KENYON NEWS

presents

APPLICATION DETAILS *of the* 6L6

THE Kenyon Transformer Co., Inc., takes pleasure in announcing a complete group of power and audio transformers together with practical audio frequency circuit applications for use with the new 6L6 vacuum tube.

We congratulate the RCA Radiotron Co. on the development of this new tube. It is our sincere opinion that the beam power tube has opened a new field in vacuum tube and vacuum tube circuit development, which can only partially be appreciated by consideration of the characteristics of the 6L6.

We earnestly recommend that all those engaged in the production and development of tube applications become thoroughly familiar with the characteristics of this new tube.

Beam Power Tube 6L6

THEORY OF THE TUBE

New in principle, the 6L6 represents the first major vacuum tube development since the insertion of a grid between cathode and plate. The fundamentally new design principle of the 6L6 involves the use of electron beams constrained and directed through the use of a set of beam forming electrodes and potential fields. These beams of high electron densities are controlled more easily and efficiently than the electron streams of the triodes and pentodes of the past. The principle of controlling a concentrated electron beam has resulted in the following practical advantages of this new tube:

High power output with low grid power
High plate efficiency
High power sensitivity
Low third and higher order harmonic distortion

The tube is a pentode with an electron field acting as the 5th element. Figure 1 shows the arrangement of the elements in the tube. The cathode is surrounded by an elliptical control grid. The functions of these elements are the same as in any other tube. The screen grid is also designed to function as any other screen grid—to accelerate the electron stream from cathode to plate and prevent the formation of a space charge which might otherwise limit the plate current flow. The screen surrounds the control grid and has the same contour as that electrode. The mesh of the screen coincides exactly with that of the control grid. The elements are aligned turn for turn. A cylindrical anode surrounds all of the electrodes. Two beam forming deflecting-plates placed as shown comprise the remaining physical elements of the tube. Electrons emitted from the cathode are constrained by the deflecting plates to flow, as shown, in two main beams. These beams are further sliced into smaller ones by the control grid mesh.

Since the screen grid wires are directly in line with the control grid wires, very few electrons strike the screen, consequently the screen current is low. This helps to increase the tube efficiency. By the concentration of the electrons into the two major diverging beams very high electron densities are produced in the region between plate and screen. These regions of potential minimum act virtually as cathodes. They return to the plate any electrons which might decide to bounce off the plate back into the beam. These "virtual cathodes" constitute the 5th element — the suppressor. This electron suppressor has all the advantages of the conventional suppressor and introduces some very valuable improvements of its own. The conventional pentode suppressor is a wire mesh similar to the screen and control grids in construction and designed to prevent the return of the secondary electrons from plate to screen.

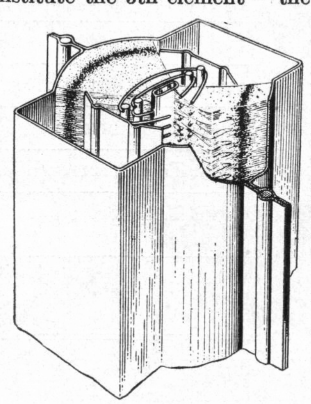


Fig. 1

It is operated at the D.C. potential of the cathode and therefore constitutes a low potential field between screen and plate. The grid wires of the conventional suppressor produce a non-uniform field which *gradually* controls the secondary electrons and thus produces a rounded knee at the low plate voltage end of the plate voltage—plate current family of curves. This means that at low voltages (encountered in large plate voltage swings) the tube is a non-linear device. Harmonic distortion is generated when the tube is operated in the region of the knee. This accounts for a good portion of the harmonic distortion associated with pentode tubes. The electron suppressor provides instantaneous control through a uniform field and thus eliminates this non-linear condition and the attendant harmonic distortion. This is an extremely important characteristic of the tube from the standpoint of fidelity of reproduction of the control grid signal. The plate voltage—plate current curves of the 6L6 are remarkably linear through the use of this electron suppressor. The remaining characteristics of the tube are very much like those of a low distortion pentode. The plate impedance and plate efficiency are high, as is the power sensitivity. Unlike the conventional pentode the harmonic distortion is low—so low in fact that under many conditions it is less than encountered in triodes of similar power capacity.

