INSTRUCTION MANUAL

FOR

MODEL 417A RC OSCILLATOR

KIKUSUI ELECTRONICS CORP., JAPAN

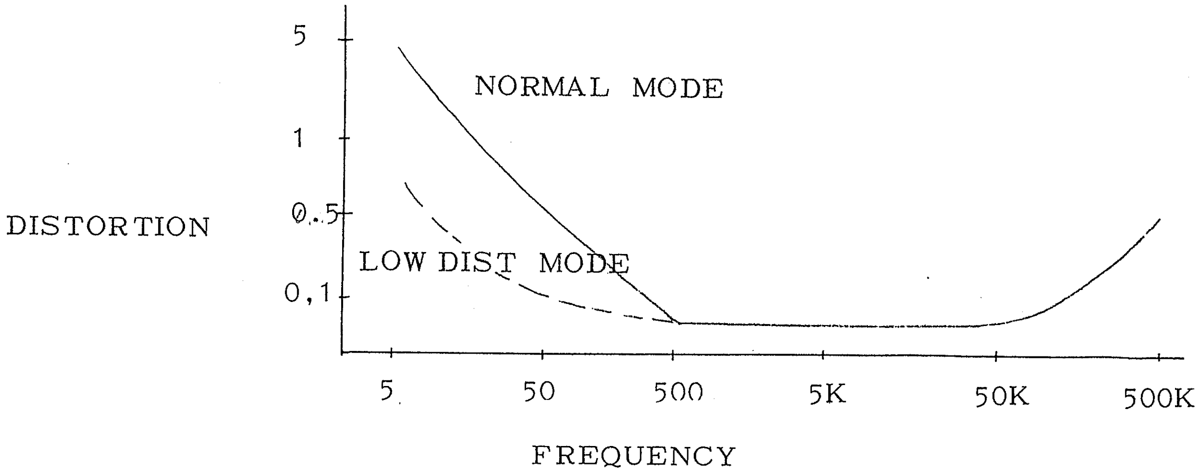
INTRODUCTION

The 417A is a solid-state Wien bridge oscillator which generates a signal for a total range of 5 Hz ~ 500 kHz, being divided into five ranges. For amplitude control, the 417A employs an AGC circuit which detects the average value of the amplitude and controls a FET circuit with the detected signal and, thus, the 417A produces a highly stable, low distortion sine wave output signal. It also produces a square wave signal with its Schmitt pulse generator circuit. The square wave has fast rise-up characteristics and its symmetry is adjustable for a range of ±10% or over. Output signal level is widely adjustable with a combination of a 40 dB attenuator (in 10 dB steps) and a 30 dB continuously variable attenuator.

TABLE OF CONTENTS

1. SPECIFICATIONS

Power requirements:	___V ±10%, 50/60 Hz.
Weight:	Approx. 5.5 kg
Dimensions:	200 mm wide, 140 mm high, 275 mm deep.
(Maximum dimensions):	(200 mm wide, 160 mm high, 315 mm deep.)
Ambient temperature:	$5^{o}C \sim 35^{o}C$
Oscillation frequency:	5 Hz ~ 500 kHz, 5 ranges.
Accuracy:	±(3% + 1 Hz) or better.
Output impedance:	600 Ω ±3% or less (at 1 kHz)
Output attenuators:	30 dB continuously variable attenuator; 10-dB step attenuator (maximum 40 dB)
Output voltage/frequency characteristics:	Within ±0.3 dB (600 Ω load).
Output voltage/temperature characteristics:	Better than 0.1%/^{o}C.
Output terminals:	3-way type, 19 mm intervals (3/4"), floating operation possible, built-in 600 Ω terminating resistor.
Output waveforms:	Sine wave and Square wave.
Sine wave output	
Output voltage:	3 V rms or over (600 Ω load) at 5 kHz; 6 V rms or over when output terminals are open.
Distortion factor:	500 Hz ~ 50 kHz ... 0.05% or less 50 Hz ~ 500 Hz ... 0.1% or less 10 Hz ~ 50 Hz ... 0.5% or less 50 kHz ~ 500 kHz ... 0.5% or less Below 10 Hz ... 1% or less



Notes: The LOW-DIST/NORM switch set in x1 or x10 range position.

