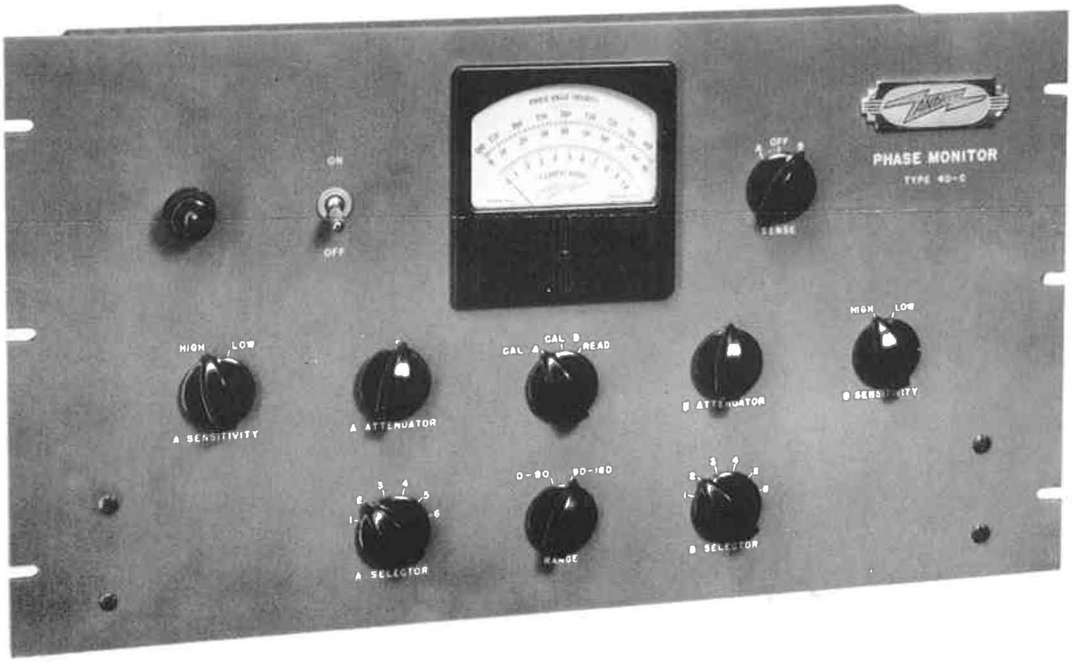
INSTRUCTIONS
FOR
TYPE 40-C PHASE MONITOR

ANDREW CO.
CONSULTING RADIO ENGINEERS

ANDREW

CHICAGO 19, ILLINOIS

TYPE 40-C PHASE MONITOR



PROVED PERFORMANCE The ANDREW Type 40-C Phase Monitor is a modern, direct-reading, phase measuring instrument designed to facilitate adjustment and maintenance of broadcast directional antenna arrays. Over one hundred directional antenna systems now rely on the accuracy and stability of this monitor to control antenna systems of all degrees of complexity.

DIRECT READING Phase angles are indicated *directly in degrees* on a single meter, permitting immediate observation of the effects of small antenna system adjustments.

CURRENT RATIOS Relative amplitude of antenna currents can be quickly and accurately determined, the ratio appearing on a special current ratio scale on the indicating meter. In this application, the monitor serves as a vacuum tube voltmeter to measure the potentials developed across 72 ohm line-terminating resistors.

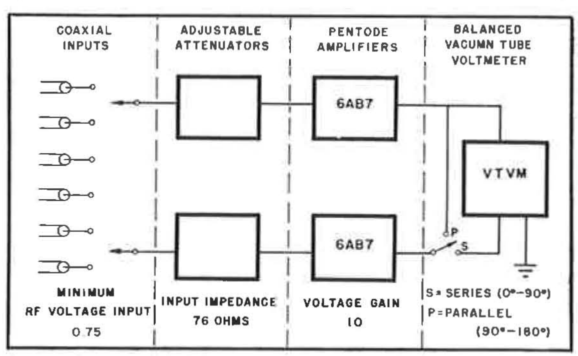
SIMPLE TO OPERATE Extremely simple to use, operation of the ANDREW Type 40-C Phase Monitor is readily mastered after a few minutes study of the instruction book.

ACCURATE—STABLE Two approximately linear phase scales with a total effective length of 7 inches assure uniform accuracy. Absolute accuracy is plus or minus 2 degrees. The monitor contains no calibrated phase shifting circuits which might become misadjusted; *it is permanently accurate and highly stable.* Users report phase readings can be repeated year in and year out, duplicating original readings within a few tenths of a degree.

SIX INPUT CIRCUITS Six individual input circuits accommodate directional systems utilizing as many as six towers. Front panel switching permits rapid selection of any two input signals for comparison. The input circuits provide 72 ohm terminating impedances for sampling lines.

SENSE INDICATOR The "sense" relationship—that is, the lead or lag relationship—of the two signals under test may be quickly determined by means of a front panel switch which introduces a simple delay network in series with one of the sampling signals.

HIGH SENSITIVITY Sensitivity is high—better than 0.75 volts over most of the range 550 to 1600 KC, and better than one volt over all of this range. The ANDREW monitor performs perfectly on many multi-element 1 KW arrays where less sensitive monitors are ineffective.



Block Diagram of Type 40-C Phase Monitor.

SPECIFICATIONS

ELECTRICAL

Frequency range	550 to 1600 Kilocycles
Phase angle range	0 to ± 180 Degrees
Absolute accuracy	± 2 Degrees
Stability	± 0.2 Degrees
Input impedance	72 Ohms
Sensivity	Better than 1 Volt
Maximum permissible signal	15 Volts
Power supply	115 Volt 60 Cycle
Power consumption	50 Watts
Tube complement	2-6AB7; 1-6AL5; 2-VR150; 1-5Y3
Meter	Precision DC microammeter with two special phase angle scales having total length of 7 inches and one special current ratio scale 2.5 inches long.

