INFORMATION REPORT INFORMATION REPORT

CENTRAL INTELLIGENCE AGENCY

50X1-HUM

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C O N F I D E N T I A L
NO FOREIGN DISSEM

COUNTRY	Germany (DDR)	REPORT	
SUBJECT	Technical Examination of German Transistors	DATE DISTR.	6 January 1964
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THIS IS UNEVALUATED INFORMATION

For ease of discussion, we have numbered the samples individually from 7 through 16.

a. MCN 19328 (7 and 8) - Two low-frequency, germanium, power transistors, produced during August 1960 at the VEB RFT Funkwerk Kolleda, Germany (DDR) for use in driver stages of unidentified equipment. Exceptionally low noise characteristics were claimed.

b. MCN 19329 (9 and 10) - Two low-frequency, germanium, power transistors, produced as for MCN 19328, but for audio amplification.

c. MCN 19335 (11 and 12) - Two Radio-frequency, germanium transistors, produced during September 1960 at the VEB RFT Funkwerk Kolleda; it is claimed that these devices are "velocity modulated".

d. MCN 19336 (13 and 14) - Two Radio-frequency, germanium transistors, produced as for MCN 19335, but for I.F. applications.

e. MCN 19337 (15 and 16) - Two Radio-frequency, germanium transistors, produced as for MCN 19335.

2. Examination and tests of these samples have revealed the following:

a. MCN 19328 - These are low-frequency germanium transistors with 67 mw power capability (determined with 45°C ambient temperature in accordance with European practice). Structurally, these devices are identical with the OC 304 manufactured by Intermetall, Freiburg Brsg. West Germany; electrically they meet Intermetall specifications for the OC 304/2.

5 b. MCN 19329 - These are transistors in cases like those used for the 5
4 OC 318 by Intermetall (with which an aluminum cooling fin is usually 4
3 supplied). The construction is typically Intermetall and the devices 3
2 conform to Intermetall characteristics for the OC 318 when measured 2
1 without the usual cooling fin. 1

GROUP 1
Excluded from automatic downgrading and declassification

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c. MCN 19335 - These are PNP germanium transistors, essentially identical with the AF 111 manufactured by Intermetall; there are slight differences in the execution of the base tab construction such as might occur through evolution in refining or adapting production processes. Electrically, the samples conform to AF 111 specifications.

d. MCN 19336 - These are identical in structure with the GFT 20 manufactured by Tekade, Nurnberg, West Germany. Poor electrical characteristics and especially the high leakage current of transistors 13 suggest that these are defective or reject devices. Power dissipation would appear to meet GFT 20 specifications.

e. MCN 19337 - These are identical structurally with the Tekade GFT 44/15; they conform with GFT 44/15 electrical specifications.

3. The external appearance and internal structure of the sample devices and of various Tekade and Intermetall transistors with which they were compared are illustrated in figures 1 through 14. Pertinent Intermetall specifications are reproduced as figures 15 through 17. Pertinent Tekade specifications are reproduced as figures 18 through 20.

4. Measured parameters have established that all of the sample devices are of "entertainment" grade. The gist of these measurements is presented in Tables I through III.

a. Table I reports breakdown characteristics for samples 7 through 16 at room temperature.

b. Table II presents small signal parameters for samples 7 through 16.

c. Table III reports thermal resistance and free air dissipation for devices 7, 8, 9, 10 and 14.

TABLE I

Room Temperature Breakdown Characteristics

Device	BV_{CBO} 2/	BV_{EBO} 2/
MCN 19328 #7	54 v	86 v
MCN 19328 #8	50	54
MCN 19329 #9	120	118
MCN 19329 #10	90	120
MCN 19335 #11	52	2.3
MCN 19335 #12	66	3.3
MCN 19336 #13	3/	3/
MCN 19336 #14	66	44 4/
MCN 19337 #15	64	68
MCN 19337 #16	49	42

2/ BV_{CBO} and BV_{EBO} are measured from the swept V-I curves at the point where the slope of the curve is 10 K ohms. This value is used in this laboratory as a measure of breakdown voltage whenever it occurs before an estimated safe power dissipation is exceeded.

3/ Transistor 13 was defective.

4/ Measured at 50 mw power dissipation as device did not reach 10 K ohm slope.

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TABLE II

SMALL SIGNAL PARAMETER MEASUREMENTS

Bias Conditions I_C = 1.0 ma, V_C = 5.0 v, f = 1.0 Kc, T_{AMB} = 24.8°C

Parameter	Device	Measured Value
h_{fb}	MCN 19328 #7	0.982
	MCN 19328 #8	0.982
	MCN 19329 #9	0.986
	MCN 19329 #10	0.990
	MCN 19335 #11	0.973
	MCN 19335 #12	0.973
	MCN 19336 #13	0.79
	MCN 19336 #14	0.66
	MCN 19337 #15	0.982
	MCN 19337 #16	0.981
h_{fe} (calculated from $h_{fb}/1 + h_{fb}$)	MCN 19328 #7	55.8
	MCN 19328 #8	54.9
	MCN 19329 #9	72.5
	MCN 19329 #10	97.0
	MCN 19335 #11	36.0
	MCN 19335 #12	35.9
	MCN 19336 #13	3.7
	MCN 19336 #14	1.9
	MCN 19337 #15	53.3
	MCN 19337 #16	50.5
f_{hfb}	MCN 19328 #7	1.3 Mc
	MCN 19328 #8	0.86
	MCN 19329 #9	1.4
	MCN 19329 #10	1.9
	MCN 19335 #11	49.0
	MCN 19335 #12	48.7

TABLE II (Cont'd)

SMALL SIGNAL PARAMETER MEASUREMENTS (Cont'd)

Bias Conditions I_C = 1.0 ma, V_C = 5.0 v, f = 1.0 Kc, T_{AMB} = 24.8°C

Parameter	Device	Measured Value
f_{hfb}	MCN 19336 #13	1.1
	MCN 19336 #14	0.93
	MCN 19337 #15	8.6
	MCN 19337 #16	12.0

TABLE III 50X1-HUM

THERMAL RESISTANCE MEASUREMENTS

Device	Thermal Resistance		Free Air Dissipation 5/	
	Oil Bath	Free Air	45°C ambient	25°C ambient
	°C/W	°C/W	mw	mw
MCN 19328 #7	188	440	68	114
MCN 19328 #8	219	432	69	116
MCN 19329 #9	60	196	153	255
MCN 19329 #10	87	216	137	231
MCN 19336 #14	252	439	68	114

5/ Calculated value based upon amaximum junction temperature of 75°C. The 45°C ambient is the standard in Europe and the 25°C ambient is the standard in the U.S.

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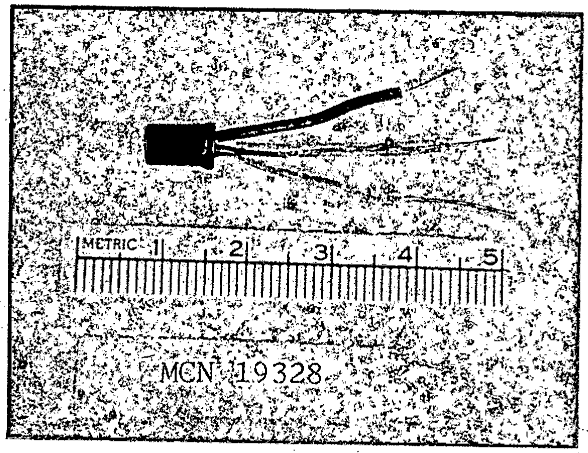


Figure I

Item MCN 19328 as it appeared upon receipt.

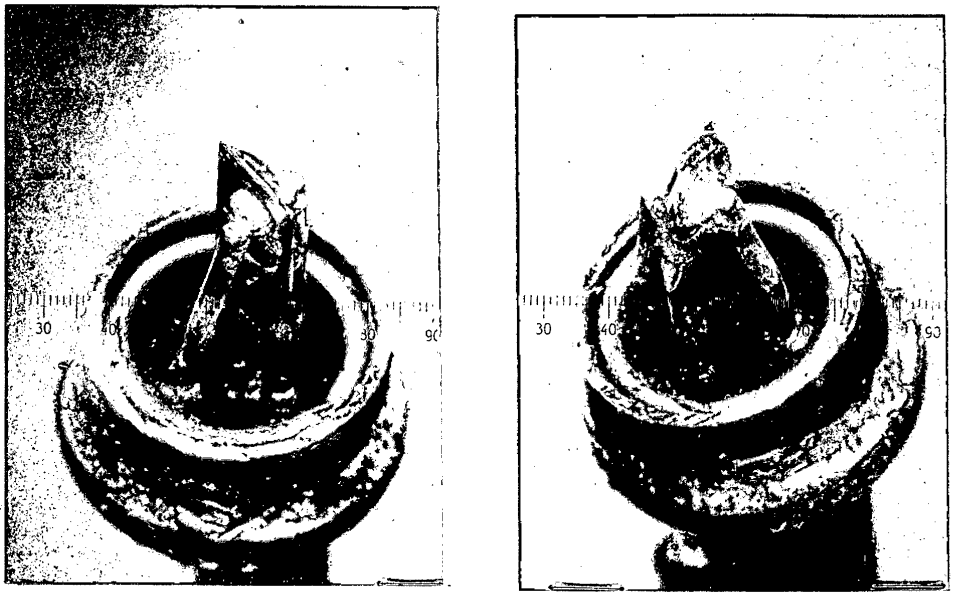


Figure 2

Three views of MCN 19328 #8 after removal of the cap.

Above: Two overall views showing the emitter side on the left and the collector on the right. Magnification 11 X (10 div/mm)

Below: View of tab showing heavily etched die and the collector dot. Magnification 17.5 X (16 div/mm).

Figure 3

Two views of interior of Intermetall OC 304/3

Above: Overall view of interior for comparison with upper photographs of Figure 2.. (Magnification 11 X (10 div/mm)

Below: View of tab showing heavily etched die and collector dot. Magnification 17.5 X (16 div/mm)

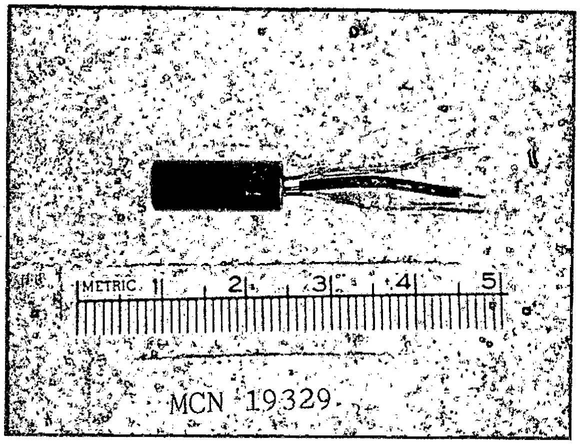


Figure 4

Item MCN 19329 as it appeared upon receipt.

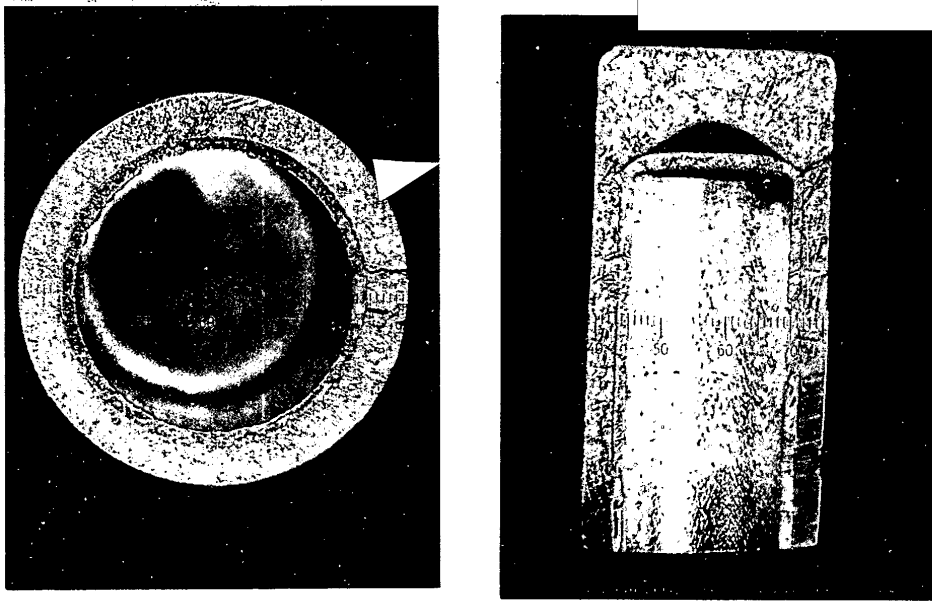


FIGURE 5

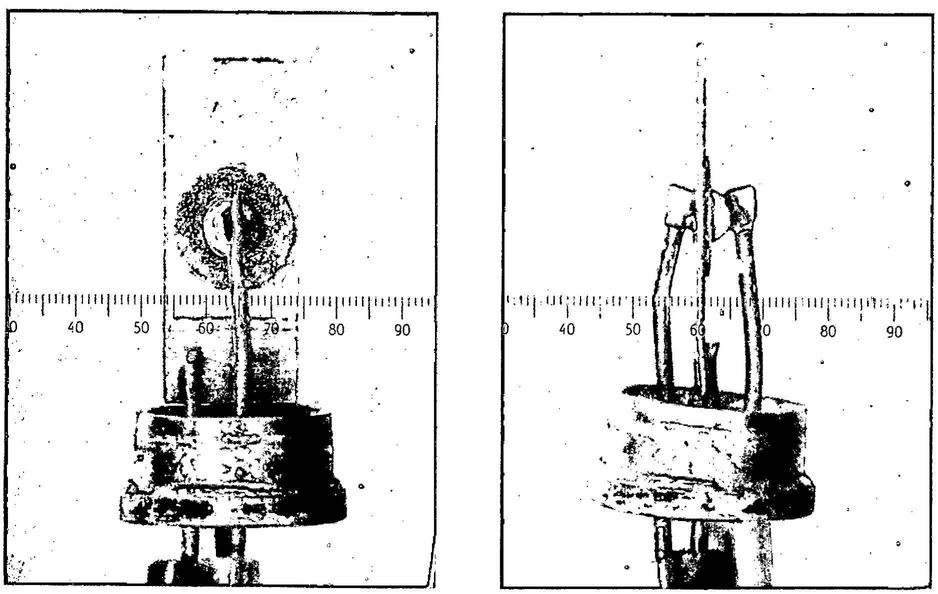
Item MCN 19329 #9

ABOVE: Two views of the two layer cap

LEFT: End view showing thin inner layer and heavy outer layer. Cause of cracks is unknown, see text. Magnification 11 X (10 div/mm)

RIGHT: Longitudinal Section showing how outer layer had been hollowed to fit over inner cap. Magnification 7 X (6 div/mm).

