from: Transistors Theory and Practice
Rufus P. Turner 1954
Gernsback Library No.54
Author wrote article in Radio-Electronics 1949
"Build A Transitor"

Chapter 10

Characteristics of Commercial Transistors

THE data presented in this chapter have been taken from manufacturers' published ratings, with their permission. All of these characteristics are tentative, since improvements steadily are being made in commercial transistors. Where blanks appear in the Tables, the data in question could not be obtained. The entire field has been solicited. Any manufacturer not appearing in this listing and who was offering transistors at the time of this writing, was omitted by that manufacturer's specific request.

In order to list in the most useful manner the numerous ratings, three sets of Tables have been prepared and appear in the following order: *Absolute Maximum Ratings, All Types; Typical Amplifier Operation, Junction and Point-Contact;* and *Typical Operation, Point-Contact Switches.*

In each table, listings are made alphabetically by the names of manufacturers.

Abbreviations Used in the Tables

a alpha. (current amplification factor)
CURR. AMP. Current amplification factor.
db decibels
F_c cutoff frequency
G-B Grounded-base
G-C grounded-collector
G-E grounded-emitter

i_c collector current
i_e emitter current
inv. v_e emitter peak inverse voltage
k times 1000
ma d.c. milliamperes
mc megacycles
mw milliwatts
μsec microseconds
N-P-N junction type N-P-N
NF noise factor or noise figure
P-C point-contact
P_c maximum collector dissipation
PG power gain
P-N-P junction type P-N-P
PO power output
R_i input resistance or impedance
R_L load resistance or impedance
R_o output resistance or impedance
temp temperature
v volts
v_c collector voltage
v_e emitter voltage

FOOTNOTES FOR TABLES ON FOLLOWING PAGES

a. At 25°C. ambient
b. At 30°C. ambient
c. Alpha loss = 3db from 1 kc value
d. Junction temperature 30°C., f = 1 kc., source imp. 100 ohms
e. Design center
f. Junction temperature 75°C., f = 1 kc., source imp. 100 ohms
g. Junction temperature 30°C., f = 1 kc., source imp. 600 ohms
h. Junction temperature 75°C., f = 1 kc., source imp. 600 ohms
i. Junction temperature 30°C., f = 1 kc., source imp. 30K ohms
j. Junction temperature 30°C., f = 1 kc., source imp. 7,500 ohms
k. Alpha loss = 3 db from 270-cycle value
l. Junction temperature 30°C., f = 1 kc., source imp. 15K ohms
m. Frequency at which alpha = 1
n. At 1,000 cycles
o. Generator impedance 50 ohms
p. Generator impedance 60 ohms, f = 1 kc.
q. Generator impedance 500 ohms, f = 1 kc.
r. Load impedance 5K ohms. High source impedance
s. Generator impedance 0.22 megohm, f = 1 kc.
t. At i_e = 0.5 ma, v_c = −15 v.
u. At i_e = 2 ma, v_c = −15 v.
v. At i_e = 0.5 ma, v_c = −7 v.

1954 Germanium transistor data chart.Transistor Products-Radio Receptor-Hydro Air-National Union-Westinghouse-GE-CBS Hytron-Texas Instruments-RCA-Raytheon-Sylvania

