Operating Notes on the New Pentodes

SINCE the brief announcement of the new Raytheon RK-23 and RK-25 and R.C.A. 802 tubes in December *QST*, more detailed information on the tubes has been released by the manufacturers, and some of the tubes themselves are beginning to get around in amateur circles. Tests have shown that they do just about what would be expected of them, considering their power ratings. Besides the suppressor-grid modulation feature for low-power 'phone work, the typical pentode characteristic of high output with low excitation power makes them ideally suited to use as buffer amplifiers—and, for that matter, as final amplifiers in transmitters in which the number of stages must be kept to a minimum. An r.f. output of 25 watts is not difficult to obtain from one tube by going slightly over the normal plate-current rating, and this with excitation quite small in comparison to that usually handed to a 10 or other three-element tube of comparable power rating.

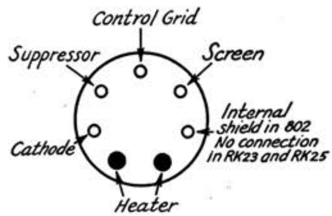

FIG. 1—SOCKET CONNECTIONS OF THE NEW R.F. PENTODES

The connections are viewed from the top of the socket.

Both the 802 and RK-23 (to save space we'll consider the RK-23 and RK-25 synonymous, since the tubes are identical except for their heater ratings) can be used in the same sockets in which the multitudinous 59's are now installed. All the 59 connections still apply except for the plate pin, which is left blank in the case of the RK-23 and is used with the 802 to make connection to extra shielding inside the tube. This shielding is not a tube element, however, so the plate pin on the socket should simply be connected to ground. Fig. 1 shows the top-of-socket connections for both tubes.

By way of review, the general characteristics of the tubes are given below:

	802	*RK-23*	*RK-25*	
Heater voltage	6.3	2.5	6.3	volts
Heater current	0.95	2.0	0.8	amp.
Grid-plate capacitance	0.15	0.04		μμfd.
Input capacitance	12.0	10.0		μμfd.
Output capacitance	8.5	10.0		μμfd.
Max. plate dissipation	10	12		watts
Max. screen dissipation	6	6		watts
Max. plate voltage	500	500		volts
Max. screen voltage	250	200		volts

The safe plate current will vary with the type of service, depending upon the plate efficiency to be expected. In Class-C service where the tube is used as an unmodulated power amplifier—for example as a buffer or telegraph amplifier—with efficiency high enough to keep the plate dissipation within the maximum rating, the maximum plate current rating is 60 milliamperes. For other types of service the plate current will be limited by the safe plate dissipation.

The screen current will likewise vary in different types of service. It is important that the screen dissipation be kept at or below the rated value; i.e., the screen should not be allowed to show more than a dull red heat.

SUPPRESSOR-GRID MODULATION

The suppressor modulation characteristics of the two tubes appear to be quite similar. Power outputs of the order of 3 to 3.5 watts, capable of being modulated 100 percent, are obtainable from both types of tubes under maximum operating conditions. The required peak audio grid swing on the suppressor is 65 volts with the 802 and 75 volts with the RK-23, negative bias on the suppressor being 45 volts on the former, 30 volts on the latter. The audio power requirements imposed by the small current taken by the suppressor-grid are slight, and are well within the capabilities of a Type 56 tube. Control-grid bias for suppressor-grid modulation is not critical, running between 75 and 90 volts.

The following table, taken from the published data on the 802, shows what may be expected from this tube as a suppressor-grid modulated amplifier under different operating conditions:

Plate voltage	400	500	500 volts
Screen voltage	150	200	200 volts
Control grid bias (approx.)	−85	−90	−90 volts
Suppressor bias	−40	−53	−45 volts
Peak audio suppressor voltage	40	53	65 volts
Peak r.f. excitation voltage	125	125	125 volts
Plate current	18	20	22 ma.
Screen current	28	28	28 ma.
Control grid current	7.5	5.0	4.5 ma.
Driving power (approx.)	0.9	0.6	0.5 watts
Peak power output (approx.)	8	12	14 watts
Carrier power output (approx.)	2	3	3.5 watts

The first two operating conditions are of interest because the audio-frequency suppressor voltage swings only to the zero-voltage point and not into the positive region, as is the case in the last column. The increase in carrier output resulting from driving the suppressor-grid into the positive region is quite small. In all cases the r.f. power required for excitation is less than one watt.

