WOW & FLUTTER METER A248
Type 1M70579

HANDBOOK 70579R

AMALGAMATED WIRELESS (AUSTRALASIA) LIMITED
Engineering Products Division
422 LANE COVE ROAD, NORTH RYDE, N.S.W.
WOW & FLUTTER METER A248

TYPE 1M70579

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Where applicable, all changes of value, transistor and transformer types, etc., should also be made on the associated diagram.

Some or all of the changes in this Revision List may have been incorporated in this printing of the Handbook.

Page

1/2 / In sub-section 1.3.3., Frequency Range, change Wow range to read: 0.5 Hz to 10 Hz change Flutter range to read: 10 Hz to 200 Hz

3/1 / In sub-section 3.1.3. Mode Switch; change Wow range to read: 0.5 Hz to 10 Hz change Flutter range to read: 10 Hz to 200 Hz

4/2 / In sub-section 4.2.6. Filters and Weighting Network; change Wow frequency range to read: 0.5 Hz to 10 Hz change Flutter range to read: 10 Hz to 200 Hz correct spelling of 'range' following 'Flutter'.

Drg 70579-1-09 Show R46 10 k as below.

Revision Record: Record the incorporation of this Revision List.

Authority: C/O 72375, 73717

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This issue of the handbook incorporates Revision Lists 1 to 4 of Issue 0. Future revision lists will commence numbering at R/11 for Issue 1.

R/11 17 Aug 79 John E. [Signature] 7/10/80
# Table of Contents

## Part 1  General Information

1.1 Introduction  
1.2 Brief Description  
1.3 Performance  
   1.3.1 Environmental  
   1.3.2 Oscillator  
   1.3.3 Meter  
1.4 General Information  
1.5 Mechanical  
1.6 Accessories Provided  
1.7 Ordering Information

## Part 2  Installation

2.1 General  
2.2 Mounting  
2.3 Connections  
   2.3.1 Power  
   2.3.2 3150 Hz Output  
   2.3.3 Input  
   2.3.4 Monitor Output  
2.4 Re-packing for Shipment

## Part 3  Operation

3.1 Operating Controls  
   3.1.1 Power Switch  
   3.1.2 Set Drift Control  
   3.1.3 Mode Switch  
   3.1.4 Wow & Flutter Range Switch
# Table of Contents

## Part 3  Operation (Cont'd)

3.2 Measuring Drift          3/2
3.3 Measuring Wow & Flutter    3/2

## Part 4  Technical Description

4.1 Principles of Operation   4/1
4.2 Circuit Drawing
   4.2.1 3150 Hz Oscillator   4/1
   4.2.2 Input Amplifier and Indicator   4/1
   4.2.3 Phase Locked Loop   4/1
   4.2.4 Drift Circuit   4/1
   4.2.5 Wow & Flutter Range Switching   4/2
   4.2.6 Filters and Weighting Network   4/2
   4.2.7 Meter Amplifier   4/2
   4.2.8 Power Supply   4/2

## Part 5  Maintenance

5.1 General                  5/1
5.2 Service                  5/1
5.3 Fault Finding Guide      5/2

## Part 6  Calibration & Test Procedure

6.1 Test Equipment Required  6/1
6.2 Instrument Calibration   6/1
   6.2.1 Oscillator Frequency   6/1
   6.2.2 V.C.O. Centre Frequency   6/1
   6.2.3 Drift Calibration   6/1
   6.2.4 Wow & Flutter Calibration   6/2
# TABLE OF CONTENTS

## PART 6  CALIBRATION & TEST PROCEDURE (Cont'd)

<table>
<thead>
<tr>
<th>Section</th>
<th>Title</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>6.3</td>
<td>Test Procedure</td>
<td>6/3</td>
</tr>
<tr>
<td>6.3.1</td>
<td>Oscillator Output Level</td>
<td>6/3</td>
</tr>
<tr>
<td>6.3.2</td>
<td>Oscillator Distortion</td>
<td>6/3</td>
</tr>
<tr>
<td>6.3.3</td>
<td>Low Level Input</td>
<td>6/3</td>
</tr>
<tr>
<td>6.3.4</td>
<td>P.L.L. Frequency Range</td>
<td>6/3</td>
</tr>
<tr>
<td>6.3.5</td>
<td>Attenuator Accuracy</td>
<td>6/3</td>
</tr>
<tr>
<td>6.3.6</td>
<td>Frequency Response</td>
<td>6/4</td>
</tr>
<tr>
<td>6.3.7</td>
<td>Monitor Output</td>
<td>6/4</td>
</tr>
</tbody>
</table>

## PART 7  COMPONENT SCHEDULE

<table>
<thead>
<tr>
<th>Section</th>
<th>Title</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>7.1</td>
<td>Explanatory Notes</td>
<td>7/1</td>
</tr>
<tr>
<td>7.2</td>
<td>Wow &amp; Flutter Meter A248, 1M70579</td>
<td>7/1</td>
</tr>
<tr>
<td>7.2.1</td>
<td>Components Mounted on Chassis</td>
<td>7/1</td>
</tr>
<tr>
<td>7.2.2</td>
<td>Components on Printed Circuit Board 1M70580</td>
<td>7/1</td>
</tr>
<tr>
<td>7.2.2.1</td>
<td>Capacitors</td>
<td>7/1</td>
</tr>
<tr>
<td>7.2.2.2</td>
<td>Connectors</td>
<td>7/2</td>
</tr>
<tr>
<td>7.2.2.3</td>
<td>Diodes</td>
<td>7/2</td>
</tr>
<tr>
<td>7.2.2.4</td>
<td>Fuses</td>
<td>7/3</td>
</tr>
<tr>
<td>7.2.2.5</td>
<td>Integrated Circuits</td>
<td>7/3</td>
</tr>
<tr>
<td>7.2.2.6</td>
<td>Resistors</td>
<td>7/3</td>
</tr>
<tr>
<td>7.2.2.7</td>
<td>Switches</td>
<td>7/4</td>
</tr>
<tr>
<td>7.2.2.8</td>
<td>Transformers</td>
<td>7/4</td>
</tr>
<tr>
<td>7.2.2.9</td>
<td>Transistors</td>
<td>7/5</td>
</tr>
<tr>
<td>7.2.2.10</td>
<td>Variable Resistors</td>
<td>7/5</td>
</tr>
</tbody>
</table>

