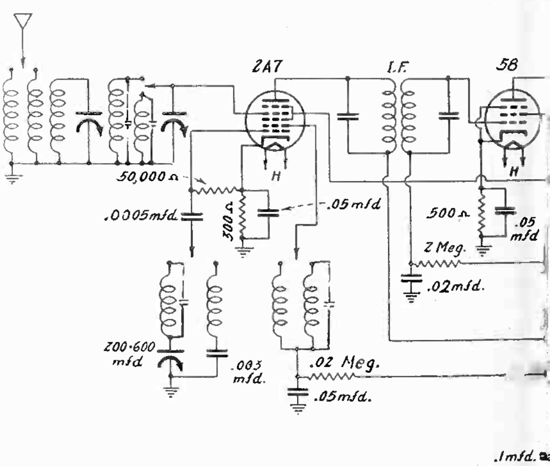
THERE are all kinds of extremes in radio. Some persons want to build receivers with a multitude of tubes and tuned circuits regardless of cost. Others want to build receivers with a minimum of tubes and tuners for a price as low as possible. Some persons want to build receivers with a terrific output, while others are content with just a little sound power. Some builders want all wave reception regardless of whether there is anything to be received on most of the waves or not, whereas others are satisfied with standard broadcast reception only.

The receiver is a dual band superheterodyne operating only on a.c. That is a kind of compromise among the many extremes. It tunes to the entire broadcast band and to the European band in addition. These two bands contain the most interesting signals, and the only signals that have any interest to a large number of radio fans. From this point of view it is an economical receiver.

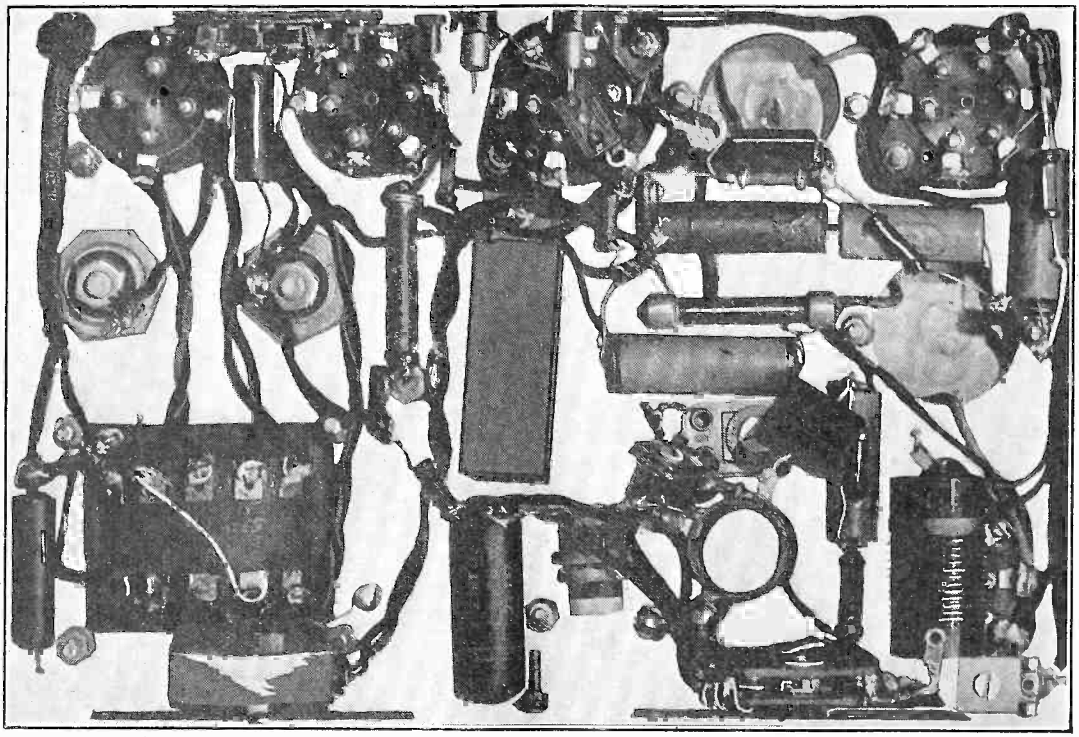
It is a superheterodyne provided with automatic volume control. Thus it is exceptionally selective and the intensity of the signals does not vary much as distant signals fade in and out. It has only one intermediate amplifier, with two r.f. transformers. More are not necessary even to receive the European stations. No more parts are used than needed.

It is axiomatic in radio that there should be high selectivity in the radio frequency level in order to eliminate images. But this does not mean that there should be a stage of radio frequency amplification when this is not needed to give the desired sensitivity. The same r.f. selectivity can be obtained with a band pass tuner in front of the mixer tube. Indeed, it can be done better this way than with a plain tuner and a radio frequency amplifier, because the band pass tuner excludes that which should be excluded and

(*Continued on page* 36)



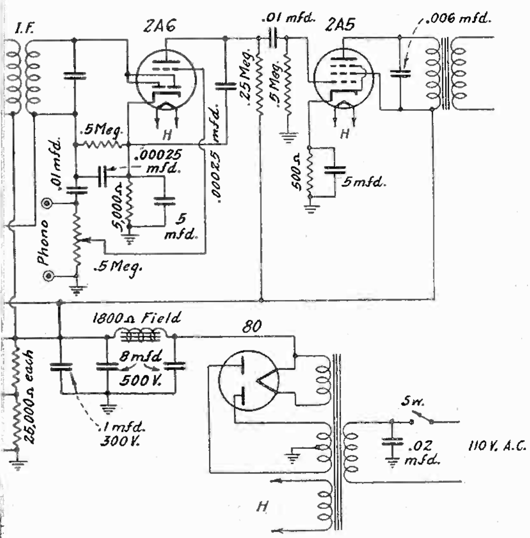
A two band set for standard broadcast and forei
The trimmers across r.f. and oscillator coils are
the trimmer is acro



LIST OF PARTS

Coils

e broadcast oscillator coil
e band pass broadcast radio frequency selector
e short wave oscillator coil
e short wave band pass radio frequency selector



eception (530 to 1,600, also 5,300 to 16,000 kc). table, 3 to 30 mmfd. On the short wave band oscillator tickler.

Two doubly tuned 456 kc intermediate frequency transformers
One five inch loudspeaker with an 1,800 ohm field coil
One power transformer

Condensers

Four small trimmers
One three gang, 365 mmfd. for tuning
One 200-600 mmfd. pad
One fixed .003 mfd. mica pad
One .00005 mfd. mica.
Two .00025 mfd. mica
Two .01 mfd.
One .006 mfd.
Two .02 mfd.
Three .05 mfd.
Two .1 mfd.
One dual 5 mfd., 35 volt electrolytic
Two 8 mfd., 500 volt electrolytic

Resistors

One 300 ohm
Two 500 ohm
One 5,000 ohm
One 20,000 ohm
Two 25,000 ohm
One 50,000 ohm
One 0.25 meg.
Two .5 meg.
One 2 meg.
One .5 meg. potentiometer with a.c. switch

Other Requirements

One wave changing switch
Six wafer type sockets (one for speaker)
Three tube shields
Three grid clips
Three control knobs
One 3 inch airplane dial
One line cord and plug
One chassis, 2x6½x10 inches
One phone jack twin

(Continued from preceding page)

does not recreate that which it is supposed to exclude. There is economy in this—namely, the omission of a tube that is not essential and the contribution of which would have to be thrown away by means of the manual and automatic volume controls.

The receiver has two stages of audio. The first is the high voltage gain amplifier in the 2A6 and the second is the high power gain amplifier in the final stage, the 2A5 power pentode. The gain in these two tubes is enormous, yet long before the triode of the 2A6 is overloaded, the 2A5s get a signal voltage that loads it up to the permissible limit, and that limit is considerably higher than one would care to tolerate in any home. Therefore the audio gain and volume are ample for all reasonable demands. To put in more gain and more output capability would mean a deviation from the central theme of economy.

Selectivity Example

We have spoken of high selectivity and sensitivity in general terms. Specific mention will have more significance. In respect to selectivity, WOR, a very strong local station on 710 kc was tuned in and there was not the slightest interference from WLW, a superpower station operating on 700 kc a few hundred miles away. Then the 700 kc station was tuned in and there was no interference from the 710 kc station. This is about the severest kind of test to which a receiver can be subjected in this locality, in fact in practically any locality.

In respect to sensitivity on the broadcast band, it may be said that there is a strong signal on nearly every division on the dial. Some of those signals have come a long way before they reach the receiver, a very long way indeed. No elaborate antenna was used in these tests either. On the contrary, the antenna was a poor one, for it violated most of the sacred "thou shalt nots" in antenna construction. This antenna was purposely selected for it gave the set a keener test.

On the subject of sensitivity on the European band, when the signals from Europe are on the air and the set is tuned to them, there is quite a stir in the loudspeaker. They are strong and clear under reasonably favorable reception conditions. We would be tempted to say that we could understand every word of it if it were not for the fact we are no linguists. The strict truth is that we hardly understand a word of the signals, unless they happen to come from Great Britain. But the music is enjoyable from all.

Short Wave Results

Even on the short wave band the receiver is selective, for it has no difficulty separating the stations in the 49 meter band although there is great crowding there. A slow motion lin'age between the tuning knob and the condenser makes precise tuning a simple operation.

Band pass tuning is not used in the high frequency band because it is neither practical nor necessary. Two high Q coils, however, are used, and these are unshielded and placed at right angles. Both are placed under the chassis where all the leads can be made very short.

As a means for reducing the coupling between the oscillator and r.f. coils in the broadcast band, the band pass selector is placed on top of the chassis whereas the oscillator coil is placed under it.

Europeans Clamor for Our Dance Tunes, Says Royal

John F. Royal, vice-president of the National Broadcasting Company, in charge of programs, recently returned from a visit to seventeen European countries, in which he made a particular study of program types, popularity and methods. He didn't find the United States eclipsed abroad in any radio particular, but he did find great short wave activity with the transmission purpose the attainment of good will in foreign lands, also the conveyance of programs to nationals sojourning under foreign flags.

"Every country I visited is radio-conscious to an amazing extent," he said. "In Germany they are broadcasting to the world twenty-four hours a day. This is propaganda. They make no bones about it. In many parts of the country I found 'listening posts' where as many as 2,000 Germans are gathered around a single set. Russia is broadcasting to the world. England is doing a marvelous job.

"Every foreign country wants a North and South American audience and I predict that within the next eighteen months, we will see the greatest program competition in the history of entertainment. By that time all the European countries will be equipped for short wave sending and receiving apparatus and, with the further improvement of long and short wave receiving sets, every radio listener will have the world in his living room!"

How do American programs stack up against those in foreign lands?

"I say, modestly, we have nothing to be ashamed of in this country. Generally speaking, I didn't find them doing anything any better abroad than we are doing it here."

One of the reasons for Mr. Royal's tour was to better the "balance of trade" in international programs. Last year for about 350 programs rebroadcast by NBC from Europe there were only 45 programs sent from NBC to the other side. The numbers will be far more even in the future, Royal said confidently. He reported great popular favor for American dance tunes.

Is Television Really as Good as This?

By L. W. Wheaton

(*Wide World*)

Here is the setup for reception of television by the German Telefunken method, using a cathode ray oscilloscope tube, but whether the picture of the Canadian Maple Leaf hockey player posed on the screen is a real television result, or just one of thos e things, is a question. Close inspection of the original photograph prompts the belief that the picture shown as if true television is a retouched photograph, as even clouds could be seen in the background, and the player's shadow is unbelievably deep.

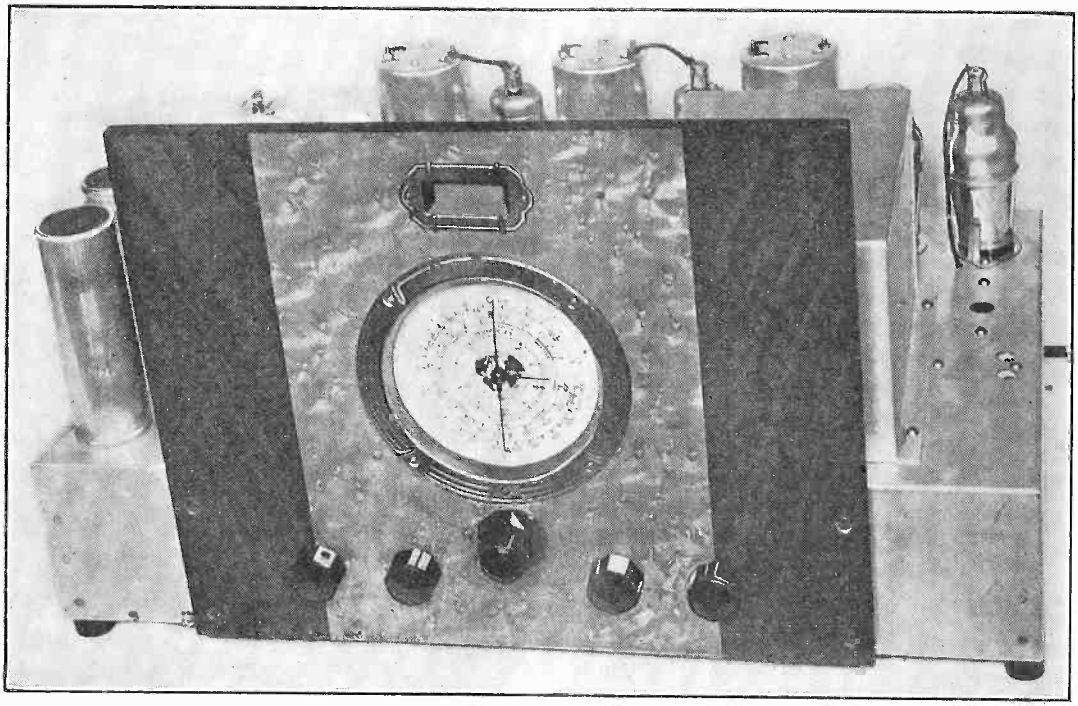
GERMANY is making progress in television, but more progress in propaganda concerning television. The photograph herewith was released through a French source and on the back pasted a caption in French, setting forth that this was a view of the television studio of Telefunken, which is the German television company, with employe sitting before the amplifier. It was stated that both sight and sound were received. Wide World Photos was RADIO WORLD's medium for obtaining the photograph for reproduction in this magazine.

On what seems to be intended to represent the screen of an oscilloscope tube appears a picture of a hockey player, identifiable in the original photograph, from the breast insignia, as a Maple Leaf player. Thus the German television science is illustrated in a studio picture representing a Canadian player and the picture is distributed through French channels to an agency for circulation in other countries.

From the reproduction herewith it can be seen that the hockey player is plainer than the observer's face, thus creating the impression that the television reproduction is clearer than the original. Allowing for camera focused on the screen rather than on the observer, which would explain this difference in definition, what seem to be clouds are observed behind the hockey player on the original photograph, although this detail is lost in the reproduction shown herewith.

The "High" 12, with High Fidelity, High Gain and High Power Output

By Samuel Miller



A frequency calibrated dial is used on this 12 tube high fidelity receiver. The driving mechanism has a planetary system of gears associated with it, so that two ratios are available, fast and slow. The small pointer on the dial moves 18 times for 180 degree rotation of the frequency indicating double pointer. Hence the small pointer is for bandspread. At top is the tuning meter escutcheon and screen.

HERE is the front view of a 12 tube all wave set, showing that the mechanical layout has been taken care of judiciously, and that there are enough controls to enable full attainment of the receiver's utmost capabilities. Since there is automatic volume control, a tuning meter is included, and this is actuated by a separate tube voltmeter that makes the visual indicator perform consistently, without reference to the quantity of sound heard, since the tuning meter is controlled by the a.v.c. circuit.

To the right is shown a shield behind the front panel, and this shield or can contains the coil system, which was specially designed by me for this receiver. The details for construction of the coils is given elsewhere in the text, and also there is an illustration showing how the coils are placed so that the shield, which has separated walls, fits nicely over the inductances.

