EXHIBIT NO. 4

/JB

COSSOR electronics

... Electronics Limited The Pinnacles, Harlow, Essex CM19 5BB England. Telephone: Harlow (0279) 26862. Telex: 81228. Cables: Cossor Harlow

GEC Ltd
Hirst Research Centre
East Lane
Wembley
Middx HA9 7PP

30th September 1982

833/1338/5/A/3512

For the attention of Mr G Swallow

Dear Sirs

With reference to our discussions concerning 29uS and 26.4uS Delay Lines please note the following requirements:

(a) 29uS Delay Line B914842/001

(i) All new lines will be 6mm wide, with new case allowing provision of gasket and new SMA connector (subject to satisfactory completion of vibration tests). These lines will be identified by the same Cossor part number and NATO number as existing but the GEC Hirst number should be S29/6. It has already been agreed with MOD that the MOD strike number increases with the introduction of the 6mm line.

(ii) The Cossor drawing will show a greater maximum height for the line to allow a thicker base plate and will call for GEC Hirst type number S29/1 and S29/6.

(b) 26.4uS Delay Line B917034/000 (New number TBA)

(i) The insertion loss figure will be 53 ± 2dB.

(ii) Input power testing will be at 5W CW.

(iii) Following the policy of 29uS lines outlined above, all 26.4uS delay lines will have one Cossor and NATO identification but the line thickness should be identified within the GEC Hirst number, e.g. S26.4/6 and S26.4/8 or similar.

EXHIBIT No. 9 (CTD.)

Further to our investigation into burn out failures of 29uS lines, we find that the dc transient on equipment switch on or mode change does not exceed +1.5V at the Delay Line input port. We believe that this is insufficient to cause the damage seen.

The line undergoing power testing has withstood up to 9W CW with no ill effect and has not failed when subjected to the transients measured above.

Yours faithfully
for and on behalf of
COSSOR ELECTRONICS LIMITED

J R Weatherley

c.c. Mr R A Swann, PDS
Mr M McCreary, Purchasing
Mr C Newson, Prog Management

Number	COMPONENT SPECIFICATION	COSSOR electronics
SAN70 - 2 -		

PART:- 1	Description
PAGE:- 2	DELAY LINE. (R.F).
ISSUE:- A	

Marking

1. Each device will be marked as follows:-
   (a) Terminal identification.
   (b) Manufacturer's type number.
   (c) Serial number.
   (d) Factory identification.
2. Each primary package containing one or more devices shall bear the above markings except (a), and in addition:
   The British Standard detail specification number.

Ordering information

Orders for devices shall contain the following information:-
(a) Quantity.
(b) Type number.
(c) Centre frequency.
(d) The British Standard specification number.

Related documents

This specification shall be read in conjunction with:-

BS2011	Methods for environmental testing of electronic components and electronic equipment.
BS6001	Sampling procedures and tables for inspection by attributes.
BS9000	General requirements for electronic components of assessed quality.
BS9300	Semiconductor devices of assessed quality.
BS9400	Integrated electronic circuits of assessed quality. Generic data and methods of test.
BS9450	Custom built integrated circuits of assessed quality. Generic data and methods of test.

cossor electronics

COMPONENT SPECIFICATION

NUMBER

SAN70 - 2 -

DESCRIPTION

DELAY LINE.
(R.F).

ORIGINAL SOURCE IDENTIFICATION

G.E.C. S26.4

CLIMATIC CATEGORY

40/080/-

PART 1 | PAGE 1
ISSUE B

Dimensions in mms.

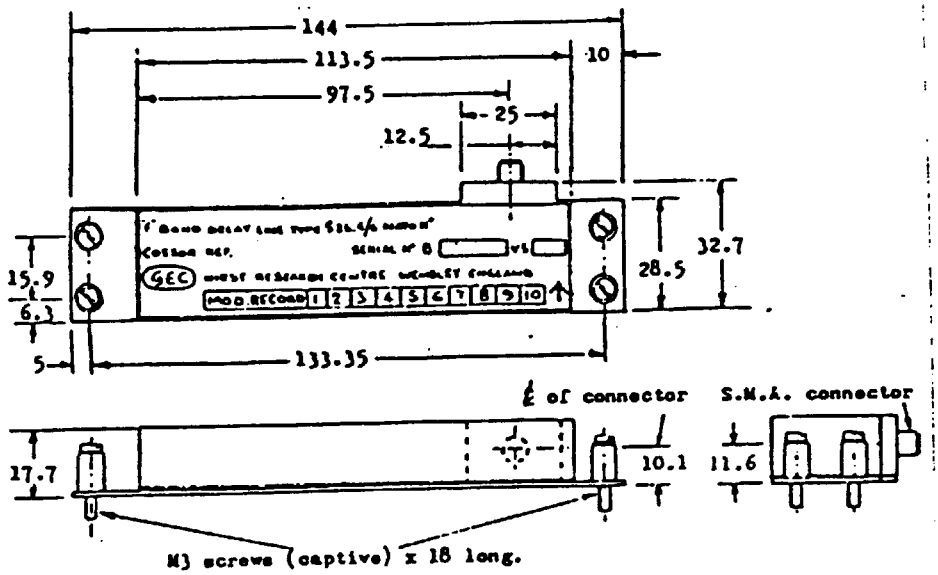

Fig.1.

Limiting conditions of use (not for inspection purposes)

Maximum input power.....5 W.

Operating temperature range.....-35 to +70°C.

Storage temperature range.....-40 to +80°C.

Finish.....External surfaces painted Olive Drab Matt to DTD5555 using BS381C Tint 298.

Weight.....0.51 lb (227 gm) max.

