G.E.C.
SEMICONDUCTORS

GERMANIUM INDUSTRIAL JUNCTION TRANSISTOR

GET104

ISSUE 2

The GET104 is a p-n-p transistor made by an alloy process. It is primarily intended for use in low power, low frequency applications. However, its current gain cut-off frequency is sufficiently high to give useful performance in tuned amplifiers up to a few hundred kilocycles per second. In addition, the current gain is maintained to high values of collector current and a pair of these transistors can be used in a single ended Class B push-pull amplifier to give an output of 800mW at an ambient temperature of 45°C. The transistor is also suitable for low voltage pulse and switching applications.

The GET104 is hermetically sealed in a metal case to ensure high reliability. A rigid construction is obtained by connecting the base of the transistor to the metal case. This also results in a low thermal resistance which gives enhanced circuit stability and increased collector dissipation. The case is covered with insulating material.

This transistor complies with the Services requirements of K1007 in respect to lead fragility, temperature cycling, climatic, photo-sensitivity, vibration fatigue, shock and soldering tests.

Matched pairs can be supplied for Class B push-pull amplifiers.

ABSOLUTE MAXIMUM RATINGS

*Total dissipation (at 45°C)	200	mW
(at 55°C)	150	mW
(at 65°C)	100	mW
†Peak collector current ($i_{c(pk)}$)	1	A
†Peak base current ($i_{b(pk)}$)	150	mA
‡Peak collector to base voltage ($v_{cb(pk)}$)	−30	V
§Peak collector to emitter voltage ($v_{ce(pk)}$)	−30	V
Peak emitter to base voltage ($v_{eb(pk)}$)	−12	V
Junction operating temperature ($T_{j(w)}$)	+85	°C
Storage temperature	−40 to +85	°C

*Mounted in free air.
†The current limitation is normally set by dissipation and the fall in current gain.
‡Common base.
§Common emitter.

The peak voltages indicated above may be continuously applied provided the collector dissipation rating is not exceeded and the bias is adequately stabilised.

It should be noted that with a transformer load the peak voltage can rise to twice the supply voltage.

CHARACTERISTICS

At T_j=25°C unless otherwise indicated.

	Min.	Average	Max.	
Collector leakage current (I_{co}) at: $V_{cb}=-30V$	—	10	25	µA
Emitter leakage current (I_{eo}) at: $V_{eb}=-12V$	—	8	25	µA
Common emitter current gain (h_{fe}, β) at: $V_{ce}=-2V$, I_c=1mA, f=1kc/s	30	55	80	—
Emitter to base voltage (V_{eb}) at: I_c=1mA, $V_{ce}=-12V$	120	140	170	mV
I_c=250mA, $V_{ce}=-0{\cdot}5V$	480	550	700	mV
Collector to emitter voltage ($V_{ce(sat)}$) at: I_c=250mA, I_b=8mA	—	250	400	mV
Large signal current gain (h_{FE}) at: I_c=250mA, $V_{ce}=-0{\cdot}5V$	30	—	—	—
*Current gain cut-off frequency (f_α) at: $V_{cb}=-6V$, I_c=1mA	0·75	1	—	Mc/s

*Defined as the frequency at which the modulus of α has decreased to 0·707 of its low frequency value.

TYPICAL PRODUCTION SPREADS

At $T_j=25°C$ unless otherwise indicated.

	Min.	Average	Max.	
Collector leakage current (I_{co}) at:				
$V_{cb}=-6V$	3	5	10	μA
$V_{cb}=-6V$ ($T_j=85°C$)	150	250	350	μA
$V_{cb}=-30V$ ($T_j=85°C$)	200	320	500	μA
Emitter leakage current (I_{eo}) at:				
$V_{eb}=-12V$ ($T_j=85°C$)	170	250	400	μA
*Thermal resistance (θ)	—	—	0·2	°C/mW
†Noise factor (N) at:				
f=1kc/s, $V_{ce}=-2V$, $I_e=0·5mA$, $R_s=500\Omega$	—	7	12	dB
Large signal current gain (h_{FE}) at:				
$I_c=50mA$, $V_{ce}=-2V$	60	100	150	—

Small Signal Parameters

Common Base Hybrid Parameters

(f=1kc/s)

	Min.	Average	Max.	
At $V_{cb}=-6V$, $I_c=1mA$:				
h_{ib}	—	28	—	Ω
h_{rb}	2×10^{-4}	4×10^{-4}	6×10^{-4}	—
h_{fb} (α)	0·973	0·983	0·989	—
h_{ob}	0·3	0·5	0·8	μmho
At $V_{cb}=-2V$, $I_c=1mA$:				
h_{ib}	—	28	—	Ω
h_{rb}	4×10^{-4}	$6·5\times10^{-4}$	$9·5\times10^{-4}$	—
h_{fb} (α)	0·968	0·980	0·988	—
h_{ob}	0·45	0·76	1·2	μmho

Common Emitter Hybrid Parameters

	Min.	Average	Max.	
At $V_{cb}=-2V$, $I_c=1mA$, f=1kc/s:				
h_{ie}	—	1·4	—	kΩ
h_{re}	—	$3·75\times10^{-4}$	—	—
h_{fe}(β)	—	49	—	—
h_{oe}	—	37	—	μmho

Common Emitter Current Gain (h_{fe}, β) at:

	Min.	Average	Max.	
$V_{ce}=-6V$, $I_c=1mA$, f=1kc/s	35	60	95	—
$V_{ce}=-2V$, $I_c=0·5mA$, f=1kc/s	25	45	75	—

Frequency Limiting Parameters

	Min.	Average	Max.	
At $V_{cb}=-6V$, $I_c=1mA$:				
Collector capacitance (c_c)	40	60	80	pF
Extrinsic base resistance ($r_{bb'}$)	30	55	80	Ω

Common Emitter Hybrid π Parameters

	Min.	Average	Max.	
At $V_{ce}=-6V$, $I_c=1mA$:				
$r_{bb'}$	—	55	—	Ω
$r_{b'e}$	—	1·5	—	kΩ
$c_{b'e}$	—	7500	—	pF
$r_{b'c}$	—	4	—	MΩ
$c_{b'c}$	—	60	—	pF
r_{ce}	—	70	—	kΩ
g_m	—	38	—	mA/V

*Mounted in free air. (Junction temperature rise above ambient.)

†N decreases with decreasing emitter current.

TRANSIENT POWER RATING

When operating at $T_{j(mean)}=75°C$

Transistor Dissipation	*Maximum Duration*
1W	10ms
2W	5ms
5W	1ms
10W	0·5ms

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TYPICAL SMALL SIGNAL AUDIO OPERATION

Cascaded Common Emitter Stages

Transformer coupled

Supply voltage (V_{cc})	−12	V
Emitter current (I_e)	1	mA
Transformer turns ratio	4·5:1	—
Source impedance (Z_s)	1	kΩ
Load impedance (Z_c)	20	kΩ
Power gain	40	dB

R.C. coupled

Collector to emitter voltage (V_{ce})	−2	V
Emitter current (I_e)	1	mA
Power gain	33	dB

In all small signal amplifiers it is advisable to employ bias stabilising circuits to reduce the effects of temperature variation.

TYPICAL LARGE SIGNAL AUDIO OPERATION

Class A Amplifier (Common Emitter)

Supply voltage ($V_{cc}=V_{ce}$)	−12	−12	V
Quiescent current (I_{cq})	8	16	mA
Source impedance (Z_s)	1	1	kΩ
Load impedance (Z_c)	1720	860	Ω
*Maximum output power ($P_{out(max)}$)	40	80	mW
Power gain	36	33	dB
Maximum internal dissipation	100	200	mW
†$T_{amb(max)}$	65	45	°C
‡D_{tot}	5	7	%

*This is the maximum output power available at the primary of the output transformer. With practical transformers 80% to 90% of this power is obtained in the load.
†Mounted in free air.
‡May be significantly reduced with negative feedback.

Class B Symmetrical Push-Pull Amplifier (Common Emitter)

Supply voltage (V_{cc})	−12	−12	V
Quiescent current (I_{cq})	2×3	2×3	mA
Source impedance (Z_s)	2×1	2×1	kΩ
Load impedance (Z_c)	2×172	2×86	Ω
*Maximum output power ($P_{out(max)}$)	400	800	mW
Power gain	28	24	dB
Maximum internal dissipation	2×110	2×200	mW
†$T_{amb(max)}$	60	45	°C
‡§D2	2	2	%
§D3	7	9	%

*This is the maximum output power available at the primary of the output transformer. With practical transformers 80% to 90% of this power is obtained in the load.
†Mounted in free air.
‡Matched pair.
§May be significantly reduced with negative feedback.

Class B Push-Pull Transformerless Output Stage (Common Emitter)

Supply voltage (V_{cc})	−12	−24	V
Quiescent current (I_{cq})	2×3	2×3	mA
Load impedance (Z_c)	41	86	Ω
Peak collector current ($i_{c(pk)}$)	2×140	2×135	mA
Output power (P_{out})	400	800	mW
Maximum internal dissipation	2×110	2×210	mW
*$T_{amb(max)}$	60	40	°C

*Mounted in free air.

To use these amplifiers at the high ambient temperatures indicated, stabilising circuits must be employed (see Circuit Design, page 4).

When these amplifiers are used to handle normal speech and music, it may be permissible to increase the peak output by about 10% to 20%; alternatively it may be permissible to increase the maximum ambient temperature by about 5°C.

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Typical Performance as a Switch (Common Emitter)

Supply voltage (V_{cc})	−12	V
Load resistance (R_c)	48	Ω
Peak output current ($i_{out(pk)}$)	250	mA
Base drive current (I_{b1})	25	mA
Base reverse current (I_{b2})	25	mA
Input pulse width (t_p)	10	μs
Output pulse rise time (t_r)	2·5	μs
Output pulse carrier storage time (t_s)	1·2	μs
Output pulse fall time (t_f)	1·9	μs

The speed of response can be increased by reducing the generator impedance to the base or by the use of a parallel RC network connected in series with the base.

CIRCUIT DESIGN

When operating transistors at high junction temperatures it is important to ensure that the circuit d.c. current gain (stability factor: *S*), is low, in order to avoid thermal instability. With a transformer load, the circuit should be so designed that the value of *S* is given by:

$$S \leqslant \frac{50}{V_{cc} \times I_{co}}$$

where V_{cc} is the supply voltage in volts and I_{co} is the collector leakage current in mA, measured at the maximum value of operating junction temperature. The required stability factor may be obtained by means of emitter feedback and this results in a stability factor given approximately by:

$$S \simeq 1/\left(\frac{1}{h_{fe}} + \frac{R_e}{R_e + R_b}\right) \simeq \frac{R_e + R_b}{R_e}$$

where R_e is the total resistance in the emitter circuit and R_b is the total resistance in the base circuit. In a Class B push-pull amplifier each transistor is 'cut off' (emitter reverse biased) during alternate half-cycles and, during these half-cycles, *S* is equal to unity. During the other half-cycles, the mean collector voltage is less than the supply voltage.

If amplifiers are to operate over a wide range of ambient temperatures it is necessary to stabilise the bias conditions. This can be achieved by the use of thermistors, diodes or emitter resistors; for very stringent requirements a combination of all three stabilising elements may be required.

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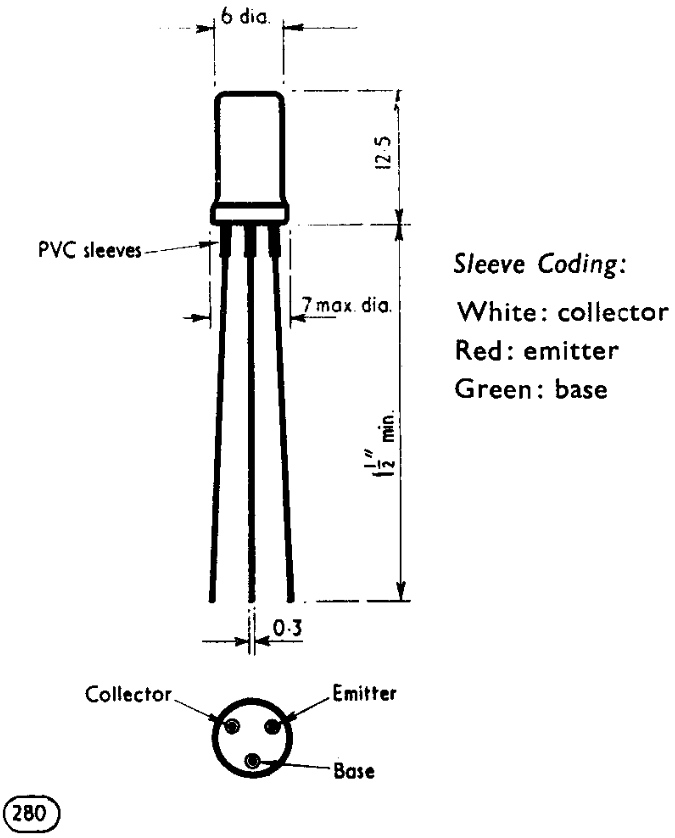

FIG. 1. OUTLINE DRAWING

Dimensions in millimetres unless otherwise stated.

