INSTRUCTION MANUAL

Serial Number ____________

TYPE 3C66
CARRIER AMPLIFIER

Tektronix, Inc.
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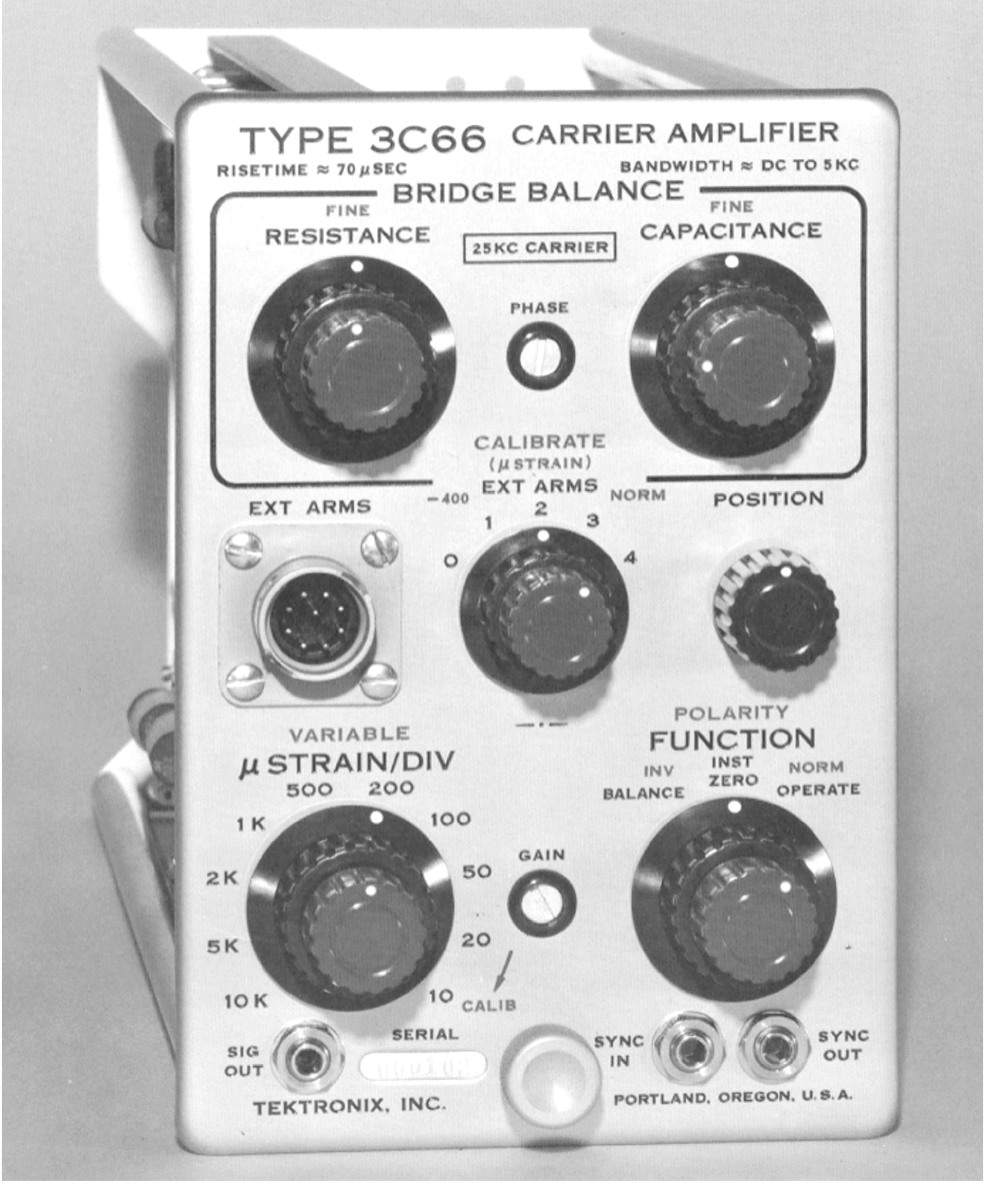
TYPE 3C66 CARRIER AMPLIFIER
RISETIME ≈ 70 μSEC
BANDWIDTH ≈ DC TO 5KC
BRIDGE BALANCE
FINE
RESISTANCE
25KC CARRIER
FINE
CAPACITANCE
PHASE
CALIBRATE
(μSTRAIN)
EXT ARMS
-400
NORM
1
2
3
0
4
EXT ARMS
POSITION
VARIABLE
μ STRAIN/DIV
500
200
1 K
100
2 K
50
5 K
20
10 K
10
GAIN
CALIB
POLARITY
FUNCTION
INV
BALANCE
INST
ZERO
NORM
OPERATE
SIG
OUT
SERIAL
SYNC
IN
SYNC
OUT
TEKTRONIX, INC.
PORTLAND, OREGON, U.S.A.

