24.4.78

DESIGNS DEPARTMENT HANDBOOK

NO. 5.121(77)

Radio Microphone 2 Watt Amplifier

AM14/21

C O N T E N T S

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Radio Microphone 2 Watt Amplifier

AM14/21

1. INTRODUCTION

The AM14/21 is a 2 watt, FM Radio microphone amplifier which incorporates the TM3/3 as modulator and low-power amplifier. It is tunable in the range 45 - 65MHz and incorporates self-monitoring facilities which enable retuning to be carried out in the field. The amplifier is housed in a fabricated box, which also contains the TM3/3 and a rechargeable Ni-Cd battery which powers both units. The RF output is via a 50Ω Female N connector which can be used either with a remote aerial, or with a selection of screw-on aerials provided.

1.1 Specification

Input Requirements	Power amplifier 200mW RF drive, 45 - 65MHz for 2 watts out. Supplied by TM3/3.
Audio Inputs	Dynamic or Sennheiser capacitor microphone; XLR inputs. Switchable high-pass filter 300/100Hz on Sennheiser input.
Output	2 watts 45 - 65MHz, type N socket, 50Ω nominal output impedance.
Power supplies	Runs from internal rechargeable 13.2 volt Ni-Cd battery; gives 4 hours operation from full charge.

2. OPERATION

2.1 Interconnection with TM3/3

The TM3/3 is housed in a pocket within the main chassis and accessible via the side-door. The flying HT leads from the AM14/21 pass through two notches in the base of the TM3/3 case and mate with the existing battery connectors. Audio input and RF output leads interface directly with the connectors on the front panel of the TM3/3; the ON/OFF switch should be left permanently 'ON' as it is overriden by the external switch on the AM14/21.

2.2 Audio Inputs

Two XLR 3-pin sockets are provided on the side of the case, one accepting low impedance dynamic microphones, and the other designed specifically for use with Sennheiser microphones. The latter provides the correct bias and impedance levels, thus dispensing with a separate supply, and also incorporates a switchable high-pass filter with a choice of two cut-off frequencies.

The dynamic microphone input is connected directly to the input of the TM3/3, and hence the high-pass filter is inoperative.

2.3 RF Circuits

A concise tuning procedure is attached inside the door of the AM14/21, and is repeated in section 3.1 Pg. 3. Note that if the aerial is moved close to reflecting surfaces it will require re-tuning in-situ.

To transmit, switch the mains ON/OFF switch ON, and the AMP/AERIAL switch to AERIAL. Shut both doors and press the 'LIGHTS' button. (This is a two-pole switch, and ambiguous readings may occur if the button is not pressed firmly). Under normal circumstances the 'lights' should indicate as follows:-

TUNE	-	dim
CURRENT	-	bright
OVERLOAD	-	OFF
BATTERY	-	ON

If the 'tune' light is bright, or the 'overload' light is on, then the aerial requires either re-tuning or substitution. Where the transmit frequency lies symmetrically between two nominal aerial frequencies, the higher frequency aerial should be used in conjunction with the aerial extender. The latter reduces aerial resonance by about 2MHz.

2.4 Batteries and Charging

A new, fully charged battery will provide continuous operation of both TM3/3 and AM14/21 for about 5 hours. During service over a number of years a battery gradually loses capacity; thus three hours continuous transmission may be regarded as a good working limit. The reduced depth of discharge on new batteries prolongs overall life.

It is important to observe the manufacturers maximum charge current when using Ni-Cd cells. Prolonged charging at elevated currents causes irreversable loss of water by electrolysis, as does charging with reversed polarity. Ambient temperatures above 60°C may also reduce life, but operation down to -30°C results only in temporary loss of capacity (30%). Refer to specific manufacturers literature for more detailed information.

3. LINE-UP PROCEDURE

3.1 Tuning

(i) Tune TM3/3 on correct frequency and insert in AM14/21.

(ii) Connect AM14/21 output to TE1/19 tester. Switch on and press 'LIGHTS' button.

(iii) Set switch to 'AMP', adjust 'LOAD' and 'TUNE' for maximum output consistent with 'OVERLOAD' lamp not being alight (approx 2.5 watts). If TE1/19 is not available, use 50 ohm load and adjust for minimum brightness of 'TUNE' lamp. Remove TM3/3 from its pocket, leaving it connected, and trim its output tuning for maximum output from AM14/21. Replace TM3/3.

(iv) Disconnect TE1/19 and replace by aerial mounting tube and aerial. Move 'TUNE' switch from 'AMP' to 'AERIAL' and close door of AM14/21. Adjust tuning capacitor in tube for minimum brightness of 'TUNE' lamp. If dip is poor, add extension piece between tube and aerial (lowers frequency about 2MHz) or try different aerial. If AM14/21 is to be used free-standing, chassis must not be touched during tuning or the aerial resonance will be altered.

