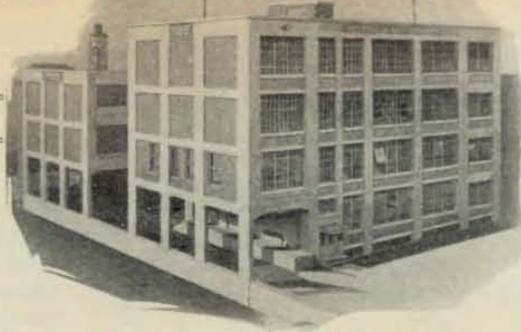


# The GENERAL RADIO EXPERIMENTER

VOL. 2 NO. 10

MARCH, 1928

The General Radio Experimenter is published each month for the purpose of supplying information of particular interest pertaining to radio apparatus design and application not commonly found in the popular style of radio magazine.



There is no subscription fee connected with the General Radio "Experimenter." To have your name included in our mailing list to receive future copies, simply address a request to the GENERAL RADIO CO., Cambridge, Mass.

## Factors Concerning the Use of the Type UX 250 Power Amplifier Tube

By A. R. WILSON, Service Department

It has been generally conceded that the greater the amount of energy or power supplied to the speaker by the last audio stage tube the better the quality. This, of course, is assuming that all other considerations are equal. The desire for good tone quality with reasonable volume is of paramount importance to the great majority of listeners. To this end power tubes such as the 171 and the 210 type have played an important part. The type 171 power tube is especially desirable for average home use as it does not require the high plate voltage of the 210 type and at the same time provides the speaker with ample volume. The type 210 tube is a logical choice for those who have demanded more volume than the 171 type of tube is capable of delivering. Power and more power has been this season's cry in regard to audio units. Realizing this demand for great volume together with good quality the Radio Corporation of America has recently announced a new power amplifier tube to be known as their UX 250 (Cunningham CX 350). The various characteristics of this tube are listed below:

The filament rating is 1.25 amperes at 7.5 volts, which is the same as that for a UX 210 tube. The material used for the filament, however, is the coated ribbon type similar to that used in the UX 281 Rectifier tube. The filament operates at a dull red heat and the low operating temperature and increased size of this filament results in minimum ripple voltage or hum when operated from an AC source. The UX 250 is of the low- $\mu$  type, the amplification factor being 3.8.

The coated filament is not affected by traces of gas and a slight blue glow will not impair or affect the performance of the tube provided the resistance in the grid circuit is kept low, preferably not over 10,000 ohms, to avoid a decrease in bias which may result from the flow of gas current to the grid.

A low-resistance output choke with a condenser, or a transformer capable of handling the heavy plate current of the UX 250 without saturation of the core or overheating of the windings, must be provided for this tube to prevent excessive voltage drop in the plate circuit and to protect the loud speaker windings.

From a casual glance it might seem that this tube is interchangeable with the UX 210. This is true to a certain extent but as the plate current required is about three times that of either the 210 or the 171 tube, special considerations must be taken into account in the filter and the tube output systems to prevent saturation. The rectifying transformer should, at the same time, be designed to furnish the requisite requirements of voltage and current for this tube with a good margin of safety. To meet the demand for satisfactory equipment for use with this new power amplifier, the General Radio Company has developed two new transformers; a complete rectifier filter consisting of suitable chokes and condensers all mounted in a single unit; and an output or speaker filter.

To secure the necessary voltage to operate the UX 250 under load at its maximum plate voltage the rectifying transformer should have a high voltage secondary of at least 600 volts. The new General Radio transformers, known as the Type 565-A and Type 565-B, are intended for use in half and full wave rectifying systems respectively, employing either one or two UX 281 rectifier tubes or equivalent. The Type 565-A transformer consists of one high voltage secondary of 600 volts and two low voltage secondaries of 7.5 volts each for the filaments of the