## PART 8  DIAGRAMS

<table>
<thead>
<tr>
<th>Diagram</th>
<th>Title</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Circuit Diagram</td>
<td>70579-1-09</td>
</tr>
</tbody>
</table>
1.3 PERFORMANCE

1.3.1 Environmental

Operating Temperature Range: 0 °C to 50 °C

1.3.2 Oscillator

Frequency: 3150 Hz ±0.1%
Output Level: +8 dBm from 600 Ω balanced source
Distortion: Less than 1%

1.3.3 Meter

Measurement Frequency: 3150 Hz ±10%
Input Impedance: >300 kΩ balanced
Input Level Range: -30 dBm to +30 dBm

Measurement Range

Wow, Flutter, Weighted Wow & Flutter: 0.1%, 0.3%, 1% & 3%
Drift: ±2%
(+4% or -4% by offsetting "Drift Cal")

Frequency Range

Wow: 0.5 Hz to 6 Hz
Flutter: 10 Hz to 200 Hz
Unweighted Wow & Flutter: 0.5 Hz to 200 Hz
Weighted Wow & Flutter: According to DIN/IEC/IEEE/ANSI Stds

Monitor output for Wow & Flutter: 1 V p-p for F.S.D.

Input level lamp provides indication of sufficient level.

1.4 GENERAL INFORMATION

Connectors

3150 Hz Tone: 3 Binding Posts (accepts 4 mm banana plugs)
Input: 3 Binding Posts (accepts 4 mm banana plugs)
Monitor Output: BNC
This apparatus has been designed according to Class 1 of IEC Publication 348, Safety Requirements for Electronic Measuring Apparatus, and has been supplied in a safe condition. The present instruction manual contains information and warnings which shall be followed by the user to ensure safe operation and to retain the apparatus in safe condition.

1.1 INTRODUCTION

The A.W.A. Wow & Flutter Meter A248 is designed to measure speed variations in all types of Consumer and Studio reproduction equipment, both balanced and unbalanced.

This instrument measures Drift, Wow and Flutter. Drift is long term variations in speed while Wow and Flutter are short term variations with Wow being variations below 6 Hz and Flutter above 6 Hz. The A248 has a "Weighted Total Wow & Flutter" to DIN, IEC, IEEE and ANSI Standards which gives the relative disturbing effect of the Wow & Flutter to the listener.

Also "Unweighted Total Wow & Flutter" measurements may be made for comparison with results made by equipments manufactured to old standards. This measurement, together with the separate Wow, Flutter measurements provides an invaluable aid to the service technician in determining the area of degradation of performance.

A pre-recorded disc or tape may be used to measure Drift, Wow & Flutter or if not available the 3150 Hz tone from the A248 may be recorded onto tape. However, results may vary from twice the actual Wow & Flutter to almost complete cancellation due to arithmetic addition of the variations. This may be detected by causing tape slippage on playback and noting the change in readings.

1.2 BRIEF DESCRIPTION

The A248 provides a 3150 Hz tone with very high frequency stability from a balanced 600 Ohm source at +8 dBm. This tone is used internally on the "Drift Cal" mode and may also be used for recording the tone onto tape.

A CMOS Phase Locked Loop is used to lock onto the incoming tone in the A248 and provides a demodulated output to give a precise indication of variations in the reproducing equipment speed.

The input is balanced with an input impedance greater than 300 kΩ.

A green L.E.D. on the A248 is used to indicate when a tone is of sufficient level to operate the instrument.

The A248 has internal filters to allow the measurement of Wow, Flutter, Unweighted Wow & Flutter and Weighted Wow & Flutter (to DIN, IEC, IEEE, ANSI Standards). A "Monitor Output is provided to enable monitoring of the Wow & Flutter by C.R.O.

The A248 is of rugged construction and designed for compact size with maximum ease of servicing. All components are accessible by removing top and bottom covers.
Power Requirements

200 - 264 V, 50 - 60 Hz, 5 VA
100 - 132 V, 50 - 60 Hz, 7 VA

1.5 MECHANICAL

Height  99 mm (including feet)
Width  269 mm
Depth  273 mm (including binding posts)
Weight  2.1 Kg.

Case is provided with tilt stand

1.6 ACCESSORIES PROVIDED

1 x Mains Cable
1 x Spare Fuse
1 x Instruction Manual

1.7 ORDERING INFORMATION

The instrument is described as AWA Wow & Flutter Meter A248, Type 1M70579.
2.1 GENERAL

The A248 Wow & Flutter Meter is a very compact instrument designed for bench operation and for operation from a.c. mains supply. For power and signal connections, see below.

The equipment should be inspected for any physical damage incurred during transportation. The accessories should be checked against the equipment schedule.

Whenever it is likely that the protection has been impaired, the apparatus shall be made inoperative and be secured against any unintended operation.

The protection is likely to be impaired if, for example:

- the apparatus shows visible damage;
- the apparatus fails to perform the intended measurements;
- after prolonged storage under unfavourable conditions;
- after severe transport stresses

Make sure that only fuses with the required rated current and of the specified type are used for replacement. The use of mended fuses and the short-circuiting of fuse-holders shall be avoided. The fuse should be of the current rating as marked on the rear panel for the mains voltage selected.