3.2 Use of LED Indicators

The 'TUNE' LED is used as a dip tuning indicator, i.e. maximum output or return loss produces minimum brightness. The brightness of the 'CURRENT' LED is proportional to the HT current of the 2 watt output stage:- hence it is possible to tune for maximum efficiency if required.

The 'OVERLOAD' LED illuminates when this current rises above 400 - 450mA, and indicates either a circuit fault, incorrect tuning or a mis-matched load. The 'BATTERY' indication is normally on, and extinguishes when the battery is within 15 minutes of failure.

4. CIRCUIT DESCRIPTION

4.1 Board No. 1

4.1.1 RF Amplifier

This is a single class C stage, employing an NPN RF transistor working from a positive earth in order to obtain compatability with the TM3/3. The input matching consists a 3 : 1 broad-band transmission-line transformer; the output network is a conventional matching circuit tuned by C11 and C9. This feeds a 20dB directional coupler, the coupled output of which indicates output return loss. Components R_1 - R_3, L_1, C_2 and D14 are included to ensure unconditional stability into mismatched loads.

4.1.2 Monitoring and Protection Circuits

(i) Battery Indicator

TR8 compares a fixed proportion of the battery voltage with reference zener D12; TR9 acts as a current limit to prevent excessive current in D11 when the battery volts are high.

(ii) Tuning Indicator

The detected voltage appearing either or C19 (return loss) or C20 (RF output voltage) is selected by S3 and fed to the input of virtual earth amplifier IC1/TR7, whose output is defined as the emitter of TR7. The virtual earth potential difference generated between the output and the reference voltage appears across shaping network R25/26, D8, which determines the current flowing through D10. Maximum output or minimum return loss correspond to minimum brightness:- D10 will be dim when 100µA flows into R22 from S3.

(iii) Current Limit and Overload

Matched pair TR5 a, and b, form a differential amplifier biassed from R13. If no current flows through the current sensing resistor R12, TR5a conducts hard and TR5b is starved due to degenerating resistor R16. Hence TR4 and TR3 both turn on, applying the full battery voltage to the amplifier.

As the current taken by the RF amplifier increases, the emitter of TR5a rises in potential relative to that of TR5b, gradually transferring base current to TR5b, causing its collector to fall and TR6 to conduct; thus D5 becomes brighter as HT current increases. As the HT current increases still further, the voltage across R10 will eventually drop below the conduction voltage of D2, hence TR4 turns off and starves TR3 of base drive, causing the output to enter a current-limited mode. When TR3 is not saturated (V_{ce} > 0.7v) TR2 turns on, causing the overload LED to light.

4.2 Board No. 2

4.2.1 Power Supply Section

TR13 (a and b) form a current mirror:- the current generated by TR13b, develops a voltage across R52 referred to ground, which is buffered through TR12 to form a low-noise supply to TR11 and Sennheisser microphone.

4.2.2 High-Pass Filter

TR11, together with R41, R42, C30 and C11 form a unity gain active high-pass filter of the 'Sallen and Key' type with a nominal f3dB of 100Hz. Switching S5 to the '300Hz' position routes the filter output through a further network C32/R48 which forms a 300Hz high-pass section.

4.3 Board No. 3

This is housed within the aerial mounting tube and consists simply of a series tuned circuit, the capacitive element being variable. This enables the reactive component of the aerial impedance to be tuned for optimum return loss.

5. MAINTENANCE

NOTE: The limits quoted below are those to which the unit was aligned during manufacture. Slight departure from limits is acceptable.

5.1 Board No. 1

5.1.1 DC Checks and Current Limit

Disconnect one end of the wire link which threads the two ferrite beads FB1/2. Connect a power supply set to 13V, +ve to SKTD, -ve to PLD. Set the power supply current limit to 50mA. Switch S1 to 'on' position and check that the current taken is less than 20mA. If not, switch off and isolate -ve HT feed to board 2 (black wire). Thus establish the offending board and check wiring as appropriate.

With the supply set to 13V, the 'tune' switch S2 set to amp, and S1 'on', press the 'lights' switch. This should produce the following states:

Overload light	off
Current light	very dim
Tune light	bright
Battery light	on

If the 'tune' light is not on, check that IC1 is inserted correctly.

Set the supply current limit to 600mA, press the 'lights' button and temporarily short the collector of TR3 to the case. The 'overload' and 'current' lights should both be on, and the current consumption should be between 450 and 550mA. If the current limit is outside this range, but the circuit appears to be otherwise working, R12 should be adjusted to bring the unit into specification.

Set the input voltage from the power supply to 12.6V, using a DVM. Press the 'lights' button, and adjust R29 until the 'battery' LED is just visible - increasing the input voltage to 13.2 should produce normal brightness, and reduction to 12V complete extinction.

