Bridge for measuring the interface impedance of oxide-coated cathodes

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BRIDGE FOR MEASURING THE INTERFACE IMPEDANCE OF OXIDE-COATED CATHODES

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A B S T R A C T

Rapid measurement of the interface impedance of oxide-coated cathodes is made possible by the instrument described in this paper. The bridge is balanced at three widely different frequencies, and the interface resistance and capacitance are read directly from decade units in the bridge circuit. All tubes to be tested are connected as diodes; thus the results are independent of tube characteristics. Low values of interface resistance may be read to within one ohm.

BRIDGE FOR MEASURING THE INTERFACE IMPEDANCE OF OXIDE-COATED CATHODES

Introduction

Several methods (1,2,3,4) of measuring the impedance of the interface layer (5,6) which develops between the nickel sleeve and the oxide coating of unipotential cathodes have been devised. Pulse methods require arithmetical computations from data that are not in very simple form, while methods involving the transconductance preclude measurements on diodes.

The most simple electrical representation of the interface layer is a parallel C-R network. Thus, an oxide-coated cathode which has developed an interface layer may be represented by an ideal cathode in series with the parallel C-R network. At normal operating temperatures the numerical values of the interface resistance may range from zero to several hundreds of ohms, and the capacitance values may range from zero to a tenth of a microfarad.

It is the purpose of this paper to describe an apparatus which measures the interface impedance and is direct reading in ohms and microfarads.

Principle of Operation

The equation describing the condition when there is no input to the difference amplifier of Fig. 1 is as follows:

$$R_o + \frac{R_i(1 - j\omega C_i R_i)}{1 + \omega^2 C_i^2 R_i^2} = r_p + \frac{R(1 - j\omega CR)}{1 + \omega^2 C^2 R^2}$$

where the interface impedance is represented by r_p, the plate resistance of the diode, in series with C and R in parallel.

The values of C and R are obtained by balancing this circuit at three different frequencies: 10 mc, 100 cps, and 100 kc, in that order. At 10 mc the term $\omega CR \gg 1$ and balance is obtained by adjustment of R_o so that $R_o = r_p$. Now, at 100 cps, $\omega CR \ll 1$ and balance is restored by adjustment of R_i so that $R = R_i$. Finally, at 100 kc, the term $\omega CR \doteq 1$, and balance is achieved by varying C_i so that $C = C_i$. Thus if R_i and C_i are decade units the value of the interface impedance may be read directly in ohms and microfarads.

Description

Fig. 2 is a photograph of the instrument which is self-contained and consists of a triple-frequency oscillator, the measuring circuit, and associated power supply.

The oscillator circuit is shown in Fig. 3. It is a C-R phase shift type, using three Type 6AK5 tubes, and operates at three fixed frequencies which are nominally 10 mc, 100 kc, and 100 cps. The precise frequencies employed are not important provided that they are approximately the values quoted. An automatic volume control stage is used to maintain constant output, and once initial warm-up drifts have subsided, the output from the oscillator will remain constant over extended periods of time. A cathode-follower output is used so that the oscillator will not be loaded by the low impedance of the test circuit.

The test unit or measuring circuit shown in Fig. 4 consists of a bridge driven from a single-ended source with balance indicated by a difference amplifier. All leads are as short and direct as possible while maintaining symmetry in the bridge circuit. The Type 1N34 crystals are matched to ensure balanced operation of the circuit. R_o is a carbon potentiometer with the cover removed. It is well insulated from the chassis to ensure minimum capacity to ground. A standard octal socket is provided for the tube under test, and tubes other than one specific type will require adapter plugs.

The only calibration needed is to adjust the 4-30 μμf trimmer capacitors so that the respective arms of the bridge are not frequency-sensitive. This can be most easily done by making a dummy tube from a parallel combination of say, a 56 ohm resistor and a 0.05 μf capacitor to represent the interface and a 470 ohm resistor in series to represent the plate resistance. The decade resistor, R_i, is set to 56 ohms and R_o is adjusted for balance at 100 cps. The two trimmers are then adjusted for balance at 10 mc. If this is properly done and the bridge is balanced, the zero-indicating meter should not shift when the signal amplitude is varied from zero to maximum for any one of the three frequencies. This method is perhaps not the most elegant one, but it has the merit of not requiring elaborate test equipment.