2.2 MOUNTING

The A248 is fitted with bottom feet and a tilt bar for bench operation. The tilt bar enables the unit to be tilted upwards for easier operation.

2.3 CONNECTIONS

2.3.1 Power

The A248 will operate from 110 V to 120 V and 220 V to 240 V nominal a.c. mains supply, 50 Hz - 60 Hz. The voltage range is selected by a plug on the rear of the circuit board inside the instrument. This voltage range should be checked before connecting to the supply. Ensure that the correct fuse rating is fitted for the supply voltage range selected. These are shown on the rear of the instrument. For 110 V to 120 V range, a 200 mA Anti-Surge fuse should be used.

For 220 V to 240 V range, a 100 mA Anti-Surge fuse should be used. An international mains socket is fitted on the rear panel of the F248. The power cord supplied should be plugged into this and connected then to the mains power receptacle.

The mains plug shall only be inserted in a socket-outlet provided with a protective earth contact. The protective action shall not be negated by the use of an extension cord without protective conductor.
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For 220 V to 240 V range, a 100 mA Anti-Surge fuse should be used. An international mains socket is fitted on the rear panel of the P248. The power cord supplied should be plugged into this and connected then to the mains power receptacle.

The mains plug shall only be inserted in a socket-outlet provided with a protective earth contact. The protective action shall not be negated by the use of an extension cord without protective conductor.
Warning!

Any interruption of the protective conductor inside or outside the apparatus or disconnection of the protective earth terminal is likely to make the apparatus dangerous. Intentional interruption is prohibited.

2.3.2 3150 Hz Output

Three binding posts are provided with the top two being the balanced output and the bottom being the earth terminal. For unbalanced operation either terminal may be grounded, however a shorting link is provided for convenience to ground the centre terminal.

2.3.2 Input

Three binding posts are provided with shorting link similar to that described for the 3150 Hz Output. Input is balanced with an input impedance greater than 300 kΩ.

2.3.4 Monitor Output

The Monitor Output is provided on a BNC connector on the rear panel. The output is 1 V p-p, for F.S.D. on the meter, with a 1 kΩ source impedance.

2.4 RE-PACKING FOR SHIPMENT

General guidance is furnished below in the event that re-packing of the instrument for shipment may be necessary at any time.

1. Should the original container be available, re-pack in the same manner as received. It is advisable to retain the original container and packing case for this purpose.

2. If the original container is not available, the unit should be wrapped in heavy paper or plastic sheet prior to placing in an inner container. Place liberal quantities of packing materials, which should be reasonably dust-free, on all sides of the container but DO NOT pack tightly. The instrument front panel side should receive extra attention when the container is being packed into the packing case.

3. Mark the case in which the instrument is shipped "DELICATE INSTRUMENT" or "FRAGILE".
PART 3

OPERATION

Warning:

Any interruption of the protective conductor inside or outside the apparatus or disconnection of the protective earth terminal is likely to make the apparatus dangerous. Intentional interruption is prohibited.

3.1 OPERATING CONTROLS

The following controls are mounted on the front panel of the A248.

3.1.1 Power Switch

This switch applies mains power to the instrument. For safety, both line and neutral are switched.

An associated red I.E.D. lamp indicates the presence of mains power.

Before switching on the apparatus, make sure that it is set to the voltage of the power supply.

3.1.2 Set Drift Control

This control is used to set the meter reading to zero when the "Drift Cal" button is selected. The meter may be set to either -3% or +2% using this control to extend the meter range from ±2% to 0 to +4% or 0 to -4% drift when in the "Drift Read" mode.

3.1.3 Mode Switch

Drift Cal: This mode internally connects the 3150 Hz to the Phase Locked Loop to enable calibration of the Drift meter reading.

Drift Read: The incoming signal frequency is compared to the reference set by the 3150 Hz and a meter reading of ±% variation given.

Wow: The wow of the incoming signal is measured over a 0.5 Hz to /0.6 Hz frequency range.

Flutter: The flutter of the incoming signal is measured over a 0.6 Hz to 200 Hz frequency range.

Unweighted Wow & Flutter: This is measured over a 0.5 Hz to 200 Hz frequency range

Weighted Wow & Flutter: This is measured to the weighting curve to DIN, IEC, IEEE, ANSI Standards.

The frequency response of the filters and weighting networks is found on Drawing No.
3.1.4 Wow & Flutter Range Switch

This switch provides 4 ranges of reading Wow & Flutter - 3%, 1%, 0.3% and 0.1% F.S.D.

3.2 MEASURING DRIFT

1. Connect the signal to be measured to the "Input" terminals of the A248 and check that the green l.e.d. is glowing, i.e. there is sufficient input level.

2. Push the "Drift Cal" button and set the meter to centre scale using the "Set Drift" control.

3. Now push the "Drift Read" button and read the drift from the meter.

Note: To extend the drift reading range to 4% (in one direction only) the meter may be calibrated to either the +2% or -2% positions.

3.3 MEASURING WOW & FLUTTER

1. Connect the signal to be measured to the "Input" terminals of the E248 and check that the green l.e.d. is glowing.

2. Select the required filter or weighting mode, set the "Range" switch to the appropriate range and read the meter.
4.1 PRINCIPLES OF OPERATION

The A248 has a high stability 3150 Hz oscillator for external recording and for the "Drift Cal" reference frequency.

The oscillator output is transformer coupled.

The incoming signal is amplified by a balanced input amplifier and fed into a CMOS Phase Locked Loop (P.L.L.). This loop locks onto this signal and the d.c. component of the input to the Voltage Controlled Oscillator (V.C.O.) in the P.L.L. is measured to give the Drift indication after calibration to the reference 3150 Hz frequency.