The tubes and their quantity were selected on the basis of maximum performance for an output of around 15 watts, the final push pull tubes being 42's operated as a sort of cross between pentode and triode, due to relatively low screen voltage. These tubes are driven by a 42 tied in as a triode, so that there is ample power, as well as voltage, to drive the final stage.

The rear view shows the coil shield at left, with the tubes associated with this system, comprising a 6D6, a 6C6 and a 76. The 6D6 is the radio frequency amplifier, the 6C6 is the modulator, while the 76 is the separate local oscillator.

Next, toward the right, come the two intermediate frequency amplifier tubes, both 6D6's, necessitating three intermediate coils. These are peaked at 460 kc. The second detector is a 76 tied in as a diode, and is therefore non-overloadable, since it will stand up to 100 volts and a few milliamperes of rectified current. Another 76 is the first audio amplifier, and, as stated, the driver is a 42 triode, and the output push pull

42's, so there are three stages of audio frequency amplification.

The three electrolytic condensers, the power transformer and the three gang tuning condenser are plainly in view in the photograph on this page.

As Seen From Underneath

Looking at the scene as revealed underneath the chassis, note that the wiring has been neatly done, that the coil switch has shield partitions between sections, and that the trimmers are placed beween these sections. As already intimated, the coils proper are atop the chassis, and the leads from the switch tabs and indices are brought to lugs located on the coil forms. The antenna connecting wire is shielded and the shield grounded, as shown at left, while one of the B chokes and the push pull interstage transformer are at right.

The output transformer is built into the dynamic speaker, which is of the high fidelity type, the speaker leads being connected to the receiver through a plug that fits into the socket at rear of the chassis, as previously shown.

Disposition of the sockets for the tubes was made on the basis of minimum distances for running leads, although the objective of leaving plenty of room, thus avoiding crowding and consequent stray coupling troubles, was always kept in mind during the three months devoted to the engineering of this receiver.

How Coils Were Designed

Soft rubber feet are adhered to the chassis bottom to take up any vibration that might be introduced acoustically when the receiver is worked at tremendous volume, and this cushioning gives a sort of "floating chassis" effect.

When the receiver was being designed first attention was paid to the coil system. An intermediate amplifier was set up and the coils were made experimentally many times before they were of exactly the right inductance. Then it became possible to proceed confidently with the rest of the receiver, and the bugs were ironed out as they were discovered, until finally the receiver was of such high caliber that even practiced radio men, rather cold to receivers in general, became enthusiastic. After the circuit's performance had met with this praise a dial was calibrated in frequencies so that direct reading of stations' waves could be enjoyed. Four bands are covered, beginning with the X band, 140 kc as low terminal, and ending with the C Band, at 18 mgc.

To accomplish this coverage honeycomb coils were used for the low frequencies and broadcast band, solenoids for the rest, the disposition of

(*Continued on next page*)

Antenna and ground posts are at left in this rear view, the twin assembly for phonograph or other separate audio input is in the center, and besides there are the inlet for the a.c. cable and the socket for the speaker plug. The hood of the Readrite tuning meter is shown against the rear of the front panel.

(*Continued from preceding page*)

coils on the form being such as to avoid the presence of deadspots.

Special Biasing

As the technical features will probably be of greatest interest to readers these will be set forth as they come to mind.

It will be noticed that a special biasing system is used. On the highest frequency band the bias on the first tube is fixed, and is as low as consistent with the permissible plate and screen currents.

The reason is that noise is held down by this method and sensitivity is made high where needed. The tendency of sets to lose sensitivity at the high radio frequencies is well appreciated by technicians, and this is one way of introducing a remedy.

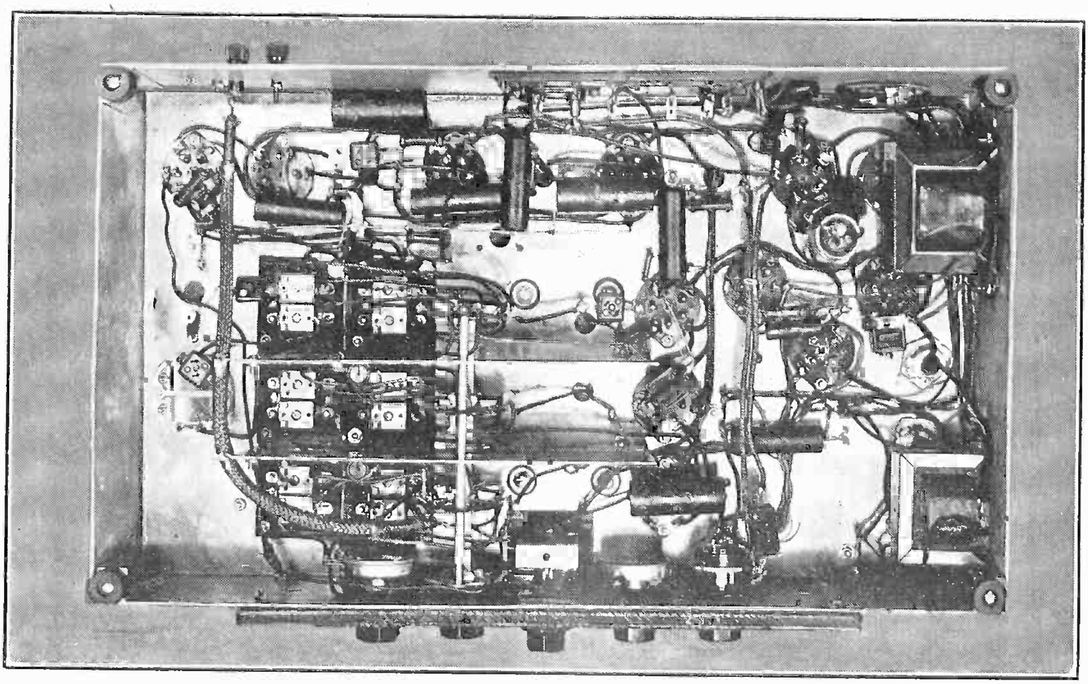
The sensitivity control, when turned, therefore does not affect this tube. The switch XABC under the first 6D6, at left, is then at the C position. For all other bands the biasing system associated with the intermediate amplifier tubes is used, and this brings into play the 12,000 ohm rheostat just to the right of the 6C6 tube voltmeter, between the 76 local oscillator and the 5Z3 rectifier in the circuit diagram.

The Other Controls

Besides the gain control at the r.f. and i.f. levels for three of the four bands, there are a tone control and an audio gain control, effective on all bands.

Insight Into Technical Features

The coil system has been alluded to, and it should be said that the series padding condensers are fixed for the short wave bands, a combination of fixed and variable in parallel connection for the broadcast band and wholly adjustable for the low frequency band. These condensers are associated with the oscillator. The parallel padders are used at low capacity settings, the coils being designed consistent with that intention, so that there will be little spring tension on the compression type trimmers, and their settings stay put much better than if tight settings were adopted.



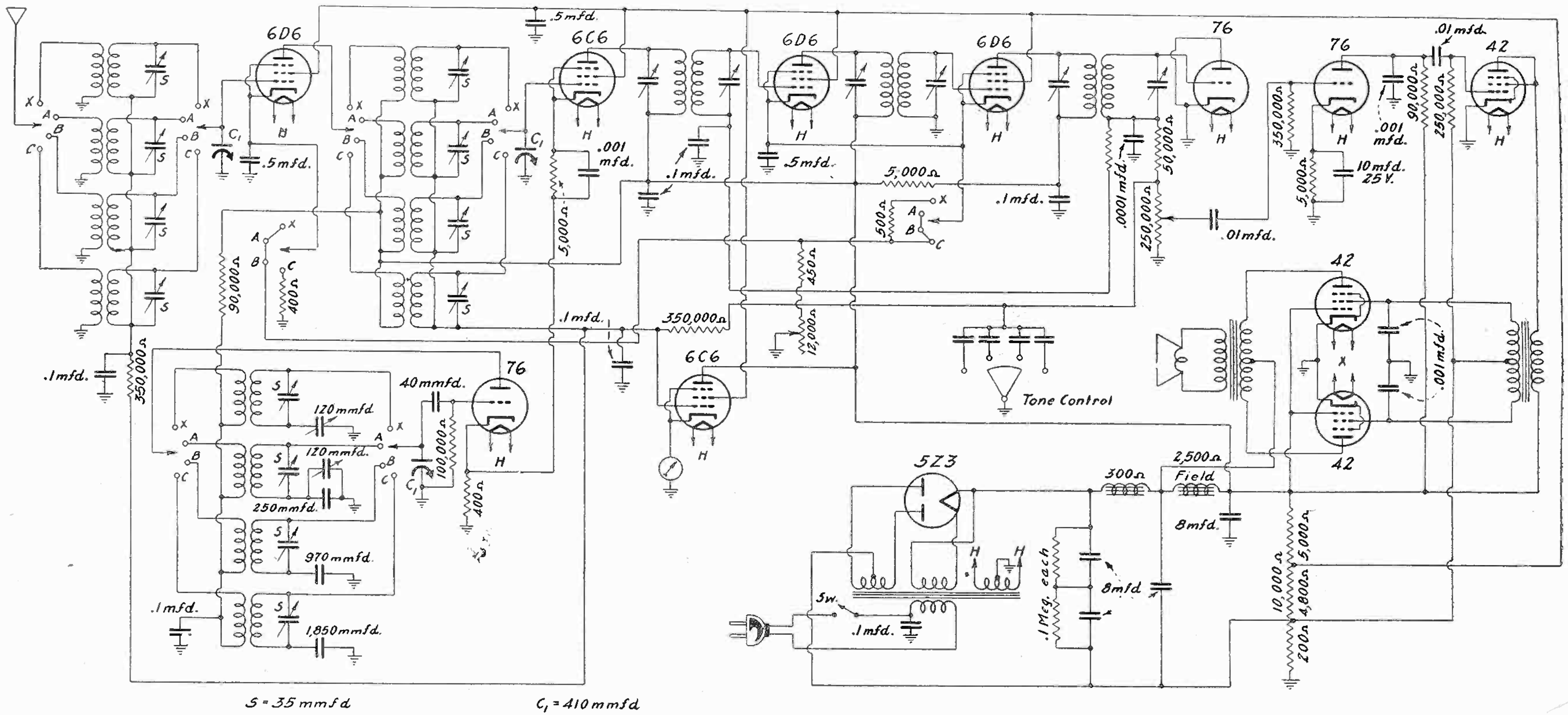
The bottom view confirms the fact that exceptional care was taken in the construction of this receiver. Note the utter absence of tuning coils from the bottom view. Actually the coils are in a compartment shield directly above the parallel trimming condensers that are shown within the walled compartments of the coil switch.

Regulation Given Attention

As highest plate voltage is needed for the power tubes, the only choke between them and the rectifier is one having a d.c. resistance of about 300 ohms, a value low enough to support fairly good regulation, that is, the actual voltage applied to the output tubes does not change much as the receiver operation, due to station strength and volume level, changes the current through the B rectifier. The regulation is sup-

(*Continued on page 42*)

HERE'S THE 12 TUBE CIRCUIT RESULTING FROM THREE MONTHS OF EXPERIMENTING



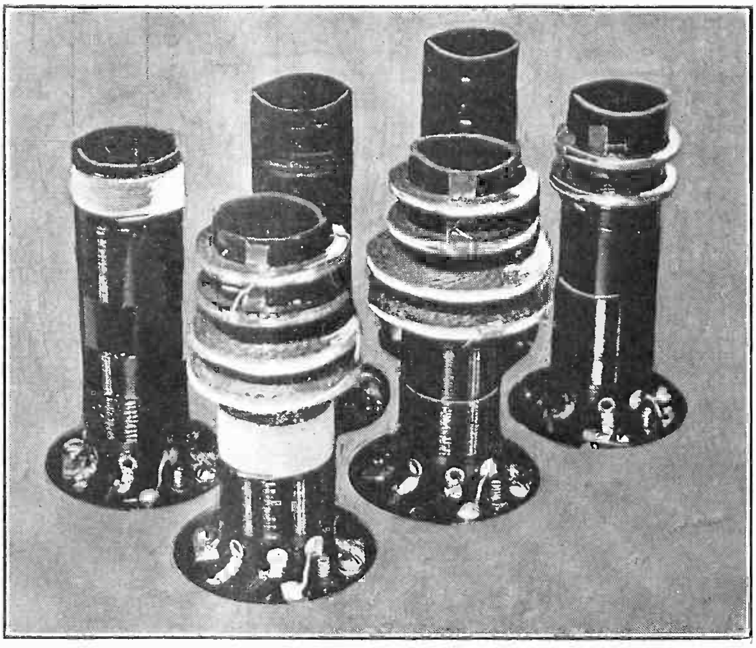
The circuit diagram reveals the values of the constants, save in the instance of the tone control, which is a Philcomatic. The trimmers, S, are 45 mmfd. maximum, but are used quite close to their minimum capacity, which is around 10 mmfd. The interstage push pull transformer has a stepdown ratio, primary to secondary, with low resistance secondary winding, as some power may have to be supplied to the output tubes when tremendous volume is being enjoyed.

(*Continued from page* 40)
ported by bleeder resistors of 10,000 ohms total. The speaker field, resistance 2,500 ohms, provides additional filtration, but this is applied to the power tubes, and besides aids in dropping the voltage to the lower values required for r.f., i.f. and oscillator.

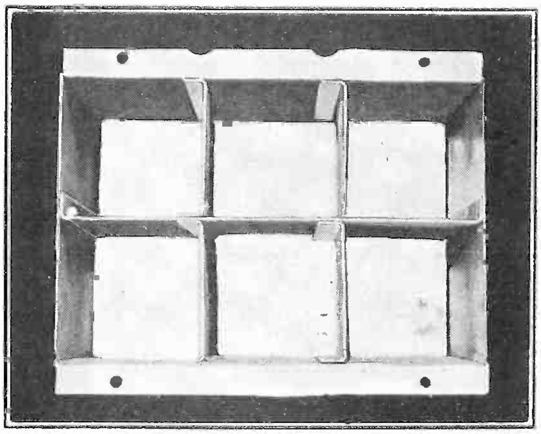
The speaker used has a 12 inch outside diameter cone frame, and of course requires suitable baffling so that the tone will be splendid This baffling may be provided in a separate speaker housing or in a console.

Performance Report

As to performance, this was judged principally on the basis of laboratory standards, using a signal generator and other measuring equipment, but as an additional precaution the receiver was tried out at the author's home, and it performed up to expectations. The usual foreign stations were tuned in with ease and dependability. One of the prime tests is that the G string and the German outlets be brought in with volume at all times, and this actually materialized. As for the unusual type of reception, wherein very weak stations greatly distant are heard, this depends very much on the conditions of the ether, and, being therefore independent of the receiver, but more closely related to the antenna, and most closely to meteorological state, there is no need to give this special mention. What was done also was to test the receiver beside one of known capabilities, manufactured by an illustrious concern, and the present model outperformed it, as there was the expected difference between a specially engineered product and a sample from a production run. This is no reflection on the other receiver, since for quantity and



The low frequency coil, for the X band, are honeycombs, and are wound in pie fashion, that is, separate windings are joined together. This reduces the distributed capacity. The rest of the coils are solenoids. Directions for winding the solenoids are given at the right.



Bottom view of the six-compartment shield that covers the coils.

Band	*Coil*	*Turns*	*Wire*
A	Osc. Pri.	78	#32 E.
A	Osc. Sec.	40	#32 E.
A	Ant. Sec.	104	#34 E.
A	Ant. Pri.	22	#30 DC
A	R.F. Sec.	104	#34 E.
A	R.F. Pri.	40	#32 E.
B	Osc. Sec.	28½	#24 E.
B	Osc. Pri.	14	#30 DC
B	Ant. Sec.	29	#25 E.
B	Ant. Pri.	26	#30 DC
B	R.F. Sec.	29	#25 E.
B	R.F. Pri.	55	#32 E.
C	Osc. Sec.	8½	#24 E Double Spaced
C	Osc. Pri.	5	#30 DC
C	Ant. Sec.	9½	#24 E. Double Spaced
C	Ant. Pri.	28	#29 E.
C	R.F. Sec.	9½	#24 E. Double Spaced
C	R.F. Pri.	38	#32 E.