NOTE TO PURCHASING

a) For new build of Delay Line, orders should preferably be in multiples of 8 off to reflect the yield from a boule of Spinel material used in the manufacture of the line.

b) Delay lines may be produced by modification of existing lines to Cossor Part Number 914842/001 and it is necessary to return lines to the manufacturer in multiples of 9 at correct build state.
i.e. multiples of 9 off at mod. strike 2 (8 mm Spinel)
multiples of 9 off at mod. strike 2 & 3 (6 mm Spinel)

	G.E.C.	
SAN70-2-626-350B	S26.4	

Raised by Specification Engineer — Issue Authorised by Application Engineer

AMEND-MENT NUMBER	DATE	PART / PAGE	1	2	3
			ISSUE NUMBER		
Draft	11 · 1 · 84	B	A	1 A	1 A	2 A

EXHIBIT No. 9 (CTD.)

CHANGE NOTE PART 2 - DRAWING OFFICE ACTION

SHEET No. 2.

DRAWING B 914842 SHEET 1 ISSUE 2A
DRAWING B 914842 SHEET 2 ISSUE 1D
DRAWING B. 914842 SHEET 3 ISSUE 1B
AMENDED TO SUIT PART 1.

CODING	CHANGE NOTE NO.
	125/6933.

192

PROCEDURE C.5016

Ossor electronics	COMPONENT SPECIFICATION SPECIAL	Number EXHIBIT NO. 9 (CTD.) SAN70 - 2 -

Description		
DELAY LINE. (R.F).	PART:-	2
	PAGE:-	1
	ISSUE:-	A

Recommended conditions of use and associated characteristics (not for inspection purposes).

Operating temperature.....25°C.
Input frequency.....3.00 to 3.41 GHz.
VSWR.....18 : 1 max.
Nominal impedance.....50 ohms.
Spurious signals.....At least 25 dB down on required output.
Ripple.....3 dB max.

cossor electronics

COMPONENT SPECIFICATION

NUMBER

SAN70 - 2 -

DESCRIPTION

DELAY LINE (R.F).

PART 3
PAGE 1
ISSUE A

INSPECTION REQUIREMENTS

Inspection or test	BS9450 reference and conditions of test	Sample size	Limits min.	Limits max.	Units
Group A					
Subgroup A1 Visual	1.2.2 Correctness of marking. Correctness of terminal identification. Correct encapsulation. Unbroken body.	100%			
Subgroup A2 Electrical Insertion loss	1.24 Major static/dynamic characteristics at 25°C. Measured with pulse duration of 10 us and duty cycle 10% at: 3.1 GHz. 3.2 GHz. 3.3 GHz. 3.4 GHz.	100%	50	56	dB
Insertion loss variation (slope)	3.1 to 3.4 GHz.			3	dB
Power test	Pulse duration 10 us. Duty cycle 10%. Test duration 30s min.		5		Watts (pk)
Group B					
Subgroup B1 (b) Dimensions	1.2.3 Length Width Height Fixing hole positions and size Coaxial connector positions	10%			
Subgroup B2 Rapid change of temperature Damp heat, cyclic	1.2.6.13 -40°C to +80°C, 5 cycles 1.2.6.5 6 cycles	10%			
Subgroup B4 Acceleration Low pressure	Not applicable Equivalent to an altitude of 12,000 feet above sea level Test as B2.	10%			
Subgroup B5 Endurance	160 hours at +80°C, non-operating	10%			
Subgroup B6 Post test end points for B2, B5.	Tests as in Subgroup A2	As Subgroup A2. Reject on 1 failure			

NUMBER	COMPONENT SPECIFICATION	cossor electronics
SAN70 - 2 -		

PART	3
PAGE	2
ISSUE	A

DESCRIPTION

DELAY LINE (R.F).

Inspection or test	BS9450 reference and conditions of test	Sample size	Limits min.	Limits max.	Units
Group C					
Subgroup C1 (a)(D)		10%			
Vibration	1.2.6.8.1 55 to 500 Hz. 98 m/s^2.				
Shock	1.2.6.6 981 m/s^2. 6 ms. Mounting to be agreed.				
Bump	1.2.6.7 Severity (a). 4000 ± 10 bumps at 390 m/s^2.				
Damp heat, cyclic	1.2.6.5 28 cycles				
Subgroup C1 (b)					
Dimensions and mass	1.2.3 Mass			227	gms
Subgroup C2 (a)		10%			
Electrical	Subgroup A2 tests at -35°C			-3	dB
	at +75°C			+3	dB
Subgroup C2 (b)					
Spurious reflection	Any spurious returns shall be down on the wanted return by		25		dB
Delay			25.9	26.9	us
VSWR				18:1	Ratio
Subgroup C4					
Post test end points for C1.	Tests as in Subgroup A2		As Subgroup A2. Reject on 1 failure.		

(D) = Destructive test.

Samples for destructive tests must be added to quantity ordered.

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EXHIBIT No. 9 (CTD.) MR. M. LUCAS IED

PURCHASING

CHANGE NOTE PART I

CHANGE REQUEST AND AUTHORIZATION

ACTION	ORIGINATORS NAME	DATE	DEPARTMENT AND SERIAL NO.
	J.R. HEATHERLEY	19-10-82	833/OCF(M)/21

UNIT AFFECTED	EQUIPMENT AFFECTED
DELAY LINE	RAPIER OCF

DRAWING NO.	ISSUE	CUSTOMER NOTE AFFECTED:
9148421001		6421S 435 Yo4 Yo5 Yo6 Yo7

REASON FOR REQUEST: MANUFACTURER DESIGN IMPROVEMENTS.

