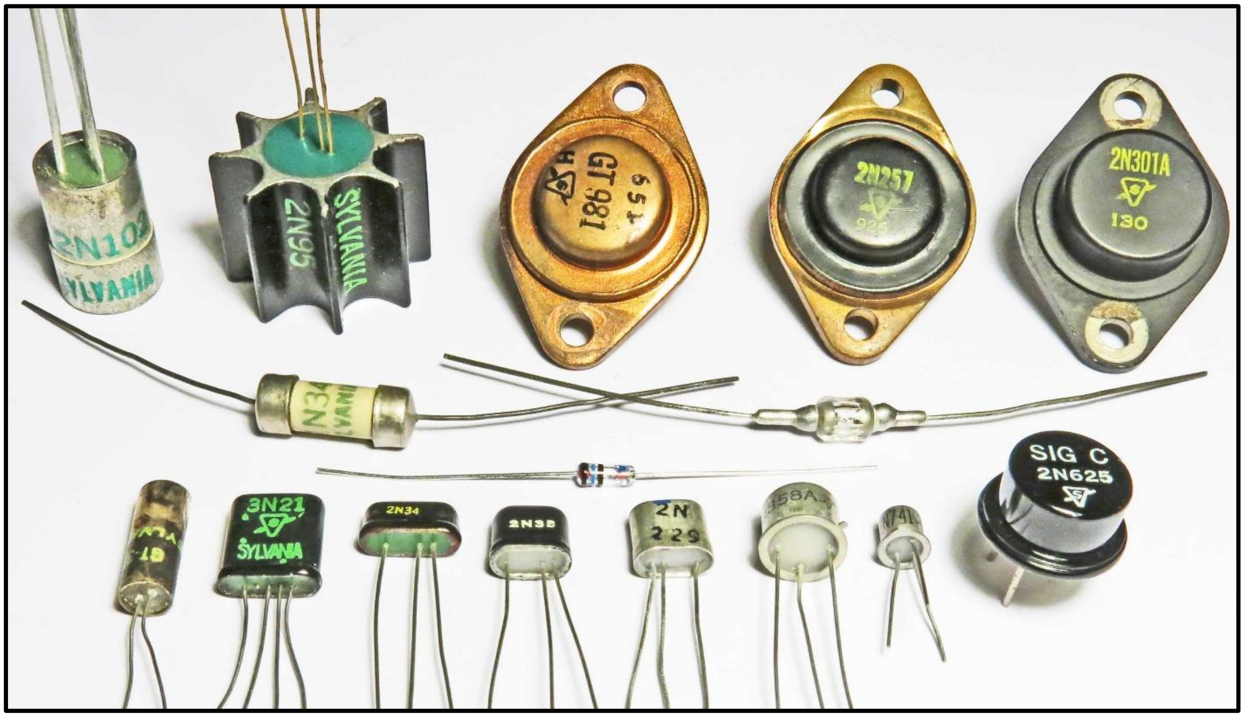
HISTORIC GERMANIUM COMPUTER TRANSISTORS

SYLVANIA



Early Sylvania Semiconductors: Sylvania was one of several large scale 1940s/1950s vacuum tube manufacturers that invested heavily in early germanium transistor technology and later became dominant producers of industrial and commercial transistors (including computer transistors) throughout the 1950s. Shown above are examples of historic Sylvania germanium semiconductors, beginning with the world's first commercial germanium diode, the 1N34, which was introduced by Sylvania in 1946 (see the white ceramic 1N34 marked with green lettering at left in the center row of the photo). Improved versions of this diode technology were developed over the next decade, with examples shown at right and just below the 1N34. Sylvania began experimentation with transistors in the late 1940s and early 1950s, starting with point contact technology such as the GT372 shown at lower left and the pioneering 3N21 junction tetrode. Sylvania was probably best known for commercializing both PNP and NPN germanium junction transistors, with the most popular identified as 2N34 (PNP) and the 2N35 (NPN) – this latter device was produced in large quantities and served as a general purpose NPN device in many commercial applications. Note the multiple case styles of early Sylvania transistors as shown along the lower row of the photo. The 2N229, a low cost experimenter's transistor, used the unique TO-22 oval case which was common for Sylvania transistors from the 1950s. Note also the more common TO-5 case (2N358A) and smaller TO-18 case (2N741) silver units at lower right, and the higher power 2N625 with a black TO-8 case. Sylvania was also well known as a major manufacturer of germanium power transistors. This was a very important market for Sylvania, which supplied a variety of power transistor models and case styles as shown across the top row. Germanium power transistors were widely used in the 1950s and 1960s before the appearance of more reliable silicon devices and Sylvania sold millions of these transistors. The top row of the photograph illustrates the range of 1950s cases and types of Sylvania power transistors, which had become more standardized by the late 1950s/early 1960s with the TO-3 case style shown at upper right.

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Early Sylvania Germanium Semiconductors for Computers: The above ad is excerpted from the December 1953 edition of Electronics magazine and illustrates the early use of Sylvania devices in computers. The large glass cased diode, shown left in the outstretched hand, dates from 1948 when Sylvania introduced the 1N34A, intended to replace the original 1946 ceramic cased 1N34. These early Sylvania diodes saw widespread use in the first vacuum tube computers, including the Whirlwind computer (used ceramic cased 1N34 diodes) and the IBM 701-705 series (used glass cased 1N34A style diodes). Sylvania's first commercial transistors, including the point contact 2N32, the tetrode 3N21 and the junction types 2N34 and 2N35 became available in the early 1950s, just in time for computer companies to begin research of this new technology for use in digital computers.