MECHANICAL

Height	10½ inches
Width	19 inches
Depth	7 Inches
Weight	21 Pounds
Shipping weight	32 pounds
Finish	Smooth gray on front panel, gray wrinkle on dust cover. Other colors on special order.
Input terminals	Six SO-239 receptacles, to receive RG-11/U solid dielectric cable fitted with PL-259 plugs.

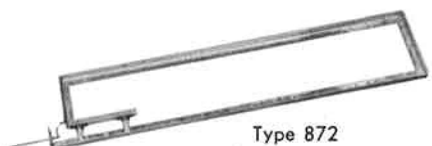
ACCESSORIES FOR PHASE SAMPLING SYSTEMS

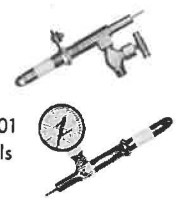

Type 8510
Current Transformer


Type 132-A
Isolation Inductor


Type 4873-A
Adaptor Assembly


Type 83
Coaxial Cable


Type 872
Sampling Loop


Type 1701
End Seals


Type L-14159
Remote Meter Panel

Type L-14159 Remote meter panel, optional with Type 40-C Phase Monitor to indicate relative antenna current. Provides three thermocouple RF milliammeters, calibrated 0-125 ma, mounted on 19 inch rack panel. Phase sampling cables are brought to switches, permitting sampling voltages to be applied either through TC milliammeters to 72 ohm resistors, or to Phase Monitor input. Reading on milliammeter is proportional to antenna current. Includes three RG-11/U cables for connection to Phase Monitor. Also available with two meters instead of three.

Type 872 Sampling loop, unshielded. Constructed of 1½ inch steel angles, galvanized. Install on towers about 0.23 wavelength from top but not less than 25 feet above ground.

Type 132-A Isolation inductor, to carry sampling line across base insulator without detuning tower. Wound of ⅜ inch coaxial cable. Diameter 12 inches. Length 15 inches. Inductance 70 microhenries.

Type 133 (not illustrated) Isolation inductor, similar to Type 132-A except in weatherproof housing.

Type 83 Semi-flexible 72 ohm, air-dielectric coaxial cable for carrying RF energy from sampling device to Phase Monitor. Available in continuous lengths, factory spliced, end seals attached and shipped under pressure. We recommend that sampling lines to all towers be equal in length.

Type 1701GV-1701R Pressure sealed end terminals for attachment to ends of Type 83 cable. Terminal with gauge and valve is recommended at the monitor end of the line; terminal with relief valve, at the tower end.

Type 4873-A Lead and adaptor assembly; one required for each sampling line when Type 83 sampling cable is used. Includes 15 feet of 72 ohm, flexible, solid-dielectric cable and suitable adaptor for connecting between Type 40-C Phase Monitor and Type 83 cable with 1701 terminal on end.

Type 8510 Current transformer, for use in place of sampling loop on short towers. Connect in series with antenna lead on transmitter side of antenna ammeter. Electrostatically shielded. Maximum RMS unmodulated voltage to ground, 1500.

PRINTED IN USA 8M-3-53

Andrew CORPORATION

TRANSMISSION LINES · ANTENNA EQUIPMENT

363 EAST 75th STREET · CHICAGO 19
TRIANGLE 4-4400 • TELEGRAPH: ANDREW CORPORATION, WUX, CHICAGO
CABLE: ANDCORP. CHICAGO, ILL.

INSTRUCTIONS
FOR
TYPE 40-C PHASE MONITOR

BULLETIN 94

8-9-47

ANDREW CO.
363 EAST 75th STREET • CHICAGO 19

BULLETIN

Type 40 C Phase Monitor

Specifications

Frequency range	500 to 1600 KC
Current ratio range	.1 to 1
Phase angle range	0° to 360°
Accuracy, phase angle measurements	± 2°
Input impedance	72 ohms
Sensitivity	.75 volt
Maximum permissible signal	15 volts
Power supply	115 V 60 cycles
Power consumption	50 watts
Vacuum tubes	2 6AB7. 1-6AL5 2 VR 150 1-5Y3
Height	10 1/2"
Width	19"
Depth	7"
Weight	21 lbs
Input connections	UG-58/U Female receptacles

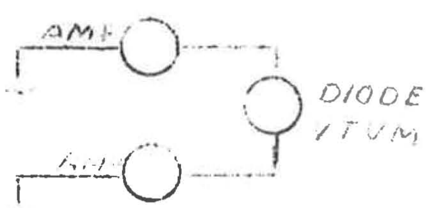
The type 40-C Phase Monitor is an instrument designed primarily for use in adjustment and operation of directional antenna arrays at broadcast frequencies. It will measure phase difference and ratio of magnitude of currents. Provision is made for six inputs, with suitable switching to allow rapid comparison of any two at a time.

The monitor is intended for use in the broadcast band, and has a sensitivity of less than one volt over that spectrum. The input impedance is approximately 75 ohms resistive, suitable for use with the 70 ohm coaxial cable commonly used for the line from the sampling loops to the monitor.

THEORY OF OPERATION

Phase is measured by adjusting the two RF voltages being compared to equal amplitude, mixing them, and impressing the resulting voltage on a diode rectifier. Since the magnitude of the resulting voltage varies as the time phase angle between them varies, the output voltage and current of the diode will also vary, and by properly calibrating a DC instrument in the diode load circuit it is possible to read the phase difference of the two impressed voltages. The voltages can be added either in series or in parallel, and suitable meter scales can be provided to read phase difference. However, if either connection is used to read the entire range from 0 to 180 degrees, the scale will be very crowded at one end or the other. The 40-C Phase Monitor therefore uses both connections and two scales; the series connection for 0 to 90 degrees, and the parallel connection for 90 to 180 degrees. This not only eliminates crowded scales and gives substantially linear calibration over the entire range, but provides a scale twice as long, allowing more accurate reading.