CHANGE AFFECTS MOD STATE? — CHANGE AFFECTS PRICE? —

DRAWINGS | DRAWING LIST | ITEMS LIST | WIRING SCHEDULE | CIRCUIT DIAGRAM

SPARE PARTS LIST | TEST SCHEDULES | OPERATING MANUAL | CATALOGUE & PRICE LIST | SALES BROCHURE

EQUIPMENT LIST | MANUF. TAB | M/R TEST | M/R CHANGE SHEET | P.C.B.'s | TOOL LIST | KIT LIST | KIT LIST CHANGE | LAYOUT MASTERS | NC WORK LAYOUTS | NEW STANDARD | VISUAL AIDS

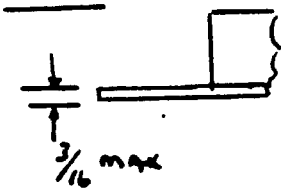
ACTIONED (SIG.) | DATE

ITC | AMD

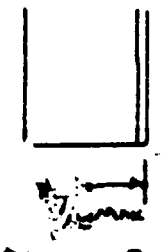
MARKETING MANAGER | DIVISIONAL MANAGER | MANAGING DIRECTOR

DETAILS OF REQUEST (ATTACH MARKED-UP PRINTS)

SHT 1



(was 1/16)



3/4)

NOTE 6 TYPE No S29/1 OR S29/6

SHT 3

4. Interchangeability

Change to read '- - - - any other 'F' Band' delay line to 9148421

SHT 2

[redacted]

3. The device shall be designed such that it will meet the above electrical specification - - - etc.

8293 2569

(Continue on part 2 if required)

RELEASED FOR PRELIMINARY ACTION

(SENIOR PROJECT ENGINEER) [signature] DATE: 20.10.82

(DESIGN AUTHORITY) [signature] DATE: 20/10/82

ADDITIONAL CIRCULATION:

THIS CHANGE HAS ____ PART 2 ____ sheets PART 3 ____ sheets PART 4 ____ sheets

SECTION LEADER

DRAUGHTSMAN: COLLINGS

RELEASED FOR FINAL ISSUE

CHANGE NOTE ENGINEER [signature] DATE: 28 10 82

D. O. ASSISTANT

(Design Authority) [signature] DATE: 20/10/82

DELETE AS REQUIRED

AMENDMENT

MODIFICATION 196

CODING: M

CHANGE NOTE NUMBER: 125/6933

Test Report No. MDLS 178

'F' Band Delay Line Type S29

POST-MODIFICATION REPORT

Insertion Loss Measurements

Rod No. 243/66/8

Serial No. B030m/83

Delay Time _____

Device State	Frequency (GHz)											Units	Comments
	3.0	3.05	3.10	3.15	3.20	3.25	3.30	3.35	3.40	3.45	3.50		
On re-assembly and tuning			59.4		59.1		58.4		57.7			dB	
After heating cycle completed			60.2		59.8		59.0		57.5			dB	
												dB	
												dB	
												dB	
Final test			59.6		58.9		58.1		57.0			dB	
Q.A. Check												dB	

Passed for Despatch: Date 18/4/83

Inspectors Signature

EXHIBIT No. 9 (CTD.)

Test Report No. MDLS 179

'F' Band Delay Line Type S29

POST-MODIFICATION REPORT

Insertion Loss Measurements

Rod No. 36/56

Serial No. B074 m/83

Delay Time _____

Device State	Frequency (GHz)											Units	Comments
	3.0	3.05	3.10	3.15	3.20	3.25	3.30	3.35	3.40	3.45	3.50		
On re-assembly and tuning			57.3		57.3		57.2		56.7			dB	
After heating cycle completed			57.2		57.0		56.6		56.3			dB	
												dB	
												dB	
Final test			58.8		58.3		57.2		56.2			dB	
Q.A. Check												dB	

Passed for Despatch: Date 16/4/83

T. T. Lewis

Inspectors Signature

1798

EXHIBIT No. 9 (CTD.)

Test Report No. MDLS 180

'F' Band Delay Line Type S29

Rod No. 85/21

Serial No. B206n/83

Delay Time _____

POST-MODIFICATION REPORT

Insertion Loss Measurements

Device State	Frequency (GHz)											Units	Comments
	3.0	3.05	3.10	3.15	3.20	3.25	3.30	3.35	3.40	3.45	3.50		
On re-assembly and tuning			60.3		60.5		60.1		59.5			dB	
After heating cycle completed			60.2		60.3		60.3		60.0			dB	
												dB	
												dB	
Final test			60.1		60.1		60.1		59.5			dB	
Q.A. Check												dB	

Passed for Despatch: Date 18/4/83

T. I. Lewis

Inspectors Signature

1799

EXHIBIT No. 9 (CTD.)

Test Report No. MDLS 181.

'F' Band Delay Line Type S29

Rod No. B089

Serial No. B290m/83

Delay Time _____

POST-MODIFICATION REPORT

Insertion Loss Measurements

Device State	Frequency (GHz)											Units	Comments
	3.0	3.05	3.10	3.15	3.20	3.25	3.30	3.35	3.40	3.45	3.50		
On re-assembly and tuning			58.2		58.5		58.4		57.9			dB	
After heating cycle completed			58.3		58.4		58.3		57.9			dB	
												dB	
												dB	
Final test			58.8		58.8		58.5		57.9			dB	
Q.A. Check												dB	

Passed for Despatch: Date 18/4/83

H.T. Lewis

Inspectors Signature

200

EXHIBIT No. 9 (CTD.)

Test Report No. MDLS 182

'F' Band Delay Line Type S29

POST-MODIFICATION REPORT

Insertion Loss Measurements

Rod No. 002R.

