L.F. SIGNAL GENERATOR

J3B

InstructionManual

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 # Introduction

The Gould Advance J3B Signal Generator is an LF instrument incorporating a high output level from a balanced, floating 600 Ω output. The main output, which is metered, gives 15V into 600 Ω (30V EMF). The frequency range of 10Hz to 100kHz is provided on four decade ranges, and the 6: 1 reduction drive with capacitor tuning gives high resolution of frequency with minimum bounce.

Three additional outputs are available, a 1W low impedance output, a square wave output and a low distortion output. The solid state circuitry results in low heat dissipation, giving a high order of frequency stability and reliability.

Switched step attenuators give 60dB of attenuation and the variable level control can be used to provide a further 20dB of attenuation with negligible hum and noise on the output.

Specification

FREQUENCY

Range: 10Hz to 100kHz in 4 decade ranges.
Scale: Common 320^{o} circular scale for all ranges.

Setability: To 1 part in 10^4
Accuracy: 2% of reading $\pm$ 1HZ
Typically 1% +1HZ

OUTPUTS

1) MAIN OUTPUT
30V r.m.s., e.m.f. (15-0-15V) from balanced floating output of impedance 300-0-300 Ohms (15V r.m.s. into 600 Ω load).

Output Impedance tolerance: 5% – Balance 3%
Balanced Attenuator: 20dB and 40dB (60dB total).

Accuracy: 0.3dB and 0.5dB respectively, each half.
Fine level control, from 0 to full output (Common to Outputs 1,2 and 3).

2) LOW IMPEDANCE OUTPUT
3V r.m.s., e.m.f. from approximately 1 Ohm.
With Output 1 fully loaded, Output 2 will deliver a typically of 1 Watt into 5 Ohms.

3) LOW DISTORTION OUTPUT (at rear of instrument).
typically 2.5V r.m.s. from approximately 5k Ω.
Overall flatness 0.3 dB.

4) SQUARE WAVE, 0 to +5V, independently controlled.
Source Impedance approximately 1kΩ. Rise and Fall times better than 1 μs into less than 100pF. Mark-space ratio better than 1.1:1.

OUTPUT LEVEL METER

Scaled 0-30V r.m.s. Open Circuit for Output 1. Scale also common to Output 2.
Decibel scale, referred to +20dBm into 600 Ω
The meter accuracy is 3% of F.S.D.

DISTORTION

1) Outputs 1 &2: less than 0.1% above 100Hz rising to less than 0.5% at 10Hz.

Typically better than 0.05% from 200 Hz to 100kHz

2) Low Distortion Output: Typically better than 0.02% above 200Hz rising to 0.2% at 10Hz.

PROTECTION

All outputs rated for full load simultaneously
All outputs Short-Circuit proof. Visible indication of overload on Output Level Meter (Intermittent reading).

SUPPLY VOLTAGE

85–130V and 170–255V
40–400Hz, approximately 20VA.
Also 42–52V . DC/300mA Max.

OPERATING TEMPERATURE RANGE:

0^{o}–50^{o}. Full specification over range 15^{o}–35^{o}C

DIMENSIONS

27 x 27 x 13 cms (10.7 x 10.7 x 7.2 in.)

WEIGHT

6kg (13 lbs.)

NOTE:
All output levels are flat within 1dB over the full frequency range.

Below 30Hz the maximum output level may not be available on full lead, on outputs 1 & 2 (typically 20V available at 10Hz).

3.1 SWITCHING ON

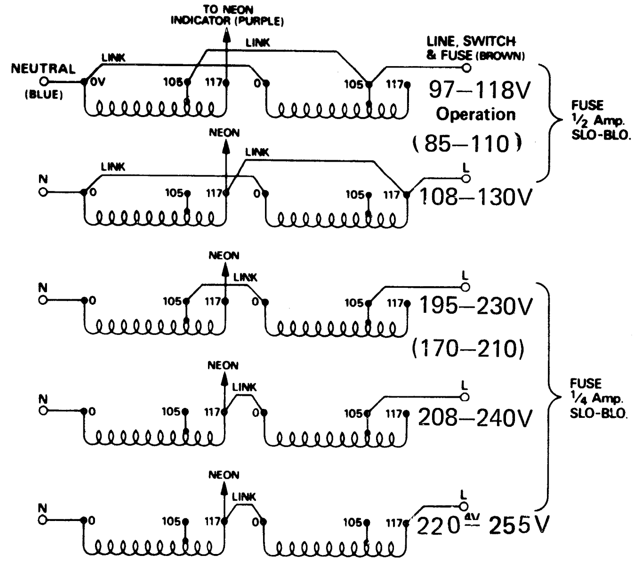
(i) Make sure that the voltage supply tap on the transformer is set correctly, and that the correct fuse is used. The transformer is accessible upon removal of the top cover of the instrument. (see 5.1). Unless labelled otherwise, the J3A is delivered for 234V $\pm$ 10% (See Fig. 1 for transformer taps, links and fuse ratings). In addition, an over-voltage tap (41V) is available on the secondary winding, which effectively extends the range of effectively extends the range of supply voltage to -20%.

(ii) Set the support/carrying handle to the required operating position. The handle is released by pulling both fixing bushes outwards, and it can then be turned to lock in any one of three positions.

(iii) It is advisable to turn the Output Level Fine control to minimum before switch-on,to avoid large surge outputs for the few seconds that the oscillator takes to stabilise.

(iv) The Instrument is ready for use half a minute after switching on and fully 'settled' within five minutes. No special precautions with cooling need to be taken normally but natural ventilation should not be restricted when operating at high ambient temperatures.

Fig. 1 Power Supply Tappings, links, and Fuse ratings
36V Secondary Tap.



Figures in brackets refer to use of 41V secondary tap.

3.2 BLOCK DIAGRAM

The broad outlines of the instrument are shown in the block Diagram in Fig. 2. Power is supplied by a Regulated supply which includes the protection circuits. The low distortion output from the Wien bridge oscillator of variable frequency is taken through a front panel Fine Output Level control to the Power Amplifier, which drives the transformer-coupled power outputs and the Meter circuitry. The same oscillator drives a Squarer, the level being adjustable through a second front panel control.