The a.c. component of the V.C.O. control voltage is amplified and filtered to give the Wow & Flutter signals.

The filter and weighting curves are shown on Drawing 70579-4-10.

This is then peak-peak detected to give a meter indication which is calibrated to read peak Wow & Flutter.

4.2 CIRCUIT DESCRIPTION

Refer to Circuit Drawing 70579-1-09.

4.2.1 3150 Hz Oscillator

IC9 is an active filter whose output is fed back to an inverting amplifier IC8 and then back into the filter input. This makes an oscillator tuned to the centre frequency of the active filter and amplitude stabilised by D9 and D11. Oscillator frequency is trimmed to 3150 Hz with RV7.

4.2.2 Input Amplifier and Indicator

IC1 is a balanced input amplifier with its output clamped by D2 and Q1. When the signal is of sufficient amplitude to cause current to flow in Q1 the green l.e.d. glows to indicate adequate signal input.

4.2.3 Phase Locked Loop (P.L.L.)

The output of IC1 is fed into IC2 which is a CMOS P.L.L. device. The Voltage Controlled Oscillator is locked to the incoming signal so that the variation of control voltage at IC2 pin 9 is proportional to the variation of input frequency.

RV1 is used to set the centre frequency of the VCO.

4.2.4 Drift Circuit

IC7 is used to measure the change in d.c. voltage at the input to the V.C.O. This gives a linear indication of frequency drift. RV8 is used to calibrate the Drift circuit by giving d.c. offset for centre meter reading when 3150 Hz is fed into the P.L.L. RV9 calibrates the gain of the meter.
4.2.5 **Wow & Flutter Range Switching**

The a.c. component of the V.C.O. control voltage is amplified by IC3. Range switching is by changing resistors in the feedback path of IC3. Q3 is used to clamp and reduce the gain of IC3 when there is no input signal to the P.L.L.

4.2.6 **Filters and Weighting Network**

The Unweighted Wow & Flutter frequency range is 0.5 Hz to 200 Hz, low frequency roll off is by C11 and C28 and high frequency roll off by C8, C13, C16, C26, C27 and C31. RV2 calibrates the meter reading in this mode.

The Wow mode frequency range is 0.5 Hz to 6 Hz with C21 and C22 determining h.f. roll off. RV3 calibrates the meter reading in this mode.

The Flutter mode frequency range is 6 Hz to 200 Hz with C23 and C24 determining the l.f. roll off. RV4 calibrates the meter reading in this mode.

The Weighted Wow & Flutter frequency range as shown in Drawing is determined by C17, C18, C19, C20.

RV6 calibrates the meter reading in this mode.

Note RV6 also affects the calibration of the other modes of Wow & Flutter measurements and therefore should be set first.

4.2.7 **Meter Amplifier**

IC6 is the meter amplifier circuit. D6 and D7 charge C32 and C33 to a peak to peak voltage which is discharged through the meter. D3 and D4 linearise the metering circuit. The Monitor Output is taken from the meter amplifier.

4.2.8 **Power Supply**

The power supply consists of a +12 V and -12 V series regulators IC11 and IC12. Both supplies are internally protected against short circuits and thermal overloads.

The A248 may be used from either 120 V or 240 V mains, change over being made by removing and reversing SKB mounted on the printed circuit board.
PART 9

MAINTENANCE

5.1 GENERAL

This is a high performance instrument and to maintain this performance level, periodic checks are advisable. Inspection should include checks on resistors to ensure that no signs of over-heating are evident. The wire used has an insulating coating of polyvinyl chloride, and the styroseal capacitors also contain thermo-plastics which must not be subjected to excessive heat. Should servicing be required, take care against a hot soldering iron coming into contact with or being placed near the wiring forms or capacitors.

The opening of covers or removal of parts, except those to which access can be gained by hand, is likely to expose live parts, and also accessible terminals may be live.

The apparatus shall be disconnected from all voltage sources before any adjustment, replacement or maintenance and repair during which the apparatus shall be opened.

If afterwards any adjustment, maintenance or repair of the opened apparatus under voltage is inevitable, it shall be carried out only by a skilled person who is aware of the hazard involved.

5.2 SERVICE

It is important to note when servicing this instrument, that any replacement of circuit components may require a re-adjustment of the pre-set controls to restore the instrument to its original calibrated condition.

Service work of any kind, particularly on sub-miniature components, should be carried out with care. Transistors and diodes, when being replaced, should receive scrupulous care because permanent damage may be caused by the application of excessive heat.

Should it be found during inspections that dust accumulation has built up inside the instrument this should be removed, preferably by a low pressure jet, or alternatively a soft brush may be lightly used.

Switch control cleaning and lubricating should always be done with an recommended agent and the use of abrasives should be avoided.

The following solution may be made up and applied with a fine brush:

12 oz. Anhydrous Lanoline (British Pharmocopeia Standard)
1 fl. oz. Mobil Aero Instrument Oil (MIL-L-7870A or NATO-0-142)
25 fl. oz. 1, 1, 1 Inhibited Trichlorethane (Dow Chemical Company "Chlorothene NU")
A convenient package of cleaner-lubricant is now available for contacts of wiping, knifing or sliding types. This fluid is pressure packed and the container is fitted with a flexible tube to facilitate the directing of fluid to obscure points. Packaged in 12 oz. cans, it may be ordered as AWA Electrical Contact Cleaning Lubricant.

5.3 FAULT FINDING GUIDE

1. If the instrument appears to malfunction, check that the front panel controls are set correctly. Refer to Operation Part 3.

2. Check that the power is connected to the instrument. The "Power" indicator l.e.d. should be on.

3. Check that the input signal is within the specified frequency and level ranges. The input l.e.d. should be glowing for adequate level input.