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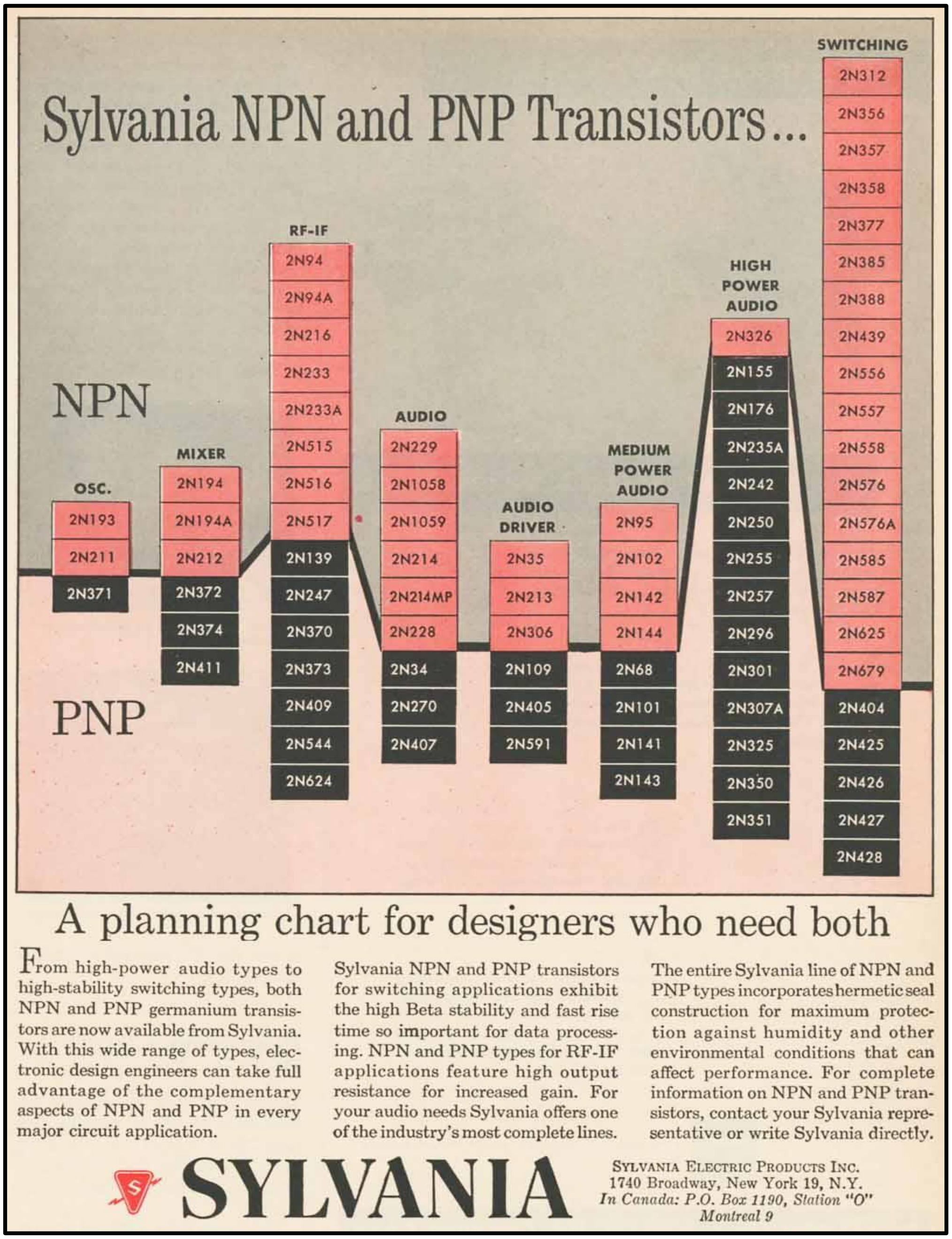

1950s Sylvania Transistors: As shown above in this January 9, 1959 ad from Electronics magazine, Sylvania developed a very extensive line of germanium transistors, with both NPN and PNP types, designed for a wide range of applications. These devices all used alloy junction technology and the list above represents the best of late 1950s germanium transistor types. In less than 10 years after the introduction of its first commercial transistors, Sylvania had become a leading supplier of germanium transistors, including a comprehensive listing of high speed switching/computer types.

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2N229: In the mid-1950s, major electronics manufacturers were interested in expanding their presence in the rapidly growing transistor market – one approach was to salvage "fallouts" from the transistor production lines that did not meet commercial levels of performance, but were adequate for the low cost hobbyist audience. This was a cost effective approach, since the yields from these early germanium transistor production processes were often very low, and large quantities of "fallouts" were available. Three companies were most active in this area - Raytheon (with the CK722), GE (with the 2N107/2N170) and Sylvania (with 2N229). Each of these companies developed hobbyist construction booklets that featured projects using the low cost transistors and this approach found a ready market for the otherwise unsaleable mounds of poor performing "fallouts". The 2N229 was the "fallout" type from the 2N35 and related NPN transistor production lines. The units shown above left were sold in large quantities to Admiral Corporation by Sylvania in the late 1950s for possible use in radio products. Paint swatches (red and blue) were used to indicate performance levels.

2N356/357/358(A): The 2N356/357/358 line of NPN computer switching transistors were initially developed and registered with JEDEC in 1957 by General Transistor Corp. General Instrument Corp updated the JEDEC registrations in the early 1960s to include the more standard TO-5 case style. Additionally the (A) series was added for higher performance specifications. This popular line of germanium NPN switching transistors was second sourced by many companies, including Sylvania. A 1958 Sylvania data sheet lists all three models as available, with a switching speed range from 3 – 9 MCs. The 2N358 was used as a core memory driver in the 1960 SAAB AB SANK-1 prototype computer. The 1961 Lafayette radio Electronics catalog shows a range of prices for this Sylvania line of transistors, with the 2N356 at the lowest price ($3.59) and the 2N358A Navy at the highest price ($7.50).

TRANSISTOR MUSEUM
Historic Semiconductor Data
Device ID: Sylvania 2N229 transistor
Type: Germanium NPN alloy junction
Case Color/Style: Silver metal TO-22
Vintage/Date Code: 1950s/1960s
Use: General purpose/audio amplifier
Notes: "Fallout" device used in hobbyist projects, including basic computer logic.

TRANSISTOR MUSEUM
Historic Semiconductor Data
Device ID: Sylvania 2N356/57/58 transistor
Type: Germanium NPN alloy junction
Case Color/Style: Silver metal TO-5
Vintage/Date Code: 1950s/1960s
Use: Computer switching applications
Notes: Popular line of computer transistors with range of speeds from 3 to 9 MCs.

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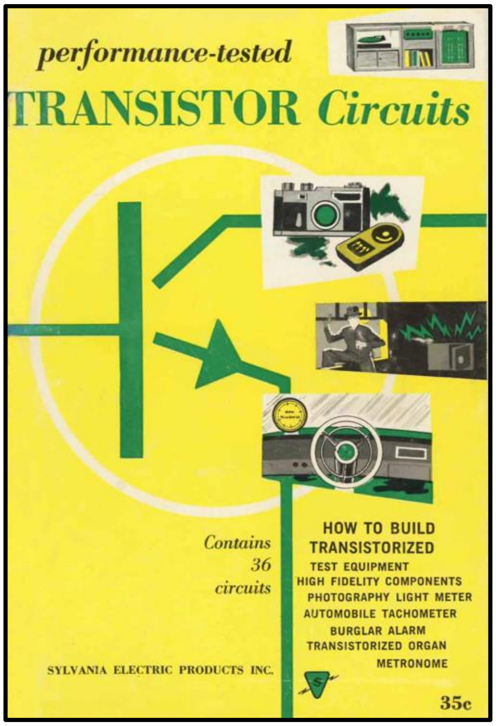