Each channel consists of a class A linear amplifier with suitable input attenuator and selector circuits. In the 0-90 degree connection, a diode voltmeter circuit is connected across the outputs of the two channels. See sketch below.

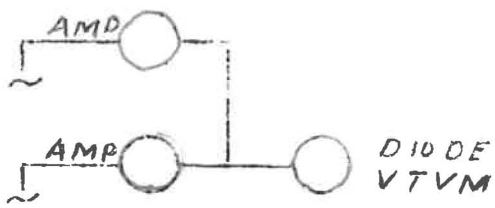


It can be seen that the outputs are in series bucking; that is, if voltages of zero phase difference are impressed, the sum of the two voltages will be zero. The sum of out-of-phase voltages will give a resultant voltage that is read on the diode voltmeter. When the channel output voltages to ground are equal, the relative voltage (E) across the VTVM is given by the expression

$$E = e \sin \frac{\theta}{2}$$

where e is the output voltage to ground of either channel. This gives a scale that is substantially linear up to 90 degrees, and therefore the calibrating point, or e, is chosen so that 90 degrees is read at full scale.

In the case of the parallel connection, the two channel output voltages are mixed at the output of the amplifiers. See sketch below.



It can be seen in this case that input voltages of 180 degree phase difference will give zero output voltage. Output voltage is expressed by the equation.

$$E = e \cos \frac{\theta}{2}$$

This expression is approximately linear from 90 to 180 degrees, which is the range of the second phase angle scale.

In addition to measuring phase difference, it is also necessary to determine which current (or voltage) is leading in time phase. This is accomplished by providing a "Sense indicator", which is a Pi network with a small phase delay characteristic (about 10 degrees) which can be inserted in either input circuit. By noting how the phase readings increase and decrease, it can be determined which current is leading and which is lagging.

Current or voltage ratio is measured by using one amplifier channel feeding into the diode voltmeter. The attenuator of that channel is adjusted to give a reference output voltage. The amplifier input is then switched from the reference input to any other input desired, and the ratio read on the ratio scale.

INSTALLATION

The instrument is provided with a standard 10 1/2 X 19 inch panel for relay rack mounting. The 110 Volt, 60 cycle power feed is plugged into the female power receptacle on the rear of the chassis. Coaxial cable receptacles J_1 to J_6, are provided along the back of the chassis for the sampling lines

It is recommended that the coaxial lines from the sampling loops or current transformers be the same length for all towers While it is possible to measure the difference in phase shift in the lines due to difference in length it represents an additional factor that may introduce error.

OPERATING INSTRUCTIONS

1 After allowing the instrument to warm up for several minutes, choose the two inputs to be measured by setting the "A Selector" and "B Selector" in the proper positions.

2. Place the two sensitivity switches in either high or low positions as required by the magnitudes of the input voltages, and the sense indicator in off position.

3. Set the range switch in 0-90 or 90-180, as determined by previous experience. If the proper range is not known select either range and proceed with measurement. If the wrong scale has been chosen the meter will read off scale.

4. Set the calibrating switch in "Calibrate A" position and adjust the A channel attenuator until the meter pointer is set on the red line (at 60 degrees on the scale).

5. Set the calibrating switch in "Calibrate B" position and repeat.

6. Set the calibrating switch in "Read" position and read the phase difference on the proper scale.

7. Determine the "Sense" of the two currents by means of the sense indicator. With the instrument in "Read" position set the "Sense Indicator" in either channel. Knowing that the sense indicator introduces a phase lag, it is easy to determine which current is leading. For example if a phase reading of 45 degrees is obtained, and if, with the sense indicator set in channel A, the phase reading is 55 degrees it is evident that current A lags current B. If, on the other hand insertion of the sense indicator gives a reading of 35 degrees, then current A is leading current B.

MEASUREMENT OF CURRENT RATIO

1. Set the range switch to "0-90" position and the calibrating switch to "Calibrate A"

2. With the selector switch for channel A set on the reference input, vary the channel A attenuator to give a meter deflection of 1.0 on the current ratio scale.

3. Switch the channel A selector to select the input desired and read the ratio directly.

It is apparent that the magnitude of the reference input must be larger than that of the inputs being compared to it. Caution must be taken that the "B Selector" is not set on either the reference or compared inputs, as this cuts the resistance of the line termination in half and will give erroneous readings.

MISCELLANEOUS OPERATING AND MAINTENACE SUGGESTIONS

1. Check the zero set of the meter occasionally, with no signal input. It will be observed that a false zero is provided on the meter scale. This is to compensate for the no signal space current of the diode rectifier. The zero set must of course, be made with the instrument turned on. Different diodes have different values of space current, so in some cases with the instrument calibrated to "0" on the scale the needle will not return to the zero current mark on the scale. This has no effect whatever on the performance of the instrument.

2. Tap the meter case lightly when making measurements. The meter movement is A 0-50 DC microammeter, and internal friction may produce slight sluggishness.

3. It is necessary to compensate the monitor for unequal phase shift through the two channels due to different tube interelectrode capacities, lead capacities etc. The adjustments are normally made at the factory for proper operation at the frequency for which the unit is ordered, but they can be done in the field if necessary. They should be made if the operating frequency of the instrument is changed.