ABSOLUTE MAXIMUM RATINGS, ALL TYPES

MANUFACTURER	Type No.	Class	v_c (volts)	i_c (ma)	P_c (mw)	v_e (volts)	i_e (ma)	inv. v_e (volts)	temp. (°C.)	Outline
CBS-Hytron	PT-2A	P-C	–40	–10	100		5	–40	55	1
	PT-2S	P-C	–40	–10	100		5	–40	55	1
	2N36	P-N-P	–20	– 8	50				50	2
	2N37	P-N-P	–20	– 8	50				50	2
	2N38	P-N-P	–20	– 8	50				50	2
General Electric	G11	P-C	–30	– 7	100		3	–50	40	3
	G11A	P-C	–30	– 7	100		3	–50	40	3
	2N43	P-N-P	–45	–10	150[a]		10		100	4
	2N44	P-N-P	–45	–10	150[a]		10		100	4
	2N45	P-N-P	–45	–10	150[a]		10		100	4
Hydro-Aire	A-O	P-C	–20		50	–10			100	5
	A-1	P-C	–20		50	–10			100	5
	A-2	P-C	–20		50	–10			100	5
	A-3	P-C	–20		50	–10			100	5
	S-1	P-C	–50		60	–30			100	5
	S-2	P-C	–35		60	–30			100	5
National Union	T18A	P-C	–50	–20	120[a]	5	15	–50		6
	T18B	P-C	–50	–20	120[a]	5	15	–50		6
	2N39	P-N-P	–30	– 5	50[a]		5			7
	2N40	P-N-P	–30	– 5	50[a]		5			7
	2N42	P-N-P	–30	– 5	50[a]		5			7
Radio Receptor	RR14	P-N-P	–25	– 5	50				50	8,9
	RR20	P-N-P	–25	– 5	50				50	8,9
	RR21	P-N-P	–25	– 5	50				50	8,9
	RR34	P-N-P	–20	– 5	30				50	
	R1698	P-C	–40		120	} See switching data under Typical Operation				
	R1734	P-C			120					
	R1729	P-C	–30				1.0			

ABSOLUTE MAXIMUM RATINGS, ALL TYPES

MANUFACTURER	Type No.	Class	v_c (volts)	i_c (ma)	P_c (mw)	v_e (volts)	i_e (ma)	inv. v_e (volts)	(°C.) temp.	Outline
Raytheon	CK716	P-C	–40	– 4	100		10			10
	CK721	P-N-P	–20	– 5	30[b]		5		50	11
	CK722	P-N-P	–20	– 5	30[b]		5		50	11
RCA	2N32	P-C	–40	– 8	50		3	–40	40	12
	2N33	P-C	–8.5	– 7	30		0.8		40	12
	2N34	P-N-P	–25	– 8	50		8		50	13
	2N35	N-P-N	25	8	50		–8		50	13
Sylvania	2N32	P-C	–40	– 8	50				40	14
	2N34	P-N-P	–25	– 8	50				50	14
Texas Instruments	102	P-C	–40	–15	75[a]		15	–40	50	15
	103	P-C	–40	–15	75[a]		15	–40	50	15
	200	N-P-N	30	5	50[b]				50	15
	201	N-P-N	30	5	50[b]				50	15
Transistor Products	2A	P-C	–50	– 8	120			–50	50	16
	2B	P-C	–50	– 8	120			–50	50	16
	2C	P-C	–50	– 8	100			–50	50	16
	2D	P-C	–50	– 8	100			–50	50	16
	2E	P-C	–50	– 8	100			–50	50	16
	2F	P-C	–100	–40	120			–50	50	16
	2G	P-C	–100	–40	120			–50	50	16
	X-22	N-P-N	40	5	50				49	17
	X-23	N-P-N	40	5	50				49	17
Westinghouse	WX-3347	P-C			100				60	18
	WX-4813	P-N-P			200				60	19

Rufus P. Turner author-Package Outline Diagrams-www.33audio.com

1954 Germanium transistor data chart.Transistor Products-Radio Receptor-Hydro Air-National Union-Westinghouse-GE-CBS Hytron-Texas Instruments-RCA-Raytheon-Sylvania