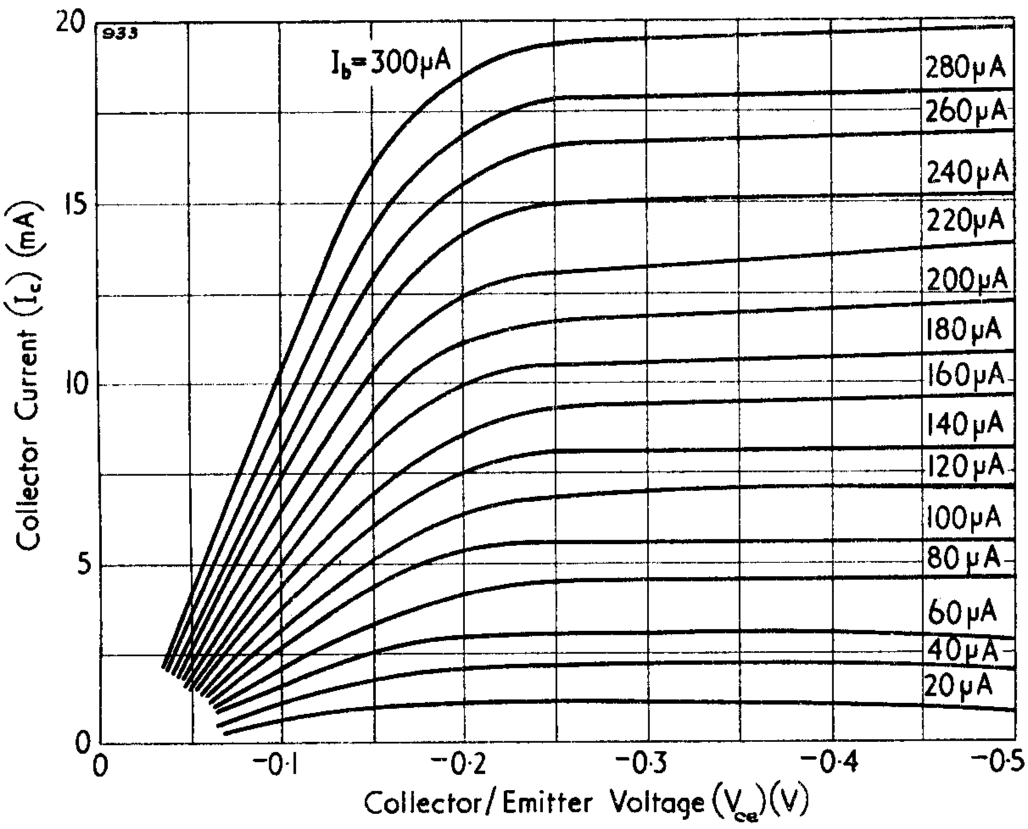

FIG. 2. COMMON EMITTER OUTPUT CHARACTERISTICS

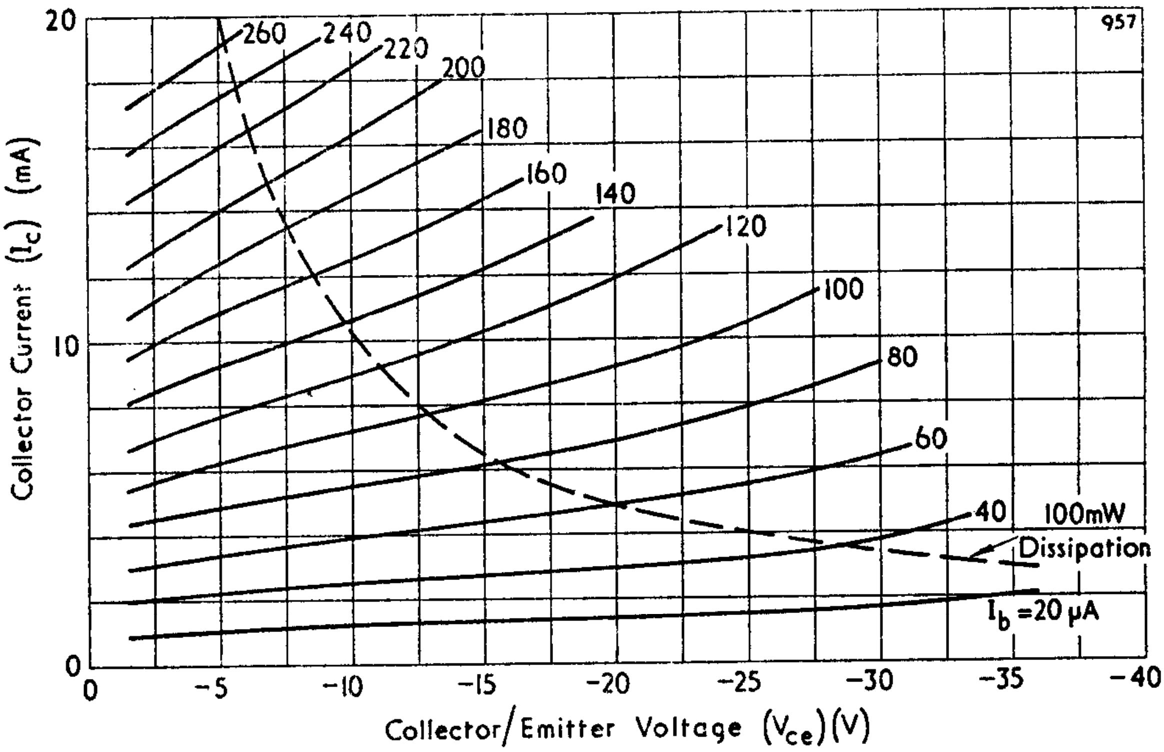

FIG. 3. COMMON EMITTER OUTPUT CHARACTERISTICS

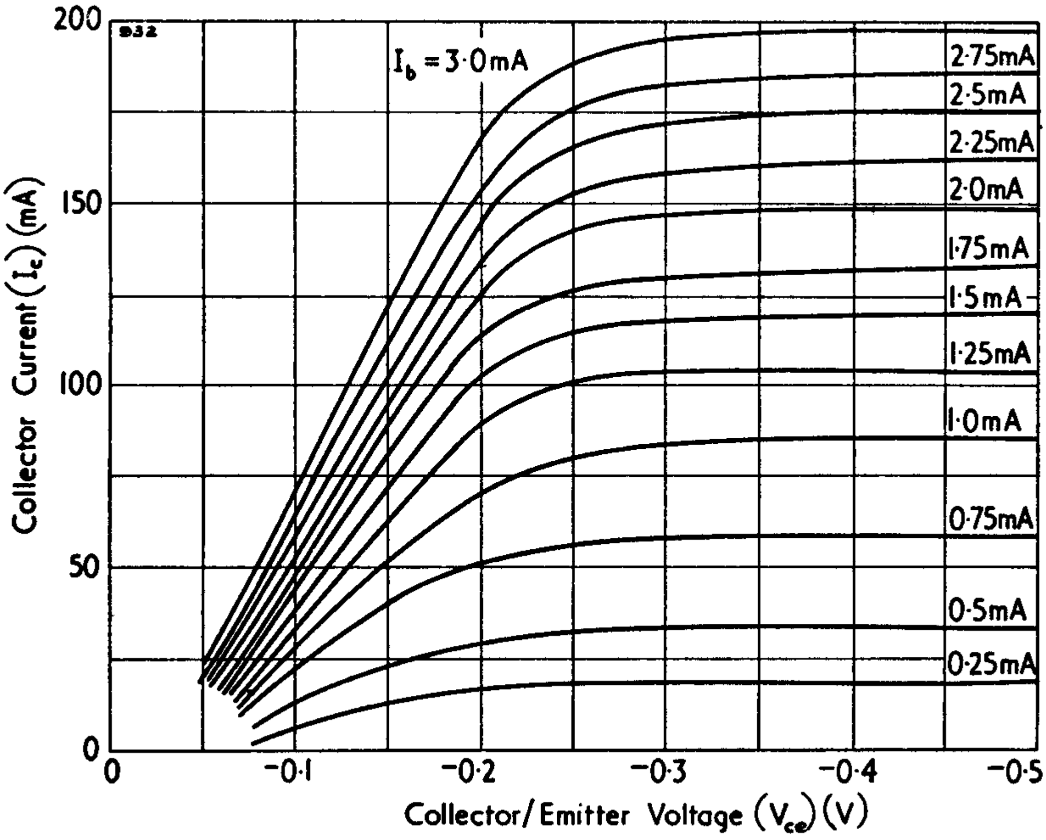

FIG. 4. COMMON EMITTER OUTPUT CHARACTERISTICS

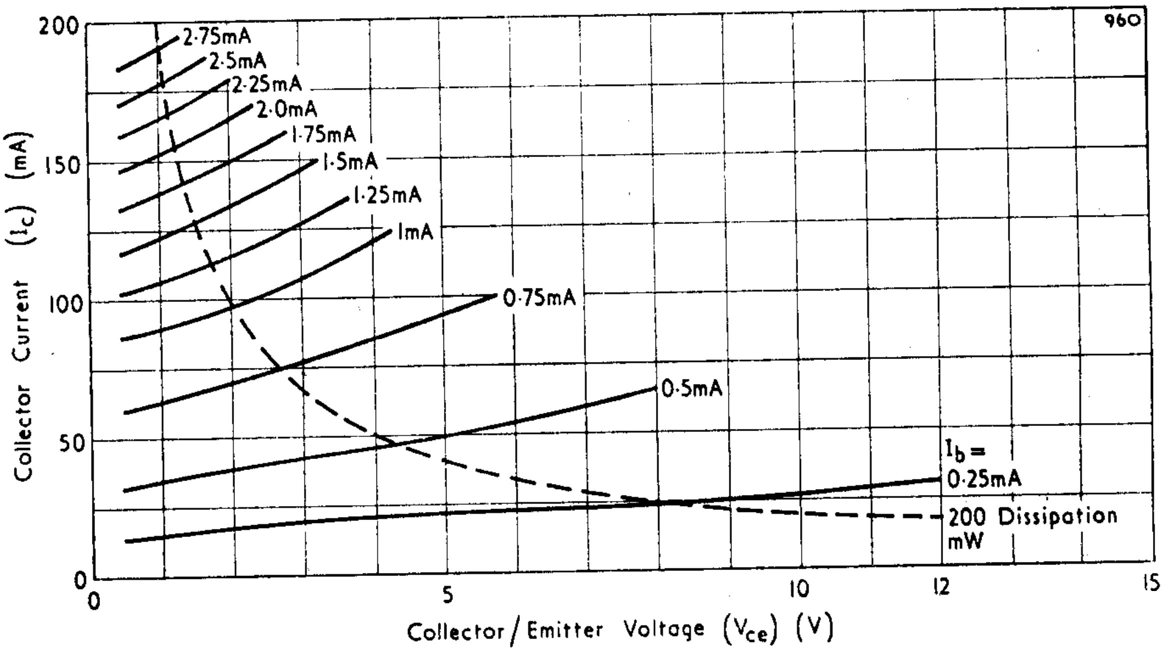

FIG. 5. COMMON EMITTER OUTPUT CHARACTERISTICS

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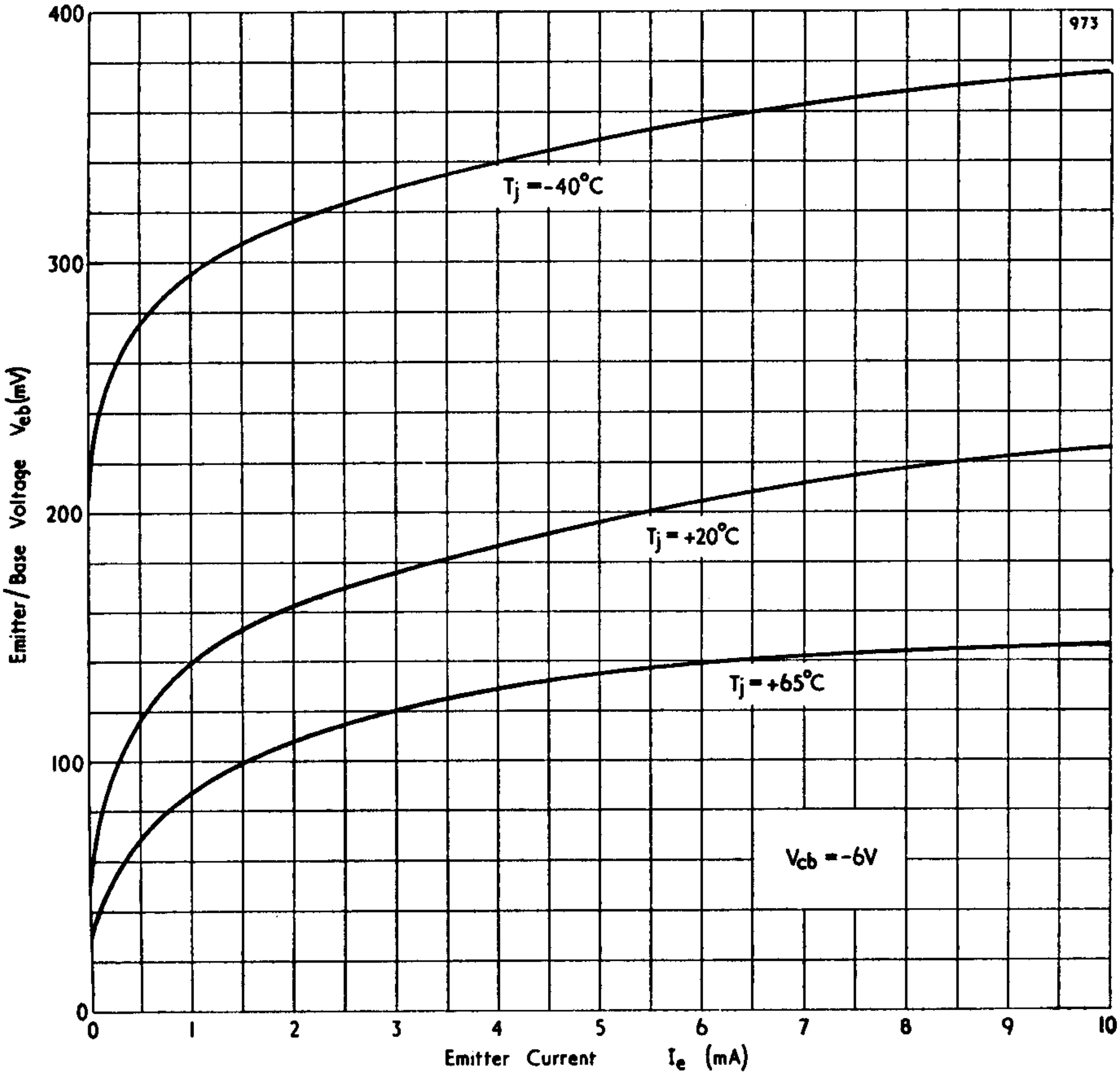