Serial No. 13446M/83

Delay Time _____

Device State	Frequency (GHz)											Units	Comments
	3.0	3.05	3.10	3.15	3.20	3.25	3.30	3.35	3.40	3.45	3.50		
On re-assembly and tuning			58.4		58.2		57.6		56.7			dB	
After heating cycle completed			59.8		59.7		59.1		58.5			dB	
												dB	
												dB	
Final test			59.3		58.8		57.7		56.7			dB	
Q.A. Check												dB	

Passed for Despatch: Date 16/4/83

D. I. Lewis

Inspectors Signature

201

EXHIBIT No. 9 (CTD.)

Test Report No. MDLS 185.

'F' Band Delay Line Type S29

POST-MODIFICATION REPORT

Insertion Loss Measurements

Rod No. 300/69/7

Serial No. B4667/83

Delay Time _____

Device State	Frequency (GHz)											Units	Comments
	3.0	3.05	3.10	3.15	3.20	3.25	3.30	3.35	3.40	3.45	3.50		
On re-assembly and tuning			57.0		57.6		57.6		57.9			dB	
After heating cycle completed			58.3		58.7		59.0		59.2			dB	
												dB	
												dB	
Final test			57.1		57.3		57.1		56.9			dB	
Q.A. Check			57.0		57.0		56.0		56.7			dB	

Passed for Despatch: Date 20/4/83

J. T. Lewis

Inspectors Signature

EXHIBIT NO. 9 (CTD.)

202

Test Report No. MDLS 184

'F' Band Delay Line Type S29

Rod No. 78/20.

Serial No. B356m/83

Delay Time _____

POST-MODIFICATION REPORT

Insertion Loss Measurements

Device State	Frequency (GHz)											Units	Comments
	3.0	3.05	3.10	3.15	3.20	3.25	3.30	3.35	3.40	3.45	3.50		
On re-assembly and tuning			57.5		57.8		57.9		57.6			dB	
After heating cycle completed			57.0		57.5		57.3		56.7			dB	
												dB	
												dB	
Final test			57.2		57.6		57.4		57.0			dB	
Q.A. Check			57.0		57.6		57.3		56.7			dB	

Passed for Despatch: Date 20/4/83

D. T. Lewis

Inspectors Signature

EXHIBIT No. 9 (CTD.)

Test Report No. MDLS 183

'F' Band Delay Line Type S29

POST-MODIFICATION REPORT

Insertion Loss Measurements

Rod No. 490/92/3

Serial No. 3234/83

Delay Time _____

Device State	Frequency (GHz)											Units	Comments
	3.0	3.05	3.10	3.15	3.20	3.25	3.30	3.35	3.40	3.45	3.50		
On re-assembly and tuning			57.2		58.6		59.5		60.0			dB	
After heating cycle completed			56.8		57.9		58.7		59.0			dB	
												dB	
												dB	
Final test			56.6		57.5		58.1		58.5			dB	
Q.A. Check			56.5		57.4		58.0		58.5			dB	

Passed for Despatch: Date 20/4/83

D. T. Lewis (DERL)

Inspectors Signature

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EXHIBIT No. 9 (CTD.)

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EXHIBIT No. 9 (CTD.)

GEC - HRC

COMPANY CONFIDENTIAL

QUALITY ASSURANCE INSTRUCTION	REFERENCE NO.	ISSUE	DATE	PAGE
	QA/105 - 001	1	16/9/80	1 of 1

TITLE: S29 MOD 1 SCHEDULE OF DRAWINGS — COPY NO.

DRAWING No	TITLE	Issue
A73 - 170 A4	CLAMP PLATE	2
A74 - 127 A4	SUBSTRATE CLAMP	1
A74 - 126 A4	COVER PLATE	2
A74 - 125 A4	LID	1
A74 - 124 A2	CASE	1
D73 - 001 A4	LABEL	4
A75 - 391 A4	LABEL	1
A75 - 390 A4	PACKING STRIP - TOP	1
A75 - 389 A4	PACKING STRIP - BOTTOM	1
A75 - 388 A4	PACKING STRIP - SIDES	1
A75 - 387 A4	DELAY ROD-BONDING OF GOLD WIRES	1
A75 - 386 A4	DELAY ROD-EVAP^{D} & SPUTT^{D} LAYERS	2
A75 - 385 A4	DELAY ROD-GRINDING & POLISHING	2
A75 - 384 A4	SUBSTRATE	2
A75 - 383 A4	EARTH PLANE	1
A75 - 382 A3	SUB-ASSY: CASE WITH ROD CLAMP PLATE	2
A75 - 382 A4	ITEM LIST	1
A75 - 381 A4	ITEM LIST	1
A75 - 381 A3	SUB-ASSY: CASE WITH DELAY ROD	1
A75 - 380 A4	ITEM LIST	1
A75 - 380 A3	SUB-ASSY: CASE WITH SUBSTRATE	1
A75 - 379 A4	ITEM LIST	2
A75 - 379 A3	ASSEMBLY	1

AUTHORISATION: G H Swallow(PROJECT) J H Holliday(Q.A.)

G H Swallow J.H. Holliday 206

This instruction must not be modified except by means of a new issue authorised by an approved Engineering Change Request (ECR)

ECR NO.

GEC + HRC

COMPANY CONFIDENTIAL

EXHIBIT No. 9 (CTD.)