BELOW: Two orthogonal views of the transistor after removal of the cap. Magnification 6.5 X (6 div/mm).



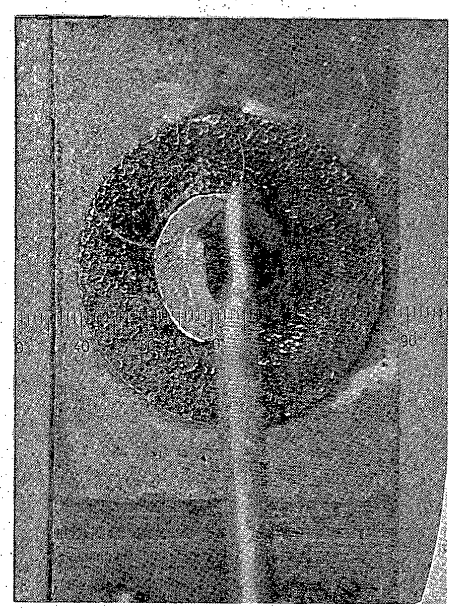
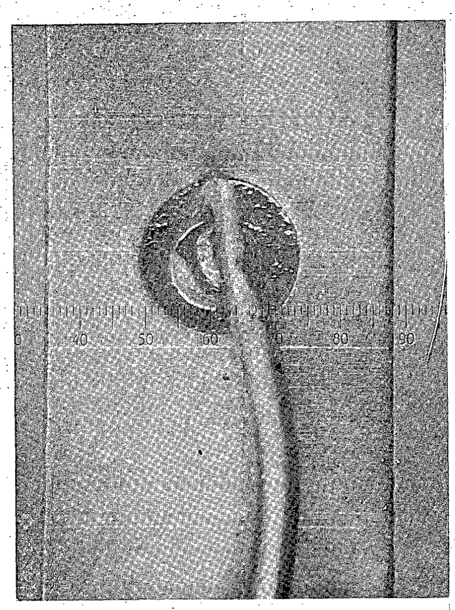


Figure 6

Two close up views of interior of Item MCN 19329 #9. Magnification 17.5 X (16 div/mm)

Above: Die and collector dot.

Below: Emitter dot.



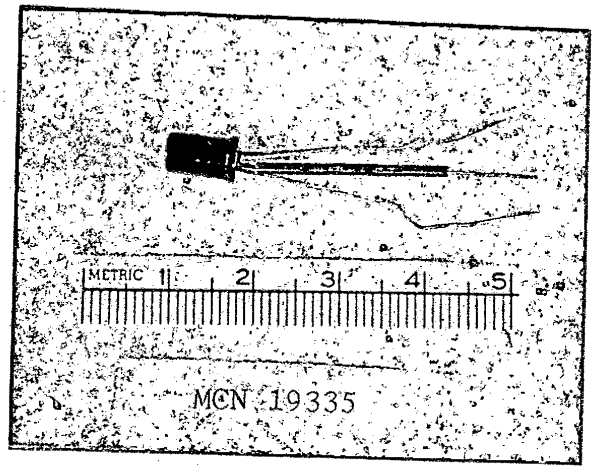


Figure 7

Item MCN 19335 as it appeared upon receipt.

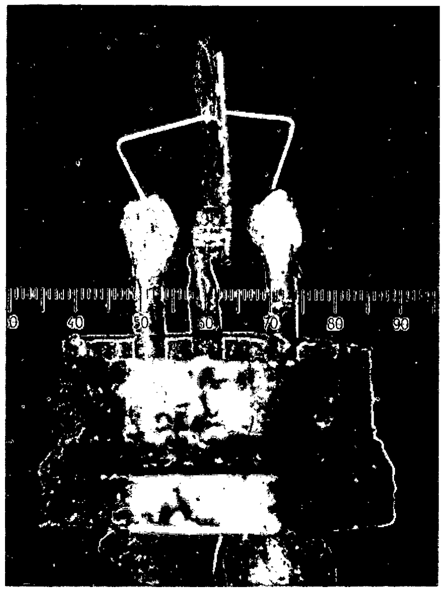


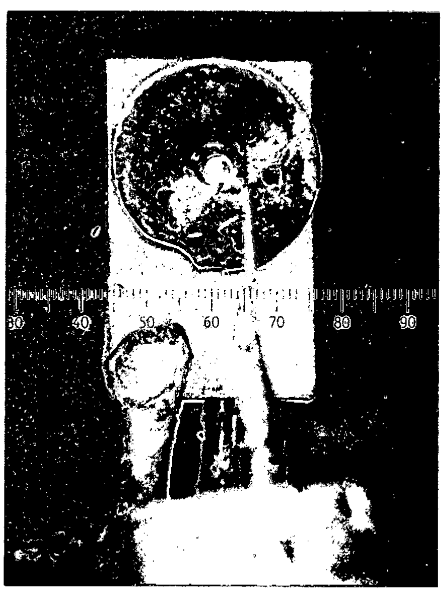
Figure 8

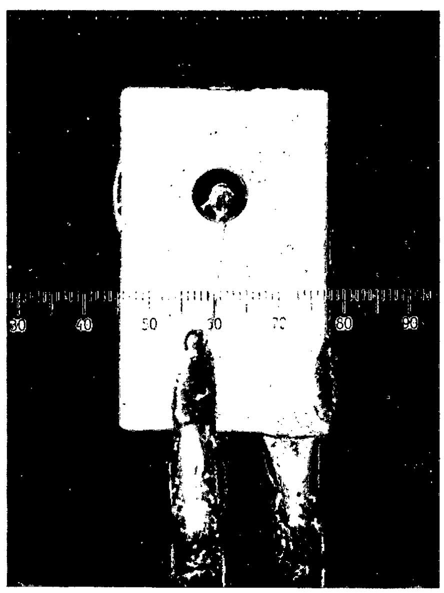
Item MCN 19335 #11 with cap removed

Above: Overall side view. Magnification 11 X (10 div/mm)

Below Left: View of die, collector dot, and lead. Magnification 17.5 X (16 div/mm)

Below Right: View of emitter dot and lead. Magnification 17.5 X (16 div/mm)





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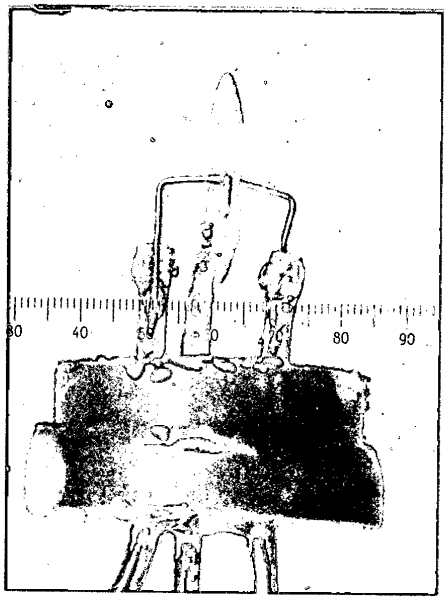


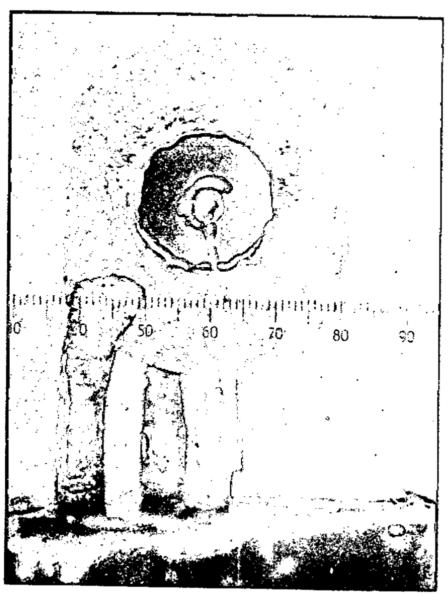
Figure 9

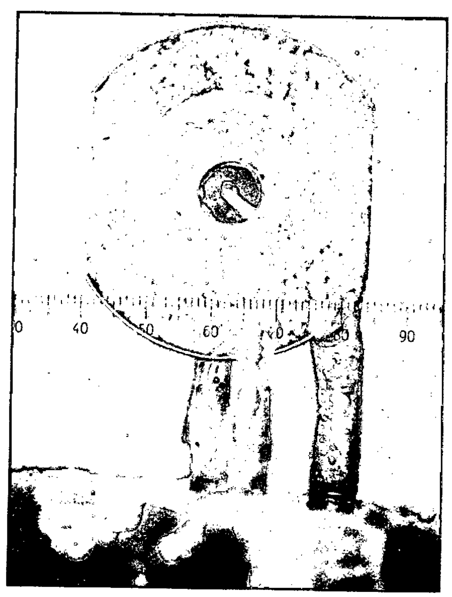
Three interior views of an Intermetall AF111

Above: Overall side view. Magnification 11 X (10 div/mm)

Below Left: View of die, collector dot and lead. Magnification 17.5 X (16 div/mm)

Below Right: View of emitter dot and lead. Magnification 17.5 X (16 div/mm).





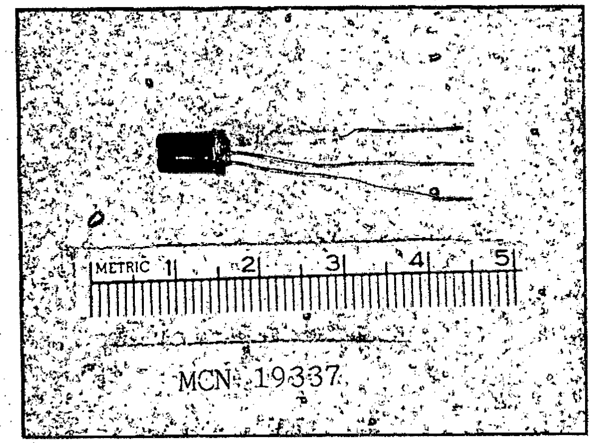


Figure 10

A transistor of Item MCN 19337 as it appeared upon receipt. Item MCN 19336 had an identical appearance.

Figure 11

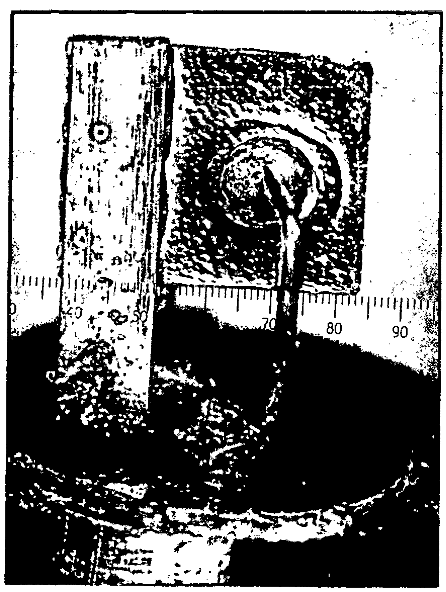
Two interior views of MCN 19336 #13. Magnification 17.5 X (16 div/mm)

Above: Die and collector dot.

Below: Support tab and emitter dot.