TYPICAL AMPLIFIER OPERATION JUNCTION AND POINT-CONTACT

MANUFACTURER	Type No.	Class	Circuit	v_c (volts)	i_c (ma)	i_e (ma)	R_i (ohms)	R_o or R_L (ohms)	Curr. Amp.	PG (db)	PO (mw)	NF (db)	F_e (mc)
CBS-Hystron	PT-2A	P-C	G-B	–30		1.0	300	20k	1.5	19		57	2[e]
General Electric	G11	P-C	G-B	–25		0.5	475	20k	2.2	17		57	2[c]
	2N43	P-N-P	G-B[d]	– 5		1.0	60	50k	0.98[e]	28			1[k]
			G-B[f]	–20		5	10	4k	0.98[e]		40		
			G-E[g]	– 5		1.0	1k	30k	0.98[e]	39			
			G-E[h]	–20		5	300	4k	0.98[e]		40		
			G-C[i]	– 5		1.0	30k	600	0.98[e]	15			
	2N44	P-N-P	G-B[d]	– 5		1.0	55	50k	0.955[e]	28			1[k]
			G-B[f]	–20		5	10	4k	0.955[e]		40		
			G-E[g]	– 5		1.0	700	30k	0.955[e]	38			
			G-E[h]	–20		5	160	4k	0.955[e]		40		
			G-C[i]	– 5		1.0	15k	600	0.955[e]	12			
	2N45	P-N-P	G-B[d]	– 5		1.0	50	50k	0.92[e]	28			
			G-B[f]	–20		5	10	4k	0.92[e]		40		
			G-E[g]	– 5		1.0	300	30k	0.92[e]	36			
			G-E[h]	–20		5	75	4k	0.92[e]		40		
			G-C[j]	– 5		1.0	7.5k	600	0.92[e]	11			
Hydro-Aire	A-0	P-C	G-B	– 8	–2	0.3	550	20k	3.0				4.5[m]
	A-1	P-C	G-B	– 8	–2	0.3	550	20k	2.0				3[m]
	A-2	P-C	G-B	– 8	–2	0.3	400	16k	2.0				1.5[m]
	A-3	P-C	G-B	– 8	–2	0.3	400	16k	2.0				0.5[m]
National Union	T18A	P-C	G-B	–15	–3	0.75	300	15k		20		50	5[c]
	2N39	P-N-P	G-E	–4.5	–1	1.0	500	30k	>0.94	>38		25[n]	
	2N40	P-N-P	G-E	–4.5	–1	1.0	500	30k	>0.90	>36		25[n]	
	2N42	P-N-P	G-E	–4.5	–1	1.0	500	30k	>0.85	>32		25[n]	
Radio Receptor	RR14	P-N-P	G-E	– 1.5	–0.5			30k		36		22[n]	
	RR20	P-N-P	G-E	– 1.5	–0.5			30k		40		22[n]	
	RR21	P-N-P	G-E	–15.0	–3.0			5k			20		
	RR34	P-N-P	G-E	– 1.5	–0.5			30k		30			
	R1729	P-C	G-B	–30		1.0	190	6k	2.5				5
Raytheon	CK716	P-C	G-B	–15	2.5	1.0	150-450	10k-40k	1.5			65[n]	0.1
	CK721	P-N-P	G-B	– 6		2	70	100k	0.975	29		22	