We have confined our circuit data to 6L6 operated in balanced push pull circuits. This mode of operation balances out the second harmonic which was purposely made high in the design of the tube in order to minimize third and higher order harmonics. The success of the various methods of harmonic elimination (tube construction and push pull operation) is unquestionably indicated by the low harmonic content specified in table 1.

TRANSFORMER CONSIDERATIONS

Two 6L6 tubes may be operated class AB in a push pull amplifier to produce a power output of 60 watts with 2% harmonic distortion. This low distortion figure is based on the assumption that the driving source has zero impedance (zero regulation) and that all electrodes receive their potential from a battery source. Thus the 2% distortion figure may be interpreted as a measure of the non-linearity of the tube alone. In practical circuits it is not economical to obtain a driving source of zero regulation nor is it economical to construct plate, screen, or grid supplies having zero regulation. Consequently an additional amount of harmonic distortion must be expected. *That added distortion is directly dependent on the quality of the audio transformers and power supplies used with the amplifier circuit.* All class AB and class B amplifiers require well designed audio and power transformers for satisfactory operation. This is especially true in units associated with 6L6 in class AB circuits, because of the high power sensitivity of the tube. The driver transformer working into the 6L6 grids deserves primary consideration. A poorly designed unit of this type can introduce harmonic distortion due to leakage reactance and poor regulation. Design considerations dictate that this transformer be constructed so that the ratio of the voltage appearing across the primary at no load (zero grid current) to the voltage appearing on primary at full load (maximum grid current) be kept close to unity. The regulation of the grid circuit is also a function of the power output capabilities of the driving tubes. The turns ratio of the transformer should be kept to the lowest value which will drive the grids of the output tubes. We recommend that the driving tubes be push pull 45's or 2A3's operated class A for ideal conditions. Transformer K-306 has been designed for this application. This driver combination has the further advantage of providing ample secondary voltage for the use of reverse feedback load stabilizing systems. Push pull type 56, 76, or 6C5 tubes will be found adequate for average applications.

Leakage reactance must be kept to a minimum in the design of both input and output transformers. This can be best appreciated, in the case of the input transformer, when it is realized that only one tube draws grid current at a time in a class AB circuit when the grid goes positive. This means that the leakage reactance between total primary and ½ the secondary must be kept as low as the leakage reactance between total primary and total secondary in a transformer used for class A circuit. The same precautions must be taken in the design of the output

6L6 OPERATING DATA—TABLE 1.
(Values Given are for 2 Tubes)

	CLASS A_1		CLASS AB_1						CLASS AB_2		
Operating Condition	A	B	C	D	E	F	G	H	I	J	
Bias System	Fixed	Self$_5$	Fixed	Fixed	Self$_5$	Fixed	Self$_5$	Fixed	Fixed	Fixed	
Plate Voltage	250	250	400	400	400	400	400	400	400	400	Volts
Screen Voltage	250	250	250	250	250	300	300	300	250	300	Volts
D. C. Grid Voltage$_6$	−16	−16	−20	−20	−19	−25	−23.5	−25	−20	−25	Volts
Zero-Signal D. C. Plate Current	120	120	88	88	96	100	112	102	88	102	MA
Max.-Signal D. C. Plate Current	140	130	126	124	110	152	128	156	168	230	MA
Zero-Signal D. C. Screen Current	10	10	4	4	4.6	5	6	5	4	6	MA
Max.-Signal D. C. Screen Current	16	15	9	12	10.8	17	16	12	13	20	MA
Peak A. F. Voltage Grid-to-Grid	32	35.6	40	40	43.8	50	57	50	57	80	Volts
Load Resistance (Plate to Plate)	5000	5000	6000	8500	8500	6600	6600	3800	6000	3800	Ohms
Peak Grid—Input Power$_7$									180	350	Milliwatts
Total Harmonic Distortion	2	2	1	2	2	2.	2	.6	2	2	Per cent
Max. Power Output	14.5	13.8	20	26.5	24	34	30	23	40	60	Watts
Output Transformers to 500 ohm line (TR2)	K-408			K-414			K-416		K-418		
Output Transformers to Voice Coil Line (TR2)	K-409			K-415			K-417		K-419		
Output Transformers to Two Lines (TR2)	K-407 K-406										
Driver Transformer to couple Push-Pull 76 or 6C5 tubes to 6L6 grids (TR1)	K-302			K-302			K-302		K-305 K-306		K-305 K-306

Heater Voltage—6.3 volts$_4$.