Figure 12

Two interior views of a Tekade GFT 20/15 for comparison with Figure 11 of MCN 19336. Magnification 17.5 X (16 div/mm)



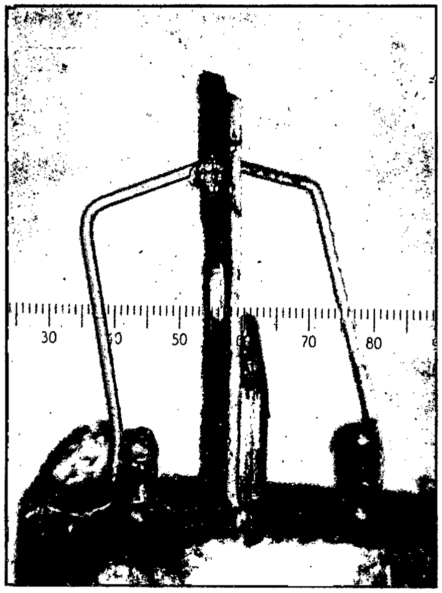


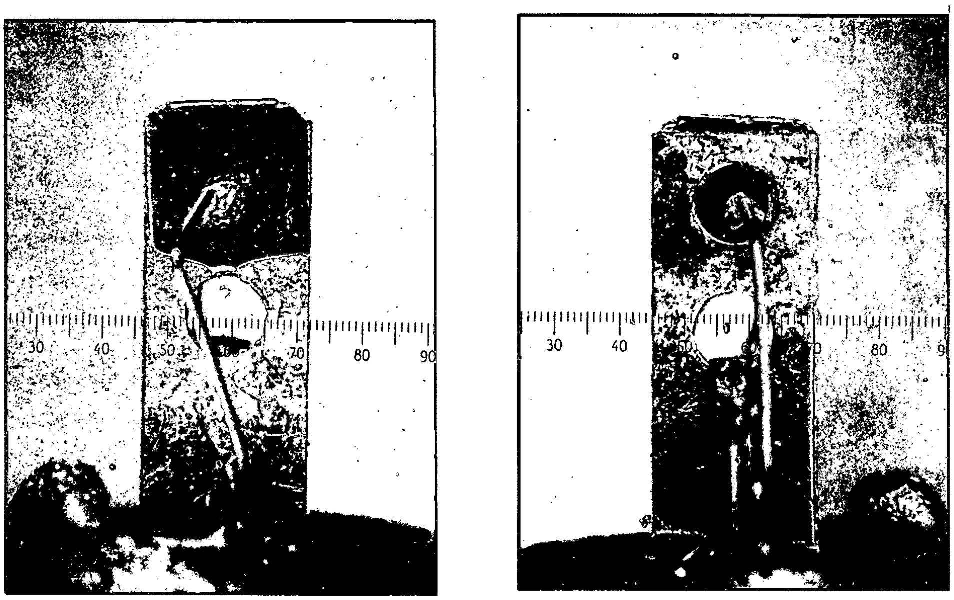
Figure 13

Three interior views of MCN 19337 #15. Magnification 17.5 X (16 div/mm)

Above; Side view showing general structure.

Below Left: Tab, die, collector dot and lead.

Below Right: Back of tab, emitter dot and lead.



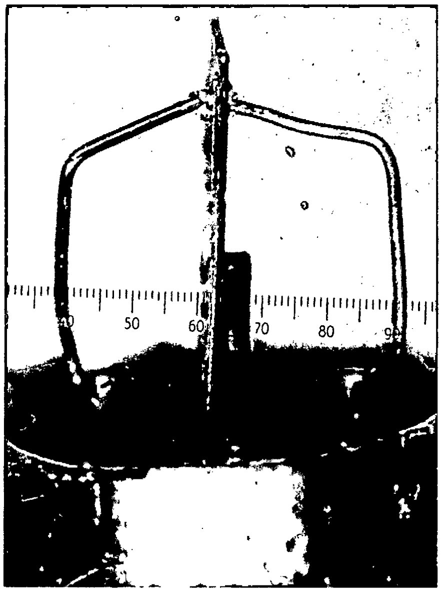


Figure 14

Three interior views of Tekade GFT 44/30.

Magnification 17.5 X (16 div/mm)

These three photos show the same views as shown in Figure 13 for MCN 19337 #15.

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INTERMETALL

OC 304/1,2 u. 3

PNP-GERMANIUM-STANDARD-TRANSISTOREN

für NF-Vorstufen, NF-Oszillatoren, Steuer- und Regelanlagen

Kennwerte in Emitterschaltung:

bei $-U_{CE} = 5$ V, $I_E = 1$ mA, $f = 1$ kHz, $T_{umg} = 25^{\circ}$C

		OC 304/1	OC 304/2	OC 304/3	
Eingangswiderstand	h_{11}	1200	1650	2800	Ω
Spannungsrückwirkung	h_{12}	4×10^{-4}	$6,5 \times 10^{-4}$	$8,5 \times 10^{-4}$	
Stromverstärkung	h_{21}	40 (30...50)	65 (50...80)	100 (80...120)	
Ausgangsleitwert	h_{22}	22×10^{-6}	35×10^{-6}	45×10^{-6}	S
Grenzfrequenz	f_{β}	20	14	11	kHz
Leistungsverstärkung bei $R_G = 600\Omega$, $R_L = 30$ kΩ	v_N		42		dB
Kollektorreststrom bei $-U_{CB} = 5$ V	$-I_{CB0}$		<10		µA
Wärmewiderstand	K		<0,45		°C/mW

Rauschzahl bei $-U_{CE} = 4$ V, $-I_C = 0,3$ mA, $R_G = 1,5$ kΩ, $T_{umg} = 25^{\circ}$C
Bandbreite 30 Hz... 15 kHz F 5 dB

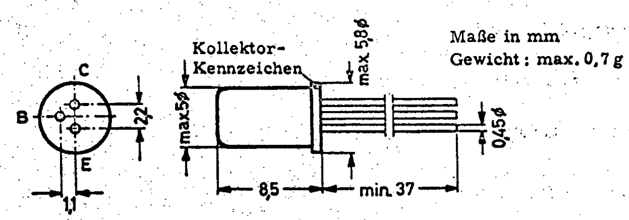
Grenzwerte:

Kollektor-Emitter-Spannung	$-U_{CE\,max}$	15	V
Kollektorstrom	$-I_{C\,max}$	50	mA
Verlustleistung bei $T_{umg} = 45^{\circ}$C	$N_{V\,max}$	67	mW
Kristalltemperatur	$T_{j\,max}$	+ 75	°C

Ausgabe 1961/4 A1/OC 304/Bl. 1

FIGURE 15

Metallgehäuse

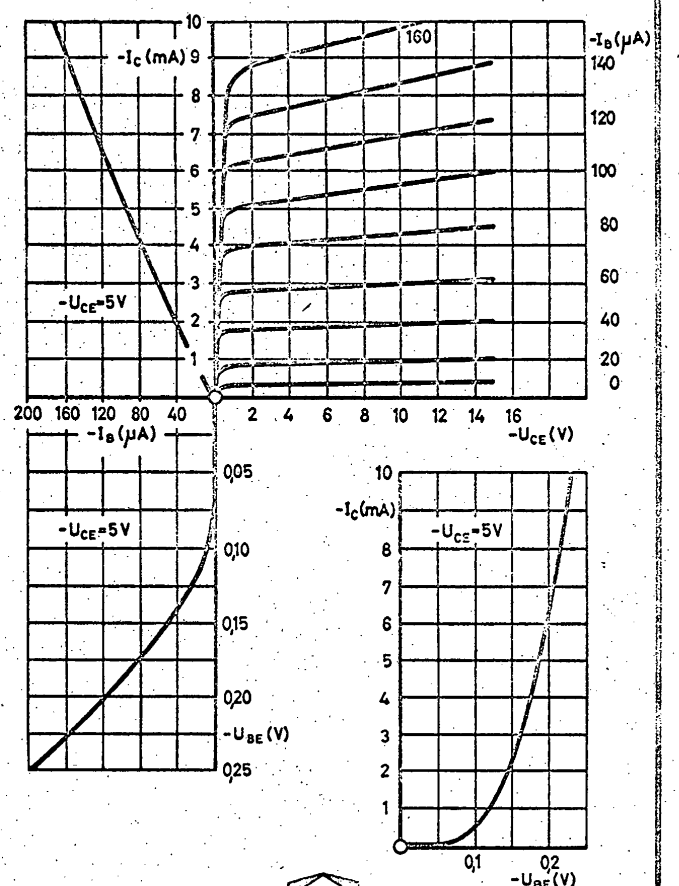


A1/OC 304/Bl. 1

FIGURE 15 A

INTERMETALL OC 304 u. OC 306

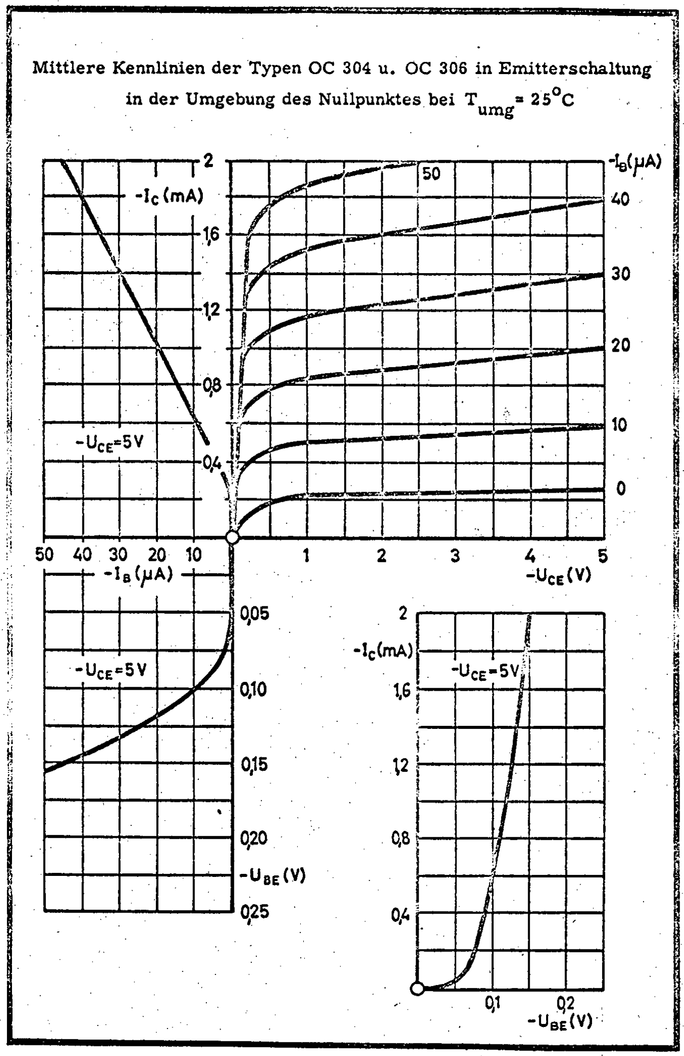
Mittlere Kennlinien der Typen OC 304 u. OC 306 in Emitterschaltung bei $T_{umg} = 25^{o}C$



Ausgabe 1961/4

A1/OC 304 u. OC 306/Bl. 2

FIGURE 15 B



A1/OC 304 u. OC 306/Bl. 2

FIGURE 15 C

INTERMETALL

OC 318
2 x OC 318

PNP-GERMANIUM-NF-ENDSTUFEN-TRANSISTOR

als Transistor-Paar 2 x OC 318 für Gegentakt-B-Endstufen bis 1,4 W

Kennwerte in Emitterschaltung bei $T_{umg} = 25^{o}C$:

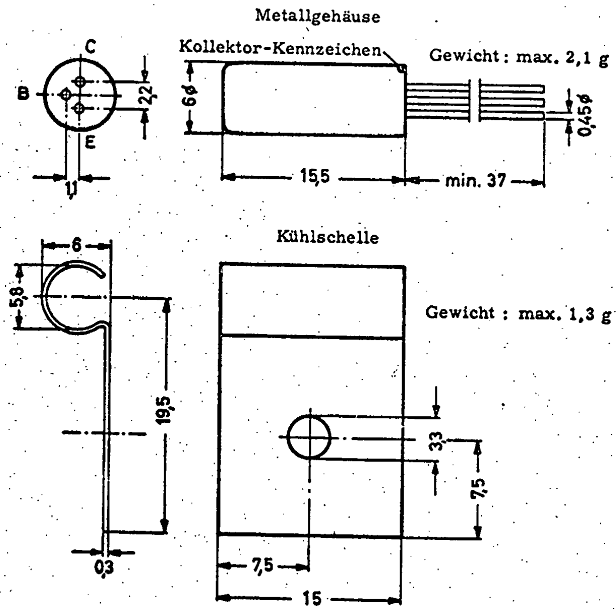
Großsignal-Stromverstärkung	$-I_B$	= 0,5 mA	bei $-I_C$ = 50 mA, $-U_{CE}$ = 6 V
	$-I_B$	= 4,5 (2...7,5) mA	bei $-I_C$ = 300 mA, $-U_{CE}$ = 1 V
Steilheit	$-U_{BE}$	= 120...200 mV	bei $-I_C$ = 5 mA, $-U_{CE}$ = 6 V
Verhältnis der Großsignal-Stromverstärkungen bei $-I_C$ = 300 mA und $-I_C$ = 50 mA	$\frac{B_{300}}{B_{50}}$	= 0,6	
Kniespannung	$-U_{CE\,K}$	< 0,6 V	bei $-I_C$ = 300 mA, $-I_B$ = 10 mA
Grenzfrequenz	f_β	15 kHz	bei $-I_C$ = 50 mA, $-U_{CE}$ = 6 V
Kollektorreststrom	$-I_{CB\,0}$	< 20 µA	bei $-U_{CB}$ = 10 V
Wärmewiderstand ohne Kühlschelle	K	< 0,22 °C/mW	
mit Kühlschelle und Kühlblech (Al 30 x 40 x 2 mm)	K	< 0,09 °C/mW	

