Ten More Tubes

LOOKS as though we were a little over-optimistic in hoping that there would be a breathing spell in the release of new-tube types (a hope expressed, it may be remembered, when the tube tabulation was published in September *QST*). The new-tube business is still going strong, as evidenced by the fact that ten — at least — new numbers have been announced in the interim. And what numbers some of them were! No more simple two- or three-digit combinations; henceforth a new tube is likely to have a cabalistic designation from which can be gleaned some inkling of the kind of tube it is. More about this later, however.

Releases on some of the types to be described in the following paragraphs are just hot off the press, but a few of them have been out for three or four months. Let's clean up these old ones first. They are the Types 19, 48, 59 and 79. Only one or two of them are likely to have general interest for amateurs.

The Type 19

The Type 19 is a two-volt battery tube designed for Class B operation. Really two tubes in one, it is a complete Class B amplifier, but is not one of those tubes that can be used as everything from a triode to a pentode. When properly excited it will deliver approximately two watts of audio power with a plate voltage of 135. The bulb is the same as is used for the 37 and 56. The tube has a 6-pin base. The grid bias used with the tube may be between zero and 6 volts, depending upon the output power required and the plate battery drain considered desirable.

The ratings and operating conditions of the 19 are as follows:

Filament voltage	2.0 d.c.		
Filament current	0.26 amp.		
Plate voltage	135	135	135 volts
Grid voltage	0	−3	−6 "
Plate current (no signal)	10	4	1 ma.
Plate current *	27	25	22 "
Load resistance (plate to plate)	10,000	10,000	10,000 ohms
Power output	2.1	1.9	1.6 watts
Input power required (on grids)	170	130	95 mw.

This tube should work nicely as the modulator in portable 5-meter 'phone transmitters, in addition to its obvious use as an audio power tube in battery receivers. For the latter application, the tube will deliver about 1.25 watts when excited by a single Type 30 tube used as an audio amplifier after the detector. For the higher powers shown in the table above, an additional audio stage will be necessary. The data on the 19 is from Sylvania.

* Signal 50 volts grid to grid.

The 48

The 48 is a power amplifier for the 110-volt d.c. broadcast receiver. A four-element tube, it has the general characteristics of a pentode without actually having a suppressor grid. A special ribbed plate construction minimizes secondary emission. The tube has an indirectly-heated cathode, the filament operating at the rather high potential of 30 volts.

Following are the ratings and operating conditions:

Heater voltage	30.0 volts d.c.	
Heater current	0.4 amp.	
Plate voltage	95	125 max. volts
Screen voltage	95	100 " "
Grid voltage	−20	−22.5 "
Load resistance	2000	2000 ohms
Amp. factor	28	28
Plate resistance	10,000	10,000 ohms
Mutual conductance	2800	2800 μmhos
Plate current	47	50 ma.
Screen current	9	9 ma.
Power output (total distortion 9%)	1.6	2.5 watts

The 48 has the large dome-top bulb and a 6-pin base. It is a standard item with all manufacturers.

The 59

Here is the first tube to have one of those long-heralded seven-pin bases. The 59 is a triple-grid power amplifier — with an indirectly heated cathode. It can be used as a Class A triode or pentode amplifier, or as a Class B amplifier by making the now-customary switches in the grid connections. Heater voltage is 2.5, a.c. or d.c., and the heater current is 2 amps.

For use as a Class A triode, the innermost grid (No. 1) becomes the usual control grid and Nos. 2 and 3 are tied to the plate. With these connections we get the following operating conditions:

Plate voltage	250 max. volts
Grid voltage	−28 "
Amp. factor	6
Plate resistance	2400 ohms
Mutual conductance	2600 μmhos
Plate current	26 ma.
Load resistance	5000 ohms
Undistorted power output	1.25 watts

By using No. 1 grid as the control grid, No. 2 grid as a screen and connecting No. 3 to the cathode the 59 becomes a pentode with the following ratings:

Plate voltage	250 max. volts
Screen voltage	250 " "
Grid voltage	−18 "
Amp. factor	100
Plate resistance	40,000 ohms
Mutual conductance	2500 μmhos
Plate current	35 ma.