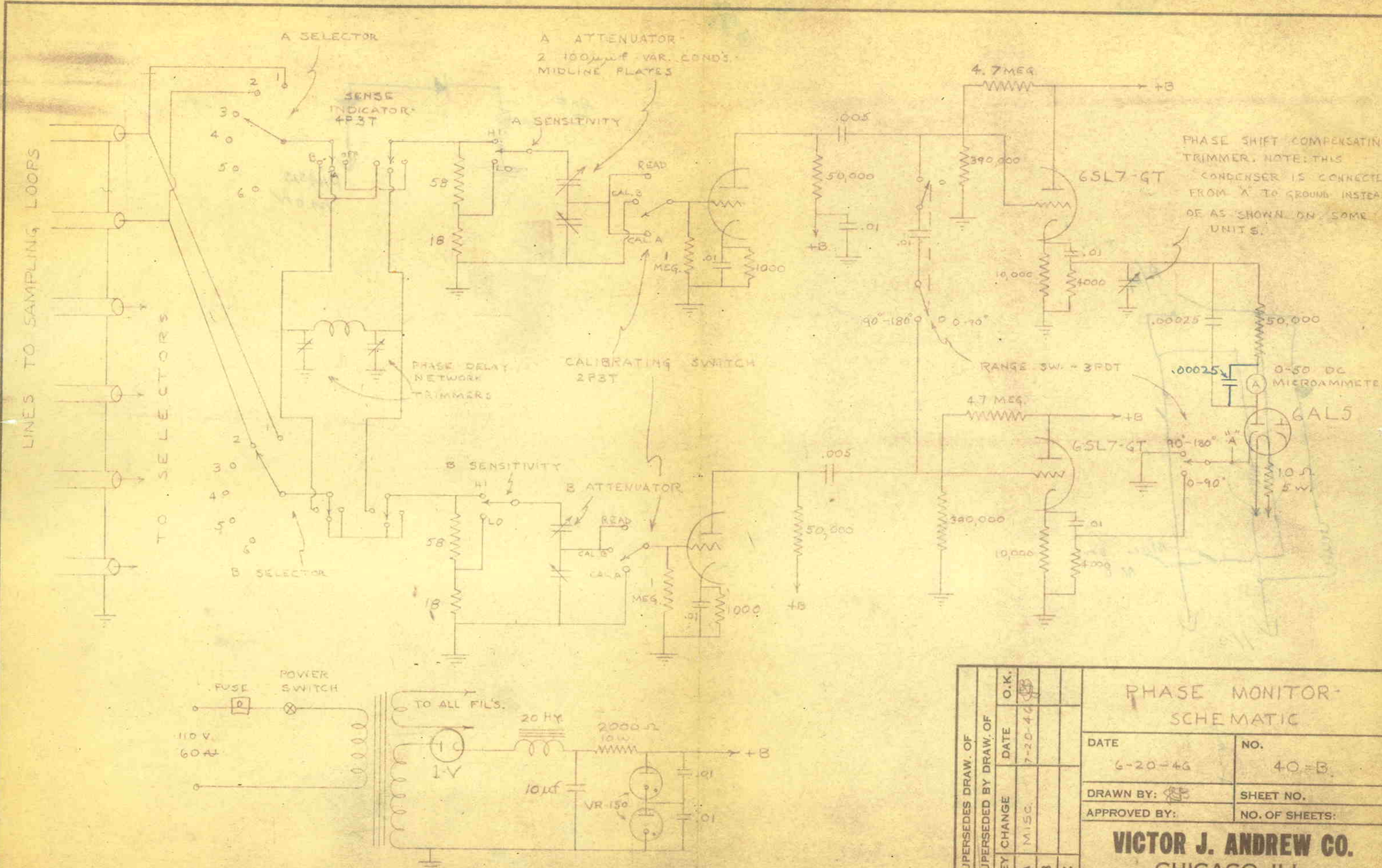
Supply signal with a small phase difference, say 30 degrees to the input of the two channels. Adjust the diode trimmer for equal readings as the channel selector switches are reversed. This equality of readings should then hold over the entire range of the instrument.

Voltages out of phase can be obtained by using cables of different length to feed the two channels.

4. The sense indicator circuit has been adjusted at the factory, and should not require any readjustment. If, for any reason, it becomes necessary to readjust the circuit, it should be done by means of an RF impedance bridge. Connect the bridge to the input grid of either class A amplifier and with the sense indicator in off position measure the RF impedance looking back towards the input. Then insert the phase delay network in the circuit and adjust the coil

until the RF impedance measures the same as it did without the sense indicator in the circuit.

5. Receptacles J_1 to J_6 are intended for use with solid dielectric cable and suitable connectors. RG 11/U is the proper cable type. The splice or connection between rigid sampling line and solid dielectric cable should be within 10 feet of the phase monitor and the lengths of solid dielectric cable should be identical.