TABLE 1

Voltages measured relative to chassis on Board 1 with AVO on 25v DC range, with a battery input of 13.2v. All are negative, and apply when the 'lights' button is pressed, and with no RF drive to TR1. Figures for 300mA load refer to potentials measured when a 41Ω 5w resistor is connected between the collector of TR3 and chassis.

	Collector							IC1	BASE
	TR3	TR4	TR5a	TR5b	TR6	TR7	TR9	Pin 3	TR5
Quiescent	13.1	4.1	12.8	1.7	11.8	10.0	1.8	5.6	12.6
300mA Load	12.8	4.3	12.5	10.0	11.5	10.0	1.8	5.8	12.4

5.1.2 RF Power Amplifier Checks

Reconnect the link threading FB1/2, and set the power supply to 13.2V. Switch on, and check that the voltage on the emitter earth plane of TR1 is within 0.1v of the input voltage with respect to the chassis.

Connect an RF signal generator, output frequency 50MHz, to a power meter, and set the output level to 200mW. Transfer the power meter to PLF via a pad* (i.e. FSD 3 watts) and connect the signal generator to PLA. Tune C9 and C11 for maximum power output. This should be 2 watts, ± 1dB; if the output power is less than this, check the wiring of T1 and the output coupler.

Reduce the drive level from the oscillator until the output power is 2 watts, and check that the current consumption is less than 450mA. Disconnect the power meter and connect the output from PLE via a 30dB pad to the input of a spectrum analyser. Check that the amplifier is not oscillating or generating any spurious outputs, and that harmonics of 50MHz can be tuned to better than -30dB relative to the fundamental.