Tubing 1 inch outside diameter 3¼ long.
E represents enamel covering.
DC represents double cotton covering.
Chassis 19" long, 11" wide, 3" high.
Coil shield 6½" long, 4½" wide, 4¼" high, divided into six equal parts.

price considerations it is the author's confession he could have done no better than the illustrious manufacturer, and perhaps not as well.

What did receive considerable attention was the stability of the oscillator. It is most annoying to have stations creep away from you, as it were, and particularly because there is a vicious form of distortion that accompanies such drifting. The series resistor in the separate local oscillator's plate leg helps a great deal to establish frequency stability, and it was possible even at the highest frequencies also to repeat reception at exactly the same dial points, further indicative of realism of stability. As another important consideration, one that the experienced radioist would take for granted in a good set, the image suppression is of a high order. To the uninitiated it might be said this is simply another form of guaranteeing the reception of only one station at a time and of reducing noise and other interference.

It can be said confidently that the set is quieter than could be reasonably expected, on all bands save the X band, on which all receivers are inclined to be noisy, as there is usually a heavy dose of static on this band. However, for weather reports and other similar listening of special purpose, this static can be endured. At least it has to be.

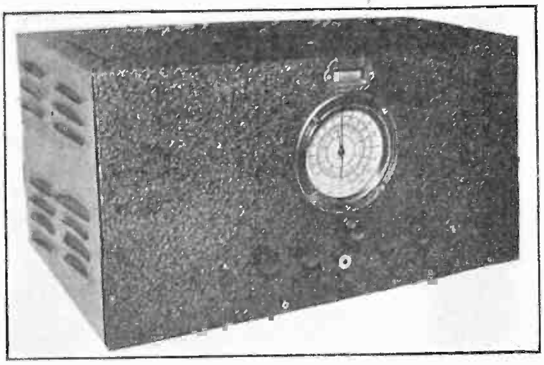
Requires Some Skill

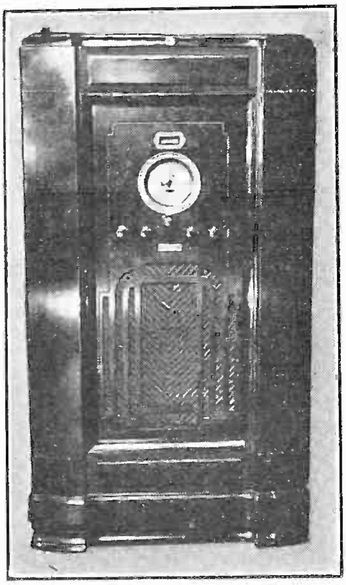
In conclusion, the author desires to state that to construct this receiver properly will require considerable pains and some skill, but that after the parts are properly placed and wired, if the coils are wound as specified, and the padding capacities duplicated, the lining up will be simple and effective.

The Two Styles of Cabinets

The receiver shown in the crinkle finished metal cabinet is intended for operation with external speaker, but of course, the console has speaker built in. The console method is a compromise for popular necessity. The table model is for laboratory and similar professional purposes, and may be used with baffles of very large dimensions. It is well to support any semi-soft baffle material with a backing of hardwood, 1 inch thick, as strong low note radiation finds full support only from material of strength.

The .001 mfd. condensers across the secondary of the push pull input transformer are necessary for prevention of radio frequency feed to the r.f. and i.f. amplifiers, which might result from the antenna effect of the speaker cable.





At left is shown the table model cabinet housing the receiver. This would be used for professional purposes, with an external speaker that has more abundant baffling than can be attained in a console model, as shown at right, which is for family use.

LITERATURE WANTED

Readers whose name and addresses are printed herewith desire trade literature on parts and apparatus for use in radio construction. Readers desiring their names and addresses listed should send their request on postcard or in letter to Literature Editor, Radio World, 145 West Forty-fifth Street, New York, N. Y.

W. Iger, 503 Grand St., Brooklyn, N. Y.
R.R.R. Quinto, Aptdo 4, Baracoa, Ote, Cuba
Richard L. Kile, Woodbourne, N. Y.
Lloyd G. La Bagh, Divines Corners, N. Y.
Herbert Davis, 11 Terrace St., Warren, Pa.
J. Norman Beck, 738 Murray Street, Elizabeth, N. J.
Bernard H. Daetera, 402 Front St., St. Paul, Minn.
E. H. Dorff, 1080 Genesee St., Buffalo, N. Y.
W. Newcomb, A.Ad.N. Radio Service, 596 Ellice 37443, Winnipeg, Can.
John T. Bailey, 1812 - 1st Ave., So., Apt. 108, Minneapolis, Minn.
Gordon Northrup, 342 Forest Ave., Winnetka, Ill.
Charles Young, 125 Harrison St., East Orange, N. J.
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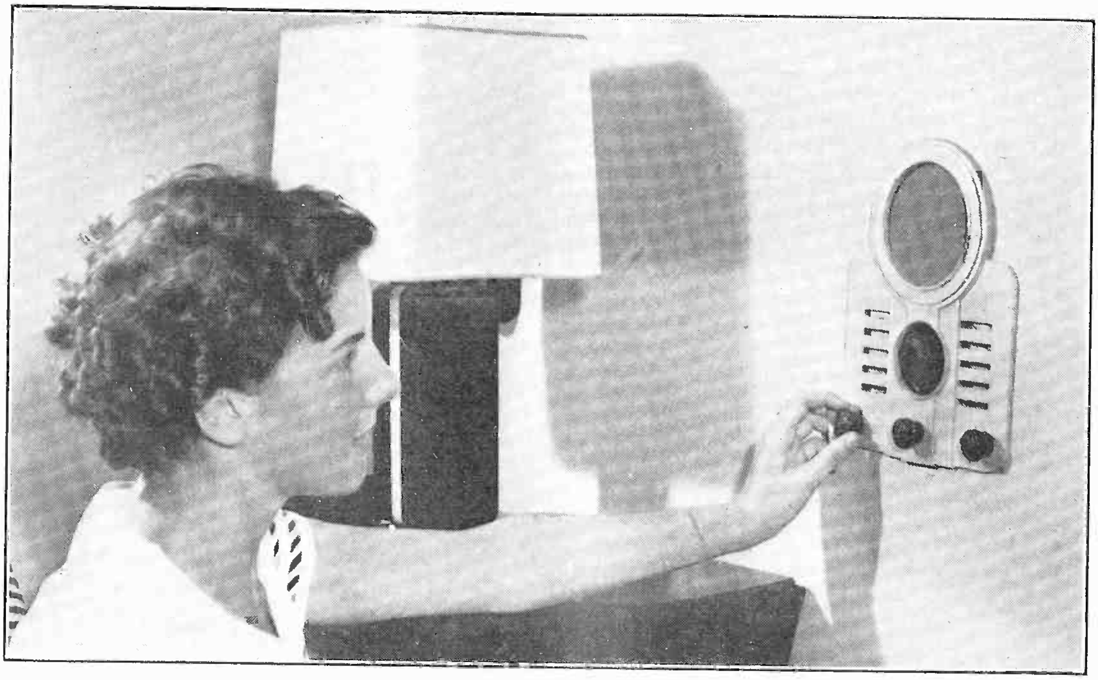
T. J. Wilson, 150 Nottingham St., Plymouth, Penna.
W. L. Stoddart, 633 No. Oxford Ave., Los Angeles, Calif.
Earl Meyer, Carleton, Mich.
Henry Bielecki, 411 E. 5th Street, New York City
Don Green, Radio Technician, 3620 Watseka Ave., Palms Station, Los Angeles, Calif.
Melvin Youngman, 830 S. Austin Blvd., Oak Park, Ill.
Albion Electric Co., Ward M. Jensen, Albion, Mich.
Fred Shanley, 3055 Gough St., San Francisco, Calif.

Insight into Radio for Laymen

Simple Explanation of Transmission and Reception

By Herbert E. Hayden



Andrew Halbran

Tuning is the process of selecting the desired station, usually accomplished by turning ganged variable condensers that are across coils. Fixed tuning, at a separate frequency level, is also present in many receivers, called superheterodynes. It is the creation of selectivity by coils and condensers that makes tuning possible. The girl in the photograph is tuning a new type of set, one that is built into the wall of the home, so that even a small speaker acquires the effects of a large one, due to the large sound radiation, or baffling, by the wall.

WHAT is the most important fact that a person should know about radio? Is it Ohm's law? Is it tuning? Is it the ether? Is it a full appreciation of what electricity is?

No, the most important single fact to know about radio is that alternating current of high frequency is used as a means of transmitting and receiving intelligence, using a carrier that needs no wires between sending and receiving location. Therefore the fundamental facts are:

(1). That alterating current is used.

(2). That intelligence is communicated by an impression made on this alternating current.

(3). That the system requires a carrier.

(4). That the medium through which the carrier travels is the ether.

What Is Electricity?

Since alternating current is electrical current, as distinguished from air currents and water currents, it would be nice in addition to know what electricity is. Unfortunately, that information can not be given at this time, not for lack of space, but for lack of a knowledge of what electricity is. Nobody knows just what it is, or, if he knows, hasn't spoken about it. All we know about electricity is from its manifestations and behavior. Nobody has ever seen it, probably nobody has ever felt it. What we have seen and felt are its effects.

The ether is in the same category. What it is we know not. It seems obvious from elementary physics that if something originates at one place and reaches another place that a movement must have occurred, and all we can appreciate in the present state of our knowledge is that movement has to have a medium in which it can take place. That is, there can not be something in nothing. (Note: Vacuum is not nothing.)

What Is the Ether?

The medium for the conducting of radio waves in space we call the ether. We do not mean the air when we speak of the ether, for all the air may be removed, as most of it is removed from a radio tube, and the conduction is if anything better. When we speak of the ether we know what we do not mean better than what we do mean.

So, like electricity, the ether must remain for a while something we freely speak about though we do not know what it is, a course of conduct not dissociated from human frailty through the ages.

Therefore the most important thing to know about radio is, what radio is.

In connection with the practical use of radio we ought to have an idea of what goes on.

The Production of the Wave

If we are to have an alternating current wave sent out through space—our friendly ether—we must produce that wave. Until the vacuum tube was invented, or rather its use for the purpose of generation of waves, it was impossible efficiently to generate a radio wave, and virtually impossible to carry on speech and music communication by radio. Dots and dashes were sent, these representing letters, spaces, abbreviations, etc., called code.

The vacuum tube is hooked up to produce alternating current waves. For transmitting purposes the tube is made to send out a particular wave, and it is the rule in this country to assign a particular frequency to a station—other than to amateurs, who have bands of frequencies in which to mok—and these frequencies are expressed in kilocycles.

A kilocycle is 1,000 cycles. Actually this is a statement of frequency per second, for cycles or kilocycles, without reference to the period during which they occur, are meaningless. But one second is the universally regarded period. is understood even when not expressed, and only the most highly scientific workers and publications go to the pains of stating that the kilocycles are per second, when they write a frequency of 1,000 kc as 1,000 kc/s.

The Transmitter

Now the vacuum tube that is hooked up so that part of its output is fed back in the right manner to the input, will radiate into an antenna, and the antenna will send the wave into the ether, really help the wave to get into the ether, but the frequency is higher than you can hear. Assume the upper frequency limit of hearing is 15,000 cycles, all radio waves are of higher frequency than that, hence can not be heard. Hence if you stand under the antenna of a transmitting station you can not hear anything the station sends out, although speech and music may be put into studio microphones and mixed with the radio wave, because only frequencies higher than you can hear are actually transmitted.

A transmitting tube will send out a single frequency because the circuit connected with that tube is tuned to that particular frequency. In general, the alternating-current producing tube will generate only one frequency at a time. A wide variety of frequencies may be generated, by tuning over a spectrum of frequencies, as by changing the capacity of a tuning condenser by rotating a shaft, but only one frequency goes out at a time.

Radiation of Radio Wave

Just as sound was radiated, that is, spread out equally in all directions, so is a radio wave radiated, but the velocity of the wave is 186,000 miles a second, as compared with the velocity of sound in air, 1,100 feet a second. Imagine the transmitter as at the hub of a wheel of infinite number of spokes, and the disturbance of the ether traveling in the direction of the spokes, and then imagine enough wheels to make the ensemble look like a ball. Then radiation in all directions would be envisaged.

The electrical constants determine the frequency of the wave sent out, and in the standard broadcast band this frequency would be between 530 and 1,600 kc per second, or, in cycles, 530,000 and 1,600,000 cycles per second. Does something happen more than a million times a second? If so, just what does happen? What can move so fast?

Today a million cycles is a relatively low radio frequency. Much work is being done right now by amateurs and others on 60,000,000 cycles, and in laboratories on waves of hundreds of millions of cycles. Do changes take place hundreds of millions of times per second? Yes, they do, and in circuits that are commonplaces in laboratories today, although not yet of much commercial value.

Exactly the same principle applies to these extraordinary high frequencies, called micro waves, as to the standard broadcast waves.

It is difficult for persons at first to comprehend what is the nature of the "movement" at such great speed. Reversals of positive and negative polarities in some medium take place at these frequencies, and such reversals are inherent in all alternating current. If it is necessary to think of something moving that bears an analogy with mechanical movement, one may say that electrons move at that frequency. We can utilize electricity only by causing movement of electrons, and the activity is electrical because all manifestations of electron action are electrical.

Elevated Above Hearing

Immediately you notice that there are two forms, one above the zero line, the other below the zero line, and each is a counterpart of the other. The top half of the 0 to the left is half a cycle, the lower half of the 0 to the right is the other half cycle. Each of these halves is called an alternation and therefore there are two alternations to each cycle, and a wave of a frequency of 1 consists of two alternations (one positive, other negative), and a wave of a frequency of 1 kc (1,000,000 cycles) has 2,000,000 alternations.

Somewhere in the transmitting circuit the audible sounds produced before the microphone are introduced. Of course when the words are spoken or the song is sung or the music played it can be heard, but after it has been mixed with the radio frequency it can not be heard, for the following reasons: The radio wave itself is too

(*Continued on next page*)

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high in frequency to hear, the audible sounds already have been changed to current pulses that change at an audio frequency rate, but pulses are electricity, and electricity can not be heard, and besides these slow pulses when mixed with the radio frequency carrier simply change the amplitude (voltage) of the carrier. So there exists a radio frequency carrier that has its very rapid alternations or cycles affected by slow changes, but the carrier frequency itself is not changed. The slow changes are called sidebands.

Two Forms of Modulation

Thus does the carrier receive its imprint of intelligence, and the act of putting something on the carrier that can convey meaning is called modulation. Varying the amplitude is one form of modulation, almost universally used. There is another form, that of varying the frequency of the carrier while the carrier amplitude remains constant, and that is called frequency modulation. Except for special uses frequency modulation is generally avoided.

If we trace the audible frequencies from the microphone to the carrier we find that the service performed by the microphone is to receive the sound waves and change them into equivalent current pulsations. This current is known as direct current, first, because just such current is introduced, say, by a small battery, and second, though variations from the microphone are influencing that current, the variations are from the zero axis line upward, never falling below zero. Therefore we call this current pulsating direct current, to distinguish it from steady battery current. By charging a condenser or a coil with this pulsating direct current the change to alternating current can be produced, and is produced in amplifiers that feed the tube that delivers the intensified audio frequencies to the radio frequency carrier.

The Wave In the Ether

While pulsating direct current can not be heard, if we put earphones or speaker in the speech amplifier line, the original can be heard, because the pulsations actuate a diaphragm and this diaphragm disturbs the air just as did the original utterer of the sound. Hence we hear the effects of the pulsating direct current, and this we call reproduction. But listening is not a part of our consideration at this time, since we are producing and modulating a carrier.