FIG. 6. COMMON BASE INPUT CHARACTERISTICS

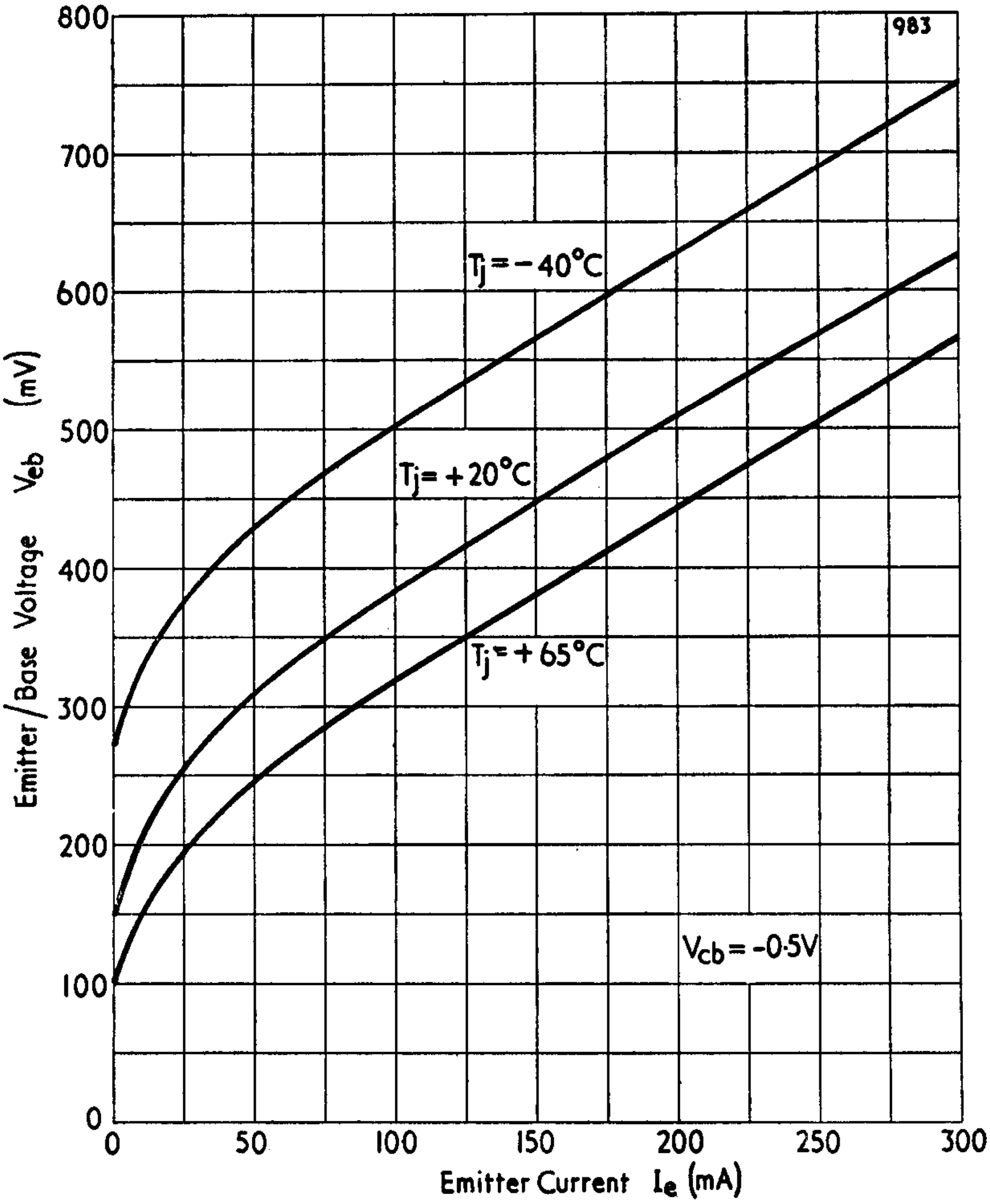

FIG. 7. COMMON BASE INPUT CHARACTERISTICS

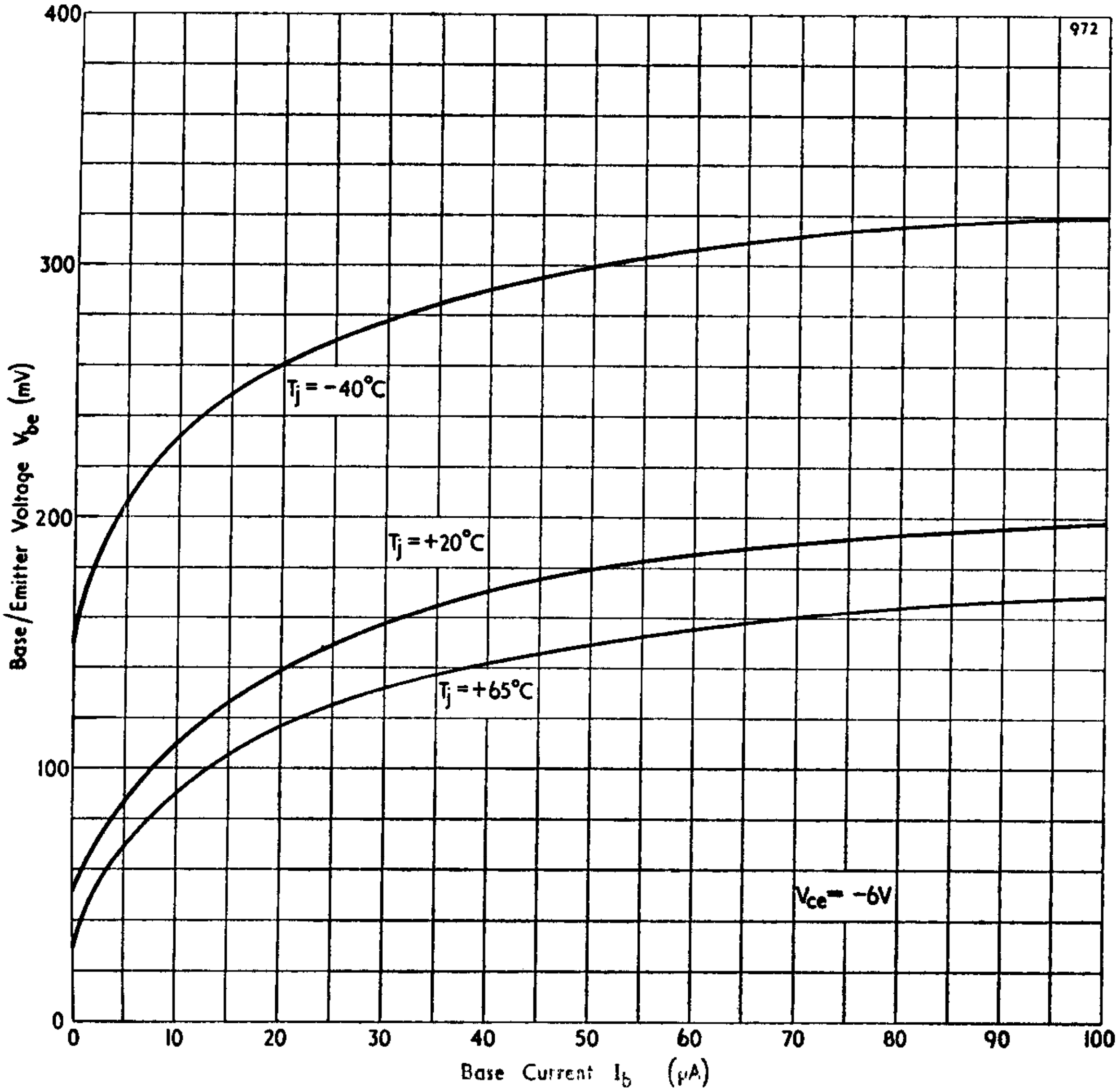

FIG. 8. COMMON EMITTER INPUT CHARACTERISTICS

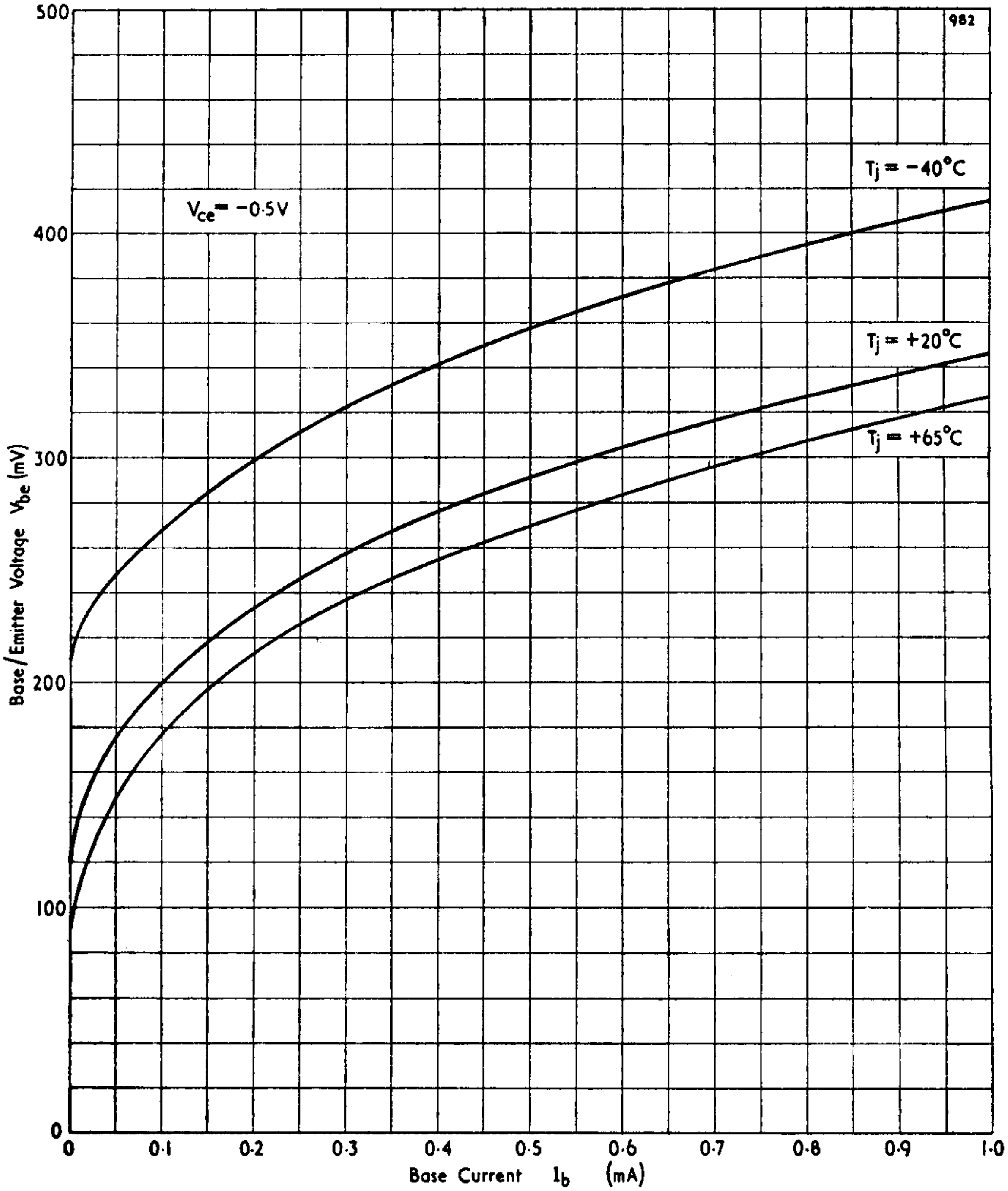

FIG. 9. COMMON EMITTER INPUT CHARACTERISTICS

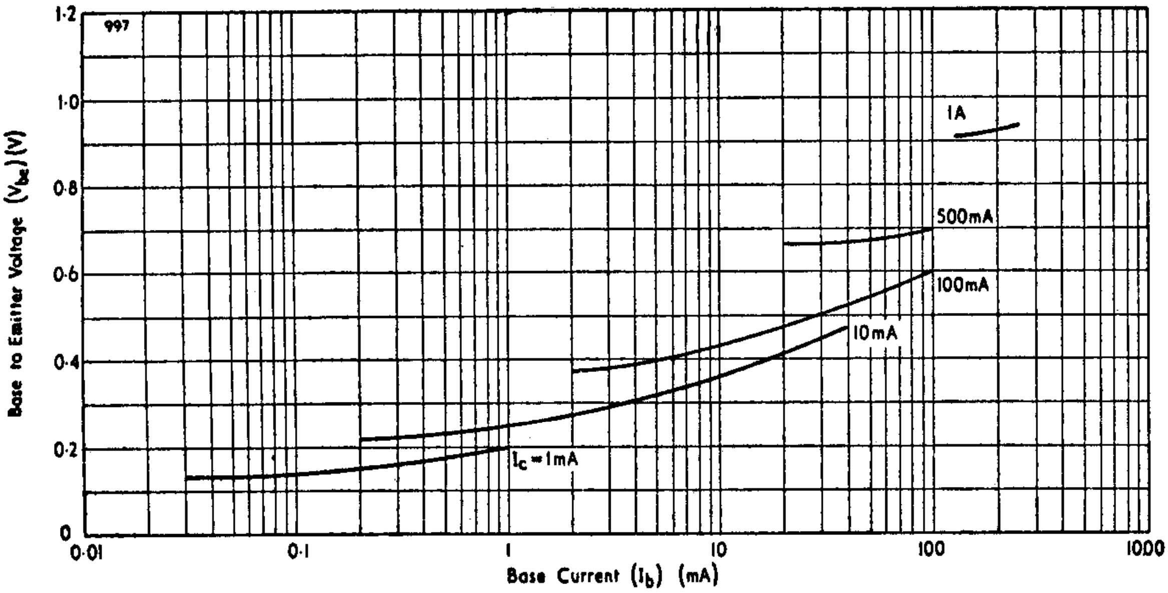

FIG. 10. COMMON EMITTER INPUT CHARACTERISTICS (CURRENT SATURATED CONDITION)

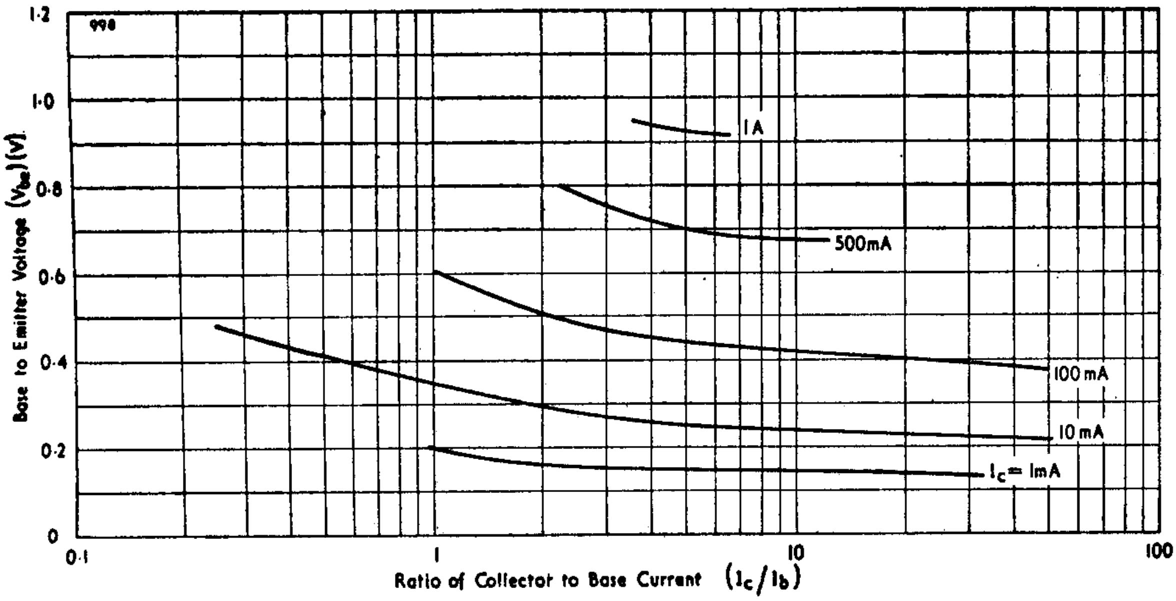

FIG. 11. COMMON EMITTER INPUT CHARACTERISTICS (CURRENT SATURATED CONDITION)