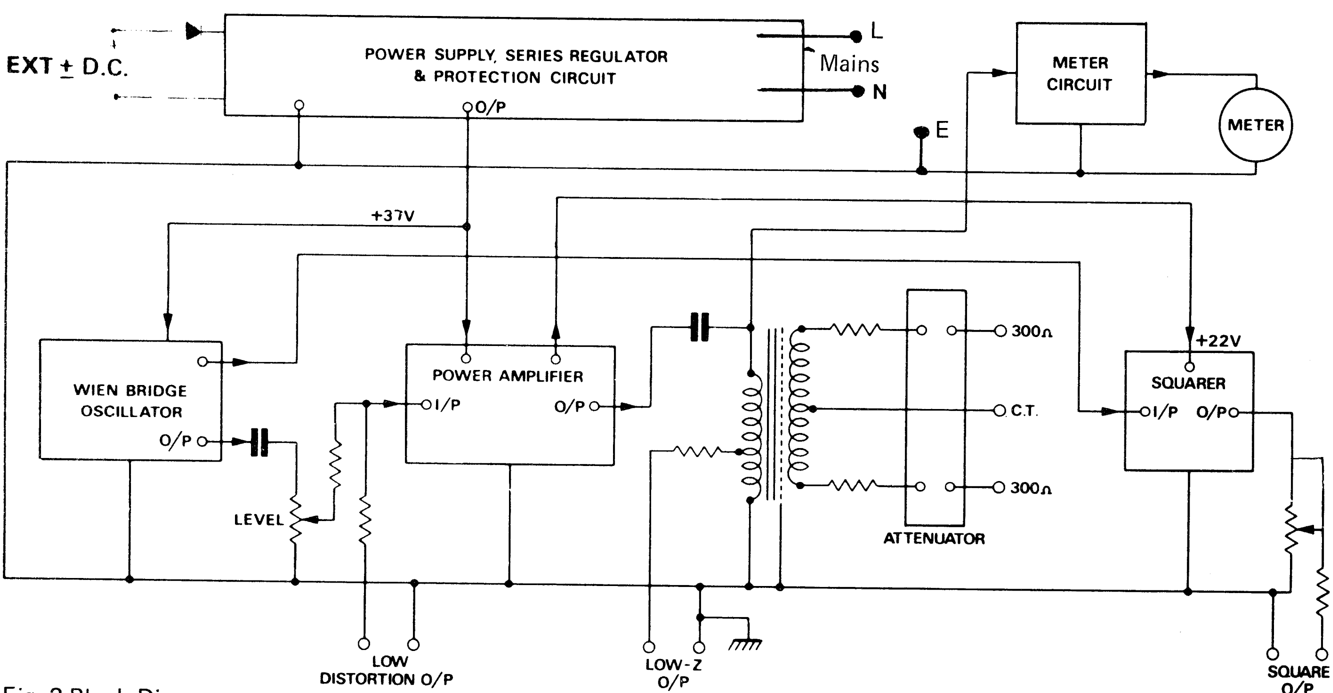


Fig. 2 Block Diagram

3.3 SELECTION OF FREQUENCY

To set frequency, the Range Switch is turned to the appropriate range. The fine control of Frequency is a circular dial which is set at the desired part of the decade in use. Although the accuracy claimed on the dial calibration is typically 1%, the resolution of the gang capacitor in the oscillator is essentially infinite and frequency can be set to any required value to within 1: 10^4. It is often convenient to use the independent square wave output to monitor the exact frequency by a Timer Counter.

3.4 BALANCED OUTPUT 15-0-15V r.m.s., e.m.s.,

(i) Output 1 is mainly intended for making balanced 600 Ω line measurements. In such use the desired amplitude is set on the Meter — remembering that half the Open Circuit voltage will appear across the load — and the balanced attenuators are used to give ÷ 10 or ÷ 100 facilities.

(ii) The balanced output can be used *unbalanced,* terminated in 600 Ω, in which case Metering and the use of the attenuators is exactly as above. If a low level unbalanced signal from a 600 source is required from the J3A — i.e. less than -40dB — it is advisable to use half the balanced output with the centre tap at the low impedance end, and use a 300 resistor in series externally to make up to 600 Ω . This avoids the pickup of small spurious signals due to the unbalance of the output, which can be significant at high attenuation.

(iii) *Half* the balanced output can also be used. If terminated with 300 Ω, again the Metering and use of attenuators remain unchanged, but of course only half the output voltage is being used, i.e. the output is a quarter of the e.m.f. indicated.

(iv) In addition, the balanced output can be used in any of the above ways without matched termination, i.e. operated into any load between open and short circuit It would then behave like an e.m.f. with a source impedance of 600 or 300 Ω , depending on whether the whole or half the output is used. The attenuators remain operative.

(v) Finally, there is no reason why different loads should not be used on each half output, remembering that they will be in phase opposition, and the resultants either measured or calculated.

(vi) The e.m.f. from the bifilar transformer secondaries is essentially balanced. The output resistances at the terminals are balanced to within 3%. Each attenuator may introduce unbalance of 3% in e.m.f., but the unbalance of output impedance remains unchanged, at a maximum of 3%.

Warning:

1. The maximum voltage applied between the balanced output and ground must not exceed 500V d.c. or peak a.c.

2. The passage of *direct current* through the balanced output must be restricted to less than 50mA, to prevent damage to the output resistors. A much smaller current than this, however, can saturate the output transformers and severely increase distortion. If some d.c. must be passed, it is an advantage to use the attenuators which will effectively reduce the current reaching the transformer by the same ratio. The permissible d.c. is a function of frequency and acceptable distortion, and can best be found by experiment.

3.5 LOW-Z OUTPUT 3V r.m.s., e.m.f. $Z_0 \simeq 1$ Ohm

(i) This can be used unloaded, and the e.m.f. can be read as 1/10th the Meter reading. The response is flat and the distortion less than at the Balanced Output. The full range of amplitude, i.e. 3V r.m.s., e.m.f., is available when output 2 is loaded by 5 Ω or more, simultaneously with normal loading of output 1.

If output 1 is unloaded and unattenuated, the load on output 2 can be generally reduced to 3 Ω at full output.
Loads smaller than 3 Ω may cause the protection circuit to operate, unless level is reduced. Under near short circuit conditions the maximum current available from output 2 is approximately 0.9A r.m.s.

Below 30Hz and at full output/loading, the protection circuit may be triggered at the peak of a cycle.

Note When the protection circuit operates because of excessive loading, the output level automatically 'cycles on and off' at intervals of about 2 seconds This is indicated by a corresponding swing on the output Meter.

3.6 LOW DISTORTION OUTPUT 2.5V r.m.s., e.m.f. $Z_0 \simeq 5$k Ohm

(i) This output, directly from the oscillator, is taken from the slider of the Fine Level Potentiometer through a buffer resistor. It can be loaded without detriment to the performance of the other outputs, although a change of loading reflects on the output levels.

(ii) An external signal from another Generator can be injected into this output and be resistively mixed with the low distortion J3A signal. The mixed signal is then available at amplified outputs 1 and 2 to permit intermodulation measurements on amplifiers, etc. However, leads left attached to this output can pick up and inject unwanted signals and noise into the J3A.

It should be noted that maximum injection occurs with the Fine Level control at its mid setting.

See also 4.2, last paragraph.

3.7 SQUARE OUTPUT 0 to 5V $Z_0 \simeq 1K$

(i) A fraction of the oscillator signal is taken to the Squarer circuit, and the independently controlled output is made available at the front panel as a positive-going square wave from 0V (ground). The mark/space ratio and rise and fall times (see Specification) are maintained over the entire frequency range of the J3A. If the mark/space ratio is preset to unity, the square edges 'lag' all the sinusoidal outputs of the generator by approximately 1% of the period + 0.1 us. In the 1 - 10kHz range, however, because of transformer phase shift, the floating output begins to lag the square wave progressively, after approximately 4kHz, by a small amount.

(ii) The square output, being independent in level of all the other outputs, can be conveniently used for Frequency Counting, for externally locking an oscilloscope time base, etc.

(iii) If terminated in 50Ω, the square wave is reduced to 150mV pk, approximately at full output, and the rise and fall times improve to better than 0.1 u s.

3.8 OUTPUT LEVEL METER & DECIBEL SCALE

(i) The Meter effectively measures the primary voltage of the output transformers and is calibrated 0 - 30V r.m.s. e.m.f., the total open circuit voltage available at the balanced output. Items 3.4 and 3.5 above describe most of the likely arrangements of load, etc., as well as the use of the matched and balanced Attenuators.

(ii) The (red) decibel scale is a 'relative' scale to enable amplitude/frequency response measurements to be made conveniently. The 0dB point, however, has been chosen to equal +20dBm, for convenience in power measurements in 600 Ω.

3.9 RELATIVE PHASE

The signal out of the left hand terminal of Output 1 with respect to the Centre Tap, is in phase with Outputs 2, 3 and 4 with respect to ground.