Finally, repeat the power output measurements with the oscillator set at 45 and 65MHz. Minimum power output in both cases should be as above. If the tuning range of C9 or C11 appears to be inadequate, a fixed trimming capacitor may be added as appropriate.

5.1.3 RF Monitor Checks

With the output tuned to 2 watts into 50Ω, press the 'lights' button and check that the 'tune' light is dim, brightening as the amplifier is de-tuned.

If operation is incorrect check D7, D9, R4, C20 and components associated with TR7. Switch S3 to 'aerial', and check that the 'tune' LED is dim - removing the 50Ω load should now cause the LED to go to full brightness. Any fault revealed will be associated either with the coupler, T2, D6 or C19.

5.2 Board 2

5.2.1 Microphone Inputs and High-Pass Filter

Connect a power supply, output voltage 13V and current limit 50mA as in 5.1.1, and switch on. Solder a 2K resistor between pins 2 and 3 of a 3 pin XLR plug and insert into SKA. Check that pins 3 and 2 are at -10.0 (± 0.7)V and -1.5 (± 0.2)V relative to chassis respectively.

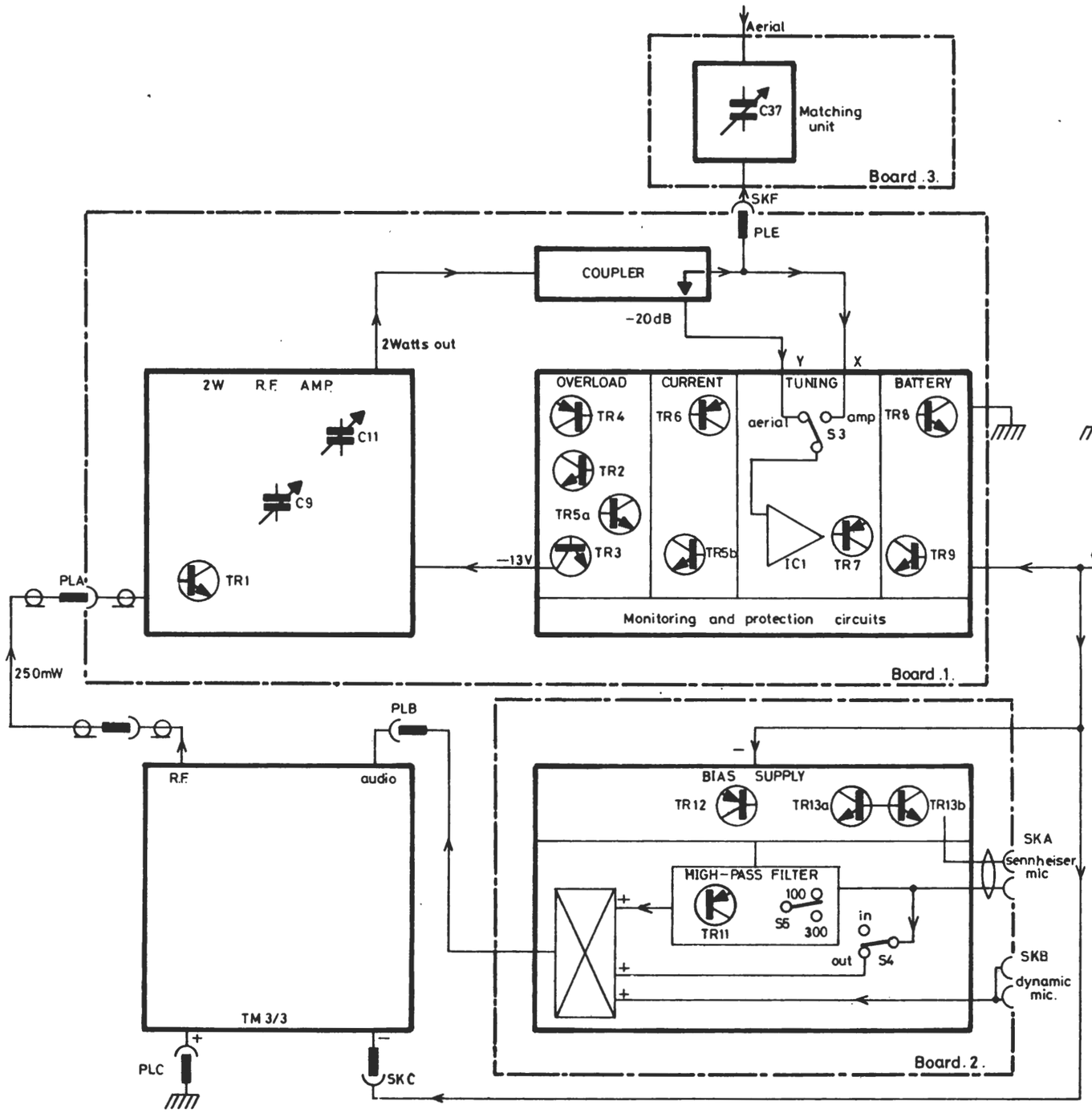
Connect the audio generator (e.g. TF 2330 - used in the 'BFO' mode) output level 100mV rms to pins 1 and 2 of SKA, and monitor the output on pin 1 of PLB using an audio millivoltmeter. With the filter switch in the 'out' position check that the response is flat within 1dB from 50Hz to 20kHz. Switch the filter to 'in', cut-off '100Hz' and measure the output level at 50Hz relative to 5kHz - it should be at least 10dB down. Switching the cut-off to '300Hz' should cause the output at 50Hz to fall by a further 17dB (± 2dB).