4. Remove the top cover and check that the +12 V and -12 V supply voltages are present.

5. Push the Drift Cal. button and check that the green l.e.d. is glowing, and there is a signal at IC1 pin 6.

6. Check that the Phase Locked Loop is locked, i.e. the waveform at IC2 pin 2 should have a constant mark to space ratio.

7. If Drift mode is faulty, check signal path through IC7 to the meter.

8. If the Wow & Flutter mode is faulty feed in the input signal, switch to Unweighted Wow & Flutter and check signal path from IC2 pin 2 to the meter.
PART 6

CALIBRATION & TEST PROCEDURE

6.1 TEST EQUIPMENT REQUIRED

1. Frequency Counter to measure 3150 Hz ±0.5 Hz

2. Low Frequency Sine Wave Oscillator with frequency range covering 0.5 Hz to 3150 Hz.

3. Test aid as described in Instrument Calibration (6.2.4).

4. Distortion & Noise Meter AWA F242 or equivalent.

5. 75 Ω Precision Attenuator.

6. 75 Ω ±0.5% Resistor.

7. Cathode Ray Oscilloscope with delayed time base and 15 MHz bandwidth.

6.2 INSTRUMENT CALIBRATION

6.2.1 Oscillator Frequency

1. Connect a suitable frequency counter to the oscillator output and adjust RV7 to be approx. 3150 Hz on a one second count.

2. Now switch to a ten second count and set RV7 for a counter reading of 3150 Hz ±0.5 Hz.

6.2.2 V.C.O. Centre Frequency

1. Set the A248 to the CAL mode and turn the SET DRIFT control to its centre position.

2. Adjust RV1 for an approximately centre reading on the meter.

Note: The oscillator frequency should have already been calibrated as described in Section 6.2.1.

6.2.3 Drift Calibration

1. Connect Low Frequency Oscillator to the counter and set the output frequency to 3087 Hz ±1 Hz.

2. Connect the oscillator with say 1 V output to the A248. Depress the "Drift Read" button and adjust the "Set Drift" control to read -2% on the meter.

3. Now depress the "Drift Cal" button and adjust RV9 for a meter reading of 0% drift.
6.2.4 **Wow & Flutter Calibration**

1. Connect the A248 to the test aid shown below

![Diagram of the test aid](image)

2. With no output from the Low Frequency Oscillator, adjust the 20 K potentiometer to 3150 Hz ±10 Hz.

3. Connect a C.R.O. to the output and measure the period of the square wave at the output of the test aid. This should be typically 317 μSec.

4. With the oscilloscope triggered from the positive edge, examine the next positive edge, using the oscilloscope delayed sweep and adjust the output of the L.F. Oscillator for a peak to peak excursion of 2% of the previous period measurement. (i.e. \(317 \times 2 = 6.34 \mu\text{Sec}\))

![Diagram of normal and delayed timebases](image)

5. Set the A247 to Weighted Wow & Flutter on the 1% Range and the L.F. Oscillator to 4 Hz and adjust RV6 for a reading of 1% on peaks of the meter excursions.
6. Now switch to Total Wow & Flutter and adjust RV2 for the same reading.
7. Set the L.F. Oscillator to 2 Hz and the A248 on Wow and adjust RV3 for a peak reading of 1%.
8. Set the L.F. Oscillator to 40 Hz and the A248 to Flutter and adjust RV4 for a reading of 1%.

6.3 TEST PROCEDURE

6.3.1 Oscillator Output Level
1. Connect the A248 3150 Hz output to the F242 with 600 Ω input impedance.
2. The output level should be +8 dBm ±1 dB.

6.3.2 Oscillator Distortion
1. Using the F242, measure the distortion which should be less than 1%.

6.3.3 Low Level Input
1. Connect L.F. Oscillator to the E248 and bridge with the F242 to monitor level.
2. Set the oscillator to 3150 Hz and -30 dBm and check that the input light is illuminated.

6.3.4 P.L.L. Frequency Range
2. Set the L.F. Oscillator to 2740 Hz and check that the phase locked loop is locked, i.e. a steady waveform on the C.R.O.
3. Now set the oscillator to 3560 Hz and check that the P.L.L. is locked.

6.3.5 Attenuator Accuracy
1. Connect the equipment as shown below:

```
    L.F. Oscillator  Precision Arten.  Test Aid  A248
                        75 Ω
```

2. Set the L.F. Oscillator to 40 Hz and adjust the level to measure 3% on the A248 Unweighted Total Wow & Flutter mode.
3. Switch in 10 dB attenuation and check for a reading of 0.95% ±0.02 on the 1% Range. (Note: the Wow & Flutter Attenuators are not 10 dB)
4. Switch in 20 dB attenuation and check for a reading of 0.3% ±0.005 on the 0.3% Range.

5. Switch in 30 dB attenuation and check for a reading of 0.095% ±0.002 on the 0.1% Range.

6.3.6 Frequency Response

1. Set the L.F. Oscillator to 4 Hz and adjust the output level for 1% peak reading in the Weighted Wow & Flutter mode.

2. Set the oscillator to 1.2 Hz and check that the peak meter reading is 0.7% ±0.07.

3. Set the oscillator to 13 Hz and check that the meter reading is 0.7% ±0.07.

4. Now set the oscillator to 0.5 Hz and the A248 to the Unweighted Total Wow & Flutter mode and check that the peak meter reading is 0.7% ±0.07.

5. Set the oscillator to 200 Hz and check that the meter reading is 0.7% ±0.07.

6. Set the oscillator to 10 Hz and check that the meter reading is 0.7% ±0.07 in both the Unweighted Wow and the Unweighted Flutter modes.

