A New Type of Rectifier Tube for Amateur Use

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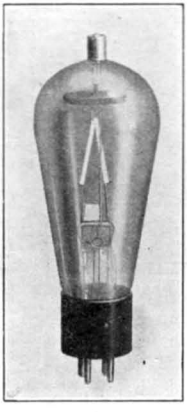
The matter of obtaining suitable rectifiers for plate supply systems for amateur transmitters has been one upon which much work has been expended. Practically all rectifiers have some bad disadvantages: the chemical rectifier is cumbersome and sloppy, the Kenotron has a high internal drop and the mercury arc requires a large amount of accessory equipment. This article describes a new mercury vapor, thermionic tube that combines the simplicity of operation found in the Kenotron with the low internal drop characteristic of the mercury vapor tube. It bids fair to become the most important development in rectifiers that the amateur has yet seen and at this time when we are looking about for suitable power supply systems for our "1929" transmitters, it is of extreme importance to us.—Editor.

THERE has recently been developed for amateur use a new rectifier tube known as the UX-866, involving a new principle of operation. This tube is known as a hot cathode mercury vapor rectifier, and the purpose of this article is to tell something of its characteristics and the best conditions for its use.

The new tube employs a hot cathode of the "Wehnelt" type and contains mercury vapor. It differs from the usual mercury arc tube in two ways. First, it operates at relatively low temperatures so that the vapor pressure of the mercury is low. This results in a high breakdown voltage between the electrodes in an inverse direction. Second, the rectified current is made up of electrons emitted from the filament rather than from a pool of mercury. In this respect the tube is similar to the ordinary high vacuum two-electrode rectifier tube but it differs from the high vacuum tube in that the ionized mercury vapor neutralizes the electron space charge around the filament. This means that where in the vacuum tube a hundred volts or more might be required to give a certain plate current the mercury tube will give the same current with only about 15 volts between plate and filament. Of course, just as in the vacuum tube the current can never be greater than the electron emission of the filament, but up to this point the voltage necessary to pass the current is practically independent of the current and is never more than about 15 volts.



RADIOTRON UX-866

This tube borrows a little from most all the types with which we are familiar. The filament is of the flat ribbon coated type drawing 5 amperes at 2.5 volts. The plate is about as large as a quarter dollar and its edge is turned down towards the filament. The plate lead terminates in a cap such as is found on the 222 and the glass envelope is similar in size to the 210.

It may seem strange that the current can increase without an increase in voltage until it is remembered that as the current increases more positive ions are formed which further neutralize the electron charge around the filament and permit additional electron current to flow.

The cathode is a coated ribbon filament which quickly assumes its operating temperature when the filament voltage is applied. This type of filament is especially well suited for operation in mercury vapor and is not harmed by high inverse voltages; that is, voltages in a reverse direction during the half cycle when no current is flowing. As the voltage drop within the tube is always low there is no harmful ionic bombardment of the filament, since the ions which do strike the filament are moving slowly.

The low voltage drop in this tube results in increased d.c. rectified voltage for a given a.c. supply and also improves the voltage regulation characteristics of the rectifier. The only reduction in rectified voltage when the load is increased is due to the drop in the transformer and filter windings. The low tube drop also allows the use of circuits employing rectifier tubes in series which is not usually a desirable connection when using high vacuum tubes.

The low drop is largely independent of tube geometry so that a simple inexpensive electrode structure is possible. This results in a somewhat smaller tube than a high vacuum tube having equivalent output.

As with high vacuum thermionic tubes, this type of mercury rectifier does not re-

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quire the usual starting mechanism, as electron emission is available as soon as the filament is lighted.

The tube is designed so that under normal voltage and current conditions, its operation is independent of temperature up to an ambient temperature of 50° C. (122° F.) Higher temperatures are not usually encountered but if under special conditions the ambient is greater than 50°, an air blast

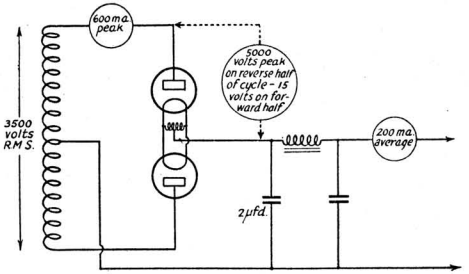

FIGURE 1. TWO TUBES ARE USED IN A FULL-WAVE RECTIFYING CIRCUIT

With condenser input to the filter, the peak current through each tube is approximately three times the average output current from the two tubes. This filter arrangement should be used where the output voltage is relatively high and the output current is low.

should be used in such a manner as to cool the lower portion of the tube.

The method of rating this tube differs from that used in the past with vacuum tubes and may require some explanation. Heretofore, rectifier tubes have usually been rated on the basis of a.c. supply voltage and the d.c. load current. Occasionally the d.c. voltage was also given. This method was very convenient where there was little variation from the usual single-phase full-wave circuit. However, with the low voltage drop of the mercury vapor tube it is possible to make use of a variety of circuits, some of which involve the use of tubes in series. The former method of rating then becomes incomplete and often misleading. For this reason the rating of this new tube is stated in terms of the fundamental limits of the tube. There are two such limits. The first is the maximum peak inverse voltage which is the safe flash back limit which the tube will stand while operating within the rated temperature range. The other limit is the peak current through the tube, which is dependent on the emission available. In the UX-866 these are 5,000 volts and 0.6 amperes respectively.

