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NEW SOVIET RADIO TUBES

A. Azat'yan

/Tables and figures referred to are appended./

I. MINIATURE TUBES FOR LINE (ELECTRIC) RECEIVERS

In the past 2-3 years, the Soviet vacuum-tube industry has designed several new types of miniature receiving and rectifier tubes to fulfill the requests of designers of radio broadcast and television receivers. These include the three sharp cutoff pentodes 6Zh1P, 6Zh2P, and 6Zh4P, Type 6K4P remote cutoff pentode, Type 6B2P remote cutoff diode-pentode, Type 6A2P frequency converter heptode, the 6N1P and 6N2P twin triodes, the 6P1P beam tetrode power amplifier, the 6Kh2P double diode, and Type 6Ts4P full-wave rectifier. All these tubes have oxide-coated cathodes with 6.3-v heaters. In addition, the Type SG1P gas-filled voltage regulator is being produced.

All these tubes have "button-type" seven-pin bases (Figure 1), with the exception of the 6N1P and 6N2P twin triodes and the 6P1P beam tetrode. The latter have the same type of base with nine pins. /Base diagrams for all tubes described in this report, including these listed in Part II, "Tubes With Octal Bases," are given in Figure 2./ The pins in the seven-pin base are placed around a circle 9.5 mm in diameter with an arc of 45° included between adjacent pins, except for the arc between pins 1 and 7, which is 90° (Figure 2). In the nine-pin base, the pins are placed around a circle 12 mm in diameter with an arc of 36° between adjacent pins (72° between pins 1 and 9). The pins of all these tubes have a diameter of 1 ± 0.05 mm and a length of 6 to 7 mm.

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The limiting operating conditions of the new rf pentodes are shown in Table 1 and their normal operating conditions and parameters in Table 2. The data of several other well-known electron tubes are shown in these tables to assist in comparative evaluation of the parameters of the new tubes.

The figures for maximum permissible operating conditions given in Table 1 and the text are established under the assumption that the supply voltages are regulated. If they are not, the maximum voltages, currents, and power must be reduced considerably.

Type 6Zh1P Pentodes

This tube is designed primarily for operation in the rf and if amplification stages of television receivers, where the band width reaches several megacycles. It has high transconductance and low interelectrode capacitances. The sum of the input and output capacitances in the 6Zh1P averages 22% less than in the 6Zh3P pentode. Therefore, by using the 6Zh1P instead of the 6Zh3P, one can obtain approximately 15-20% greater amplification, even though the transconductances of the two tubes are about the same.

The ratio of the transconductance to the sum of the input and output capacitances was increased in the 6Zh1P by reducing the distances between electrodes and also their surface area. The distance between the first grid and the cathode is about 60-70 microns. The smaller cathode surface area also reduced the required filament power; at 6.3 v, the 6Zh1P draws about 175 ma in the cathode circuit, while 300 ma is required for other similar tubes.

The ratio of transconductance to the sum of the in and out capacitances, expressed in ma/v $\mu\mu$fd, is equal to 0.8, which is considerable higher than the corresponding figures for the 6Zh3P and 6Zh4 pentodes. However, actual wide-band amplifier circuits contain not only the output capacitance of the preceding tube and the input capacitance of the following tube, but also the capacitance of the sockets, coils, and resistors and wiring capacitance. All these capacitances must be taken into consideration properly to evaluate the amplifying properties of the 6Zh1P pentode. It can be assumed that careful construction will reduce this additional capacitance to about 7 $\mu\mu$fd; the values of the ratios $S/C_{in} + C_{out} + C_o$, where C_o is taken to be 7 $\mu\mu$fd, are shown in Table 2. These values are proportional to the product of amplification by band width and therefore may serve for comparative evaluation of the amplifying properties of wide-band pentode amplifiers. A comparison of these values shows that the 6Zh1P pentode with $S = 5.2$ ma/v is equal to the 6Zh4 with $S = 9$ ma/v when used for wide-band amplification and can give 15% higher amplification than the 6Zh3P.