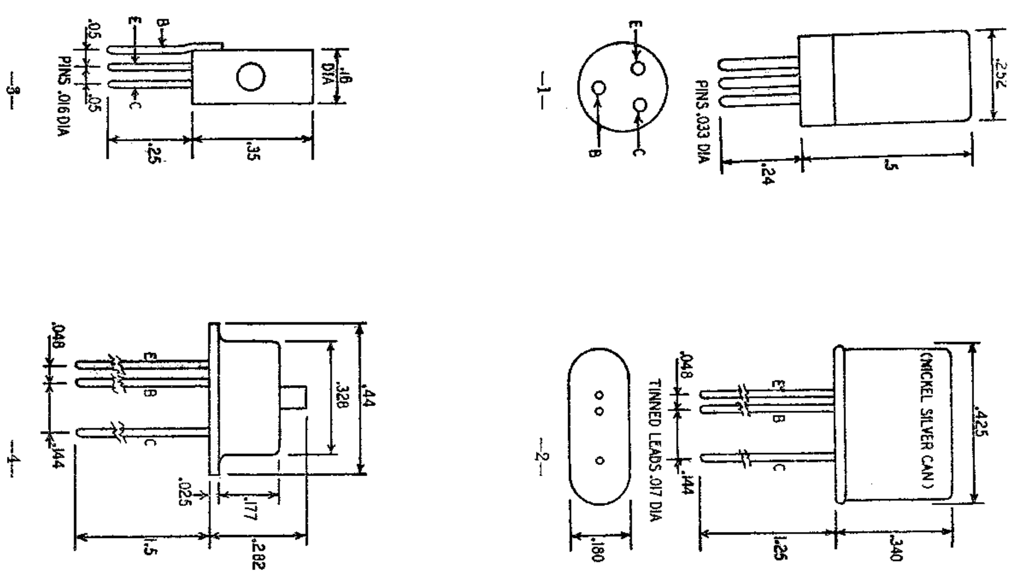
TYPICAL AMPLIFIER OPERATION JUNCTION AND POINT-CONTACT

MANUFACTURER	Type No.	Class	Circuit	v_c (volts)	i_c (ma)	i_e (ma)	R_i (ohms)	R_o or R_L (ohms)	Curr. amp.	PG (db)	PO (mw)	NF (db)	F_e (mc)
Raytheon	CK721	P-N-P	G-E	– 1.5		0.5	1k	20k		36			
			G-E	– 3		2		1250			2.8		
				– 6		2	650	20k	0.975	38		22	
			G-C	– 6		2	300k	20k	0.975	12		22	
	CK722	P-N-P	G-B	– 6		2	50	100k	0.90	29[o]			
			G-E	– 1.5		0.5	1k	20k		30			
			G-E	– 6		2.0	325	20k	0.90	34			
RCA	2N33	P-C	G-B	– 8	–3.3	0.3	special oscillator up to 50 mc			1.0			
			Special				See Figure 507, chapter 5.						
	2N34	P-N-P	G-B	– 6	–10	1		30k	0.98	40			
	2N35	N-P-N	G-B	6	10	–1		30k	0.98	40			
Sylvania	2N34	P-N-P	G-B	– 6		1		30k		40			
Texas Instruments	200	N-P-N	G-B	5		1	60	100k	0.90	29[p]		22	
			G-E	5		1	500	20k		34[q]			
	201	N-P-N	G-B	5		1	60	100k	0.95	30[p]		22	
			G-E	5		1	500	20k		40[q]	2.3[r]		
			G-C	5		1	220k	20k		12[s]			
Transistor Products	2A	P-C	G-B	–40	–2	0				20			
				– 4	–5.5	3				20			
				– 3	–2	1				20			
	2B	P-C	G-B	–40	–2	0				20			1[e]
				– 4	–5.5	3				20			1[e]
				– 3	–2	1				20			1[e]
	2D	P-C	G-B	–15	–1	0				20			2[c]
				– 2	–4	3				20			2[c]
	2E	P-C	G-B	–15	–1	0				20			
				– 2	–4	3				20			
	X-22	N-P-N	G-B	–4.5		1	35	100k	0.90				
	X-23	N-P-N	G-B	–4.5		1	35	500k	0.95				
Westinghouse	WX-3347	P-C	G-B	–22.5	2 to 3	0.3-0.8	400	10k	2	18			2
	WX-4813	P-N-P	G-E	– 6	1 to 2		400	10k		30			