QUALITY ASSURANCE INSTRUCTION	REFERENCE No QA/105 -002	ISSUE 1	DATE 16/9/80	PAGE 1 of 1
TITLE: S29 MOD 1 MEASURING EQUIPMENT AND CALIBRATION STATUS				COPY No

MEASUREMENT	EQUIPMENT DESCRIPTION	HRC CALIBRATION REGISTRATION	CALIBRATED BY:
Boule Orientation	Philips quartz crystal goniometer, Model 12074	H528	
Reference angle measurement	Reference angle gauges	H524	
Dimensional checks	Micrometers	HST1554 HST1595	HRC Inspection Department
Flatness measurement	Slip gauge set	H300C	
Flatness	Fizeau Interferometer		
Flatness	Nikon optical flat	H291C	
	Universal meter AVO Model 8	H538	HRC Inspection Department
	IF attenuator TEXSCAN SA 50 Ser. 7637	H541	Marconi Stevenage
	RF piston attenuator FLANN CA/S Ser. 79	H509	HRC Inspection Department
	Signal generator, RHODE & SCHWARZ SLRC BN 4100S Ser. 2954/28	H508	HRC
	Spectrum Analyser, HP 141 T Display RF Section 8555A - IF Section 8552B	H534 A H534 B H534 C	Hewlett Packard Wokingham
	Tektronix oscilloscope 585 Ser. 000362	H613	
	Tektronix oscilloscope 533A Ser. 100218	H262	HRC
Power	Power meter HP 432 A Ser. 1151 U02551	H426	Marconi (Stevenage)
Power	Power meter head HP 478 A	H426 A	Marconi (Stevenage)
	Frequency counter HP 5254 L Electronic Counter	H267	HRC
	Frequency divider HP 5260 A	H267 A	
	RF attenuator. 60 dB fixed NARDA 757C No 30214	H625	NARDA Certificate HRC Inspection Dept.

AUTHORISATION: G H Swallow (PROJECT) J K Holliday J H Holliday (Q.A.)

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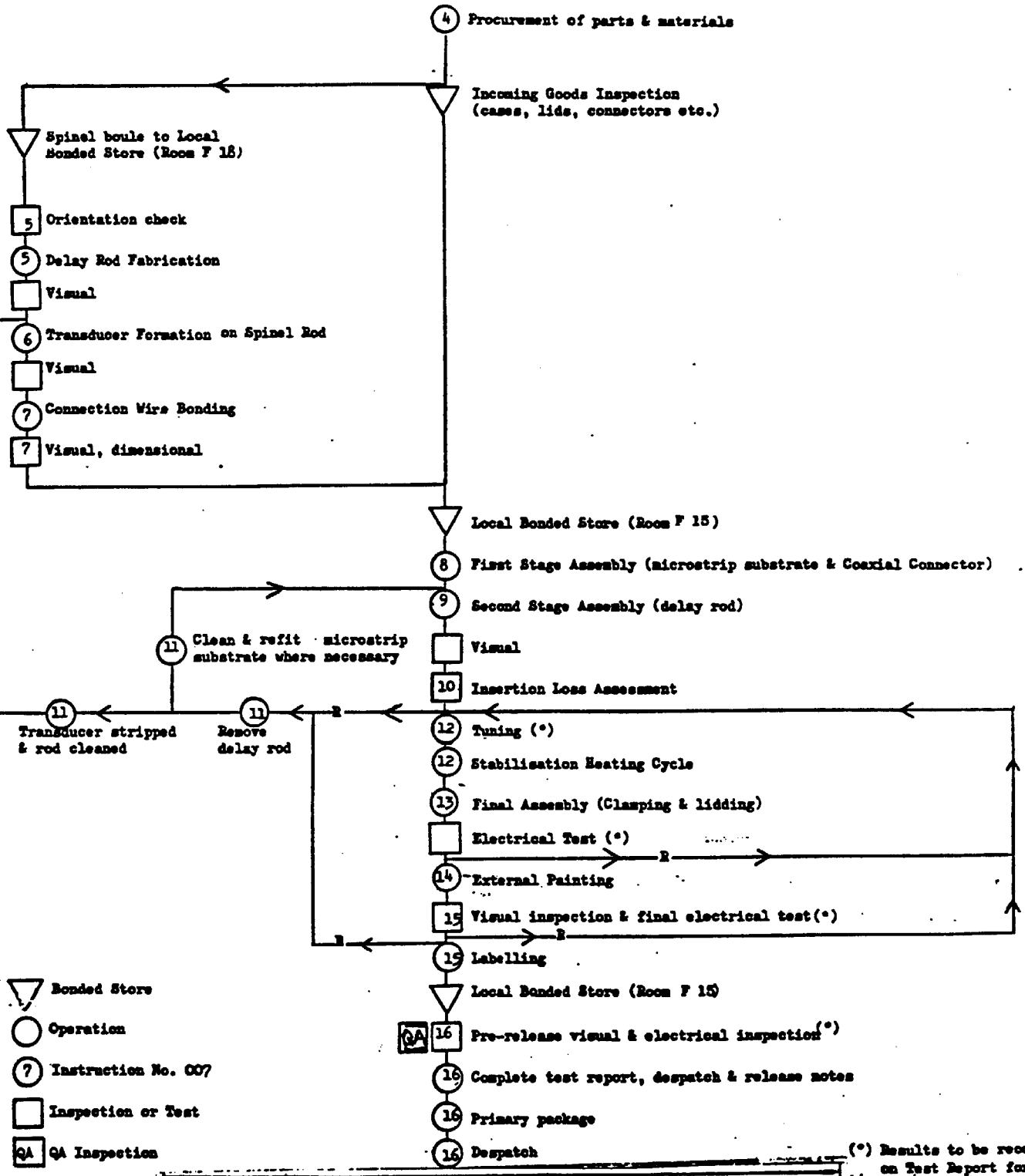
ECR No.

EXHIBIT No. 4 (CTD.)

QUALITY ASSURANCE INSTRUCTION	REFERENCE NO.	ISSUE	DATE	PAGE
	QA/IO5 - 003	1	16/9/80	1 of 1
TITLE: PRODUCTION FLOW CHART FOR DELAY LINE TYPE S29,MOD 1.				COPY NO.



(*) Results to be recorded on Test Report form

AUTHORISATION: G H Swallow (PROJECT) J H Holliday (Q.A.) J.H. Holliday

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ECR NO.