All tubes to be tested are diode-connected, either at the socket or by means of the adapter plugs. The measurement of the interface impedance does not depend on tube characteristics, except that the plate resistance must be within the range of R_o. The range of the bridge is sufficient for measurement of most values of interface resistance and capacitance found in commercial receiving-type tubes, and may be extended by the addition of external decade units. The

accuracy is largely dependent upon the stability of the oscillator and the difference amplifier. With reasonable care in construction and operation the error should not exceed 10 per cent for interface impedances where the resistance is greater than 10 ohms.

Acknowledgements

It is a pleasure to acknowledge the many helpful suggestions made by Mr. P.A. Redhead during the development of this instrument.

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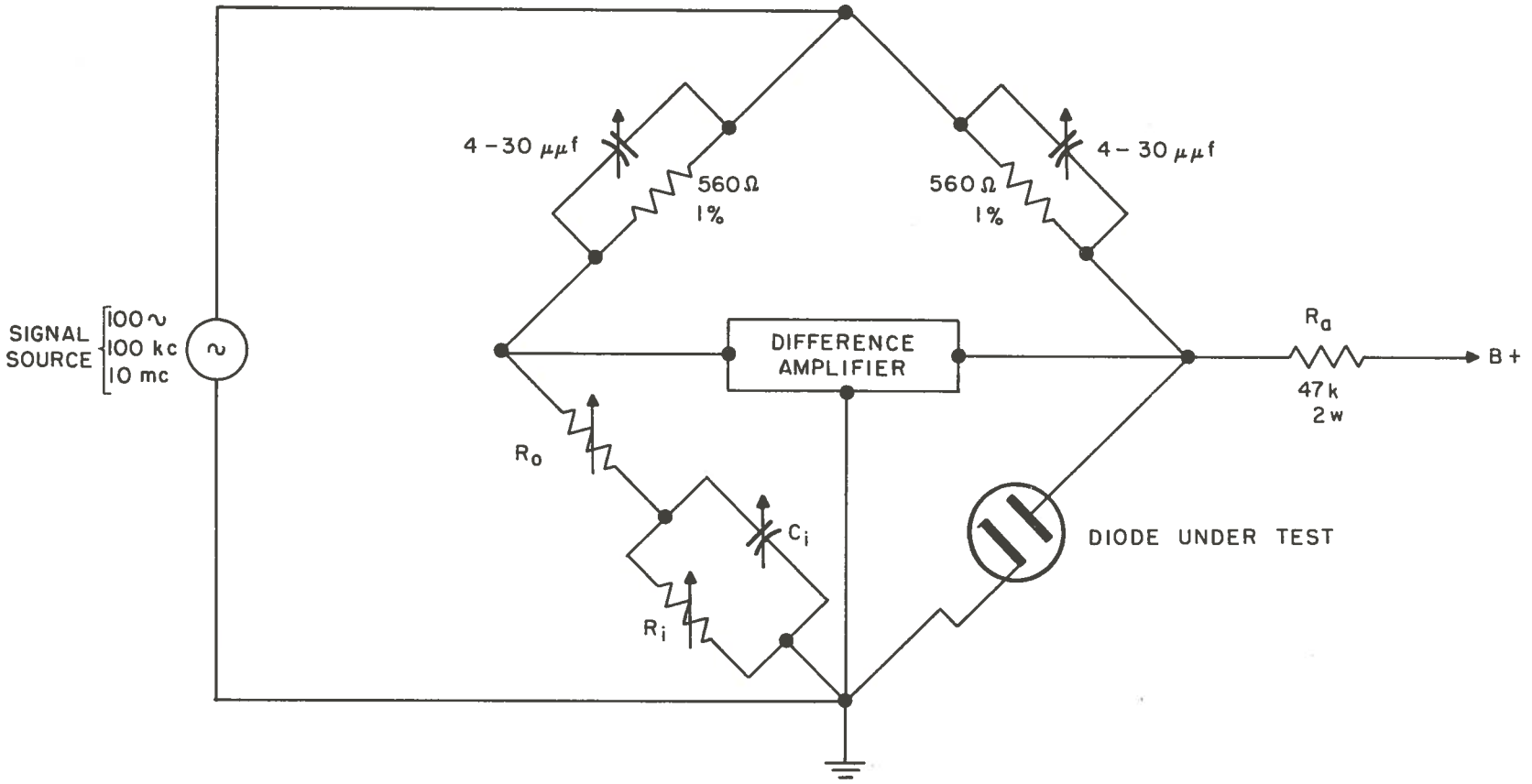