Square wave output

Output voltage:	6 Vp-p or over (600 Ω load) at 5 kHz; 12 Vp-p or over when output terminals are open.
Symmetry adjustable range:	±10% or over.
Rise time:	Less than 100 nsec.
Overshoot:	Less than 2% (at maximum output voltage)
Sag:	Less than 10% at 5 Hz

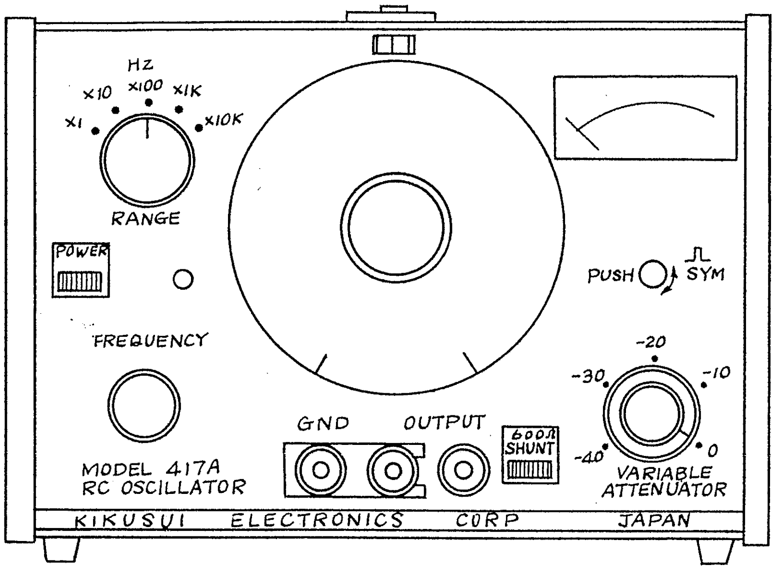
Output voltmeter

Scale:	V rms and dBm, 3 V rms full scale.
Accuracy:	Better than ±3% full scale at 1 kHz sine wave.

Sync.input:	7% or over at sine wave input 6 V rms (Sync. range is almost directly proportional to input voltage.) With sine wave input voltage of less than 0.5 V rms, no effect on distortion factor or output voltage.
Accessories:	Output terminal jumper bars ... 2 ea. Instruction manual ... 1 copy ea.

2. OPERATION METHOD

2.1 EXPLANATION OF FRONT PANEL



POWER: Pressing this pushbutton switch turns on the oscillator power, the power pilot lamp lights, and the switch is locked.

FREQUENCY: With this dial knob, oscillation frequency is continuously variable up to 10 times.

RANGE: Selects multiplication factor for oscillation frequency. The product obtained by multiplying the dial reading by this factor is the oscillation frequency.

ATTENUATOR: Attenuates the output voltage in 10-dB steps, up to maximum 40 dB.

VARIABLE: For continuously variable adjustment of output voltage.

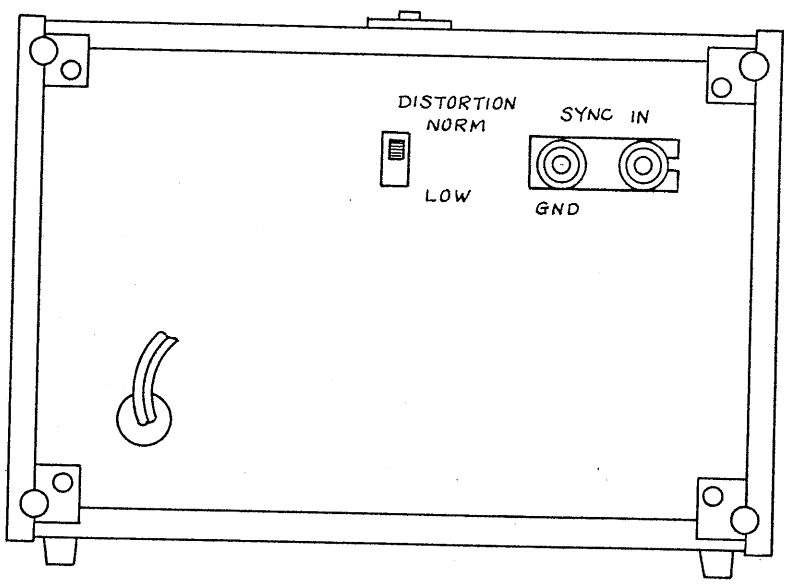
OUTPUT: Output terminals are color coded for red (H), black(L), and black (GND). The black terminal is connected to the internal chassis and isolated from the housing. When an output floated from GND is required, disconnect the jumper bar from the terminals.

∿ ⎍: Pressing of this button changes output waveform between sine wave and square wave, alternately. The square wave state is indicated by the red mark on the button side surface. Waveform symmetry is adjustable by turning this knob.

600Ω SHUNT: Pressing of this button internally shunts the output with a 600 Ω resistor.

OUTPUT METER: Indicates the output voltage for the state of the attenuator set for 0 dB. The upper scale is for V rms and the lower scale for dBm.

