Is Voltage a Certain Indication of Merit?

A Study of the Requirements for a Satisfactory Plate-Current Supply Unit

By JAMES MILLEN

WHEN "B" power-supply devices first made their appearance on the radio market, not so many years or —for that matter—months ago, there were in the mind of the public in general many misconceptions regarding their proper use. Gradually most of these errors have been corrected, until now the average radio set owner has a rather clear idea of just what a "B" power unit is and what it will do. There still exist, however, a few erroneous ideas that can well stand correction.

One such is the present-day method of differentiating, between various "B" socket-power units, employed by the average radio dealer. He has learned the necessity for using a high-resistance voltmeter for checking "B" units. He has, undoubtedly invested in one or more of the special instruments made for just such a purpose. Having such an instrument, however, it is not very long before he notices that some power units give slightly higher voltages than others. Perhaps, at one time, he has actually obtained better performance from a set when using a "B" power unit with a higher voltage output than that of another power unit. The result is that he soon considers his voltmeter as an indicator of merit and begins to judge the excellence of "B" units solely by their voltage output. The higher his voltmeter reads the greater, to his mind, the merit of the power unit.

A SELLING ARGUMENT

As a result, manufacturers' salesmen soon found that they had trouble in selling their "B" units to a dealer unless these could furnish a higher voltage output than their competitors. Consequently, the manufacturers began to raise the output voltage of their "B" units.

Within certain limits, such a general trend toward higher-voltage "B" units was a very desirable event. The 171-type power tube came along about the same time, and the higher voltages were necessary for its most successful operation.

But, there is always danger in going from

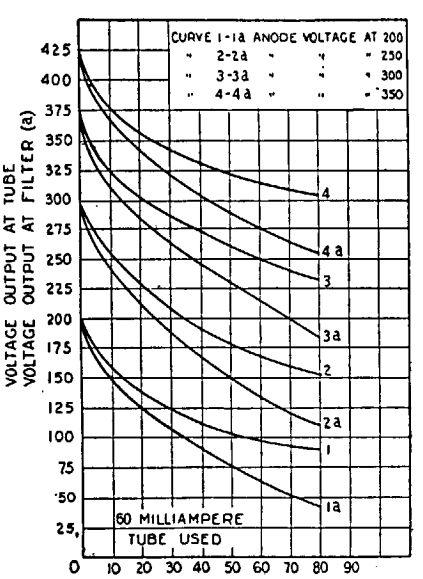
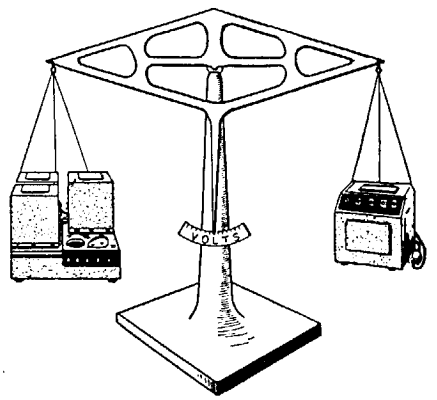


Fig. 1. This chart shows the voltages delivered, from given values of the supply source, by a 60-milliampere rectifier tube, as the load upon it varies, up to an amount in excess of its rating.



Equal output voltage—what about the regulation and the margin of available power?

one extreme to another like the proverbial pendulum.

A year ago, the average "B" socket-power unit would not supply sufficient power at a voltage high enough to operate, to the best advantage, a receiver employing a 171-type power tube. Today the average high-grade "B" unit meets this requirement. But still the tendency seems toward even higher voltages; not because of sound engineering practice, but because of the dealers' no-longer-valid method of using voltage as an "indicator of merit."

What is the voltage and current that a "B" power unit should deliver to the average radio receiver in order to insure the optimum performance?

WHAT IS REALLY NEEDED?