Rufus P. Turner author-Package Outline Diagrams-www.33audio.com

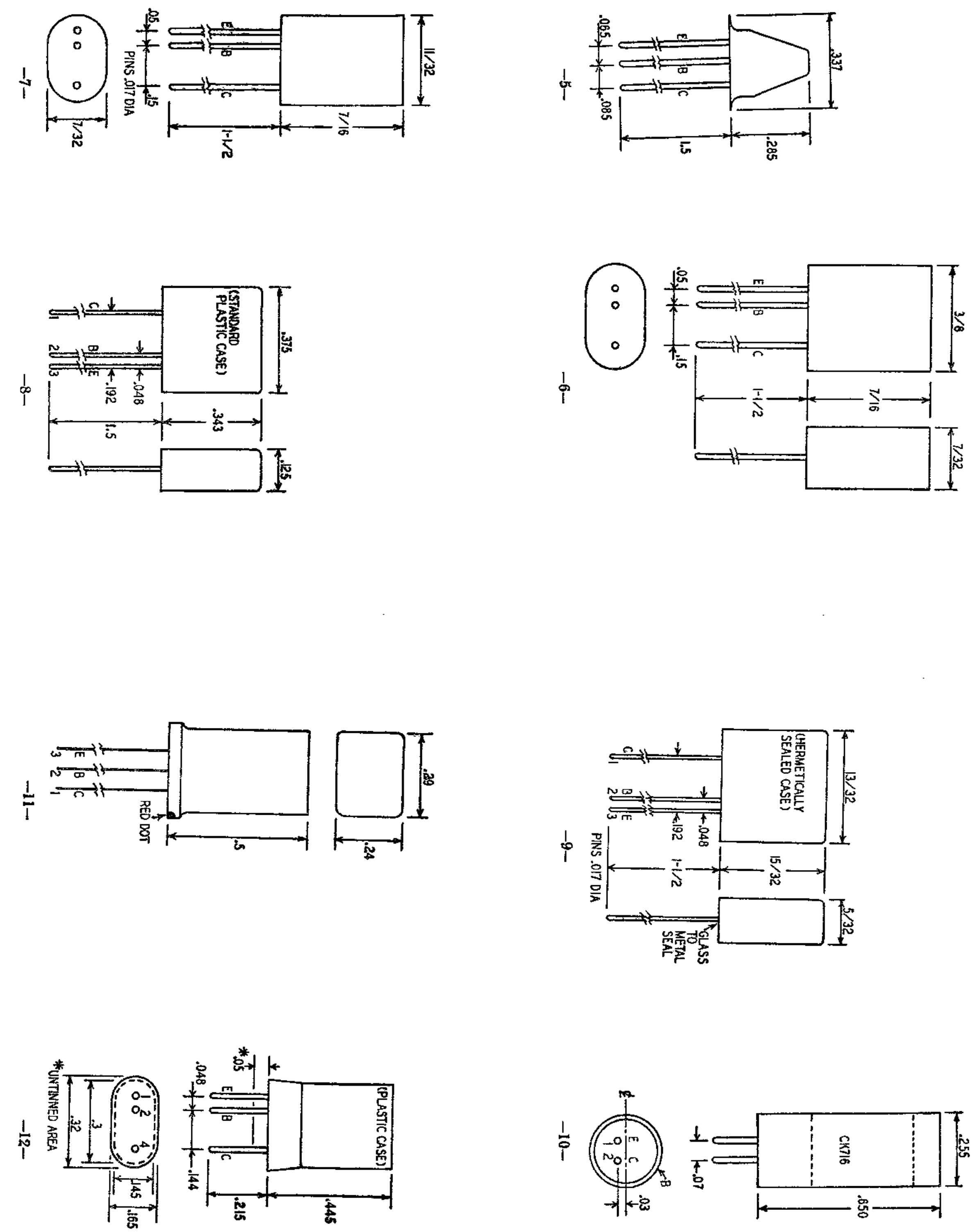
TYPICAL OPERATION, POINT-CONTACT SWITCHES

MANUFACTURER	Type No.	Off Collector Current (ma)	On Collector Voltage (volts)	Rise Time (μsec.)	Turnoff Time (μsec.)	Curr. Amp. a	F_c mc
CBS-Hytron	PT-2S	−1.5 (i_e=0 ma., v_c=−30v.)	−4 (i_e=3 ma., i_c=−5 ma.)		1	2 (i_e=0.05 ma., v_c=−30v.)	
General Electric	G11A	−0.8 (i_e=0, v_c=−15v.)	−2 (i_e=3 ma., i_c=−4 ma.)			2.5 (i_e=.05 ma., v_c=−15v.)	3t
Hydro-Aire	S-1			<0.5	<2		
	S-2			<1	<6		
National Union	T18B	−1 (i_e=0.1 ma., v_c=−35v.)	−2 (i_e=1 ma., i_c=−2 ma.)		1	1.7 on 0.15 off	
Radio Receptor	R1698	−2.2 (i_e=0, v_c=−40v.)	−4 (i_e=3 ma., i_c=−5.5ma.)				1.5
	R1734	−0.7 (i_e=0, v_c=−7v.)	−1.2 (i_e=3 ma., i_c=−4 ma.)				10
Texas Instruments	102	−1.5 (i_e=0, v_c=−30v.)	−1.8 (i_e=1 ma., i_c=−2 ma.)	<0.2	<2		
	103	−1.5 (i_e=0, v_e=−30v.)	−1.8 (i_e=1 ma., i_c=−2 ma.)		>2		
Transistor Products	2C	0 to −1 ma. (i_e=0, v_c=−15v.)	0 to −2 (i_e=3 ma., i_e=−4 ma.)		0.2u	2	2v
	2F	0 to 0.7 (i_e=0, v_e=−15v.)	0 to −1.2 (i_e=3 ma., i_e=−4 ma.)		0.15u	2	5v
	2G	0 to 0.7 (i_e=0, v_e=−15v.)	0 to −1.2 (i_e=3 ma., i_e=−4 ma.)		0.10u	2	10v



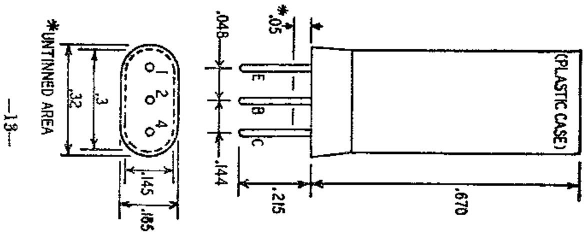
In these outlines, E = emitter; C = collector; B = base. All dimensions are in inches. All illustrations twice actual size.