EXHIBIT No. 9 (CTD.)

COMPANY CONFIDENTIAL

GEC - HRC

QUALITY ASSURANCE INSTRUCTION	REFERENCE No QA/105 -004	ISSUE 1	DATE 16/9/1980	PAGE 1 of 1
TITLE: S29 MOD 1 PROCUREMENT OF PARTS AND COMPONENTS				COPY No.

ITEM	PART OR MATERIAL	DRAWING, PART OR TYPE NUMBER	MANUFACTURER	SUPPLIER	QUALIFICATION STATUS
1	Strain free, single crystal spinel	- -	Union Carbide Company	Roditi International	HRC Inspection
2	Clamp plate	A73 - 170 - A4 Issue 2	As supplier	Verdict Engineering	C of C
3	Subtrate Clamps	A74 - 127 - A4 Issue 1	As supplier	Verdict Engineering	C of C
4	Cover Plate	A74 - 126 - A4 Issue 2	As supplier	Verdict Engineering	C of C
5	Lid	A74 - 125 - A4 Issue 1	As supplier	Verdict Engineering	C of C
6	Case	A74 - 124 - A2 Issue 1	As supplier	Verdict Engineering	C of C
7.	Label	D73 - 001 - A4 Issue 4	As supplier	London Nameplate Co. Brighton	
8	Label	A75 - 391 - A4 Issue 1	As supplier	London Nameplate Co. Brighton	
9	Substrate to mask 2095	A75 - 384 - A4 Issue 2	As supplier	HRC Thin Film Facility	BS9450
10	SMA microwave connector	244 - 4A OSM	Omni-Spectra	Auriema	C of C
11	External Finish Paint	See Instruction 014			BS 381 C
12	P.T.F.E Tape				
13	Aluminium foil	See Drawing Nos: A75 - 388 - A4 A75 - 389 - A4 A75 - 390 - A4			
14	Transformer paper				
15	Cellulose Varnish				
16	Silver Dag			Acheson Colloids Co. Plymouth	

AUTHORISATION: G E Swallow (PROJECT) J H Holliday (Q.A)

This instruction must not be modified except by means of a new issue authorised by an approved Engineering change Request (ECR)

ECR No.

EXHIBIT No. 4 (CTD.)

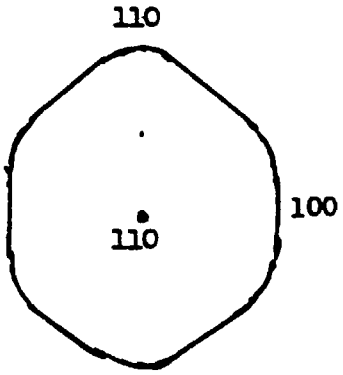
GEC - HRC

COMPANY CONFIDENTIAL

QUALITY ASSURANCE INSTRUCTION	REFERENCE NO. QA/105 - 005	ISSUE 1	DATE 16/9/80	PAGE 1 of 3
TITLE: S29 MOD 1 ORIENTATION CHECK AND DELAY ROD FABRICATION				COPY NO.

Finished rod requirements are shown in Drawing No A75 - 385 - A4, Issue 2.

1. Rods must be oriented with respect to the 100 and 110 crystal planes. These can usually, but not always, be identified on the rough boule by observation of the growth faces. Thus the boule is usually narrower parallel to the 100 direction which is normal to a pair of flat crystal faces, while the 110 axis at right angles to this comes out at the intersection of two faces. The second 110 axis, used to define the rod length, should be parallel to the boule axis within two degrees, as shown in the figure below. In case of doubt or difficulty the boule in question should be submitted to the X-ray Crystallography group for positive identification by Laue techniques.



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ECR NO.

QUALITY ASSURANCE INSTRUCTION	REFERENCE NO. QA/105 - 005	ISSUE 1	DATE 16/9/80	PAGE 2 of 3
TITLE: S29 MOD 1 ORIENTATION CHECK AND DELAY ROD FABRICATION				COPY NO.

2. Flat faces must be produced on the boule, orientated parallel to the 100 and 110 crystal planes. Grinding is done on a surface grinder (Jones & Shipman Model 540) which is fitted with a 240 grit resin bonded diamond wheel (Diagrit Diamond Tools). Two accurate tilting tables, the tilt axes of which are mounted mutually perpendicular, are used on the grinder table for correction of orientation errors. Orientation is measured on a Philips Quartz Crystal goniometer, Model 12074. The size of faces produced is, to some extent, affected by the likely yield of rods, but mainly by the amount of angular error present in the boule i.e. the angular difference between the 110 axis and the geometric axis of the boule. Typically the boule width after grinding the 100 and 110 faces is 31-33 mm.

3. Two flat and parallel faces at an angle of $53^{\circ}25'$ from the 100 faces must be produced one at each end of the boule. At this stage the length of the boule, as measured between the two angled faces, is longer than the delay length by a lapping and polishing allowance of approximately 0.5 mm. The boule is now stuck down onto a 3-4 mm thick glass with a suitable thermoplastic cement (Shellac or Dekhotmsky), and then both glass and boule are mounted on a flat and parallel steel plate with a lower melting point cement (Opticians cement, 6 to 1 Resin to Beeswax). The steel plate allows the boule to be held by a magnetic chuck on the sawing machine (Type Capco Q25 or Meyar & Burgess TS3) on which the angled ends of the boule are cut. A diamond blade one millimetre thick is used. (Diagrit Diamond Tools). After sawing the boule is demounted, cleaned in a suitable solvent (Methylated Spirits), and is then ready for the next step which is to accurately grind the end faces to the correct angle and length. This is carried out on a surface grinder using the 240 grit resin bonded diamond wheel, the boule being held in an accurate tilting vice. Angles are checked by a Hilger & Watts autocollimator against a glass master angle which is itself calibrated by a stack of reference angle gauges.