2.2 EXPLANATION OF REAR PANEL



SYNC IN:	Input terminals for external sync. signal.
DISTORTION NORM/LOW:	When this switch is set in the LOW position, the waveform distortion is reduced for the x1 range and x10 range. However, a longer restoration period is required when the FREQUENCY dial is turned or RANGE switch is changed, as compared with the NORM mode of operation.

2.3 OPERATING PROCEDURE

(1) Press the POWER button so that it is locked, the power pilot lamp lights, and the Oscillator becomes operating state within several seconds.

(2) Setting the oscillation frequency:

Set the required frequency with the RANGE switch and FREQUENCY dial. The product obtained by multiplying the FREQUENCY dial reading by the RANGE switch factor denotes the actual oscillation frequency.

(3) Output voltage:

The impedance of the load connected to the Oscillator should be matched with the Oscillator output impedance (600 Ω). When the load impedance is sufficiently large as compared with the Oscillator output impedance (600 Ω), impedance matching can be accomplished simply by pressing the 600Ω SHUNT button. If there is impedance mis-matching between Oscillator and load, the actual output voltage may not conform with the value indicated by the output meter.

When the output impedance is correctly matched, the required output voltage can be obtained at the output terminals by means of the ATTENUATOR and VARIABLE controls and output meter. The voltage at the output terminals can be known by multiplying the output meter reading by the factor indicated by the ATTENUATOR control.

It is possible to reduce the output to 0 V (zero volts) with the VARIABLE control alone. However, if the output voltage is reduced to below -10 dBm with the VARIABLE control alone, the output signal waveform will be degraded. Hence, the use of the VARIABLE control in a region where the output meter indicates less than 20% of full scale is unrecommendable.

The output meter can measure the voltage of either the sine wave or square wave signal. For the square wave signal, however, the output meter indicates the correct voltage only when the symmetry factor of the waveform is 1.

(4) External synchronization:

The oscillation frequency can be synchronized with an external signal applied to the SYNC IN terminal. Synchronization can be obtained when the set frequency of the Oscillator is the same with or close to the external synchronization signal. The Oscillator can also be synchronized with a harmonic frequency of the synchronization signal. State of synchronization varies according to both voltage and frequency of the synchronization signal. The range of frequency shift within which the synchronization is maintained is almost directly proportional to the synchronization signal voltage. The output signal is not distorted when the synchronization signal is a sine wave and its amplitude is small. However, distortion increases when the signal voltage is large and the synchronization frequency is subtantially deviated from the set frequency of the Oscillator. When the synchronization signal is abundant in harmonics, successful synchronization can be realized for such a high frequency as 10th harmonics. In such a case, however, waveform distortion will increase.

The SYNC IN terminals can be utilized for the following purposes:

(a) The Oscillator frequency can be synchronized with a high accuracy frequency of a crystal oscillator or tuning fork oscillator, to obtain a signal of highly accurate frequency and low distortion.

(b) Using a badly distorted signal as the synchronization signal, a clean waveform output signal can be obtained from the Oscillator.

(c) Using a plural number of Oscillators and synchronizing them at the fundamental and harmonic frequencies, the following modes of operation are attainable.

(i) Using an oscilloscope, stationary Lissajous figures can be displayed. Without synchronization, displayed figures can hardly be made still for frequencies ratios of 5:3, 10:3, etc. With synchronization, figures of such ratios also can be easily observed as still patterns.

(ii) A composite signal can be obtained by combining the output of a plural number of Oscillators.

(iii) A pulse signal can be obtained by differentiating the square wave signal, and the pulse phase can be made either advancing or lagging with respect to the reference pulse and, thus, the pulse interval can be varied.

(5) Sine wave output:

When the range selector is set for the x1 or x10 range, the DISTORTION selector switch on the rear panel may be switched as required. The switch will be set in the NORMAL position for frequency response measurement or other uses where some distortions are permissible, but in the LOW position when a signal with very small distortions is required. Note that, when the switch is set in the LOW position, a longer period will be required for the amplitude to stabilize after the RANGE switch is changed or the FREQUENCY dial is turned, as compared with that in the NORMAL mode of operation.

(6) Pulse wave output:

The symmetry of the square wave output is adjustable by turning the SINE/SQUARE button. In a region the output voltage is small, the rate of overshoot will be unstable. It is recommended to use a region of a larger output in order to obtain a better output waveform.

(7) **Environments:**

(a) The ambient temperature should be $5^{o}C$ ~ $35^{o}C$. Note that, even when the ambient temperature is below $35^{o}C$, the internal temperature of the Oscillator may be higher if it is exposed to direct sunlight or other heat source.

(b) The Oscillator employs very high resistors (38 MΩ) in Wien bridge circuit for the x1 range. Do not use the Oscillator in highly humid or dusty environments.