FIG. 1
BASIC INTERFACE IMPEDANCE MEASURING CIRCUIT

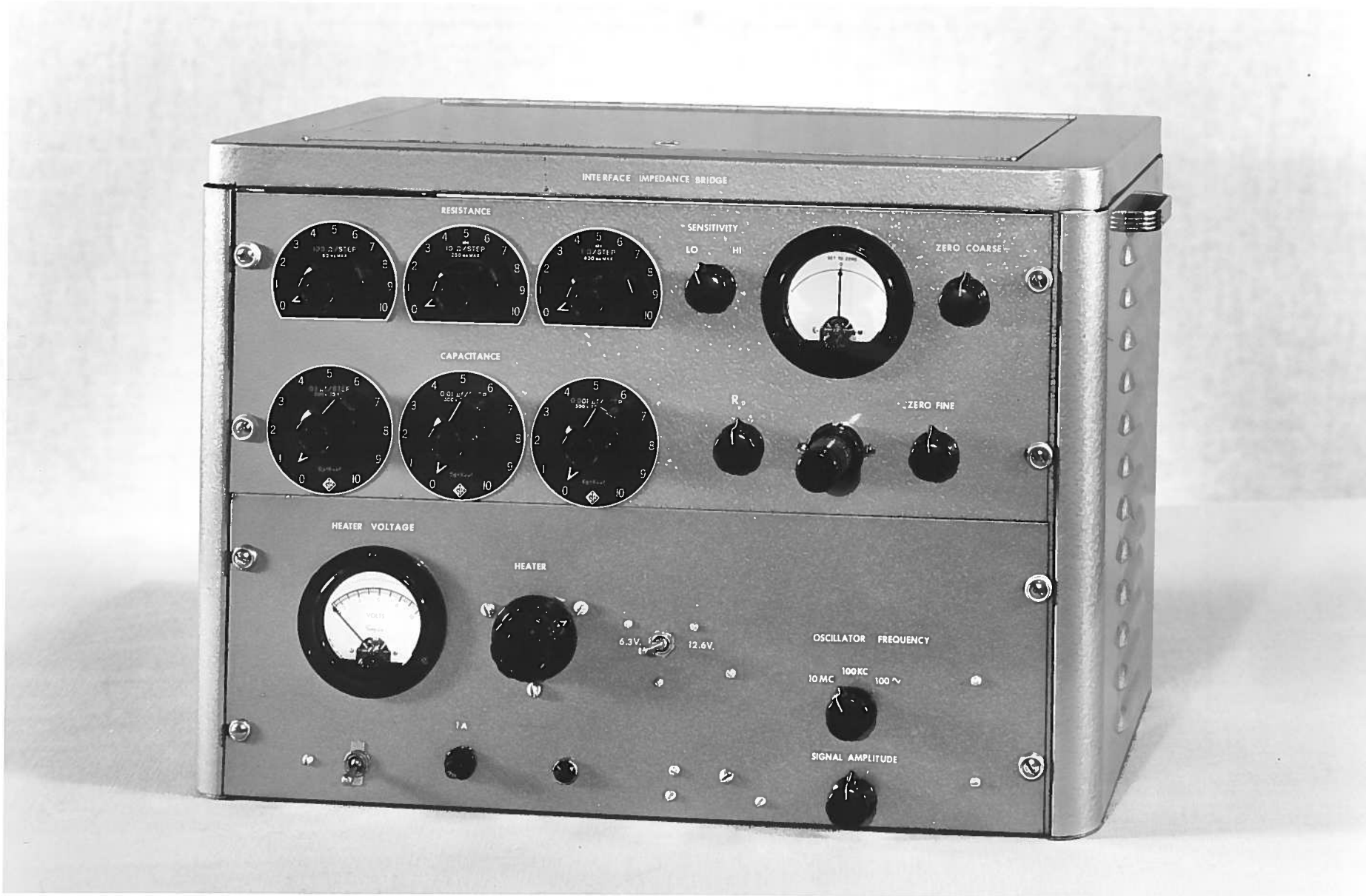
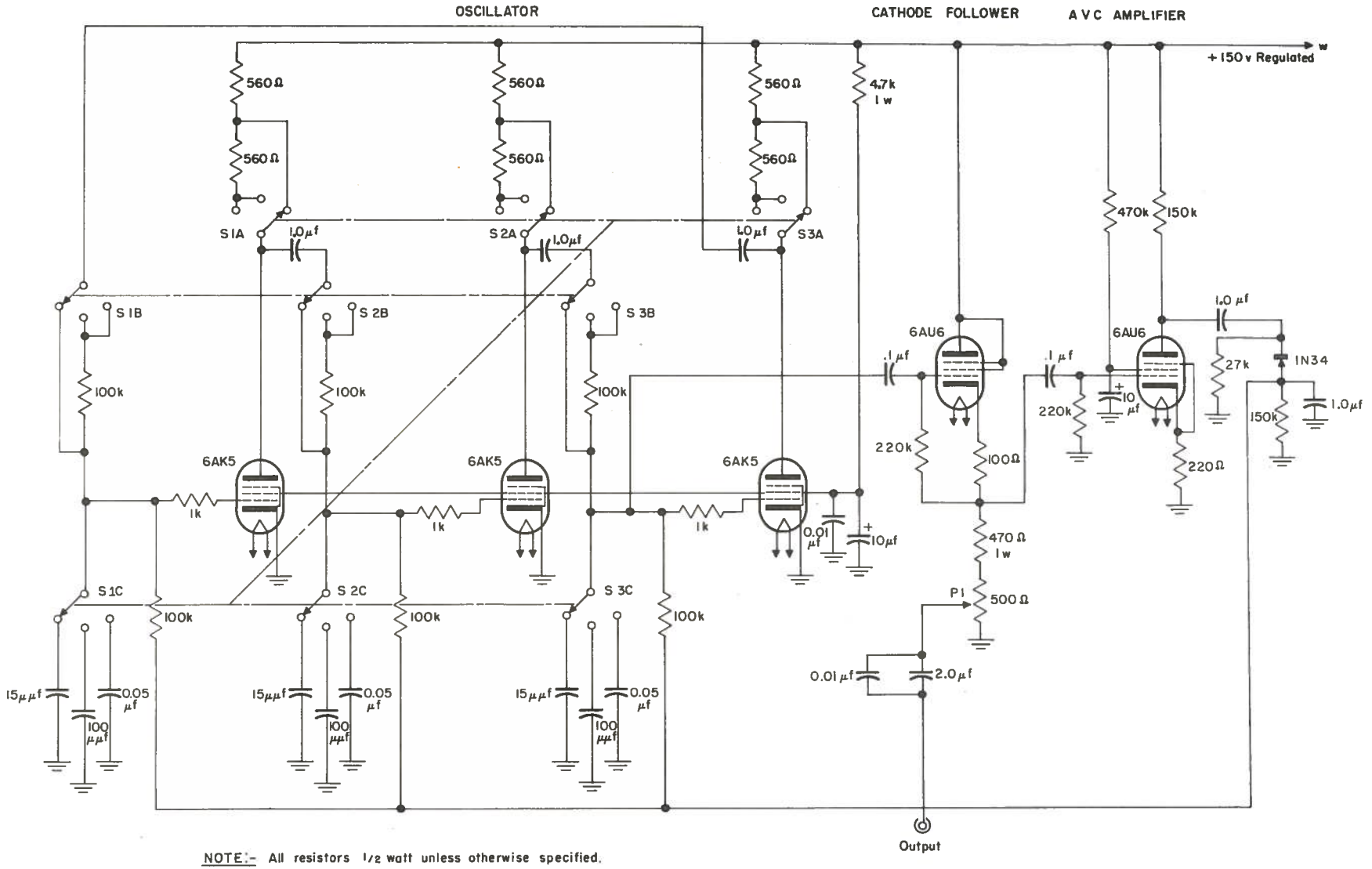