The 6Zh1P has two cathode terminals, which is essential for operation in the ultrashort-wave band. It can be used effectively at frequencies up to 300-350 Mc. In order to reduce the inductance of the cathode lead, which has a detrimental effect on the input resistance of the tube, the second and seventh pins of the socket are connected together and two or more conductors are connected to the corresponding points of the circuit. A better way of using the two cathode leads is to connect one of them into the plate circuit of the tube and the other into the grid. This separates the output circuit from the input circuit and increases the input resistance of the tube. At frequencies of 30 Mc and higher, connection of one cathode lead to the bias resistor and the other to the by-pass capacitor is incorrect.

Small voltage variations on the control grid of the 6Zh1P cause substantial plate-current variations because of the tube's large transconductance. Therefore, it is best to apply automatic bias on its control grid in such a way that the dc negative feedback provides the necessary stability for the tube's operation. For plate and screen-grid voltages of 120 v, a 200-ohm resistor should be connected in the cathode circuit to obtain the recommended operating conditions.

Type 6Zh2P Pentode

This tube has much in common with the 6Zh1P pentode both in internal and external construction, but the third grid of the 6Zh2P has a separate terminal so that it can serve as a second control grid. Consequently, the 6Zh2P belongs to that group of tubes having double control (similar to mixer and converter tubes). However, it is not recommended for use as a frequency converter at low signal levels, since its internal noise level is higher than that of other converter tubes. Nevertheless, the 6Zh2P can be used in various other circuits where the control action of its third grid is desirable, i.e., so that plate-current changes are accompanied by changes in screen-grid current which are equal in magnitude and opposite in sign.

Type 6Zh4P Pentode

The transconductance of the 6Zh4P is close to that of the 6Zh1P and the 6Zh3P, but its output capacitance is larger. The maximum value of through capacitance was reduced to 0.005 $\mu\mu$fd in this tube by the use of a number of internal shields, including a cylindrical screen encircling the plate. The low through capacitance and the high input resistance of the 6Zh4P makes for stable amplification at radio-broadcast frequencies, where the load resistance reaches hundreds of kilohms. In addition, the 6Zh4P can also be used for perliminary af amplification to obtain a gain of 200 or more in a stage.

Type 6K4P Pentode

Type 6K4P remote-cutoff rf pentode, which also has special internal shielding and low through capacitance, is designed for controllable rf and i-f amplification in radio-broadcast receivers, including automobile receivers. Structurally, it differs from the 6Zh4P only in that several of the middle turns in its first grid have a larger pitch than the rest of the turns. As a result, when the negative voltage on the control grid increases, the stream of electrons from the cathode is not cut off immediately, but gradually instead; it is cut off first where the turns of the grid have the smallest pitch and finally at points where there is the largest gap between turns. This dependency of plate current and transconductance upon the bias voltage makes possible controlled amplification and is useful in automatic volume control.

In such parameters as transconductance, through capacitance, input resistance, and others which determine the quality of a tube as a controllable rf amplifier, the miniature 6K4P pentode is as good as the single-ended Type 6K4 pentode and considerably better than the quite satisfactory Type 6K3 single-ended metal pentode. The 6K4P can be used in radio-broadcast receivers of all classes.

Type 6B2P Diode-Pentode

Type 6B2P diode-pentode with remote cutoff is designed primarily for controllable rf amplification followed by diode detection. The pentode section can also follow the diode section if amplification greater than 25-30 is desired. The parameters of the pentode section of the 6B2P are considerably poorer than those of the 6K4P, but are better than those of the 6K3 and considerably better than those of the pentode section of the 6B8S tube.

Type 6A2P Heptode Converter

In Type 6A2P heptode converter, which has a remote cutoff, the fifth grid is the suppressor and the second and fourth are screens. Therefore, an oscillator employing a 6A2P should use a Hartley circuit (as is the case for the 6A7).

The limiting filament voltages of the 6A2P in operation are 5.7 v and 7.0 v. The maximum permissible voltages on the plate and screen grids and filament with respect to the cathode are 330 v, 110 v, and ± 100 v, respectively. The maximum permissible power dissipated by the plate and screen grids is 1.1 watt each.

Typical operating conditions and parameters are as follows: plate voltage, 250 v; screen-grid voltage, 100 v; third (control) grid voltage, - 1.5 v; grid-leak resistance in the first (oscillator) grid, 20,000 ohms; plate current, 2.9 ma; screen-grid current, 6.8 ma; first-grid current, 0.5 ma; cathode current, 10.2 ma; transconductance, 0.47 ma/v, output resistance, 1 megohm. The maximum diameter of the tube is 19 mm and the maximum height, 54 mm.