4.1 WIEN BRIDGE OSCILLATOR

Transistors, TR1 – TR6, comprise the oscillator amplifier. Transistor TR7, is a supply rail stabiliser.

The input of the amplifier goes to a field effect transistor, TR2, which is in a long-tailed coupling with TR3. TR2 is driven in cascode with TR1, to avoid Miller capacitance to the input gate. The base of TR1 is d.c. coupled to the 'common' emitters of TR2 and TR3, thus providing TR2 with a constant emitter-collector voltage to reduce distortion with the large signal swing at the emitter of TR2 (3Vp-p).

The signal from the collector of TR1 is fed to emitter-follower, TR4, with bypassed collector resistance, R35, serving to limit current at switch-on, before the oscillator d.c. levels are established. Diode D4, from the collector of TR5 to the emitter of TR4, 'catches' the collector of TR5 and prevents it from rising and bottoming by almost the full Zener potential of D2. TR4 drives the base of the transistor TR5, which inverts the signal, feeding it to the output emitter-follower, TR6. From the emitter of TR6 the signal is taken to the input of the Wien Bridge consisting of ganged variable capacitors, C7A, C7B, and the switched Range resistors, R1-R8. The range resistors, R1 to R4, are returned to variable bias at T.P. (A) which sets the d.c. level at the output, T.P. (E). The stability of this d.c. level is maintained by feedback to the base of TR3.

In the symmetrical Wien Bridge configuration used in the J3A oscillator, the voltage transfer of the bridge at 'resonance' is precisely 1/3. A similar voltage transfer is effected in the feedback network comprising Thermistor, R44, its shunt resistors R33 and R34, and the feedback resistor, R30, thus maintaining the high-gain amplifier in operational equilibrium. If the output level is low, Thermistor R44, is cold and hence its resistance is high. This reduces the negative feedback which, in turn increases the gain of the amplifier until equilibrium is re-established. The opposite happens if the output level is high. The same voltage transfer of 1/3 is also a.c. coupled to the resistor, R28 (the 'long tail' of TR2, TR3), effectively producing constant current in R28. The same 1/3 voltage is also applied through buffer resistor, R31, to the 'Guard' T.P. (C), which is connected to guard screens placed around the variable capacitor gang to reduce variations of capacitance between the rotor and ground.

R27, C24, and R37, C30 are frequency roll-off elements to maintain stability and diode, D3, provides signal continuity and circuit stability when TR6 cuts off during the period before the termistor reaches operating temperature and thus reduces output signal level to normal.

The full output of the oscillator from the emitter of TR6, is applied through R9 and C8 to amplitude control, R10, and thence to the Power Amplifier. A tap on the load resistor of TR6 supplies a lower level signal to the input of the Squaring circuit, R46 provides extra current to TR6 to assist "pull-up". The entire oscillator is mounted in a screen box to minimise hum and noise pick-up.

Thermistor R47 compensates for amplitude changes in the oscillator with temperature.

4.2 POWER AMPLIFIER

The power amplifier of the J3A is fed from a regulated rail of +37V and consists of transistors, TR101 – TR106. TR101 and TR102 are connected in a 'long tail' configuration the input signal from the amplitude control, R10, being applied to TR101 and the negative feedback to TR102. The base of TR101 is biased at 1/4 rail voltage via R104 and R102, and the input signal is a.c. coupled through C102. The signal path through the Amplifier is from the collector of TR101 through emitter follower, TR103, and the common-emitter stage, TR104, to the complementary output pair, TR105 and TR106.

There are two negative feedback paths to the base of TR102, via equal resistors, R108 and R120. R120 is connected directly to the output, and R108 is returned to a feedback winding on the output transformer. As this is effectively 'grounded' for d.c., stability is reached when the mean output voltage is twice the base voltage of TR102, that is *half the rail voltage,* enabling the Class B output transistors, TR105 and TR106, to swing equally in both directions.

For signal currents, R108 and R120 are in parallel, since the feedback winding has turns equal to the primary of the output transformer. The negative feedback signal through these resistors develops a voltage across R110+R111, which defines the voltage gain of the Power Amplifier. Bypass capacitor, C106, is large enough not to affect the feedback at the lowest frequency.

Quiescent current for the output transistors, TR105 and TR106, is controlled by transistor TR108 which, together with diodes D103 and D104, is in intimate contact with the heat sink on which the output pair are mounted. When the heat sink temperature begins to rise, TR108 also heats up and as its base- emitter voltage is fixed, it draws increasing emitter-collector current, thus diverting bias current away from the output transistors and restoring equilibrium.

To increase the gain of inverting stage, TR104, and to assist 'pull-down', the load of TR104 is bootstrapped to the output of the amplifier. A tap on the bootstrap through resistors, R116 and R117, provides a voltage approximately equal to the negative feedback at TR102 base, and to this is returned the common emitter resistance of the input pair, TR101 and TR102. As in the oscillator, this technique reduces distortion by maintaining constant signal current in the long tailed pair.

R109 and C104, R107 and C105, R118 and C112, and C113 are frequency roll-off components to maintain stability. Bypassed resistance, R112, limits switch-on surge currents in the amplifier, and D102 prevents hard bottoming of TR104, which could occur while the oscillator amplitude is settling. The input to the amplifier is taken via R101 to a socket at the back of the instrument, thus providing the low distortion amplitude controlled signal directly from the oscillator. An external signal can be *injected* at this point also, to mix resistively with the oscillator waveform, be amplified and become available at the power output of the J3A. **The injected signal must be within the frequency range of the output transformer in circuit at any one time.**

4.3 POWER OUTPUTS

The output of the Power Amplifier is coupled through C116 and a section of the Frequency Switch of the J3A, to the primary of T1 or T2. These are the Low Frequency and High Frequency output Transformers and operate respectively from 10Hz – 10kHz and 10kHz – 100kHz. Their feedback and secondary winding are also switched by the Frequency Switch as range is changed.

(i) LOW-Z OUTPUT

A tapping on the primary of each output transformer provides 3V r.m.s., e.m.f., between ground and the Low-Z terminal. The source impedance is approximately 1 Ω permitting about 1 Watt to be delivered into a load of 5 Ohms. The maximum available *current* is approximately 0.9A r.m.s.

(ii) 300-0-300 Ohm OUTPUT

Bifilar wound secondaries on each transformer supply 2 x 15V r.m.s., e.m.f. to the balanced output terminals through balanced attenuators of 20 and 40dB. Separate resistors are brought in by the Frequency Switch to pad the secondaries of both transformers to 300 Ohms each. The respective centre-taps are also switched and the outputs are thoroughly screened.

(iii) A protection circuit will cause the J3A to 'Cycle' on-off this condition being visible on the output meter if an attempt is made to draw excess power from the instrument. In view of its low output resistance excess power is almost invariably drawn from the Low-Z output by a short circuit. The protection circuit will be explained in the section dealing with the Power Supply. (See reference to peak current limiting).

4.4 SQUARE WAVE OUTPUT

As has already been mentioned, a tap on the load resistor of the output of the Wien Bridge Oscillator supplies the input signal to the Squarer. Emitter follower, TR131, further isolates the Oscillator from the Squarer to minimise interaction. The output from TR131 is coupled through C132 to the base of TR132, which, with TR133 forms a Schmitt trigger circuit in which the long-tail current through R134 is switched on-off at the collector of TR133. The output level is controlled by potentiometer, R142, and taken to the output terminal via R139. C133 is a speed-up capacitor to the base of TR133 and preset trimpot, R136, sets the mark-space ratio. R143 is selected on test in parallel with R142 to adjust the output level to be between +5V and +5.5V.

