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The Status of "A" Battery Elimination

By C. T. BURKE, Engineering Department

The question most frequently heard at the New York Radio Show, just past, was, "How about A eliminators?" "B" battery eliminators were exhibited in great numbers and many varieties, but no "A" substitutes of general application appeared.

The problem of filament supply from alternating current is essentially different from that of plate supply. It is not a question of the power supplied, but the voltage at which it is supplied. The power required for filament supply ranges from 0.18 watt for the dry cell tubes to 9.5 watts for the 210, while the plate power for these tubes is .2 watt and 9 watts, respectively. The average set draws a filament load of about 7 watts and a plate load of perhaps 4 watts. There is not enough difference between the wattage requirements of plate and filament to involve great difficulty.

The essential difference between the plate and filament supplies is the supply voltage, which is about 100 for the plate as compared to 5 for the filament. As power in watts is equal to the current supplied, times the supply voltage, roughly twenty times the current is required to supply a given number of watts to filament as would be required at the plate. The great difference then between the demands of filament and plate supplies is not of power, but of current. Plate current supply devices are not called on to deliver more than 50 milliamperes, while the filament may draw two or more amperes.

Direct current power differs from alternating, in that power at high voltage and low current cannot be transferred into power at low voltage and high current without the use of rather expensive equipment. It is, therefore, necessary to use the D. C. power at the current and voltage supplied by the rectifier.

Rectification and filtering is generally necessary in order to use alternating current for filament supply. The last stage of audio amplification can be run with alternating current on the filament with excellent results. When the slight hum resulting from A. C. on the filament is amplified through successive tubes, it reaches an objectionable magnitude. Thus the use of raw A. C. is confined to the last tube. This is generally a power tube, and requires a greater filament supply than the others. Under certain conditions, where some hum is not objectionable, it may be possible to operate two stages of audio amplification on alternating current. The detector tube must have a supply of well filtered direct current.

The maximum current available from a single tube of the kinds popularly used in plate supply devices is about 85 milliamperes. This is the current required by a one tube set, employing a UX-199 tube. It is delivered at high voltage. If the set is so wired that the tubes are in series, any number (up to 50) UX-199 tubes may be operated from such a tube when supplied with a suitable transformer and filter. As the same unit is generally used for both A and B supply, it would be necessary to design transformers and chokes to deliver this current at about 220 volts in order to take care of the plate and grid voltage of the UX-171 tube. This is somewhat expensive, but by no means impossible. A rheostat of sufficient resistance and current carrying capacity is also required.

It will be seen that A elimination for UX-199 tubes is feasible. So far as the writer knows, however, there is no commercial eliminator for this service available. The field for such a device would be very limited, first because of the comparatively few sets using 60 mil tubes, and second because rewiring of the set is required. The making of individual installations of this kind, however, including building the unit, and rewiring the set, should prove a source of considerable profit to those dealers and service stations who undertake it. The same type of installation would not be entirely beyond the bounds of practicability with 201A tubes if a rectifier tube were available supplying 250 milliamperes. The chokes and resistances for this arrangement would present considerable difficulty. This would result in greater bulk, and materially greater expense than would the equipment for 199 tubes.

There are a number of low voltage rectifiers available which are used to charge batteries. The output of these units is ample to supply the filament current drain of any set, and they would be suitable for a general purpose filament supply.

The great obstacle in this case is filtering. The condensers in the filter act as reservoirs, storing surplus current during one part of the cycle and feeding it to the load at another. The large current required by the filament supply would require condensers of many times the capacity now required on plate supply units. The filter inductances also present a serious problem. The low voltage available from high-current rectifying devices permits a very small drop in the filter system. This requires chokes having very large wire and few turns. In order to get the proper inductances, and avoid saturation, the cores would have to be of very large cross section, and would require air gaps. Fortunately, as the current drain increases, the amount of inductance required for a given degree of smoothing decreases somewhat. Even allowing for this, the filter choke for a filament power supply to furnish 2 amperes would cost much more than do those for a plate supply. The condenser cost would be multiplied by an even greater proportion unless electrolytic condensers were used.

The cost of a storage battery is, of course, many times less than that of such a filter would be. This brings us to the trickle charger—battery combinations, which, while not a battery substitute, do provide a reliable filament source from the alternating current line. The trickle charger is probably at present and likely to remain for some time the most satisfactory general purpose filament supply. The use of UX-199 tubes in series will, however, prove interesting to the experimenter and to the service man.