As seen from the above data, the 6A2P miniature pentode is very close in operating conditions and parameters to the well-known 6A7 single-ended metal heptode, and even slightly more economical than the latter with respect to current drain (9.7 instead of 12 ma). The excellent parameters of the 6A2P justify its use in electric radio-broadcast receivers of all types designed for AM and FM reception.

6N1P and 6N2P Twin Triodes

The individual triodes in the 6N1P and 6N2P tubes can be used either in the same or adjacent stages of radio receivers and amplifiers. These tubes are useful for transferring from straight to push-pull amplification, for push-pull preamplifier stages, and also for saw-toothed line and frame oscillators in television receivers. In addition, the 6N1P provides a low internal noise level when used in the first stages of highly sensitive television receivers. The operating conditions of these tubes (with the exception of filament current) is shown in Tables 3 and 4.

6P1P Beam Tetrode

This tube is designed basically for audio-frequency power amplification. It can deliver up to 4.5 w power in Class A operation and up to 10-11 w power can be obtained from two 6P1P's in Class AB push-pull operation. As seen from Tables 5 and 6, the 6P1P is very similar in parameters to the 6P6S beam tetrode and is actually a 6P6S in a miniature design.

6Kh2P Double Diode

This tube has the same external appearance and dimensions as the 6Zh1P pentode ($d_{max} = 19$ mm and $h_{max} = 48$ mm). The 6Kh2P draws the same filament power and has approximately the same interelectrode capacitances as the well-known 6Kh6S double diode, but its transconductance is considerably higher. The diodes in the tube are well shielded and insulated from each other; the maximum permissible voltage between either cathode and the filament is 330 v. Because of this factor, the 6Kh2P can be used for various functions, e. g., for rectification of an ac voltage when a dc of up to 16 ma is required. However, the 6Kh2P is designed primarily to detect FM signals in a discriminator or partial detector circuit. With its high transconductance, the 6Kh2P double diode operates well as a video signal detector. The natural resonant frequency of the diodes is about 700 Mc.

6Ts4P Double-Anode Rectifier

The maximum diameter of this tube is 19 mm and the maximum height, 62 mm. The 6Ts4P rectifier is designed for use in second-class line receivers and also in automobile receivers. Since in the latter case the filament is supplied from a storage battery, the electrical strength of the cathode insulation must be high; the maximum permissible voltage on the cathode with respect to the filament is 450 v. The maximum permissible peak inverse voltage is 1250 v and the maximum average rectified current, 70 ma. The filament current of the 6Ts4P is 0.6 a at 6.3 v. In its typical operation as a full-wave rectifier, an ac voltage of up to 325 v is supplied to each plate. Then, with a maximum rectified current of 70 ma and a resistance of the dc choke of 150 ohms, the dc voltage at the filter output will be about 360 v. The 6Ts4P is a miniature analogue of the 6Ts5S rectifier.

Type SG1P Voltage Regulator

The maximum diameter is 22.5 mm and the maximum height, 72 mm. The basic data of the regulator are as follows: maximum firing voltage, 180 v; working voltage, 150 v; minimum current through regulator, 5 ma, and maximum, 40 ma. Because of the smaller volume occupied by the gas, the SG1P is not quite as good as Type SG4S 150-v regulator with an octal base.

II. TUBES WITH OCTAL BASES

New glass tubes with octal bases include the following: the 6P7S beam tetrode, the 6N5S twin triode, and the high-voltage rectifier 1Ts7S. The first two tubes are the most powerful of a number of new receiving-amplifying tubes and therefore cannot be made in the miniature form. With regard to the rectifier, it was found necessary to remove the plate lead from the cathode leads by a considerable distance in connection with the high inverse voltage. This necessitated the use of an octal base and the arrangement of the plate lead on top of the envelope.

