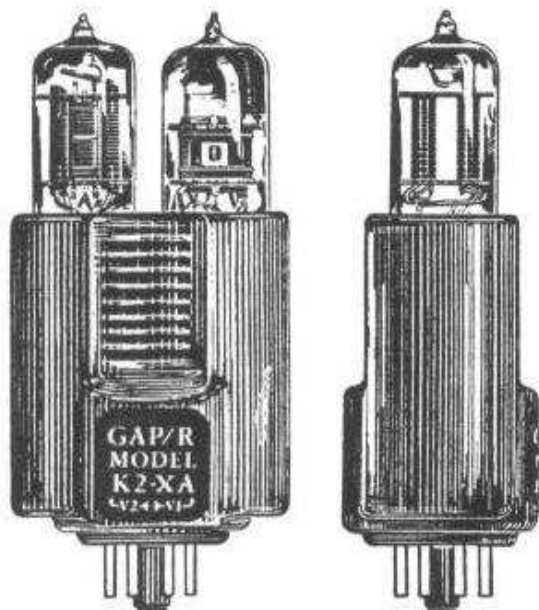


# GEORGE A. PHILBRICK

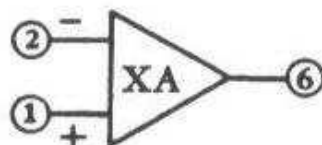
RESEARCHES, INC.

127 CLARENDON STREET, BOSTON 16, MASS.

## Model K2-XA Operational Amplifier



### OPERATIONAL SYMBOL



### GENERAL CHARACTERISTICS Design Center Electrical Characteristics

#### Gain:

30,000 dc open loop (depending upon the applications — see text)

#### Response: — Small signal:

1  $\mu$ sec rise time with bandwidth over 250 kc when used as a unity-gain inverter under ideal circuit conditions

#### Drift Rate:

$\pm 8$  mv per day referred to the input (See text — "DRIFT")

#### Differential Input Levels:

Impedance: — Either input: typically above 100M (open grid)  
Voltage Range:  
Inputs together (common mode)

#### Output Capabilities:

Output Voltage	Output Current (steady state)	
	Normal	Case HP*
-100v	-2.8 ma	-4.1 ma
0v	+4.0 ma	+2.0 ma
+100v	-5.0 ma	-7.0 ma
	+6.1 ma	+4.3 ma

Maximum available transient output current is very much larger in the positive direction, but is the same in the negative direction.

#### Power Required: (for full output) Normal Operation: (50K load)

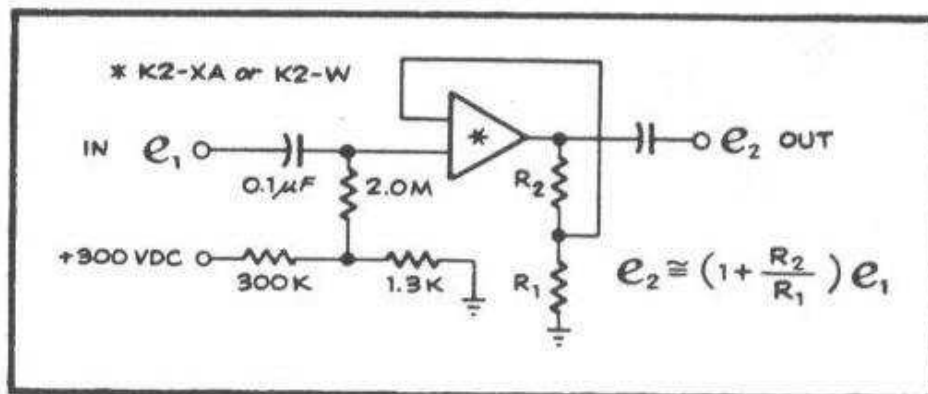
Supply Voltage	At output +100v	At output -100v
100v	1.5w	1.5w

can readily be biased out. (See BIASING METHODS.)

Operationally, the K2-XA plugs into the same socket as the K2-W, and uses the same connections for power and for computing signals. Although momentary short circuiting of the output does no harm, its output must not be grounded for an extended period. Load capacitances in excess of 200  $\mu$ f usually require additional stabilization networks.

### APPLICATIONS

The K2-XA Operational Amplifier can be used for analog computation in feedback systems of any complexity. It is entirely compatible with the K2-W and the two can be used in the same assemblages, each being used to exploit its own special characteristics. The K2-XA permits steeper wave fronts and greater signal excursions. Also, its greater output power allows the use of computing networks that require higher voltages and currents than are possible with the K2-W. However, be sure to provide ample ventilation.