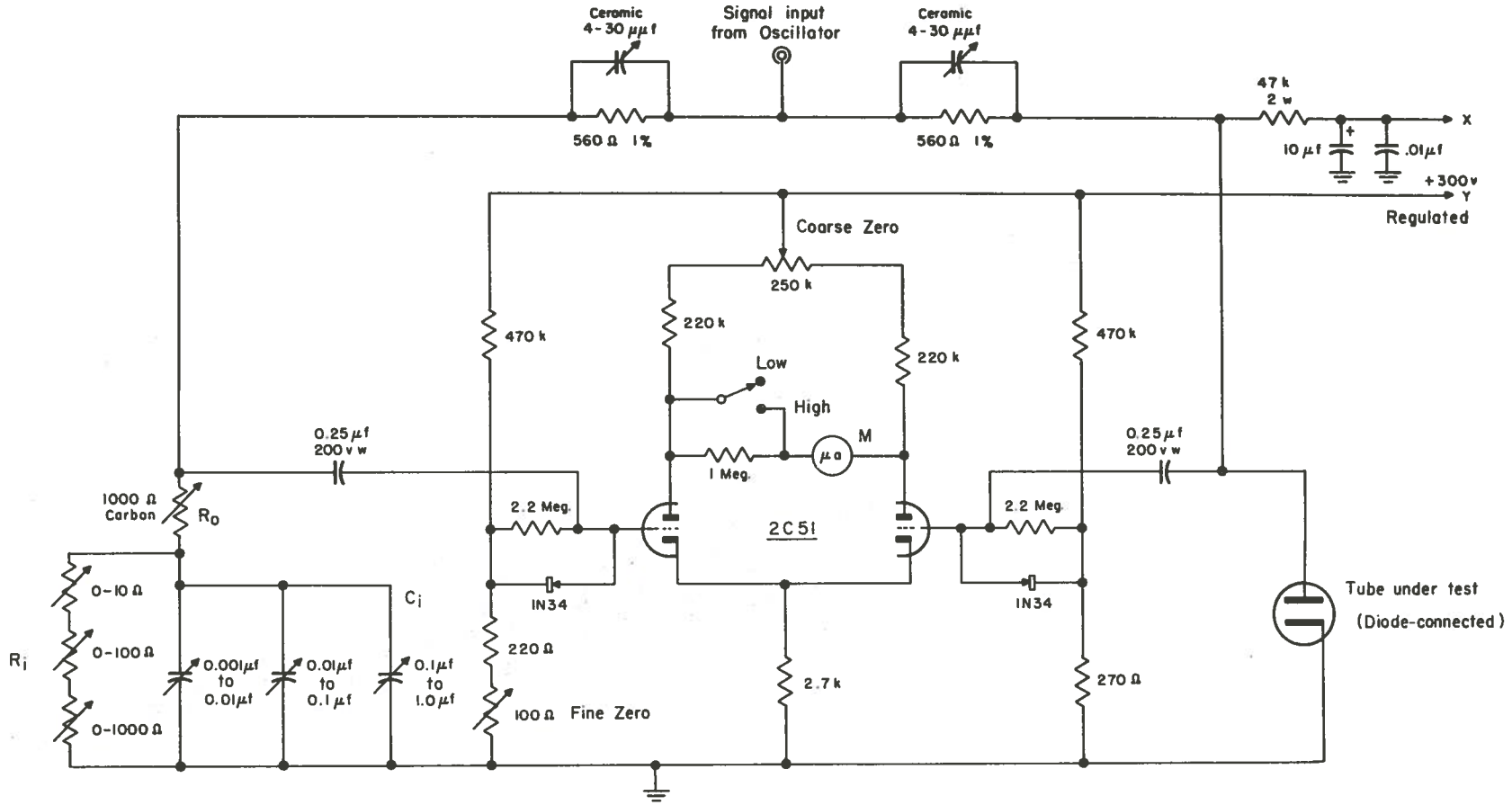