Screen current	9 ma.
Load resistance	6000 ohms
Power output (total distortion 7%)	3 watts

The following operating conditions obtain when the 59 is used for Class B work, in which Grid No. 3 is tied to the plate and Nos. 1 and 2 are connected together:

Plate voltage	300	400 volts
Grid voltage	0	0 "
Static plate current (per tube)	10	13 ma.
Dynamic peak plate current (per tube)	200	200 ma.
Load resistance (plate to plate)	4600	6000 ohms
Power output (2 tubes)	15	20 watts

The 59 can dissipate continuously 10 watts on the plate and 1.5 watts on the Nos. 1 and 2 grids.

From the above it is apparent that as a Class A triode the 59 is about the equivalent of a 45; as a pentode it is similar to a 47, and as a Class B amplifier is approximately the same as a 46. It can likewise be put to the r.f. uses which those tubes perform in low-power transmitters. The indirectly heated cathode is advantageous because no filament by-pass condensers are needed and because a single filament transformer can serve for all the tubes in the transmitter, while at the same time each tube has an independent cathode. This is fine if center-tap keying is to be used on one of these tubes in an amplifier stage.

The 79

This tube is another "twin" Class B amplifier — two high-μ triodes in one envelope. It belongs to the 6.3-volt series of tubes, has a small dome-top bulb, a six-pin base, and sports a grid cap on top. Power output of about five watts at 180 volts which isn't bad for the modulator in a small 'phone set. Typical operation is as follows:

Heater voltage	6.3 volts
Heater current	0.6 amp.
Plate voltage	180 volts max.
Grid voltage	0 volts
Static plate current	7.5 ma.
Dynamic peak plate current (per plate)	90 ma. max.
Load resistance (plate to plate)	7000 ohms
Power output (with average grid power 380 mw.)	5.5 watts

The 79 is capable of dissipating 7 watts continuously on its two plates.

The ER-1

The four tube types just described are, as we pointed out at the beginning, not exactly new journalistically speaking because they have been purchasable for the past three or four months, although no doubt a large number of amateurs have never heard of them. The group we are coming to now is unique because none of the tubes in it are multi-purpose affairs but are either bigger and better versions of some of the old straightforward types or else are miniature rectifiers. Number one of this bunch is the ER-1, made by Eveready-Raytheon.

The ER-1 is a half-wave high-vacuum rectifier. It has an indirectly-heated 6.3-volt cathode, and is intended to be used in series-operated a.c. receivers ("transformerless") or in automobile "B" substitutes, replacing the gaseous rectifiers in the latter. It has a small dome-top bulb and a 4-pin base. In looking at this (and other tubes of this miniature rectifier series) one can't help but be impressed by the unbelievably small separation between plate and cathode, yet all these tubes are rated to handle 250 volts r.m.s. on the plate. The voltage drop in the tubes is low in comparison with other high-vacuum rectifiers, probably as a result of the construction.

The ER-1 has the following ratings:

Heater voltage	6.3 volts
Heater current	0.3 amp.
A.C. plate voltage	250 volts r.m.s. max.
D.C. output current	50 ma. max.
Peak current	250 ma. max.
Heater-cathode bias	300 volts max.

This last refers to the maximum allowable difference of potential between the cathode and heater. In rectifier circuits for which this tube is intended the source of heater potential usually will be grounded, while the cathode will, as in other rectifier circuits, usually be at the plate potential above ground.

The 84 (6Z4)

The 84 (or 6Z4 under the new system of notation) is a full-wave companion to the ER-1. It is also being made by Eveready-Raytheon. It is designed for use in "B" eliminators made for automobile receivers, has an indirectly-heated cathode, and its ratings are approximately the same as the ER-1. They follow:

Heater voltage	6.3 volts
Heater current	0.3 amp.
A.C. plate voltage (per plate)	225 volts r.m.s.
D.C. output current	50 ma. max.
Peak plate current (per plate)	125 ma. max.
Heater-cathode bias	300 volts max.

The 84 has the small dome-top bulb and a 5-pin base. And now a word about the new system of tube designation. Each designation consists of a numeral, a letter and a second numeral, as in the alternative designation given above for the 84. The first numeral refers to the filament voltage (i.e., the number 6 means that the tube has a 6.3-volt filament), the letter identifies the particular tube, and the last figure gives the number of elements in the tube. Tubes carrying the letter "Z" are rectifiers, while those having "A," "B," etc., are radio and audio amplifiers, detectors, etc. Thus, the "6Z4" can be identified roughly as a rectifier with a 6.3-volt filament and having four elements — in this case the heater, cathode and two plates — if one has the key to the cipher. It looks as though the new system should be useful even though it does not tell exactly what the tube is — and it *does* have some logic to it. The old system certainly didn't.