3. OPERATING PRINCIPLE

3.1 OSCILLATOR CIRCUIT

Circuits with R and C as frequency determining elements are most commonly used for low frequency oscillators. Among these RC oscillators, Wien bridge oscillation circuits are most typical. Wien bridge circuits have advantages over other types of oscillator circuits in that the oscillation frequency is easily variable, the output waveform includes less distortions, and the oscillation is stable. The 417A Oscillator also employs a Wien bridge oscillation circuit, the construction of which is illustrated in Fig. 1.

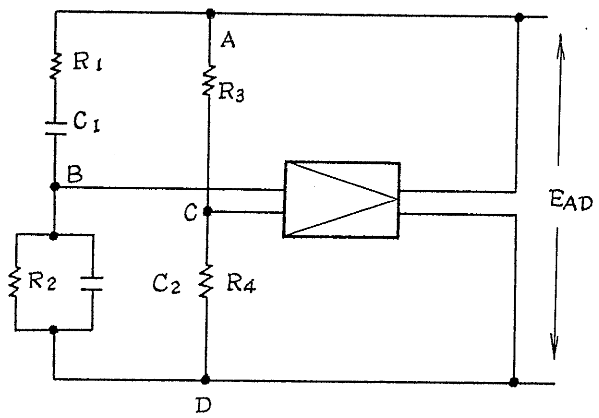


Fig. 1

Referring to Fig. 1, E_{BC} and E_{AD} are mutually in phase when the following condition is satisfied.

$$f = \frac{1}{2\pi\sqrt{R1\ R2\ C1\ C2}} \quad \cdots\cdots\cdots\cdots\cdots\cdots (1)$$

E_{BC} is given as

$$E_{BC} = \left[\frac{1}{1 + \frac{R1}{R2} + \frac{C2}{C1}} - \frac{R4}{R3 + R4} \right] \cdot E_{AD} \cdots\cdots\cdots (2)$$

The circuit oscillates when the following condition is satisfied.

$$\frac{1}{1 + \frac{R1}{R2} + \frac{C2}{C1}} - \frac{R4}{R3 + R4} \geqq \frac{1}{A} \quad \cdots\cdots\cdots\cdots (3)$$

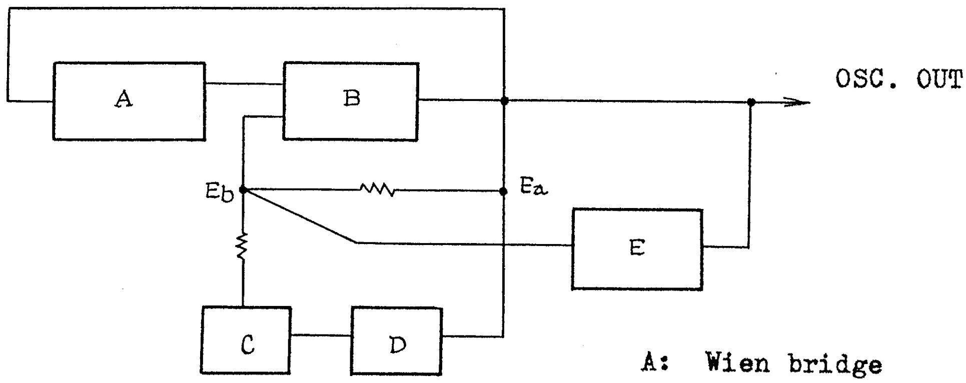
The stable oscillating condition is attained when the following condition is satisfied.

$$\frac{1}{1 + \frac{R1}{R2} + \frac{C2}{C1}} - \frac{R4}{R3 + R4} = \frac{1}{A} \quad \cdots\cdots\cdots\cdots (4)$$

In practice, the requirement of equation (4) can hardly be satisfied with a circuitry as shown in Fig. 1. If this requirement is satisfied from the beginning, no oscillation can start. The conditions for oscillation are determined by equations (1) and (3), and are irrelative to emplitude. For an actual oscillator, such a provision must be incorporated that the condition of equation (3) is initially satisfied and, after oscillation has built up to a stable level, the condition of equation (4) is satisfied. To meet this requirement, the resistance of R3 or R4 must automatically vary in response to the oscillation amplitude. The most commonly practiced method is to use a thermistor as for R3. A provision which employs a thermistor satisfies the condition of equation (4) with a simple circuitry and covers a wider variation of circuit constants. However, the thermistor circuit is disadvantageous in that it is affected by ambient temperature variation and a longer period is required for oscillation stabilization if oscillation with a low waveform distortion is required.