* 3 watts minimum power rating.

5.3 Overall Test

Tune the amplifier to 50MHz as per section 7.2, remove the power meter and connect the aerial tube to PLE. Screw on a 50MHz aerial, and monitor the radiated signal using about 6" of unscreened wire attached to the spectrum analyser input. Check that C37 affects the radiated signal strengh, move the 'tune' switch to aerial and adjust C37 with a low capacitance trimmer for minimum LED brightness.

If tuning is unaffected by C37, examine the assembly and wiring of the aerial tube for faults.



277mm · 400mm | DS/A3

CHANGE	ISS
- 9 .76	1

THIRD ANGLE PROJECTION

All dimensions in millimetres unless other wise stated

Normal tolerances

no decimal place	: 1 mm
one decimal place	: 0 3mm
two decimal places	: 0 1mm

unless otherwise stated

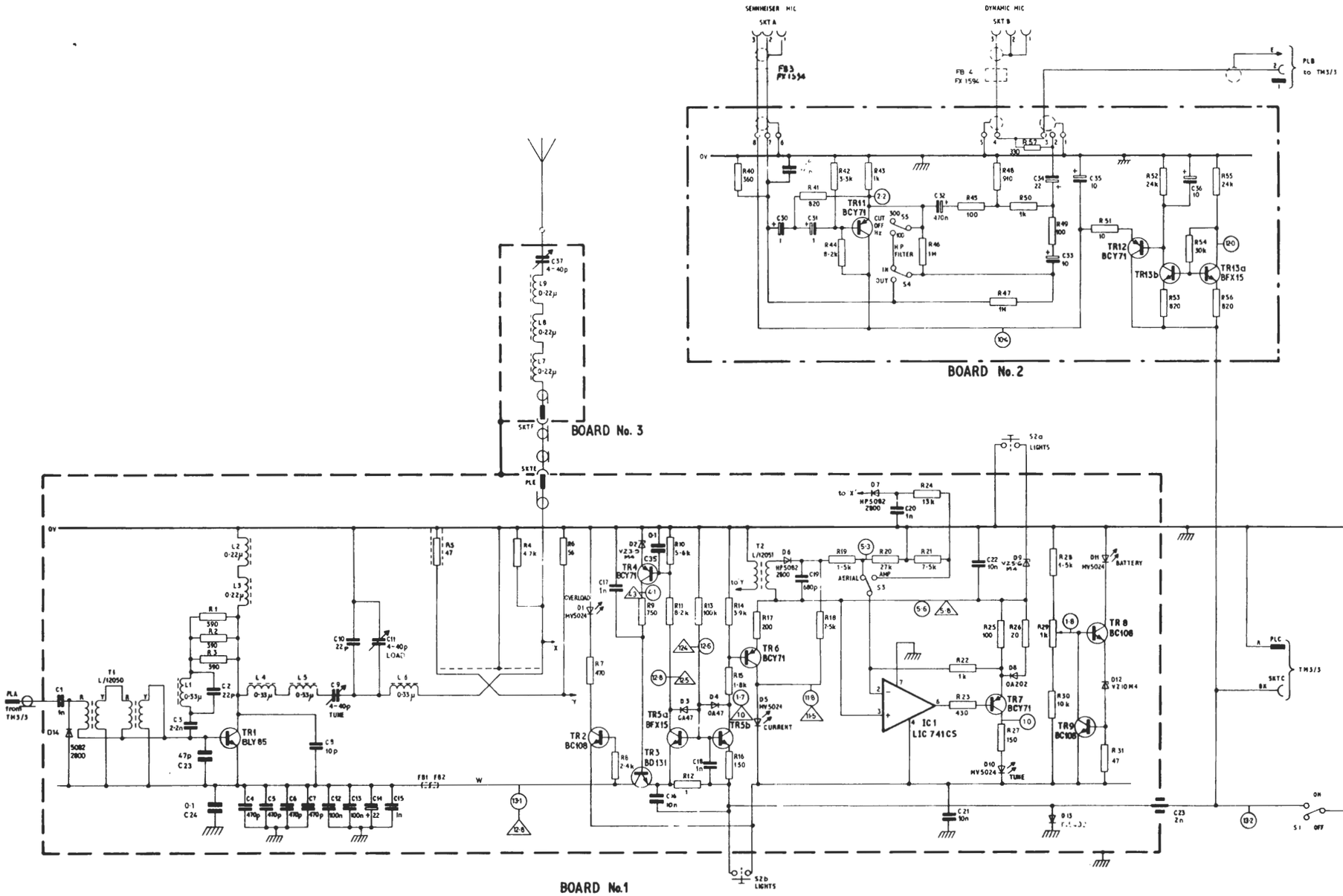
AM14/21 BLOCK DIAGRAM

DRN.	TCD.	CKD	APPD
J.S.	K.d.S.		

DESIGNS DEPARTMENT.

DSK 18671 A3

SCALE:



BOARD No. 1

WORKING VOLTAGES, 'LIGHTS' BUTTON PRESSED.

ALL VALUES -ve (AVO 8 20K/v)

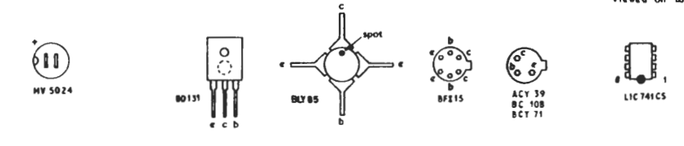
○ NO LOAD - (RF-INPUT DISCONNECTED)

△ 41Ω LOAD (300 ma) 'W' TO GROUND.