Now that we get the wave into the ether we find that to receive it we need first some collecting agency, and this is the antenna, and also a device for selecting the carrier frequency (station) we want, amplifying the carrier, detecting it, amplifying the restored audio frequencies, and reproducing those audible frequencies for our enjoyment.

The antenna is very familiar. It is in general a condenser, really, in that it receives a charge from the wave of the transmitting station. Each condenser must have two plates, or electrodes, and the antenna proper is one of them, the ground being the other. So the carrier wave finds a special medium on which to act, and this is the condenser formed by the antenna and ground. Between these plates the wave oscillates electrically.

When antenna is connected to one terminal of a coil, ground to the other, the alternating current of the carrier appears across the winding, called the primary, and is communicated in elevated form to an adjacent larger winding, called the secondary, which has a variable condenser across it, hence the secondary is tuned. By tuning we mean favoring one frequency. Thus the aim is to discriminate in favor of one frequency and against all others, thus producing selectivity. Hence tuning is the means of producing selectivity.

Actuating the Reproducer

We need several tuned stages to get enough selectivity. After we have enough selectivity and amplification, we detect the carrier, that is, we suppress the carrier and leave only the audio frequencies, called the modulation envelope.

These original audio frequencies are often referred to as audio even when they simply change the radio frequency amplitude, although it must be remembered that in conjunction with the carrier there are simply radio frequencies. When we eliminate the carrier, and retain the imprint or modulation, we perform detection, and by amplifying the detected result, now alternating current of audio frequencies, we finally have brought the amplitude to such a level that we have enough signal voltage to actuate a loudspeaker, better called a reproducer.

From the aerial to the loudspeaker therefore we have a system generally referred to as a receiver. The object of the receiver is to enable us to reproduce in our own locations the sounds as originally put into the microphone. When there is no discrimination in reproduction of the tonal values of the sounds originally uttered we say that the receiver is of the high fidelity type, a new development.

Where Power Is Needed

From the antenna up to the final tube in the receiver (but not including the final tube) we are interested in gaining selectivity and raising the carrier voltage and the audio frequency voltage. We need only to step up the voltage from stage to stage to get enough, but after we have reached that goal we have to introduce a system that permits radiating considerable energy, that is, does work, and to do work power is needed. Power is the time rate of energy. If we want to have a device do a lot of work in shorter time we need more power.

Because therefore something has to be driven, and we need the driving force, we have to use final or output tube or tubes that will accommodate the needs. These are called power tubes. Hence for very loud and far-reaching reproduction with small distortion we use more power than for medium volume and diffusion. So the power output of a receiver is a measure of how much sound can be radiated without distortion. For ordinary home use an output power rating of 5 watts is ample. For an auditorium 50 watts may be required.

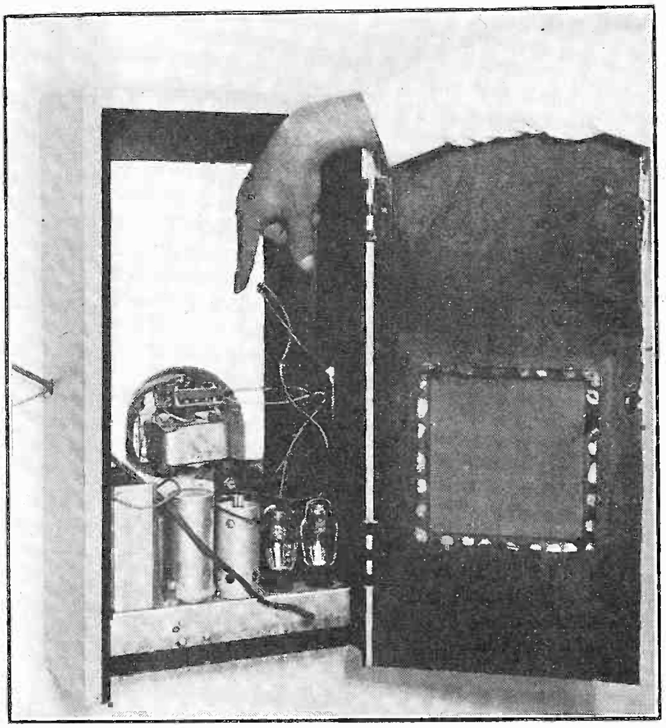
Advantage of Reserve Power

The actual average wattage in use may be much less than cited values. One of the advantages of large power output capability is that even if the receiver is played at room volume, there may occur passages of speech or orchestra when a great deal more than average energy has to be dissipated, otherwise distortion would accompany these sudden surges, hence reserve power is advisable. Ordinary home use of a set is at an average output of 1 watt, approximately, but a 5 watt capability or rating is suitable for the reserve power.

Although a single output tube may be used, a special system, called push pull, uses two tubes, to reduce the distortion of some of the frequencies practically to zero, hence reducing the total percentage distortion. For great power output two pair of push pull tubes may be used, and for amphitheatres and the like four pair may be necessary, all of the tubes large and husky, and requiring very large amounts of power for their own operation (heating the filament and supplying the plate voltage), for the tubes can not reproduce distortionlessly greater power than they receive for their operating necessities.

Law Still Holds

Therefore it must not be imagined that there is anything akin to the reproduction of more than what is put into the set. The sources of A, B and C supply, the socalled terminal voltages, and the currents flowing when those voltages are applied, all have to be considered in the light of what is put into the tubes just to make them well operable. The carrier and the audio frequencies that are put into the tubes from another direction (that is, into different elements of the tubes than those considered for energizing) in no instance are made greater, stronger, louder, etc., at no sacrifice. There is nothing like 100 per cent. efficiency, certainly never more than 100 per cent., which would express perpetual motion. Always what can come out is less than what has been put in. Something for nothing is as far removed from radio as it is from all other branches of science. The law of conservation of energy still holds with adamant vitality.



The receiver picks up the station carrier by means of the antenna connection to the first coil in the set, rejects other carriers, and amplifies the desired one, whereupon detection is introduced, so that the sounds uttered before the microphone are restored in the form of audio frequency pulses, which actuate the speaker. The model's finger points to the small speaker used in the receiver shown in front view on page 44. This picture was taken in a garage on the other side of the wall of a model house on Long Island.

Andrew Halbran

COMPLETE SHIP EQUIPMENT

Eight electro-dynamic loudspeakers, a radiophonic receiver and acoustic intensifiers have been installed on a ship, making it possible to broadcast concert music, news, dispatches, addresses, etc., on all decks. The equipment further makes it possible to broadcast various programs simultaneously in different sections of the ship. A portable microphone, equipped with amplifiers, permits the broadcast of ship concerts, lectures, etc., to particular cabins on various decks. Through portable megaphones passengers may even listen to programs from such places as the sports deck and promenade.

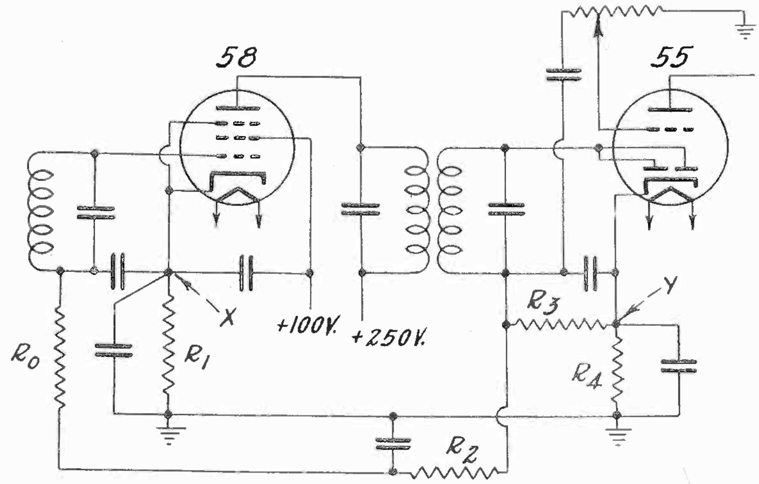
FREQUENCIES COMPARED

If you tap your desk with your pencil fifteen times in fifteen seconds the frequency of tapping is one cycle. Expressed in kilocycles this would be .001 kc. Besides the rapidity with which the striking is done another aspect of frequency arises, and that is, the frequency of the sound produced, which may be 500 cycles per second. That is, once every second a note is struck and that note has a frequency of 500 cycles per second.

Avoiding Mistakes With A. V. C.

Positive Grid Danger and Slow Action Eliminated

By Barclay Forrest



This circuit illustrates a common fault with a.v.c. controlled amplifiers. The point X should be positive with respect to point Y. Frequently it is negative because R_1 is too low.

AN important point that is often overlooked in the design of amplifiers provided with automatic volume control is illustrated in the drawing. The first tube in this circuit operates in a typical setting for automatically controlled amplification. The control grid is returned through the secondary of the input transformer, through the filter resistor R_0, through the blocking resistor R_2, and finally through the load resistance R_3 of the diode detector to the cathode of the 55 tube. A resistance R_1 is placed between the cathode of the 58 and ground to provise bias for the amplifier. Also, a resistor R_4 is connected between the cathode of the 55 tube and ground to provide the bias for the triode section of the 55.

The 58 normally requires a minimum bias of 3 volts; and since the sum of the screen and plate currents of this tube is 11.5 milliamperes, the value of R_1 should be 261 ohms to give the required bias. The usual value is 300 ohms because it is all right to overbias the tube a little and 300 is the nearest available resistor. Yet under certain conditions this value is entirely inadequate, and is so in the circuit illustrated.

The Bias on the 55 Counts

The main difficulty is that the 55 has a negative bias on its control grid amounting to 20 volts. That is, if the grid of the 55 triode is returned to ground, as it is in this case as well as in most practical circuits utilizing this tube for detection and audio amplification, the point Y, or the cathode, must be twenty volts above ground. It is to this point, 20 volts positive with respect to ground, that the grids of the a.v.c. controlled tubes are returned. But the point X, the cathode of the controlled tube, is only 3 volts positive with respect to ground. Therefore the grid of the 58 tube is not negative on no signal, but it is actually positive by 17 volts. Few tubes will function with such a high positive grid bias, and certainly the 58 will not function under such conditions.

A Great Deal of Resistance

It is true that with the positive voltage on the grid of the 58 the screen and plate currents are much higher than the normal value of 11.5 milliamperes so that the drop in R_1 is higher than 3 volts. This makes the actual grid voltage less positive than the 17 volts computed, but still it is positive. Moreover, grid current will flow through the four resistances R_0, R_2, R_3, and R_4, and this current will lower the positive voltage still further. But still the voltage on the grid is positive.

A positive voltage on the grid of the 58 will have two undesirable effects. First, it will lower the selectivity of the tuner connected to the grid drawing current. A concomitant effect is a lowered amplification. Second, the grid current will cause blocking of the grid because of the high resistance between the grid and the cathode.

In this case there are no less than five resistances through which the grid current must flow before it gets back to the cathode, and three of these, and sometimes four, have high values. Often the total resistance intervening between the grid and the cathode is not less than 2 meg. That is sufficient to cause severe blocking even when only a slight amount of grid current flows.

There is a rather simple remedy for the condition. The resistance R_1 must be increased to such a value that when the sum of the screen and plate currents of the 58 amounts to 11.5 milliamperes, the point X is three volts higher above ground than the point Y. If Y is 20 volts above ground, the point Y should be 23 volts above ground. To obtain a drop of 23 volts in R_1 its values should be 2,000 ohms instead of 300 ohms. It is rarely that such a high value is used, yet it is the correct value.

Another way of correcting the condition is to put a variable resistor between R_1 and ground. When such a resistor is used, often for two or more a.v.c. controlled tubes, it is usually called a sensitivity control. It might also be called a selectivity control, for it acts that way too on very weak signals. The fixed resistor serves the purpose just as well and it has the advantage that it diminishes the number of controls in the set.

The 2B7 and 6B7

Sometimes the maximum value of the variable resistor employed is 10,000 to 12,000 ohms. It is not necessary to use such a high value, unless the voltage drop in R_4 is greater than 20 volts. However, in many instances it is advantageous to use a higher value than 2,000 ohms. This is the value for a single tube. If there are two tubes on the bias resistor, the value should be cut in half for the same effect. If there are three similar tubes on the bias resistor, an appropriate value would be from 600 to 750 ohms, preferably the higher value.

In case the rectifier tube is a 2B7 (or 6B7) instead of a 55, the same principles apply, but not to the same degree. The proper grid bias for the amplifier in the 2B7 might be 3 volts. Therefore the point Y would be only 3 volts above ground. Therefore the point X should be only 6 volts above ground, which would be obtained, approximately, by using a 600 ohm bias resistor instead of one of 300 ohms.

The 85 tube is treated in the same manner as the 55 because it requires a high bias on the triode. The 75 and the 2A6 are treated more like the 2B7 for they require low bias. In any case the point Y, the cathode of the rectifier-amplifier, must be three volts negative with respect to point X, provided that the a.v.c controlled tube requires a negative bias of three volts.

Methods for Avoiding Trouble

The use of a value for R_1 does not prevent operation of the circuit, because on strong signals the voltage developed across the load resistance R_3 will make the controlled grids negative. The main effects occur on no signal or on very weak signals. When the circuit blocks in the intermediate amplifier the cause may well be grid current due to positive bias on the grid because of insufficent resistance in R_1, and conjointly too much resistance between the grid of the tube and the point X.

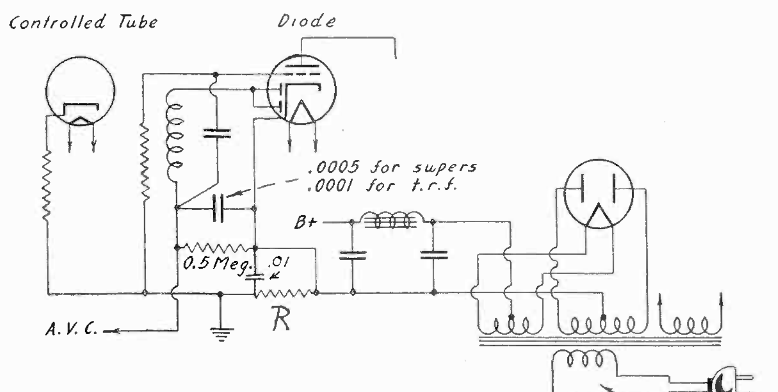
Still another way of avoiding the difficulty of positive bias on the a.v.c controlled tube or tubes when the detector triode requires a high negative bias is to provide this bias by some other means. Practically it may be provided by a resistor in the negative leg of the power supply circuit, so placed that all the current drawn by the receiver flows through it yet so that it is thoroughly filtered. That is, it should be placed between the ground connection and the point to which the filter condensers are connected to the negative side of the circuit.

The Separate Rectifier

An even better way is to provide the bias by a separate rectifier and filter that supplies the bias for all the tubes in the circuit, especially those that require a high bias. This is practical in the larger sets.

In either of these cases the bias may be considered fixed, but the important thing, from the point of view of proper bias on the a.v.c. controlled tubes, is that the cathode of the detector tube can be grounded.

Another method is to use diode biasing, but this is not applicable to high gain tuner-amplifiers, because even the 55 and 75 triode "cuts off" prematurely.



The resistor, R, lower center, is interposed between the negative lead of the rectifier and the return circuits of the tubes, which return is commonly grounded. In this way the self biasing resistors of controlled tubes always furnish a negative bias, and the automatic volume control circuit merely adds to that negative bias as the rectified signal voltage rises high enough to permit this. R biases the triode of the tube marked "Diode," although the cathode is grounded.

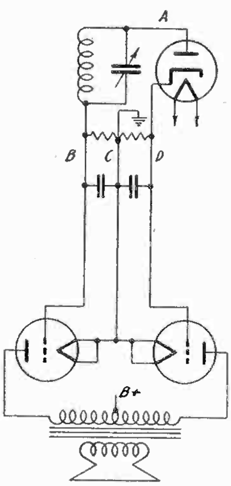
Try This Trick With Diode:

Establish Nonreactive Push Pull Circuit

By Edward C. Sturgis

A BALANCED diode detector—some call it a push pull detector—nonreactively coupled to push pull output tubes. How would you go about accomplishing this?