Heater Current—.9 amperes per tube.

Plate and Screen Dissipation—24 max. watts$_3$ per tube.

Subscript 1.—Indicates that grid current does not flow during any part of the input cycle.

Subscript 2.—Indicates that grid current flows during some part of the input cycle.

Subscript 3.—Indicates that the dissipation rating must not be exceeded with line voltage variations. This precaution must be observed, especially in the fixed bias systems.

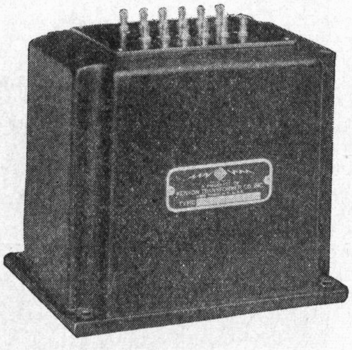
Subscript 4.—Indicates heater voltage should never exceed 7.0 volts.

Subscript 5.—Indicates bias is measured with no signal.

Subscript 6.—Indicates that input coupling device should have a low resistance. Transformer or impedance coupling devices are recommended.

Subscript 7.—Indicates that the driving tubes should be capable of delivering these signal levels with low distortion.

transformer since the plate current flows through less than 360 degrees of the cycle. It also must be remembered that secondary load on the driver transformer is continually varying with the grid current cycle. Therefore, the relation between leakage reactance and primary and secondary impedance also varies. While leakage reactance losses may be small at no grid current they may cause serious distortion when the grid begins to go positive.



Top Mounting

The plate, screen, and grid supplies deserve equal consideration. The grid supply is obviously the most important. Slight variations in the D.C. grid potential over the operating cycle will be greatly amplified due to the high power sensitivity of the tube. We recommend a separate grid supply rectifier in all fixed bias applications of the 6L6. The screen supply is next in importance. Measurements of the tubes indicate that the power output of the 6L6 varies approximately as the square of the screen voltage. This voltage should therefore be held constant for minimum amplitude distortion. The power output of the tubes varies almost directly as the plate voltage. The overall regulation of the grid, screen and plate supplies should be made as good as is economically possible.

Regulation of the grid supply should be approximately 2% throughout grid current cycle. Regulation of the screen supply should be approximately 5% over the current range of this electrode. Regulation in the plate supply should be approximately 5 to 10% over the plate current range. These specifications covering regulation can only be met through the use of power supply systems employing transformers and chokes carefully designed for the application in the specific circuits involved.

The various audio transformers and power transformers listed below have been designed by the Kenyon Transformer Co., Inc., for amplifier circuits using the 6L6. We unconditionally guarantee them to be satisfactory in every respect.

Purchase good transformers and reactors for class AB or class B circuits if you are interested in constructing a linear amplifier.

Class A and Class AB Driver Transformers

Type No. — **List Price**

K-302 Laboratory Standard type to couple P.P. 56, 76, or 6C5 plates to P.P. 6L6 grids operated class A or class AB with no grid current.
Frequency response: ± ½ DB 30 to 15,000 cycles
Shielded in cast high-permeability crosstalk-proof case T-1
Approximate weight: 3¾ lbs.............................**$22.00**

K-304 Laboratory Standard type to couple a single 56, 76, or 6C5 to P.P. 6L6 grids operated class Aor class AB with no grid current.
Frequency response: ± ½ DB 30 to 15,000 cycles
Shielded in cast high-permeability crosstalk-proof case T-1
Approximate weight: 3¾ lbs.............................**$17.50**

K-305 Laboratory Standard type to couple P.P. 56, 76 or 6C5 plates to P.P. 6L6 grids operated class AB with grid current.
Frequency response: ± ½ DB 30 to 15,000 cycles
Shielded in cast high-permeability crosstalk-proof case T-1
Approximate weight: 3¾ lbs.............................**$16.00**

K-306 Laboratory Standard type to couple P.P. 45 or 2A3 plates to P.P. 6L6 grids operated class AB with grid current.
Frequency response: ± ½ DB 30 to 15,000 cycles
Shielded in cast high-permeability crosstalk-proof case T-2
Approximate weight: 6½ lbs.............................**$18.00**