4. The oriented angled boule is now ready to be lapped and polished on the two angled ends. For this the boule is held in a specially made jig designed to hold two boules at the correct angle; as a further aid to lapping and polishing the jig is faced with scrap spinel to form a symmetrical block. The block is lapped on a cast iron lap using 800 grit carborundum in water on a semi-automatic machine (Logitech PA30). Lapping is continued until all damage from the surface grinding operation is removed at the same time preserving parallelism with the opposite face; control is achieved by offsetting the lapping weights as necessary (about $100g/cm^2$ of spinel). A measurement check is made with the autocollimator. The lapped block is now ready for polishing by one of two methods;

   (a) by $\frac{1}{4}$ micron diamond powder on a pure tin lap or
   (b) by 1 micron alumina in water on a pitch polisher.

QUALITY ASSURANCE INSTRUCTION	REFERENCE NO. QA/105 - 005	ISSUE 1	DATE 16/9/80	PAGE 3 of 3
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Method (a) is slightly quicker but requires more skill. Method (b) is somewhat slower but allows more control over the shape of the surface. Both methods can be used on the same machine. Flatness is measured interferometrically against an optical flat or in a Fizeau interferometer; 1 fringe over the face is the maximum error. The boules are reversed in the jig and the second end is processed in exactly the same way.

5. The next operation is to saw the polished angled boule into slabs parallel to the 100 plane using the same techniques as those for sawing the angled ends. The boule is cemented onto a 110 face and cut into three slabs not less than 9 mm thick. At this point crystal orientation must be checked. The two outside slabs will each have one of the original reference faces on it, so all that is necessary here is to grind the sawn faces parallel to them.

   Orientation of the middle slab however must be checked on the X-ray goniometer as both faces are sawn and the orientation may have altered in the sawing process. If this has happened then suitable corrections must be made on the surface grinder as before. When all three slabs are oriented they are surface ground to a thickness of 8.2 mm giving a lapping and polishing allowance of 0.2 mm. Finally the central recess is ground as shown in Drawing No A75-385-A4.

6. Both 100 faces must now be lapped to thickness and polished to the same tolerances of flatness and parallelism as the angled faces. To do this 3 oriented slabs are cemented to a plane parallel glass disc with Opticians cement and the first side is lapped and polished parallel to the face of the glass disc. After demounting and cleaning the second side is worked in exactly the same way with one exception, lens tissue is inserted between the polished first side and the glass plate to protect the polish when waxing down.

7. The final operations are to saw the slabs into rods, chamfer all sharp edges, inspect and number each rod. Sawing is carried parallel to the 110 edges as previously described and rods are sawn directly to size without grinding. Chamfering is done by hand on a rotating cast iron lap with 600 grit carborundum. After inspection the rods are given serial numbers.

   NOTE: The following equipment must be calibrated.

   1. Philip's Quartz Crystal Goniometer Model 12074.
   2. Reference Angle Gauges.
   3. Micrometer
   4. Fizeau Interferometer.

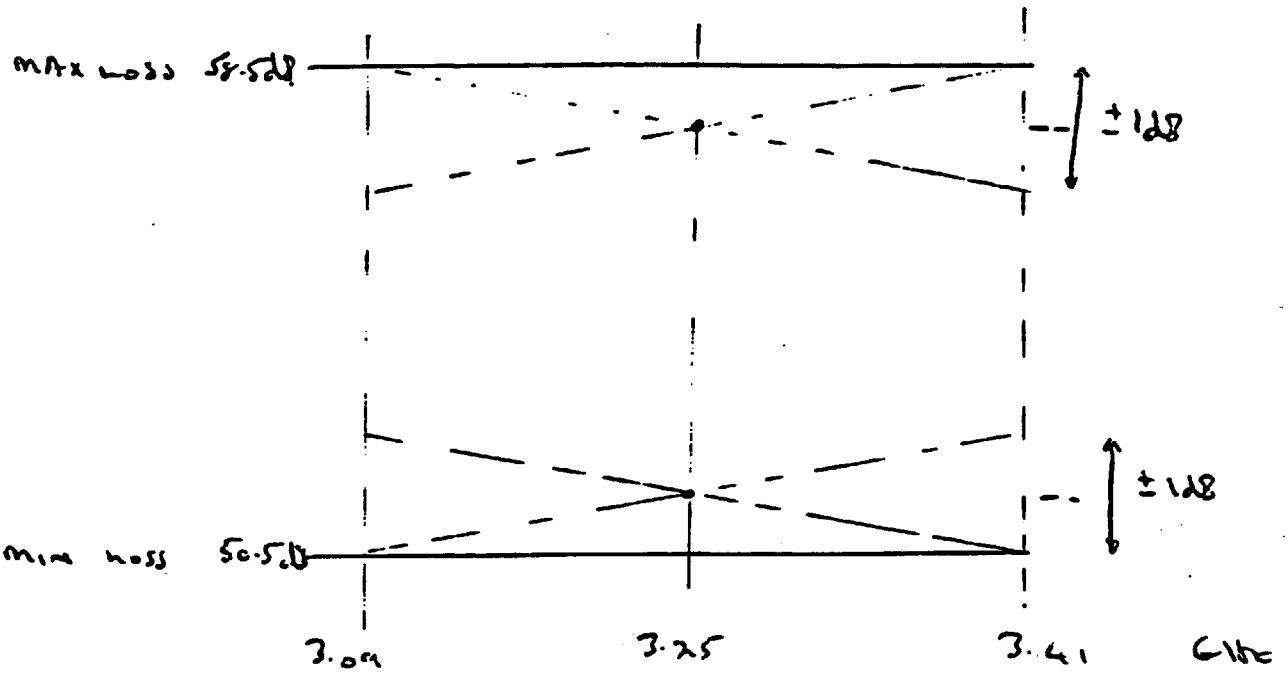
F Band Delay 26.4μs

Except

min loss 50.5 dB

max loss 58.5 dB.