	250	300	350	400	450
PLATE VOLTAGE					
NEG. GRID BIAS voltage	45	54	63	70	84
PLATE CURRENT (milliamperes)	28	35	45	55	55
PLATE RESISTANCE (ohms)	2100	2000	1900	1800	1800
VOLTAGE AMP. FACTOR	3.8	3.8	3.8	3.8	3.8
MAX. UNDISTORTED OUTPUT (milliwatts)	900	1500	2350	3250	4650



IET LABS, INC in the GenRad tradition  
534 Main Street, Westbury, NY 11590

www.ietlabs.com  
TEL: (516) 334-5959 • (800) 899-8438 • FAX: (516) 334-5988

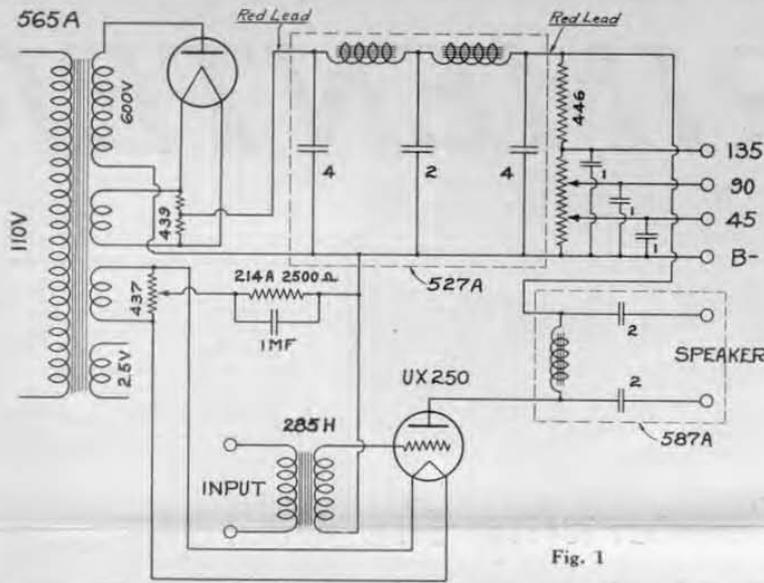


Fig. 1

rectifier and power amplifier tubes. There is also another low voltage secondary of 2.5 volts which is primarily intended for use in conjunction with the 226 or 227 types of tubes when this unit is used in a complete two or three stage amplifier.

The Type 565-B full wave transformer is identical in size and appearance with the Type 565-A and consists of two 600-volt high-voltage secondaries together with two low-voltage secondaries of 7.5 volts each.

The Type 527-A rectifier filter incorporates two heavy duty chokes, each having an inductance of 15 henries, and a condenser assembly of 4-2-4 M. F.

Both the Type 565-A and 565-B transformers are rated at 200 watts. In order to eliminate any danger due to short circuits all connections to the instrument are brought out in the form of rubber-covered leads of various colors which are plainly indicated on the name plate. The connections to the Type 527-A Rectifier Filter are also leads and it is very important that the red lead be used in the high voltage side of the rectifier system. The direct current resistance of the chokes used in the Type 527-A Rectifier Filter is 175 ohms each. These chokes are made with butt joints and have a .003 inch air gap in order to prevent saturation at high values of plate current.

One of the most common causes of distortion in the tube itself is that resulting from the flow of grid current. The amount of signal voltage that may safely be impressed upon the grid of the tube without causing grid current to flow is fairly well indicated by the grid

bias voltage; actually it is half the square root of two, or .707 times the grid bias voltage. At the same time that we are interested in preventing the tube from distorting we are also desirous of securing the maximum power output that the tube is capable of delivering. The power output of a tube, however, is proportional to the square of the input voltage. For instance, if we had a theoretical tube that was designed to give a one-watt power output with a ten-volt grid swing, and only five volts were available on the grid of this tube, a quarter of a watt power output would result. This brings us to another consideration of the new UX 250 power amplifier tube. A study of its characteristics shows that at its maximum plate voltage the signal input voltage necessary to obtain the 4650 milliwatt power output is