Class A and Class AB Output Transformers

K-406 Laboratory Standard type to couple P.P. 6L6 plates operated class A—5000 pl. to pl.—to 1.8, 3.75, 6.8, 7.5, 11, 15, 500, 1000, 1700, 2000, 3000, and 4000 ohms.
Level — 15 watts
Frequency response (500 to 4000 ohms) — ± ½ DB 30 to 15,000 cycles
Frequency response (1.8 to 15 ohms) — ± 1.5 DB 30 to 15,000 cycles
Shielded in cast high-permeability crosstalk-proof case T-2
Approximate weight: 6½ lbs.............................**$21.00**

K-407 Laboratory Standard type to couple P.P. 6L6 plates operated class A—5000 pl. to pl.—to 1.8, 3.75, 6.8, 7.5, 11, 15, 50, 125, 200, 250, 333 or 500 ohms.
Level — 15 watts
Frequency response (1.8 to 15 ohms) — ± 1.5 DB 30 to 15,000 cycles

Type No. — **List Price**

Frequency response (50 to 500 ohms) — ± ½ DB 30 to 15,000 cycles
Shielded in cast high-permeability crosstalk-proof case T-2
Approximate weight: 6½ lbs.............................**$21.00**

K-408 Laboratory Standard type to couple P.P. 6L6 plates operated class A—5000 pl. to pl. load—to 50, 125, 200, 250, 333 or 500 ohms.
Level — 15 watts
Frequency response: ± ½ DB 30 to 15,000 cycles
Shielded in cast high-permeability crosstalk-proof case T-2
Approximate weight: 6¼ lbs.............................**$18.00**

K-409 Laboratory Standard type to couple P.P. 6L6 plates operated class A—5000 pl. to pl.—to 1.8, 3.75, 6.8, 7.5, 11 or 15 ohms.
Level — 15 watts
Frequency response: ± ½ DB 30 to 15,000 cycles
Shielded in cast high-permeability crosstalk-proof case T-2
Approximate weight: 6¼ lbs.............................**$18.00**

K-414 Laboratory Standard type to couple P.P. 6L6 plates operated class AB with no grid current.
Balanced primary tapped for 8500 or 6000 pl. to pl. load.
Secondary terminations of 50, 125, 200, 250, 333 or 500 ohms.
Level — 27 watts
Frequency response: ± ½ DB 30 to 15,000 cycles
Shielded in cast high-permeability crosstalk-proof case T-3
Approximate weight: 12 lbs.............................**$25.00**

K-415 Laboratory Standard type to couple P.P. 6L6 plates operated class AB with no grid current.
Balanced primary tapped for 8500 or 6000 pl. to pl. load
Secondary terminations of 1.8, 3.75, 6.8, 7.5, 11 or 15 ohms
Level — 27 watts
Frequency response: ± ½ DB 30 to 15,000 cycles
Shielded in cast high-permeability crosstalk-proof case T-3
Approximate weight: 12 lbs.............................**$25.00**

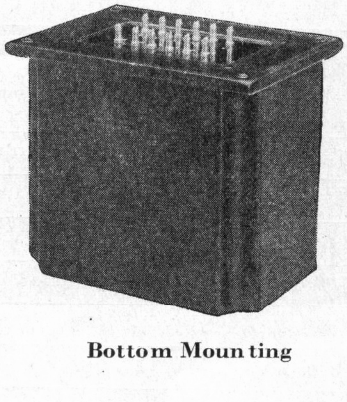
K-416 Laboratory Standard type to couple P.P. 6L6 plates operated class AB with no grid current.
Balanced Primary tapped for 6600 or 3800 pl. to pl. load.
Secondary terminations of 50, 125, 200, 250, 333 or 500 ohms
Level — 34 watts
Frequency response: ± ½ DB 30 to 15,000 cycles
Shielded in cast high-permeability crosstalk-proof case T-3
Approximate weight: 12 lbs.............................**$25.00**

K-417 Laboratory Standard type to couple P.P. 6L6 plates operated class AB with no grid current.
Balanced primary tapped for 6600 or 3800 pl. to pl. load
Secondary terminations of 1.8, 3.75, 6.8, 7.5, 11 or 15 ohms
Level — 34 watts
Frequency response: ± ½ DB 30 to 15,000 cycles
Shielded in cast high-permeability crosstalk-proof case T-3
Approximate weight: 12 lbs.............................**$25.00**