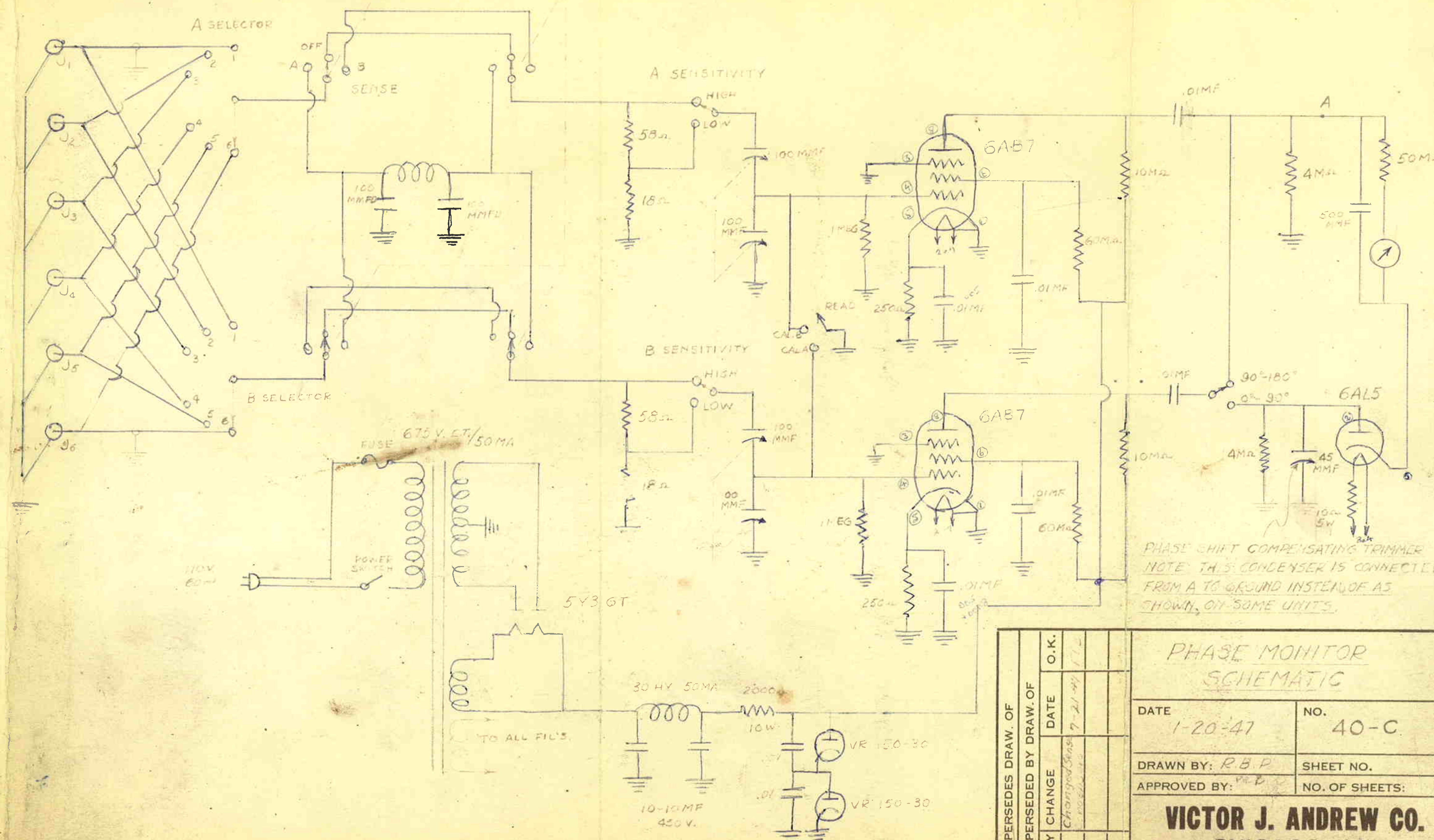
PHASE MONITOR SCHEMATIC

DATE: 6-20-46	NO. 40-B
DRAWN BY: [initials]	SHEET NO.
APPROVED BY:	NO. OF SHEETS:

KEY	CHANGE	DATE	O.K.
A	MISC.	7-20-46	[initials]
B			
C			

SUPERSEDES DRAW. OF
SUPERSEDED BY DRAW. OF

VICTOR J. ANDREW CO.
CHICAGO, ILL.



PHASE MONITOR SCHEMATIC

KEY	CHANGE	DATE	O.K.
A	Changed Sense	7-21-47	
B			
C			

SUPERSEDES DRAW. OF

SUPERSEDED BY DRAW. OF

DATE: 1-20-47

NO. 40-C

DRAWN BY: R.B.P.

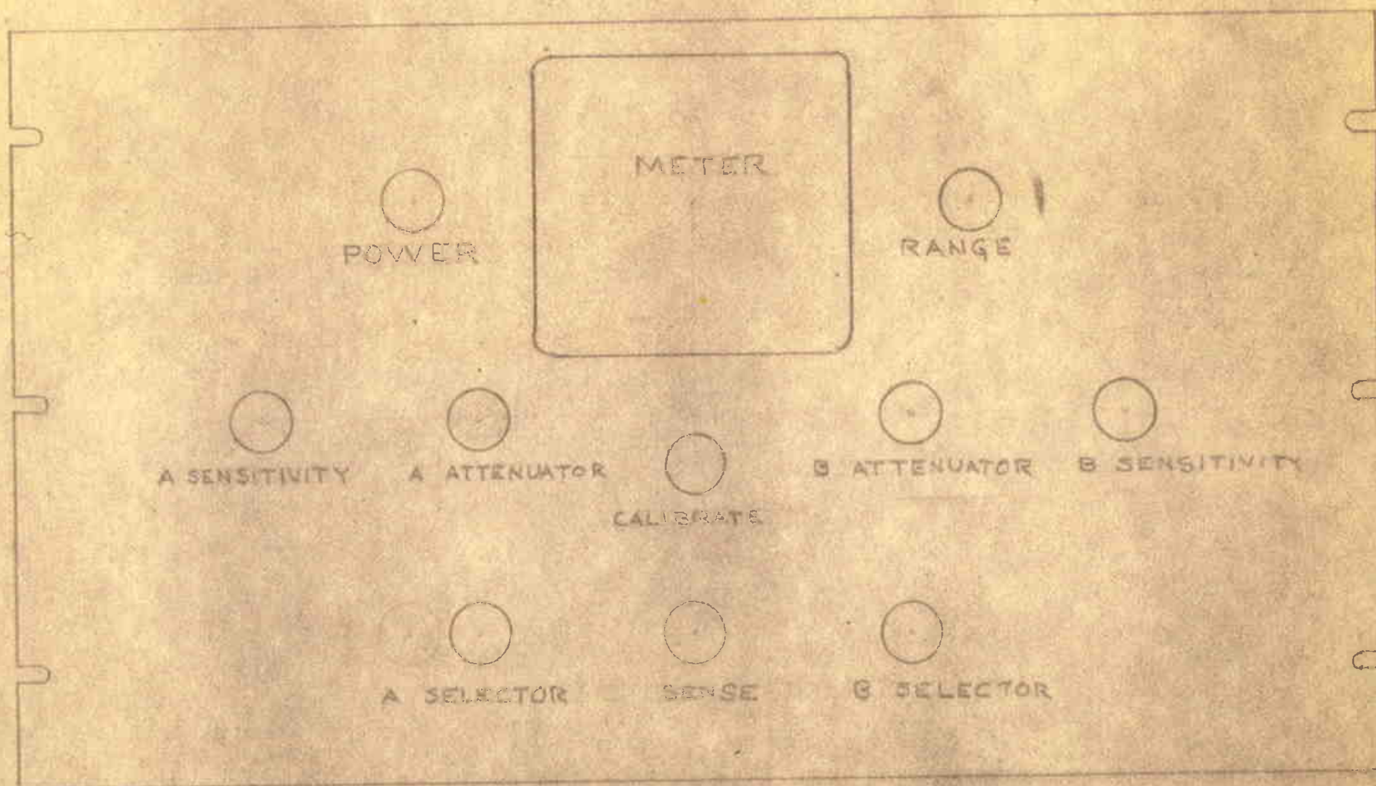
APPROVED BY:

SHEET NO.

NO. OF SHEETS:

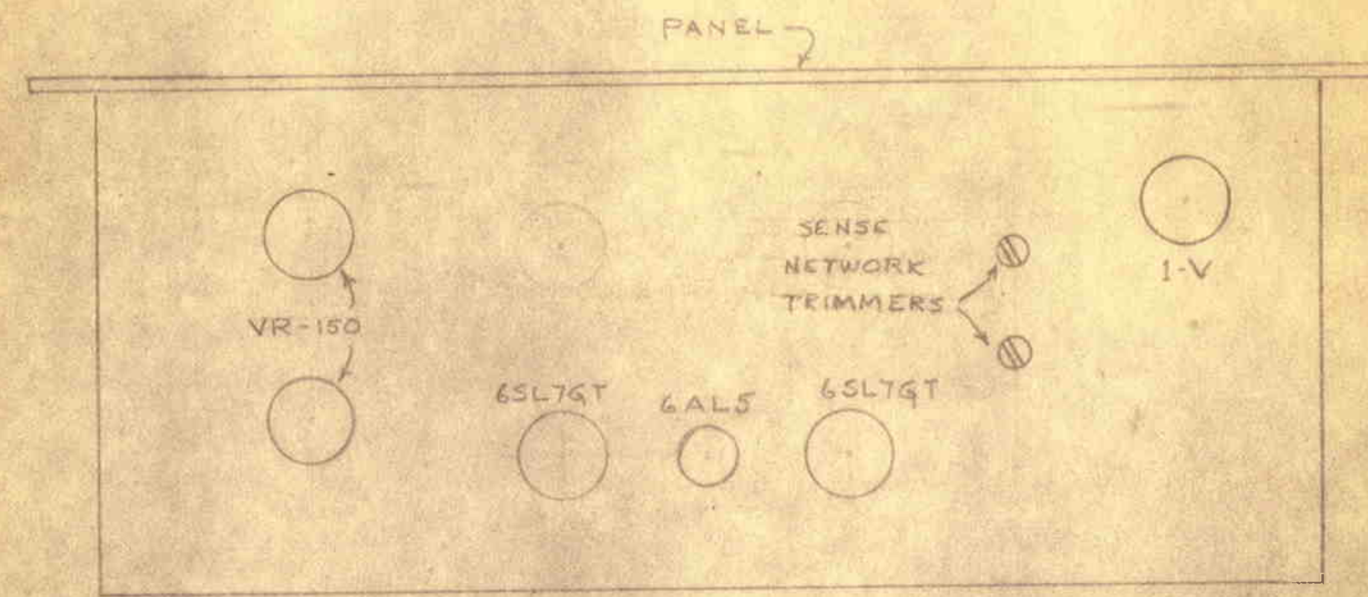
VICTOR J. ANDREW CO.
CHICAGO, ILL.