58.8 volts R. M. S. (.7 times the grid bias voltage) compared to 24.5 volts R. M. S. for maximum output of the UX 210 tube and 28 volts R. M. S. for the UX 171 tube. Now if we had only enough signal voltage to operate a UX 210 tube at its maximum power output available on the grid of the UX 250 tube, a little figuring with pencil and paper would readily show that the output available under this condition would be about that of the 171 type of tube. All this means that sufficient voltage amplification must be employed between the detector and the grid of the UX 250 tube if its greatest power output is to be realized. It is well, though, in normal service, to operate the last audio stage tube below full capacity, leaving a large reserve of volume available, a condition favorable to best quality of reproduction.

The UX 250 tube is not particularly suited for use in a push-pull output system on account of the extremely high signal voltage necessary to operate it at anywhere near its maximum output. The push-pull method of connecting two tubes necessitates twice as much signal input voltage as a single tube to secure the maximum power output. This means that a voltage amplifier of high gain must be employed between the output of the detector tube and the two UX 250's. This is not particularly recommended since an amplifier of this sort is rather unstable. If more power is desired than a single tube is capable of producing, two UX 250's may be connected in parallel with the result that the power output will be doubled with the same input voltage as is

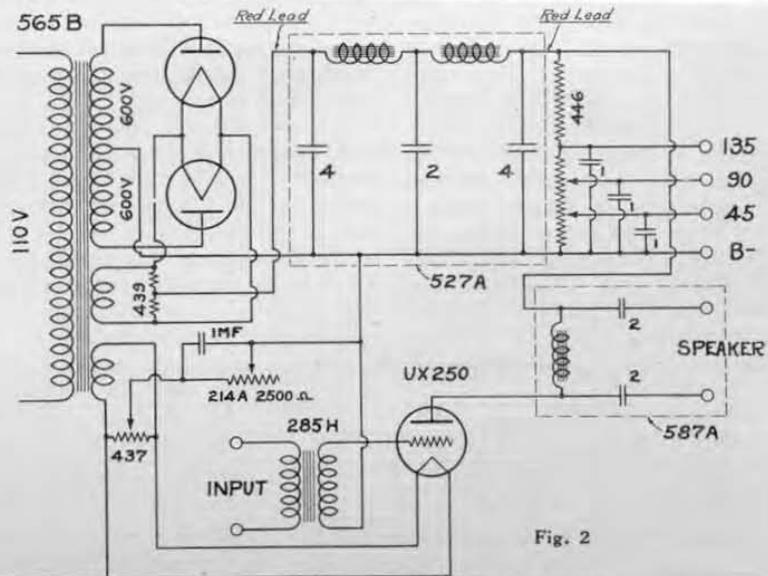


Fig. 2





necessary for the operation of a single tube.

To secure a maximum transfer of undistorted energy it has been determined empirically that the load resistance should be equal to twice that of the plate resistance of the tube. The DC resistance of the windings of an average loud speaker is of the order of 1000 ohms. This is the resistance offered to the flow of the plate current from the plate supply when the speaker is used without an output transformer or equivalent. The resistance offered by the speaker to the signal voltage generated by the output tube is very much higher than the DC resistance of the windings, especially at the higher audio frequencies. This resistance is termed the impedance of the speaker and it is the combined effect of the resistance and the reactance of the unit.

The average impedance of present-day speakers, such as a Western Electric, is approximately 4000 ohms. Because of this fact and the low plate impedance of the UX 250 tube it is not necessary to use an impedance adjusting device such as an output transformer. However, some method of coupling must be used between the output of this tube and the speaker to prevent the high plate current from eventually burning out the speaker windings. For this purpose the Type 587-A speaker filter was designed, and it thoroughly insulates the speaker from both the high voltage and direct current of the tube. This device consists of a heavy duty choke similar in construction to the chokes used in the Type 587-A Rectifier Filter but having a direct current resistance of 250 ohms. Two 2mf condensers are also used. The wiring diagram of this instrument is shown below:

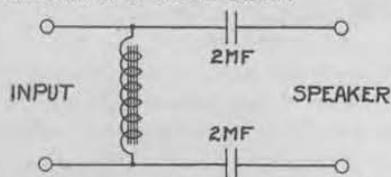


Fig. 1 and 2 show respectively the schematic wiring diagram of a single stage power amplifier combined with a plate supply unit utilizing half and full wave rectifying systems respectively, while Fig. 3 shows an experimental model of a complete amplifier. As mentioned before, this amplifier should be preceded by a voltage amplifier of sufficient voltage gain, such as two stages of double impedance employing UX 112 tubes, in order to operate the UX 250 tube properly.