-50 to +50 volts

Current: — Either input:

Typically less than  $10^{-7}$  amp (insulation leakage and grid current)

Bias Required for Balance:

Adjustable from 1.1 to 2.0 volt between pins 1 and 2 (pin 1 positive with respect to pin 2)  
(See figure 3.)

+300	+10.4 ma	+3.4 ma
-300	-11.4 ma	-7.9 ma
6.3 vac or vdc	0.75 amp	0.75 amp

\*Case HP (with 33K load)

+300	+14.1 ma	+3.7 ma
-300	-14.1 ma	-9.2 ma
6.3 vac or vdc	0.75 amp	0.75 amp

\*With a 150K, 2-watt resistor connected between pin 6 (output) and pin 3 (-300v).

## PHYSICAL CHARACTERISTICS

Tube Complement:

1 12AX7A or 7025  
1 6BR8A or 6CL8A

Casing:

Molded plastic, sealed unit

Dimensions:

Overall:  $4\frac{1}{16}$  in. h (max.)  
Above Socket:  $1\frac{1}{2}$  w x  $2\frac{1}{8}$  lg.  
x  $4\frac{1}{8}$  in. h (max.)

Base: Octal plug

Temperature:

Maximum allowable case temperature (hot spot)  $+65^{\circ}\text{C}$  ( $149^{\circ}\text{F}$ )  
(See text)

Weight: Installed:  $3\frac{1}{4}$  oz.  
Packed:  $6\frac{1}{2}$  oz.

## GENERAL DESCRIPTION

The Model K2-XA is a high gain, wide band, plug-in, dc operational amplifier, designed and constructed for use as a basic subassembly for analog computer and instrument applications. It is primarily useful in feedback circuits where a high open loop gain and an output voltage range of from minus to plus 100 volts are required. The open loop dc gain for normal operation with a  $\pm 60$  volt swing and a 50K load is 30,000. With a  $\pm 110$  volt swing, the dc gain may decrease to 10,000. With these units, computing devices of nearly all speeds can be assembled with a minimum of external circuitry.

Like K2-W the Model K2-XA features balanced differential inputs. Its range of operation is from DC to above 250KC when connected as a unity-gain inverter.

With appropriate circuitry, the K2-XA maintains the two inputs at nearly equal potentials. The residual offset

Figure 2. As an Ac Amplifier

The K2-XA, although inherently a dc operational amplifier, may suitably be used as an ac amplifier. The arrangement shown in figure 2 is typical of such application. The ratio  $e_2$  to  $e_1$  is given by  $(1 + R_2/R_1)$  for all frequencies for which  $RC \gg 1/(2\pi f)$ . For the examples shown, amplitude is "flat" and phase shift less than 6 degrees at 8 cps. Note that the network represented by  $R_{12}$ ,  $R_2$  may be complex or even non-linear. If required, narrow bandwidth may be obtained by shunting  $R_2$  with a capacitance. This will obviously attain a very low noise figure. The K2-XA in figure 2 has a high input impedance which may be connected to a low impedance source. Unlike the conventional "operational" case, the mid-band gain of such a circuit is virtually independent of the input impedance.

## INSTALLATION

Connect the desired external circuitry to a mica-filled or ceramic octal socket or a GAP/R Manifold and plug in the K2-XA (Information about GAP/R Manifolds is available upon request.)

## NOTE

Operation of tubes for long periods with the cathodes heated and without plate voltage has been known to deactivate the cathodes. Therefore, if equipment is not to be used within a few hours, open the heater circuit.

All K2's made after Nov. 1, 1961 are housed in gray Lexan. The new case can withstand a much higher temperature than the  $65^{\circ}\text{C}$ . recommended max. for the yellow cases. However, longer component life will result, if the case hot-spot temperature can be kept below  $45^{\circ}\text{C}$ . Avoid severe overloading.

## CAUTION

Although momentary shorting of the output to ground will not harm the K2-XA, prolonged operation under these conditions will cause overheating and subsequent damage. The K2-XA and its load may dissipate 14 watts. Unless there is plenty of free air under 30°C (86°F) around the unit, forced ventilation will probably be necessary. The K2-XA is not recommended for those applications where either the ventilation is poor or the ambient temperature high. For such applications the MIL equivalent K2-YJ is recommended.

## DRIFT

The K2-XA needs a seasoning period of about 100 hours of operation. Then, under optimum conditions typically found in analog computer installations, and after temperatures have become equalized, the drift rate of the typical K2-XA will average about  $\pm 8$  milivolts per day. The optimum conditions include heater voltage regulated to  $\pm 0.5\%$ , the plate voltage regulated to 0.03%, the ambient temperature constant at about 86°F (30°C), adequate ventilation, and the heaters invariably warmed for at least one minute prior to the application of plate voltage.