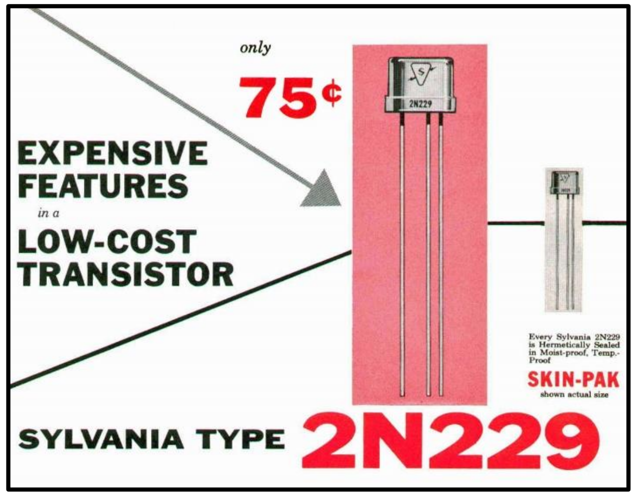

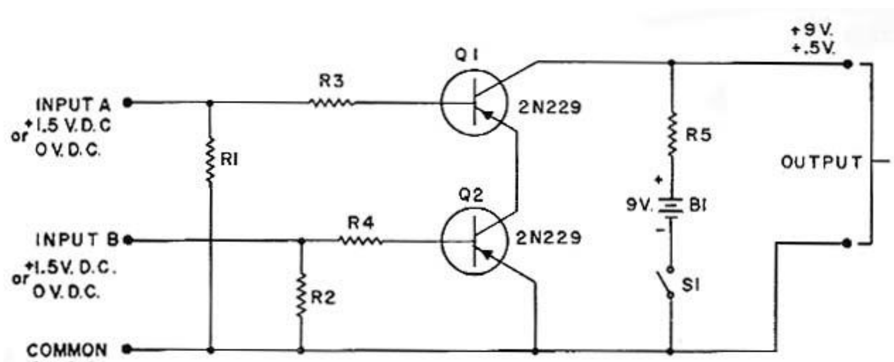

Computer Logic Circuit.

Sylvania Transistor Circuits Construction Book: Sylvania published a number of books documenting various circuits that could be built by hobbyists using Sylvania transistors. The bright yellow cover above left is from a 1958 Sylvania construction book that contained 36 unique circuits (some examples noted on the cover), each requiring Sylvania germanium transistors. Of note is the Computer Logic Circuit shown above as excerpted from pages 11 and 12 of the publication. Circuit description of operation is stated in part as "This circuit can be used to make electronic combination locks or control devices in pre-arranged sequences. A device to test the intelligence of friends could be implemented by this circuit". As can be seen from the schematic above, this is a Direct Coupled Transistor Logic gate, of a type that was used in commercial transistors of the time. The hobbyist type 2N229 transistor was selected for the circuit by Sylvania, likely in an effort to boost sales of these otherwise poor performing "fallout" devices. Above right is a section of a mid-1950s ad offering the 2N229 for only $0.75 each. It would be interesting to develop a small scale hobbyist digital computer using a few hundred of these unique germanium transistors.

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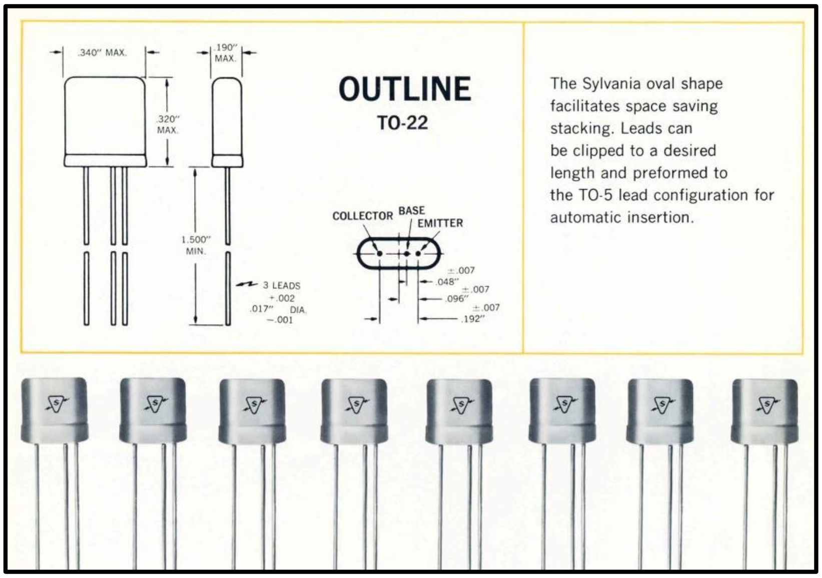

Sylvania Transistor "Unique Oval Shape" and Univac Computer Card: The top scan is a section of a 1964 Sylvania brochure titled: "8 Typical Circuits for Time Tested Sylvania NPN Germanium Alloy Transistors – Oval Shaped for High Stacking Density." Interesting text in the brochure states: " Since 1954, Sylvania NPN Germanium Alloy Transistors have recorded trouble-free performance throughout a broad spectrum of industrial and entertainment applications from satellites to stereos, including mobile communications, business recording equipment, computers, paging systems, electronic medical equipment, industrial power supplies, test equipment, etc. As a measure of its reliability, customer returns have run less than 1/10 of 1%". Also of interest is the discussion of the Sylvania "Oval Shape" TO-22 case style, shown in the brochure. This highly recognizable case style was used extensively by Sylvania in the 1950s and even promoted as "facilitates space saving stacking". The photo above shows a row of eight Sylvania oval shaped transistors used in a Univac File System Computer "495" series circuit card from the mid-1950s. The card in the photo has been backlit to illustrate the simplicity of the wiring connections.