Last month we broached the subject, and cited the diagram herewith as representing right hand push pull tube running a positive grid. Also there is capacity unbalance to grounds as between cathode and ground and high side (B) of load resistor and ground. It was hinted the 6H6, double diode with separate cathodes, might offer a solution. Resistance coupling is to be used, no stopping condensers.



What is the objection to this 6H6 circuit? Does it do the trick?

Suppose we set forth an argument in favor of the circuit—but remember there may be a catch in it—then show the thesis to the professor to hear what he has to say?

The circuit under discussion now is the one herewith, and the tube at top is the 6H6 metal tube, which has no glasstube counterpart.

In the previous examples whatever d. c. appeared across the diode load resistor, in the first instance across BD and in the second across BC, had to be halved, even to show the theory. With full wave rectification, of course, the voltage has to be halved. What appears across the sum of the two secondaries is one voltage, and only half of that voltage is supplied to each anode effectively at a time, or there are two half wave rectifier detectors the outputs of which are noncumulative. Again, in the load resistor halving will be applied. But these are details that can be compensated in coupling increases at r. f.

No Push Pull Detection

Besides capacity and other balance that the new tube affords, we introduce a balanced load in the following manner. Take the left hand diode. Assume that anode E is positive, the diode at left conducting. Instead of returning directly to cathode of this diode through a load resistor we return to "dead" cathode of the other diode, and put the resistor between the two cathodes. Thus in the stated supposition, rectified current flows through the diode load resistor BC, where B is negative in a d. c. sense and C is positive, or zero. On the basis of the d. c. axis applied to the pulsating current, C as zero states the fact.

But if we ground the center of CB, at point D, then with D as datum, we find that C is positive in respect to D, while B is negative in respect to D. Moreover, the output load resistor is connected in regular push pull manner, and the temptation would be to refer to this as a push pull detector, since input is full wave and output is now symmetrical. However, the detection is full wave, and the opportunities at the diode load resistor are seized to yield a push pull condition, but the detection itself is not push pull, as it is hard to conceive of the symmetry of push pull being applied to the unsymmetrical operation of detection.

Criss Cross Returns

Now consider the a. c. voltage positive at E, the other diode plate. The return is made to the cathode of the other diode, point C, and through the load resistor CB to cathode of the right hand diode.

Such returns as are made to cathodes opposite to the diode under consideration find those cathodes inoperative as rectification adjuncts, for there is no conduction in that other circuit, the negative pulses being on the companion anode. But only through criss-crossing of the returns this way, putting the load resistor between the cathodes, is the same load resistor useful for both operations.

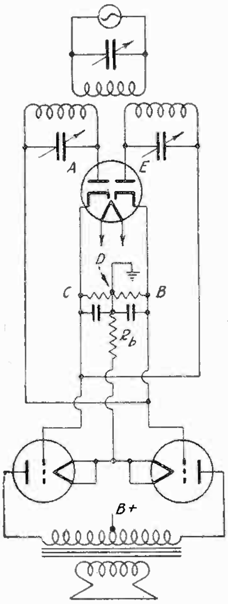
Now we find that one diode rectifies, and the d. c. potential at C is negative in respect to D, while B is positive in respect to D at the same instant. When the other diode rectifies, E being positive to a. c., C, which was positive to d. c. in the previous example, is now negative in a d. c. sense, D is zero again, and B is positive. So the lowest bias voltage that could appear on the grids of the output tubes would be zero. As a precaution in limitation of current through the output tubes at zero bias, other bias may be introduced, hence the biasing resistor R_b is shown.

No Positive Grid Now

Thus the objection of running a positive grid is overcome, the symmetry of the tube is utilized as the first step toward balance, and the output of the diode is taken in the particular manner shown so that equal and opposite voltages will appear on the grids of the output tubes. You might say there is push pull input to output tubes without push pull detectors.

The circuit is direct coupled and, up to the output transformer, is nonreactive. The output transformer may be so selected that the primary on load will look into the plates as a pure resistance. This is a matter of correct matching. Then the reaction would be confined to the speaker, but that is something beyond the scope of the amplifier circuit itself.

The new tube will stand a large a. c. input to detector, 100 volts per diode, and the linear current limit is 2 milliamperes, which is very high.



Professor's Comment

Well, that was an interesting argument, let us assume. Everything was all right but—

The professor now may say:

"The right hand diode's plate E acquires a positive d.c. potential from cathode C when the diode a.c. at left is conducting, therefore both tubes conduct at once, and unequally. A semi-parallel effect ensues."

The professor is right. But he has no solution. That's the trouble with the professors. "That won't work," they rightfully say, but may not be able to produce the solution themselves. Then along comes the bright student (played by your humble author as understudy on the real one, who is sick) and presents a solution, a real solution, and leaves the professor without a critical leg to stand on:

"Use a balanced detector and feed two push pull 6A5 tubes, where positive grids matter not, as the tubes work (and how!) on zero bias, with straight live amplification on negative and positive sides and, if anything, straighter line on positive than on negative."

And if the professor says, "Let's see the circuit," you draw a sheet of paper from your pocket and show him.

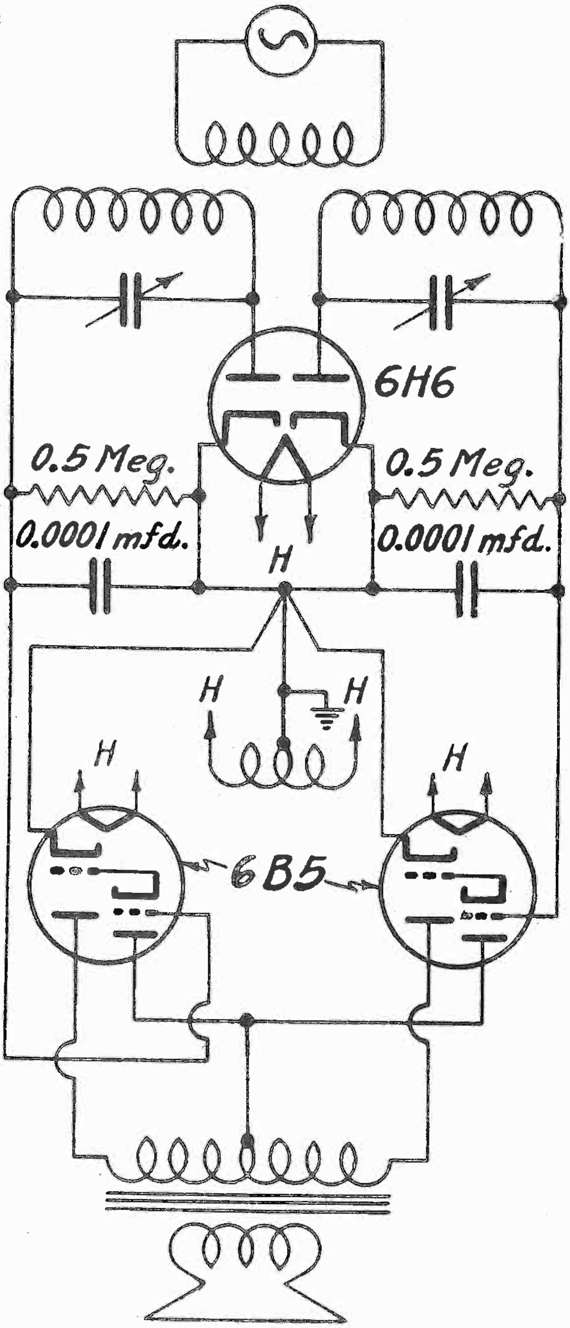
The Diagram at Right

Maybe the diagrams that you draw will be like the one at right, which uses the 6H6 double diode tube, has a sort of push pull circuit, at least in appearance, and feeds a pair of the new 6B5 output tubes.

It will be noticed that one diode is intended to detect at a time, and when that one is idling the other diode is detecting, so there's something going on all the time. But—and there is a "but" here as in previous considerations— each grid is driven only negative, hence one side is dead during each alternation, the other during the other alternation, and push pull requires that the voltages be equal but phases opposite. So it is not truly push pull. And the small condensers across the 0.5 meg. load resistors are not large enough to carry over the positive action for low or even medium frequency audio notes. For high audio frequencies there might be some positive displacement current, but that is not nearly enough.

Have you a solution for the balanced detector?

What Do You Think of This "Solution"?

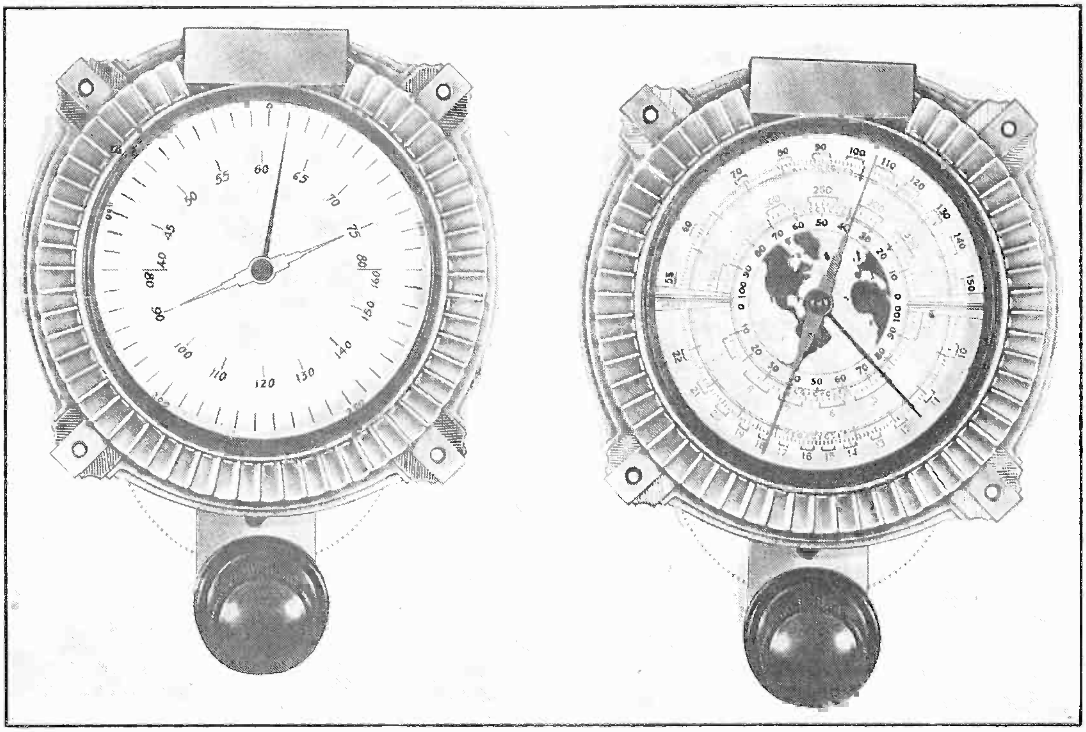


Look this circuit over carefully and decide whether you think it is push pull.

A Precision Tuning System

For Direct Frequency Readings to 0.3%

By Herman Bernard



The general idea of the dial arrangement of a precision tuning system. The fast pointer (black single) travels 16 times the speed of the double pointer. For a 180 degree condenser the effective ratio of movement is 8. Therefore 8 positions of the double pointer are frequency calibrated and the single pointer divides the frequency differences, e.g., for 500 outside divisions (50 shown) the reading is 1 part in 4,000.

The system is used at present in a very popular dial. Here the frequency is determined by the slow double pointer only, and the fast pointer permits close numerical readings (0-100) in reference to frequency calibrated positions, but the fast pointer is not frequency indicative. Hence logging is required, whereas in the previous example all readings are directly in frequency, no logging necessary.

TUNING in short waves requires very close adjustment, and since the same capacity or frequency ratio is used on all bands in nearly every instance, the higher the frequency the more severe the requirement for close tuning. A given change of capacity in the tuning condenser on one band usually will increase the frequency for the same capacity displacement, same dial positions, three times or more on the next band. Therefore bandspread devices came into vogue.

In experimental practice it has been common to use a small parallel condenser for bandspread, but this was in conjunction with non-frequency calibrated tuning systems. It was bandspread in the real sense, where the electrical dimensions of a band were reduced, hence greater dial spread resulted. In commercial receivers the substitute has been mechanical bandspread, by high reduction ratios of the driving system, and the use of slow speed pointers.

Nonlinear Tuning

Thus, as in the illustration of a popular airplane dial using the large or fast moving double pointer for frequency indication, and the small, slow moving pointer for reading relative numerical values from 0-100, it is practical to log a station closely. First the large pointer is used for approximate frequency indexing, then the small one to ascertain how many divisions of the inside 0.100 scale, in one direction or another, are to be traversed to tune in a particular frequency. The result is not a frequency

The author sets forth his original system for tuning without logging, applicable particularly to short waves where close tuning is imperative. The general idea can be comprehended quickly by imagining one of the electric clocks that has second hand longer than either of the other hands, and operating from the center. The minute hand would be as usual, the hour hand neglected. The fast moving second hand measures time in close values, and here a dial is worked the same way to disclose frequencies directly in close values. In reading the article bear in mind that the fast moving pointer is the close dissector, the slow moving pointer the coarse indicator. The author's decimal repeating system also is introduced, as shown in a table, and you might say the dial does everything but talk.—EDITOR.

determination, since the 0-100 scale is not directly related to frequency.

If the distance between 60 and 70 at the top left is noticed, evidently to disclose frequencies 600 to 700 kc, and then the distance between 70 and 80, for the same frequency difference, there is obviously much more separation at the low frequency extreme part of the tuning than at the next adjacent part, after which the separation is fairly regular. This disparity is called nonlinear tuning.

By the system as shown in the illustration the frequency disclosure depends only on the double pointer, the one that moves fast, while logging is attained with good accuracy by observing the numerical reading of the secondary pointer, the single one that moves slowly and provides the visual effects of bandspread.

Straight Frequency Line

If the system is made linear it becomes more useful, and if certain other precautions are taken, the readings may be made very closely, say, to better than 1 part in 1,000. In fact, one part in 3,000 could be accomplished, and if the tube circuits, particularly the oscillator, were stable enough, this would take on real significance.

It is proposed therefore that straight frequency line tuning be introduced, so that the ratio of the gears would have frequency disclosing possibilities, that the double pointer be made the smaller one, to disclose gross steps of frequencies, and that the bandspread pointer, or secondary movement, be relied on for the actual reading of the frequency.

To give significance to the subdivision of the band is to be tuned, it is necessary that the gear ratio, or mechanical system that relates the movement of the slow pointer to the fast one, be divisible into the frequency span, so as to yield a whole number dividend, and this number is to be scanned or dissected by the fast moving pointer. It may be regarded that the slow moving or double one is attached to the condenser shaft at no reduction and the slow moving one is geared to the other.

Getting the System Started

The system to be discussed deals only with this ratio, and need not concern any auxiliary reduction drives, such as the popular two-speed planitary drive. The dials shown have this provision, where one front knob is turned to give a 5 to 1 ratio, a larger knob behind it, when turned, omits this reduction; the fast knob actuates a ratio of 9, so the slow speed is 45 to 1, fast speed 9 to 1, all applicable to 360 degrees, and besides the secondary pointer travels 16 times faster than the primary pointer, independent of number of degrees.

We shall consider the example of the 180 rotation condenser, which has the effect of reducing the ratio by half; in fact, the dial usually has end stops that produce the same limitation.

Therefore we have a system whereby the 180 degrees through which the condenser turns are traversed 16/2 times by the slow moving pointer, while the fast moving one goes around (really half way around) only once. Therefore any frequency span for a band should be divisible by 8.