K-418 Laboratory Standard type to couple P.P. 6L6 plates operated class AB with grid current.
Balanced primary tapped for 6000 or 3800 pl. to pl. load
Secondary terminations of 50, 125, 200, 250, 333 or 500 ohms
Level — 60 watts
Frequency response: ± ½ DB 30 to 15,000 cycles
Shielded in cast high-permeability crosstalk-proof case T-4
Approximate weight: 16¼ lbs.............................**$30.00**

K-419 Laboratory Standard type to couple P.P. 6L6 plates operated class AB with grid current.
Balanced primary tapped for 6000 or 3800 pl. to pl. load
Secondary terminations of 1.8, 3.75, 6.8, 7.5, 11 or 15 ohms
Level — 60 watts
Frequency response: ± ½ DB 30 to 15,000 cycles
Shielded in cast high permeability crosstalk-proof case T-4
Approximate weight: 16¼ lbs.............................**$30.00**

K-601 Laboratory Standard type plate and filament transformer for push pull 6L6's class A together with driver and voltage amplifiers.
Primary: 100/110/115/125 volts — 60 cycles
Secondary: #1 — 720/840 volts CT — 165 MA
(secondary #1 tapped for fixed bias operation of 6L6 tubes)
#2 — 5 V. — CT — 3A
#3 — 2.5 V. — CT — 3A
#4 — 2.5 V. — CT — 5A
#5 — 2.5 V. — CT — 7A
#6 — 6.3 V. — CT — 4A
Construction:
Cast case T-4
Approximate weight: 20 lbs. **$25.00**



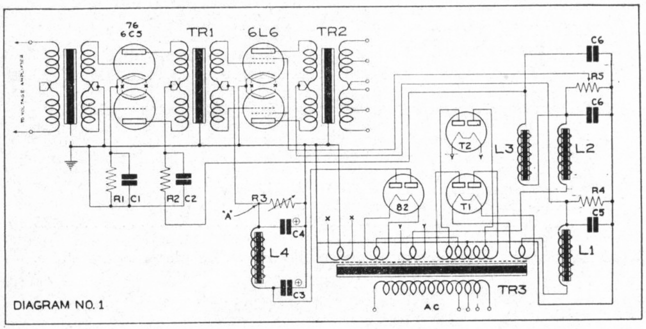
Bottom Mounting

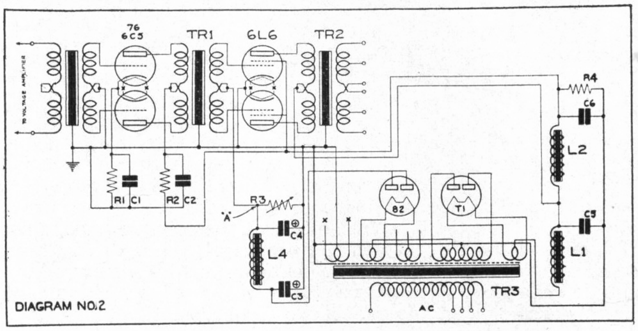
K-604 Laboratory Standard type plate and filament transformer for push-pull 6L6's, class AB_1 together with driver and voltage amplifiers.
Primary:
100/110/115/125 V. — 60 cycles
Secondary:
#1 — 730/940 V. — CT — 200 MA
(Secondary #1 tapped for fixed bias operation of 6L6 tubes)
#2— 5 V.—CT—3A
#3—2.5 V.—CT—3A
#4—2.5 V.—CT—3A
#5—6.3 V.—CT—3A
Construction: Cast case T-4
Approximate weight: 20 lbs.............................**$28.00**

Type No.		List Price
K-605	Laboratory Standard type plate and filament transformer for push-pull 6L6's class AB_2 together with driver and voltage amplifiers.	
	Primary: 100/110/115/125 volts — 60 cycles	
	Secondary: #1 — 740/950 volts — CT — 250 MA (secondary #1 tapped for fixed bias operation of 6L6 tubes)	
	#2 — 5 V. — CT — 3A	
	#3 — 2.5 V. — CT — 3A	
	#4 — 2.5 V. — CT — 3A	
	#5 — 6.3 V. — CT — 3.5A	
	Construction: Cast case T-4	
	Approximate weight: 22 lbs	$32.00