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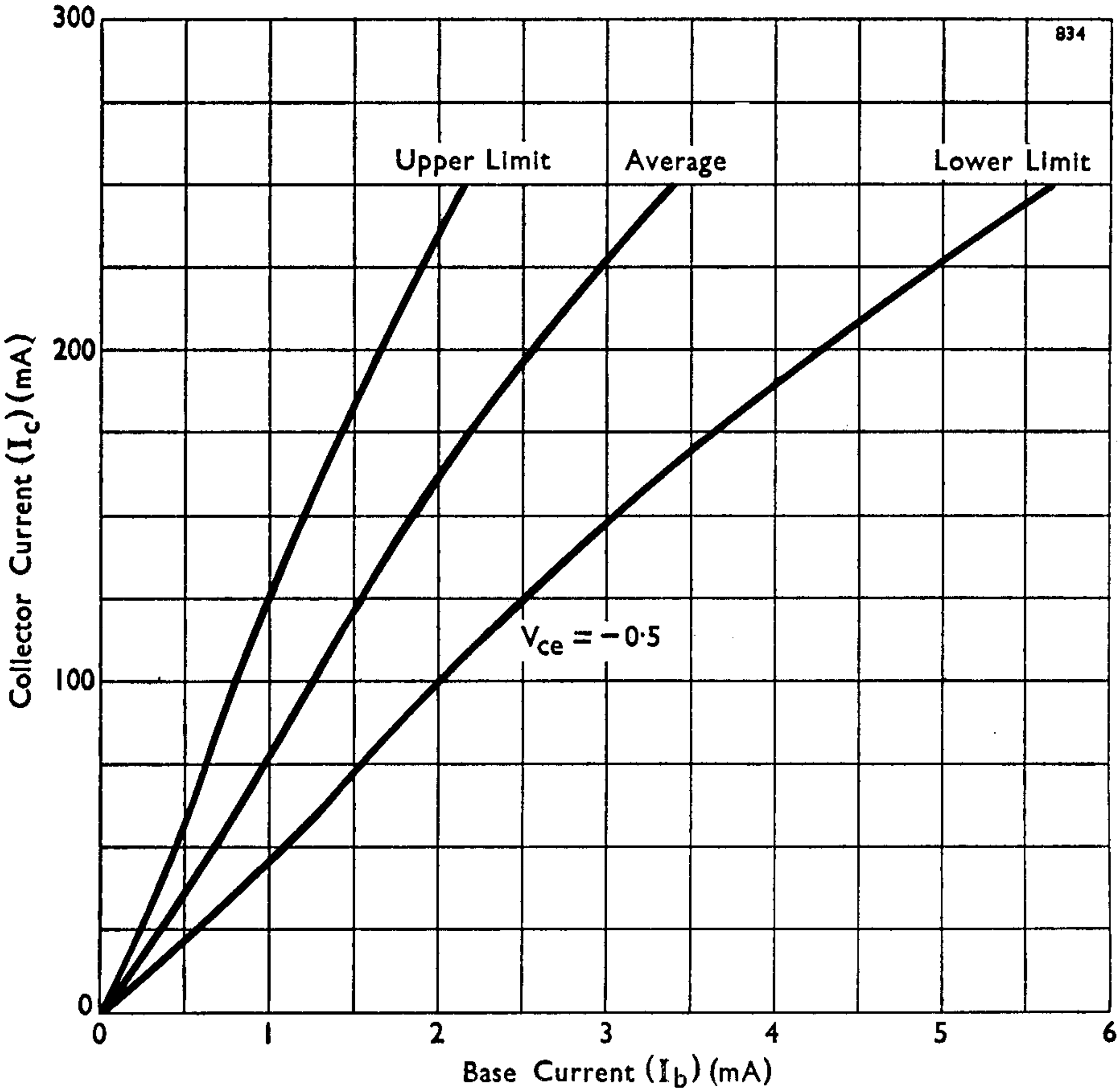