To secure as large a voltage gain as possible in the power amplifier an audio transformer having a ratio of 1 to 6 has been employed. From a frequency standpoint the use of a high ratio transformer is perfectly permissible in this case as it is working out of a relatively low impedance tube. In order to keep this impedance as low as possible it is recommended that the 112 type of tube be employed in the preceding stage.

Two of the General Radio Type 446 voltage dividers connected in series are used as the output potentiometer device to supply the correct plate potentials for a radio receiver.

should be set so as to use approximately 3/5 of the total resistance, since a resistance of 1500 ohm is about right to give the proper bias for the UX 250 tube.

In both Figs. 1 and 2 it was thought advisable to use an adjustable center tapped resistance across the filament of the power amplifier tube and adjust it under actual operating condition for minimum hum.

The list of parts used in the model as illustrated is as follows:

- 1 General Radio Type 565-A Transformer
- 1 General Radio Type 527-A Rectifier Filter
- 1 General Radio Type 587-A Speaker Filter
- 2 General Radio Type 349 Sockets

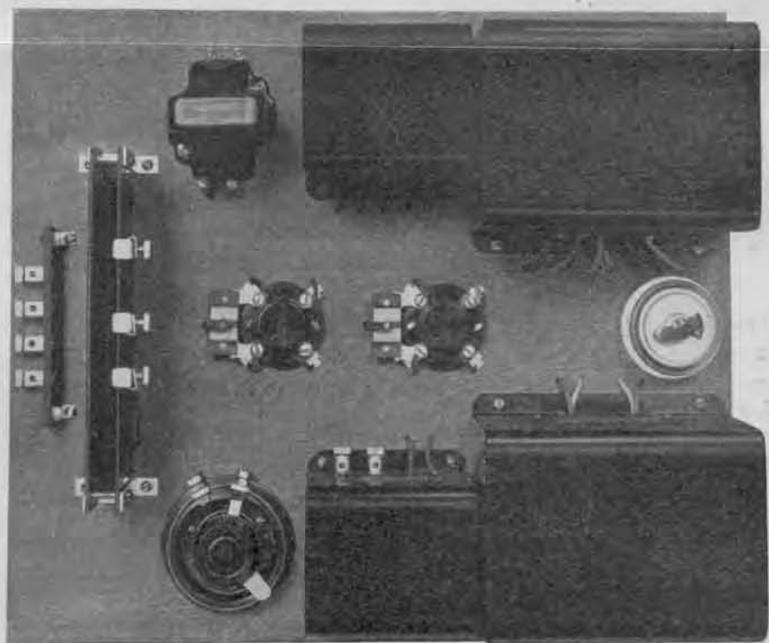


Fig. 3. An Experimental Single Stage Amplifier Combined with a Plate Supply Unit

It is desirable that the bias required by the tube be supplied from the voltage drop across a resistance in series with the B-return as shown in Figs. 1 and 2. It will be found that this connection compensates almost completely for changes in plate voltage which may occur as a result of line voltage variation, since an increase in plate voltage causes a small increase in plate current, which in turn raises the applied "C" bias sufficiently to compensate for the new value of plate voltage, thus maintaining the proper operating condition at all times. If a decrease in voltage occurs, such as would be caused by a sudden drain upon the plate supply, the reverse action would take place. The movable arm of the Type 214-A—2,500-ohm Resistor used to secure the proper bias voltage