Grenzwerte:

Kollektor-Basis-Spannung	$-U_{CB\,max}$	20 V	bei I_E = 0
Kollektor-Emitter-Spannung	$-U_{CE\,max}$	20 V	bei R_{BE} < 500 Ω
Kollektorstrom	$-I_{C\,max}$	300 mA	
Kristalltemperatur	$T_{j\,max}$	+ 75 °C	
Verlustleistung bei T_{umg} = 45 °C, ohne Kühlschelle	$N_{V\,max}$	135 mW	
mit Kühlschelle und Kühlblech (Al 30 x 40 x 2 mm)	$N_{V\,max}$	330 mW	

Ausgabe 1961/4 A2/OC 318/Bl. 1

FIGURE 16



Maße in mm

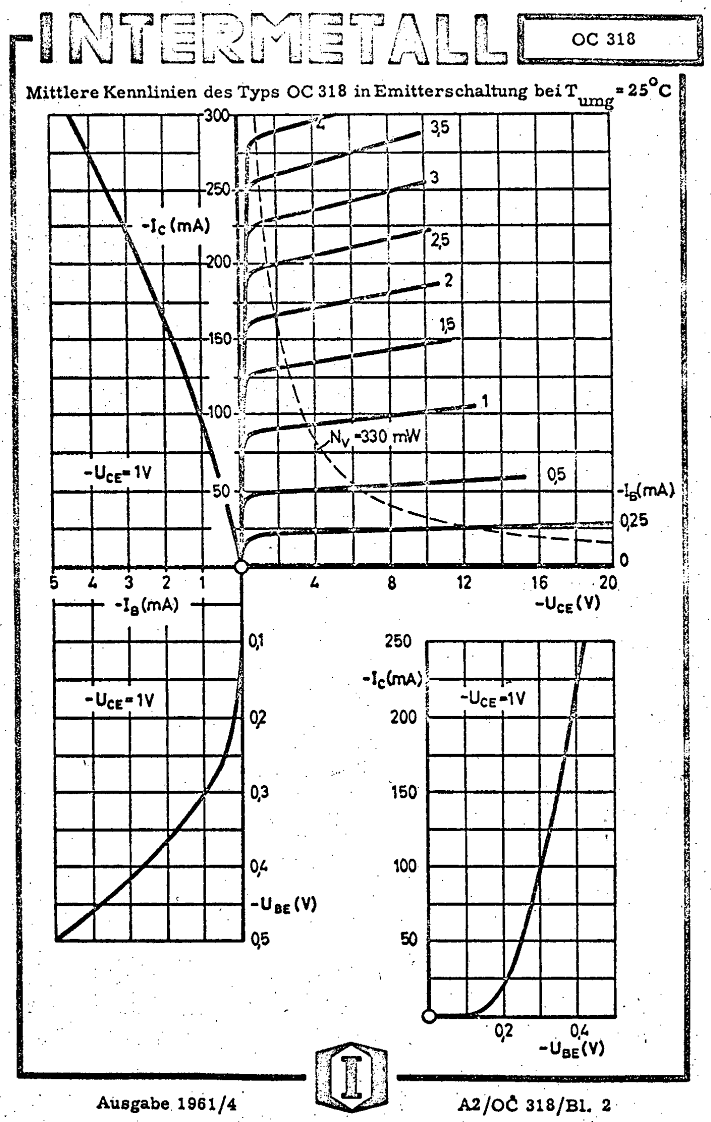
Bedingungen für ein Transistor-Paar 2 x OC 318:

Bei den Meßpunkten $-I_C = 50$ mA, $-U_{CE} = 6$ V und $-I_C = 300$ mA, $-U_{CE} = 1$ V weichen die jeweiligen Basisströme der Transistoren eines Paares um höchstens 7,5% vom Mittelwert aus beiden Strömen ab.

Die Basis-Emitter-Spannungen weichen bei $-I_C = 5$ mA, $-U_{CE} = 6$ V maximal um 20 mV voneinander ab.

A2/OC 318/Bl. 1

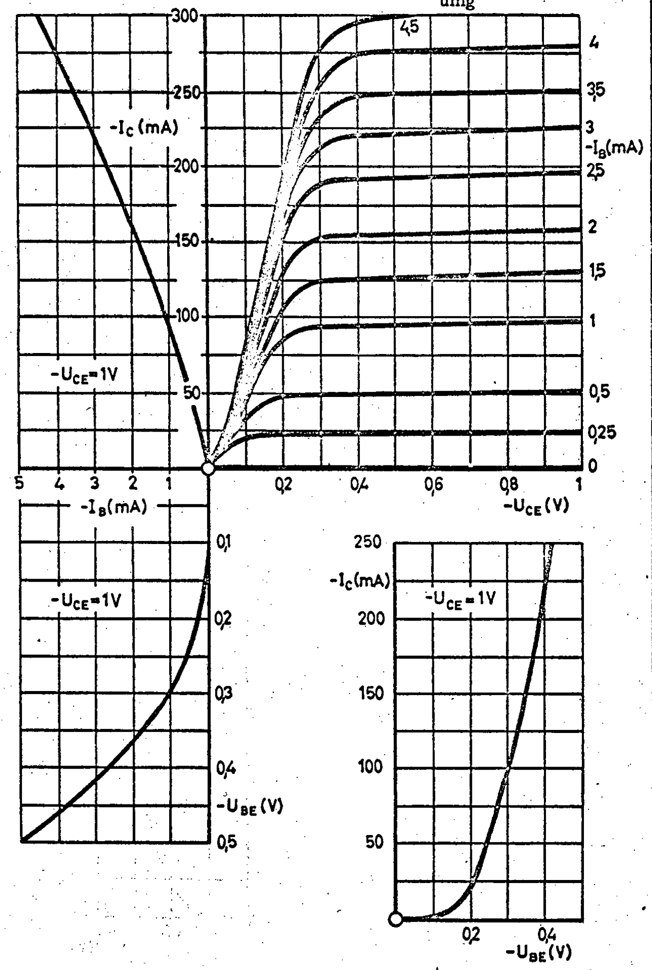
FIGURE 16 A



Ausgabe 1961/4 A2/OC 318/Bl. 2

FIGURE 16 B

Mittlere Kennlinien des Typs OC 318 in Emitterschaltung in der Umgebung des Nullpunktes bei $T_{umg} = 25^{o}C$



A2/OC 318/Bl. 2

FIGURE 16 C

INTERMETALL

OC 410

PNP-GERMANIUM-HF-TRANSISTOR

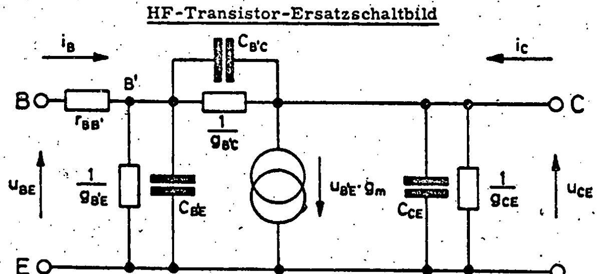
für HF-Verstärker, Misch- und Oszillatorstufen
beschränkt lieferbar

Kennwerte in Emitterschaltung:

bei $-U_{CE}$ = 5 V, I_E = 0,5 mA, f = 470 kHz, T_{umg} = 25°C

Eingangswiderstand	$1/g_{B'E}$	2500	Ω
Ausgangswiderstand	$1/g_{CE}$	20	kΩ
Rückwirkungsleitwert	$g_{B'C}$	2	µS
Steilheit	g_m	15	mA/V
Eingangskapazität	$C_{B'E}$	300	pF
Ausgangskapazität	C_{CE}	45	pF
Rückwirkungskapazität	$C_{B'C}$	12	pF
innerer Basiswiderstand	$r_{BB'}$	110	Ω
Stromverstärkung bei $-U_{CE}$ = 5 V, I_E = 1 mA, f = 1 kHz	h_{21E}	110 (>20)	
Grenzfrequenz bei geerdeter Basis, $-U_{CB}$ = 5 V, I_E = 1 mA	f_α	12 (>10)	MHz
Kollektorreststrom bei $-U_{CB}$ = 10 V	$-I_{CB0}$	<10	µA
Wärmewiderstand	K	<0,46	°C/mW

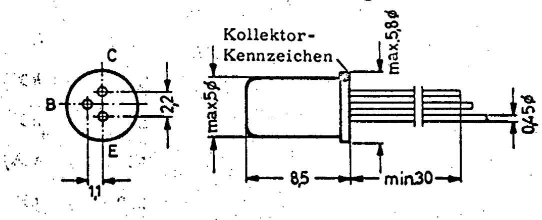
HF-Transistor-Ersatzschaltbild



Ausgabe 1961/4 A5/OC 410/Bl. 1

FIGURE 17

Metallgehäuse
Maße in mm
Gewicht: max. 0,7 g



Grenzwerte:

Kollektor-Basis-Spannung	$-U_{CB\,max}$	15	V
Kollektor-Emitter-Spannung	$-U_{CE\,max}$	6	V
Kollektorstrom	$-I_{C\,max}$	40	mA
Verlustleistung bei $T_{umg} = 45^{o}C$	$N_{V\,max}$	65	mW
Kristalltemperatur	$T_{j\,max}$	+ 75	°C

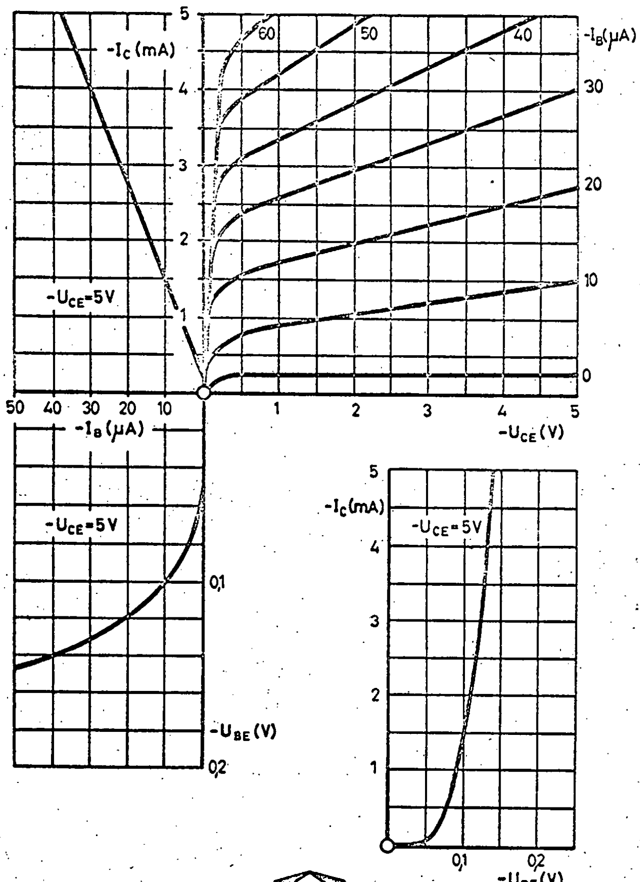
A5/OC 410/Bl. 1.