SECTION 1
CHARACTERISTICS

General Information

The Type 3C66 Carrier Amplifier plug-in unit is designed to be used with Tektronix 560-Series oscilloscopes that will accept 3-Series plug-in units. The unit is self contained and requires no external equipment other than the transducers. Excitation voltage for the transducers is provided by the Type 3C66.

Frequency Response

Dc to 5 kc, risetime approximately 70 μsec.

Carrier Frequency

25 kc.

Mode of Operation

Suppressed-carrier amplitude modulation produced by unbalancing an ac bridge with strain gages or other transducers. A phase sensitive demodulator produces the proper direction of trace deflection.

Strain Sensitivity

Ten calibrated steps from 10 μstrain (microunits per unit)/division to 10,000 μstrain/division. The sensitivity is continuously variable, uncalibrated, between 10 and 25,000 μstrain/division. These values apply when the unit is used with a single active strain gage with a gage factor of approximately 2. Active strain gage with a gage factor of 2 inserted into each arm of the bridge increases the sensitivity to 2.5 μstrain/division.

Input Bridge

A 5-position switch allows selection of from zero to four external bridge arms. The zero position checks the instrument for normal operation without an external transducer. Total bridge voltage is approximately 5 volts rms. Standard resistances supplied with the instrument are 120 ohms.

Capacitance Balance Range

Up to 250 pf across any one of the bridge arms.

Resistance Balance Range

Sufficient to accommodate most conventional transducers.

Phase Adjustment

Phase control has sufficient range to allow the use of either resistive or reactive transducers.

Gage Resistance Range

For cable lengths up to 100 feet the range of useful gage resistances is from 50 ohms to over 2,000 ohms. The recommended range of gage resistances is from 120 ohms to 500 ohms.

Gage Factor Calibration

The gage factor calibration is accomplished by adjusting the amplifier gain. No special gage factor dial is used.

Capacitive and Inductive Transducers

A capacitive transducer with a four-arm resistive bridge results in the following useful sensitivities: 120-ohm bridge (available internally), 1.0 pf/div; 1000-ohm bridge, 0.2 pf/div.

The unit can also be used with inductive transducers; however, differential transformers designed for use at 60 cps are only partially satisfactory at 25 kc.

Capacitance Measurement

Can be calibrated for direct reading in capacitance from 1 pf/division to a maximum value of 1000 pf/division without using a correction curve. With a correction curve, the range can be extended to 10,000 pf/division. These specifications apply when using the internal 120-ohm resistive bridge circuit. With a 1000-ohm external circuit the lower limit can be extended to 0.2 pf/division.

Noise

Typically equivalent to 2.0 μstrain peak-to-peak.

Line-Frequency related spikes no more than 2.5 mm at 60 Hz increasing to no more than 1 cm at 400 Hz.

Attenuator Accuracy

When the Type 3C66 is accurately calibrated on any one range of the μSTRAIN/DIV switch, the accuracy of all other range steps is within 2% of the indicated strain sensitivity.

Accessories

Information on accessories for use with this instrument is included at the rear of the mechanical parts list.