Another type of A eliminator, in which dry batteries are used as filter condensers, is appearing this year. In this type a tungar rectifier is generally used. The filter consists of a choke of small inductance which can, therefore, be made with low resistance and dry cells in place of the filter condensers. A number of these devices will be on the market this year and they offer interesting possibilities.

In the meantime, tube manufacturers are at work on the problem of developing tubes which will not require A batteries. Various types of tubes have been suggested in which the heating current does not pass through the anode, and one such tube has been placed on the market. Further developments along this line are certain, and it is possible the final answer to the "A" eliminator question will be provided by the tube manufacturer.

What Tube Shall I Use in My Power Amplifier?

As there are two tubes available for use in the last audio stage where considerable power is desired with perfect quality, some question has arisen as to which of these tubes should be used in a given case.

The plate characteristics of these tubes (UX-171 and UX-210) or (CX-371 and CX-310) are as follows:

UX 171

Grid Volts	Plate Volts	Output Resistance	Maximum* Undistorted Output (Milliwatts)	Amplification Factor
16½	90	2500	130	3
27	135	2200	330	3
40	180	2000	700	3

UX 210

Grid Volts	Plate Volts	Output Resistance	Maximum Undistorted Output (Milliwatts)	Amplification Factor
4.5	90	9200	18	7.5
9	135	8000	65	7.5
10.5	157.5	7400	90	7.5
18	250	5600	340	7.5
27	350	5100	925	7.6
35	425	5000	1540	7.7

* Proper bias assumed.

Considering first the output resistance, it will be seen that it is lower for the 171 for all conditions of plate voltage. A low output resistance increases the energy transferred from the tube to the speaker, and in part compensates for the low amplification factor of this tube. The low resistance also results in a greater energy transfer at low frequencies, where loud-speakers are inefficient.

The input voltage which may be applied to a tube without causing grid distortion is fairly well indicated by the grid bias voltage. An inspection of the table will show that the 171 permits a greater input at 180 volts than does the 210 at 425 volts, and more than twice as much as the latter tube at 180 volts plate.

Considering next "maximum undistorted output," it is seen that the 171 will deliver about twice the power at 180 volts that the 210 will at 250 volts plate. At 425 volts the 210 will deliver somewhat more than twice the power than the 171 delivers at its maximum plate voltage.

The amplification factor of the 210 is greater at all voltages.

From the above data it is possible to deduce a few rules for the use of these two tubes.

Where the plate voltage available is less than 200, the 171 tube should invariably be used.

Where it is desired to obtain the greatest possible volume, as might be the case in a hall or large assembly room, the 210 tube should be used with 425 volts on its plate.

The 171 tube is the ideal type for use when it is desired to obtain the proper volume for a living room without the distortion resulting when 201A tubes are forced. The undistorted output is more than ten times that of the 201A. Its low output resistance makes it particularly well suited for working into a low impedance cone. When the input is sufficient to work it to its capacity, the power delivered is ample for home use.

In order to obtain results equivalent to those delivered by the 213 rectifier, two 216B rectifiers must be used to supply the high voltage required by the 210 tubes. A transformer secondary voltage of nearly 1000 volts is also required. It is felt that a unit of these proportions is an extravagant and possibly a dangerous one for home use. These considerations have led the engineers of the General Radio Company to build their power units around the 171 tube.

NOTICE

In order that the Experimenter may be published and circulated around the first of every month, the September issue has been omitted, and the October issue distributed earlier in the month than has been the custom in the past few issues. Future issues will be mailed out on or shortly after the first of each month.

The Vacuum Tube Bridge

By HORATIO W. LAMSON, Engineering Department

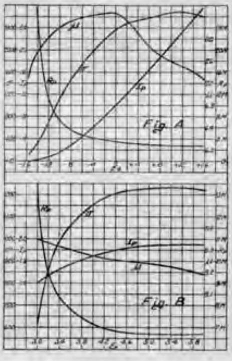
Figure 1. The Type 361-A Vacuum Tube Bridge Manufactured by the General Radio Co.