The Squarer is supplied through buffer emitter-follower, TR134, and Zener base reference, D131, to isolate the fast transients from other parts of the J3A. The same Zener D131 after filtering serves as the reference for the Power Supply.

4.5 POWER SUPPLY

Long-tailed pair, TR161 and TR162, compare the Zener reference to a fraction of the d.c. output voltage at the slider of trimpot, R162. The collector of TR161 conventionally drives compounded series output emitter followers, TR164 and TR165, the latter being the main series regulator connected to a heat sink. Zener diode D162 applies bootstrap feedback from the emitter of TR165 to R168, the collector load of TR161/TR163, thus presenting a high impedance load and increasing the loop gain.

R169 and C164 are frequency roll-off stability components. The input to the P.S. is provided by the secondary of mains transformer, T3, and Bridge Rectifier, BR161, feeding Reservoir capacitor, C166, whose negative terminal is taken to the 0-volt (ground) line through 1 Ohm, R170.

The protection circuit referred to under Section 4.3 (iii) is composed of R164, a 2.2 Ohm resistor between TR165 and the P.S. output; transistor, TR163; R170; trimpot, R165, and C163. TR163 is connected so that its base-emitter monitors the d.c. voltage drop in R164, its collector being in common with that of control transistor, TR161. Hence, if a current of more than approximately 250mA is taken through R164, TR163 will conduct and reduce the base current available to the series control transistor. This conventional current sensing and limiting alone, would also limit the positive current peaks of the output waveform, especially at the lower frequencies.

While the current overload sensor, TR163, is arranged so that its base is d.c. biased by potential across R164, the a.c. component is balanced out in trimpot, R165, with a fraction of the opposing signal voltage generated across R170 and a.c. coupled via C163. Increasing mean current in R164 causes TR163 to conduct, limiting the drive to TR164 and TR165, thus dropping the output voltage. C163 then, however, discharges through R178 into the base of TR163, thus collapsing the supply. In addition, the time constants are such that when the supply collapses on overload, the Wien bridge oscillator is stopped and waits until its control thermistor cools before it can restart. The absence of signal effectively removes the overload from the P.S. which then restores output. The cycle of events continues until the overload is removed or the signal level is turned down. Overload is shown by the Output Level meter cycling on-off at approximately 2 second intervals. A faster 'cycling' visible on the Output Level meter generally indicates an internal fault, rather than excessive external loading.

Note: Under certain conditions of overload, the peak current limiting circuitry of the output stage can initiate the 'cycling' of the protection circuit. This situation is most likely to arise when excessive magnetising current is required by the output transformer, either because of external d.c. magnetisation or through a fault. This initiation of cycling will cause no damage to the instrument.

4.6 METER CIRCUIT

Equal signals from the output of the P.A. and the feedback winding, supply the germanium diode full wave bridge rectifier through equal resistors, R151 and R152. The resultant d.c. is then set and filtered by R153, R154 and C151. The rectifier is essentially average current, as most of the applied voltage is dropped across the two equal resistors. By monitoring the two points that supply the feedback to the Power Amplifier, the meter circuit is effectively connected to the 'ideal' transformer driving the balanced Outputs, and thus compensates for transformer losses.

4.7 MAINS INPUT

Transformer, T3, is conventionally arranged with a series-parallel primary and has a single well-screened secondary. The primary is switched and fused, and a Neon indicator is fed from one half primary. (See 3.1 (i) and Fig. 2)

4.8 EXTERNAL D.C. SUPPLY

Two coded sockets at the back of the instrument permit operation from a **FLOATING** D.C. supply of 40-48V. Current at maximum output and loading is approx. 250mA. A diode, internally, protects against incorrect polarity of the external supply.

5.1 REMOVAL OF COVERS

Warning: Take care not to touch the supply transformer or fuse with the supply *ON*.
To remove the covers from the instrument, firstly remove the bottom by unscrewing the 4 retaining screws. Then by gently pulling the side panels outwards the cover should lift off. It will generally be found more convenient to carry out adjustments or repairs with the bottom of the instrument upwards and to use an external supply (See 4B) for testing and calibration.

5.2 REMOVAL OF OSCILLATOR BOX COVER

This is held on by seven screws, 4 at the bottom and 3 at the top, all 7 screws working in slots. After undoing each screw by about 3 turns, the cover can be slid out. Refitting is a reversal of the above procedure, being careful to butt the cover well against the steel oscillator box when tightening the screws.

5.3 REMOVAL OF PRINTED CIRCUIT BOARD ASSEMBLIES

(i) Removal of Oscillator P.C.B. (Fig. 4)
This is released by undoing 4 screws, as shown in the figure. Then the yellow lead on the underside of the board to pin 'C' (Guard) is unsoldered. The board is now free and can be eased out and swivelled about the cables and leads going to the Range Switch.

(ii) Release of Master P.C.B.
- (a) Remove 4 screws securing rear panel. Disconnect the 2 leads from the Low Distortion terminals.
- (b) Undo the two screws that hold the board to the bracket near the Mains transformer.
- (c) Disconnect the two brackets that support the board to the case (top and bottom) towards the middle of the P.C.B.
- (d) Remove the top screw securing the output transistors' heat sink to the side member, near the two large electrolytics mounted on the board. Slacken the corresponding bottom screw securing the heat sink. The board can now be swivelled against the cables and harness to remove damaged components, although *many of these are accessible simply by removing the rear panel.*

Note: Complete removal of the P.C.B.'s requires disconnection of all leads, which should be clearly labelled for correct reconnection.

5.4 SETTING UP OF WIEN BRIDGE OSCILLATOR

(i) Work which is possible with cover removed.
The cover should not be removed unless a fault exists in the oscillator board.
1. Turn Fine Output Control to minimum.
2. Disconnect coax. lead from Point D (to squarer)
3. Check incoming +37V rail at check position on switch, or on master P.C.B. (red leads). If faulty, disconnect the oscillator from +37V rail and use an external +37V supply rated at 50mA to supply the oscillator.
4. Connect an a.c. coupled oscilloscope (1V/div., 0.1 mS/div.) to 'Oscil. Test Point' as shown in Fig. 4 (On the middle switch wafer outside the oscillator box).
5. Set frequency to approximately 3kHz, and switch on.
6. If there is no fault, oscillations should build up die out, restart and stabilise.
7. Connect D.V.M. or 20k ΩV Voltmeter, across C25. Trim R22 for a reading of 12.5—13V Examine the waveform on the oscilloscope for possible clipping, etc. It should be clean.
8. Trim R34 for 8v p-p on the oscilloscope. Restore wiring to normal.