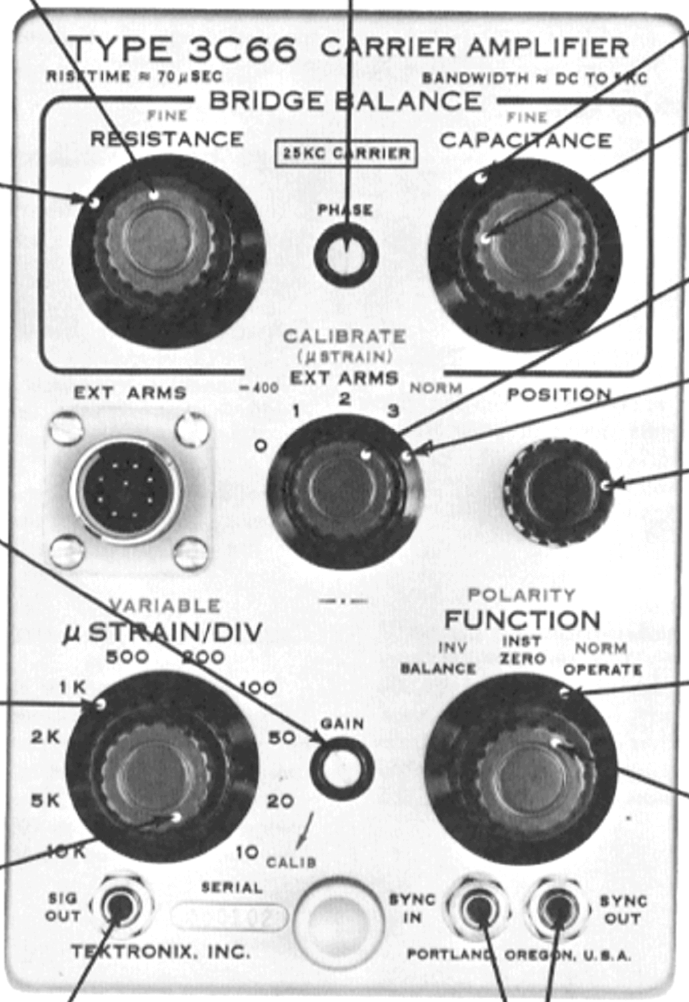

Fig. 2-1. Functions of Type 3C66 front-panel controls.

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SECTION 4
CIRCUIT DESCRIPTION

General Information

The carrier system used in the Type 3C66 has many advantages over a dc system. Since only ac voltages are amplified, an ac-coupled amplifier with high gain and almost zero drift is used. The modulation system has a bandpass of dc to 5 kc that allows both static and dynamic strain measurements. Because the amplifier is designed to pass a specific band of frequencies, most of the stray pickup is eliminated. One additional advantage of the ac carrier system is the use of capacitive and inductive transducers.

Block Diagram

The block diagram for the Type 3C66 is shown in Fig. 4-1. The input circuit is an ac bridge with an external transducer connected into one or more of the bridge arms. Excitation voltage for the bridge is supplied by a 25-kc oscillator.

Under no-signal conditions, the bridge is balanced and the carrier output to the amplifier is suppressed. When the bridge is unbalanced by a change in one of the arms, sidebands are produced. The amplitude of the sidebands depends on the amount of unbalance. The phase of the sidebands depends on the direction and type of unbalance (resistive or reactive).

The sidebands from the bridge circuit are applied through a filter network to the ac amplifier. Unwanted frequencies are rejected while the sidebands are amplified. An attenuator and gain control set the overall sensitivity of the unit.

The amplified sidebands are then applied to a phase-sensitive demodulator. The other input to the demodulator is a 25-kc carrier (derived from the oscillator). The output of the demodulator passes through a filter where the unwanted modulation components are eliminated. The demodulated signal is then applied to the output circuit, which drives the vertical plates of the oscilloscope. This signal corresponds exactly to the variations applied to the input bridge from an external transducer.

Input Bridge Circuit

Signals to the input bridge are in the form of impedance changes. These changes can be resistive, capacitive, inductive, or a combination of these. Since an external transducer is effectively an impedance in one or more arms of the bridge, any change to the transducer will change the bridge impedance. The bridge is designed to sense any change in arm impedance and produce an electrical output in proportion to the impedance change. The amplitude of the bridge output signal depends on the impedance changes within the arms of the bridge.