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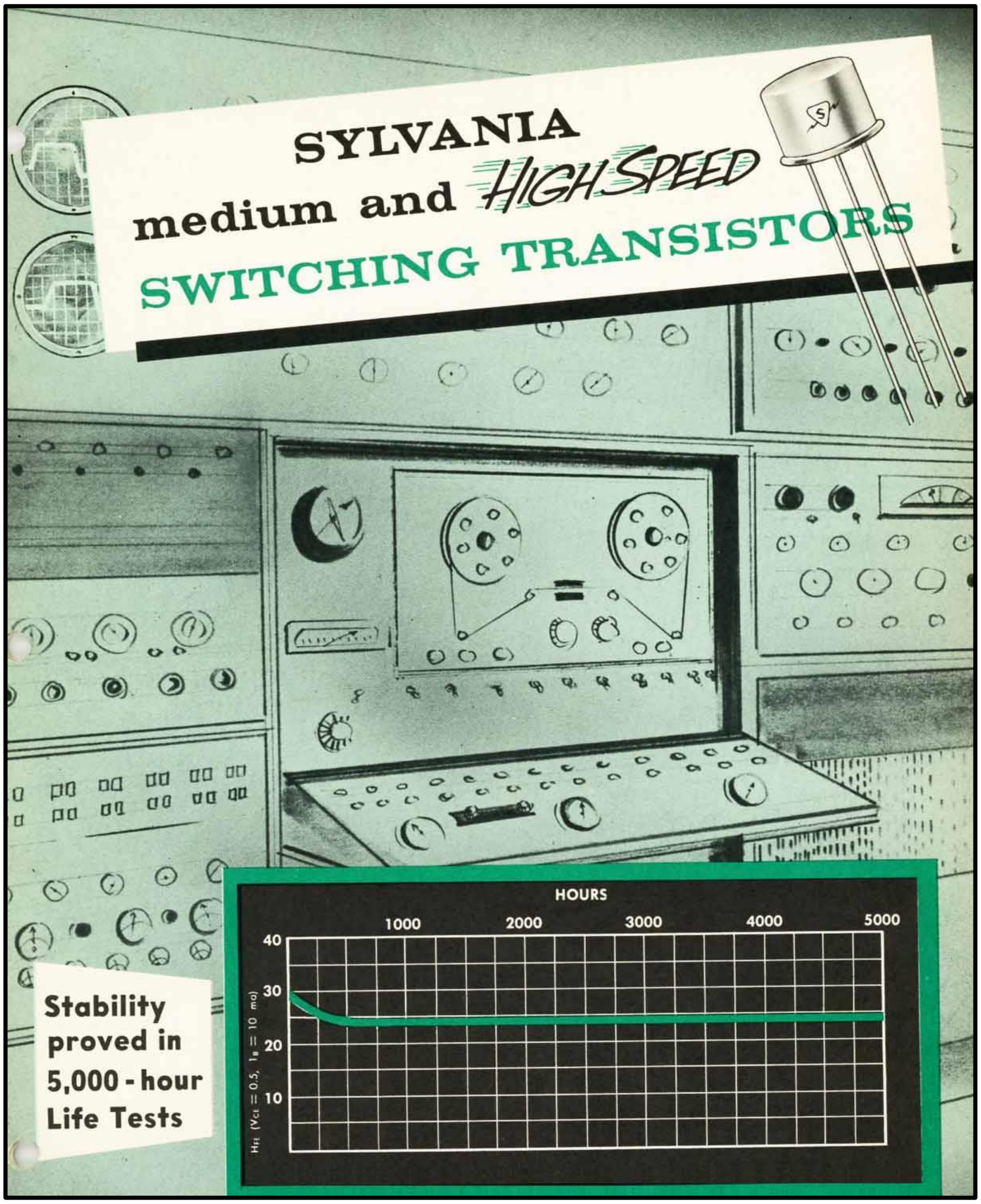

1950s Sylvania Switching Transistors: Above is the cover of a 25 page Sylvania informational publication from 1959 that provided detailed specifications on over 30 different types of NPN and PNP germanium alloy switching transistors available from the company at that time. The late 1950s were the high point in the large scale use of germanium transistors in computer applications, and Sylvania was a major supplier of these devices. This publication lists JEDEC industry standard types, such as the 2N388, 2N404, and 2N425 as well as Sylvania proprietary numbered devices such as SYL 1454, SYL 1717, and SYL 1617. This publication stressed the reliability of Sylvania germanium switching transistors.

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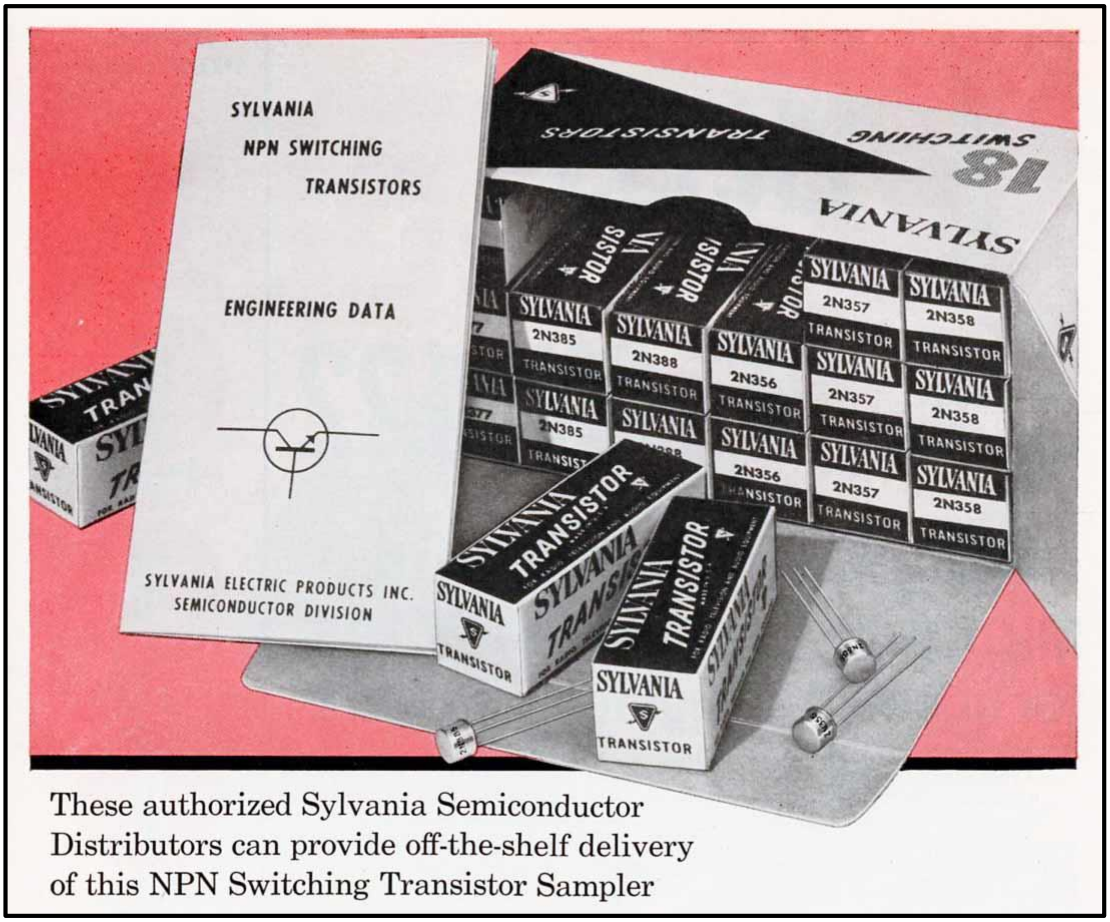