(ii) Work with cover in position:
(In the absence of a fault, begin setting up here)
Step 7 above may be carried out by connecting a d.c. Voltmeter to 'Oscil. Test Point').
1. Connect the a.c. high impedance Voltmeter to 'Oscil. Test Point' replacing the oscilloscope. The Voltmeter should be calibrated to 1% at 2.8V r.m.s., and have a flat frequency response from 10Hz to 100kHz, inclusive of the screened cable connector.
2. Connect the Frequency counter to the Squarer output. Set this to a convenient level.
3. Select the 1-10kHz Range, and set the dial to 1kHz. Note the frequency on the counter.
4. Trim R34 for 2.8V r.m.s. on the Voltmeter and tune towards the high frequency end of scale, carefully observing the voltmeter reading. If the Wien bridge is trimmed correctly, the reading should stay constant at 2.8V.
5. Set the dial to 10kHz and trim C2 and C3 to obtain *ten times* the frequency noted in step 3 above. Note that *increasing* C2 and/or C3, *decreases* the frequency, and that *increasing* C2 and *decreasing* C3, can keep the frequency constant while *decreasing* the output of the oscillator. The two trimmers should be set for the right frequency and *least* amplitude variation over the range. Note the amplitude at 10kHz.
6. Reset 1kHz on the counter. Slacken the two grub screws that hold the tuning gang spindle in the epicyclic drive and reposition the scale to agree with the counter.
7. Set the dial to 10kHz and trim frequency to agree, with amplitude retained at that giving least variation over the band. (Step 5.)
8. Check frequency/dial agreement on 100-1000Hz and 10-100kHz ranges at various points, and if necessary, reset the dial (repeating Steps 6 and 7) for minimum frequency error overall. If the error approaches 2% a fault in the appropriate range resistors should be suspected, or else in the gang.
9. Check 10-100Hz range, allowing for the +1Hz tolerance in the specification. The oscillator should now be set and be flat within 0.3dB.
10. Finally, return to the 1-10kHz Range at 9kHz setting, note frequency reading and 'rock' the tuning knob whilst adjusting C2 and C3 for minimum amplitude bounce. Check that the noted frequency reading has been held unaltered.
It should be noted that clockwise dial rotation producing amplitude *increase* requires *increase* (frequency lowering) of the Trimmer C3 nearest the edge of the oscillator box (grounded trimmer).
Conversely, C2 has the opposite effect.

Note: A piece of insulated wire is wrapped around the highest range resistor R8 shunting it by approx. 1/4pF This raises the frequency at the top end of the highest range by 1% approx., to produce closer agreement with the scale.

5.5 SETTING UP OF POWER SUPPLY

Note: All trim potentiometers on Master P.C.B. can be adjusted from the back of the board through suitable holes.

1. Turn the level control to zero.
2. Adjust R162 for +37V $\pm$ 0.5V at pin +'37V' carrying red lead.
3. Provisionally set R165 at its mid setting. *After* adjusting the Power Amplifier, the frequency is set to 300Hz and a.c. coupled and *floating* millivoltmeters is connected between +37V point and the slider of R165, to test point marked "SET NULL". The P.A should be loaded with approximately 5 Ohms at the Low -Z tap, the 40dB attenuator engaged to load the balanced output, and the Level control should then be advanced and R165 adjusted, for minimum signal on the voltmeter while increasing level to maximum. The adjustment is eased if the oscilloscope Timebase is set to 1μ s/div. and 'free run', in which case the 3kHz signal appear as a multiple trace whose width should be reduced to a minimum. If the protection circuit operates, switch off and check R164 and R170. The minimum unbalance signal is generally less than 1 millivolt.
4. Check that, at the nominal mains voltage for the transformer tap in use, the reading between the collector of TR165 (heat sink) and ground, is not less than +44V under load as in Step 3 above.

5.6 SETTING UP THE POWER AMPLIFIER

(i) Quiescent Current of Output Stage.

1. Set the Level control to zero and remove the loading from the instrument. Switch out the attenuator.
2. Switch off and disconnect the link between the collector of TR106 and ground (Fig. 4) The link is at the bottom rear right corner of the instrument, near a large electrolytic. Replace the link by a d.c.milli-ammeter (-ve to ground) and solder a capacitor of value 0.5 to 1 μF across the link pins. R129 is adjusted to give a quiescent current in the output pair of 18–30mA. It should be noted that current through R130 modifies the behaviour of TR108 (see 4.2, para. 4) so that quiescent current is slightly reduced with increased heat sink temperature, caused by running at full load over long periods.
3. Switch off and restore circuit link.

(ii) Check the output d.c. devel between ground and the +ve end of C114 (See Fig. 4). It should be within 1 volt of *half* the supply rail. If not, check R102 R104, R108, R120 and C106 for leakage.

5.7 SETTING UP SQUARER

(i) Connect the oscilloscope to Square Output, 1V/div.. 0.1ms/div.

(ii) Select Range 1-10kHz and a frequency of 1kHz, so that 1 cycle (square) occupies exactly 10 oscilloscope divisions.

(iii) Trim R136 for mark/space ratio of unity.

(iv) Change the polarity of trigger on the oscilloscope and retrim, if necessary, so that the transition of the square wave occurs at the same point on the oscilloscope, near the 0.5ms centre. This should eleminate possible oscilloscope nonlinearity.

(v) Verify that amplitude is within specification. If excessive, suitably shunt front panel control R142 (1kΩ) by A.O.T. resistor, R143 across the pins at the output of the squarer projecting from the track side of the PCB. Should the output be less than specified, check D131 (24V Zener), R142, R132, R133 and R134, in this order.

(vi) Confirm that rise and fall times are within specification. If not, check R135 and C133.

5.8 DISTORTION (See Fig. 3)

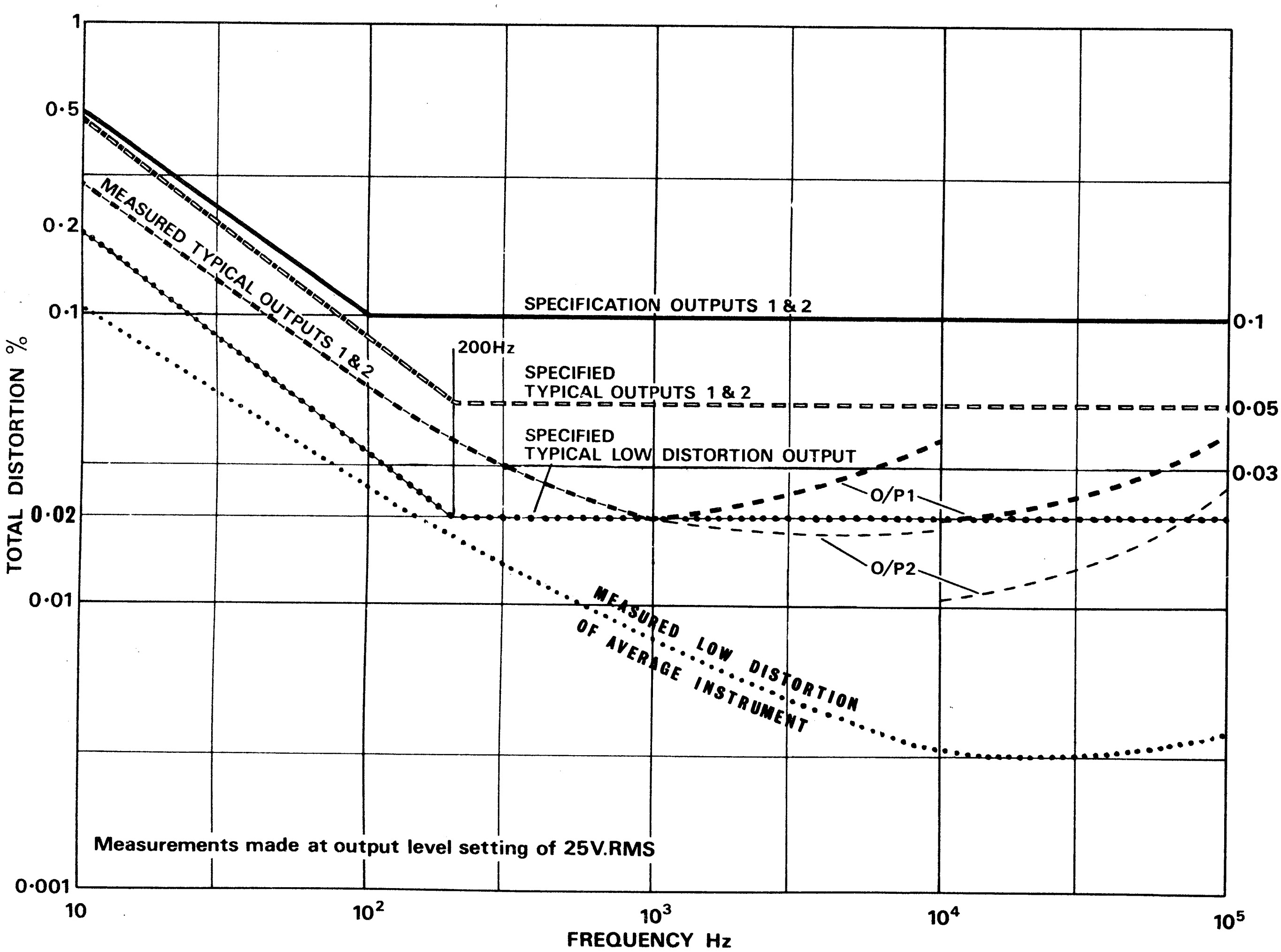
(i) If the preceding adjustments have been carried out correctly, distortion should be well within specification Apart from obviously faulty circuitry, the following is a short check list of the more likely causes of excessive distortion, if the instrument is functioning in other respects. If available, a Distortion Factor Meter is invaluable in tracking down distortion, particularly if possessing an output giving residual component frequencies after cancellation of the fundamental.