For the 417A Oscillator, more sophisticated circuit is employed. That is, the average value of the oscillation voltage is detected and the gate voltage of a FET transistor is controlled by the detected voltage signal. This circuit enables the Oscillator to produce an output signal, the distortion factor of which is very low and the amplitude of which is less affected by temperature even at a very small output signal level.

3.2 AMPLITUDE CONTROL CIRCUIT



A: Wien bridge

B: Amplifier circuit

C: Voltage-control variable-resistance circuit

D: AGC rectifier circuit

E: Transient variation suppression circuit

Fig. 2

Circuit D rectifies the oscillation voltage into a DC voltage. The DC voltage increases in direct proportion to the oscillation amplitude. Circuit C has such characteristics that its resistance varies in accordance with the above DC voltage. As the voltage increases, the resistance increases in direct proportion and the ratio of Eb/Ea also increases. As the ratio increases, the negative feedback rate of Amplifier B increases and the oscillation voltage reduces until the equilibrium state satisfying the condition of equation (4) is obtained. Even when a circuit element of the Wien bridge or gain of Amplifier B is varied, the variation is compensated for by variation of resistance of Circuit C so that a stable oscillation is maintained. Circuit E has a function to suppress transiential sharp variation of oscillator output which could, if otherwise, be caused when the RANGE switch is changed or the FREQUENCY dial is rapidly turned. When the oscillator output tends to increase to a large peak amplitude, Circuit E provides a large negative feedback in order to instantaneously suppress the peak amplitude.

4. MAINTENANCE

4.1 ACCESS TO CHASSIS

To gain access to the internal chassis, undo the four screws shown in Fig. 3 and remove the studs and, then, slowly pull out backwards the two side plates and the top and buttom plates.

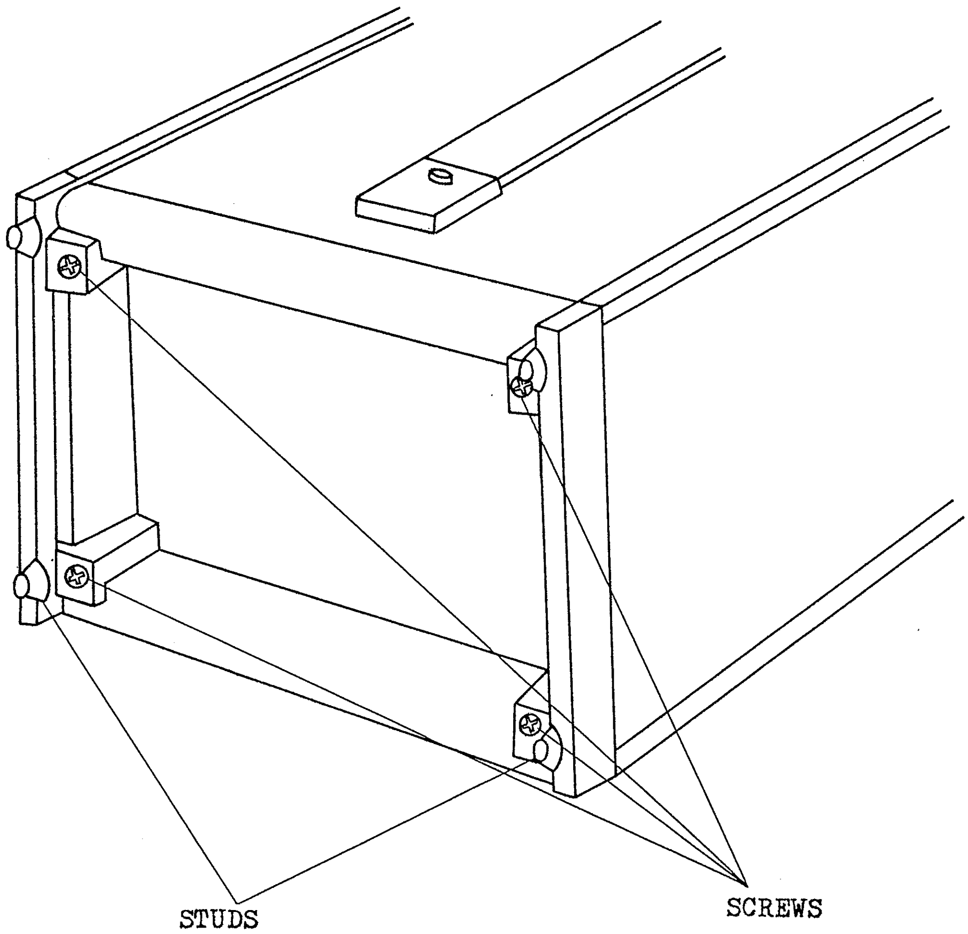


Fig. 3 (Rear view)

Notes: Note that the top plate may come off the frame if the panel front is inclined by holding the handle under the state the studs of the rear plate is removed.