The peak inverse voltage in single phase circuits may be taken as 1.4 times the total transformer voltage (r.m.s. value). The peak plate current is not as easy to determine as it depends upon the filter constants. With a large condenser (greater than 2 μfd.) on the rectifier tube side of the filter (Fig. 1), the peak current *per tube* is roughly three times the load current *from two tubes.* With a large choke (greater than 10 henries) on the rectifier tube side of the filter (Fig. 2) the peak current *per tube* is approximately 1.5 times the load current *from two tubes.*

No attempt will be made here to include all the rectifier circuits sometimes used with this tube, but the accompanying table shows the ones most useful on single phase circuits. However, three phase circuits are often desirable when three phase power is available.

This table assumes the use of several well known transmitting tubes. For every case the maximum allowable plate voltage for c.w. use is chosen except for the UX-852 where both 2000 and 3000 volts are listed. The maximum safe input current to the transmitting tube is also assumed. A suitable rectifier is then shown for each transmitter. It is interesting to note that either two or four UX-866 tubes will supply every ordinary need for plate power for amateur transmitters.

The last two circuits are of special interest, where greater than 2000 volts is required. Here two tubes are used at each

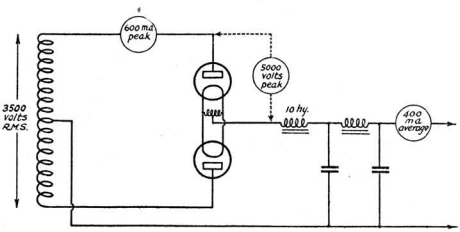

FIGURE 2. IN THIS CIRCUIT ARRANGEMENT, THE FILTER INPUT IS THROUGH A CHOKE

Here the peak current through each tube is only approximately one and a half times the average output current obtained from both tubes. A sacrifice in output voltage results, though, and this type of filter should be employed in cases where the output voltage may be low but where high output current is necessary.

end of the transformer so that full-wave rectification is accomplished without the use of a transformer mid-tap. As this connection makes full use of the transformer without increasing the peak inverse voltage, twice the usual voltage may be obtained. Two tubes act in series with this circuit, but this does no harm as the combined voltage drop is very low.

It is interesting to see how the choice of filter affects the output obtained. For instance, in supplying the UV-203-A tube, comparatively low voltage but high current

is required. Here a choke is used next to the tube to reduce the peak tube current at the expense of the voltage output. In the case of the UX-852, at 2000 volts, lower currents are required so that a condenser

LAYOUT FOR AMATEURS

OSCILLATOR			RECTIFIER			RECTIFIER DIAGRAM	⊗ FILTER
TUBES	VOLTAGE	AMPERE	TUBES	TOTAL TRANSFORMER VOLTAGE	PEAK PLATE CURRENT PER TUBE		
UX-210 ○	450	0.060	2-UX-866	1250	0.090 ★		120-VOLT DROP
UV-211 OR UV-203-A ○	1250	0.175	2-UX-866	3500	0.265		350-VOLT DROP
UX-852 OR UX-860 ○	2000	0.100	2-UX-866	3500	0.300		200-VOLT DROP
UX-852 OR UX-860	3000	0.100	4-UX-866	3500	0.150		200-VOLT DROP
UV-204-A	2500	0.275	4-UX-866	3500	0.400		550-VOLT DROP

NOTES.
⊗ *1000 ohms chosen as resistance of typical choke.*
★ *Approximate values*
○ *Two tubes may be used in parallel without overloading rectifier*

TABLE INDICATING VARIOUS USES OF THE UX-866

The above table indicates a suitable rectifier and filter arrangement for transmitters employing six different types of tubes commonly used by amateurs. It should simplify greatly the problem of picking the correct combination for most amateur transmitters. The cases treated are varied enough to allow other combinations to be determined without much guesswork being involved.

may be used next to the tube without exceeding the peak tube current limit. The result is a higher output voltage than in the former case. The only difference between the two cases is whether a choke or a condenser is placed on the rectifier tube side of the filter.

There are a few operating limits which might be emphasized here, although they are covered in the instructions accompanying the tube.

The filament of the UX-866 tube should always be operated at rated voltage. Less than this voltage may result in a high voltage drop across the tube with consequent bombardment of the filament and eventual loss of emission or even puncturing of the bulb. Greater than rated voltage will shorten the life of the filament by burn out.

A UX base is provided, the grid and plate terminals being anused.

During shipment the mercury may have become spattered onto the filament and anode and therefore when tubes are first placed in operation the filament should be lighted at normal temperature for a few minutes with no plate voltage applied to the tube in order to properly distribute the mercury. Once in service, it should not be necessary to repeat this process.

When starting rectifiers using these tubes, at more than 2100 volts peak inverse the filament should be lighted for 30 seconds before plate voltage is applied. This may be automatically accomplished by a time delay relay in the plate circuit.

During life the bulbs will eventually darken. This is not an indication of the end of life and tubes should not be discarded on this account.

Strays

A new printing has been made of the Constitution and By-Laws of the A.R.R.L., revised to March 1928. A copy will be mailed upon request to any member of the League.

An idea of controlling regeneration in the short-wave receiver is suggested by W8AXW. A variable resistor of 50,000 ohms maximum is connected in series with a 250 μμfd. fixed condenser, the two being shunted across the tickler coil. The rotating arm of the resistor is connected to the side of the coil going to the "B" battery so as to reduce "body capacity effects" This method, he states, gave as good control as the use of a "throttle" condenser with the added advantage that it caused practically no detuning when being adjusted.

"With two or more wires in a counterpoise, care should be taken that this arrangement does not act as an inefficient Hertz and absorb most of the energy from the set. In one particular station, the counterpoise was of such dimensions that it resonated to the wave on which it was desired to transmit. After taking down four of the six wires and testing about every piece of metal in the vicinity, the trouble was corrected by cutting two feet off each wire and using a four-wire counterpoise. This trouble was fought against for eight months before it was finally conquered."—*W5AUR.*