In applications where optimum conditions do not prevail, the drift rate may be ten to twenty times as much as under optimum conditions.

If bias is derived from resistive networks (figure 3) or 300v sources than can shift 1%, for example, such shift will manifest itself as "drift" of 15 millivolts. Wirewound resistors and Philbrick tracking type power supplies are recommended (viz. R-100B).

If the amplifier is overloaded the drift rate may be ten to twenty times as much as under optimum conditions.

The introduction of the GAP/R K2-P Stabilizing Amplifier is recommended for those applications in which drift must be kept well under 1 mv long term. (See the K2-P Data Sheet, available upon request.)

## BIASING METHODS

For most applications, a bias adjustment is necessary.

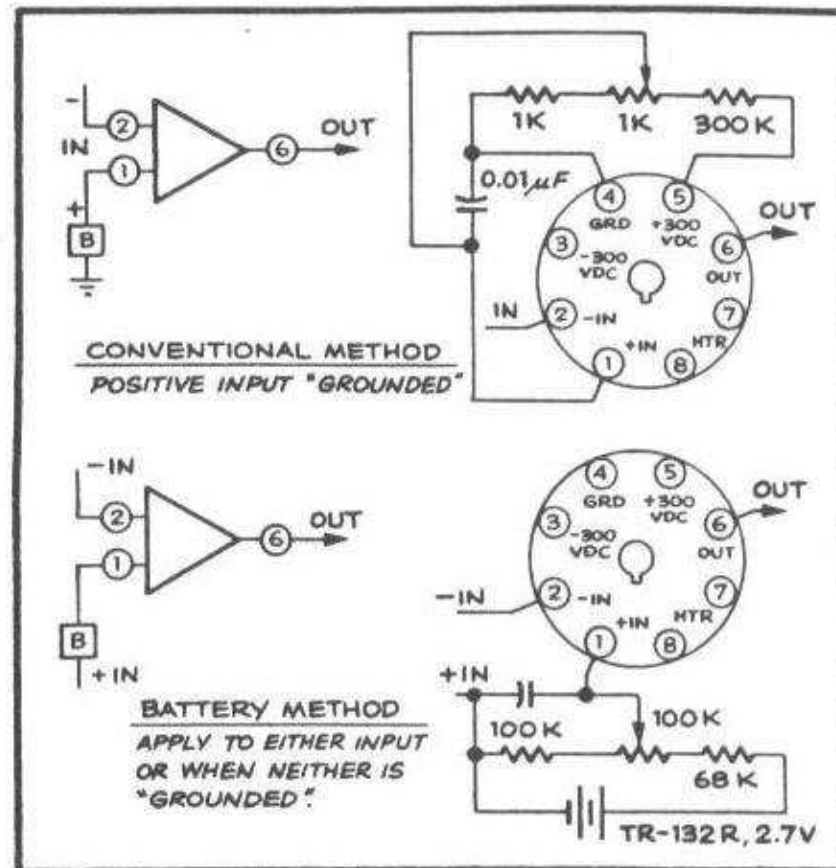


Figure 3. Biasing Methods

When using any of these methods, set the potentiometer for zero dc error under feedback. When setting the potentiometer, ground the input of the computing network for most accurate balancing.

## AUGMENTED POWER — CASE HP

When substituted for a K2-W, a K2-XA will handle most computing networks with the higher performance already described. For still greater speeds and output, connect a 150K 2-watt resistor externally between pins 3 (-300 vdc) and 6 (output). (See figure 4.) The K2-XA (Case HP) will supply a load of 33K with a voltage swing from -100 to +100 volts.

This necessarily operates the 6BR8A near its maximum plate dissipation and shortens tube life.

The K2-XA is a higher output ( $\pm 100$ v at 3 ma) version of the familiar octal plug-in Model K2-W Utility



For most applications, a bias adjustment is necessary, and may be applied in any of several ways. Two arrangements are illustrated in figure 3. Variations of one of these arrangements have been found to be quite effective for cases involving differential inputs, as shown in figure 2. For further illustration ask for the Application Manual for Philbrick Octal Plug-in Computing Amplifiers.

## MAINTENANCE

### Preventive Maintenance

1. During operation:
  - a. Make sure that tubes are firmly seated.
  - b. Make sure that K2-XA is firmly seated.

### Trouble Shooting

If trouble in the K2-XA is suspected:

1. Check the tubes by substitution.
2. Check for loose connections, ground, and/or shorts in the associated circuitry.
3. Check the plug-in by substitution.