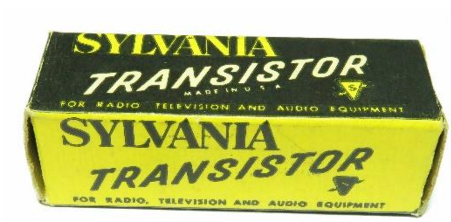

1959 Switching Transistor Kit from Sylvania: Sylvania was heavily promoting its germanium computer switching transistors in the late 1950s. Shown above is a section of an ad from the June 1959 issue of TeleTech magazine which contained 18 of the most popular computer transistors, each individually boxed. Also included was a brochure with engineering data for each of the transistor types supplied with the kit. Although the above ad was only printed in two-tone graphics, the actual kit and contents would have been very colorful. Note the Sylvania packaging shown at right, with distinctive bright yellow and contrasting black colors. The upper package is vintage 1959 and is identical to the packages that would have been included in the switching transistor kit. At lower right is a larger package with similar yellow and black colors that is labeled as "Electronic Tube". Sylvania was a large scale electron tube manufacturer in the 1940s and 1950s and frequently used similar packaging for tubes and transistors.

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Sylvania Transistors Assembled by Hand: The above 1950s industry photo is captioned as follows: "This machine seals the housing in which the transistor's sensitive elements are located. This welding operation is the final seal. This scene is in Sylvania's semi-conductor plant in Woburn, Mass. Final seal welding of Sylvania's transistors for computer applications." These devices appear to be TO-5 cased and are likely Sylvania NPN germanium alloy switching transistors. It is interesting to note that the first transistorized commercial computers from the 1950s used tens of thousands of transistors, with each transistor hand-assembled as depicted above.

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2N625: The 1958 JEDEC listing for the Sylvania 2N625 included a four page Advance Data sheet with a description of the device and specific performance graphs. This transistor addressed a real need in the computer industry of the mid to late 1950s, which was a device capable of driving magnetic core memory cells – this required a medium to high power device that could pass considerable current with a short switching time. The higher current capability also resulted in greater heat buildup, so the unique thick metal TO-8 case was used to aid in thermal dissipation. Development work on the 2N625 is described by C. Huang and C.M. Chang of Sylvania Electric Products, Woburn Mass, in the April 1957 Transactions on Electron Devices. This work was funded with contract support from the Army Signal Corps, and devices built to these specifications were often labeled "Sig C" as shown above. Sylvania also worked under contract with the Signal Corps at this same time to develop the MOBIDIC (Mobile Digital Computer). It is likely that the 2N625 was employed in some versions of MOBIDIC and similar computers that used magnetic core memory. The early versions of the 2N625 were very expensive – for example, the 1960 Radio Shack Buying Guide lists the 2N625 for $36.75, which is equivalent to $300 today.

2N711A/2N741: Texas Instruments registered the 2N711 with JEDEC in 1960, and quickly followed with the improved 2N711A in 1961. Motorola registered the similar 2N741 and 2N741A types in 1960. These companies were leaders in the new high speed transistor type described as "epitaxial germanium mesa". Sylvania, building on its established reputation as a supplier of computer transistors, quickly developed the technical expertise to manufacture these new types in quantity. In 1961, Sylvania introduced its first commercially available germanium epitaxial mesa transistors, the 2N781-4 line of devices, and by 1963 was selling over 30 different types, including many second sourced types such as the 2N711A and 2N741 as shown above. The 1962 Illiac II computer used thousands of germanium epitaxial mesa transistors.

TRANSISTOR MUSEUM
Historic Semiconductor Data
Device ID: Sylvania 2N625 transistor
Type: Germanium NPN alloy junction
Case Color/Style: Black metal TO-8
Vintage/Date Code: 1950s
Use: Computer memory core driver
Notes: Very rare 1950s device developed by Sylvania under Signal Corps contract.

TRANSISTOR MUSEUM
Historic Semiconductor Data
Device ID: Sylvania 2N711A/741 transistor
Type: Germanium PNP epitaxial mesa
Case Color/Style: Silver metal TO-18
Vintage/Date Code: 1960s
Use: High speed computer switch
Notes: High performance 1960s Sylvania germanium diffused base computer devices.

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SYLVANIA engineering data service

ADVANCE DATA SYLVANIA 2N625

Description: The Sylvania Type 2N625 is an hermetically sealed NPN germanium alloy transistor. Its new package design features improved thermal characteristics in a switching transistor.

Intended primarily for core driving applications, this transistor has improved voltage and switching time characteristics.

Company	Device Designation	Material	Polarity	Application	Power Dissipation	Frequency Response	Fabrication Technique
SYLVANIA ELECTRIC	2N1001	Ge	*p-n-p*	medium power audio	7.5 watts @ 25°C case temperature	0.5 Mc f_α	A
	2N1002	Ge	*n-p-n*	medium power audio	3.75 watts @ 25°C ambient temp.	0.5 Mc f_α	A
	2N624	Ge	*p-n-p*	12.5 Mc-20-db a	100 mw @ 25°C ambient temp.		D
	2N625	Ge	*n-p-n*	0.5 a switch	1.25 watts @ 25°C case temp.	$t_r+t_s+t_f=1.5$ μsec	A
	Device 13	Si	*p-n-p*	medium power audio	2 watts @ 25°C case temp.		DEC
	Device 13	Si	*n-p-n*	medium power audio	2 watts @ 25°C case temp.		DEC

Legend: *Materials* Ge—germanium, Si—silicon; *Fabrication Technique* A—Alloy, DEC—Diffused Emitter Collector, D—Drift

Sylvania and the Signal Corps: The 2N625 transistor was developed by Sylvania under contract with the Army Signal Corps. Shown above top is a section of the 1958 JEDEC listing for the 2N625. Also shown above is an excerpt from a 1960 article in the IRE Transactions on Military Electronics identifying the transistors developed by Sylvania under the Signal Corps FY-56 PEM contract. The Signal Corps was very active in the early days of transistor technology in funding companies to develop specific types of devices and to ensure a general state of national industrial preparedness for the potential military use of transistors. The Signal Corps also funded the development of early solid state computers, including the Army MicroPac portable computer shown at left on the cover of the Spring 1961 RCA Electronic Age publication. Sylvania was the prime contractor for several of these early computers, including the legendary MOBIDIC.

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SYLVANIA semiconductor engineering data **2N781**

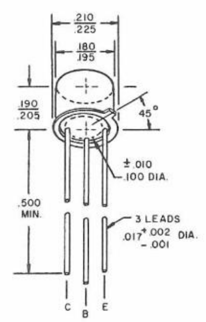
PNP GERMANIUM EPITAXIAL SWITCHING TRANSISTOR

GENERAL DESCRIPTION: The Sylvania 2N781 is a PNP Epitaxial Diffused-Base Germanium Transistor of the mesa design. It is primarily designed for reliable operation in high speed switching applications in the millimicrosecond range. The 2N781 is in the EIA outline TO-18 with welded case and glass-to-metal hermetic seal between case and leads.