Specify loss at mid band as frequency variation is a slope rather than ripple



Prefer max loss 56 dB

min loss 48 dB

loss may increase by 3dB +25°C to +70°C

" " reduce by 3dB +25°C to -30°C

Sub group k2 / ± 1.5 dB

QUALITY ASSURANCE INSTRUCTION	REFERENCE NO. QA/105 - 006	ISSUE 1	DATE 16/9/80	PAGE 1 of 2
TITLE: S29 MOD 1	TRANSDUCER FORMATION ON SPINEL ROD			COPY NO.

Refer to Drawing No. A75 - 386 - A4, Issue 2

New Rods

1. Boil in trichlorethylene (or suitable solvent) to dissolve wax.
2. After rinsing in IPA, blow dry thoroughly with nitrogen gun. Transfer the delay rod quickly into the gold evaporation equipment.
3. Evacuate the chamber to 10^{-5} torr and heat substrate to 100°C.
4. Evaporate NiCr from a tungsten filament, at a rate of approximately 3 Å per second, to a thickness of about 150 Å.
5. Evaporate gold from a molybdenum boat at a rate of about 120 Å per second, to a thickness of 4500 Å.
6. Allow the system to cool to below 60°C.
7. Transfer the delay rod into the holder, and apply the appropriate mask.
8. Place in sputtering chamber and pump chamber down to 10^{-5}torr. Bake for 1 hour.(Variac setting 60 to 70) or for ½ hour with Variac Setting at 90.
9. Admit argon/oxygen mixture into chamber to a pressure of about 5×10^{-3} torr. Mixture is 80% Ar + 20% O_2.
10. Presputter the ZnO on to the shutter for ½ hour ensuring that the matching is optimised. Adjust sputtering rate to approximately 155 Å/min, with the r.f. power adjusted to 1kw.
11. Remove shutter and sputter the ZnO onto the delay rod to a thickness of 8600 Å, as indicated by the deposition rate data for the equipment.
12. After sputtering is complete, stop argon/oxygen flow and pump chamber down to approximately 10^{-5} torr, keep system at these conditions for 12 hours.
13. Transfer the delay rod into the gold deposition chamber.
14. Using the appropriate mask to define dots 0.25 mm diameter, evaporate 150 Å of NiCr followed by 500 Å of gold with the substrate at 25°C.

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TITLE: S29 MOD 1 TRANSDUCER FORMATION ON SPINEL ROD				COPY NO.

15. When system is cold, remove delay rod from chamber.
16. Visually inspect.

Used Rods

1. Remove bonds with tweezers.
2. Remove ZnO with dilute HCl and rinse in deionised water.
3. Remove Au and NiCr in gold etch and nichrome etch and rinse in deionised water.

   Repeat 2 and 3 if spots remain.
4. Soak in chromic acid for at least ½ hour, and rinse in deionised water. Rub rods with a piece of "Ultra Clean" cloth damped with deionised water and using polishing alumina Grade 3/50. Wipe rods free of alumina with another piece of the cloth.
5. Boil in deionised water and neutra-clean for at least ½ hour, and ultra-sonically clean.
6. Warm in deionised water followed by ultra-sonic clean. Repeat at least twice using fresh deionised water each time.
7. Bubble in deionised water.
8. Boil in IPA and dry thoroughly.
9. Soak in concentrated nitric acid followed by rinsing in deionised water.

The rod can then be treated as new and the transducer re-formed as described on page 1 of this instruction.

EXHIBIT No. 9 (CTD.)

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QUALITY ASSURANCE INSTRUCTION	REFERENCE NO.	ISSUE	DATE	PAGE
	QA/105 - 007	1	16/9/80	1 of 1

TITLE: S29 MOD 1 CONNECTION WIRE BONDING

COPY NO.

A substrate heater is used for this process.

The rod (Dwg. No A75 - 385/6 - A4 Issue 2) is clamped firmly in the holder of the bonding machine and the delay rod temperature raised to 150°C for two minutes before bonding commences. Gold wire 25 microns diameter is then bonded to the gold dots using the Kulicke and Soffa Model 447 bonding equipment in Room F15, the pressure being applied for 30 seconds during this operation. (See drawing A75 - 387 - A3, Issue 1).

The mechanical bond strength is assessed by gently pulling each wire with a pair of tweezers.

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QUALITY ASSURANCE INSTRUCTION	REFERENCE NO. QA/I05 - 008	ISSUE 1	DATE 16/9/80	PAGE 1 of 1
TITLE: S29 MOD 1	FIRST STAGE ASSEMBLY (Microstrip substrated & coaxial connector)			COPY NO.

The dural case (Dwg. No. A74-124-A2, Issue 1) is prepared for the delay rod insertion by assembling components as shown in Dwg. No. A75 - 380 - A3, Issue 2.

The first item to be fitted is an alumina microstrip substrate on one face of which is delineated a gold pattern (Dwg. No. A 75 - 384 - A4 Issue 2).

The substrate is held firmly in the box by two aluminium clamps (drawing A74 - 127 - A4 Issue 1) on two opposite edges of the substrate, fixed by four, 10BA cheese head brass screws, 3/16" long. The clamp face in contact with the substrate is first covered with ptfe tape.

A two hole flange mount captured centre contact jack/wedge, type OSM 244-4ASF is then screwed to the case by two 8BA x 3/16" cheese head screws such that the centre wedge pin makes good electrical contact to the gold stripe on the alumina substrate.

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