NOTE

Inductors – 0·22 µ are type 58/10/0001/10
0·33 µ are type 58/10/0002/10

Transistor terminations viewed on leads



parts list D 34660 A3

DSK 20373 A1

BBC
DS A1
153

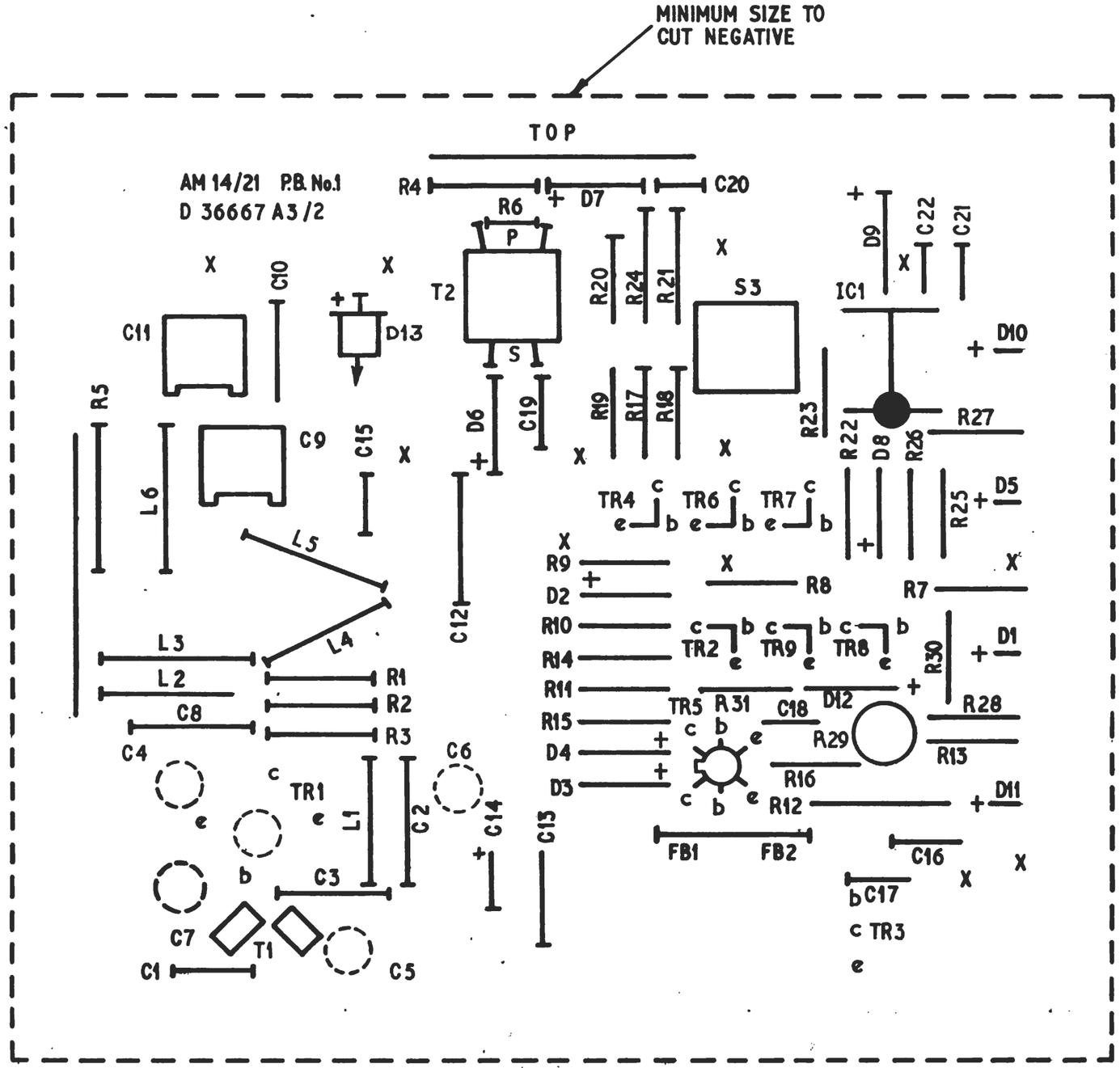
AM14/21
R.F. AMPLIFIER
(RADIO MICROPHONE)
HANDBOOK
CIRCUIT

DRN	TCD	CKD	APPD
S.T			

DESIGNS DEPARTMENT

DSK 20373 A1

D 36667 A3



CHARACTERS & LINES TO BE PRINTED IN BLACK
PRINTED WIRING ON REVERSE SIDE OF BOARD IS D36665 A3
PRINTED WIRING ON COMP SIDE OF BOARD IS D36666 A3

SCALE:- 2:1

SCALE:- 2/1

277mm × 400mm | D3/A3

CHANGE	ISS
25-3-76	1
25.6.76	2

THIRD ANGLE PROJECTION

All dimensions in millimetres unless otherwise stated:
Normal tolerances
no decimal place:– ±1 mm
one decimal place:– ±0.3mm
two decimal places:– ±0.1mm
unless otherwise stated

AM14/21

PRINTED BOARD No.1

COMPONENT LOCATION

DRN.	TCD	CKD.	APPD.
	S.E.		