6P7S Beam Tetrode

This tube has an oxide-coated indirectly-heated cathode and is designed primarily for operation in saw-toothed oscillators or in the output amplifiers of television line-scanning units. The plate lead is placed on top of the tube because voltages of several kv are developed at the plate in such circuits during flyback. The maximum operating conditions of the 6P7S beam tetrode are shown in Table 5 and the typical operating conditions and parameters, in Table 6. As seen from these tables, the 6P7S has the same parameters as the type 6P3S beam tetrode and differs from the latter only in its ability to withstand short-duration peak voltages of up to 6 kv on the plate. The power delivered by the 6P7S is sufficient to obtain full beam deflection in Type 18LK15, 23LK1B and 31LK1B kinescopes.

6N5S Twin Triode

This tube also has an indirectly-heated oxide-coated cathode. The maximum and typical operating conditions and parameters for the tube are given in Tables 3 and 4. The 6N5S is distinguished by its exceptionally low internal resistance which was obtained by increasing the surface area of the cathodes, by using a small separation between plate and cathode, and also by the use of grids with a widely-spaced winding. One of the major uses of the 6N5S is as a television damping tube to suppress the damped oscillatory process arising in the coils of the line-scanning system when flyback starts and also to improve the linearity of horizontal beam deflection.

The tube can also be used for audio-frequency power amplification in high-quality devices. One 6N5S triode can deliver up to 10 watts' power with a harmonic content not exceeding 2%. Finally, this tube with its low output resistance can be used as a variable resistance in electronic voltage regulators. In such units, the control tube must pass high currents with a comparatively low voltage drop between plate and cathode. If one 6N5S tube is used in this type of regulator, the output voltage of the rectifier can be adjusted from 0 to 250 v and held stable when the current drain varies from 0 to 250 ma.

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Type 1Ts7S High-Voltage Rectifier

This rectifier is designed for rectification of the high voltage used for supplying the anodes of cathode-ray tubes. It has a directly-heated oxide-coated cathode. Because of the economy of this cathode, the output of the line-scanning saw-toothed oscillator or the rf oscillator can be used to heat it. The data of the 1Ts7S are as follows: filament voltage, 1.25 v; filament current, 0.2 a; plate-filament capacitance, 1.6 μμfd; maximum permissible peak inverse voltage, 30 kv; maximum permissible peak rectified current, 17 ma; maximum average rectified current, 2 ma. The above data holds when the rectifier is supplied with a voltage of 300 kc maximum frequency. Any voltage necessary for supplying the 18LK15, 23LK1B, and 31 LK1B kinescopes up to 15 kv can be obtained from a half-wave rectifier circuit using the 1Ts7S. Still higher voltages can be obtained by connecting two 1Ts7S rectifiers in a voltage-doubler circuit.

The 15 tube types for radio-broadcast and television receivers constitute a very good addition to the already existing assortment of receiving-amplifying tubes and should make possible a considerable improvement in the quality of widely-used radio equipment.

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Table 1. Limiting Operating Conditions for RF Pentodes

Electrical Quantity	Unit	6Zh1P	6Zh2P	6Zh3	6Zh3P	6Zh4	6Zh4P	6K4P	6Zh8	6B2P	6K3	6K4
Maximum filament voltage	v	7.0	7.0	6.9	6.9	6.9	7.0	7.0	7.0	6.9	6.9	6.9
Minimum filament voltage	v	5.7	5.7	5.7	5.7	5.7	5.7	5.7	5.7	5.7	5.7	5.7
Maximum plate voltage	v	200	200	330	330	330	330	330	330	330	330	330
Maximum screen-grid voltage	v	150	150	165	165	165	140	140	140	140	140	220
Maximum filament-to cathode voltage	±v	100	100	100	100	100	100	100	100	100	100	100
Maximum power dissipated by plate	w	1.8	1.8	3.3	2.5	3.3	3.3	3.3	2.8	1.1	4.4	3.3
Maximum power dissipated by screen grid	w	0.55	0.85	0.7	0.55	0.45	0.7	0.7	0.7	--	0.44	0.7
Maximum cathode current	ma	20	20	--	--	--	--	--	--	--	--	--

Table 2. Typical Operating Conditions, Parameters, and Dimensions of RF Pentodes

Electrical Quantity	Unit	6Zh1P	6Zh2P	6Zh3	6Zh3P	6Zh4	6Zh4P	6K4P	6Zh8	6B2P	6K3	6K4
Filament voltage	v	6.3	6.3	6.3	6.3	6.3	6.3	6.3	6.3	6.3	6.3	6.3
Plate voltage	v	120	120	250	250	300	250	250	250	250	250	250
Screen-grid voltage	v	120	120	150	150	150	100	100	100	100	100	125
Control-grid voltage	v	*	*	-1.0	*	*	*	--	-3.0	-3.0	-3.0	-1.0