The 25Z5

Knowing the idea behind it, we immediately call this one a rectifier with 5 elements and a 25-volt filament. But why five elements in a rectifier tube? It's quite simple, after all: the 25Z5 has a heater, two cathodes and two plates; in other words, two entirely separate half-wave rectifier tubes with a single source of cathode heating.

The two separate cathodes make it possible to use the 25Z5 as a voltage doubler in a.c. receivers not equipped with transformers. Voltage doubling circuits (which, incidentally, are shown in *The Radio Amateur's Handbook*) will give a higher d.c. output voltage than could be expected from the source with ordinary rectifier circuits, but the regulation is generally poorer. The 25Z5 can be hooked up to the 110-volt line without any transformer but simply a series resistor for the heater and will deliver d.c. output voltages of the order of 180 at 100 milliamperes if the filter condensers are big enough. The tube also can be used as a half-wave rectifier in "universal transformerless" sets working from the 110-volt line, either a.c. or d.c. Seems superfluous to "rectify" the current from a 110-volt d.c. line, but that makes the receiver "universal." When used in this way the drop through the tube is extremely small — a matter of about 6 volts with a current of 100 milliamperes, better even than a mercury-vapor tube could do.

The ratings on the 25Z5 are as follows:

Heater voltage	25 volts
Heater current	0.3 amp.
A.C. plate voltage	125 max. per plate
D.C. output current	100 ma. max.
Peak current (per plate)	250 ma. max.

The information on this tube comes from Eveready-Raytheon and RCA Radiotron-Cunningham.

The 25Z5 has a small dome-top bulb and a 6-pin base.

The 2A5

The 2A5 is a power pentode, indirectly-heated cathode, 2.5-volt heater. Its general performance is so nearly like that of the 59 when the latter is used as a pentode that we can't help but wonder just why it was thought necessary to bring out a separate type for pentode use only. Here are its tentative ratings and characteristics:

Heater voltage	2.5 volts
Heater current	1.75 amp.
Plate voltage	250 volts max.
Screen voltage	250 " "
Grid voltage	—16.5 volts
Plate current	34 ma.
Screen current	6.5 ma.
Plate resistance	100,000 ohms approx.
Amplification factor	220 approx.
Mutual conductance	2200 μmhos
Load resistance	7000 ohms
Power output (total distortion 7%)	3.0 watts

The 2A5 has a medium-size dome-top bulb and a 6-pin base. The information on the tube came from RCA Radiotron-Cunningham.

The 2A3

The introduction of Class B audio provided the means of obtaining relatively tremendous power outputs to take care of the fortissimo passages of large orchestras and at the same time made it possible to get a decent amount of audio power with an economy of plate input power. From the standpoint of the set manufacturer, however, it has its disadvantages. The exciter stage has to be capable of delivering real power also, which sometimes necessitates an extra audio stage, and the harmonic distortion is not so easily controlled, since an amplifier which has satisfactory distortion at full output may, to the hypercritical, have more-than-permissible distortion at low output.

So we find that the 2A3 tube is a step back toward fundamentals. It is a real he-man Class A triode amplifier. A 2.5-volt tube with three (only three!) elements; filament, grid and plate. This tube is not yet available, but the bulletin on it issued by RCA Radiotron-Cunningham states that a pair of 2A3's in push-pull can deliver 15 watts of audio power. Instead of a single filament the 2A3 has a large number of coated filaments arranged in series-parallel to give a large cathode area, which results in unusually high mutual conductance and low plate resistance.

The tentative ratings and characteristics of the 2A3 are given below:

Filament voltage	2.5 volts	
Filament current	2.5 amp.	
Interelectrode capacitances:		
Grid to plate	13 μμfd.	
Grid to filament	9 μμfd.	
Plate to filament	4 μμfd.	
As a single Class A amplifier:		
Plate voltage	250 volts max.	
Grid voltage	−42 volts	
Plate current	60 ma.	
Plate resistance	765 ohms	
Amp. factor	4.2	
Mutual conductance	5500 μmhos	
Load resistance	2500 ohms	
U.P.O.	3.5 watts	
In-push-pull:		
	Fixed Bias	*Self-Bias*
Plate voltage	300 max.	300 max. volts
Grid voltage	−62	−62 volts
Plate current (per tube)	40	40 ma.
Load resistance (plate to plate)	3000	5000 ohms
Total harmonic distortion	2.5	5 %
Power output	15	15 watts

It is apparent that a single 2A3 is the equivalent of two 45's in power output as a straight Class A amplifier. The push-pull ratings are interesting because the operation runs into the variable plate current region. The tubes are slightly overbiased so that large grid swings can be handled without grid current being drawn. The second-harmonic distortion in each tube is quite large in this method of operation, but it is cancelled in the output because the two tubes are in push-pull. Hence the power output obtainable for a given percentage of total distortion is much greater than twice that of a single tube.