DESIGNS DEPARTMENT

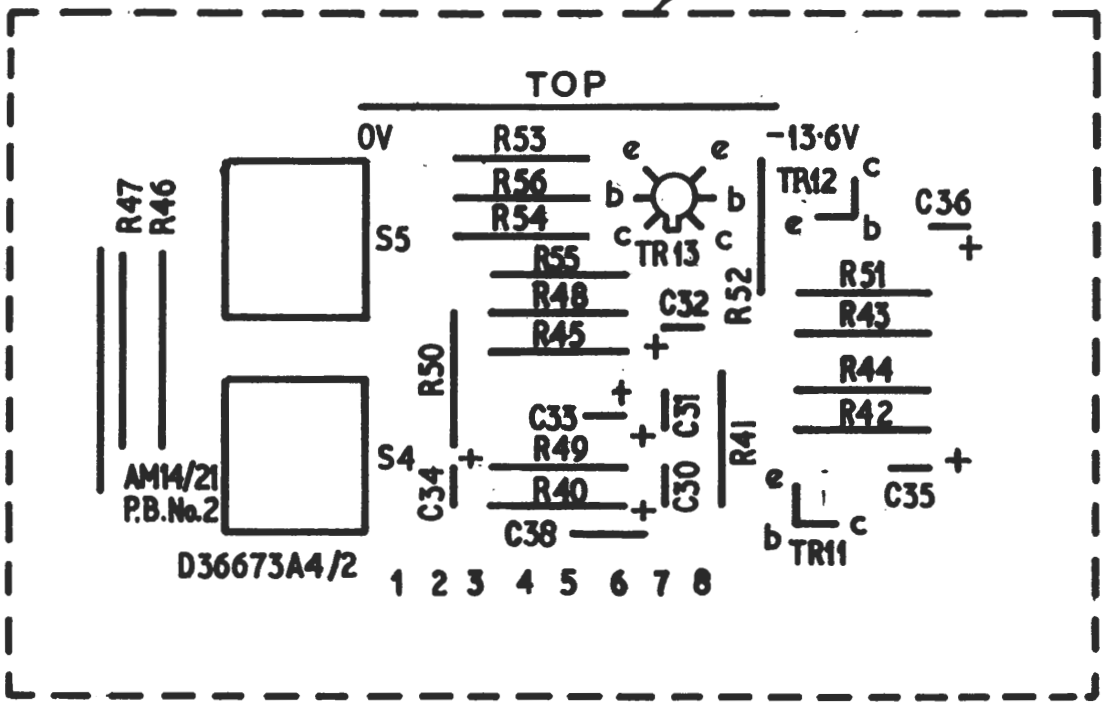
D36667A3

AM14/21 PRINTED BOARD COMPONENT LOCATION No. 2

D36673A4

CHANGE
25-3-76
25.6.76

MINIMUM SIZE TO CUT NEGATIVE



CHARACTERS AND LINES TO BE PRINTED IN ~~WHITE~~/ BLACK.

PRINTED WIRING ON REVERSE SIDE OF BOARD IS D36672A3

SCALE 2:1

AM14/21 PRINTED BOARD COMPONENT No.2 LOCATION

DRN | TCD | CKD | APPD

D36673A4

DESIGNS DEPT

C9 C11 POSITIONED ON BOARD SO THAT ADJUSTING SCREW SLOTS ARE CONCENTRIC WITH HOLES ON ITEM 29

DL3 + END SOLDERED TO TOP OF BOARD. 100Ω LEAD EXTENDED WITH WIRE ITEM 230, 20cm COVERED WITH SLEEVING ITEM 231

FIXED TO INSIDE OF FRONT PANEL. HERE

WIRES ITEM 230 COLOUR AS SHOWN, SOLDERED TO COPPER ON THE SIDE OF BOARD, RUN AS SHOWN

WITH MOUNTING WASHERS

DIODES D40 ETC. MOUNTED IN RUBBER WHICH ARE FIXED TO ABOVE BOARD. PASSED TO FRONT THRU HOLES IN PANEL.

PANEL REMOVED FOR CLARITY.

SEE NOTE 7

49 TO 154 FOR COMPLETE LAYOUT OF COMPONENTS SEE D36647A3

SEE NOTES 2, 3 & 4 DETAIL A

SCREEN OF CABLE TERMINATED, INNER SOLDERED TO BOARD

SEE NOTE 1

SEE NOTE 6

LABEL, ITEM 46 STUCK TO OUTSIDE OF PANEL IN THIS POSITION. APRON

H.P. FILTER

FINISHED LENGTH OVERALL 12"

TH3/3.18 INSERTED THROUGH THIS DOOR IT SLIDES INTO COMPARTMENT IN MOUNTING FRAME.

MOUNTING BARS, WHICH ARE SUPPLIED LOOSE, FIT HERE, ACROSS REAR.

SEE NOTE 5

SOLDER TO UNDERSIDE OF BOARD HERE.

SEE NOTES 2 & 3

BOARD N°2 (WIRING SIDE)

TOP

AMPLIFIER ASSEMBLY
SHOWN REMOVED FROM CASE

SEE NOTE 13

SENNHEISER MIC.

DYNAMIC MIC.

SIGNWRITE R6.0 IN BLACK CHARS

CASE ASSEMBLY SEE D36662A1

SKTF & SKTE ARE CONNECTED BY 12" OF CABLE ITEM 228

STUCK TO INSIDE OF DOOR HERE BETWEEN WINDOW & BOSSES 3 REQ.

AMPLIFIER ASSEMBLY FIXED TO MOUNTING BY SCREWS ITEM 210

FIXING MOUNTING AND AMPLIFIER INTO CASE

RUBBER BATE 3"x1" STUCK TO SIDE OF AMPLIFIER CASTING.

RUBBER BATE 2"x3" STUCK TO INSIDE OF DOOR ABOVE BATTERY COMPARTMENT.

SPARE LENGTH OF ALL WIRING TO BE TIED & HELD UNDER MTG. FRAME

BATTERY FITS HERE & CONNECTS TO SKTD & PLD

DOOR SHOWN CUT AWAY FOR CLARITY.

DETAIL B
SEE NOTE 3

DETAIL C
SEE NOTE 4

THIS IS A JOINT BETWEEN WINDINGS AND DOES NOT CONNECT TO BOARD

TI EACH WIRE SHOWN REPRESENTS 2 WIRES, CONNECTED IN PARALLEL TERMINATION: SOLDERED TO COPPER WHERE SHOWN.