When the bridge is balanced (no-signal) the 25-kc excitation voltage is suppressed and no bridge output signal is present. Because the excitation voltage is ac, both resistive and reactive circuits are needed for complete bridge balance. The resistive balance circuit compensates for both resistance difference between transducers and resistance in leads. Unbalance of the bridge due to either capacitive or inductive reactance is 90° out of phase with the resistive component, thus a separate capacitive balance circuit is used. From Fig. 4-2 it can be seen that to balance the bridge resistively, the ratio of R2 to R4 must equal the ratio of R6 to R8. The resistive balance controls adjust the ratio of R6 to R8 to produce a balanced condition. To obtain capacitive balance, the ratio of the arm 2 capacitance to the arm 1 capacitance must equal the ratio of the arm 3 capacitance to the arm 4 capacitance. The capacitive balance controls adjust the capacitance ratio on the left side of the bridge to equal the capacitance ratio on the right.

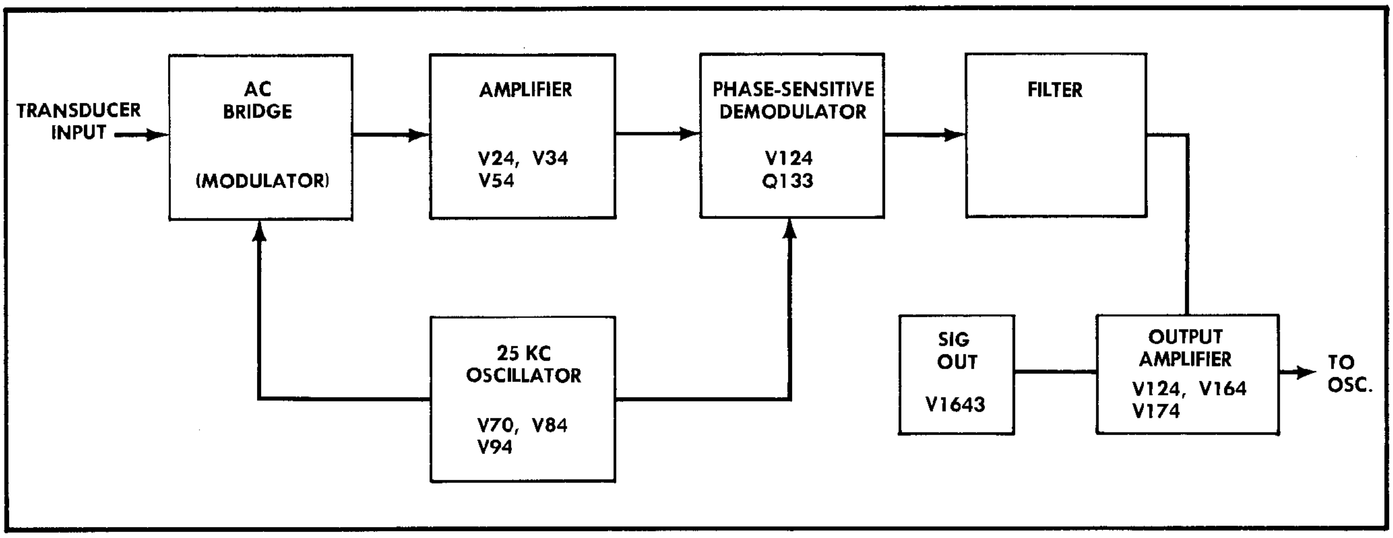


Fig. 4-1. Type 3C66 block diagram.