1. Change of component parameters could cause short burst of high frequency oscillation at some specific point of the signal cycle, as seen on an oscilloscope, particularly immediately after switching on when oscillator amplitude is still unstablised. When the J3B with this form of distortion is used as a signal source, it will generally result in 'noisy' or flickering measurements.
2. Cross-over distortion in the power output stage, generally due to failure or error in the bias components (see section 5.7 i) or damaged output transistors.
3. Supply hum or signal ripple across the 37V rail, caused by power supply failure or damaged electrolytic, C115. At full loading, the total supply + signal ripple across C115, should not exceed 40-50 mV p-p.
4. Square Wave break-through, caused by failure of TR131 or TR134.
5. If the distortion output gives predominantly 3rd harmonic at 10kHz, higher than the value specified, with corresponding increases of distortion at lower frequencies, suspect a faulty stabilising Thermistor in the oscillator.

(ii) Any failure or error in the feedback paths (including Switching) in the P.A., or wrongly set protection and limiting circuits in the P.S., can cause large distortion, increasing with output level.

(iii) If the distortion increases with output level beyond the specified limits then the fault is with the P.A. If the fault is in the oscillator, then distortion is sensibly independent of level at all outputs.

Fig. 3 Graph of Distortion and Frequency



ABBREVIATIONS USED FOR COMPONENT DESCRIPTIONS

RESISTORS				
CC	Carbon Composition	½W	10%	unless otherwise stated
CF	Carbon Film	1/8W	5%	unless otherwise stated
MO	Metal Oxide	½W	2%	unless otherwise stated
MF	Metal Film	¼W	1%	unless otherwise stated
WW	Wire Wound	6W	5%	unless otherwise stated
CP	Control Potentiometer		20%	unless otherwise stated
PCP	Preset Potentiometer MPD PC		20%	unless otherwise stated
CAPACITORS				
CE(1)	Ceramic		+ 80% − 25%	
CE(2)	Ceramic	500V	± 10%	unless otherwise stated
SM	Silver Mica			
PF	Plastic Film		± 10%	unless otherwise stated
PS	Polystyrene			
PE	Polyester		± 10%	unless otherwise stated
PC	Polycarbonate			
E	Electrolytic (aluminium)		+ 50% − 10%	
T	Tantalum		+ 50% − 10%	

NOTE: Components coded on the master
PCB in YELLOW are not used.

Circuit Ref.	Value	Description	Tolerance %		Part No.
RESISTORS					
R1	30M	MF	±1		32772
R2	3M	MF	±0.5		32773
R3	300K	MF	±0.5		32774
R4	30K	MF	±0.5		32775
R5	30M	MF	±1		32772
R6	3M	MF	±0.5		32773
R7	300K	MF	±0.5		32774
R8	30K	MF	±0.5		32775
R9	270	CF	±5	1/8W	28720
R10	5K	Cp			A4/32606
R11	47K	CF	±5	1/8W	21815
R21	100K	CF	±5	1/8W	21819
R22	25K	PCP			29602
R23	47K	CF	±5	1/8W	21815
R24	1K	CF	±5	1/8W	21799
R25	15K	CF	±5	1/8W	28727
R26	5K6	CF	±5	1/8W	21806
R27	560	CF	±5	1/8W	21798
R28	1K8	CF	±5	1/8W	28725
R29	750	MO	±2		28790
R30	390	MO	±2		26740
R31	2K2	CF	±5	1/8W	21802
R32	1K5	MO	±2		26733
R33	820	MO	±2		27346
R34	2K5	CP			28969
R35	12K	CF	±5	1/8W	21810
R36	330	CF	±5	1/8W	28721
R37	180	CF	±5	1/8W	21795
R38	1K8	CF	±5	1/8W	28725
R39	680	CF	±5	1/8W	28723
R40	1K	CF	±5	1/8W	21799
R41	33K	CF	±5	1/8W	21814
R42	100	CF	±5	1/8W	21794
R43	2K7	CF	±5	1/8W	28726
R44	1.9V/1ma Wkg.	Thermistor R15		3mW SELECTED	32421
R45	330	CF	±5	1/8W	28721
R46	3K9	CF	±5	1/8W	21804
R47	1K8/25°C	Thermister RP152CY	10%	1/4W	35712
R101	4K7	CF	±5	1/8W	21805
R102	33K	CF	±5	1/8W	21814
R103					
R104	100K	CF	±5	1/8W	21819
R105	6K8	CF	±5	1/8W	21807
R106	3K3	CF	±5	1/8W	21803
R107	82	XX	+5	1/8W	28717
R108	16K	MO	±2	1/8W	28805
R109	820	CF	±5		28724
R110	330	CF			28721
R111	2K7	MO	±2	1/8W	26728
R112	8K2	CF	±5	1/8W	21808
R113	68	CF	±5	1/8W	28716
R114	330	CF	±5	1/8W	28721
R115	1K	CF	±5	1/8W	21799
R116	270	CF	±5	1/8W	28720