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Table 2 (Contd)

Electrical Quantity	Unit	6Zh1P	6Zh2P	6Zh3	6Zh3P	6Zh4	6Zh4P	6K1P	6Zh8	6B2P	6K3	6K4
Cathode resistance	ohms	200	200	--	200	160	68	68	--	--	--	--
Filament current	ma	175	175	300	300	450	300	300	300	300	300	300
Plate current	ma	7.5	5.5	10.8	7.0	10.0	7.2	10.5	3.0	6.6	9.2	11.8
Screen-grid current	ma	2.5	≤5.5	4.1	2.0	2.5	2.6	4.0	0.8	1.6	2.6	4.4
Transconductance	ma/v	5.2	3.55	4.9	5.0	9.0	4.7	4.2	1.65	2.7	2.0	4.7
Output resistance	megohms	0.3	0.075	0.9	0.8	1.0	1.0	0.8	>1.0	0.7	0.8	0.9
Rated in capacitance	μμfd	4.3	4.3	8.5	6.5	11.0	5.3	5.2	6.0	4.2	6.0	8.5
Max. through capacitance	μμfd	.02	.02	.003	.025	.015	.005	.005	.005	.02	.003	.005
Rated out capacitance	μμfd	2.2	2.3	7.0	1.8	5.0	6.0	5.0	7.0	4.1	7.0	7.0
Ratio $S/(C_{in}\ C_{out})$	ma/v·μμfd	.80	.54	.32	.60	.56	.42	--	.13	--	--	--
Ratio $S/(C_{in}\ C_{out} + C_o)$ $C_o = 7$ μμfd	ma/v·μμfd	.39	.261	.22	.33	.39	.26	--	.08	--	--	--
Maximum diameter	mm	19	19	34	19	34	19	19	34	19	34	34
Maximum height	mm	48	48	67	54	67	54	54	67	54	67	67

* Automatic bias

Table 3. Limiting Operating Conditions of Twin Triodes

Quantity	Unit	6N1P	6N2P	6N5S	6N15P	6N8S	6N9S
Maximum filament voltage	v	7.0	7.0	6.9	6.9	6.9	6.9
Minimum filament voltage	v	5.7	5.7	5.7	5.7	5.7	5.7
Maximum plate voltage	v	300	300	250	330	330	275
Maximum filament-to-cathode voltage	± v	250	100	300	100	100	100
Maximum power dissipated by plate	w	2.0	1.0	13	1.6	2.75	1.1
Maximum cathode current	ma	25	10	125	--	20	--

Table 4. Typical Operating Conditions, Parameters, and Dimensions of Twin Triodes

Quantity	Unit	6N1P	6N2P	6N5S	6N15P	6N8S	6N9S
Filament voltage	v	6.3	6.3	6.3	6.3	6.3	6.3
Plate voltage	v	250	250	135	100	250	250
Grid voltage	v	--	-1.5	--	--	.8	-2
Cathode resistance	ohms	600	--	250	100	--	--
Filament current	ma	600	300	2500	450	600	300
Plate current	ma	8	2.3	110	9	9	2.3
Transconductance	ma/v	4.3	2.0	6.7	5.6	2.6	1.6
Amplification factor	--	35	100	2	38	20	70
Internal resistance	kilohms	8	50	0.3	6.8	7.7	41
Maximum diameter	mm	22.5	22.5	53	19	34	34
Maximum height	mm	57	57	137	54	54	54

Table 5. Limiting Operating Conditions of Beam Tetrodes

Electrical Quantity	Unit	6P1P	6P3S	6P6S	6P7S	6P9
Maximum filament voltage	v	7.0	6.9	6.9	6.9	6.9
Minimum filament voltage	v	5.7	5.7	5.7	5.7	5.7
Maximum plate voltage	v	250	400	350	500*	330
Maximum screen-grid voltage	v	250	300	310	350	330
Maximum filament-to-cathode voltage	± v	100	100	100	135	100

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Table 5 (Contd)

Electrical Quantity	Unit	6P1P	6P3S	6P6S	6P7S	6P9
Maximum power dissipated by plate	w	12	20.5	13.2	20	9
Maximum power dissipated by screen grid	w	2.5	2.75	2.2	3.2	1.5
Maximum cathode current	ma	70	--	--	--	--

*Maximum peak voltage is 6000 v.