FIGURE 17 A

50X1-HUM

INTERMETALL OC 410

Mittlere Kennlinien des Typs OC 410 in Emitterschaltung
bei $T_{umg} = 25^{\circ}C$

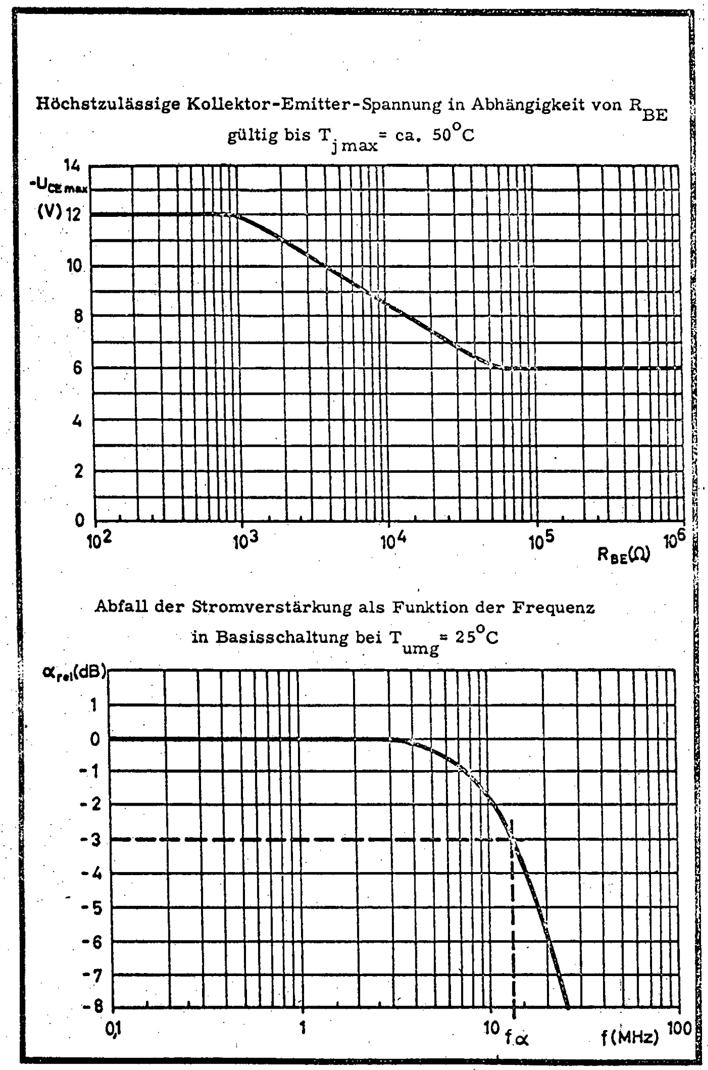


Ausgabe 1961/4

A5/OC 410/Bl. 2

FIGURE 17 B

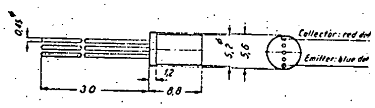
50X1-HUM



A5/OC 410/Bl. 2

FIGURE 17 C

TE-KA-DE	PNP Junction Transistor Tentative Data	GFT 20



Operating Characteristics at 25°C		Common base circuit	Common emitter circuit	
Collector voltage	U_c	−3	−3	V
Collector current	J_c	−1	−1	mA
Emitter current	J_e	~1	~1	mA
Collector current (base circuit open)	J_{co}	−5 (< 10)	−70 (< 150)	μA
Current transfer ratio	$\alpha = h_{21}$	−0,96 (> 0,94)	25 (> 15)	
Max. power gain*)	g_{opt}*)	24	35	db
α-cut-off frequency	$f_{g\alpha}$	600	24	kHz
Noise factor**)	F**)	4 (< 10)	4 (< 10)	db
h-Parameters (f = 1 kc/s):				
Input resistance with output short circuited	h_{11}	40	1000	Ω
Reverse voltage transfer ratio, input circuit open	h_{12}	$8 \cdot 10^{-4}$	$8{,}5 \cdot 10^{-4}$	
Forward current transfer ratio, output short circuited.	h_{21}	−0,96	25	
Output conductance, input circuit open	h_{22}	$2 \cdot 10^{-6}$	$35 \cdot 10^{-6}$	S
	Δh	$8{,}5 \cdot 10^{-4}$	$140 \cdot 10^{-4}$	

*) Input and output matched

**) at $V_c = -1$ V, $I_c = -0{,}2$ mA, f = 1 kc/s, $R_g = 400\ \Omega$

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FIGURE 18

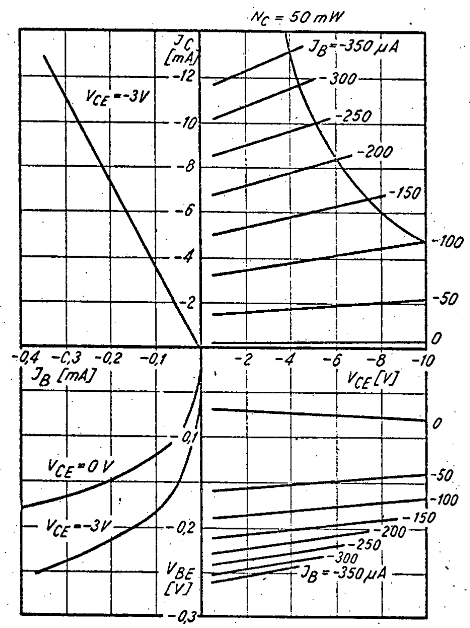
TE-KA-DE

PNP Junction Transistor

Tentative Data

GFT 20

Absolute Max. Ratings:		Common base circuit	Common emitter circuit	
Collector supply voltage	$U_{c\ max}$	− 10	− 7,5	V
Collector peak voltage	$U_{cp\ max}$	− 20	− 15	V
Collector current	$J_{c\ max}$	− 10	− 10	mA
Collector peak current	$J_{cp\ max}$	− 20	− 20	mA
Emitter current	$J_{e\ max}$	10	10	mA
Emitter peak current	$J_{ep\ max}$	20	20	mA
Max. Collector dissipation	$N_{c\ max}$	50	50	mW
Ambient temperature limit for N_c max.	$T_{u\ max}$	+ 45		°C
Thermal resistance	R_w	0,6		°C/mW



Common emitter circuit

FIGURE 18 A

50X1-HUM

TE-KA-DE | **PNP Junction Transistor** Tentative Data | **GFT 20**

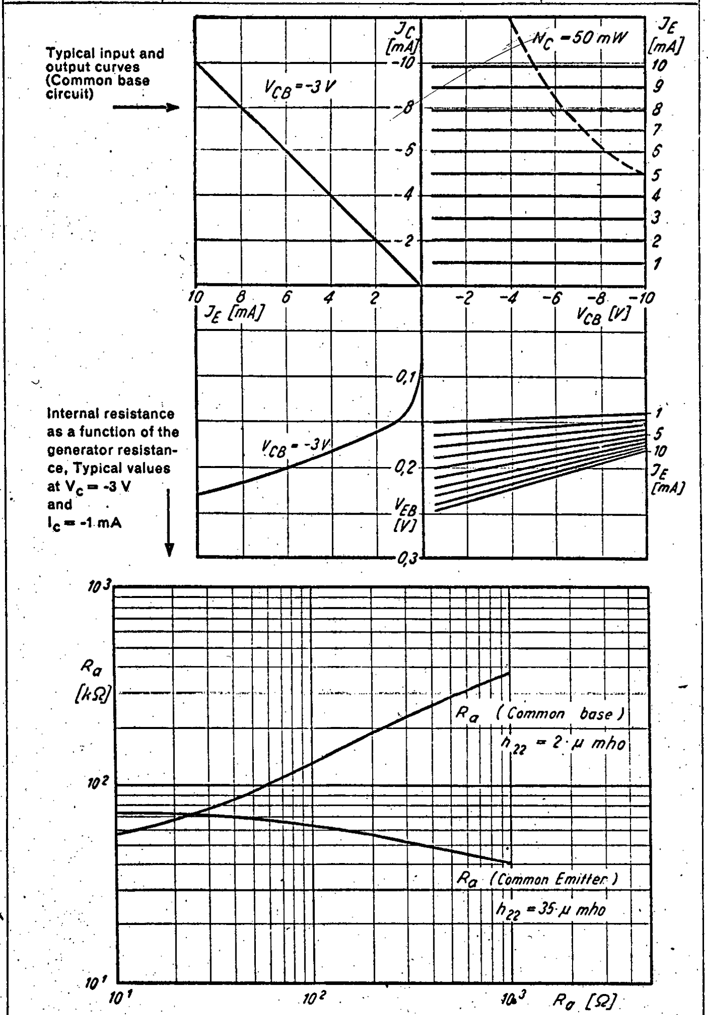


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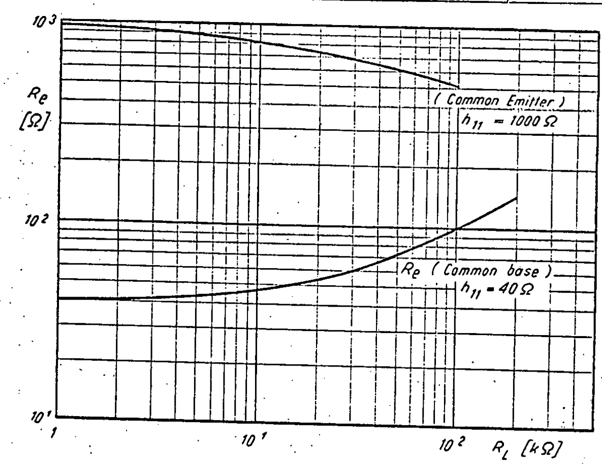
FIGURE 18 B

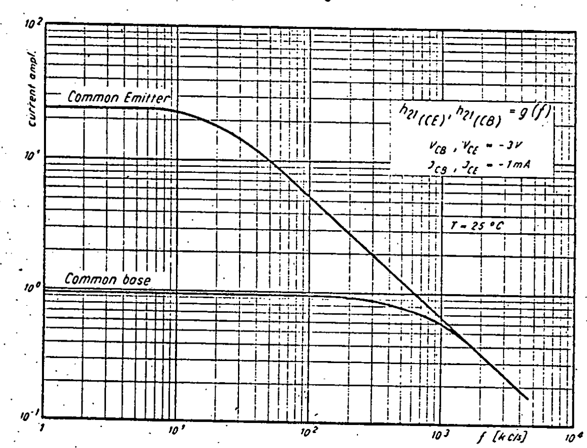
NO FOREIGN DISSEM

50X1-HUM

TE-KA-DE	**PNP Junction Transistor** Tentative Data	**GFT 20**



Input resistance as a function of the load resistance. Typical values at: V_c = -3 V and I_c = -1 mA



Current transfer ratio as a function of frequency in common base or common emitter circuit respectively

FIGURE 18 C

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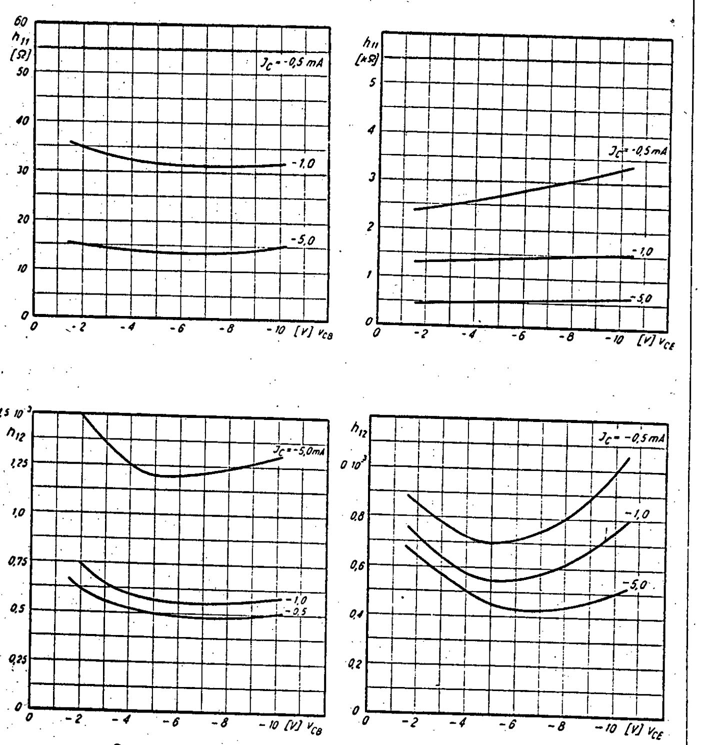
TE KA DE	**PNP Junction Transistor** Tentative Data	**GFT 20**



Common base circuit

Common emitter circuit

Variation of the h-parameters h_{11} and h_{12} with collector voltage and current.
(Measuring frequency f = 1 kc/s)

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FIGURE 18 D

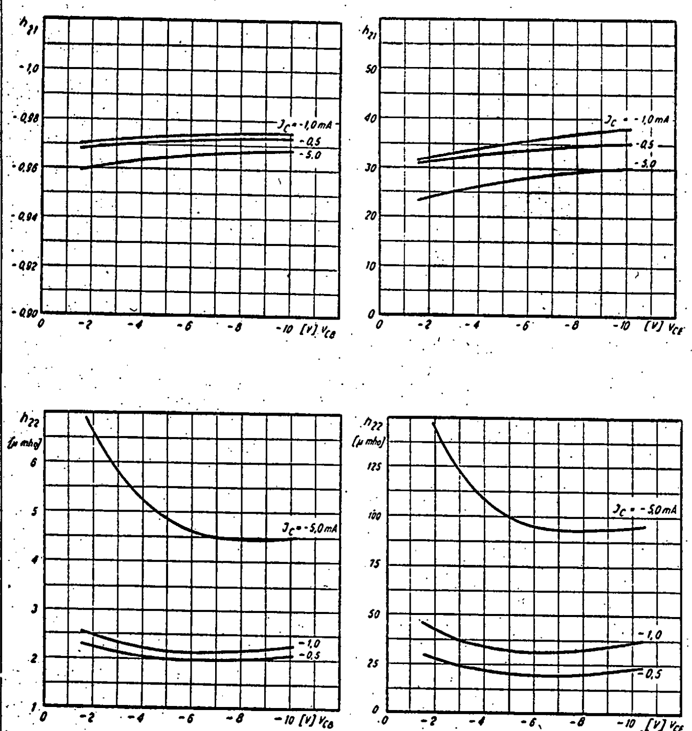
50X1-HUM

TE KA DE

PNP Junction Transistor

Tentative Data

GFT 20



Common base circuit

Common emitter circuit

Variation of the h-parameters h_{21} and h_{22} with collector voltage and current.
(Measuring frequency f = 1 kc/s)