ABSOLUTE MAXIMUM RATINGS (25°C):

Collector to Base Voltage, V_{CB}	-15 volts
Collector to Emitter Voltage, V_{CE}	-15 volts
Emitter to Base Voltage, V_{EB}	-2.5 volts
Collector Current, I_C	200 ma
Total Power *(free air)*	150 mw
Total Power *(case at 25°C)*	300 mw
Storage Temperature, T_{stg}	-65° to +100 °C
Junction Temperature, T_j	+100 °C

OUTLINE



B-BASE, C-COLLECTOR, E-EMITTER
COLLECTOR CONNECTED INTERNALLY TO METAL CASE
TAB LENGTH .033 .043
TAB WIDTH .041 ± .003
TAB THICK. .020 MAX.
ALL DIMENSIONS IN INCHES

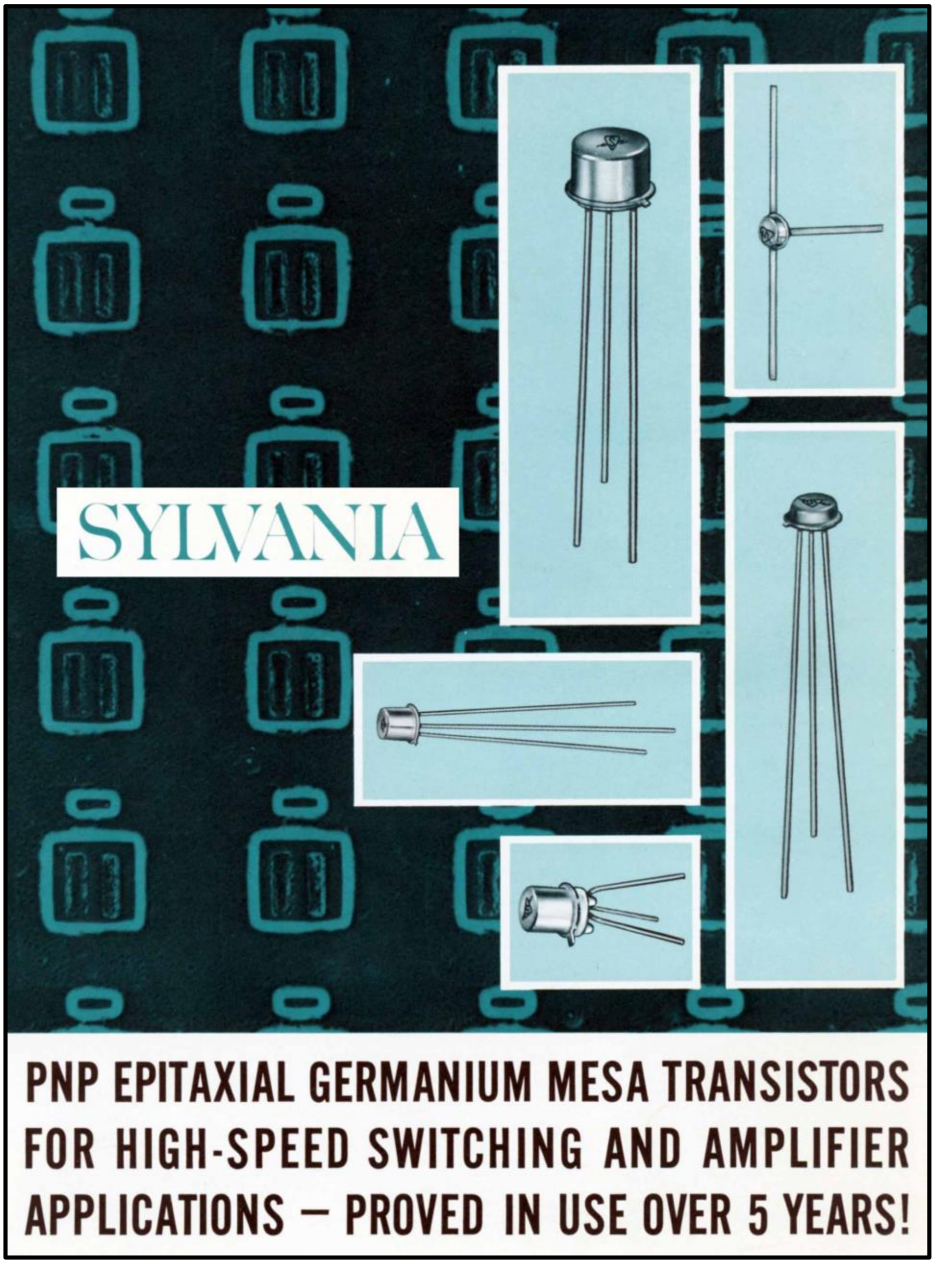
ELECTRICAL CHARACTERISTICS AT 25°C:

	Min	Max	Unit
Collector Breakdown Voltage, BV_{CBO} $I_C = -100$ ua, $I_E = 0$	-15	--	volts
Emitter Breakdown Voltage, BV_{EBO} $I_E = -100$ ua, $I_C = 0$	-2.5	--	volts
Collector to Emitter Breakdown Voltage, BV_{CES} $I_C = -100$ ua, $V_{BE} = 0$	-15	--	volts
Current Gain, h_{FE} $V_{CE} = -0.22v$, $I_C = -10$ ma	25	--	--
Input Voltage, V_{BE} $I_C = -10$ ma, $I_B = -0.4$ ma	-0.34	-0.44	volts
Collector Cutoff Current, I_{CBO} $V_{CB} = -5v$, $I_E = 0$	--	-3.0	ua
Saturation Voltage, $V_{CE}(sat)$, $I_C = -10$ ma, $I_B = -1.0$ ma	--	-0.16	volts
$I_C = -100$ ma, $I_B = 10$ ma	--	-0.25	volts
Turn-On Time, $t_d + t_r$ $I_{B1} = -1.0$ ma, $V_{CC} = -3.5$ v $V_{BE(off)} = 0.5v$, $R_C = 300$ ohms	--	60	musec
Storage Time, t_s $I_{B1} = -1.0$ ma, $V_{CC} = -3.5$ v $I_{B2} = 0.25$ ma, $R_C = 300$ ohms	--	20	musec
Fall Time, t_f $I_{B1} = -1.0$ ma, $V_{CC} = -3.5$ v $I_{B2} = 0.25$ ma, $R_C = 300$ ohms	--	50	musec

Sylvania Electric Products Inc.
Semiconductor Division
Woburn, Mass.
PREPARED & RELEASED BY
TECHNICAL DATA SECTION
MAY 29, 1961

The First Sylvania Epitaxial Mesa Transistors: Sylvania began development of epitaxial mesa transistors in the late 1950s and registered its first devices of this type with JEDEC in 1961. Shown above is the 1961 data sheet for the 2N781, which is a PNP germanium epitaxial diffused-base (mesa) transistor intended for use in switching applications. Sylvania also listed the 2N782, a similar device with slightly lower switching speed, and likely consisting of lower performing units selected by test from the same production line as the 2N781. Silicon technology was also becoming available during this time frame, and Sylvania introduced the 2N783 and 2N784 epitaxial mesa silicon transistors in 1961 in an effort to stay current with technological advances from other semiconductor companies such as Fairchild.