INDUCTORS

Type No.			List Price
K-500	Filter inductor		
	Rated D.C. —	120 MA	
	Inductance at rated D.C. —	15 hy.	
	D.C. resistance —	220 ohms	
	Construction —	Cast case T-2	
	Approximate weight —	6½ lbs.	$8.00
K-501	Filter inductor		
	Rated D.C. —	180 MA	
	Inductance at rated D.C. —	15 hy	
	D.C. resistance —	90 ohms	
	Construction —	Cast case T-3	
	Approximate weight —	12½ lbs.	$11.50
K-503	Filter inductor		
	Rated D.C. —	60 MA	
	Inductance at rated D.C. —	40 hy	
	D.C. resistance —	500 ohms	
	Construction —	Cast case T-2	
	Approximate weight —	6½ lbs.	$8.00
K-504	Filter inductor		
	Rated D.C. —	100 MA	
	Inductance at rated D.C. —	15 hy	
	D.C. resistance —	350 ohms	
	Construction —	Cast case T-1	
	Approximate weight —	3½ lbs.	$6.00





The schematic diagrams shown above illustrate some practical applications for push-pull 6L6 tubes. The voltage amplifier combination should follow conventional lines—the design being of course dependent upon gain requirements.

Two master schematic diagrams are shown. Diagram No. 1 covers conditions C to J inclusive, (Table 1) using Kenyon Laboratory Standard transformers and reactors. The general design illustrated is recommended for maximum undistorted output of the 6L6.

Diagram No. 2 covers conditions A and B (Table 1). Kenyon Laboratory Standard units are specified.

Table 2 indicates the transformers and reactors to be used with any of the operating conditions shown in Table 1.

The diagrams show fixed bias applications. When self bias is to be used omit bias rectifier system consisting of L-4, C3, C4, R3 and the 82 rectifier. Ground point "A"—Insert resistor equal to $\frac{\text{bias voltage}}{\text{static pl. current (2 tubes)}}$ between cathode and ground. Shunt the resistor with 50 mfd—50 V. condenser.

Legend for Diagrams Nos. 1 and 2

R1 — 1300 ohms (for type 76) — 1 watt
500 ohms (for type 6C5) — 1 watt

R2 — 2500 ohms — 2 watts

R3 — 1000 ohms (adjustable) — 10 watts
Adjust R3 to 6L6 grid bias indicated in Table 1.

R4 — 20,000 ohms — 25 watts

R5 — 10,000 ohms (adjustable) — 25 watts
Adjust R5 to 6L6 screen voltage indicated in Table 1.

C1 — 25 mfd. — 25 volts (peak)

C2 — 2 mfd. — 525 volts (peak)

C3 — 4 mfd. — 50 volts (peak)

C4 — 16 mfd. — 50 volts (peak)

C5 — 16 mfd. — 600 volts (peak)

C6 — 16 mfd. — 525 volts (peak)

TABLE 2.

	OPERATING CONDITIONS (Refer to Table 1)									
	A	B	C	D	E	F	G	H	I	J
TR1	K-302	K-302	K-302	K-302	K-302	K-302	K-302	K-302	K-305	K-305
TR2	K-406 K-407 K-408 K-409	K-406 K-407 K-408 K-409	K-414 K-415	K-414 K-415	K-414 K-415	K-416 K-417	K-416 K-417	K-416 K-417	K-418 K-419	K-418 K-419
TR3	K-601	K-601	K-604	K-604	K-604	K-604	K-604	K-604	K-605	K-605
L1	K-500	K-500	K-501	K-501	K-501	K-501	K-501	K-501	K-501	K-501
L2	K-503	K-503	K-500	K-500	K-500	K-500	K-500	K-500	K-500	K-500
L3			K-503	K-503	K-503	K-503	K-503	K-503	K-503	K-503
L4	K-504		K-504	K-504		K-504		K-504	K-504	K-504
T1 (rect.)	5Z3	5Z3	83	83	83	83	83	83	83	83
T2 (rect.)			82	82	82	82	82	82	82	82