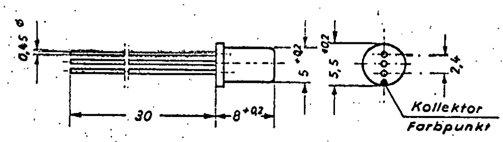
FIGURE 18 E

50X1-HUM

TE KA DE

PNP-Flächentransistor
für KW-Vor- und Mischstufen
vorläufige Daten

GFT 43 B



Gleichstrom-Meßwerte bei + 25° C:

Kollektorspannung	U_{ce}	=	— 3		V
Basisstrom (konst.)	I_b	=	— 10		μA
Kollektorstrom	I_c	=	— 0,6	(> 0,3)	mA
Großsignalstromverstärkung	$\overline{\alpha}_e$	=	80	(> 30)	
	$\overline{\alpha}_b$	=	0,988	(> 0,968)	

Kollektorrestströme

bei U_{cb} = — 15 V	I_{co}	=	— 10	(< 20)	μA
bei U_{ce} = — 3 V	I_{co}'	=	— 200	(< 1000)	μA
Emitterreststrom bei U_{be} = 0,5 V	I_{eo}	=	10	(< 50)	μA

Grenzwerte

Kollektorspitzenspannung	$U_{cb\,max}$	=	— 15	V
Basisspitzenspannung	$U_{be\,max}$	=	0,5	V
Kollektorspitzenstrom	$I_{c\,max}$	=	— 10	mA
Basisspitzenstrom	$I_{b\,max}$	=	0,1	mA
Kollektor + Emitterverlustleistung bei + 45° C Umgebungstemperatur	N_v	=	30	mW
Sperrschichttemperatur	$t_{j\,max}$	=	+ 75	°C
Wärmewiderstand bei freier Konvektion (Luft)	R_w	=	1	°C/mW

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FIGURE 19

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TE-KA-DE	**PNP-Flächentransistor** für KW-Vor- und Mischstufen vorläufige Daten	**GFT 43 B**

Innerer Basiswiderstand

bei f	=	5 Mc				
I_e	=	1 mA	$r_{bb'}$ =	15	(< 30)	Ω

Grenzfrequenz

bei U_{ce} (U_{cb})	=	−6 V				
I_e	=	1 mA	$f_{g\alpha}$ =	60	(> 30)	Mc
			$f_{g\beta 1}$ =	58	(> 28)	Mc

Rauschfaktor in Emitterschaltung

bei U_{ce}	=	−6 V				
I_c	=	−1 mA				
f	=	500 kc ± 50 kc				
R_g	=	200 Ω	F =	5	(< 10)	db.

FIGURE 19 A

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50X1-HUM

TE KA DE

PNP-Flächentransistor

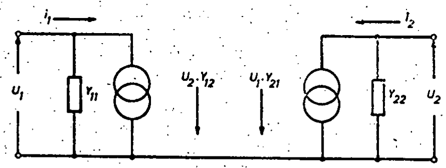
für KW-Vor- und Mischstufen

vorläufige Daten

GFT 43 B

Kleinsignal-Parameter

bei U_{ce} (U_{cb}) = -6 V
I_c = -1 mA
t_u = $+25°$ C



$i_1 = y_{11}u_1 + y_{12}u_2$
$i_2 = y_{21}u_1 + y_{22}u_2$
$y_{ik} = g_{ik} + jb_{ik}$
mit $b_{ik} = \omega C_{ik}$

Basisschaltung

Meßfrequenz 10,7 Mc

g_{11b} = 33 mS	g_{22b} = 91 μS
b_{11b} = $-3{,}35$ mS	b_{22b} = 200 μS
c_{11b} = -50 pF	c_{22b} = 3 pF
$\lvert y_{21b}\rvert$ = 28 mS	$\lvert y_{12b}\rvert$ = 400 μS
φ_{21b} = 30°	φ_{12b} = $-56°$

Emitterschaltung

Meßfrequenz 10,7 Mc

g_{11e} = 3 mS	g_{22e} = 91 μS
b_{11e} = 7 mS	b_{22e} = 200 μS
c_{11e} = 105 pF	c_{22e} = 3 pf
$\lvert y_{21e}\rvert$ = 28 mS	$\lvert y_{12e}\rvert$ = 180 μS
φ_{21e} = $-30°$	φ_{12e} = $-90°$

Meßfrequenz 500 kc

g_{11e} = 590 μS	g_{22e} = 1 μS
b_{11e} = 470 μS	b_{22e} = 15,7 μS
c_{11e} = 150 pF	c_{22e} = 5 pF
$\lvert y_{21e}\rvert$ = 30 mS	$\lvert y_{12e}\rvert$ = 4,5 μS
φ_{21e} = $-20°$	φ_{12e} = $-90°$

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FIGURE 19 B

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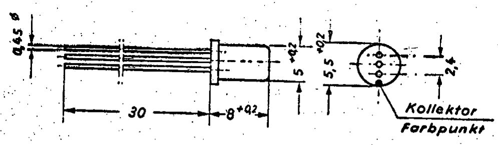
50X1-HUM

TE KA DE	**PNP-Flächentransistor** für Misch- und ZF-Stufen in MW-Geräten vorläufige Daten	**GFT 44/15 E**



Gleichstrom-Meßwerte bei + 25° C:

Kollektorspannung	U_{ce}	= −3		V
Basisstrom (konst.)	I_b	= −10		μA
Kollektorstrom	I_c	= −0,2	(> 0,1)	mA
Großsignalstromverstärkung	$\overline{\alpha}_e$	= 20	(> 10)	
	$\overline{\alpha}_b$	= 0,953	(> 0,910)	

Kollektorrestströme

bei U_{cb} = −15 V	I_{co}	= −10	(< 20)	μA
bei U_{ce} = − 3 V	I_{co}'	= −80	(< 300)	μA
Emitterreststrom bei U_{be} = 0,5 V	I_{eo}	= 10	(< 50)	μA

Grenzwerte

Kollektorspitzenspannung	$U_{cb\,max}$	= −15	V
Basisspitzenspannung	$U_{be\,max}$	= 1,0	V
Kollektorspitzenstrom	$I_{c\,max}$	= −10	mA
Basisspitzenstrom	$I_{b\,max}$	= 0,1	mA
Kollektor + Emitterverlustleistung bei + 45° C Umgebungstemperatur	N_v	= 30	mW
Sperrschichttemperatur	$t_{j\,max}$	= + 75	°C
Wärmewiderstand bei freier Konvektion (Luft)	R_w	= 1	°C/mW

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FIGURE 20

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NO FOREIGN DISSEM

50X1-HUM

TE KA DE	**PNP-Flächentransistor** für Misch- und ZF-Stufen in MW-Geräten vorläufige Daten	**GFT 44/15 E**

Innerer Basiswiderstand

bei f	=	5 Mc				
I_e	=	1 mA	$r_{bb'}$ =	50	(< 100)	Ω

Grenzfrequenz

bei U_{ce} (U_{cb})	=	−6 V				
I_e	=	1 mA	$f_{g\alpha}$ =	15	(> 7)	Mc
			$f_{g\beta 1}$ =	14	(> 6,5)	Mc

Rauschfaktor in Emitterschaltung

bei U_{ce}	=	−6 V				
I_c	=	1 mA				
f	=	500 kc ± 50 kc				
R_g	=	200 Ω	F =	5	(< 10)	db

FIGURE 20 A

REFERENCE B-721.1 and B-723.1 (Selected Items)

Items

MCN 19328 Two germanium transistors numbered 7 and 8

MCN 19329 Two germanium transistors numbered 9 and 10

MCN 19335 Two germanium transistors numbered 11 and 12

MCN 19336 Two germanium transistors numbered 13 and 14

MCN 19337 Two germanium transistors numbered 15 and 16

CONTENTS PAGE NO.

50X1-HUM

INTRODUCTION

These ten transistors were measured together to complete the evaluation of a group of miscellaneous small germanium PNP devices. Accompanying the Items was the following information:

"MCN 19328 - Two AF germanium power transistors produced during August in East Germany for use in driver stages of unspecified equipment. These devices are claimed to be of exceptionally low noise characteristic."

"MCN 19329 - Two AF germanium power transistors produced as for 19328 for use in an unspecified audio-amplifier."

"MCN 19335 - Two RF germanium (velocity modulated) transistors produced during September 1960."

"MCN 19336 - Two RF germanium transistors produced during September 1960 in Germany."

Sometime after the receipt of the transistors further data was received as shown below.

			MCN 19328 (7 & 8)	MCN 19329 (9 & 10)
$-U_{CB}$		max.	18 v	24 v
$-U_{EB}$		max.	10 v	12 v
$-I_C$		max.	60 ma	360 ma
N_v		max.	80 mw	400 mw
T_i		max.	75°C	80°C
$-I_{CO}$	bei	max.	10 μa	15 μa
$-U_{CB}$			18 v	24 v
$-I_{EO}$	bei	max.	10 μa	15 μa
$-U_{EB}$			18 v	24 v
h_{21e}	(f:1000HZ)	max.	90	75

		MCN 19335 (11 & 12)	MCN 19336 (13 & 14)	MCN 19337 (15 & 16)
U_{CB}	max.	18 v	18 v	36 v
U_{CE}	max.	12 v	18 v	36 v
$-J_c$	max.	12 ma	60 ma	260 ma
$-J_{CO}$	bei max.	6 μa	8.5 μa	10 μa
U_{CB}		5 v	5 v	5 v
N_v		not given	65 mw	120 mw
a_e		not given	120	70
B		100 MHz	1.5 MHz	0.8 MHz
t_i		90° C	90°C	90°C
C_{CB}		1.5 pf	not given	not given

All ten of the transistors were covered with black paint when received and no identifying indications were found. The numbers 7 through 16 were assigned to the devices at this laboratory, in accordance with the listing on the title page.

The leads on devices 7 through 12 were arranged in a triangular pattern as they passed through the header and were of unequal length in devices 7, 8, 11 and 12. In addition, one red and two transparent insulating sleeves had been slipped over the leads. Examination revealed the following device connections.

Device	Collector	Base	Emitter
MCN 19328 #7	short—red sleeve	medium	long
MCN 19328 #8	short—red sleeve	medium	long
MCN 19329 #9		red sleeve	
MCN 19329 #10		red sleeve	
MCN 19335 #11	short	medium—red sleeve	long
MCN 19335 #12	short	medium—red sleeve	long

Transistors 13 through 16 had equal length leads arranged in an equally spaced collinear array. In all four, the center lead was the base connection.

SUMMARY

These ten transistors are small germanium PNP devices. Numbers 11 and 12 are diffused alloy or drift types while the other eight are alloy junction types. Transistors 7, 8, 9, 10, 13, and 14 are low frequency types with common base cut-off frequencies in the range of 0.86 to 1.9 Mc. Devices 15 and 16 are of medium frequency with cut-offs of 8.6 and 12 Mc while members 11 and 12 have cut-off values of 48 and 49 Mc.

Thermal resistance measurements made on half of the transistors, measurement difficulties prevented satisfactory measurements on the others, showed the small transistors to have dissipation limits of about 60 mw. This value was based on a 45°C ambient, the standard temperature used in Europe for power ratings. If the U.S. value of 25°C were used, the rating might be raised to 100 - 110 mw. Transistors 9 and 10 are larger than the others and will dissipate over 120 mw at 45°C or 225 mw based on a 25°C ambient. These values assume the use of these devices as received, that is without a cooling fin. If the fin, which normally accompanies a device of this shape, were used, the dissipation rating might well be the 330 mw of the possible equivalent type OC 318.

In general this group of devices would be considered to be only of entertainment quality with their irregularities in leakage current, soft solder seals, etc., precluding any military applications.

Each of the five Items had a different interior structure and when this was compared with some commercial devices on hand and with electrical specifications the following possible equivalent types were found.