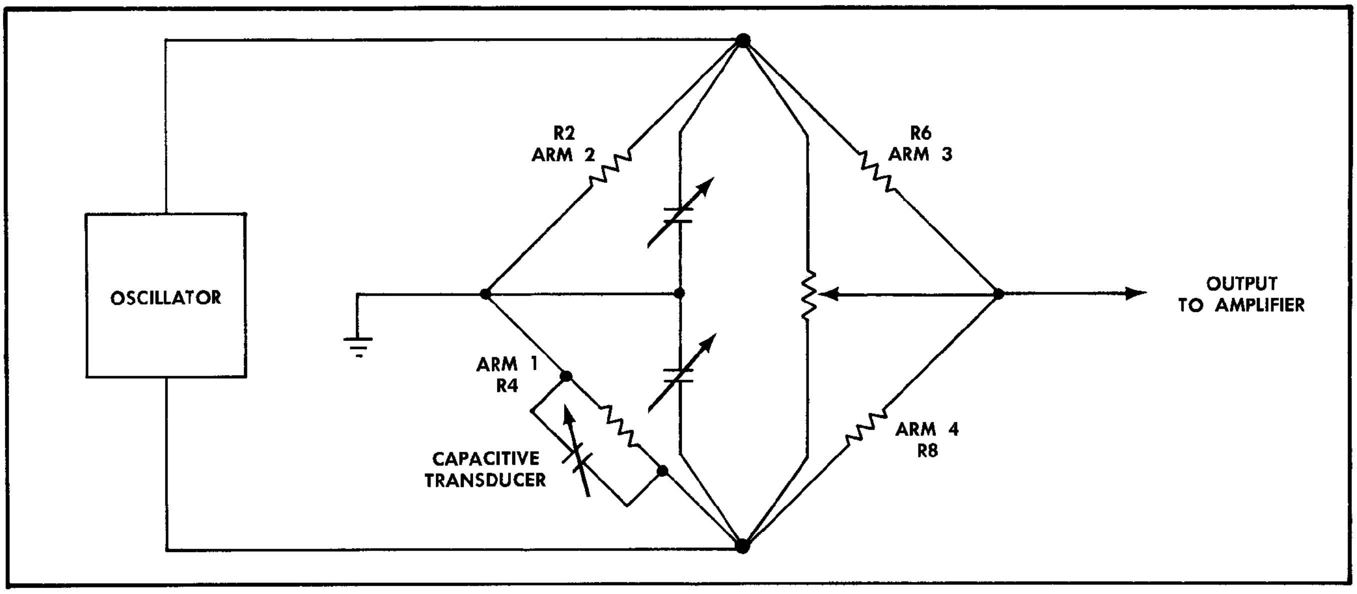


Fig. 4-2. Simplified Bridge schematic showing Bridge Balance circuits.

Under perfect balance conditions, the 25-kc carrier is suppressed and no output is obtained from the bridge. When a transducer is activated, impedance changes cause the bridge to unbalance and modulate the 25-kc carrier. This produces output sidebands which are the sum and difference of the impedance change and the carrier frequency. For example, if the transducer is activated by a 1-kc vibration, the sideband frequencies will be 24 kc and 26 kc. If the transducer is activated by a static force (zero frequency), the output of the bridge will be only 25 kc. The amplitude of the bridge output signal is directly proportional to the amount of bridge unbalance. The phase of the output signal is determined by the type of unbalance. Capacitive unbalance is approximately 90° out of phase with any resistive unbalance. Usually resistive and capacitive unbalance do not occur at the same time. The phase angle of the bridge output signal is usually 0, 90°, 180°, or 270° with respect to the carrier. The upper and lower sidebands at the output of the bridge are applied to the ac amplifier through L20 and C21.

To produce a definite amount of bridge unbalance for calibration, a special circuit is used. This consists of CALIBRATE switch SW10, resistor R5, and capacitor C5. When the switch is turned to —400, R5 is connected in parallel with external arm 1 of the bridge. This causes a resistance change in the bridge arm that corresponds to a —400-μstrain signal. The resultant output signal from the bridge is used to set the PHASE and GAIN controls. When reactive transducers are used, reactive components may be used in place of R5 to produce the correct calibration signal. When the CALIBRATE switch is at —400, a small amount of stray capacitance is connected in parallel with external arm 1. This stray capacitance produces a capacitive unbalance in addition to the resistive unbalance. To eliminate this effect, C5 is connected in parallel with the arm when the switch is set to NORM. This capacitor is adjusted so the same amount of capacitance exists in both positions of the switch. The small amount of capacitance is then balanced out with the capacitive balance controls. Since the same amount of capacitance exists in both positions of the switch, no capacitive unbalance is introduced when the CALIBRATE switch is turned to —400. The bridge then sees a pure resistive unbalance.

Oscillator Circuit

The oscillator circuit V70 produces the excitation voltage for the bridge and the carrier voltage for the phase-sensitive demodulator. The push-pull output of the oscillator is applied directly to the grids of V84A and V84B. The output of this amplifier is then applied to the primary winding of T84. One secondary winding of T84 supplies the bridge excitation voltage while the other passes through a phase-shifting network to the phase-sensitive demodulator. The output amplitude of the oscillator is held constant by a feedback regulator network V94.