Suppressor modulation characteristics of the 802 are shown graphically in Fig. 2. The r.f. output current curve bends off quite sharply above 25 volts positive on the suppressor, indicating that this is about the limiting voltage for distortionless modulation.

GRID-BIAS MODULATION

The curves of Fig. 3, showing the performance of the 802 as a grid-bias modulated amplifier, also will be of interest. Two sets of operating conditions for this type of service are given below:

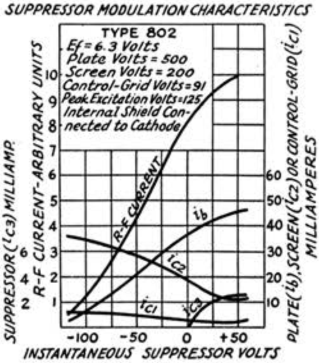

FIG. 2—SUPPRESSOR-GRID MODULATION CHARACTERISTICS OF THE 802

Plate voltage	400	500 volts
Screen voltage	150	200 volts
Control-grid bias (approx.)	−105	−130 volts
Suppressor voltage	0	0 volts
Plate current	25	25 ma.
Screen current	7.5	8 ma.
Grid current	2	1 ma.
Peak r.f. excitation voltage	125	145 volts
Peak audio grid voltage	40	50 volts
Driving power (approx.)	1	0.8 watts
Peak Power output (approx.)	12	16 watts
Carrier power output (approx.)	3	4 watts

Comparison of grid-bias modulation with suppressor modulation shows that the plate efficiency and output to be expected are approximately the same, and also that the same modulator tube that satisfies the requirements of suppressor modulation also will be adequate for grid-bias modulation. Slightly more excitation power is needed for grid-bias modulation, although the difference is not great. The chief differences between the two systems lie in practical operating considerations; the grid-bias system requires more careful adjustment than the suppressor system for linear modulation, and it is necessary to use a bias source having exceptionally good voltage regulation, such as a bank of batteries. Suppressor modulation, on the other hand, is quite tolerant so far as adjustment is concerned, and the bias for both control grid and suppressor can be obtained in the same way as they would in ordinary telegraph service.

The tubes also can be used as Class-B linear amplifiers, giving outputs and plate efficiencies comparable to those obtained with grid-bias and suppressor modulation. Because of the small power output, however, it is probable that a set-up with a preceding modulated amplifier requiring, as it might, additional driving stages, would be an uneconomical way of obtaining three or four watts of modulated output. The tubes are not recommended for use as Class-C plate-modulated amplifiers.

USING THE TUBES AS AMPLIFIERS

If the tubes are used to replace 59 doublers in an existing layout with the hope that they also can be used as straight un-neutralized amplifiers, it is quite possible that some physical changes in the circuit will have to be made. As is the case with any screen-grid amplifier, care must be taken that there is no chance for feedback between plate and grid circuits by a path external to the tube itself. This may or may not mean that the input and output circuits will have to be shielded. From our experiments with the tubes it seems quite certain, however, that the tubes themselves have to be shielded, although complete shielding is not necessary. A short shield which encloses the base and lower part of the tube and extends up around the lower part of the plate is sufficient, its purpose presumably being to shield the plate lead from the rest of the tube and thus eliminate any extra and unwanted grid-plate capacity. Both types of tubes have been operated successfully with no tendency toward self-oscillation with no other shielding in the circuit than this. It was necessary, however, to arrange the input and output tuned circuits so that coupling between them was minimized (coil axes at right angles) and to have them fairly well separated physically. In compact sets the input and output circuits probably would have to be rather completely shielded from each other.