Item	Commercial Type	Remarks on equivalence
MCN 19328 (Nos.7 and 8)	OC 304/2 1/	Good electrical equivalence - Identical structure.
MCN 19329 (Nos. 9 and 10)	OC 318 1/	Good electrical equivalence - No sample was available for structure comparison. With allowence for change in size, structure is similar to that seen in other Intermetall types.
MCN 19335 (Nos. 11 and 12)	AF 111 1/	Little commercial data is available, but there is some electrical similarity. Structure is similar, but not identical.
	GFT 43 2/	Electrically similar - Structure is quite different.

1/ Manufactured by Intermetall, Freiburg/Brsg. West Germany.

2/ Manufactured by Tekade, Nurnberg, West Germany.

Item	Commercial Type	Remarks on equivalence
MCN 19336 (Nos. 13 and 14)	GFT 20 2/	Test devices are poor electrically - Structures are identical.
MCN 19337 (Nos. 15 and 16)	GFT 44 2/	Good electrical equivalence - Good structural equivalence.

2/ Manufactured by Tekade, Nurnberg, West Germany.

With the exception of device 13, the collector breakdown voltages, based on a 10 K ohm slope of the V-I characteristics, were in the range 50 to 120 volts. Device 13 was defective in that a 10 K ohm slope was reached at less than one volt and the leakage current was excessive.

Values of common-emitter current amplification factor ranged from 1.9 to 97. Devices 13 and 14 were so low as to be considered defective with measurements of 1.9 and 3.7. Values for all the remaining eight were above 36.

Two of the transistors MCN 19328 #8 and MCN 19337 #16 lacked hermetic seals and as mentioned above all devices used soft solder to seal the caps to headers. No features unique to this series of devices were discovered in the construction of any of these transistors and in general their manufacture would be considered of no more than average quality.

ELECTRICAL MEASUREMENT PROCEDURES

The electrical measurement techniques and the instruments used in evaluating these devices were the same as have been described many times in this series of reports.

PERFORMANCE ANALYSIS

A visual inspection of swept characteristics was made to determine the lead configuration and polarity type of these transistors. From this inspection it was determined that all ten transistors were PNP germanium devices and in general that they had collector breakdown voltages in the tens of volts.

Figures 1 through 9 are graphs of capacitance versus reverse biased junction voltage for the collector-base and emitter-base diode sections. No measurements were made on transistor 13 because the swept curves had shown it to be defective with very low breakdown voltages. A correction was applied to the measured points so as to take in to consideration the built-in contact potential of a PN junction. This correction was +0.3 volts, a value typical of germanium devices. Transistors 11, 12, 15 and 16 of Items MCN 19335 and MCN 19337 have very low values of capacitance and a second correction for the constant case capacitance is necessary so that the plotted curve will represent the junction capacitance. This correction was approximately two picofarads for MCN 19335 and one picofarad for MCN 19337.

The emitter-base diode curve for transistor 12 is curved and has a slope considerably steeper than 0.5. When combined with a collector-base diode plot which is stright and very nearly 0.5 in slope the indication is that the device is of the diffused alloy or drift type. This would agree with the claims made by the source that the transistors of MCN 19335 were "velocity modulated." The emitter base diode was not measured for transistors 11 and 15 but the plots for all of the other diode sections have slopes of very nearly 0.5 the theoretical value for an abrupt or alloy type junction.

Figures 10 through 19 show photographs of breakdown curves for the ten transistors. The data from these curves is summarized in Table I. Notice should be taken of the low value of the emitter-base breakdown voltage for transistors 11 and 12. This also is characteristic of drift transistors. From the photographs for the ten devices, it will be seen that the average quality of the junctions is not very high. The curves are generally characterized by soft knees, with several devices showing hysteresis and evidence of channels.

Further evidence as to the quality of the junctions and surfaces of these transistors may be found in an examination of the leakage current drift curves in Figures 20 through 41. Curves are plotted of I_{CBO} and I_{EBO} at reverse junction bias voltages of 1.0 v, 5.0 v, and a higher voltage chosen to correspond to that of a possible equivalent type. Further examination and the structure analysis caused some subsequent changes in the choice equivalents, however. A plot of an I_{CEO} curve was made for MCN 19328 (7 & 8) and one of an I_{CES} curve for MCN 19329 (9 & 10). No single transistor is free of drift and the amount ranges up to 700% for I_{CBO} of number 15 at V_{CBO} = 5.0 v. Drift is measured in the interval between ten and sixty seconds in accordance with method 3015 of MIL-STD-705. The defective transistor 13 was measured only at 1.0 v because of the excessive leakage current of nearly 400 μa in both the collector and emitter junctions. Several of the devices in addition to large drifts, show evidence of low frequency instabilities or noise as well.

Some small signal measurements were made on the transistors at V_C = 5.0 v and I_C = 1.0 ma, which is a standard bias condition. The results of these measurements are shown in Table II. Some rather striking differences between Items are revealed in this table. Transistors 13 and 14 have extremely low values of h_{fe} while those of the other devices range from 36 to 97 with Item MCN 19329 (9 and 10) having the highest values. The common base cutoff frequency values fall into three groups of approximately one, ten, and fifty megacycles. Devices 7, 8, 9, 10, 13 and 14 are in the lowest group, 15 and 16 the middle, and devices 11 and 12 have cutoff values of 48 and 49 Mc.

Figures 42 through 46 show photographs of swept families of common emitter output curves for the ten test transistors. Figures 47 through 52 show similar curves for different types of commercial devices, the OC 304/3, OC 410, and AF 111 manufactured by Intermetall, and the Tekade types GFT 20/15, GFT 43B, and GFT 44/30. Figures 42 and 47 may be compared and will show that the transistors of MCN 19328 (7 and 8) and the OC 304 have similar characteristics. These figures should also be compared with the data sheet at the end of this report. The test transistors appear to be more nearly similar to the commercial device OC 304/3 #Z than to the other two commercial samples. It will be seen however, that there is a rather wide variation in the curves of the three Intermetall devices.

Item MCN 19329 (9 and 10) was swept so as to compare the curves with those shown for the intermetall type OC 318 and a comparison with the data sheet will reveal a rather good agreement. No commercial samples of an OC 318 were available for analysis.

Figure 44 shows transistors 11 and 12 swept to a peak power dissipation of about 70 mw. The curves of these two transistors may be compared with the commercial types, the Intermetall AF 111 and the Tekade GFT 43 as shown in Figures 49 and 51. Both of these commercial types are drift transistors with common base cutoff frequencies in the range of 50 megacycles. It will be seen that the curves of one sample of each of the commercial types are very similar to those of the test transistors and that a second sample has a much higher gain. One AF 111 sample would appear defective with a very low gain, in fact the first four steps of the family are indistinguishable.

The upper photograph of Figure 45 is of transistor 13 and the characteristics would again indicate that this is a defective device. The lower photographs are of transistor 14 and, as in the small signal measurement, the very low current amplification is quite evident. It will be shown in the section on Structure that the Tekade GFT 20 had an identical construction. Figure 50 shows curves for three of these devices and their much better amplification characteristics are readily seen.

Figure 46 shows curves for Item MCN 19337 (15 and 16) swept under conditions permitting comparison with the Intermetall OC 400 and OC 410. Figure 48 shows some curves for three OC 410 types and all have amplifications which are greater than the test devices. The internal structure of MCN 19337 will be shown below to be the same as that of a Tekade GFT 44 and Figure 52 contains photographs of curves for three of these transistors. The commercial devices as shown in these photographs have current amplification values which bracket those of the test devices. None of the commercial devices shows any evidence of the hysteresis seen in MCN 19337 #16 however.

A measurement was made of thermal resistance on several of the devices. Because of instabilities and other measurement difficulties not all of the transistors were able to be measured. Table III presents the measured results for both an oil bath and a free air measurement. The measurement in rapidly moving oil gives a measure of the thermal resistance between the collector junction and the case while the free air measurement includes the case to still air resistance. Included in the table are calculated values of maximum power dissipation. These calculations are based upon the free air measurement and a junction temperature of 75°C. One is based upon a 45°C ambient as is done with European devices in calculating a power rating which is not increased when the device is operated at lower temperatures. However, a calculation based on the U.S. standard of 25°C is also included.

The final measurement was for hermetic sealing. After twenty-four hours storage in an ammonia atmosphere, a rerun was made of the I_{CBO} leakage current curves at the highest voltage used for the earlier curves. These curves are shown in Figures 53 through 57. Current in transistor number 8 increased by a factor of ten and in number 16 the current was doubled indicating a leak through which the ammonia penetrated to the junctions. The remaining eight devices did not show evidence of leaks on this test.

STRUCTURE

The five Items will be discussed separately due to the different internal structure which was found in each.

A transistor of Item MCN 19328 is seen in Figure 58 as it appeared when received. It is a small cylindrical device 8.2 mm high, exclusive of leads and 4.7 mm in diameter. At the base, the diameter is expanded to 5.5 mm. Three leads, arranged in a triangular pattern, emerge through a soft glass seal. This case meets the requirements of the outline drawing for the Intermetall OC 304.

Figure 59 shows three views of the interior of MCN 19328 #8. The soft glass seal is contained within a stepped ring of iron and nickel 3.4 mm in I.D. with a 0.4 mm wall and 2.4 mm high. The step is 0.8 mm high and is formed by increasing the wall thickness to 1.0 mm, giving a base diameter to the case of 5.4 mm. The three leads of iron and nickel are 0.45 mm in diameter. The lead at the apex of the triangular pattern has been cut short within the case and to its upper end is welded an iron, nickel, cobalt base tab. This tab is 2.0 mm wide, 3.3 mm long, and 0.1 mm thick with a 1.5 mm diameter hole near its top edge. A circular die of germanium, 2.1 mm in diameter and 0.1 mm thick is soldered with tin to this tab. In the center of the free face of the die, a dot of indium and gallium is alloyed as a collector dot. The dot is 1.1 mm in diameter and 0.3 mm high. The upper 0.5 mm of a lead has been flattened to 0.35 x 0.5 mm cross section and the narrow edge is tin soldered to the dot. Alloyed to the back surface of the die and projecting through the hole in the tab is the indium-gallium emitter. This dot is 0.9 mm in diameter and 0.3 mm high and connects to its lead in a manner similar to that of the collector. The die has been heavily etched in the region about the junctions. The cap of a 0.2 mm thick copper, zinc, and nickel alloy has been filled with a protective grease and placed over the transistor. It rests on the header step to which it is soft soldered. Figure 60 shows the interior of an Intermetall type OC 304 which is seen to have an identical structure.

Transistor #9 of MCN 19329 is seen in Figures 61 through 63. Although larger than the device described above, the general structure is very similar. The case is a right cylinder 6.0 mm in diameter and 15.5 mm long exclusive of leads. As before, the leads are arranged in a triangular pattern where they pass through a soft glass seal. The transistors match the outline drawing of an Intermetall OC 318 without its attendent cooling fin.

The glass of the seal is contained within an iron nickel ring of 3.4 mm I.D. This ring is 2.4 mm high with a 0.4 mm wall. The lower 0.8 mm of the ring is 1.4 mm thick forming a step on which the cap rests. The lead at the apex of the triangular pattern has been cut off short and spot welded to a lower corner of the iron, nickel, colbalt base tab. This tab is 3.5 mm wide, 8.3 mm long and 0.2 mm thick with a central hole 1.5 mm in diameter. A circular germanium die has been soldered to the tab using a tin lead solder. The die is 0.12 mm thick and 3.0 mm in diameter and is centered over the tab hole. An indium-gallium collector dot 1.4 mm in diameter and 0.6 mm high is alloyed to the center of the free face of the die. The collector lead which is a 0.45 mm diameter wire of iron, nickel, and cobalt has had its upper end flatted to 0.2 x 0.75 mm and the narrow edge of this region is soldered to the collector dot. The emitter dot is also of indium with gallium and, alloyed to the back of the die, projects through the opening in the base tab. The dot is 0.9 mm in diameter and the connection to the emitter lead is the same type as that used for the collector. The die has been heavily etched to clean up the junctions. The cap was filled with a protective grease, which would also aid in transfering junction heat to the heavy wall, and placed over the assembled transistor. Soft solder has been used to seal it to the header.

The cap is made in two layers, the inner portion is 0.2 mm thick of a copper zinc alloy which has a silver white color.. Surrounding this is a 0.6 mm thick cap also of a copper zinc alloy but with a higher proportion of copper which imparts a yellow color. A recess is formed in the cap such that when it is in place on the header step, a rim 0.2 mm thick projects down the outside of the step until flush with the bottom of the header. The outside of the cap is cadmium plated. The inner and outer portions of the cap are in intimate contact as can be seen in Figure 62. From the cross section view it can be seen that the outer cap is quite heavy and has evidently been applied to a completed device by shrink fitting as a form of heat sink and as mentioned earlier in the report, this device would appear to be designed to fit into a cooling fin. The origin of the cracks visible in the end view of the cap is not known. They may have resulted from damage when the cap was removed or earlier when it was applied to the device.

The transistors of Item 19335 were packaged in the same style small case as Item 19328 and as is used by Intermetall. Thus the case is 8.2 mm high, exclusive of leads, and 4.7 mm in diameter. At the base the diameter expands to 5.5 mm. The leads are arranged in a triangular pattern where they pass through the soft glass seal. Figures 64 and 65 show the structure of these devices.