134

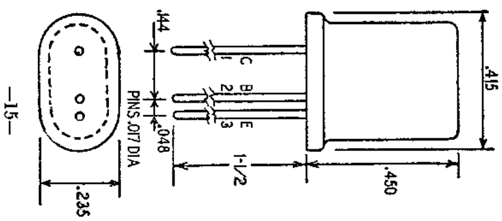


—5—
.065
.085
.337
1.5
.285
E
B
C
—6—
.05
.15
3/8
7/16
1-1/2
7/32
—7—
PINS .017 DIA
11/32
7/16
1-1/2
7/32
—8—
(STANDARD PLASTIC CASE)
.375
.343
1.5
.125
.048
.192
—9—
(HERMETICALLY SEALED CASE)
13/32
15/32
1-1/2
5/32
.048
.192
PINS .017 DIA
GLASS TO METAL SEAL
—10—
CK716
.255
.650
.07
.03
—11—
.29
.5
.24
RED DOT
—12—
(PLASTIC CASE)
.445
.215
.144
.048
*.05
.3
.32
.145
.165
*UNTINNED AREA

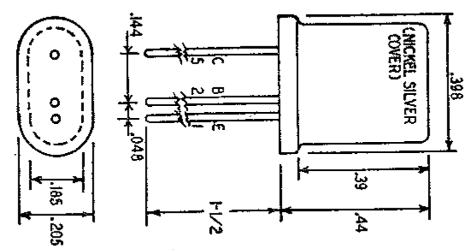
135



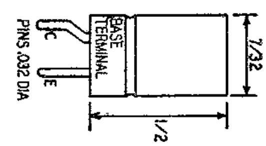
—13—



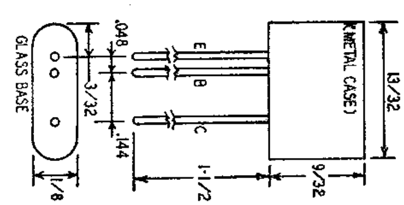
—15—



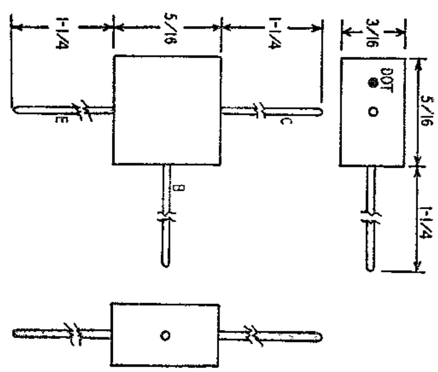
—14—



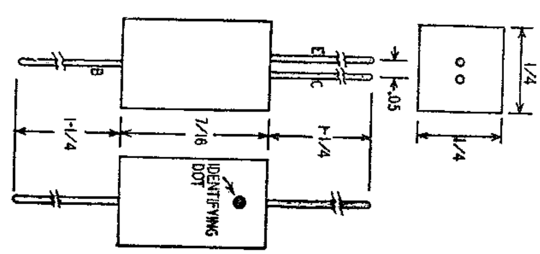
—16—



—17—



—19—



—18—

between two P-type layers in the same block or wafer of germanium. Here, the P-layers are emitter and collector, and the central N-layer is the base. The N-layer is very thin, often 0.001 inch or less. Low-resistance connections to the three layers terminate in pigtails or pins.