Components List and Illustrations

Circuit Ref.	Value	Description	Tolerance %			Part No.
RESISTORS (Con't)						
R117	120	CF	±5	1/8W		28718
R118	56	CF	±5			28715
R119	1K5	CF	±5	1/8W	A.O.T.	21801
R120	16K	MO	±2			28805
R121	1	WW				34200
R122	1	WW		1/8W		34200
R123	330	CF	±5			28721
R124	2R2	WW		1/8W		31894
R125						
R126						
R127	470	CF	±5	1/8W		21797
R128	220	CF	±5	1/2W		18524
R129	1K	PCP				32523
R130	15K	CF	±5	1/8W		28727
R131	12K	CF	±5	1/8W		21810
R132	15K	CF	±5	1/8W		28727
R133	8K2	CF	±5	1/8W		21808
R134	2K7	MO	±5	1/8W	A.O.T.	26728
R135	150	CF	±5	1/8W		28719
R136	2K5	PCP				28969
R137	15K	CF	±5	1/8W		28727
R138	8K2	CF	±5	1/8W		21808
R139	470	CF	±5	1/8W		21797
R140	2K2	CF	±5	1/8W		21802
R141	12K	CF	±5	1/8W		21810
R142	1K	CP				A4/32607
R143		CF	±5	1/8W	A.O.T.	
R144 (FITTED IN	56	CF	±5	1/8W		28715
R145 (PLACE OF	2R2	WW	±5	2½W		31894
R151 ('SET IQ LINK'.	10K	CF	±5	1/8W		21809
R152	10K	CF	±5	1/8W		21809
R153	2K5	CP				28969
R154	1K5	CF	±5	1/8W		21801
R161	12K	CF	±5	1/8W		21810
R162	5K	PCP				28970
R163	22K	CF	±5	1/8W		21812
R164	2R2	CF				34201
R165	5K	PCP				28970
R166	22K	CF	±5	1/8W		21812
R167	2R2	CF	±5	1/8W		34201
R168	6K8	CF	±5	1/8W		21807
R169	68	CF	±5	1/8W		28716
R170	1	WW				34200
R171	470	CF	±	1/8W		21797
R174	1-10M	A.O.T.				
R178	1K2	CF	± 5	1/8W		21800
R201	1480	MF	±1			32776
R202	15K	MF	±1			32777
R203	1480	MF	±1			32776
R204	15K	MF	±1			32777
R205	367	MF	±1			32778
R206	306	MF	±1			32779
R207	367	MF	±1			32778
R208	306	MF	±1			32779
R209	367	MF	±1			32778
R210	306	MF	±1			32779
R211	367	MF	±1			32778
R212	306	MF	±1			32779

Circuit Ref.	Value	Description	Tolerance %			Part No.
RESISTORS (Con't)						
R221	OR68	CF	±5			31888
R222	280	MF	±1			32826
R223	280	MF	±1			32826
R224	187	MF	±1			29471
R225	187	MF	±1			29471
CAPACITORS						
C1						
C2	6/25pF	Trimmer				23593
C3	6/25pF	Trimmer				23593
C7	518pF +518pF				C7A + C7B	33999
C8	68µF	E		16V		32174
C9	1.5pF	S/M				813
C21	150 F	E		16V		32175
C22	0.22µF	PE		250V		35607
C23	68µF	E		6.3V		32162
C24	68pF	CE(2)	±10	500V		22374
C25	1000µF	E		16V		32178
C26	5.6pF	CE(1)		500V		22361
C27	150µF	E		16V		32175
C28	470µF	E		6.3V		32164
C29	.01µF	CE(1)		250V		22395
C30	33pF	CE(2)	±10	500V		22370
C31	470µF	E		40V		32191
C32	47µF	E		40V		32188
C101	0.22µF	PE				31379
C102	22µF	E		25V		32181
C103	5.6pF	CE(2)		500V		22361
C104	56pF	CE(2)		500V		22373
C105	680pF	CE(2)	±10	500V		22385
C106	150µF	E		16V		32175
C107	82pF	CE(2)		500V		22375
C108	470µF	E		6.3V		32164
C109	.01µF	CE(1)		250V		22395
C110	56pF	CE(2)		500V		22373
C111	470µF	E		6.3V		32164
C112	56pF	CE(2)		500V		22373
C113	5.6pF	CE(2)		500V		22361
C114	330µF	E		16V		33998
C115	2200µF	E		40V		31844
C116	2200µF	E		25V		32520
C117	100µF	E		4V		34994
C131	.1µF	CE(1)		30V		36709
C132	25µF	E		25V		32181
C133	33µF	E		500V		22370
C134	47µF	E		25V		32182
C135	560 pF	CE				22384
C151	47µF	E		10V		32167
C161	33µF	E		16V		32173
C162	47µF	E		25V		32182
C163	47µF	E		63V		32199

Circuit Ref.	Value	Description	Tolerance %		Part No.
CAPACITORS (Con't)					
C164	2200pF	CE(2)	±10	500V	22389
C166	1000µF	E		63V	32521
C167	.047µF	CE(1)	+40		
C168	560pF	CE(2)	-20	250V	19657
				500V	22384
TRANSISTORS					
TR1		2N3904			24146
TR2		AE15			A32067
TR3		2N3904			24146
TR4		2N3906			21533
TR5		2N3906			21533
TR6		2N3906			21533
TR7		BC107			26790
TR101		2N3904			24146
TR102		2N3904			24146
TR103		2N3906			21533
TR104		BCY70			23354
TR105		2N6179			34330
TR106		2N6181			34331
TR107	NOT FITTED				
TR108		BC209			33331
TR131		BC209			33331
TR132		2N3906			21533
TR133		2N3906			21533
TR134		2N3904			24146
TR161		2N3904			24146
TR162		2N3904			24146
TR163		BC209			33331
TR164		BC107			26790
TR165		2N5296			28630
DIODES					
D1	5V6				4109
D2	5V6				4109
D3		1N4148			23802
D4		1N4148			23802
D101	5V6				4109
D102		1N4148			23802
D103		1N4003	MOTOROLA ONLY		32771
D104		1N4003			32771
D105		1N4148			23802
D131	24V				22175
D151		AAZ13			4472
D152		AAZ13			4472
D153		AAZ13			4472
D154		AAZ13			4472
D161		1N4003			23462
D162	3V9				33925
D163		1N4148			23802

Circuit Ref.	Value	Description	Tolerance %	Part No.
MISCELLANEOUS				
L1		Choke		A4/32781
MR161		W02		19725
T1		Transformer	L F.O/P	A1/32590
T2		Transformer	H.F.O/P	A1/32591
T3		Transformer	Supply	34891
FS1	250mA	Fuse	SLO-BLO	1898
N1		Neon		31870
S1		Switch(Range)		34466
S2		Switch(P.B.)		32604
S3		Switch(Rocker)		32612
ME1		Sifam Type 23		A3/32600
SKA		Terminal Guest Type TP2/4mm (Red)		30137
SKB		Terminal Guest Type TP2/4mm (Black)		35719
SKC		Terminal Guest Type TP2/4mm (Red)		30137
SKD		Terminal Guest Type TP2/4mm (Red)		30137
SKE		Terminal Guest Type TP2/4mm (Green)		32735
SKF		Terminal Guest Type TP2/4mm (Red)		30137
SKG		Terminal Guest Type TP2/4mm (Red)		23635
SKH		Terminal Guest Type TP2/4mm (Black)		23636