6.3.7 Monitor Output

1. Set the oscillator output for a full scale meter reading and check for 1 V P-P at the Monitor Output with the C.R.O.
PART 7

COMPONENT SCHEDULE

7.1 EXPLANATORY NOTES

The component schedule is laid out as follows:

<table>
<thead>
<tr>
<th>Column 1</th>
<th>Column 2</th>
<th>Column 3</th>
</tr>
</thead>
<tbody>
<tr>
<td>Circuit Reference Number</td>
<td>Description</td>
<td>AWA Stock Code Number</td>
</tr>
</tbody>
</table>

Because of unavailability at the date of manufacture, some components in the equipment may differ slightly from the components listed in the schedule. These substitute components do not degrade the performance of the equipment.

When ordering replacement components from AWA, the type number of the unit (or sub-unit) and the circuit reference number of the component should be quoted in addition to the details appearing in the component schedule. This information will ensure the supply of a suitable substitute component should the listed component be obsolete or unavailable.

7.2 WOW & FLUTTER METER A248, 1M70579

7.2.1 Components Mounted on Chassis

<table>
<thead>
<tr>
<th>SWC</th>
<th>Mains switch DP-DT Toggle</th>
<th>C&amp;K Type 7201-P3-PYQZ</th>
</tr>
</thead>
<tbody>
<tr>
<td>D1</td>
<td>Diode, light emitting. Green</td>
<td></td>
</tr>
<tr>
<td>D13</td>
<td>Diode indicator, light emitting</td>
<td></td>
</tr>
<tr>
<td>M6L</td>
<td>Meter</td>
<td></td>
</tr>
<tr>
<td>RV8</td>
<td>Resistor, variable, 1kΩ±10% linear</td>
<td></td>
</tr>
<tr>
<td>SKA</td>
<td>Socket Assembly Utilux Receptacle H9373, Utilux Terminal H9001 and Utilux Terminal H9002</td>
<td></td>
</tr>
<tr>
<td>SKD</td>
<td>Socket. B.N.C. Bulkhead Receptacle UG.6258/U</td>
<td></td>
</tr>
<tr>
<td>SKE</td>
<td>Socket. Light emitting diode Robinson Nugent Skinny Strip SB-25-100 25 Way Solder Dip</td>
<td></td>
</tr>
<tr>
<td>PLC</td>
<td>Mains Input Plug</td>
<td></td>
</tr>
</tbody>
</table>

7.2.2 Components on Printed Circuit Board 1M70580

7.2.2.1 Capacitors

| C1 | Capacitor, ceramic disc, 1nF, ±20%, 500 V, HIK |
| C2 | Capacitor, ceramic disc, 1nF, ±20%, 500 V, HIK |
| C3 | Capacitor, ceramic disc, 33pF, ±5%, 500 V, N.P.O. |
| C4 | Capacitor, ceramic disc, 33pF, ±5%, 500 V, N.P.O. |
| C5 | Capacitor, ceramic disc, 2p2F, ±0.5%, 500 V, N.P.O. |
| C6 | Capacitor, ceramic disc, 47nF, ±80-20%, 25 V, HIK |
| C7 | Capacitor, polystyrene, 33nF, ±2%, 100 V |
| C8 | Capacitor, electrolytic tantalum, 22µF, ±10%, 15 V |
| C9 | Capacitor, met. polyester, 47nF, ±10%, 250 V |

AEE. PFE216 DC533G
| C10  | Not used                                    |
| C11  | Capacitor, electrolytic tantalum, 22μF, ±10%, 15 V |
| C12  | Capacitor, ceramic disc, 47nF, +80-20%, 25 V, H1K |
| C13  | Capacitor, met. polyester, 100nF, ±10%, 250 V |
| C14  | Capacitor, ceramic disc, 33pF, ±2%, 500 V, N.P.O. |
| C15  | Capacitor, ceramic disc, 100pF, ±2%, 500 V, N750 |
| C16  | Capacitor, met. polyester, 680nF, ±10%, 250 V |
| C17  | Capacitor, met. polyester, 10nF, ±10%, 250 V |
| C18  | Capacitor, met. polyester, 220nF, ±10%, 250 V |
| C19  | Capacitor, met. polyester 330nF, ±10%, 250 V |
| C20  | Not used                                    |
| C21  | Capacitor, met. polyester, 680nF, ±10%, 250 V |
| C22  | Capacitor, met. polyester, 150nF, ±10%, 250 V |
| C23  | Capacitor, met. polyester, 330nF, ±10%, 250 V |
| C24  | Capacitor, met. polyester, 10nF, ±10%, 250 V |
| C25  | Not used                                    |
| C26  | Capacitor, ceramic disc, 33pF, ±2%, 500 V, N.P.O. |
| C27  | Capacitor, ceramic disc, 47nF, +80-20%, 25 V, H1K |
| C28  | Capacitor, electrolytic tantalum, 22μF, ±10%, 15 V |
| C29  | Capacitor, ceramic disc, 33pF, ±2%, 500 V, N.P.O. |
| C30  | Not used                                    |
| C31  | Capacitor, ceramic disc, 1nF, ±10%, 100 V Philips 2222-630-03102 |
| C32  | Capacitor, electrolytic tantalum, 100nF, ±10%, 10 V |
| C33  | Capacitor, electrolytic tantalum, 100nF, ±10%, 10 V |
| C34  | Capacitor, met. polyester, 1μF, ±2%, 250 V |
| C35  | Capacitor, ceramic disc, 47nF, +80-20%, 25 V, H1K |
| C36  | Capacitor, ceramic disc, 47nF, +80-20%, 25 V, H1K |
| C37  | Capacitor, ceramic disc, 150pF, ±2%, 500 V, N750 |
| C38  | Capacitor, ceramic disc, 47pF, ±0.5%, 500 V, N.P.O. |
| C39  | Capacitor, ceramic disc, 150pF, ±2%, 500 V, N750 |
| C40  | Capacitor, met. polyester, 680nF, ±10%, 250 V |
| C41  | Capacitor, radial lead ceramic, 4n7F, ±5%, N.P.O. Vitramon VK44BA723 |
| C42  | Capacitor, radial lead ceramic, 4n7F, ±5%, N.P.O. Vitramon VK44BA723 |
| C43  | Capacitor, met. polyester 100nF, ±10%, 250 V |
| C44  | Capacitor, electrolytic aluminium, 1000μF, ±50-10%, 25 V |
| C45  | Not used                                    |
| C46  | Capacitor, electrolytic aluminium, 100μF, ±50-10%, 25 V |
| C47  | Capacitor, met. polyester, 330nF, ±10%, 250 V |
| C48  | Capacitor, met. polyester, 330nF, ±10%, 250 V |
| C49  | Capacitor, electrolytic tantalum, 1μF, ±10%, 35 V |
| C50  | Not used                                    |
| C51  | Capacitor, electrolytic tantalum, 1μF, ±10%, 35 V |