First, let us consider voltage. The highest plate voltage is used only for the power tube, which may be of either the 112 or the 171 type. Because of the greater undistorted volume obtainable from a set equipped with a 171 power tube in place of a 112 tube, the former is more generally used. According to the tube manufacturers, the optimum plate voltage for use with this tube is approximately 180. As all of the other tubes in a receiving set operate at a plate voltage less than 180, this power-tube voltage determines the maximum voltage which the "B" unit must deliver, while supplying sufficient current to operate the receiver.

As a result of the study of the characteristic curves of the general-purpose tubes and the collection of data on the current drain of various popular commercial receivers, it has been found that the great majority of sets impose on the "B" power unit a total load between 30 and 35 milliamperes. There are some sets that draw as much as 40 milliamperes, but they are very few.

In order to segregate this total load into its various components, the following data are given:

	"B" current in milliamps.
Average R.F. amplifier per stage, at 67½ volts ..... (usually 2 or 3 stages)	2.5
Average R.F. amplifier per stage, at 90 volts ..... (usually 2 or 3 stages)	5
Average A.F. amplifier per stage, at 90 volts ..... (usually one stage general-purpose tube)	5
171-type power tube at 180 volts.... (40.5 volts—"C" bias)	20

This gives from 32.5 to 37.5 milliamperes as the total "B" current required for the average set. (Note: the detector tube is omitted, as its drain is quite negligible—usually well under 1 milliampere.)

Thus, to meet fully the requirements of the average receiver, a "B" power unit need be capable of supplying but 40 milliamperes at 180 volts. Granted that it is well to have a little margin for good measure, in order that sufficient power at a high enough voltage shall be still obtainable as the rectifier tube gets fairly well along toward the natural end of its useful life—let us set the maximum desirable rating as 60 milliamperes at 180 volts. Why, then, go further? Surely there is no use, at this time, for higher voltages, or higher currents at the same high voltage.

Far better would it be for the manufacturer to provide for the absorption of the power, in excess of 60 milliamperes at 180 volts, by means of a parasitic-load resistor or a voltage-regulator tube located within the power unit in order simultaneously to improve the voltage regulation and to decrease the effective output impedance.

PURCHASE OF NEW TUBES

While on the subject of the fallacies regarding "B" power units which are entertained by the radio public to a considerable extent and by the radio dealer almost universally, it may be well to say a few words about replacement of rectifier tubes.

It seems to be generally believed—particularly by radio dealers—that, when the rectifier tube in a "B" power unit has served its useful life and the time comes for its replacement, it must be replaced by a tube of the identical rating. While this is a safe rule to follow, in some cases it deprives the user of the advantages to be gained from a newer development, or from a reduction in the cost of a formerly higher-priced device.

At this time both of these reasons apply to the use of the Raytheon 125-milliampere rectifier tube as a replacement tube for the original 60-milliampere tube.

There are now, according to all available

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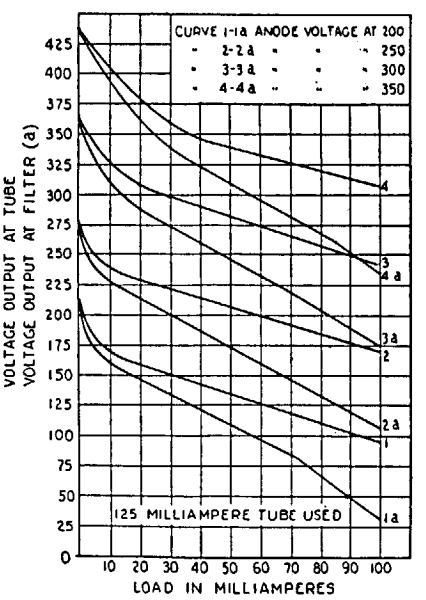

Fig. 2. A comparison of the curve for a 125-milliampere tube with the preceding diagram will show how much the margin of reserve power counts for in holding voltage steady as the current drawn increases.

it becomes necessary to balance their outputs by means of resistors. Cells after some use show evidence of *fatigue;* that is, a deterioration of the photoelectric surface, often due to leakage currents which flow when the cell is not exposed to light. This difficulty regarding "dark currents" is, however, eliminated by careful design.