### Corrective Maintenance

1. Replace defective tubes.
2. Do NOT open the sealed case.

Opening the case voids guarantee. The unit should be returned to the factory for repair.

NOTE: For Quality Control Data and other general characteristics for circuit design use, ask for K2-XA Specification Control Data No. 6041-A-02.

Differential Amplifier. It provides up to six times the output of the K2-W but ventilation sufficient to carry away a maximum of 12.1 watts must be provided. Gain and bandwidth are about one octave better than the corresponding quantities for K2-W over the  $\pm 50$  volt output range.

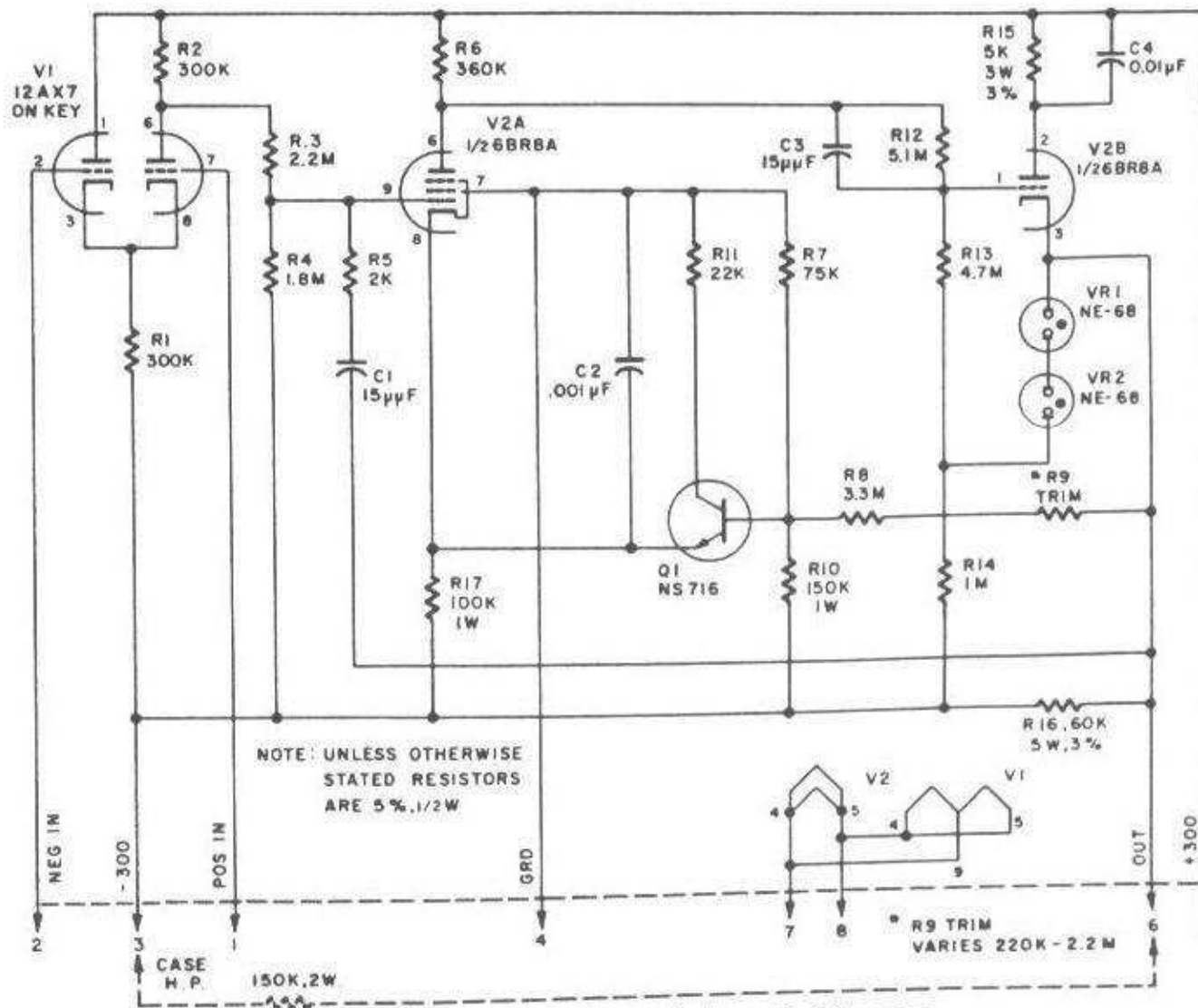


Figure 4. K2-XA, Schematic Diagram

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