Getting Terminal Frequencies

In treating a circle, then, there are nine bars, or eight differences, each difference equalling 180/8 or 22.5 degrees. Suppose we assign some frequency value to the 1/8 separations. If it is 5 kc, then the total frequency difference between one extreme or tuning and the other would have to be 40 kc. The frequency ratio depends only on the condenser, so we take the ratio that exists, and produce a span, with proper inductance selection, to yield a difference of 40 kc. The frequency ratio, say, is 2 to 1. The required frequency span is

$$Fs = \frac{40}{Fr - 1} : Fr\left(\frac{40}{Fr - 1}\right).$$

where Fs is the frequency span and Fr is the frequency ratio.

In this instance the range is simply 40 to 80 kc. The difference is 40, and two adjacent bars among the nine represents 5 kc difference and no other registration of the frequencies is necessary for this band, except for the fast moving pointer, now assumed at outside, hence the longer one, which has its described circle calibrated to small parts of the 5 kc difference.

Gross and Five Calibrations

Since we are dealing with two dissections, let us call the assignments in steps of eight equal frequency apportionments the gross calibration,

(Continued on next page)

(*Continued from preceding page*)
and let us call the dissection of the gross calibration the fine calibration.

How many divisions may be put on the circle described by the slow moving pointer will depend on the diameter of the scale, and to some extent the fineness of reading permitted by the pointer. For the largest size scale commonly encountered, 4 inch face, it is almost practical to put on 500 divisions, so that the frequency could be read to 5000/500 cycles, or 10 cycles for this band. The receiver would not be so stable as to permit utilization of this refinement, and the possibility is mentioned simply theoretically.

For the system to work well, even for coarser reading than the one part in 4,000 just discussed, it is necessary that there be no backlash between the gear and the condenser, and that the fast moving pointer be made to rotate the very instant that the force is applied for that purpose. Some dials will have a lag of this nature equal to about 1 part in 1,800, others may have some spring or ball bearing system to take up this play. We will assume a model from which this lag has been practically eliminated.

Aspects of Accuracy

It will be noticed that the gross calibration need not be highly accurate, as it is used merely as a reference point. Suppose the gross pointer indicates a little bit to one side of 45, not so far off however as to leave one in doubt whether 50 is meant, then 45 is the frequency of gross reference, and the actually reading of frequency is obtained from the fast moving pointer, for when this is at zero it represents 45 kc in this example. When the fast pointer describes 180 degrees the slow one moves 22.5 degrees, to indicate now a frequency of 50 kc, next time 55 kc, next time 60 kc, etc. Since there are 500 divisions on the outside of the circumference, to which the slow pointer refers, each division on the periphery represents, as stated, 10 cycles.

For multi wave tuning it is always desirable to have the frequencies dissected in units related to the usual separations in frequency assignments by Governments, or as required for testing and measurements. We find from the foregoing that we read to 10 cycles, and with retained ratio of 2 for tuning, the next coil switch position would result in each fine division representing 20 cycles, next band 40 cycles, next 80, next 160, etc. Likewise awkward factors would arise later as applied to kilocycles.

Two Large Scales

So it is advisable that there be two large scales to which the fast moving pointer refers. One may be colored red and refer to dissections of gross divisions also in red, the other "outside" scale black, and refer to black gross divisions.

The frequencies just considered were taken for the sake of easy example.

Scarcely ever would it be necessary to receive or generate such low frequencies. Considering a generator, it would be practical to apply the system as follows, applicable to receiver practice, also, by omitting the two low frequency bands, frequency ratio being 2.28:

Band	*Terminal Frequencies*	*Kc per Gross Division*	*Cycles per Fine Division*	*Red Scale*	*Black Scale*
1	100 : 228	16	50	320	...
2	225 : 513	36	100	...	360
3	500 : 1,140	80	250	320	...
4	1,000 : 2,280	160	500	320	...
5	2,250 : 5,130	360	1,000	...	360
6	5,000 : 11,400	800	2,500	320	...
7	10.000 : 22,800	1,600	5,000	320	...
8	22,500 : 51,300	3,600	10.000	...	360

Decimal Repeating System, Too

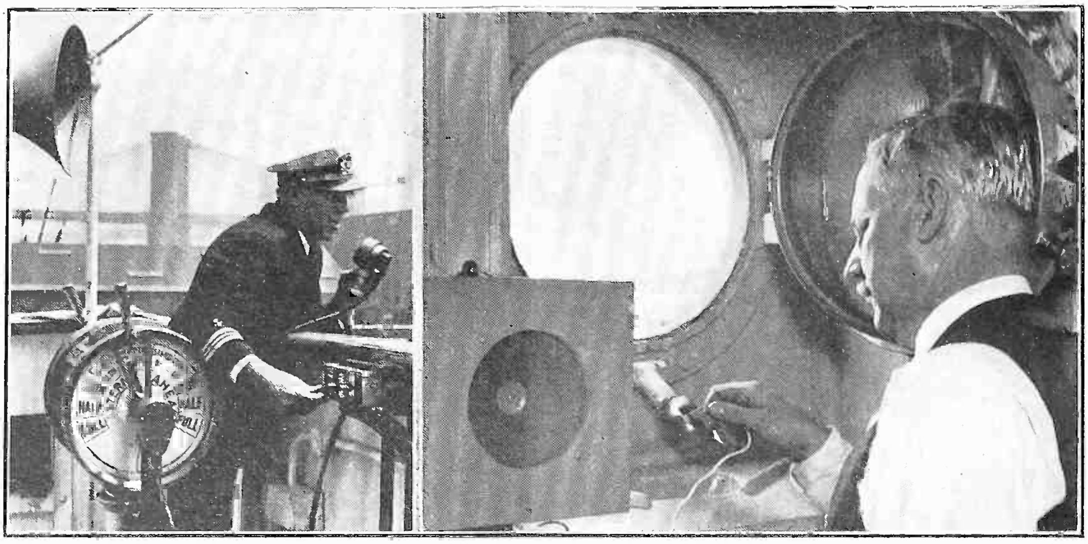
Actually only three calibrations are required for the bands, since the fourth repeats the first decimally (times 10), the fifth repeats the second the same way, the sixth repeats the third likewise, and the seventh is the first times 100, the eighth is the second times 100.

An examination of the two outside scales, one divided into 320 parts and the other into 360 degrees, shows retention of convenient subdivisions of the gross gradations, in terms of kilocycles per fine division, for example, 1, 2.5, 5 and 10 kc. It should be noted that without pressing the system beyond the ready mechanical attainments the highest frequency band, terminating at below 6 meters, is read to 10 kc separation. It is of course necessary to have an electrical system that is stable at least to the degree that the mechanical system is stable, 1 part in 2,880 in this instance (black scale), and one part in 2,560 for the other classification (red scale), or, roughly for both, about 0.3 per cent. This is by no means an impossible feat in a laboratory engineered custom product, either signal generator or receiver.

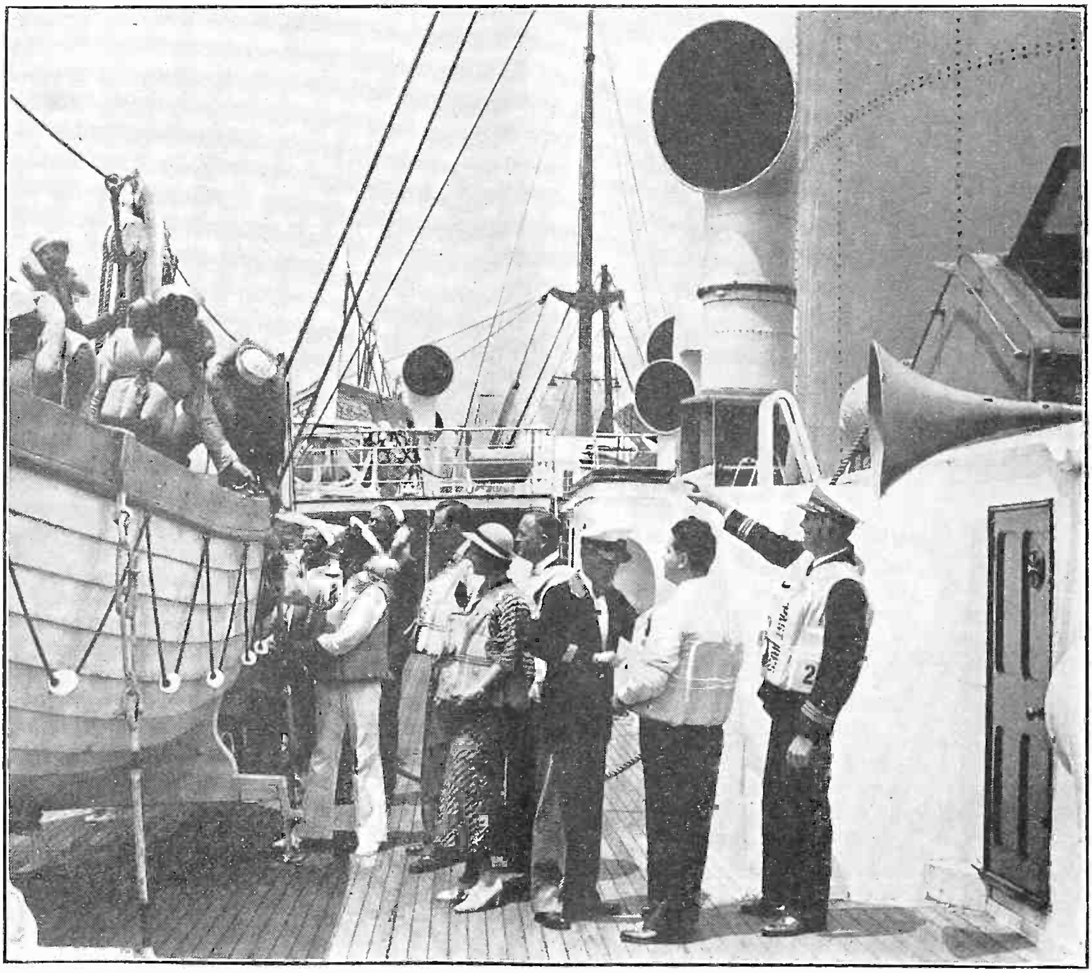
Since one of the outside scales is 0-360, and since each time the fast pointer goes around once the other one moves 22.5 degrees, the dial could be used for protraction measurements, with very small inaccuracy, less than that resulting from use of ordinary protractors. By the red scale one way dissect the 22.5 degree gross stops in fine terms of 0.07 degree per division. The error is only .0043 per cent. theoretically, which may be neglected because the mechanical system would not approach such accuracy.

It should be pointed out that a modified version of the plan is applicable to nonlinear tuning systems, if tuning ratio is not so high as to produce gross division crowding. Some accuracy is lost and the five readings have reduced significance as to frequency, unless various values per division are assigned, and thus calculation introduced.

In conclusion, a dial system has been set forth for direct frequency reading to very fine values, by using the familiar airplane dial structure, particularly the type with slow moving pointer on the outside, and correlating both pointers to frequencies, so that absolute value of frequencies always are read and no computation or record required. Present close systems are not frequency connected and require voluminous records compiled from long hours of attentive listening.



First Officer (left) on bridge of ocean liner can talk to officers, crew and passengers by new adaptations of sound system. He is talking into a portable microphone, having depressed one of three switches for selecting various parts of vessel to receive message. Sound is conducted through steel hull of vessel. At right one speaker lead is clipped to porthole clamp, other lead to pipe nearby, used as ground.



Andrew Halbran

Lifeboat drill aboard liner, passengers and crew summoned by new sound system. It is practical to shout into the speaker and thus use it as microphone for two way communication.

(*Continued from preceding page*)
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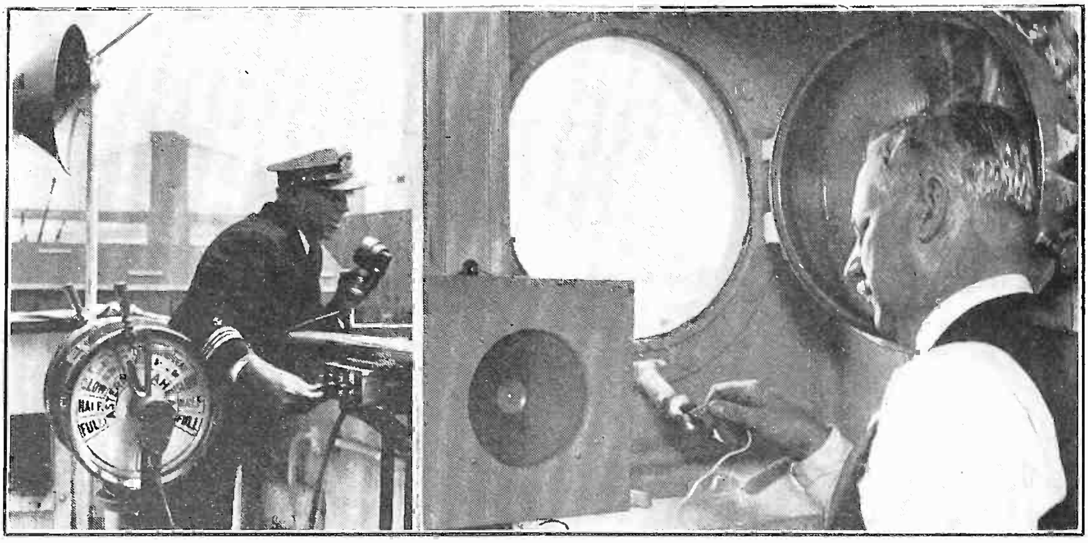
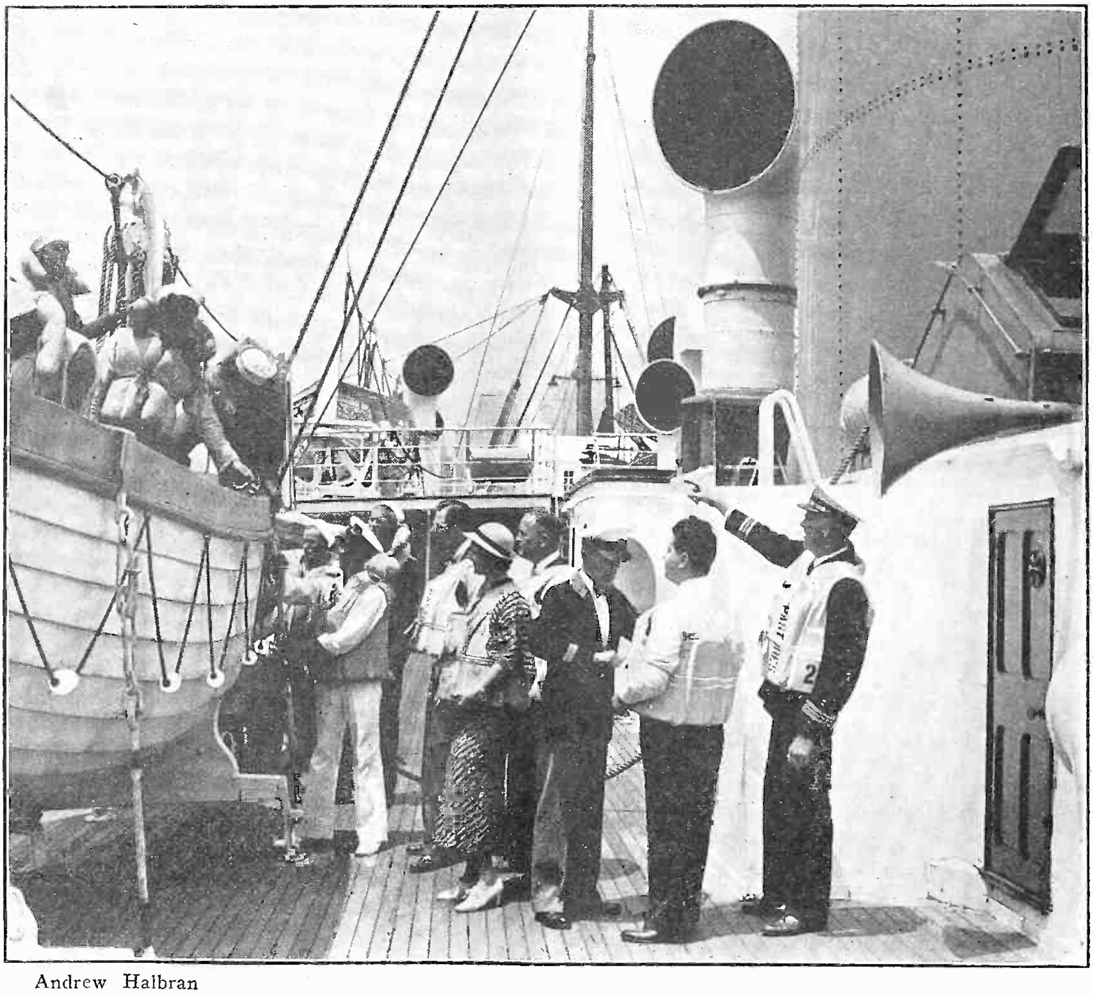
In conclusion, a dial system has been set forth for direct frequency reading to very fine values, by using the familiar airplane dial structure, particularly the type with slow moving pointer on the outside, and correlating both pointers to frequencies, so that absolute value of frequencies always are read and no computation or record required. Present close systems are not frequency connected and require voluminous records compiled from long hours of attentive listening.