- 1 General Radio Type 439 Center Tapped Resistance
- 1 General Radio Type 437 Adjustable Center Tapped Resistance
- 1 General Radio Type 285-H Audio Transformer
- 2 General Radio Type 446 Voltage Dividers
- 1 General Radio Type 214-A—2,500 ohm Resistor
- 1 Base Board 14" x 16"
- 1 BP Strip & 4 Binding Posts
- 1 Snap Switch, Cord and Plug
- 4—1 MF Condensers (In model these condensers are mounted in a can similar in appearance to that of the Type 587A Filter)

The experimental model makes use of the half-wave rectifying system. If a full-wave system is desired the Type 565-B transformer should be substituted for the Type 565-A Transformer and another socket should be added for the additional rectifier tube. All other parts, however remain the same.



# New General Radio Apparatus

In designing suitable equipment for use with the new UX 250 Power Amplifier Tube several considerations must be taken into account. The high plate current of this tube requires that the transformers and chokes employed in the plate supply unit be so designed that saturation and overheating effects are eliminated. For safety's sake, due to the high voltages used, all connections to these new instruments are made in the form of leads. This eliminates the danger from exposed terminals and removes the possibility of short circuits from the terminal strip to the metal case. These leads are of generous proportions in regard to length, and practically all wiring of the plate supply unit may be accomplished with them. With the exception of size, the physical appearance of the new transformers and filters is identical with that of previous apparatus of the same classification. All these instruments are built with same attention to precision and quality of both material and workmanship as is characteristic of all General Radio products.



**Type 565 B Full Wave Transformer**

A transformer designed for full-wave rectification utilizing two UX 281 Rectifiers. The plate voltage winding is for 1200 V. with a center tap. There are also two 7.5 volt secondaries for the filaments of the rectifier and power amplifier tubes. The primary is designed for 105 to 120 volt 50-60 cycle line. This transformer is rated at 200 watts.

Price \$20.00

Dimensions 5 3/4" x 5 1/4" x 5 1/4"

Code word: "TACIT"

use on a 105-120 volt, 50-60 cycle line. There are four secondaries: one of 600 volts for the plate voltage; two of 7.5 volts each for the filaments of a rectifier and power amplifier tubes; and one of 2.5 volts for the filaments of 226 or 227 type of tubes in case this transformer is incorporated in a complete two or three stage amplifier. This transformer is rated at 200 watts.

Price \$20.00

Dimensions 5 3/4" x 5 1/4" x 5 1/4"

Code word: "TABOO"



**Type 527 A Rectifier Filter**

In the filter unit caution must be exercised in choosing the condensers and chokes which go to make up this very important unit. The chokes should have a sufficient current-carrying rating, in excess of what will ultimately be drawn from the plate supply, so that at no time the inductance of the choke will drop due to high direct current.

The Type 527-A Rectifier Filter is mounted in the same size and style case as the type 565-A & -B transformers. It consists of two heavy duty chokes with an inductance of approximately 13 henries each and a continuous current rating of 100 milliamperes. The direct current resistance of each choke is but 175 ohms. The condenser assembly consists of a 4-2-4 mf combination which are rated at 1000 volts DC.

Price—\$25.00

Dimensions 5 3/4" x 5 1/4" x 5 1/4"

Code word: "FATTY"



**Type 587 A Power Speaker Filter**

A speaker filter that thoroughly insulates the speaker from the high plate voltage and current of the last stage tube. The choke used is of unusually heavy construction. This choke has an inductance of approximately 15 henries and a continuous current rating of 100 milliamperes. The direct current resistance is but 250 ohms. Two microfarad condensers are used on each side of the speaker to insulate it from high voltage. Connections to the input side are in the form of leads while the speaker is connected to the two binding posts.

Price \$10.00

Dimensions 4 1/4" x 3 5/8" x 4 1/2"

Code word: "FATAL"



**Type 565 A Half Wave Transformer**

This transformer is designed for half-wave rectification in conjunction with one UX 281 tube or equivalent. The primary is designed for