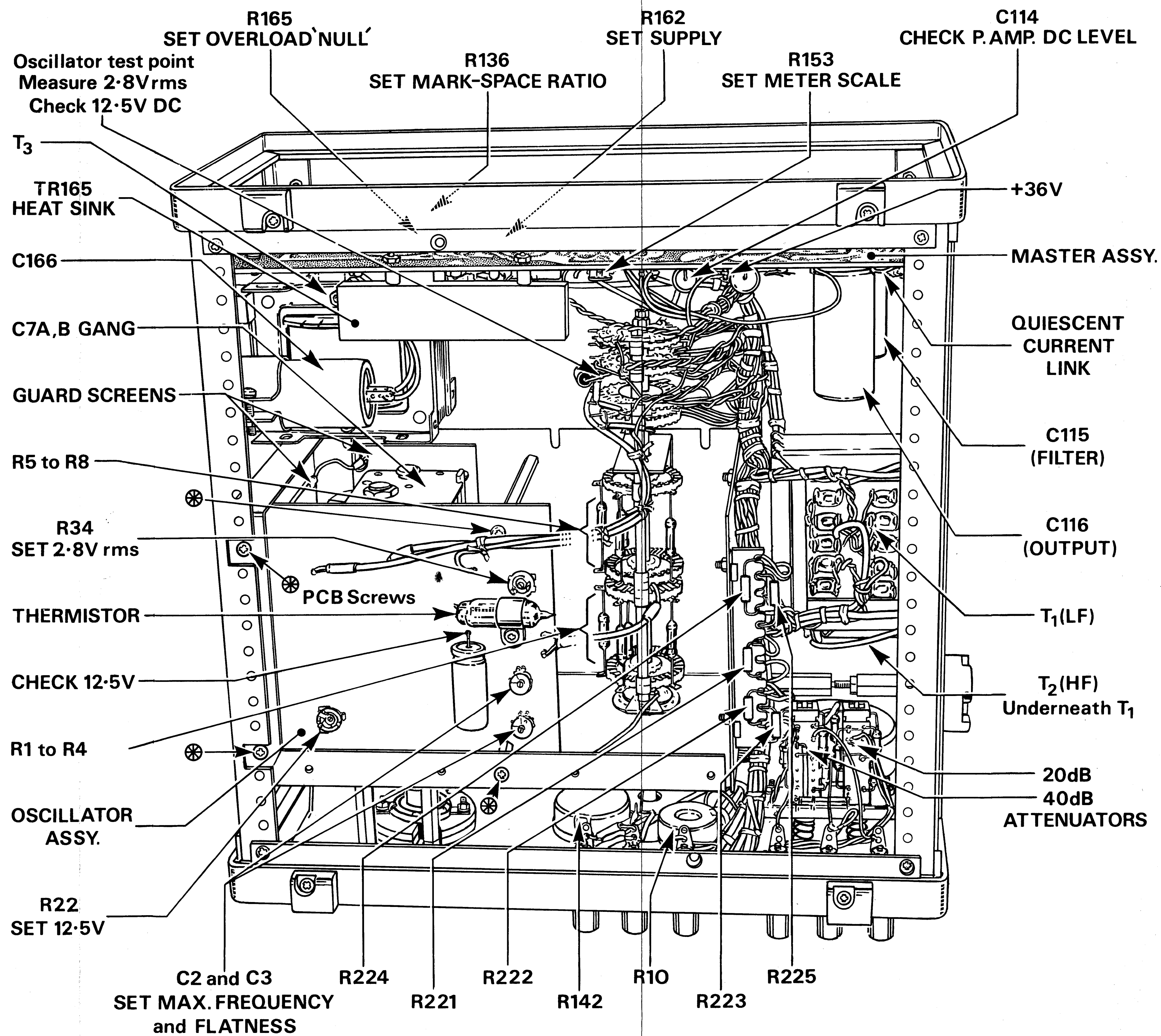
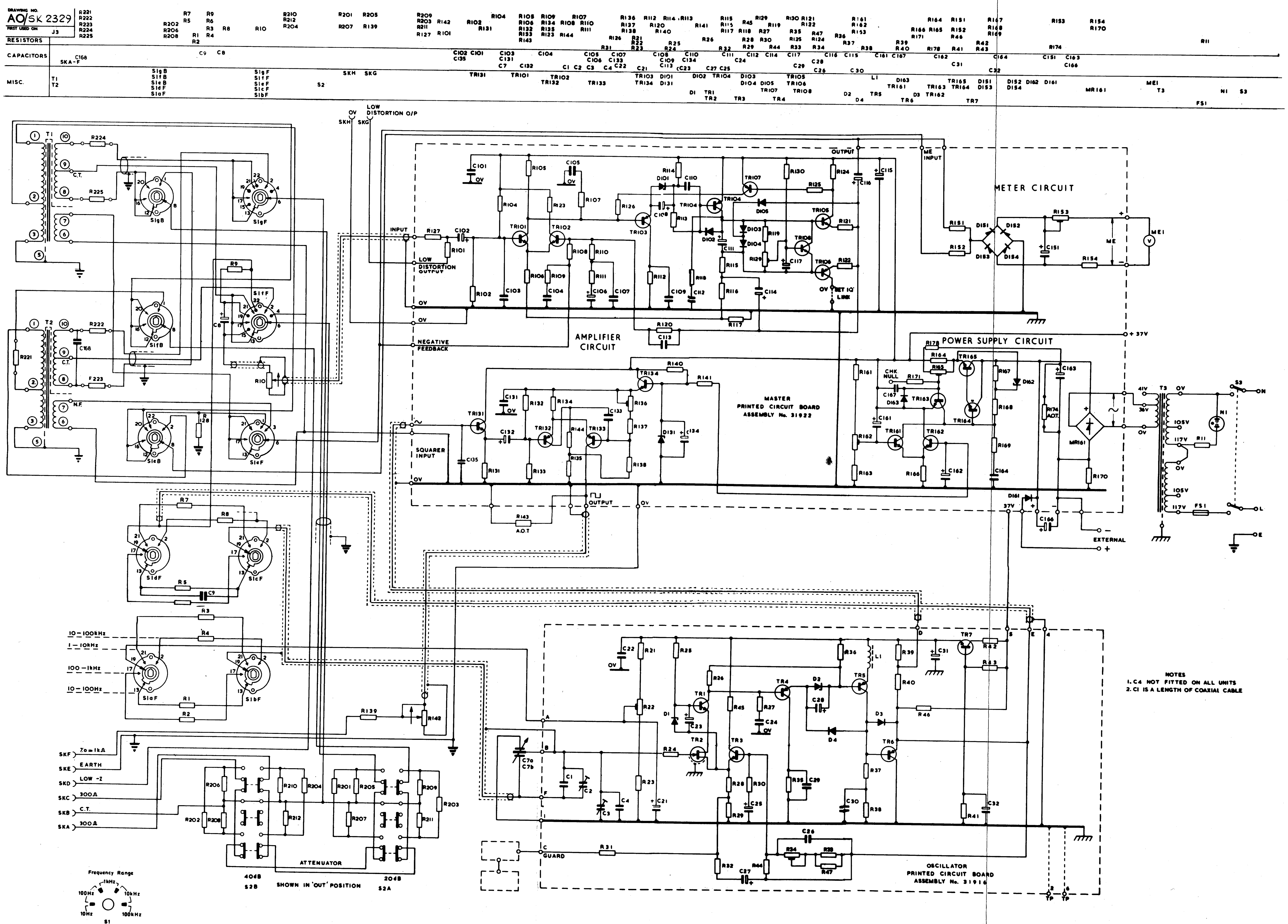


Fig. 4 Component Location Diagram


DRAWING NO. AO/SK 2329
FIRST USED ON J3
RESISTORS
CAPACITORS
MISC.
LOW DISTORTION O/P
INPUT
LOW DISTORTION OUTPUT
NEGATIVE FEEDBACK
SQUARER INPUT
OUTPUT
ME INPUT
METER CIRCUIT
AMPLIFIER CIRCUIT
POWER SUPPLY CIRCUIT
CHK NULL
MASTER PRINTED CIRCUIT BOARD ASSEMBLY No. 31922
SET 1Q' LINE
EXTERNAL
GUARD
ATTENUATOR
SHOWN IN 'OUT' POSITION
OSCILLATOR PRINTED CIRCUIT BOARD ASSEMBLY No. 31916
NOTES
1. C4 NOT FITTED ON ALL UNITS
2. C1 IS A LENGTH OF COAXIAL CABLE
Frequency Range
10-100kHz
1-10kHz
100-1kHz
10-100Hz
SKF 7Ω-1kΩ
SKE EARTH
SKD LOW -Z
SKC 300Ω
SKB C.T.
SKA 300Ω