FRONT PANEL LAYOUT

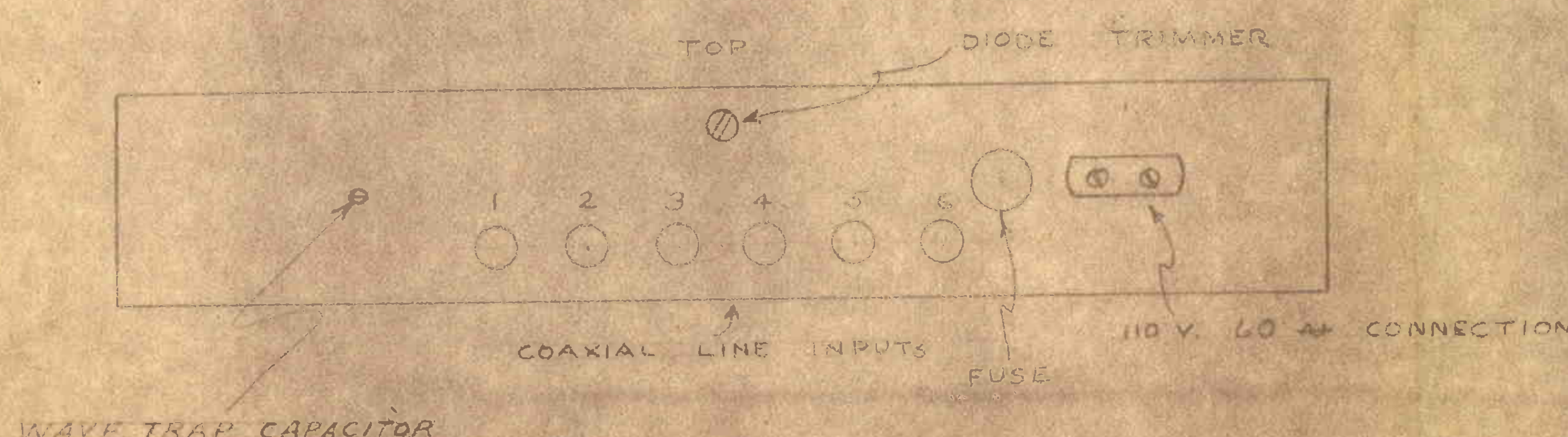


TOP VIEW OF CHASSIS

SHOWING LOCATION OF TUBES



BACK OF CHASSIS



KEY	CHANGE	DATE	O.K.
A	MISC	7-1-46	
B	Add Wave Trap Cap.	11/6/46	
C			

SUPERSEDED BY DRAW. OF

SUPERSEDES DRAW. OF

40-B PHASE MONITOR –
CHASSIS & PANEL LAYOUTS

DATE 6-15-46

NO. L-11020

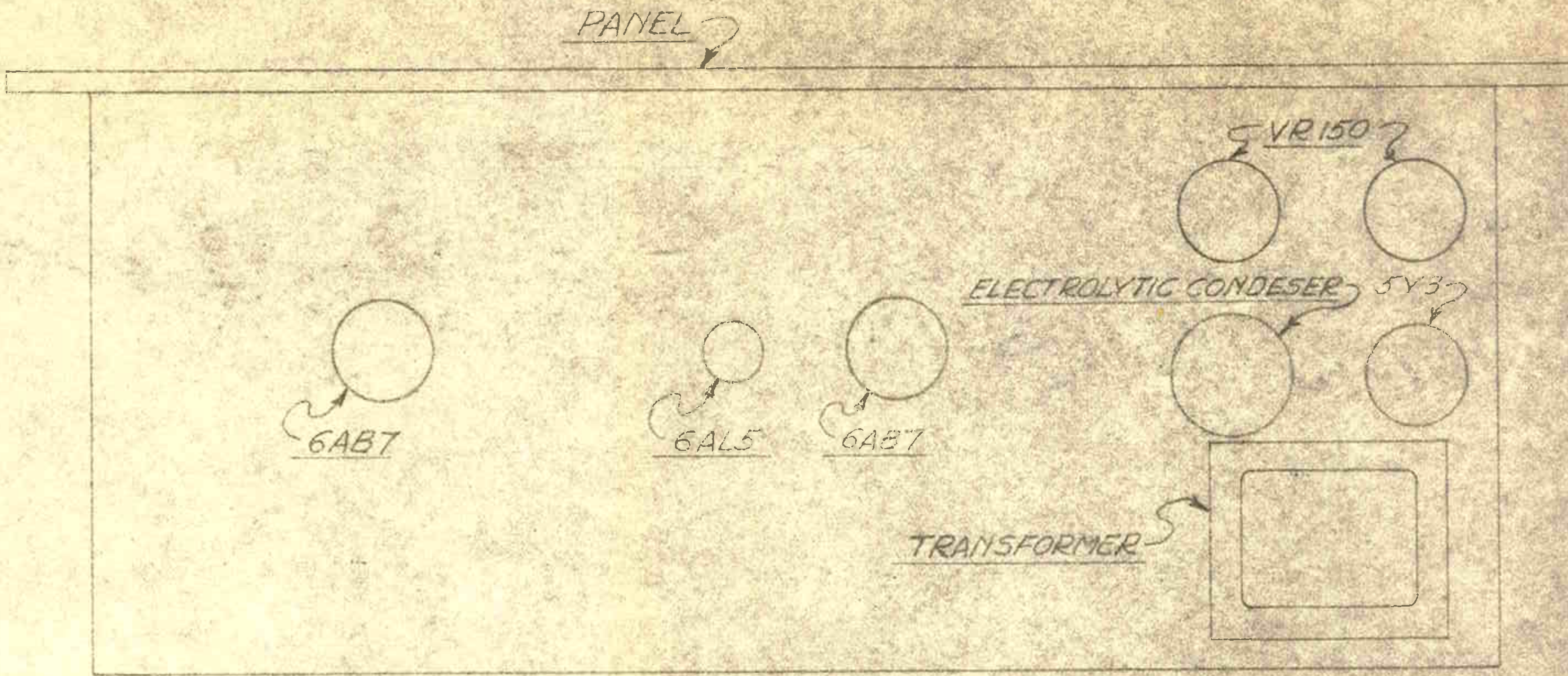
DRAWN BY:

SHEET NO.

APPROVED BY:

NO. OF SHEETS:

VICTOR J. ANDREW CO.
CHICAGO, ILL.



TOP VIEW OF CHASSIS
SHOWING LOCATION OF TUBES

SE

TION

MATERIAL:

FINISH:

FIRST USED ON SCALE REMOVE ALL BURRS AND SHARP EDGES

TOLERANCE UNLESS OTHERWISE SHOWN: ± .005 ON DECIMAL DIMENSIONS ± 1/64 ON FRACTIONAL DIMENSIONS.