Table 6. Typical Operating Conditions, Parameters, and Dimensions of Beam Tetrodes

Electrical Quantity	Unit	6P1P	6P3S	6P6S	6P7S	6P9
Filament voltage	v	6.3	6.3	6.3	6.3	6.3
Plate voltage	v	250	250	250	250	300
Screen-grid voltage	v	250	250	250	250	150
Control-grid voltage	v	-12.5	-14	-12.5	-14	-3.0
Filament current	ma	450	900	450	900	650
Plate current	ma	45	72	45	72	30
Screen-grid current	ma	5	8	5	≤ 8	7
Transconductance	ma/v	4.5	6.0	4.1	5.9	11.7
Internal resistance	kilohms	50	30	50	30	130
Load resistance	kilohms	5	2.5	5	--	10
Output power	w	4.5	6.5	4.5	--	3
Harmonic content	%	--	10	8	--	7
Maximum diameter	mm	22.5	46	34	52	34
Maximum height	mm	72	109	85	145	83

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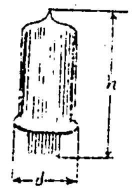

Figure 1. External Appearance and Dimensions of Miniature Tubes

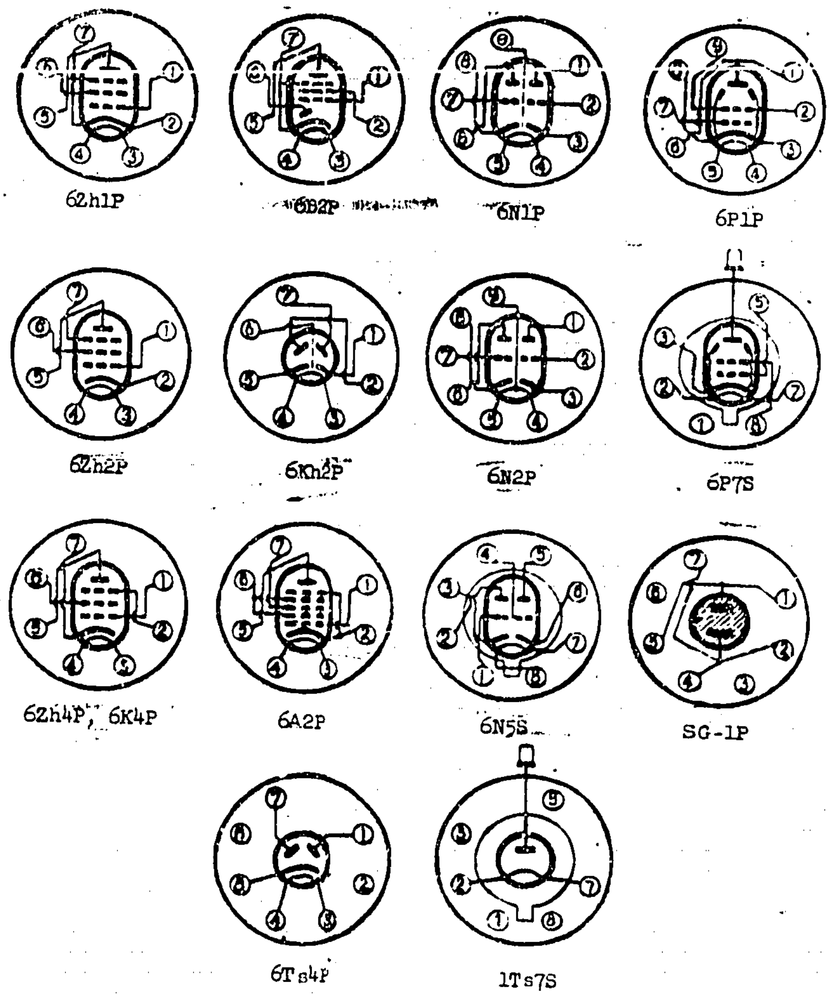

Figure 2. Tube Base Diagrams

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