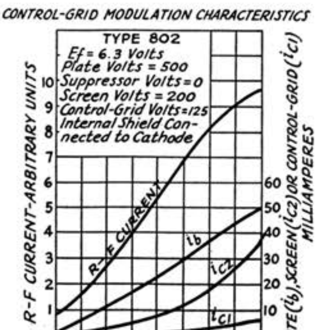

FIG. 3—GRID-BIAS MODULATION CHARACTERISTICS OF THE 802

A typical amplifier circuit is shown in Fig. 4. The plate tuned circuit LC should be low-C at the operating frequency. The grid leak R, when used, may have a value between 20,000 and 50,000 ohms, the former giving somewhat more output when amplifying straight through and the latter better output when doubling. The difference is small, however. The by-pass condensers, C_2, are not critical as to value and should be fairly large

—0.002 or more. The exception to this would be the suppressor-grid by-pass when the suppressor is to be modulated, in which case the condenser should not be so large as to cut off the higher audio frequencies. A 0.001 condenser should be satisfactory for this work.

When the tube is capacity-coupled to the preceding stage the capacity of the excitation condenser, C_1, should be adjustable for best results. Too much capacity at C_1 will overload the previous stage and reduce the output. A value around 30 $\mu\mu$fd. is about right; satisfactory adjustment can be obtained by using an air midget having a maximum capacity of 50 or 100 $\mu\mu$fd. and adjusting it for best output under actual operating conditions.

Cathode bias may be used according to the alternative system shown in Fig. 4, in which case the grid leak R may be omitted. The cathode resistor R_1 should be variable and have a maximum resistance of about 2000 ohms, and should be capable of dissipating about 10 watts. The adjustable feature makes it possible to find the optimum operating bias. Cathode bias offers protection to the tube, in case of excitation failure, which is lacking when the grid leak alone is used.

As power amplifiers, the tubes give greatest output when the screen-grid voltage is maintained at the recommended values. Increasing the screen voltage beyond this only causes the tube to become unstable and exhibit the usual sign of grid emission—climbing plate current. Very nearly maximum output can be obtained with the suppressor grid tied directly to the cathode. A slight increase in output results when the suppressor is operated at a positive potential of 40 or 50 volts, but the increase does not seem to warrant the extra power supply complication unless a suitable tap already is available on the voltage divider. Screen voltage is preferably obtained from a voltage-divider tap, although a dropping resistor from the plate supply may be used. A 10-watt resistor of about 20,000 ohms is recommended as a series dropping resistor.

When using the tubes as doublers the screen voltage sometimes can be reduced with benefit. In one case cutting the screen voltage to half the rated maximum value left the power output unchanged but improved the plate efficiency, as evidenced by lower plate current. An output of 5 to 10 watts is to be expected from one of the tubes as a doubler.

Excitation requirements appear to be quite small and the plate efficiency high when the tubes are used as straight power amplifiers for c.w. work. In a test set-up one of them gave an output of 25 watts on 7 mc. with a d.c. plate input of slightly over 30 watts, the excitation being taken from a Tri-tet oscillator doubling from a 3.5-mc. crystal with only 250 volts and 15 ma. on the plate. Higher oscillator voltage gave no increase in output.

The tubes also can be worked successfully as controlled oscillators or oscillating amplifiers, locking in very readily when coupled to a weak crystal-controlled source. Ordinarily there will be a tendency toward self-oscillation in non-shielded circuits if particular care is not taken to prevent feedback external to the tube itself; this tendency can be used to advantage if the tube is to be used as a locked oscillator, since no particular provision need be made for intentional feedback.