The point-contact transistor is seen to resemble the point-contact diode (Fig. 104-c), and the junction transistors the junction diode (Fig. 104-a and Fig. 104-b), with one extra electrode

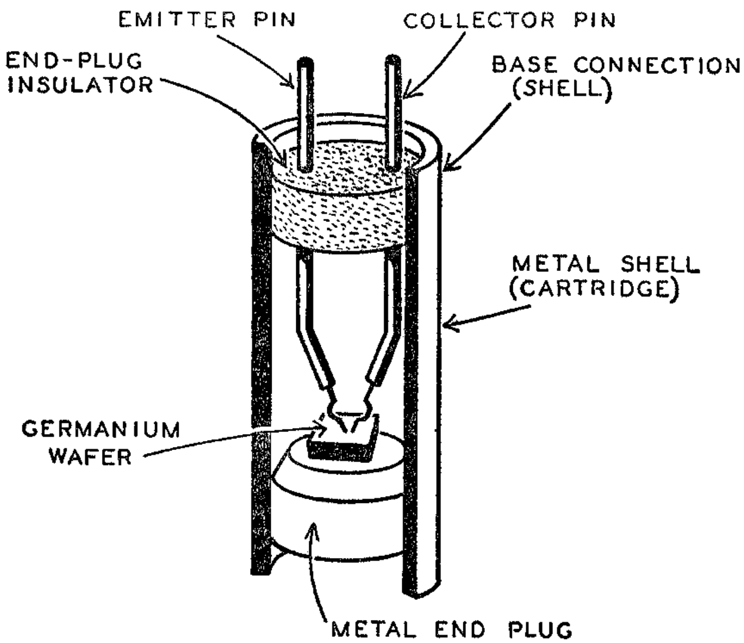
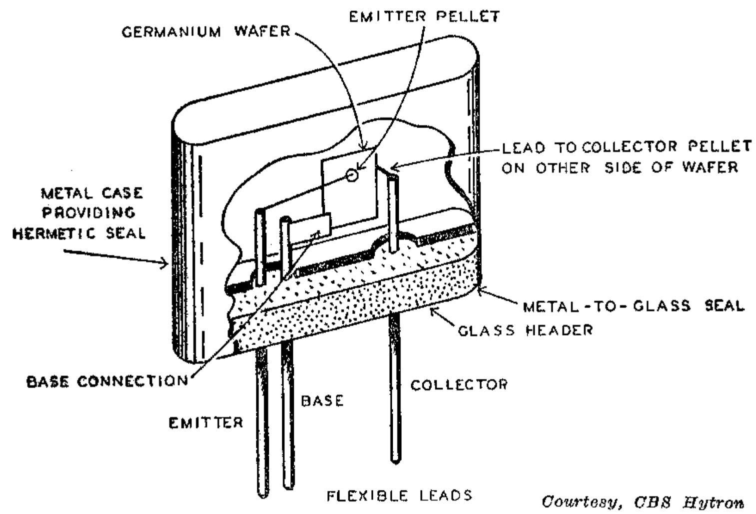


Fig. 204. Cutaway view of point-contact transistor assembly.

provided in each instance. In Fig. 202, the corresponding standard symbol is shown with each type of transitor. Note that the same symbol is used for both point-contact and P-N-P types.

As in the junction diodes, the layers of the junction transistors may be of the grown-type or diffused-type. The grown-type is obtained by adding the required impurities during the process of single-crystal pulling to create the adjacent N and P layers. This is the most difficult type to manufacture. Fig. 203 shows the

cross section of a diffused-junction P-N-P type. Here, a pellet or button of indium (or boron, gallium, etc.) is melted on each face of a thin wafer of N-type single-crystal germanium. Some of the indium diffuses into the germanium from each side, creating P-type regions in the wafer. The process is continued until the separation between the two P-regions is very narrow (say 0.001 inch) but is halted before short circuit occurs. In practical diffused-junction P-N-P transistors, the emitter pellet is somewhat smaller in size than the collector pellet.



Courtesy, CBS Hytron

Fig. 205. Cutaway view showing inner construction details of junction transistor.

Transistors of both types are manufactured to several mechanical designs. Fig. 204 is a cutaway view of one style of point-contact transistor. This type is housed in a metallic cartridge, shell, or barrel and is intended for insertion into a special subminiature socket. The two pins fit into the socket clips, while the transistor shell (base connection) is gripped by the socket ring or spring. The germanium wafer is soldered to the metal end plug or to a metal pin passed through this plug. The plug makes a tight-fit contact with the shell to form the low-resistance base connection.

Fig. 205 is a cutaway view of a junction transistor of one style of construction. Here, the germanium wafer is supported ver-