4.2 ADJUSTMENTS

For adjustment of the Oscillator, follow the below-mentioned procedure referring to Figs. 4-7.

(1) Adjustment of DC supply voltages (+15 V and -15 V):

Adjust variable resistors TP4 and TP5 of printed board A2 so that the supply voltages are made +15 V (±2%) and -15 V (±2%), respectively.

(2) Gain adjustment:

Set the RANGE switch in the 1K position and the FREQUENCY dial in the "5" position. Connect a 150 kΩ resistor (1/4 W, 5%) in parallel with RG shwon in Fig. 4. Measure the voltage of Tp1 with a voltmeter having an input resistance of higher than 1 MΩ, and adjust the GAIN ADJ control so that the voltmeter reads -0.7 V ±10%. After the adjustment is complete, remove the 150 kΩ resistor.

(3) Output voltage adjustment:

Set the SINE/SQUARE selector button in the SINE state, the ATTENUATOR switch in the 0 position, the VARIABLE knob in the fully clockwise position (maximum position). Set the output circuit in such a state that the output terminals are terminated with a 600 Ω load. Under the above state, adjust the OUT LEVEL control so that the output terminal voltage is made 3.3 V rms. If the output amplitude is unstable, turn clockwise the DAMP LEVEL control so that the output amplitude is stabilized.

(4) Damping balance adjustment:

Observe the waveforms of TP2 and TP3 using an oscilloscope. The displayed waveforms would be as illustrated below. Adjust the DAMP (±) control to make $e_1 = e_2$.

(5) Damping level adjustment:

Adjust the DAMP LEVEL control to make $e_1 = e_2 = 32$ mV ±2 mV, referring to above item (4) for e_1 and e_2.

(6) DC level adjustment:

Set the VARIABLE knob in the fully counterclockwise position, and turn the DC LEVEL control so that the output voltage is made 0 ±1 mV.

(7) DC balance adjustment:

Short-circuit the RG shown in Fig. 4, set the VARIABLE knob in the fully clockwise position, and adjust the DC BAL control so that the output voltage is made 0 ±1 mV.

(8) Distortion factor adjustment:

Measure the distortion factor of the output, and adjust the DIST control so that the distortion factor is made less than 0.03% (1 kHz).

(9) Repeat the adjustment of items (2), (3), (4) and (5) above.

(10) Frequency adjustment:

(i) Dial position setting:

Remote the center knob of the dial plate. Measure the frequencies corresponding to position "5" of the dial scale with the RANGE switch set in the x10, x100, x1K, and x10K range positions (50 Hz, 500 Hz, 5 kHz, and 50 kHz), and find the position where the errors of frequencies are made minimum. Loosen the set-screw of the dial plate clamp, and adjust the mechanical position of the dial to the minimum-error position as found above.

(ii) Adjustment of x1 RANGE 5 Hz:

Under the state of the above item (i), measure the voltage of TP1 and make the voltage (E_{TP1}) approximately 2 ~ 5 V DC. Measure the frequency with the x1 RANGE position, and adjust A3R3 and A3R9 so that the frequency is made 500 Hz and the voltage of TP1 is made E_{TP1}.

(iii) Turn the dial plate to the "50" position. Adjust A3C1 and A3C8 so that the frequency is made 50.0 Hz and the voltage of TP1 is made E_{TP1}.

(iv) Keeping the dial plate in the above position, measure the frequencies at x10, x100, and x1K range positions. Adjust A3C6 and A3C9 so that the errors of the frequencies are made minimum and the voltage of TP1 is made E_{TP1}.

(v) Set the RANGE switch in the x10K position and the dial plate in the "40" position. Adjust the HF trimmer capacitor so that the frequency is made 400.0 kHz.

(11) Output voltage/frequency characteristics adjustment:

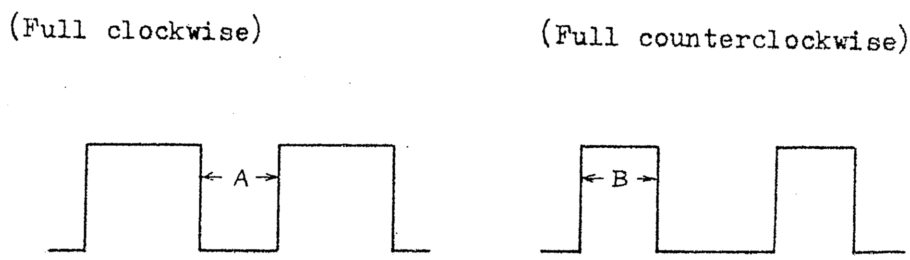
Set the dial plate in the "50" position and the RANGE switch in the x100 position, and measure the output voltage. Next, turn the RANGE switch to the x10K position and adjust the OUT LEVEL (C) control so that the same output voltage is obtained.