### Connectors

| PLA | Plug, circuit board mounting |
| PLB | Plug, five pin, circuit board mounting |
| SKB | Socket Assembly, Wafer AMP 5 Way COMBO LINE TYPE 280050, CONNECTOR AMP TYPE 153351 |

### Diodes

| D1  | Not used |
| D2  | Not used |
| D3  | Diode 1N914 |
| D4  | Diode 1N914 |
| D5  | Not used |
| D6  | Diode 1N914 |
7.2.2.4 Fuses
FS1 20 mm Fuse link, 100 mA delayed action  Australux DA 205

7.2.2.5 Integrated Circuits
IC1 Integrated circuit LM308N  National Semiconductor
IC2 Integrated circuit CD4046AE  RCA
IC3 Integrated circuit LM301 A.N.  National Semiconductor
IC4 Integrated circuit LM301 A.N.  National Semiconductor
IC5 Not used
IC6 Integrated circuit LM301 A.N.  National Semiconductor
IC7 Integrated circuit LM301 A.N.  National Semiconductor
IC8 Integrated circuit LM301 A.N.  National Semiconductor
IC9 Integrated circuit LM301 A.N.  National Semiconductor
IC10 Not used
IC11 Integrated circuit MC7812 CP c/w Mounting Kit MK199-3  Motorola
IC12 Integrated circuit MC7912 CP c/w Mounting Kit MK199-3  Motorola