FIG. 12. COMMON EMITTER TRANSFER CHARACTERISTICS

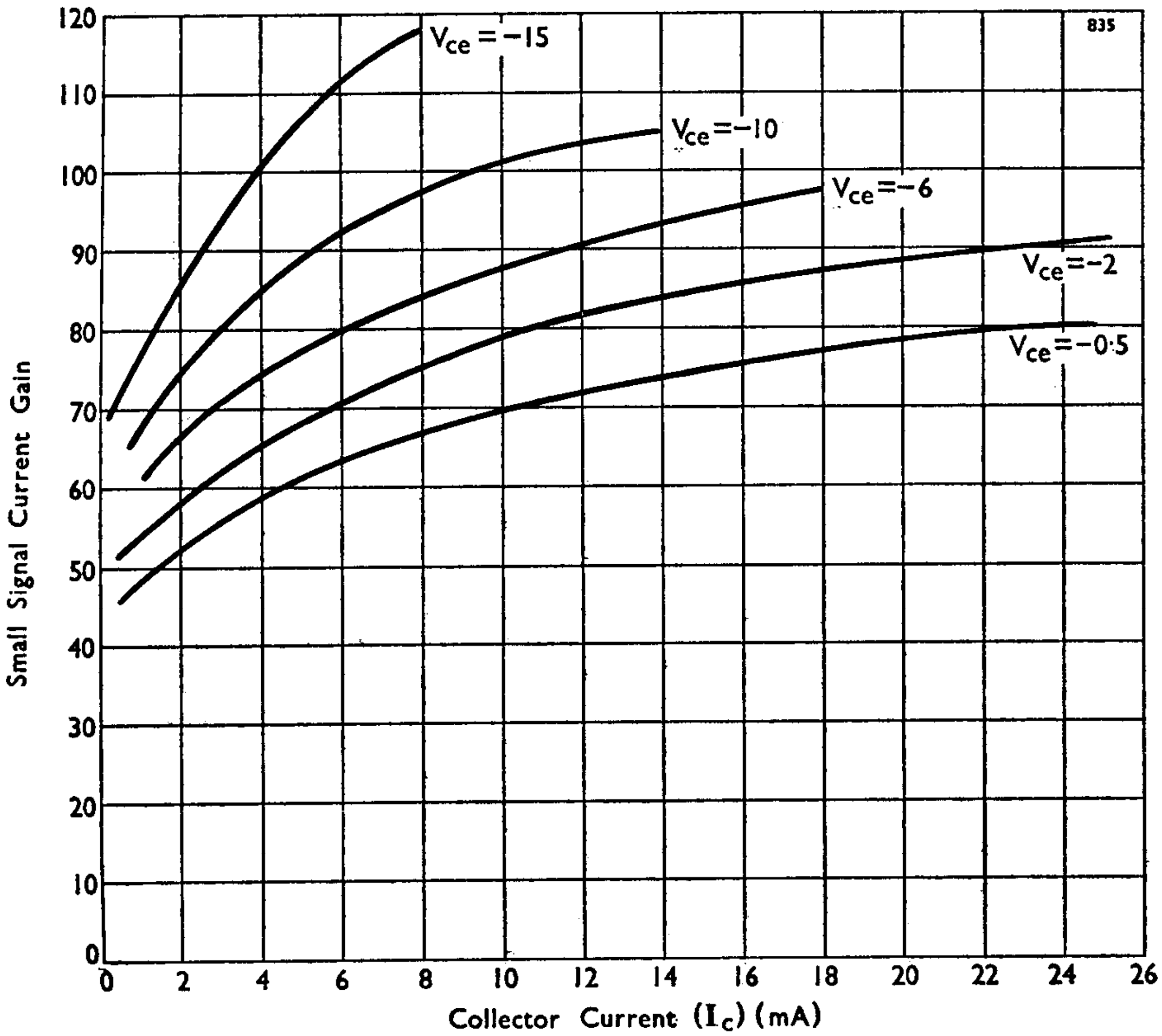

FIG. 13. VARIATION OF SMALL SIGNAL CURRENT GAIN WITH COLLECTOR CURRENT

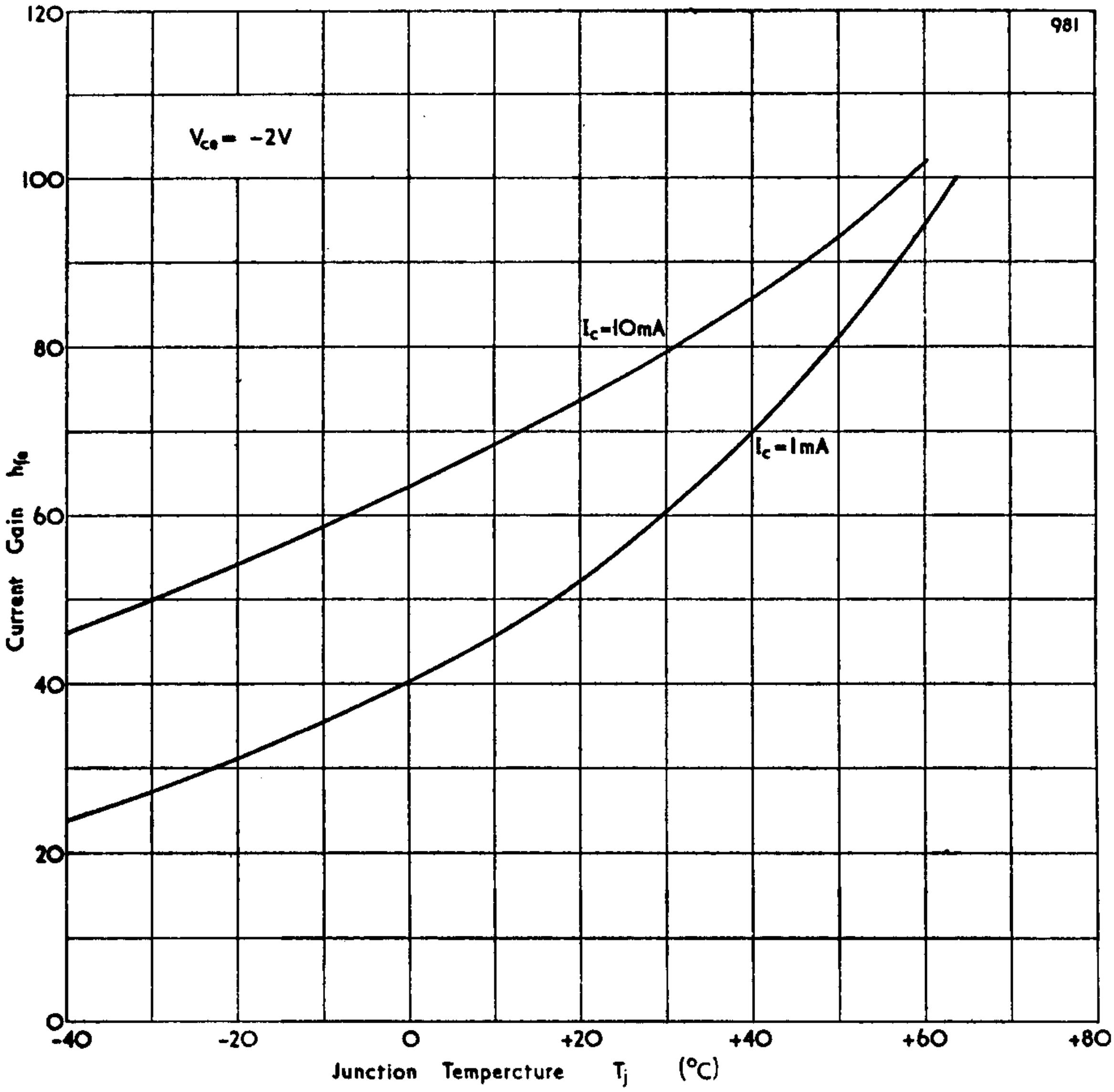

FIG. 14. VARIATION OF SMALL SIGNAL CURRENT GAIN WITH JUNCTION TEMPERATURE

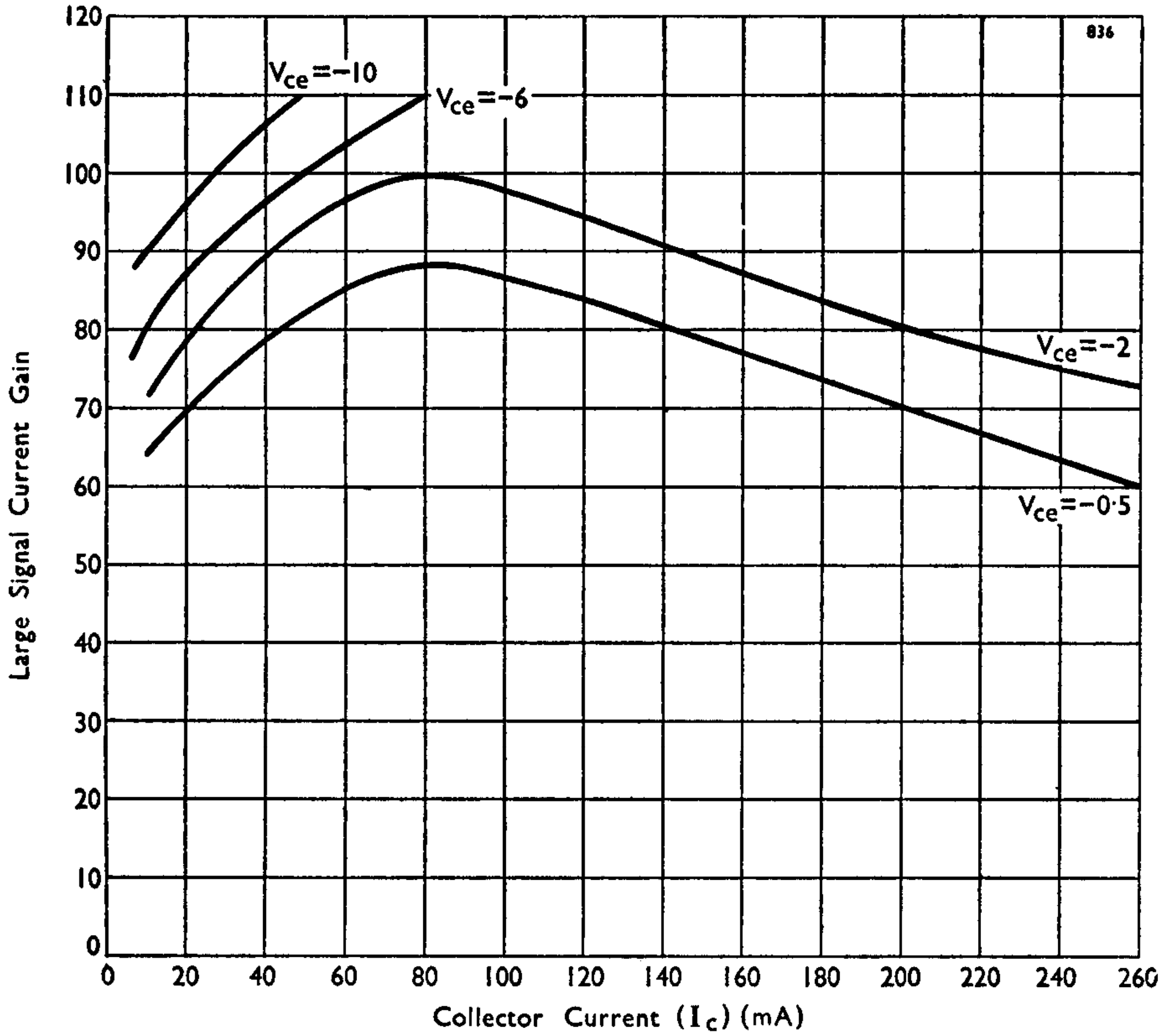

FIG. 15. VARIATION OF LARGE SIGNAL CURRENT GAIN WITH COLLECTOR CURRENT

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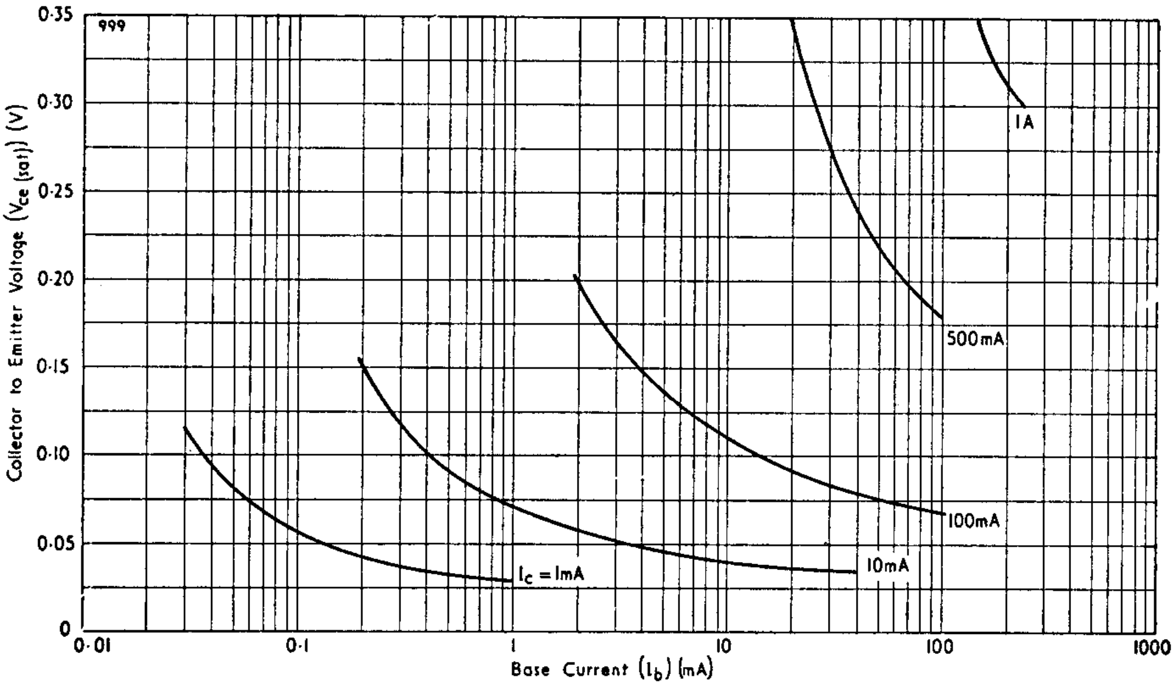

FIG. 16. COLLECTOR SATURATION CHARACTERISTICS

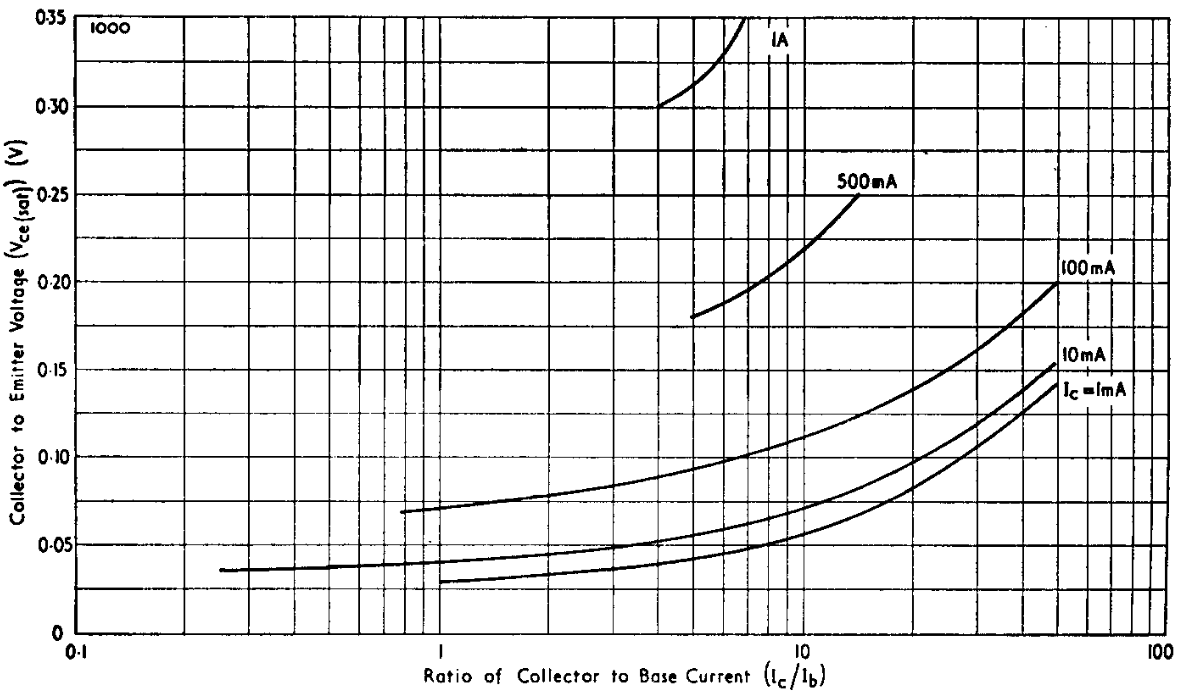

FIG. 17. COLLECTOR SATURATION CHARACTERISTICS

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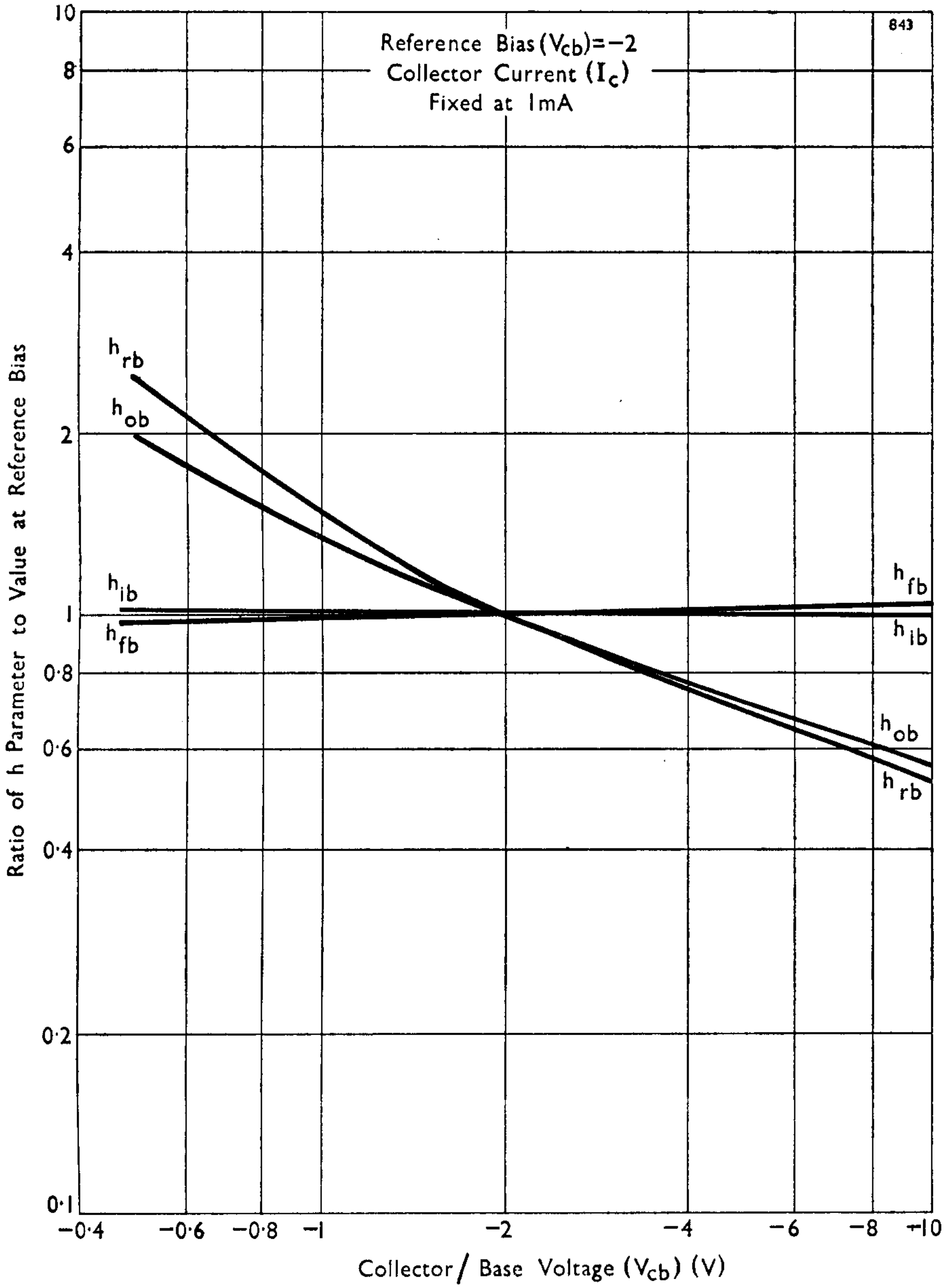

FIG. 18. VARIATION OF COMMON BASE h PARAMETERS WITH COLLECTOR/BASE VOLTAGE

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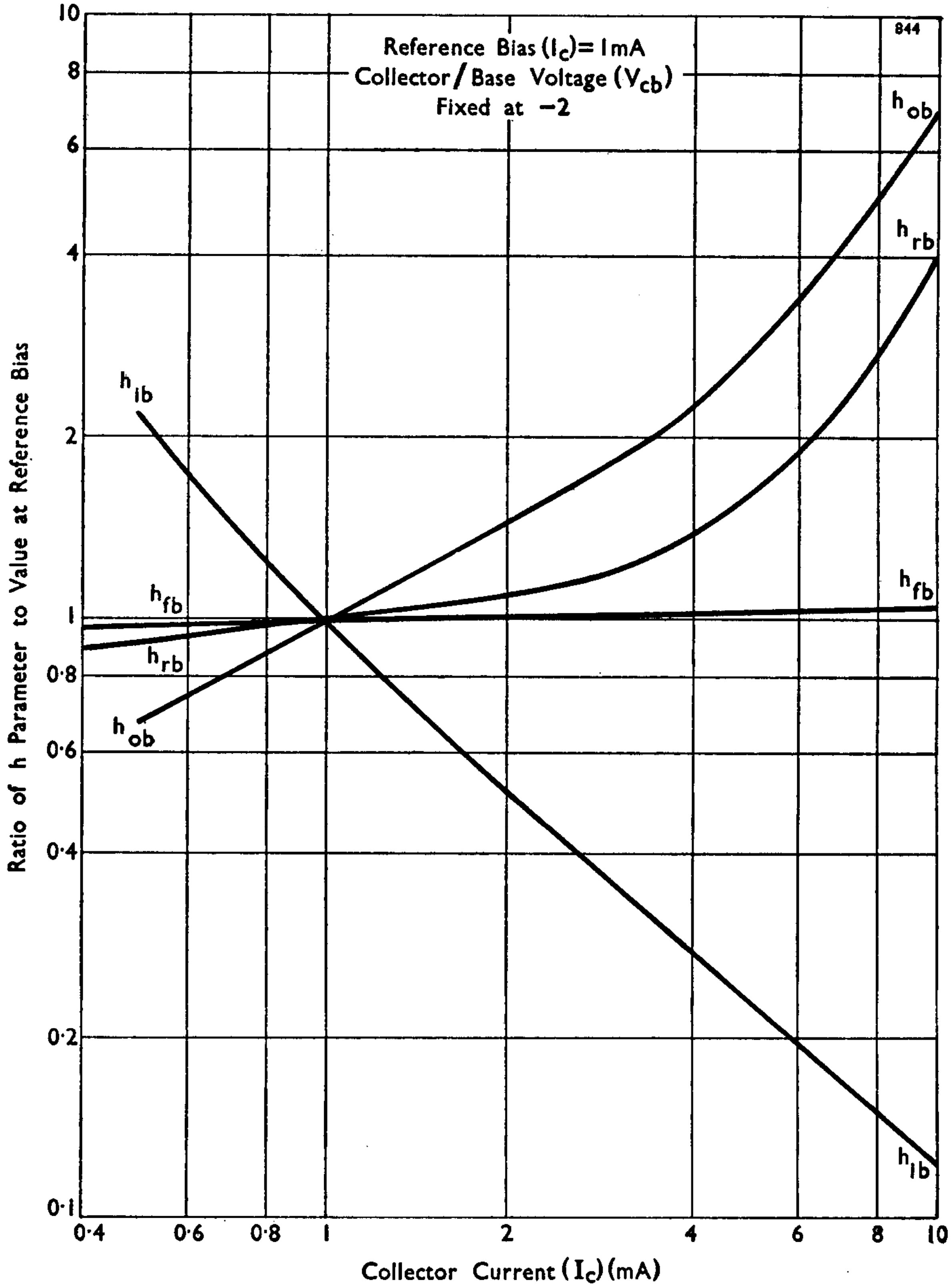