The uses of the three-electrode vacuum tube have become so manifold that the study of its various characteristics is of considerable importance. Several tube-testing devices, more or less elaborate in design, have been developed and placed on the market. These usually consist of a series of meters and rheostats, with or without enclosed batteries, and are designed to check filament power and to measure certain so-called "static characteristics," such as the joint emission to grid and plate or the steady plate current passing under any particular conditions of filament current or voltage, plate voltage, and DC grid bias. From characteristic curves obtained in this manner the "static amplification constant" and other data of value may be determined. Under certain conditions, however, the "dynamic characteristics" of a tube are of more fundamental importance. Chief among these are the Amplification Constant, the Plate Resistance, and the Mutual Conductance, which is the ratio of the former to the latter.

The actual value of the Amplification Constant, together with the variation of this quantity with different filament temperatures, plate voltages and grid potentials, is of paramount importance in determining the operating characteristics of a particular tube when used as a voltage amplifier. The Plate Resistance is more or less determined by the geometrical construction and the filament emission of the tube, so that any defect or abnormal variation in these factors may readily be detected by measuring this particular dynamic constant. Knowledge of the mutual conductance of a tube is important in determining its behavior as a power amplifier and as an oscillator.

To obtain such data it is necessary to supply an audio frequency tone source, preferably sinusoidal in character, to the grid of the tube and to make use of certain balanced-bridge measurements. Three circuits for measuring these tube constants are shown on page 203 of Van der Bijl's text book "The Thermionic Vacuum Tube." Beside the regular batteries and filament current controls, these circuits require two decade resistance boxes, three fixed resistances of 10, 100, and 1000 ohms respectively, a tone source and a pair of telephones. For accurate measurements it has been found beneficial to add a small variocoupler to introduce an inductive coupling between the tone source and the phones in order to counteract the effect of capacity between the tube elements.

These circuits may be set up with individual pieces of apparatus, but a higher degree of precision and better shielding, as well as freedom from other minor troubles, may be obtained by building the several parts into a properly designed bridge unit. Such a bridge is described more fully in the General Radio Bulletin 414.



The attached curves are given to illustrate data obtained with this bridge upon two different tubes. In the first set, marked "A," the grid bias was varied over a considerable range. In the second set, marked "B," the filament voltage was adjusted at various values. In either case the plate current Ip, the amplification constant Mu, the plate resistance Rp, and the mutual conductance Sigma, were measured directly on the bridge.

Referring to Figure A we see that the emission is practically cut off at sixteen volts negative on the grid, while no sign of saturation is reached at sixteen volts positive. The amplification constant remains essentially the same from 0 to about 9 volts negative, and then falls off as the plate current becomes abnormally low. With an increasingly positive grid the value of Mu falls away rapidly.

With a strong negative bias the plate resistance is of course, high, but this falls rapidly and becomes essentially constant for positive values of grid voltage. On the other hand, the mutual conductance rises rapidly as the negative bias is reduced and attains an approximately uniform value with the grid positive.

Figure B shows that the plate current rises with the filament temperature reaching saturation at about the rated filament voltage of the tube. The amplification constant is a maximum at the lowest workable filament temperature and falls off more or less uniformly as Ef is increased. The plate resistance remains constant down to 4.5 volts and then rises with increasing rapidity as the filament is cooled. The mutual conductance curve, of course, exhibits a reciprocal characteristic.

For All Popular Makes and Circuits *of radio receiving sets*

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Voltages are readily adaptable to all popular makes and circuits of radio receivers by means of fixed resistances which are tightly sealed from dust and moisture, thus eliminating bothersome and noisy tendencies of variable resistance voltage controls. The unit is contained in a metal case with attractive black crystalline finish, and has a conveniently located A.C switch.

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Type 400 Power Amplifier and Plate Supply

THE type 400 is similar to the above described unit except that it has the additional feature of a Power Amplifier and uses the UX-213 or CX-313 Rectron tube as a rectifier instead of the Raytheon.

A power amplifier in conjunction with the plate supply permits the convenient use of a power tube in the last audio stage, regardless of whether the receiver may be operated by dry cell or storage battery tubes—the filament current of the power tube being supplied by A.C. from the secondary of the rectifier transformer. The power stage overcomes the tendency toward tube overloading and removes the most common cause of distortion in loudspeaker operation.

The plate supply provides voltages of 45 and 90 for the receiver and 180 direct to the power tube, (UX-171 or CX-371) together with the proper bias for this tube.

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GENERAL RADIO COMPANY, Cambridge, Mass.

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