7.2.2.6 Resistors
R1 Resistor, metal glaze, 300kΩ±2%, 1/4 W  1008805
R2 Resistor, metal glaze, 300kΩ±2%, 1/4 W  1008805
R3 Resistor, carbon film, 10MΩ±10%, 1/3 W  Philips CR25 2322-211-12106
R4 Resistor, carbon film, 10MΩ±10%, 1/3 W  Philips CR25 2322-211-12106
R5 Not used
R6 Resistor, metal glaze, 270kΩ±2%, 1/4 W  1008732
R7 Resistor, metal glaze, 10kΩ±2%, 1/4 W  1008730
R8 Resistor, metal glaze, 1kΩ±2%, 1/4 W  1008736
R9 Resistor, metal glaze, 10kΩ±1%, 1/4 W  1008789
R10 Resistor, metal glaze, 33kΩ±2%, 1/4 W  1008782
R11 Resistor, metal glaze, 10kΩ±2%, 1/4 W  1008764
R12 Resistor, metal glaze, 1kΩ±2%, 1/4 W  1008746
R13 Resistor, metal glaze, 10kΩ±2%, 1/4 W  1008780
R14 Resistor, metal glaze, 4kΩ±2%, 1/4 W  1008762
R15 Not used
R16 Resistor, metal glaze, 18kΩ±2%, 1/4 W  1008736
R17 Resistor, metal glaze, 47kΩ±2%, 1/4 W  1008786
R18 Resistor, metal glaze, 10kΩ±1%, 1/4 W  1014288
R19 Resistor, metal glaze, 10kΩ±1%, 1/4 W  1014334
R20 Not used
R21 Resistor, metal glaze, 100kΩ±1%, 1/4 W  1014384
R22 Resistor, metal glaze, 300kΩ±1%, 1/4 W  1014430
<table>
<thead>
<tr>
<th>Part</th>
<th>Description</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>R23</td>
<td>Resistor, metal glaze</td>
<td>680(\pm 2%), 1/4 W</td>
</tr>
<tr>
<td>R24</td>
<td>Resistor, metal glaze</td>
<td>120k(\pm 2%), 1/4 W</td>
</tr>
<tr>
<td>R25</td>
<td>Not used</td>
<td></td>
</tr>
<tr>
<td>R26</td>
<td>Resistor, metal glaze</td>
<td>100k(\pm 2%), 1/4 W</td>
</tr>
<tr>
<td>R27</td>
<td>Not used</td>
<td></td>
</tr>
<tr>
<td>R28</td>
<td>Resistor, metal glaze</td>
<td>18k(\pm 2%), 1/4 W</td>
</tr>
<tr>
<td>R29</td>
<td>Resistor, metal glaze</td>
<td>68k(\pm 2%), 1/4 W</td>
</tr>
<tr>
<td>R30</td>
<td>Not used</td>
<td></td>
</tr>
<tr>
<td>R31</td>
<td>Resistor, metal glaze</td>
<td>39k(\pm 2%), 1/4 W</td>
</tr>
<tr>
<td>R32</td>
<td>Resistor, metal glaze</td>
<td>82k(\pm 2%), 1/4 W</td>
</tr>
<tr>
<td>R33</td>
<td>Resistor, metal glaze</td>
<td>220k(\pm 2%), 1/4 W</td>
</tr>
<tr>
<td>R34</td>
<td>Resistor, metal film</td>
<td>1M(\pm 2%), 1/4 W</td>
</tr>
<tr>
<td>R35</td>
<td>Not used</td>
<td></td>
</tr>
<tr>
<td>R36</td>
<td>Resistor, metal glaze</td>
<td>150k(\pm 2%), 1/4 W</td>
</tr>
<tr>
<td>R37</td>
<td>Resistor, metal glaze</td>
<td>2k(\pm 2%), 1/4 W</td>
</tr>
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<td>R38</td>
<td>Resistor, metal glaze</td>
<td>39k(\pm 2%), 1/4 W</td>
</tr>
<tr>
<td>R39</td>
<td>Resistor, metal glaze</td>
<td>330k(\pm 2%), 1/4 W</td>
</tr>
<tr>
<td>R40</td>
<td>Not used</td>
<td></td>
</tr>
<tr>
<td>R41</td>
<td>Not used</td>
<td></td>
</tr>
<tr>
<td>R42</td>
<td>Resistor, metal glaze</td>
<td>330k(\pm 2%), 1/4 W</td>
</tr>
<tr>
<td>R43</td>
<td>Resistor, metal glaze</td>
<td>13k(\pm 2%), 1/4 W</td>
</tr>
<tr>
<td>R44</td>
<td>Resistor, metal glaze</td>
<td>1k(\pm 2%), 1/4 W</td>
</tr>
<tr>
<td>R45</td>
<td>Not used</td>
<td></td>
</tr>
<tr>
<td>R46</td>
<td>Resistor, metal glaze</td>
<td>10k(\pm 2%), 1/4 W</td>
</tr>
<tr>
<td>R47</td>
<td>Resistor, metal glaze</td>
<td>470k(\pm 2%), 1/4 W</td>
</tr>
<tr>
<td>R48</td>
<td>Resistor, metal glaze</td>
<td>470k(\pm 2%), 1/4 W</td>
</tr>
<tr>
<td>R49</td>
<td>Resistor, metal glaze</td>
<td>220k(\pm 2%), 1/4 W</td>
</tr>
<tr>
<td>R50</td>
<td>Not used</td>
<td></td>
</tr>
<tr>
<td>R51</td>
<td>Resistor, metal glaze</td>
<td>6k80(\pm 2%), 1/4 W</td>
</tr>
<tr>
<td>R52</td>
<td>Resistor, metal glaze</td>
<td>3k30(\pm 2%), 1/4 W</td>
</tr>
<tr>
<td>R53</td>
<td>Resistor, metal glaze</td>
<td>1k(\pm 2%), 1/4 W</td>
</tr>
<tr>
<td>R54</td>
<td>Resistor, metal glaze</td>
<td>6800(\pm 2%), 1/4 W</td>
</tr>
<tr>
<td>R55</td>
<td>Not used</td>
<td></td>
</tr>
<tr>
<td>R56</td>
<td>Resistor, metal glaze</td>
<td>10k(\pm 2%), 1/4 W</td>
</tr>
<tr>
<td>R57</td>
<td>Resistor, metal glaze</td>
<td>10k(\pm 2%), 1/4 W</td>
</tr>
<tr>
<td>R58</td>
<td>Resistor, metal glaze</td>
<td>3k90(\pm 2%), 1/4 W</td>
</tr>
<tr>
<td>R59</td>
<td>Resistor, metal glaze</td>
<td>120k(\pm 2%), 1/4 W</td>
</tr>
<tr>
<td>R60</td>
<td>Not used</td>
<td></td>
</tr>
</tbody>
</table>
| R61  | Resistor, metal film             | 301k\(\pm 0.5\%), 25 ppm, 1/4 W | Roederstein MK2
| R62  | Resistor, metal film             | 3320\(\pm 0.5\%), 25 ppm, 1/4 W | Roederstein MK2
| R63  | Resistor, metal glaze            | 10k\(\pm 2\%), 1/4 W |
| R64  | Resistor, metal glaze            | 1k\(\pm 2\%), 1/4 W |
| R65  | Not used                         |                |
| R66  | Resistor, metal glaze            | 27k\(\pm 2\%), 1/4 W |
| R67  | Resistor, metal glaze            | 470\(\pm 2\%), 1/4 W |
| R68  | Resistor, metal glaze            | 2k\(\pm 2\%), 1/4 W |

7.2.2.7 Switches

SW4 Switch Assy

7.2.2.8 Transformers

T1 Output Transformer
T2 Power Transformer. Circuit board mounting

Ferguson Type PF4016-1
7.2.2.9 Transistors

Q1  Transistor BC559
Q2  Transistor BC549
Q3  Transistor BC549

Philips BC559
1024854
1024854

7.2.2.10 Variable Resistors

RV1  Resistor, variable, cermet 20 kΩ ±10%
RV2  Resistor, variable, cermet 100 kΩ ±10%
RV3  Resistor, variable, cermet 100 kΩ ±10%
RV4  Resistor, variable, cermet 20 kΩ ±10%
RV5  Not used

Beckman 72PM

RV6  Resistor, variable, cermet 20 kΩ ±10%
RV7  Resistor, variable, cermet 100 Ω ±10%
RV8  Resistor, variable, cermet 1 kΩ ±10%
RV9  Resistor, variable, cermet 1 kΩ ±10%

Beckman 72PM

Bourns 3299W-1-101
AWA 70579-4-12

Beckman 72PM
FREQUENCY RESPONSE WEIGHTING CURVES
WOW & FLUTTER METER
A248