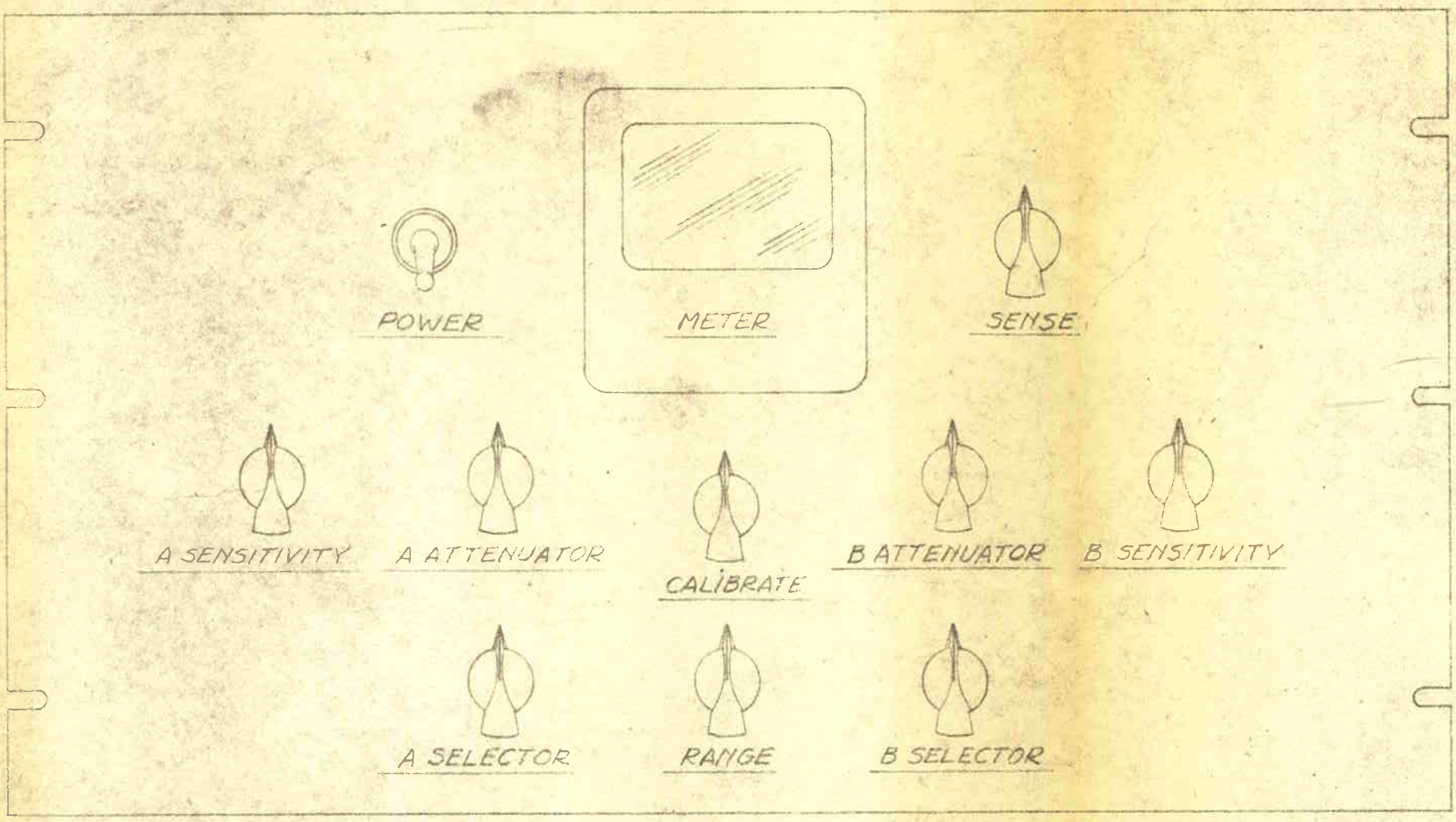
KEY	CHANGE	DATE	O.K.
A	Removed Sense Network Cond-ensers	7 FEB 11 47	

SUPERSEDES DRAW. OF

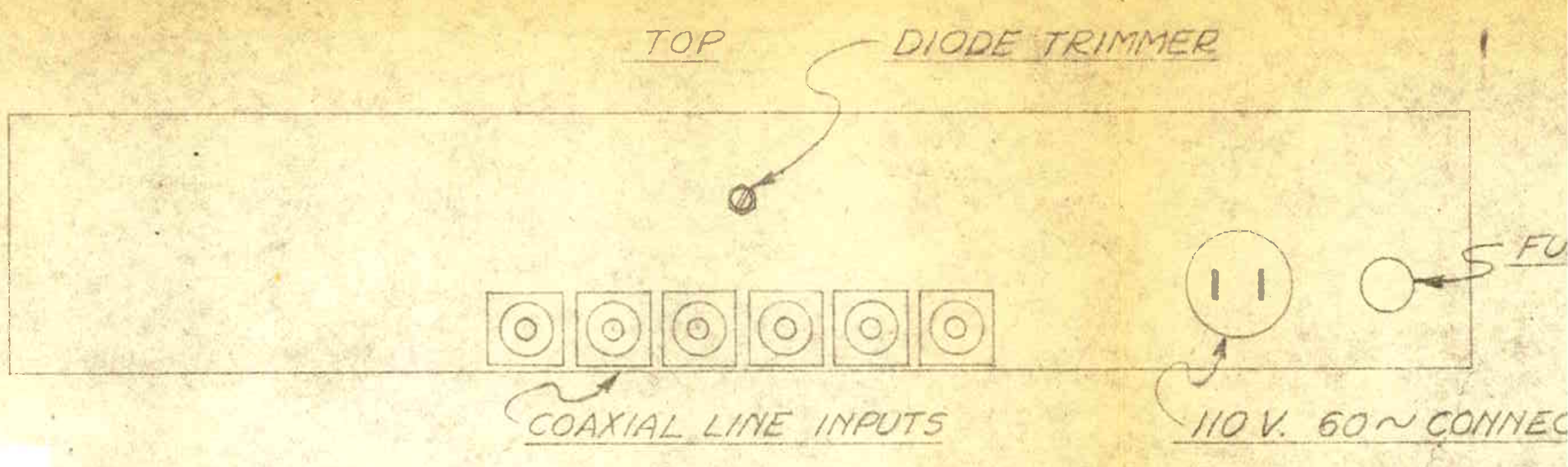
40-C PHASE MONITOR
CHASSIS & PANEL LAYOUTS

DRAWN BY	DATE	NO.
R.B.R.	1-25-47	M-11402
ENGR. APP. PRB	DATE 1-27-47	SHEET NO.
PROD. APP.	DATE	NO. OF SHEETS

ANDREW CO.
CHICAGO 19, ILL.



FRONT PANEL LAYOUT



BACK OF CHASSIS