First Officer (left) on bridge of ocean liner can talk to officers, crew and passengers by new adaptations of sound system. He is talking into a portable microphone, having depressed one of three switches for selecting various parts of vessel to receive message. Sound is conducted through steel hull of vessel. At right one speaker lead is clipped to porthole clamp, other lead to pipe nearby, used as ground.

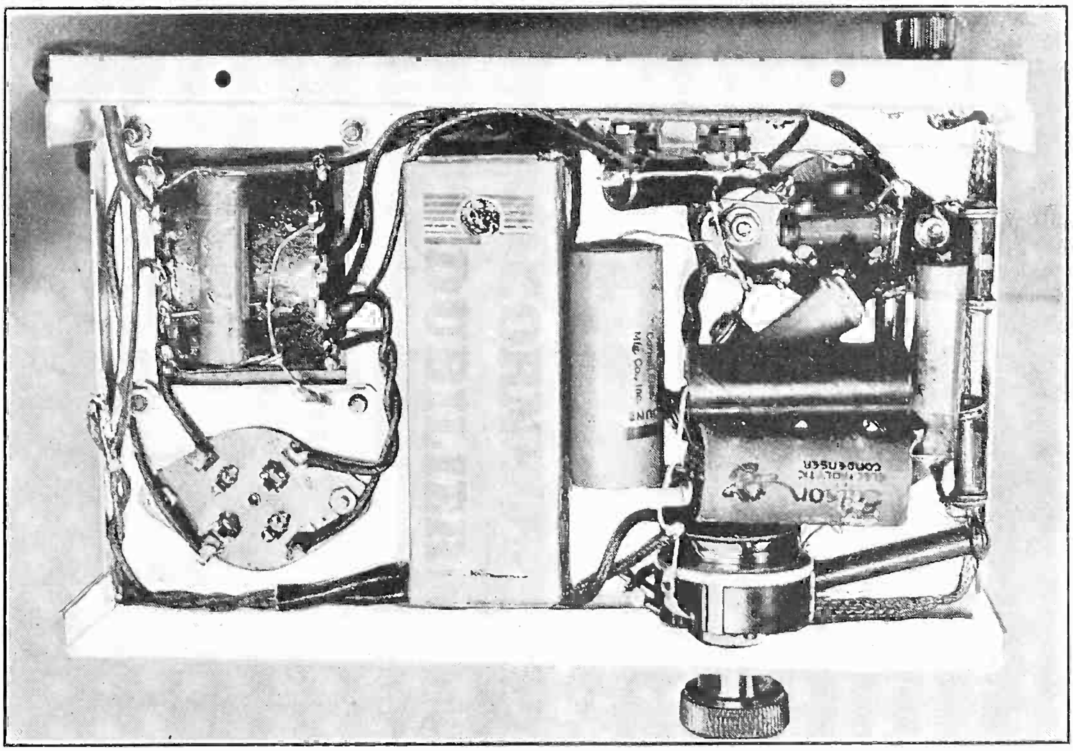


Andrew Halbran

Lifeboat drill aboard liner, passengers and crew summoned by new sound system. It is practical to shout into the speaker and thus use it as microphone for two way communication.

RADIO CONSTRUCTION UNIVERSITY

Answers to Questions by Readers on the Building of Radio and Allied Devices. Readers Should Address Questions to Radio Construction University, Radio World, 145 West 45th Street, New York, N. Y.



Underneath view of the layout for a three tube amplifier. The Cornell-Dubilier condenser at center is used for filtration of the rectified a.c. used fo r B supply. If a resistor of 10,000 ohms replaces usual choke, the capacities would be 8 and 8 mfd., in one envelope.

DB Notation for Power Output

WHY is not the system of decibel notation applied to the rating of power output tubes, instead of the wattage rating, as the db method gives a much better picture, enables instantaneous comparisons related to the sensitivity curve of the ear, and simplifies reckoning?—L. W. S.

The decibel notation should be applied as you suggest and no doubt will be in the fullness of time. Since two powers would be compared, the system that reflects directly the comparison of these powers in terms consistent with realistic results, is far preferable. It would be necessary, of course, to have an accepted standard or basis of comparison, and as you know, .006 watt has been used a great deal. From a standard reference point all other data would have to proceed, and then instead of saying 1 watt for an output rating we might say 22.2 db. The plus sign may be understood, minus being applied only when pertinent, as is done in ordinary numerical practice. At present both minus and plus are used to avoid any possibility of misunderstanding, but with a wider application of the method the plus sign no doubt will be dropped.

* * *

Small Power Amplifier Layout

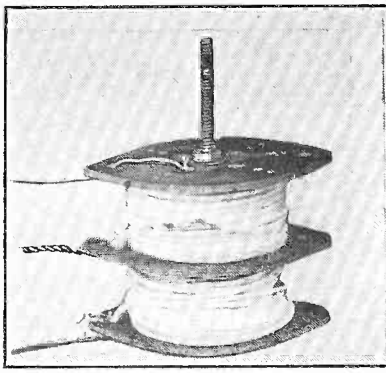
SINCE I desire to build a very small power amplifier, consisting of three tubes including rectifier, I wonder if you could show an underneath view of such a device to guide me in the placement of parts?—I. L.

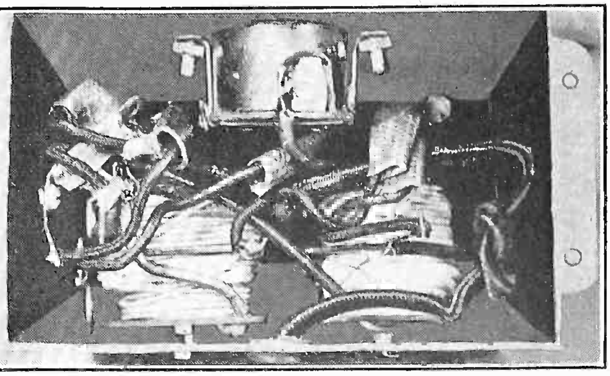
The desired view is pictured herewith.

* * *

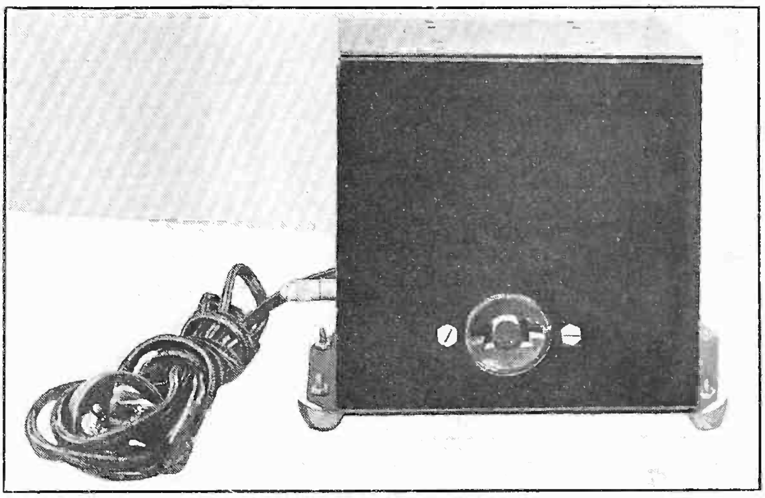
Heat of Metal Tubes

IS IT not a fact there is no basis to the argument that there is much more heat generated by the metal tubes than by their glass envelope



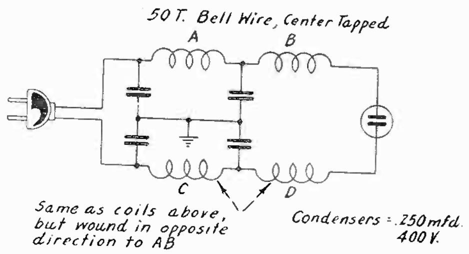


Above, at left, is shown one of the two coil systems used in a satisfactory line filter. The object of this device is to get rid of noises that come in through the line to disturb reception. At upper right is an interior view of the metal cabinet housing the filter. Below is an external view, with the female socket, into which the receiver plug is to be inserted, facing the reader. The line cord plug of the filter goes into the wall socket.



equivalents? I have heard the contention made that there is no difference, while others state that the difference is pronounced. What is the correct answer?—L. C.

There is no difference in the quantity of heat dissipation since the power is the same for metal tube or glass envelope equivalent. The fact that the metal shell gets hotter than the glass envelope is just a detail, and may be viewed as a favorable one, since it discloses that the conduction of heat away from the tube proper is more rapid. Since the power is equal, the more rapid dissipation may be construed as advantageous. It is not a fact, however, that the shells of the run of metal tubes get very hot. Only the rectifier tube does that, and its construction is somewhat different, with an outer shell with ventilating perforations. Some instances of extraordinary heat may be ascribed to early attempts at refining the manufacturing process, but as the tubes get into regular production, and become more or less uniform as to characteristics, as they probably are by this time, such difficulties disappear. Some manufacturing difficulties might be assumed from retardation of preliminary deliveries of tubes by factories, but the minor markets and the stores began to get their stocks about the middle of September, thus indicating that the wheels are rolling nicely.



Construction of a Line Filter

IS a line filter practical? If so please give a few details on how to build a simple one. —L. C. M.

The simplicity of the device is apparent from the accompanying illustrations. The coil system consists of two separate center tapped inductances, wound on any convenient bobbin, and separated by a spacer, two spacers also used as end pieces. If the coils are inserted side by side, as shown in the view at upper right, and beginning of each winding occupies the same relative position, then the coils should be reverse wound, as the diagram indicates. We attended a demonstration in a radio store in New York City (Thor's) where the filter had been built, and objectionable line noise actually was killed off.

(*Continued on page* 59)

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Radio University

(*Continued from page 57*)

Straight Frequency Line

WILL you please tell me whether straight frequency line tuning can be accomplished with condensers that are not of themselves straight frequency line, and if you can supply the information, please indicate approximately the capacities to use for padding.—K. D.

Absolutely straight frequency line can not well be achieved by the padding method, which consists principally of putting a critical value of parallel capacity across the tuning condenser, unless some of the tuning span is to be sacrificed. There is no particular objection to this sacrifice, so long as, say, 90 per cent. of the condenser rotation can be utilized on as basis of s.f.l. The commercial type socalled .00035 mfd. tuning condenser, with approximately midline tuning characteristics, as made by DeJur Amsco, General Instrument Company, Federal and others, requires a parallel capacity approximately equal to the maximum capacity of the condenser itself. The low frequency end is more extended than s. f. l. With 0 of dial representing minimum capacity setting of the tuning condenser, the rotation may be from 0 to 85. There is no point to using also a series fixed condenser, as that makes matters worse, since the separation for given frequency difference becomes greater where already it is too great. Only for precision work, or in very high class sets, would it be necessary to adhere strictly to s. f. l. and therefore the condenser may be used for its full span with benefit of wide spreadout, but disadvantage (if such it be regarded) of greatly reduced frequency ratio of tuning. Instead of 3.2 to 1 or thereabouts the ratio would be 1.4. The Hammarlund junior midline condenser of .0001 mfd. capacity may be padded for a ratio of 1.9 to 1 by putting across it an air dielectric trimmer of 35 mmfd., with plates of trimmer engaged about one third the way. Use a test signal from a generator to produce a response at 100, and turn the condenser to 0. If there is a response near 0, use more capacity until the response is just tuned out. The full ratio of 2 to 1 may be obtained with the new National straight frequency line condensers, which require a mini-

(*Continued on next page*)

(Continued from preceding page)

mum capacity of around 40 mmfd. supplied by trimmer. The circuit then is adjusted for responses exactly at full capacity and exactly at minimum capacity. It can be seen there is advantage in keeping the ratio at or near 2, the other examples resulting in too high a minimum capacity (commercial .00035 mfd. condensers), so that the inductance to capacity ratio becomes too small. It is important to keep this ratio large in the interest of higher gain and less noise, and the importance is greatly enhanced at high radio frequencies (on short waves). No doubt the day of wider use of s. f. l. tuning for its convenience and precision will arrive soon. At present the run of sets has too high a frequency ratio of tuning, so that on the highest frequency band, ratio unchanged, the crowding is far too great. The bandspread clock dials help out, but could be better applied to systems of 2 to 1 ratio or thereabouts.

* * *

Wants Health from Tube

SINCE there is ultra violet in the mercury vapor tubes, is it not possible to obtain some healthful benefit from the operation of these tubes, not necessarily as rectifiers, but as health lamps?—W. D.

The mercury vapor rectifiers have the characteristics that you mention, and therefore Vitamin D benefit might be obtained, to give strength to bones, but the glass envelope in which the tube is contained is a filter against the very rays that you desire to bring out. Other tubes specially made for the health purpose have processed glass that permits the ultra violet rays to come through, and there has been developed recently a tube that yields the health benefits without producing any tan. The ultra violet rays of sunlight produce tan, but the benefits are lodged in the rays themselves and it is possible to produce synthetic sunlight, as stated, with the tanning effects absent. There is some good reason for doing it this way as overdose of tan may be quite injurious because of attrition of the vital oils of the skin.

* * *

Sky or Ground Ultra Waves?

DOES the ground wave exist on ultra frequencies, or should one say that only the sky wave is radiated and that there is no ground wave to speak of? Also, what is the reason for the polarization angle of an ultra wave changing when directivity is introduced?—K. W. D.

The ground wave is strong for standard broadcast frequencies, especially at night, and that accounts for the better night reception, compared to day reception. Also it accounts for fading experienced at night and not in the daytime, since the two components arrive sometimes exactly out of phase, hence one element cancels the other, and there are inbetween phase shifts, so that volume rises from maximum to minimum, and minimum may be zero, with rapid cyclic changes. As the frequencies increase the ground wave becomes less important, due to rapid dissipation, and only the sky wave is pertinent. That is the wave reflected from the ionospheric layers, of which there are two major ones, at varying heights from the earth's surface. The decline of the strength and importance of the ground wave may be considered to be carried to the ultra frequencies, but since these frequencies are practically not reflected from above, and there is no point to making a distinction, the radiation may be loosely spoken of as that of a ground wave. This is because the definition of a ground wave is one that travels close to the ground. It does not mean a wave that travels in and through the ground, for a wave is dead ended by literal grounding. Support for the definition of the ultra frequency

RADIO UNIVERSITY

(Continued from preceding page)

transmission as a ground wave is found in the fact that the radiation follows the curvature of the earth, in a general sense. When directional transmission is used the plane of polarization changes, so that a vertically polarized wave may turn out to be polarized horizontally in some locations, and antennas would have to be tilted so that maximum pickup is experienced. What is the reason for this bending over is not fully understood yet, but may be due to the difference in index of refraction as existing in the ether between the two points of comparison, somewhat in line with the natural phenomenon of a mirage, the scientific reason for which is not firmly established, either, but the mirage may be due to the change in relative angle of vision introduced by refractive index changes.