Amplifier Circuit

Sidebands from the bridge are applied through a filter network (L20 and C21) to the grid of amplifier V24A. The filter rejects high-frequency pickup but allows the sidebands to pass with little attenuation. The signal is amplified by V24A and applied through cathode follower V24B to the μSTRAIN/DIV attenuator. The selected signal is amplified by V34A and B and applied to the grid of V54A. A twin-tee filter between the grid of V54A and the cathode of V34A presents low impedance to frequencies above and below the sideband frequencies, but presents high impedance to frequencies in the vicinity of 25 kc. Unwanted frequencies are thereby coupled back as inverse feedback which reduces the amplifier gain for these frequencies.

The plate output of V54A is amplified by V54B and connected through C58 and the 75-kc rejection filter to the FUNCTION switch. A degenerative feedback network is connected between the plate circuit V54B and the cathode of V54A. The impedance of C56 is quite low at 25 kc so that at this frequency R57 is bypassed to ground. Thus, the amount of feedback depends on the ratio of R60 and R61 in series with the parallel resistance of R55 and R57. Both VARIABLE control R55 and GAIN control R61 affect this ratio and thus the amount of feedback. The VARIABLE control produces an additional effect on the gain of V54A by varying the cathode resistance of the stage.

75-Kc Notch Filter

L66, C66, and R66 form a notch filter for third harmonics of the 25-kc oscillator frequency.

Phase Sensitive Demodulator

In the demodulator, the carrier is first added to the sidebands. The resulting modulation envelope is then demodulated and applied through a filter to the output stage. The sidebands are applied from the output of the amplifier while the carrier is applied from the oscillator through a phase-shifting network. The sidebands are coupled to the primary of T110 from the cathode of V104A, and the carrier is connected to the center-tapped secondary of T110 from the cathode of V104B.

The upper and lower sections of the secondary of T110 are diode demodulators. Thus, when the carrier voltage at the center tap goes positive, D111 is forward biased and C111 is charged by the positive half-cycle of the carrier. On the negative cycle, D112 is forward biased and the peak negative voltage charges C112. Thus, the peak-to-peak voltage appears across R111 and R112. Since these two resistors are of equal value, the voltage at their junction is zero. When the sidebands pass through the primary of T110, they are coupled into the secondary and combine with the carrier. If the POLARITY switch is in the NORM position, the phase of the sidebands adds to the negative cycle and subtracts from the positive cycle of the carrier. The effect is to increase the negative voltage across R112 and reduce the positive voltage across R111. Thus, the junction of R111 and R112 goes negative. This change is coupled through cathode follower V124A and the filter networks to the output amplifier.

If the POLARITY switch is set to INV, the sidebands add to the positive cycle of the carrier and the output voltage to the grid of V124A is positive.

To obtain maximum sensitivity from the demodulator, the phase relationship between the carrier and the sidebands should be either 0 or 180°. The front-panel PHASE control adjusts the carrier phase to meet this requirement.

Filter and Output Amplifier

Cathode follower V124A serves as a buffer between the demodulator and the filter network. Q133 couples the signal from V124A to the filter. Q133 has a low output impedance and sufficient dynamic range to maintain linearity of the signal through the required voltage swing. The filter consists of two parallel LC networks with a pi-section between. The response of this combined network is shown in Fig. 4-3.