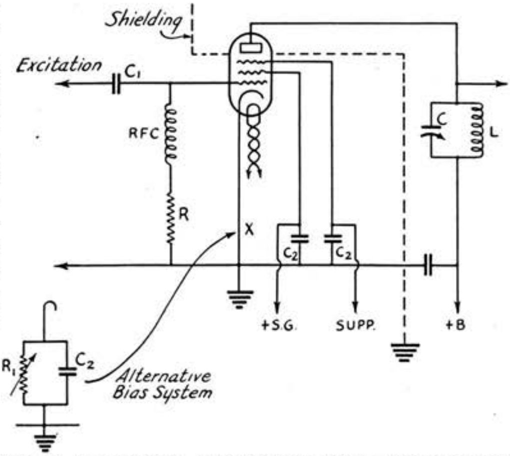

FIG. 4—A TYPICAL AMPLIFIER CIRCUIT FOR THE R.F. PENTODES

Tuned-circuit and by-pass values do not differ from those used with other tubes. The only circuit element likely to be critical in adjustment is the coupling condenser, C_1, which preferably should be a midget variable of about 100 $\mu\mu$fd. maximum capacity.

One of the tubes used as a regenerative amplifier can easily be controlled on 14 mc. by a Tri-tet oscillator having its plate circuit tuned to the fourth harmonic of a 3.5-mc. crystal.

AS OSCILLATORS

The tubes may be used as electron-coupled oscillators, in which case they have the advantage over the 59 that the plate circuit may be tuned to the fundamental as well as a harmonic frequency. Experience with them indicates that tuning through resonance on the fundamental produces a considerable frequency change, at least in an unshielded circuit. Possibly thorough shielding would help to reduce such a frequency change. Frequency stability with respect to changes in plate-supply potentials (with the screen supply coming from a voltage divider across the plate supply) is excellent, however; changes in supply voltage of the order of 25% produce only a barely perceptible change in frequency. For maximum stability of this type it is necessary to find the optimum screen-to-plate voltage ratio, just as in the case of other electron-coupled oscillator tubes. A screen voltage of one-third the plate voltage is about optimum.

(Continued on page 66)

Ahoy! the Guard!

U.S.S. *Louisville*, San Francisco, Calif.

Editor, *QST:*

How about putting locks on the *QST* covers? If I'm not on deck when the mail comes out, I'm apt to be reading my copy over the shoulders of the rest of the gang. Hi! It's an FB mag and I'll always get mine if I have to call out the guard of the day.

—*C. G. Shipman*

Split Phase

Box 180, R.F.D., Crichton, Ala.

Editor, *QST:*

W9NET complained of the bad a.c. hum from his kitten. Perhaps he would find, upon some experimentation, that it is commutator ripple instead of hum. If this is the case, he can overcome the trouble by installing a split phase motor, though it would be wise to consult kitty first.

—*Charles W. Sigler, Jr.*

Operating Notes on the New Pentodes

(*Continued from page 31*)

As Tri-tet oscillators with the output circuit tuned to a harmonic the tubes perform in about the same way as 59's. The plate circuit may also be tuned to the frequency of the crystal, however. From our experience their performance when worked in this way is a good deal like that of an ordinary pentode oscillator. As resonance is approached from the high-frequency side the plate current decreases until a minimum point is reached, the output then being maximum. Further increase in tuning capacity causes a sharp rise and then oscillations cease. The cathode circuit should have the same constants as recommended for the 59. In general, it will be found that the fundamental output will be increased by tuning the cathode circuit far off on the high-frequency side of resonance, the maximum point coming when the cathode circuit is tuned almost to the second harmonic of the crystal. This point also gives low r.f. voltage across the crystal. When the output circuit is tuned to the second harmonic the cathode circuit should be tuned about midway between the second harmonic and the fundamental for maximum output and low crystal voltage. The cathode tuning for maximum output in either case is rather broad, and a condenser setting giving the least crystal voltage, as indicated by a neon lamp touched to the control grid of the tube, should be used. A grid leak of 50,000 ohms seems to be satisfactory.

—*G. G.*

Strays

MNI TNX, FELLERS

The Headquarters Staff acknowledges with deep appreciation approximately one bushel of holiday greeting cards and messages from hams all over the world. They added greatly to our Christmas cheer. Many thanks, gang, and much Happy DX to you!

K. B. W.