* * *

Telephone Not Radio Frequencies

WHEN I pick up the telephone in my home or office and use it am I not engaging in radio rather than audio practice, since a carrier is used?—K .D.

Although a carrier is used, this is not classed as radio, since the frequency of the carrier is low, around 30 kc, and also radiation is not used, but directed transmission over wires.

Underwriters' Receiver Rules

Splices, Leadins, Conductors, Grounding Fully Detailed

RULES of the Board of Underwriters are binding on owners of installations in respect to insurance features. Last month were printed the rules for amateur transmitting stations. Herewith are the rules for receiving stations (amateur and commercial):

For Receiving Stations Only

a. Outdoor antenna and counterpoise conductor sizes shall be not less than No. 14 if of copper or No. 17 if of bronze or copper-clad steel. Antenna and counterpoise conductors outside buildings shall be kept well away from all electric lights or power wires or any circuit of more than 600 volts, and from railway, trolley or feeder wires, so as to avoid the possibility of contact between the antenna or counterpoise and such wires under accidental conditions.

b. Antenna and counterpoise where placed in proximity to electric light or power wires of less than 600 volts, or signal wires, shall be constructed and installed in a strong and durable manner, and shall be so located and provided with suitable clearances as to prevent accidental contact with such wires by sagging or swinging.

c. Splices and joints in the antenna span shall be soldered unless made with approved splicing devices.

d. The preceding paragraphs, a, b, and c, shall not apply to light and power circuits used as receiving antenna, but the devices used to connect the light and power wires to radio receiving sets shall be of approved type.

e. Lead-in conductors, that is, conductors from outdoor antennas to protective devices, shall be of copper, approved copper-clad steel or other metal which will not corrode excessively, and in no case shall they be smaller than No. 14, except that bronze or copper-clad steel not less than No. 17 may be used.

f. Lead-in conductors from the antenna to the first building attachment shall conform to the requirements for antennas similarly located. Lead-in conductors from the first building attachment to the building entrance shall, except as specified in the following paragraph, be installed and maintained so that they cannot swing closer to open supply conductors than the following distances:

Supply wires 0 to 600 volts......... 2 feet

Supply wires exceeding 600 volts...10 feet

Where all conductors involved are supported so as to insure a permanent separation and the supply wires do not exceed 150 volts to ground, the clearance may be reduced to not less than 4 inches. Lead-in conductors on the outside of buildings shall not come nearer than the clearances specified above to electric light and power wires unless separated therefrom by a continuous and firmly fixed non-conductor which will maintain permanent separation. The non-conductor shall be in addition to any insulating covering on the wire.

g. Each lead-in conductor from an outdoor antenna shall be provided with an approved protective device (lightning arrester) which will operate at a voltage of 500 volts or less, properly connected and located either inside the building at some point between the entrance and the set which is convenient to a ground, or outside the building as near as practicable to the point of entrance. The protector shall not be placed in the immediate vicinity of easily ignitable stuff, or where exposed to inflammable gases or dust or flyings of combustible materials.

h. The grounding conductor from the protective device may be bare and shall be of copper, bronze or approved copper-clad steel, and if entirely outdoors shall not be smaller than No. 14 if of copper nor smaller than No. 17 if of bronze or copper-clad steel. If wholly indoors or with not more than ten feet outdoors it need not be larger than No. 18. The protective grounding conductor shall be run in as straight a line as possible from the protective device to a good permanent ground. The ground connections shall be made to a cold-water pipe where such pipe is available and is in service and connected to the street mains. An outlet pipe from a water tank fed from a street main or a well may be used, provides such outlet pipe is adequately bonded to the inlet pipe connected to the street water main or well. If water pipes are not available, ground connections may be made to a grounded steel frame of a building or to a grounding electrode, such as a galvanized iron pipe or a rod driven into permanently damp earth or to a metal plate or other body of metal buried similarly. Gas piping shall not be used for the ground.

i. The protective grounding conductor shall be guarded where exposed to mechanical injury.

An approved ground clamp shall be used where the protective grounding conductor is connected to pipes or piping.

j. The protective grounding conductor may be run either inside or outside the building. The protective grounding conductor and ground, installed as prescribed in the preceding paragraphs h and i, may be used as the operating ground.

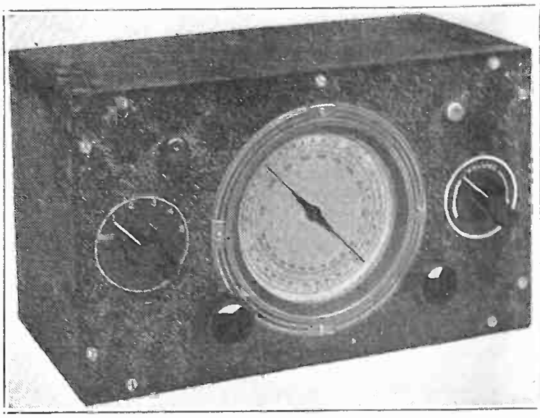
It is recommended that in this case the operating grounding conductor be connected to the ground terminal of the protective device.

If desired, a separate operating grounding connection and ground may be used, this operating grounding conductor being either bare or provided with an insulated covering.

k. Wires inside buildings shall be securely fastened in a workmanlike manner and except as provided in paragraph m of this section shall not come nearer than two inches to any electric light or power wire not in conduit unless separated therefrom by some continuous and firmly fixed non-conductor, such as porcelain tubes or approved flexible tubing, making a permanent separation. This non-conductor shall be in addition to any regular insulating covering on the wire.

1. Storage-battery leads shall consist of conductors having approved rubber insulation. The circuit from a filament, "A," storage battery of more than 20 ampere-hours capacity, NEMA rating, shall be properly protected by a fuse or circuit-breaker rated at not more than 15 amperes. The circuit from a plate, "B," storage-battery shall be properly protected by a fuse.

The Outstanding All-Wave SIGNAL GENERATOR



MODEL 339. A 5-band Signal Generator, 54 to 17,000 kc, all on fundamentals, switch operated, direct reading in frequency and wavelength; universal operation. Modulation on-off switch and attenuation. Electron coupled. Wired, tested, calibrated, with three tubes (6D6, 37 and neon). Shipping weight, 8 lbs. **$16.00**

THE three low frequency coils of the generator are honeycombs, wound in quantity with special accuracy from the same spool of wire to insure uniform wire diameter hence uniform inductance. The tuning condenser is of the precision ball bearing type. The switch for band changing has a capacity of less than 1 mmfd. and a contact resistance of 0.004 ohm (four thousandths of one ohm). Everything is of the best, including black crinkle finish shield cabinet and finished chassis. Sylvania tubes are supplied.

THE highest requirements of precision and convenience for all-around work are met in the Model 339 Signal Generator, that works on a.c. or d.c. of 90-125 volts, to measure frequencies from 54 to 17,000 kc and line up channels. It also serves for determining the frequency of a station that is being received. Model 339 is outstanding because though all-wave, switch type, with airplane dial, attenuator and removable modulation, it is priced at only $16.00 net.

The frequencies are in five bands:

(1)—5,400 to 17,000 kc. (2)—1,700 to 5,400 kc.
(3)—540 to 1,700 kc. (4)—170 to 540 kc.
(5)—54 to 170 kc.

It can be seen from the above that the calibration is decimal repeating, by noting left-hand column alone, then right-hand columns alone. Thus two calibrations afford maximum spreadout, each at outside of dial scale.

The two inside scales are for reading wavelengths, 18 to 5,500 meters.

Coincidence of generated frequency and scale reading is 1 per cent. This high order of accuracy obtains in no other instrument selling at less than twice the cost of the 339.

Many, no doubt, have been somewhat confused by the numerous type of signal generators, but will note that the best of them cover wide ranges on fundamentals, have an attenuator, and permit of pressure or absence of modulation. Also they have a vernier dial and are direct-reading in frequencies, accurate to at least 3 per cent. The 339 has all these advantages, besides affording wavelength determinations as well, and operation on 90-125 volts a.c. (any commercial frequency) or d.c. And the accuracy is three times as great. Moreover, the 339 is well built, for lifetime use, and covers all waves fundamentally, besides permitting measurements of frequencies up to 100 mgc (down to 3 meters) by resort to a slight calculation method, applying a simplified harmonic system to the 5,400 to 17,000 kc fundamental band.

The 339 has a 6D6 r.f. oscillator, a 37 rectifier tube, so that d.c. is used on the plate, while modulation is provided by a neon tube relaxation oscillator at a frequency of about 1,000 cycles.

Model 339, wired, calibrated, adjusted, complete with three tubes, ready to operate; instructions (shipping weight, 8 lbs)................ **$16.00**

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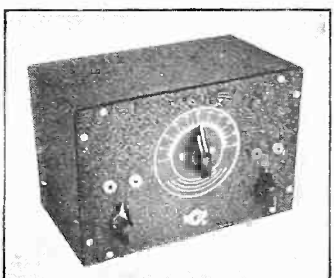

An inexpensive 1 tube 5 and 10 meter Transceiver.

This extremely efficient transceiver is recommended for the short wave enthusiast who is interested in exploring the fascinating 5 and 10 meter bands.

The circuit utilizes the type 19 two-volt twin tube, and is exceedingly sensitive since the super-regenerative principle is employed when the receiving position is switched on. A double pole single throw switch is the means by which the instrument may be switched to either receiving or transmitting.

Range on 5 meters, 35 miles. Range on 10 meters, 100 miles.
Batteries required as follows.

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Dimensions: 5" x 6" x 9".

- Complete Kit with 5 meter Coils $4.75
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- R.C.A. Licensed tube .... .65
- Wired and Tested 1.00
- Wiring diagram and complete instructions included in every kit.

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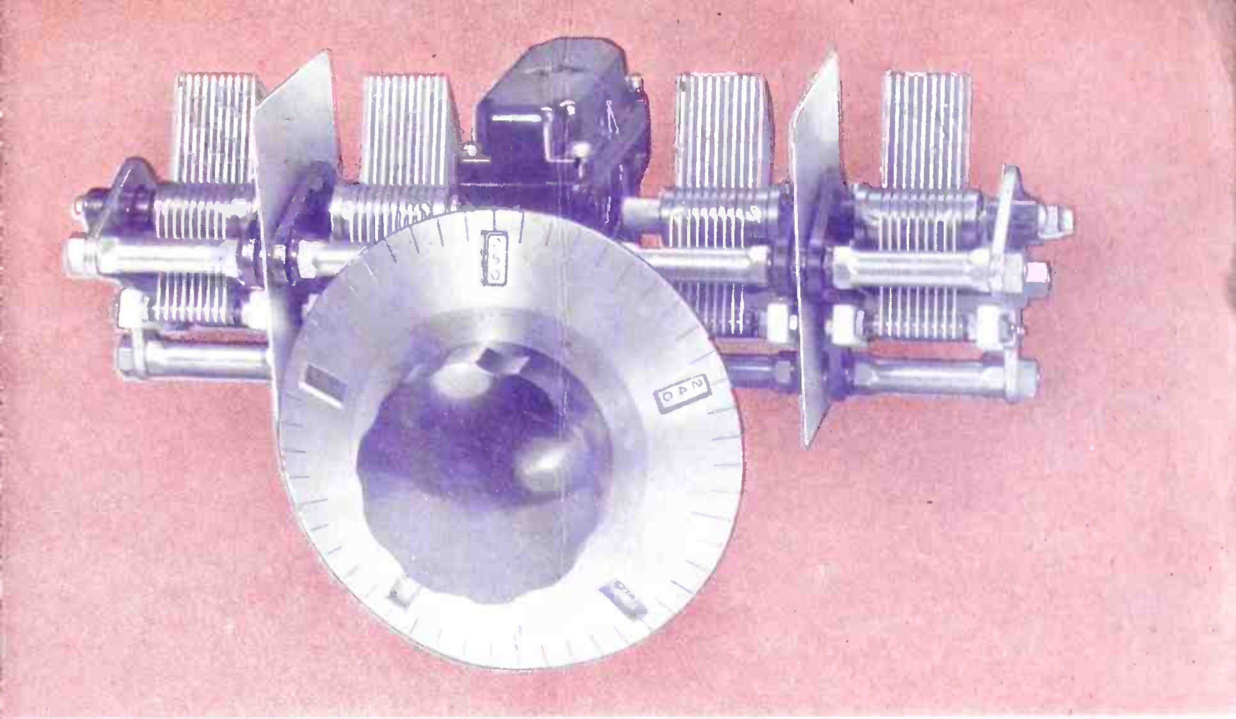

THE MICROMETER DIAL. The dial on the PW Precision Condenser is of an entirely new type, being direct reading to 1 part in 500. It is read exactly like an ordinary dial. Fifty division lines are engraved on the rim of the dial shell, and each tenth division is numbered in the usual way. However, the dial revolves ten times in covering the tuning range. Each revolution the numbers change automatically, giving continuous readings to 500. The numbers turn with the division lines, and change rapidly at the bottom of the dial when they are out of the operator's line of sight.

THE PRECISION CONDENSER. The condenser is of extremely rigid construction, with four bearings on the rotor shaft. The drive is through a preloaded worm gear of great accuracy. Each rotor is individually insulated from the frame by bakelite; each stator is individually insulated by low-loss Steatite. End bearings are insulated for quietness. The condenser is mounted rigidly to the chassis by bosses on the base of the gear housing. Neither the frame nor the dial touches the chassis or panel at any point, making the assembly immune to bending of the chassis.

RANGES. The PW condensers are available in 1, 2, 3 or 4 sections with 150 or 225 mmf maximum per section. A new single section model now in preparation will provide capacities up to 500 mmf. The plate shape of all ranges is designed to give straight line frequency tuning when the frequency range is exactly 2 to 1.

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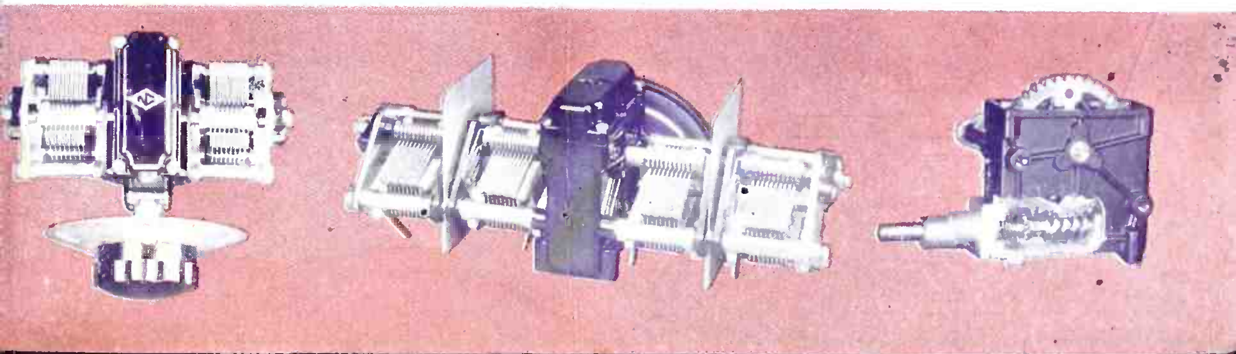

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MODEL 430

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4. Sloping all metal lithographed panel.
5. Leakage tests and all short.
6. Quartered Oak Case.
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8. Tubes tested at actual load values.
9. Four simple operations.

Model 430, complete with Triplett Model 221 Meter, Dealer Net	$18.00
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NEW ALL-WAVE SIGNAL GENERATOR

READRITE has incorporated all improvements and advantages of present day engineering in this new All-Wave SIGNAL GENERATOR. All frequencies are fundamentals and thoroughly stabilized—complete shielded and tube modulated.

Has plug-in type coil for each of the present five frequency bands. 100-21000 Kc. (any new frequency range can be added by new coil). Calibration curves supplied for each band. Has attractive Leatherette Case and complete with batteries and two No. 30 tubes. Dealer Net Price.. **$14.40**

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