(12) Adjustment of distortion factor for high frequency range:

Set the RANGE switch in the x1K position, and adjust the DISC (C) control so that the distortion factor is made minimum.

(13) Adjustment of symmetry of square wave:

Set the RANGE switch in the x100 position and the SINE/SQUARE selector in the SQUARE position. Observing the waveform with an oscilloscope, adjust the SYM control so that the condition of A = B (refer to the illustration below) is obtained when the SINE/SQUARE selector is turned to the fully clockwise position and then to the fully counterclockwise position.



(14) Meter circuit adjustment:

Set the RANGE switch in the x100 position and the SINE/SQUARE selector in the SINE position, and measure the output voltage. Adjust the VARIABLE control so that the output is made 3 V rms. Next, adjust the METER control so that the meter indicates 3 V.

Turn the RANGE switch to the x10K position, and adjust the meter circuit in the same manner as above.

4.3 LAYOUT OF CONTROLS

Fig. 4 (Left-hand side)

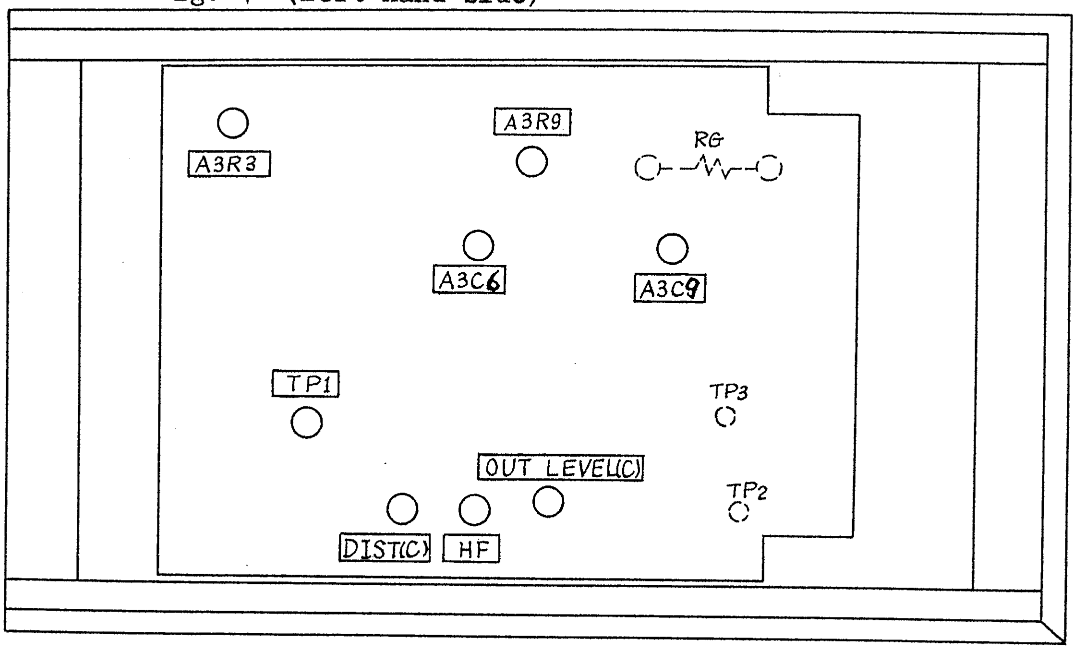


Fig. 5 (Top view)