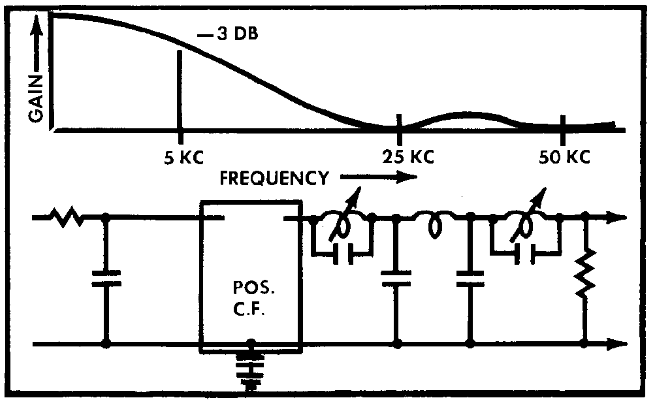
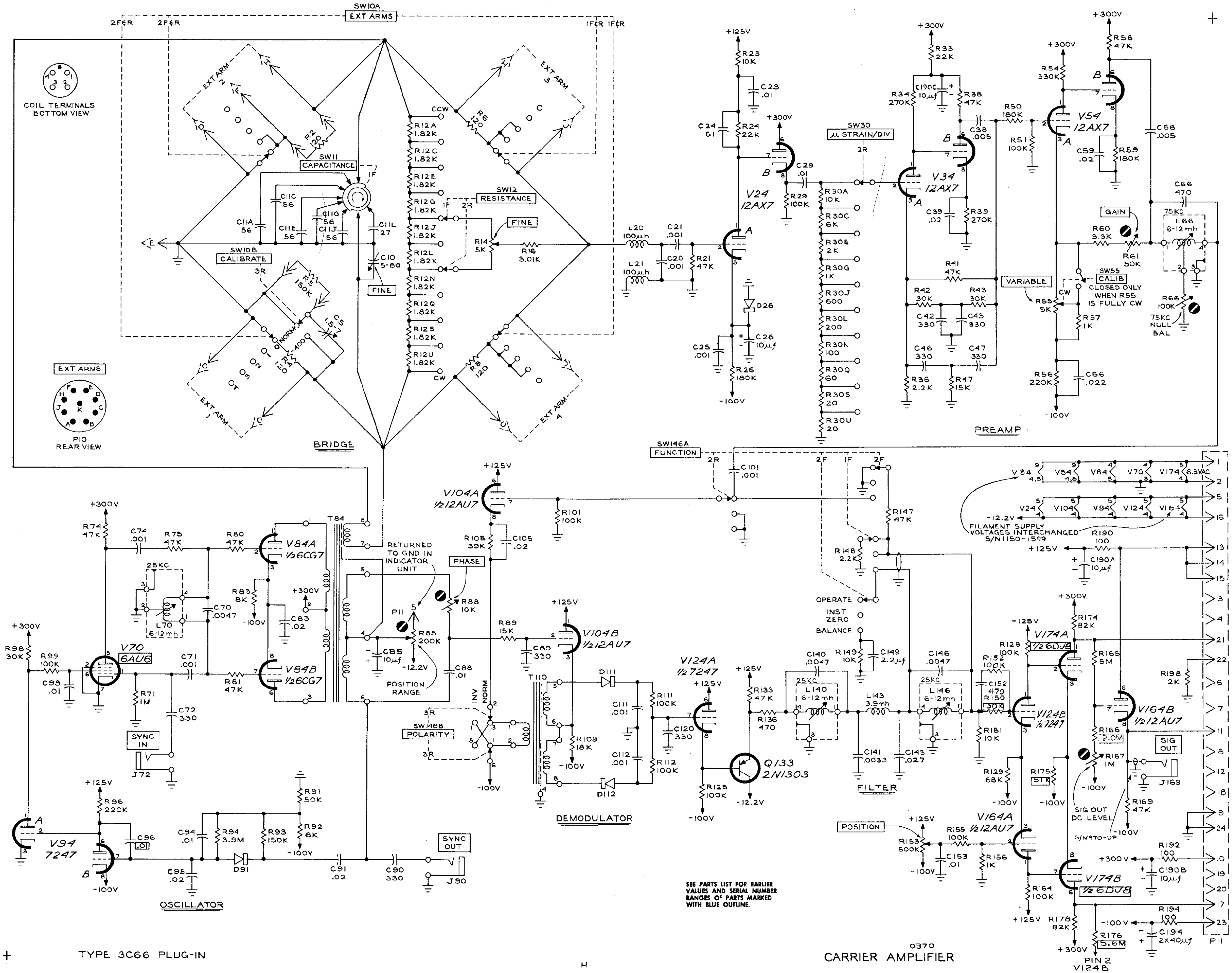


Fig. 4-3. Response curve and simplified schematic for the filter network.

The signal, devoid of high-frequency components, is applied to the grid of V124B. V124B and V164A form a cathode-coupled paraphase amplifier. This stage produces a push-pull signal to drive output stage V174A and B and the crt vertical deflection plates. A portion of the output signal is coupled through cathode-follower V164B for the SIG OUT jack on the front panel and to the time-base circuitry for a trigger signal. R167 (SIG OUT DC LEVEL) sets this signal level.



TYPE 3C66 PLUG-IN

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CARRIER AMPLIFIER

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