SYLVANIA



1960s Sylvania High-Speed Switching Transistors: Above is the cover of an eight page Sylvania promotional publication from 1963 that provided detailed information on epitaxial germanium mesa transistor technology, including drawings, case style diagrams for five different types of cases, a listing of over 30 different "2N" series transistors of this type available from Sylvania, and circuit schematics for typical high speed switching applications. Note the background image of the cover shown above - multiple squares with two parallel lines in each square. These patterns represent actual mesa transistor structures and illustrate the photo-lithographic nature of the design and manufacture of these devices. Photographic imaging of semiconductor structures and subsequent diffusion and etching to form functional devices was an important process step that was also used on the first ICs that were appearing at this time.

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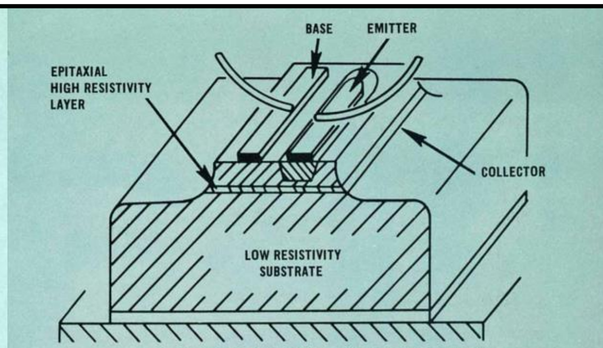

EPITAXIAL DIFFUSED TRANSISTOR CONSTRUCTION

The Sylvania epitaxial structure uses a main collector body region of very low resistivity material with a thin epitaxially grown high resistivity region. This permits a significant reduction of collector series resistance (saturation voltage) and an increase in switching speed (less excess stored charge). Also collector capacitance is reduced through the use of the epitaxially grown high resistivity region.

THE LOGICAL CHOICE FOR YOUR HIGH-SPEED SWITCHING AND AMPLIFIER APPLICATIONS

The versatility and reliability of these transistors make them the popular choice wherever PNP high-speed transistors are required — in commercial and military computer and aero-space applications, communication equipment, industrial controls and other commercial uses.

They meet and beat the toughest mechanical and environmental requirements of MIL-S-19500B, USN 2N962, USN 2N964.

SOME SYLVANIA RELIABILITY TECHNIQUES . . .

Quality control from the initial stages of raw material through finished product can be more rigidly applied as the variable factors are more completely within Sylvania control.

Sylvania developed jigs and fixtures and Sylvania designed equipment are applied with Sylvania developed processes throughout the manufacturing cycle. For example:

. . . precisely controlled diffusion furnaces for introduction of dopants of known purity

. . . control of thickness and resistivity of epitaxial growth layers

. . . uniquely adapted thermal compression bonding procedures

. . . dry box techniques (dew point less than −70°C) for moisture control and anticontaminant protection

. . . automatic computer controlled testing

. . . environmental testing facilities designed by Sylvania to duplicate actual performance requirements

DESIGNED-IN QUALITY AT EVERY STAGE OF MANUFACTURE

These factors, plus the experience and techniques of skilled Sylvania personnel (acquired from the time the first commercially available germanium semiconductor was developed by Sylvania in March, 1945), give the Sylvania epitaxial germanium mesa transistor the *built-in* dependability that industry has come to expect from all Sylvania products.

Sylvania Epitaxial Mesa Transistor Technology Explained: Excerpted for the 1963 Sylvania publication mentioned on the previous page, the diagram at top illustrates the actual physical structure of the mesa transistor, including the geometry of the mesa area and the location of the high resistance epitaxial layer. As noted in the text, this mesa transistor structure results in devices that operate at high switching speed. Other benefits of Sylvania transistors are also discussed, as well as a reference to the fact that Sylvania had almost 20 years of commercial semiconductor experience, beginning in 1945 with the famous 1N34 germanium diode.

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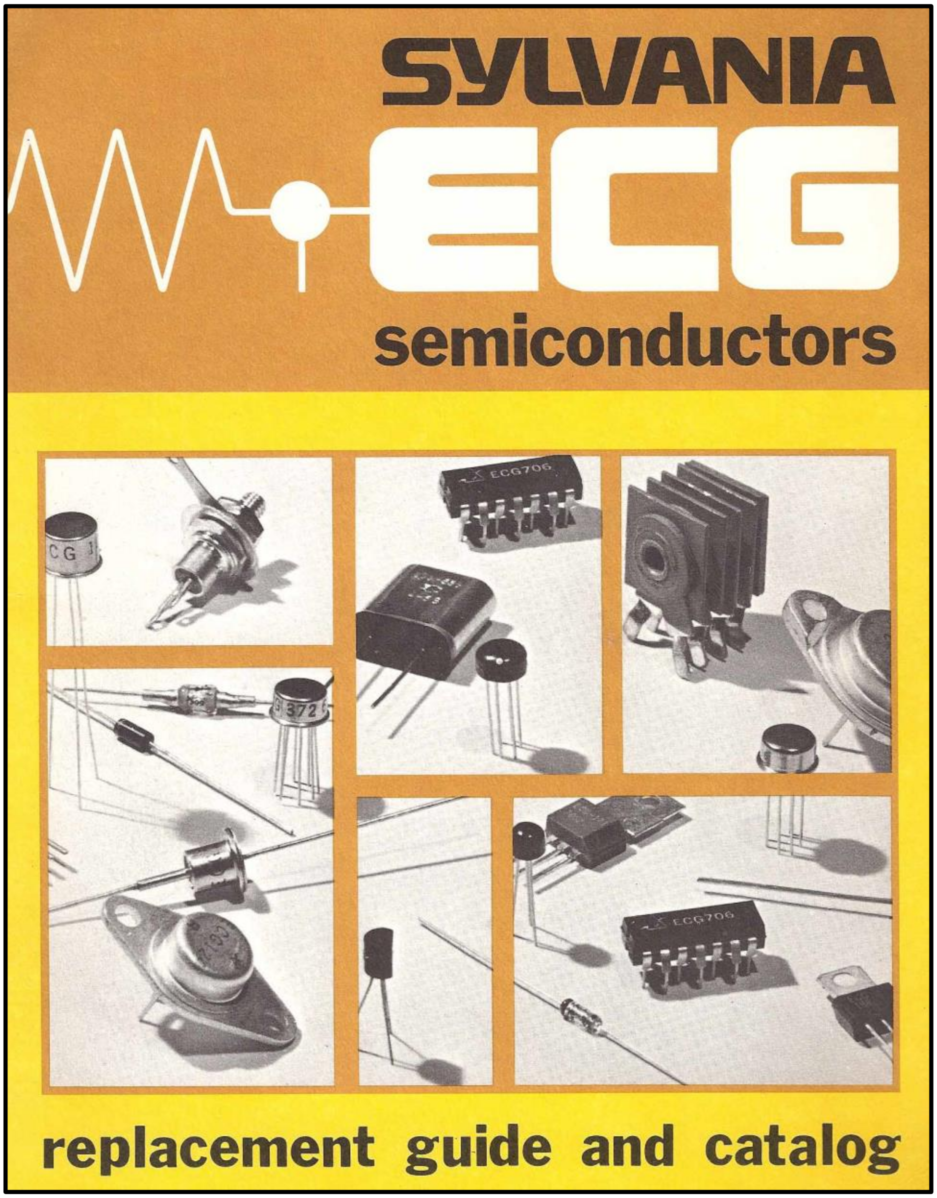
PNP EPITAXIAL GERMANIUM MESA TRANSISTORS
(Amplifier/Switching)