FIG. 2
BRIDGE FOR MEASURING INTERFACE IMPEDANCE
OF OXIDE-COATED CATHODES



NOTE:- All resistors 1/2 watt unless otherwise specified.

FIG. 3
CIRCUIT DIAGRAM
OF
TRIPLE-FREQUENCY PHASE-SHIFT OSCILLATOR



NOTE:

R_i and C_i — decade units

M — 12.5-0-12.5 microammeter (modified 0-25 μa movement)

All resistors $\frac{1}{2}$ w, 20% unless otherwise specified

FIG. 4

CIRCUIT DIAGRAM OF TEST UNIT FOR INTERFACE IMPEDANCE BRIDGE

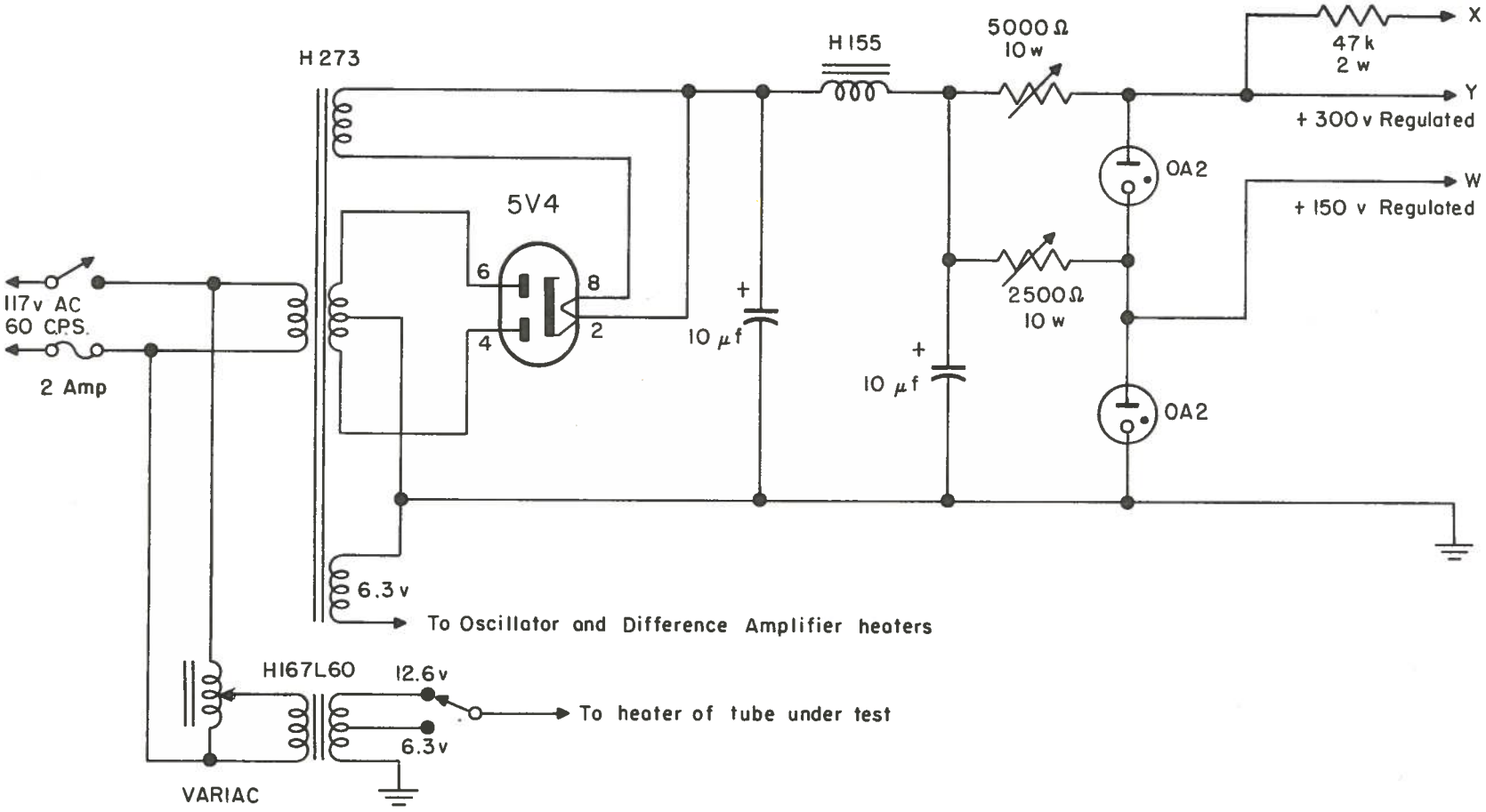


FIG. 5
CIRCUIT DIAGRAM OF POWER SUPPLY