FIG. 19. VARIATION OF COMMON BASE h PARAMETERS WITH COLLECTOR CURRENT

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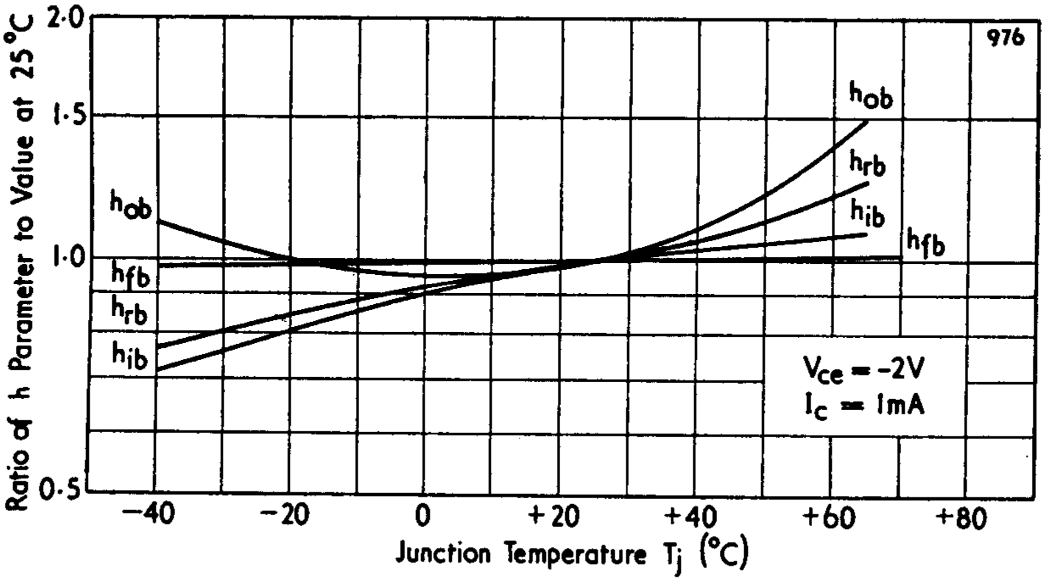

FIG. 20. VARIATION OF COMMON BASE h PARAMETERS WITH JUNCTION TEMPERATURE

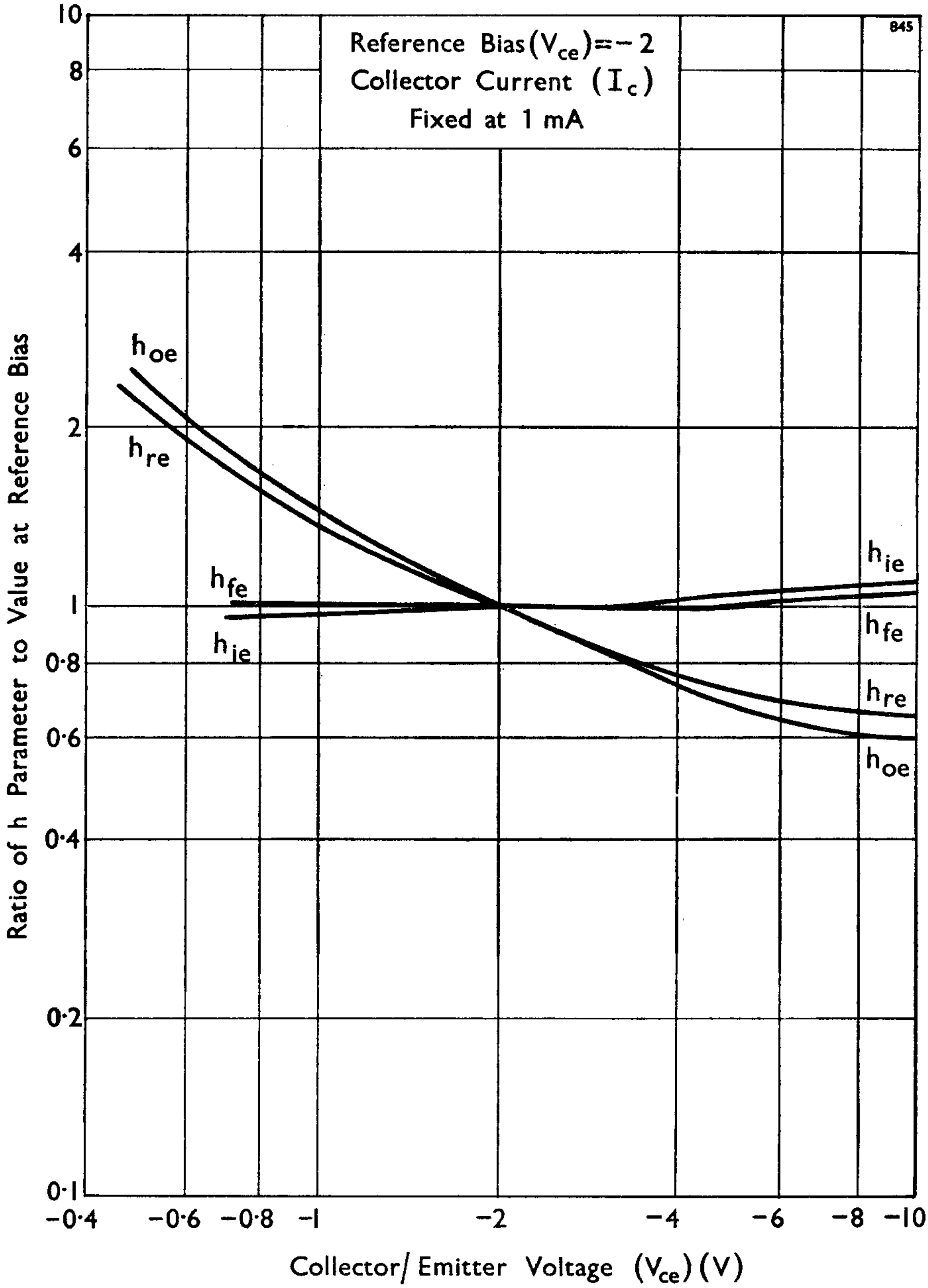

FIG. 21. VARIATION OF COMMON EMITTER h PARAMETERS WITH COLLECTOR/EMITTER VOLTAGE

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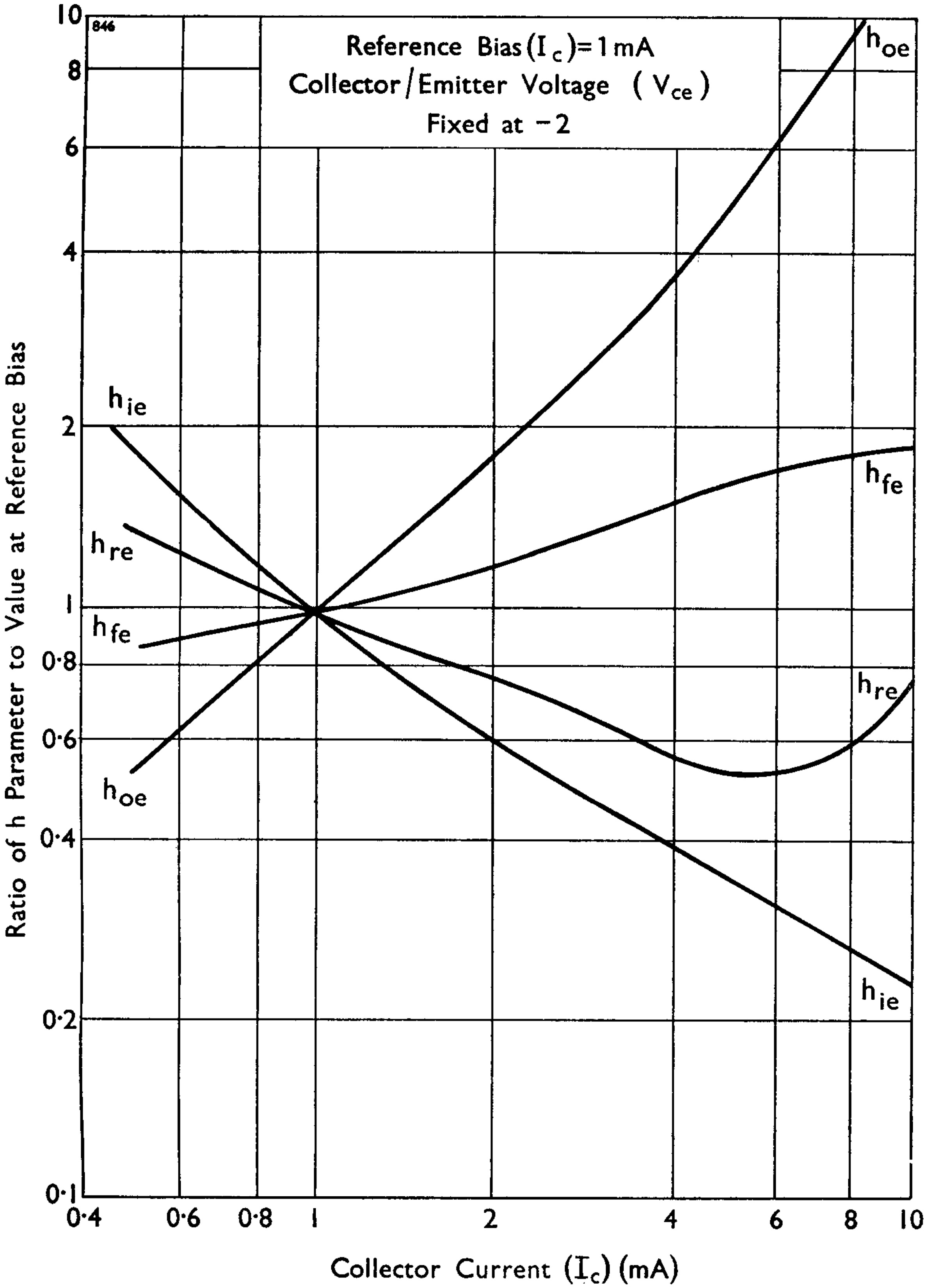