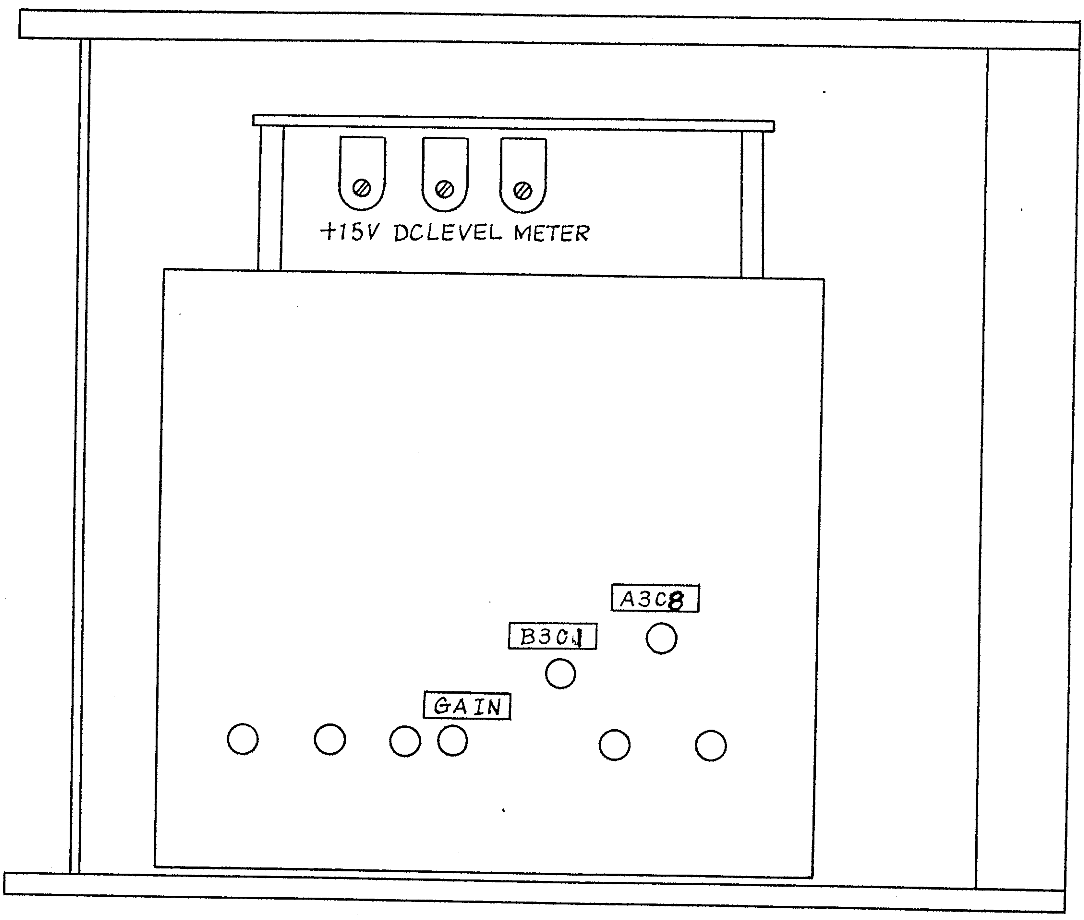


Fig. 6 (Right-hand side)

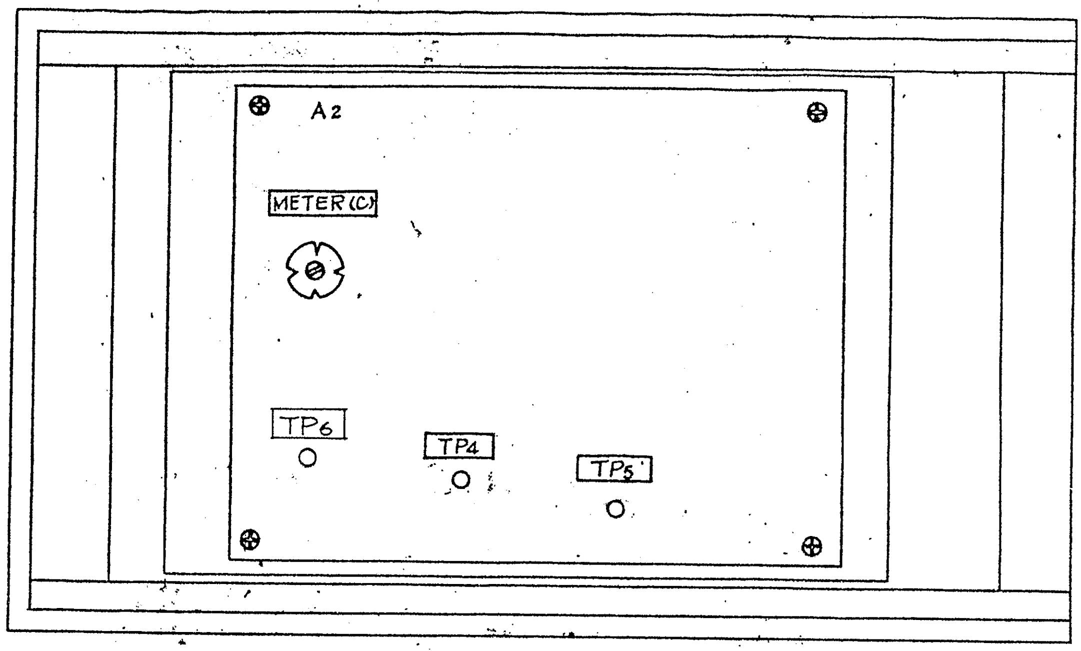


Fig. 7 (Bottom view)