C9, C5, C6 & C7 TO BE TESTED IN TURN, AS THEY ARE SOLDERED IN POSITION, FOR SHORT CIRCUIT BETWEEN TOP & BOTTOM FOILS.

DETAIL D
SEE NOTE 1

AERIAL ITEM 237 SCREWS ONTO HERE

BOARDS CEMENTED WITH ARALDITE, CENTRALLY IN SLOT IN END PLUG

SEE NOTE 7

HEAD OF SCREW SOLDERED TO COPPER OF BOARD CUT OFF SIDE OF HEAD OR BOARD SIDE AS REQUIRED.

THIS END OF C237 & L3 ETC SOLDERED TO FOIL SIDE OF BOARD

SCREEN OF CABLE SOLDERED TO OTHER SIDE OF BOARD.

SCREEN OF CABLE SOLDERED TO CASE OF CONNECTOR.

AERIAL TUBE ASSEMBLY

WIRING
CERTAIN WIRES, CABLE LENGTHS ETC, ARE SHOWN IN ASSEMBLY ABOVE, AMP. REMOVED FROM CASE & INVERTED.

WIRES CONNECTED TO BOARD AS FOLLOWS, STRIP INSULATION FOR ½", HEAT WIRE FROM COPPER SIDE, BEND OVER ALONG COPPER FOR ½" AND SOLDER.

NOTES:
1/ C4 C5, C6 & C7 FITTED AS SHOWN IN DETAIL 'D' 3/8 LONG x ¼ WIDE STRIP OF .005" THICK TINNED COPPER FOIL SWEATED TO UNDERSIDE OF BOARD, FIT CAPACITOR IN HOLE, APPLY SOLDERING IRON TO OUTSIDE OF FOIL TO SOLDER PREVIOUSLY TINNED CAPACITOR AND FOIL COVER HOLE IN TOP SIDE OF BOARD WITH SECOND PIECE OF FOIL, & SWEAT TO PREVIOUSLY TINNED CAPACITOR & BOARD. L.H.F. SOLDER & A MINIMUM OF HEAT MUST BE USED ON THESE CAPACITORS.

2/ TR1 SOLDERED IN POSITION SHOWN, CUT DOWN CONNECTING TABS AS REQD. ON ASSEMBLY OF BOARD INTO BOX FIT WASHER ITEM 26 BETWEEN THIS BOX. FIXING NUT TO BE TIGHTENED WITH APPLIED TORQUE OF BETWEEN 7.6 & 8.5 kg/cm

3/ BRIDGE AS DETAIL 'B'. .005" THICK COPPER FOIL, FITTED OVER ER1, FLANGES SOLDERED TO BOARD EACH SIDE, ON TOP OF EMITTER TABS.

4/ RB WRAPPED IN .005" THICK TINNED COPPER FOIL AS SHOWN IN DETAIL C WHICH IS THEN SOLDERED TO TOP OF BOARD

5/ FIT FERROXCUBE TOROID, ITEM 43 OVER CABLE ADJACENT TO SKT. A

6/ COMPONENT LEAD OUT WIRES SHOWN THUS —4 ARE SOLDERED TO COPPER ON COMPONENT SIDE OF BOARD.

7/ X INDICATES PINS ITEM N° 50 WHICH ARE SOLDERED TO COPPER ON BOTH SIDES OF BOARD.

8/ TR1 AND TR3 ARE MOUNTED WITH HEAT SINK COMPOUND, "DOW CORNING 340".

9/ ASSEMBLY TO BE IN ACCORDANCE WITH BWG. CA10484 NOTES 1, 4 & 7

10/ WIRING TO BE IN ACCORDANCE WITH BWG. CA10435 NOTES 1, 2 & 13

11/ COMPONENTS ARE IDENTIFIED BY THEIR PARTS LIST ITEM, OR CIRCUIT REF NUMBERS.

12/ CABLES FROM SKTA & B ALSO PLB ARE TO BE BOUND SECURELY TO THIS PILLAR, TO PREVENT ANY STRAIN ON TERMINATIONS.

13/ SOCKETS SKTA & SKTB ARE TO BE INSULATED FROM PANEL. GASKET CUT FROM .005" THICK POLYTHENE SHEET FITTED BETWEEN SOCKET & PANEL. ONE TURN OF "LABGO" TAPE AROUND BODY OF PLUG, WHERE THIS PASSES THROUGH PANEL.

SCALE:- 1/1 & 2/1 PARTS LIST D36660A4 CIRCUIT D36659A1

CHANGE	
25-3-76	1
FROM 230, 43 & 46 ADDED. WLB	2
JCR. 19.8.76	

AM14/21
ASSEMBLY

DESIGNS DEPT.

D36661A1