FIG. 22. VARIATION OF COMMON EMITTER h PARAMETERS WITH COLLECTOR CURRENT

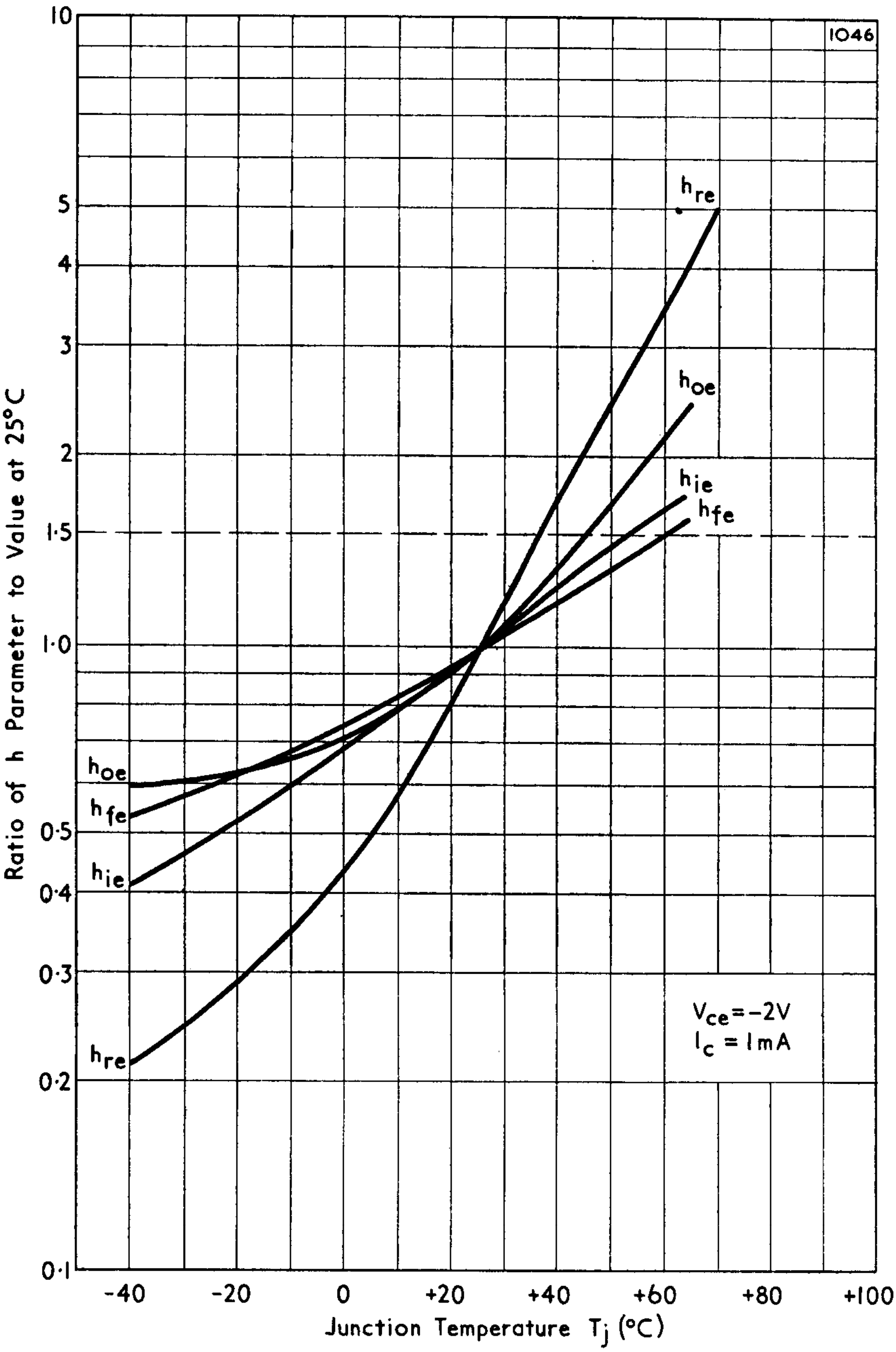

FIG. 23. VARIATION OF COMMON EMITTER h PARAMETERS WITH JUNCTION TEMPERATURE

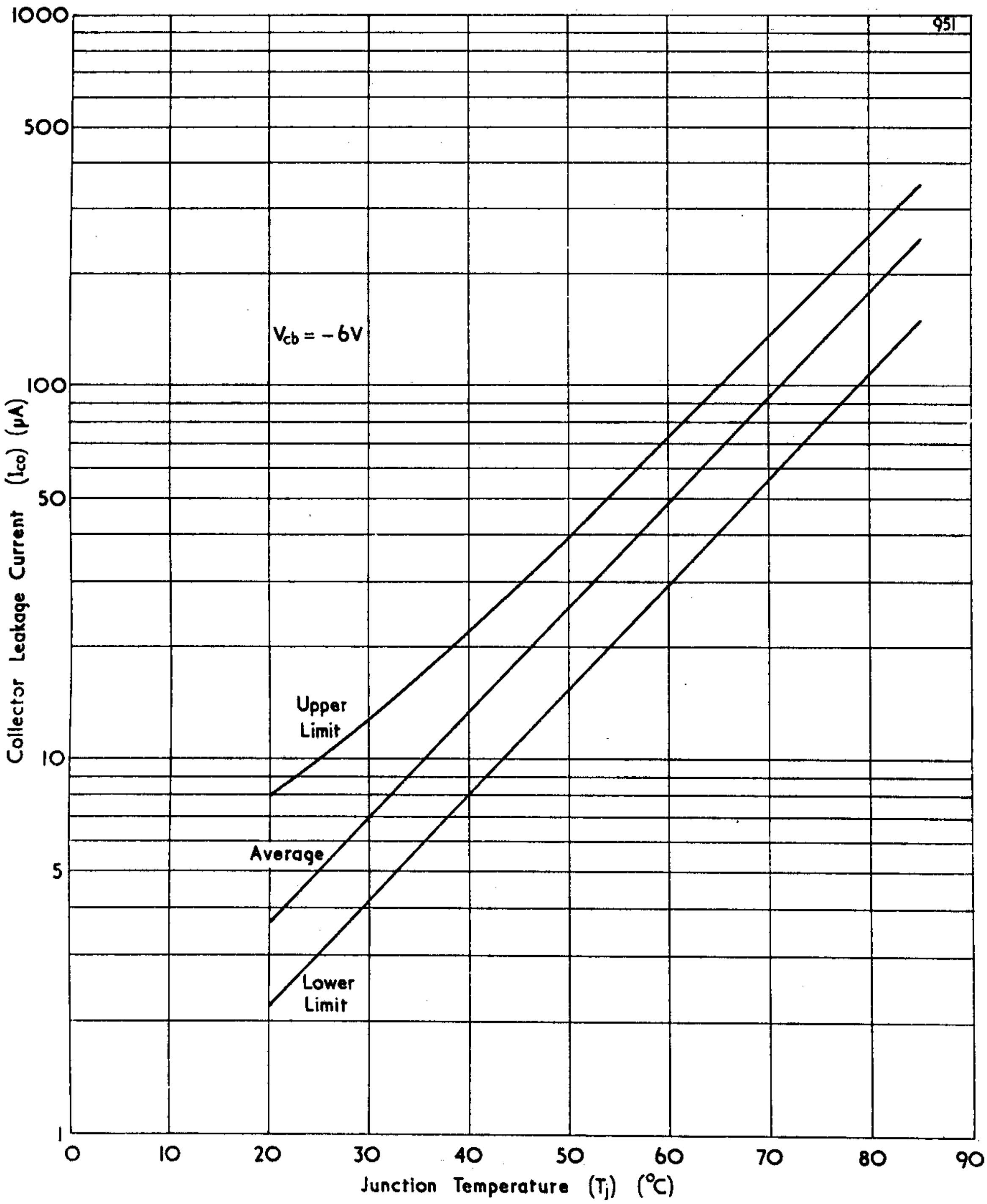

FIG. 24. VARIATION OF COLLECTOR LEAKAGE CURRENT WITH JUNCTION TEMPERATURE

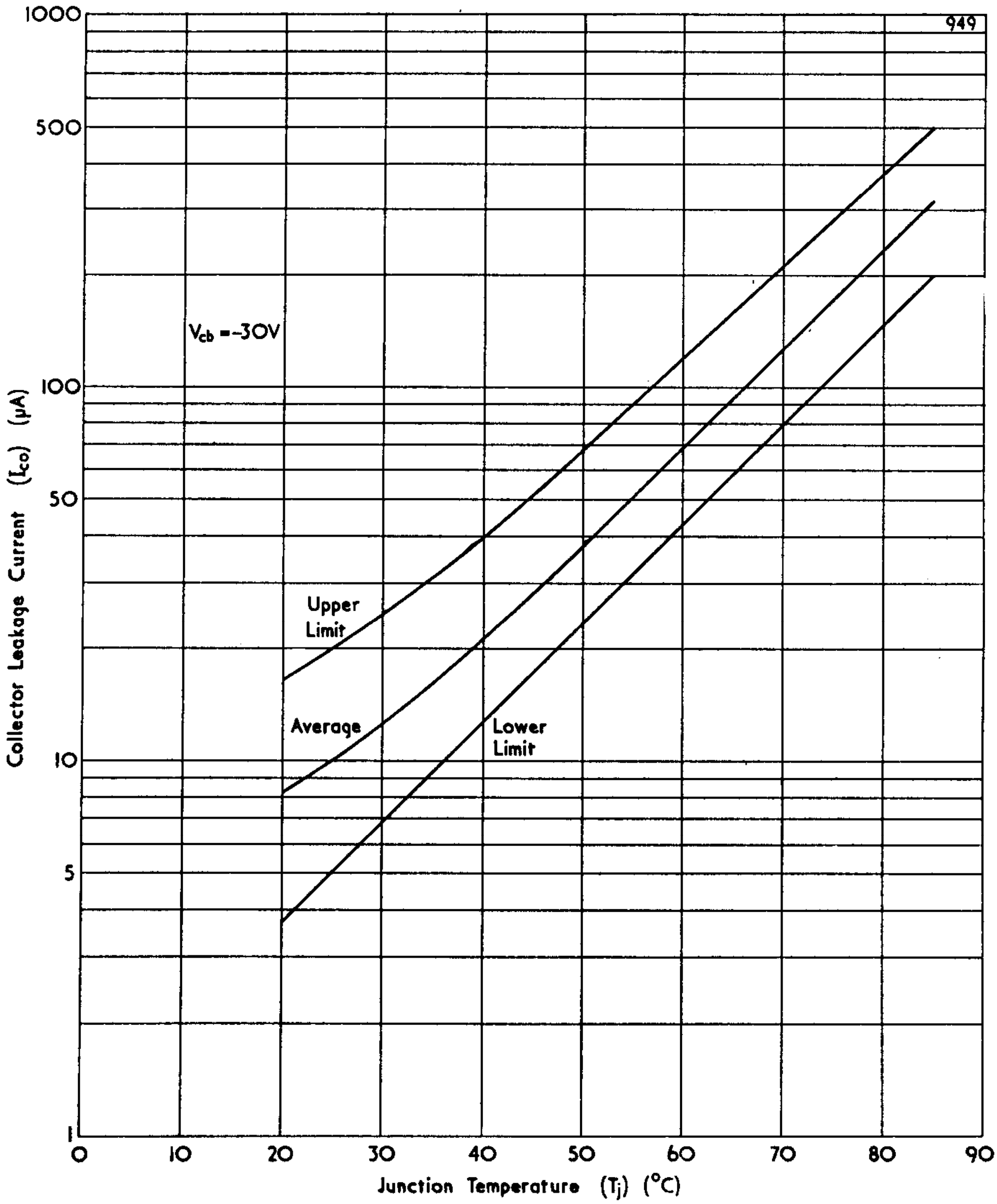

FIG. 25. VARIATION OF COLLECTOR LEAKAGE CURRENT WITH JUNCTION TEMPERATURE

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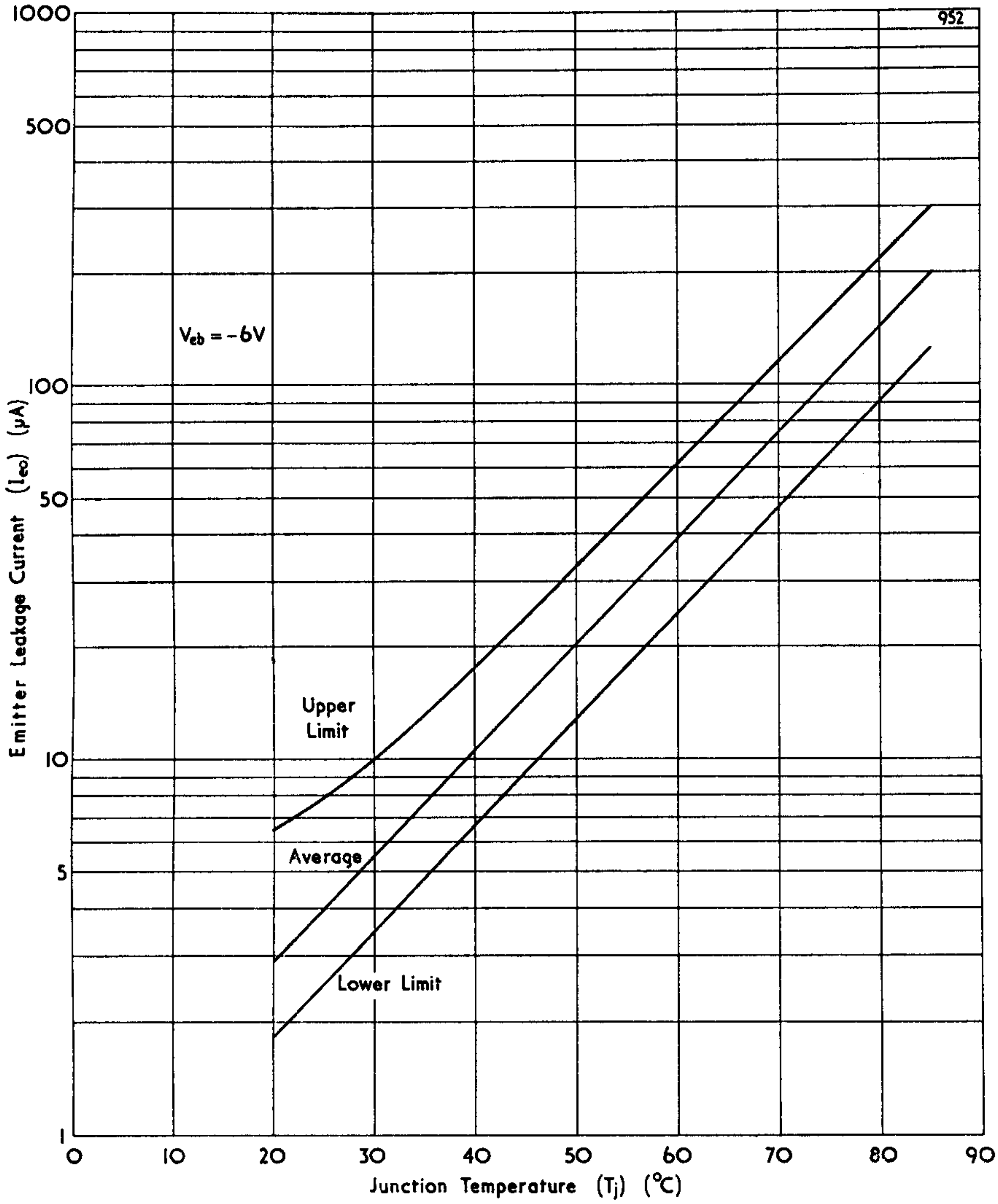

FIG. 26. VARIATION OF EMITTER LEAKAGE CURRENT WITH JUNCTION TEMPERATURE

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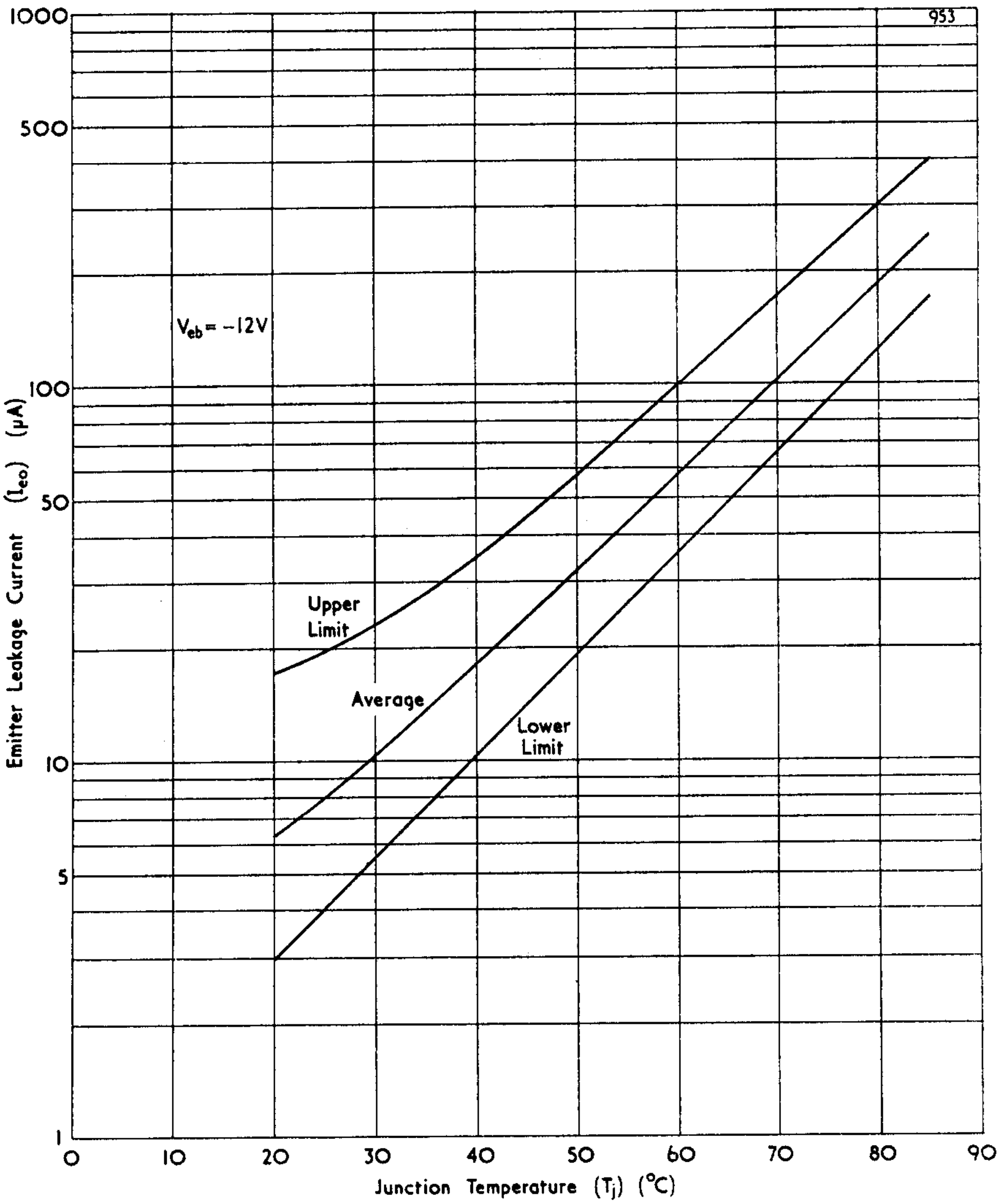