The 2A3 may turn out to be a fairly good tube for r.f. as well, although from the published characteristics it would appear to have some disadvantages. The inter-electrode capacitances are rather large, and the plate resistance is so low that loss of bias probably would mean that the tube would draw dangerous plate currents.

The 2A3 has a large dome-top bulb and a 4-pin base.

The 5Z3

With a couple of tubes like the 2A3 going into a receiver, something has to be done about the plate supply. A Type 80 rectifier won't stand the gaff and the mercury tubes introduce filtering difficulties; consequently we find the 5Z3 being brought out. This tube is a high-vacuum full-wave rectifier capable of handling about twice the current that can be passed by an 80. The ratings on the 5Z3 follow:

Filament voltage..................	5.0 volts
Filament current..................	3.0 amp.
A.C. voltage per plate............	500 volts r.m.s. max.
D.C. output current..............	250 ma. max.

The 5Z3 is just like the 2A3 in external appearance: large dome-top bulb and 4-pin base.

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This completes the list of new tubes announced since the publication of our tube table in September *QST*. Undoubtedly some of them will find favor for amateur purposes. At any rate we now have an infinite variety of vacuum tubes with all sorts of cathodes and for all sorts of jobs. It seems, however, that the end of the procession is not yet in sight, for rumors are going the rounds that more new tubes are to be released in the immediate future. The "good old days" of three or four types which everybody knew about are gone forever — but the only people who are shedding any tears about it are the ones who refuse to keep up with technical progress.

— *G. G.*

Checking the Behavior of Ultra High-Frequency Waves

(*Continued from page 17*)

point there seemed to be elliptical polarization with the vertical component about three times as strong as the horizontal at the distances used in these tests. Second, going down over a small hill, the antenna usually had to be kept in a vertical position with respect to ground for maximum received signal; in other words, perpendicular to the wavefront.

Results similar to the latter were observed when using a horizontally transmitted wave, i.e., the receiving antenna always gave best results when perpendicular to the wave front of a transmitted beam such as plotted in Fig. 2 or 3. With the horizontal half-wave transmitting antenna, the vertical component was as strong as the horizontal down behind small hills but on top or in direct view, the horizontal was much stronger. Very little change of polarization seemed to take place on any type of simple antenna at distances of 10 or 15 wavelengths but beyond that, hills seemed to change the polarization.

Using a 40-meter half-wave horizontal antenna with single-wire feed, just as used in the 7-mc. band with no changes in feeder location, the vertical and horizontal components seemed to vary. Some places one would be louder than the other and further along in the same direction, or at a different angle, the other component would be stronger. There seemed to be several loops or beams from this antenna for both horizontal and vertical waves. The r.f. feeder was apparently radiating a fairly strong vertical component, itself being mostly vertical, because on the axis of the horizontal wire no horizontal component could be detected though a vertical component could be heard nicely. The horizontal loops or beams were much more noticeable than the vertical values of maximum signal.

The results of these tests indicated that either vertical or horizontal antennas could be used for distances of more than a mile or so but with usually better results if both receiving and transmitting antennas were in the same plane. Intervening hills seemed to alter these conditions, especially if the hills were near the transmitter.

Similar results were obtained when listening with a super-regenerative receiver to various 56-mc. 'phone stations. Sometimes a half-wave horizontal antenna would be best, even when the transmitter used a vertical antenna. However, by an average ratio of about 3 to 1, a vertical receiving aerial gave better results regardless of the type of transmitting antenna. The location of the transmitter with respect to hills and large buildings seemed to have an important effect on the degree of vertical or horizontal polarization at the receiving end. Often the combination of a long, high antenna plus a short vertical (half-wave) one gave the best received signal and is the one most used at this station. The directional antennas also work very well for receiving providing the natural resonant period is not at the wrong end of the amateur band — a director wire for the low-frequency end of the five-meter band becomes nearly a reflector at the other end.

One advantage of a vertical antenna is that its radiation is equal in all directions in a horizontal plane whereas the horizontal half-wave antenna has a figure-eight directional characteristic with minimum signal in its line of axis.