The glass seal about the leads is contained within an iron header ring 3.4 mm I.D. and 2.5 mm high. This ring has a 0.4 mm wall which becomes 1.0 mm in the bottom 0.8 mm to form a step on which the cap may sit. The ring has been given a nickel plating over a strike of copper. A base tab is welded to the upper end of the lead which is at the apex of the triangular pattern. The tab is of iron, nickel, and cobalt and 2.0 x 3.4 x 0.1 mm in dimensions, with a 0.5 mm hole the center of which is 0.9 mm down from the top edge. Tin is used to solder a germanium die to one face of this tab. The die is 1.8 mm in diameter and only 0.025 mm thick. To the free face of this die is alloyed an indium gallium collector dot 0.27 mm in diameter. To the back of the die and centered within the hole in the base tab is the emitter dot. This emitter is also of indium and gallium and is 0.15 mm in diameter. As was pointed out in the Performance Analysis Section this device was an alloy diffused or drift type. Thus although the emitter dot is alloyed to the die a continued heating causes impurities to diffuse from the emitter into the die forming a diffused zone which becomes the base of the transistor. The dot with its regrowth region remains as the emitter. Connection is made to each of the dots by means of a 0.1 mm nickel cobalt wire. This wire extends about 1.5 mm straight out from each dot and is then bent through slightly more than 90^{o} until the free end is near one of the leads which pass through the header. The connection from the dot is spot welded to the end of the 0.45 mm nickel lead. The die has been given a heavy etch to clean the area about the junctions. A copper, nickel, and zinc alloy cap with its 0.2 mm wall is filled with a protective grease, slipped over the transistor and soft-soldered to the header step. Figure 66 shows the interior of a type AF 111. The structure is generally similar although the difference in the base tabs used is readily seen. The die as used in this transistor is also smaller in diameter than that of the test devices. Although a portion of this size change may be due to the heavy etch which the die has received, the base tab depression within which the die is soldered is not large enough to accept the die from the test transistors. Changes such as these are of the sort which may be evolutionary in a production process. Figure 71 shows the interior of a Tekade GFT 44 which has the identical structure of the drift type GFT 43 to which these devices have earlier been compared. In addition to the obvious differences in tab and die shape there were differences in packaging such as in-line leads. The Tekade device is discussed in more detail below.

Items MCN 19336 and MCN 19337 had an identical external appearance which is to be seen in Figure 67. This appearance was similar but not identical to that of the small transistors such as MCN 19335 described above. The most notable difference was that the leads were gold plated and emerged through the soft glass seal equally spaced in a linear array rather than in the triangular pattern described above. A second difference was the presence of a small flange on the bottom of the cap which projects 0.1 mm beyond the step on the header ring. Basically the package is a right cylinder 8.5 mm long, exclusive of leads, and 5.0 mm in diameter. The agove mentioned cap flange is 5.6 mm in diameter and sits on the header step which is 5.4 mm in diameter and 0.8 mm high.

The soft glass seal about the leads of MCN 19336 #13 is contained within an iron ring 2.4 mm high and 3.6 mm I.D. An 0.8 mm step is formed at the bottom of the ring by an increase in wall thickness from 0.3 mm to 0.9 mm.

Figure 68 illustrates the internal device construction. The center one of the three leads, which are 0.45 mm nickel iron wire, is bent through 90^{o} slightly above the surface of the glass. Spot welded to the end of this lead is a vertical die support tab. This tab is made of an iron, nickel, cobalt alloy and is 0.9 x 4.2 x 0.1 mm in size. A lead tin solder is used to fasten one edge of the germanium die to this tab. The die is 2.3 mm high 3.0 mm wide and 0.15 mm thick. In the center of the die area left uncovered after attachment to the tab a dot of indium 0.75 mm in diameter and 0.45 mm high is alloyed as an emitter. To the other side of the die and directly behind the emitter the indium collector dot, 1.3 mm in diameter and 0.7 mm high, is alloyed. Note that no gallium was used in either the emitter or collector of these transistors. A 0.2 mm copper wire is used to connect the emitter and collector dots to their respective leads with spot welding used to join the wires. The die has been given a heavy etch to clean the junction area and then coated with a clear protective "varnish." The flanged cap of copper, zinc, and nickel is then placed over the device and soft soldered to the step on the header ring. This structure is identical to that used in the Tekade GFT 20/15 devices on hand at this laboratory. Figure 69 shows the interior of one of these devices for comparison with the test Item.

As was mentioned above, the exterior dimensions and appearance of MCN 19337 were the same as that of MCN 19336. The interior structure was however, different as can be seen in Figure 70. The three in-line gold plated leads are sealed through a soft glass seal contained within an iron nickel ring. This header ring is 2.4 mm high with a 3.6 mm I.D. and 0.3 mm wall. A step on which the cap rests is formed at the bottom of the ring by increasing the wall thickness to 0.9 mm for a height of 0.8 mm. Spot welded to the center lead is an iron die support tab with dimensions of 4.0 x 1.6 x 0.12 mm. This tab has two holes through it and a portion of a third. At the bottom of the tab, is a semicircular cut out 0.52 mm in diameter. Two millimeters above the bottom is the center of an 0.8 mm diameter hole and 1.25 mm above this is another opening 0.52 mm in diameter. The spot-welded lead reaches the bottom of the larger or middle hole. The entire tab has been given a light gold plating and gold is used to solder the germanium die to the tab. The die is 1.6 mm square and is soldered at the top of the tab over the upper opening. The die is approximately 0.25 mm thick and has been heavily etched. In the center of the free face of the die an indium collector dot 0.4 mm in diameter has been alloyed. A similar dot 0.3 mm in diameter is alloyed to the back of the die forming the emitter. No gallium was found in either the emitter or collector of the examined device. A 0.12 mm nickel wire connects each dot to an iron, nickel, cobalt lead at the glass seal. These two leads 0.45 mm in diameter are cut off about 0.8 mm above the glass and spot welding was used to attach the nickel wires. A clear protective "varnish" was applied over the junction and dot assembly. The cap of 0.2 mm thick copper, zinc, and tin was placed over the device and its flange soldered with indium and tin solder to the header step.

This structure is identical to that found in a commercial Tekade GFT 44/30 photographs of which are to be seen in Figure 71.

COMPARISON WITH CLAIMS OF THE SOURCE AND WITH POSSIBLE EQUIVALENT TYPES

These five items will be treated separately in this section due to their different characteristics.

MCN 19328 (7 and 8): Thise are low frequency germanium transistors with power capabilities of approximately 67 mw (based on European standard 45°C ambient) They have the same structure as that used in the Intermetall type OC 304 and in so far as measured they would meet the electrical characteristics of this type, in particular the subtype OC 304/2. The test devices will easily meet the voltage claims made for them, but the claims as to power and h_{21e} both are high for the present devices. Leakage current was measured at a higher voltage than that in the claim but only I_{CBO} of device 8 has a current higher than the maximum permitted. It is not certain whether this current would be 10 μa or less at 18 v but this device is within the OC 304 requirements.

MCN 19329 (9 and 10): These transistors are in a case very similar to that used by Intermetall for its OC 318 and with which an aluminum cooling fin is usually supplied. The OC 318 is a low frequency output transistor. In so far as measured, the test transistors will meet the electrical characteristics of the OC 318 when not mounted in a cooling fin. The voltage claims made by the source are easily met with a generous safety factor and measurements agree well with the claimed value of h_{21e}. However, the measured leakage currents exceed the maximum values permitted in the claims although they are well within the specified maximums for the OC 318. The thermal resistance measurements show that devices 9 and 10 match the data given for the OC 318 very well, and consequently meet its power rating but they fall far short of the power claims given in the Introduction of this report. These claims also exceed by twenty percent the OC 318 rating when a cooling fin is used.

MCN 19335 (11 and 12): These two transistors are PNP germanium devices similar, but not identical, in structure to the Intermetall AF 111. The collector-base breakdown voltage and leakage current claims made for these devices were met with satisfactory safety factors by the measured transistors. A minimal amount of data is given for the drift type AF 111, but in so far as the measurements made can determine, the test Item will meet the specifications and in the swept family photographs it matches the gain of the median measured commercial sample. Although structural differences are more pronounced between the test devices and the Tekade GFT 43 B, the electrical characteristics in so far as measured will satisfy the requirements of this commercial type.

MCN 19336 (13 and 14): These are two small germanium transistors identical in structure to the GFT 20 as made by Tekade. Both devices had very poor electrical characteristics. Transistor 13 had extremely high leakage current and common base breakdown voltages of less than a volt. Although the measured collector-base breakdown voltage for device 14 was 66 volts, well above the claimed voltage or the GFT 20 rating, the leakage current was much higher than the maximum permitted by the data accompanying the Item or by the specifications of the Tekade type. In spite of the high leakage current, some small signal measurements were made and both transistors revealed values of h_{fe} of less than four whereas the minimum allowed in the GFT 20 specifications is 15. When checked for thermal resistance device 14 was well within the value permitted the GFT 20. Power dissipation would appear to meet both the claims made and the GFT 20 specifications.

MCN 19337 (15 & 16): These two transistors are small germanium devices identical in structure to the Tekade type GFT 44/15 and in so far as measured would appear to meet most of the electrical specifications as well. The collector-base breakdown voltage claim is easily met with a satisfactory safety factor, however the leakage current is too high in the test transistors to satisfy either the claims or the GFT 44 specifications. Considering the size of the device and the lack of any grease to transmit heat to the case the 120 mw claim seems quite excessive. A value of about 60 mw could possibly be tolerated but the 30 mw rating of the GFT 44 would provide a greater safety factor.

TABLE I

Room Temperature Breakdown Characteristics

Device	BV_{CBO} 1/	BV_{EBO} 1/
MCN 19328 #7	54 v	86 v
MCN 19328 #8	50	54
MCN 19329 #9	120	118
MCN 19329 #10	90	120
MCN 19335 #11	52	2.3
MCN 19335 #12	66	3.3
MCN 19336 #13	2/	2/
MCN 19336 #14	66	44 3/
MCN 19337 #15	64	68
MCN 19337 #16	49	42

1/ BV_{CBO} and BV_{EBO} is measured from the swept V-I curves at the point where the slope of the curve is 10 K ohms. This value is used in this laboratory as a measure of breakdown voltage whenever it occurs before an estimated safe power dissipation is exceeded.

2/ Transistor 13 was defective. See curves of Figure 16.

3/ Measured at 50 mw power dissipation as device did not reach 10 K ohm slope.

TABLE II

SMALL SIGNAL PARAMETER MEASUREMENTS

Bias Conditions I_C = 1.0 ma, V_C = 5.0 v, f = 1.0 Kc, T_{AMB} = 24.8°C

Parameter	Device	Measured Value
h_{fb}	MCN 19328 #7	0.982
	MCN 19328 #8	0.982
	MCN 19329 #9	0.986
	MCN 19329 #10	0.990
	MCN 19335 #11	0.973
	MCN 19335 #12	0.973
	MCN 19336 #13	0.79
	MCN 19336 #14	0.66
	MCN 19337 #15	0.982
	MCN 19337 #16	0.981
h_{fe} (calculated from $h_{fb}/1 + h_{fb}$)	MCN 19328 #7	55.8
	MCN 19328 #8	54.9
	MCN 19329 #9	72.5
	MCN 19329 #10	97.0
	MCN 19335 #11	36.0
	MCN 19335 #12	35.9
	MCN 19336 #13	3.7
	MCN 19336 #14	1.9
	MCN 19337 #15	53.3
	MCN 19337 #16	50.5
f_{hfb}	MCN 19328 #7	1.3 Mc
	MCN 19328 #8	0.86
	MCN 19329 #9	1.4
	MCN 19329 #10	1.9
	MCN 19335 #11	49.0
	MCN 19335 #12	48.7

TABLE II (Cont'd)

SMALL SIGNAL PARAMETER MEASUREMENTS (Cont'd)

Bias Conditions I_C = 1.0 ma, V_C = 5.0 v, f = 1.0 Kc, T_{AMB} = 24.8°C

Parameter	Device	Measured Value
f_{hfb}	MCN 19336 #13	1.1
	MCN 19336 #14	0.93
	MCN 19337 #15	8.6
	MCN 19337 #16	12.0

TABLE III

THERMAL RESISTANCE MEASUREMENTS

Device	Thermal Resistance		Free Air Dissipation [1/]	
	Oil Bath	Free Air	45°C ambient	25°C ambient
	°C/W	°C/W	mw	mw
MCN 19328 #7	188	440	68	114
MCN 19328 #8	219	432	69	116
MCN 19329 #9	60	196	153	255
MCN 19329 #10	87	216	137	231
MCN 19336 #14	252	439	68	114

1/ Calculated value based upon amaximum junction temperature of 75°C. The 45°C ambient is the standard in Europe and the 25°C ambient is the standard in the U.S.

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