FIG. 27. VARIATION OF EMITTER LEAKAGE CURRENT WITH JUNCTION TEMPERATURE

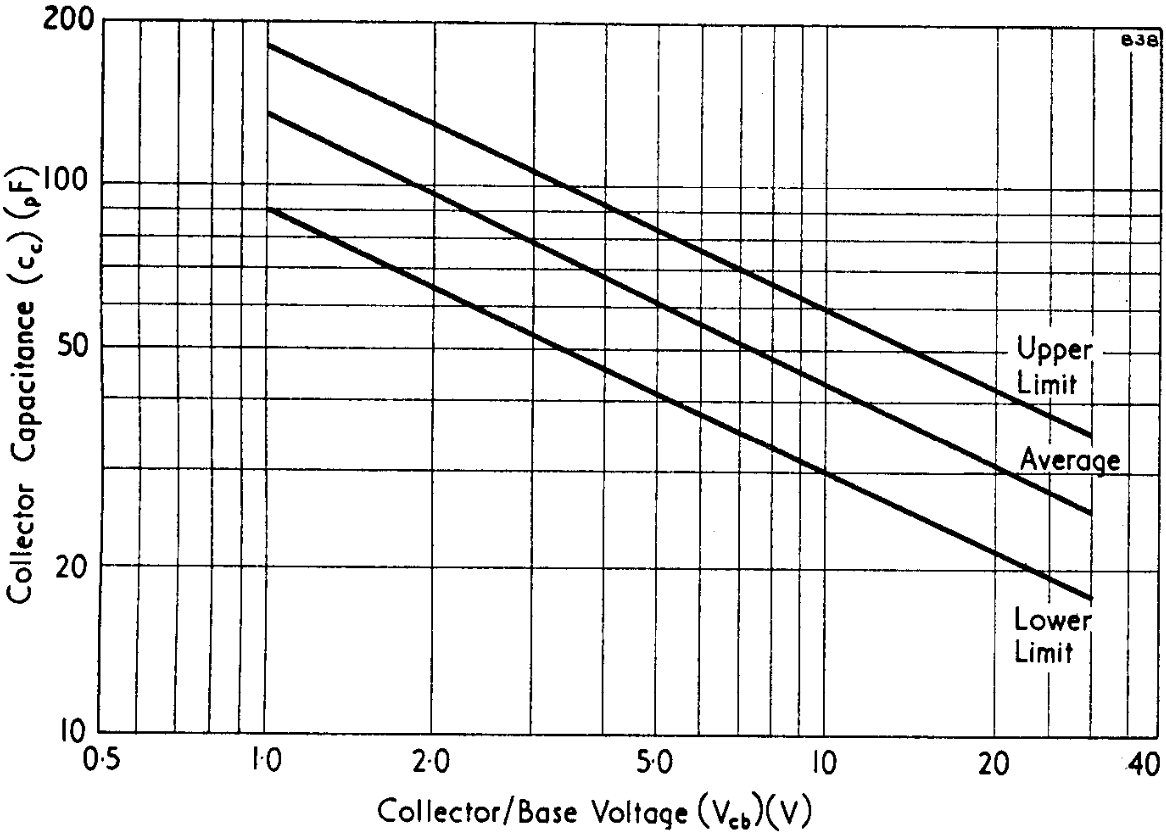

FIG. 28. COLLECTOR CAPACITANCE

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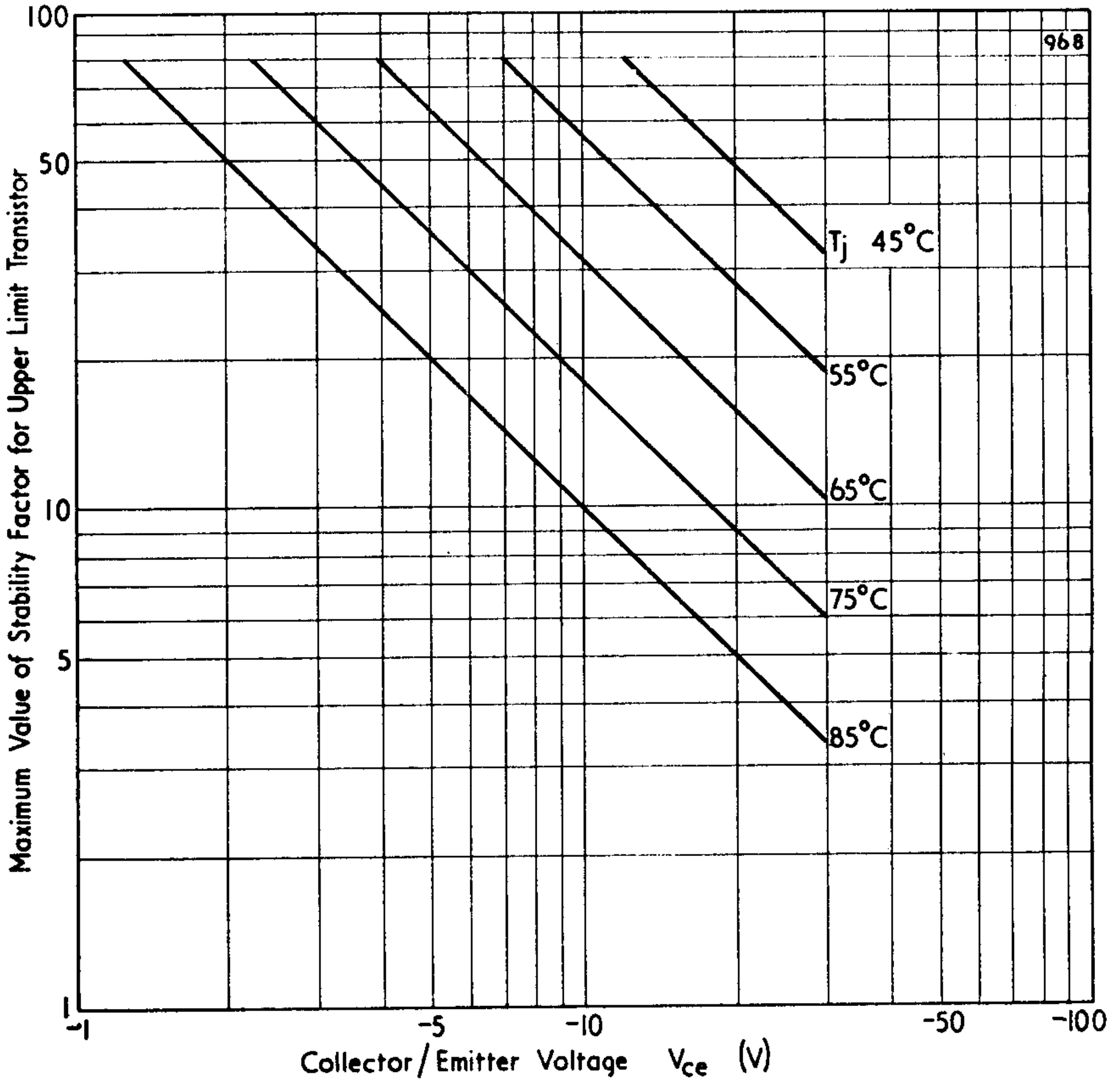

FIG. 29. STABILITY FACTOR

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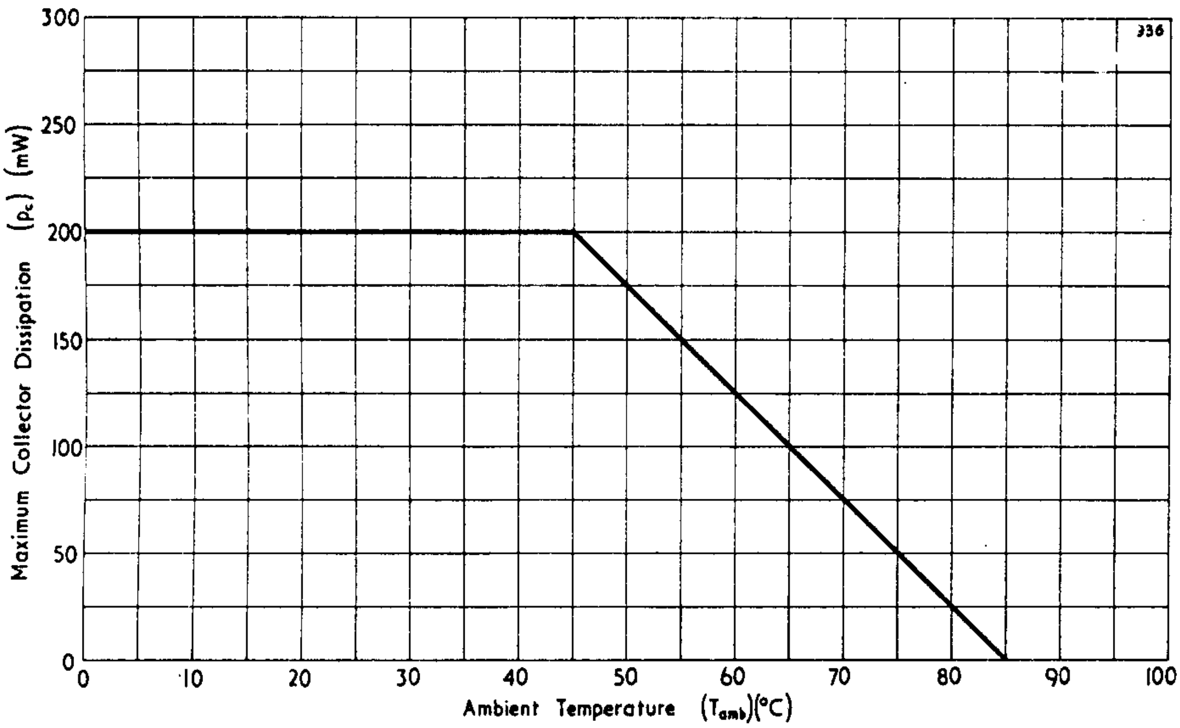

FIG. 30. POWER DISSIPATION

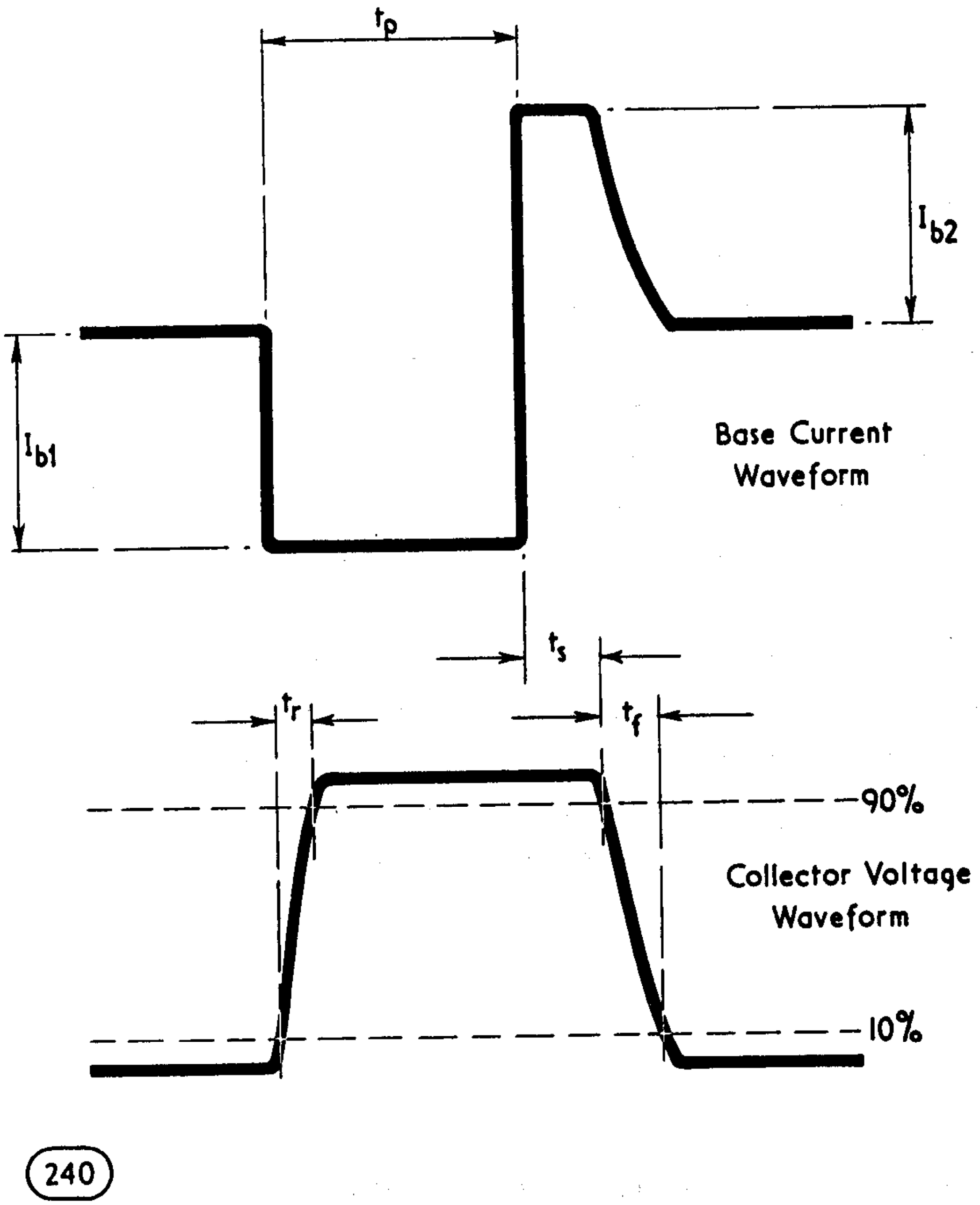

FIG. 31. PULSE RESPONSE WAVEFORMS