The thought will arise that cells may be more sensitive to certain light frequencies than to others; this is a fact. The cells we have discussed show a maximum sensitivity in the blue-violet part of the spectrum, while yellow-green elicits the greatest response from the average eye.

In conclusion it may be mentioned that the photoelectric effect has been produced with other than the metallic elements. Crystalline substances and many inorganic compounds respond to the action of light, but these facts, while interesting, are of no service in communication work and need no further consideration here. (A discussion of this subject will be found on page 32 of RADIO NEWS for July, 1927.)

Does Voltage Indicate Merit?

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statistics, in use between 600,000 and 700,000 "B" power units which were designed for use with the original 60-milliampere tube. As by far the greater percentage of these units have been in service for a length of time close to the normal life of the tube, some data on this subject should be at present of interest to the readers of RADIO NEWS.

Though the 60-milliampere rectifiers cannot, as a rule, be used to replace a 125-milliampere rectifier, there are a great many instances in which several worth-while advantages are to be had by the use of the 125-milliampere tube as a replacement unit for the smaller one.

The first of these is increased output. In gaseous-conduction rectifiers the voltage drop across the tubes is very nearly a constant; about 120 volts for the 60-milliampere tube and 90 volts for the 125-milliampere tube, regardless of the load current. As the majority of power units originally designed for use with the former type tube were of the lower-voltage type previously referred to, there is generally an advantage to be gained by increasing their output. Most such power units have a maximum voltage output in the neighborhood of 150 volts at 40 milliamperes.

By the use of the 125-milliampere tube, the output is increased to about 180 volts and 40 milliamperes or sufficient to operate a 171-type tube at full plate voltage, while supplying sufficient current for the great majority of radio receivers.

CONDENSER SAFETY MARGIN

Perhaps it may be thought that this higher output voltage will damage the filter condensers in the power unit. Such is, however, not the case, as the condensers of all reliable power units are made to withstand voltages very much higher than the normal operating voltage; an increase of thirty volts is quite insignificant.

The manufacturer, in the design of the condensers for his power unit, must, in fact, provide against the possibility of the device being operated without load; as this would result if the power unit were turned on without being connected to a radio receiver, or if the filament switch of the receiver were turned off while the "B" unit remained in operation. In this case, the voltage across the filter condensers might well be two or more times the normal operating voltage. It will be seen that the slight increase in voltage due to the use of a 125-milliampere tube in place of a 60-milliampere one seems even more insignificant.

The voltage across the buffer condensers is determined by the power transformer and not by the rectifier tube. Thus, the strain on these condensers is the same, regardless of the voltage drop across the rectifier tube.

In fact, the use of a tube of the 125-milliampere type in place of a smaller one may even reduce the strain on the condensers, in the case of some "B" power units which are equipped with "high" and "low" voltage switches; the former tube with the switch at "low" position gives about the same output as the latter with the switch at "high" position.

LARGER TUBES LAST LONGER

But perhaps the most important reason for replacing a small tube with a larger one when the occasion arrives, is that the latter will ensure longer life and smoother operation. Anyone will readily appreciate the fact that any device—whether an automobile engine or a radio tube—will last longer and perform more smoothly, if operated below its maximum rated output. It is only reasonable to expect that the 60-milliampere tubes, having a normal life of 1000 hours (which is equivalent to one year of average use), will not last as long while operating close to full load as a 125-milliampere tube, also having a life rated at 1000 hours, but only operating at less than half its full load.

When the 125-milliampere rectifier is used to replace a 60-milliampere one, it may be found necessary to readjust slightly the voltage controls on the power unit and, perhaps, to increase the negative "C" voltage in the last audio or power stage.