(Type)	Vcb Volts	Ic MA	Power Diss. MW	Junction Temp. °C	General Characteristics
2N501/18	−15	200	150	100	t_{on} = 18nsec, t_{stg} = 12nsec, t_f = 10nsec
2N700/18	−25	50	75	100	f_t = 500 mc
2N705	−15	50	150	100	t_R = 60nsec, t_{stg} = 75nsec, t_f = 80nsec
2N705USN	−15	50	150	100	t_R = 60nsec, t_{stg} = 75nsec, t_f = 80nsec
2N705A	−15	100	150	100	t_R = 75nsec, t_{stg} = 50nsec, t_f = 75nsec
2N710	−15	50	150	100	t_R = 60nsec, t_{stg} = 75nsec, t_f = 80nsec
2N711	−12	50	150	100	t_R = 70nsec, t_{stg} = 100nsec, t_f = 90nsec
2N711A	−15	200	150	100	t_R = 100nsec, t_{stg} = 150nsec, t_f = 150nsec
2N711B	−18	200	150	100	t_R = 100nsec, t_{stg} = 140nsec, t_f = 110nsec
2N741	−15	100	150	100	Gpe at 30 mc = 16db min
2N741A	−20	100	150	100	f_t = 300 mc min
2N781	−15	200	150	100	t_{on} = 60nsec, t_{stg} = 20nsec, t_f = 50nsec
2N782	−12	200	150	100	t_{on} = 75nsec, t_{stg} = 35nsec, t_f = 75nsec
2N828	−15	200	150	100	t_{on} = 70nsec, t_{stg} = 50nsec, t_f = 50nsec
2N960	−15	150	150	100	t_{on} = 50nsec, t_{off} = 85nsec
2N961	−12	150	150	100	t_{on} = 50nsec, t_{off} = 85nsec
2N962	−12	150	150	100	t_{on} = 50nsec, t_{off} = 100nsec
2N962USN	−12	150	150	100	t_{on} = 50nsec, t_{off} = 100nsec
2N963	−12	150	150	100	t_{on} = 60nsec, t_{off} = 120nsec
2N964	−15	150	150	100	t_{on} = 50nsec, t_{off} = 85nsec
2N964USN	−15	150	150	100	t_{on} = 50nsec, t_{off} = 85nsec
2N964A	−15	100	300	100	t_{on} = 50nsec, t_{off} = 85nsec
2N965	−12	150	150	100	t_{on} = 50nsec, t_{off} = 85nsec
2N966	−12	150	150	100	t_{on} = 50nsec, t_{off} = 100nsec
2N967	−12	150	150	100	t_{on} = 60nsec, t_{off} = 120nsec
2N968	−15	200	150	100	t_{on} = 75nsec, t_{off} = 150nsec
2N1141	−35	100	300	100	f_t = 1200 mc
2N1142	−30	100	300	100	f_t = 1000 mc
2N1143	−35	100	300	100	f_t = 800 mc
2N1646	−15	50	150	100	t_{on} = 70nsec, t_{off} = 100nsec
2N1646USAF	−15	50	150	100	t_{on} = 70nsec, t_{off} = 100nsec
2N1853/18	−18	100	150	100	t_{on} = 0.8μsec, t_{off} = 0.9μsec
2N2455	−15	200	150	100	t_{on} = 30nsec, t_{off} = 65nsec, ft = 600 mc
2N2456	−15	200	150	100	t_{on} = 15nsec, t_{off} = 65nsec, ft = 1000 mc
2N2860	−18	150	150	100	t_R = 40nsec, t_{stg} = 120nsec
2N2928	−15	100	150	100	ft = 400 mc

Comprehensive List of Sylvania Epitaxial Mesa Transistors Available in 1963: For a few years from the late 1950s to the mid-1960s, germanium epitaxial mesa transistor technology provided an excellent overall solution to computer manufacturers for high speed performance, reliability, and low cost. The list of these types of transistors available from Sylvania is shown above. These devices were inexpensive and could be designed and manufactured to meet a wide range of specific performance requirements. Sylvania, Motorola and Texas Instruments were the leading manufacturers of these devices. By the late 1960s, silicon planar transistor technology had matured and germanium devices were no longer in demand.

SYLVANIA



Sylvania into the 1970s and 1980s: Sylvania was a major producer of germanium transistors and diodes in the 1950s and 1960s, and competed successfully with a broad range of device types, including transistors designed for high speed switching and computer use. Much has been written about the Sylvania merger with GTE in 1959 and the subsequent large scale corporate changes that followed. By the late 1960s, Sylvania had exited the germanium transistor manufacturing business, and was never able to transition successfully to silicon transistors or integrated circuits technology. However, Sylvania/GTE did establish a successful semiconductor replacement business, relabeling and reselling devices from other companies as replacements for repair of electronic equipment. These replacement semiconductors were branded "ECG" and were marketed from the late 1960s into the 1980s. Shown above is the cover of the 1971 ECG catalog, which listed replacements for over 41,000 JEDEC registered semiconductor types.