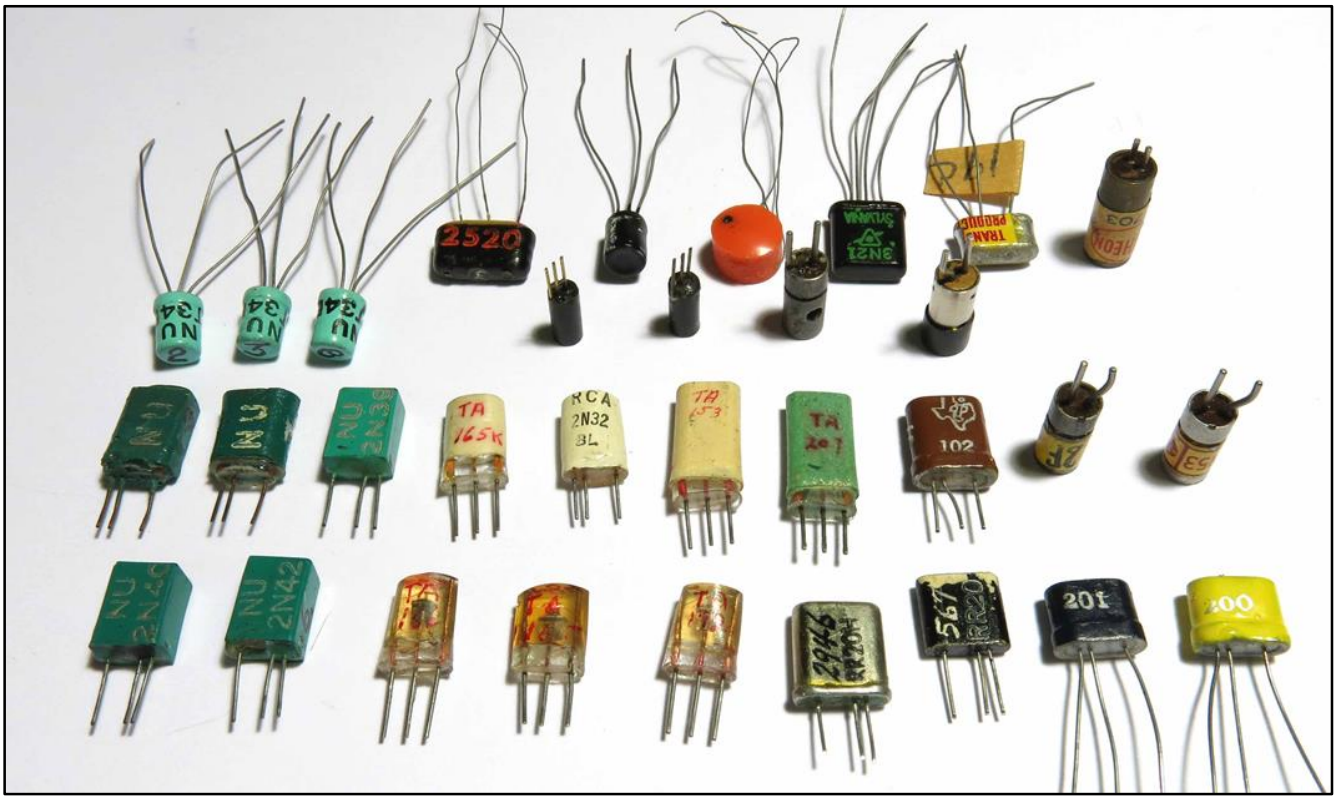
Mr. Jonathan Hoppe
TRANSISTOR MUSEUM DONATION
March 2014

Historic 1950s Germanium Computer Transistors

PROTOTYPE AND LIMITED PRODUCTION DEVICES FROM THE EARLY 1950s

DONATION COMMENTS: "I have in my possession a box with a number of early transistors. My grandfather worked as a Co-op for the Burroughs corporation in the early 1950s and one of his first projects was taking test data from these transistors to document their performance parameters. Some of the tests were recorded on film (stills of the o-scope screen) and are in the box as well. Now if these were commonplace ones I would not be emailing you, but these are far from commonplace. There are quite a few experimental ones, which I do not see listed on your page. I would be more than happy to donate an example of the ones you do not have."



CURATOR'S COMMENTS: The early 1950s, when Jonathan Hoppe's grandfather worked as a Co-op at the Burroughs Corporation, were an exciting time in the history of transistor development. The first commercial transistors were just becoming available, and computer manufacturing companies were eager to evaluate the performance of these crude devices for use in digital circuits. This historic collection provides an unparalleled view into the state of the art from the first days of transistor technology. The Transistor Museum wishes to thank Mr. Hoppe for this generous and historic donation. The following pages provide detailed photos and technical descriptions of many of the transistors from the Hoppe collection. We'll also include links and references for further information on these historic device types.

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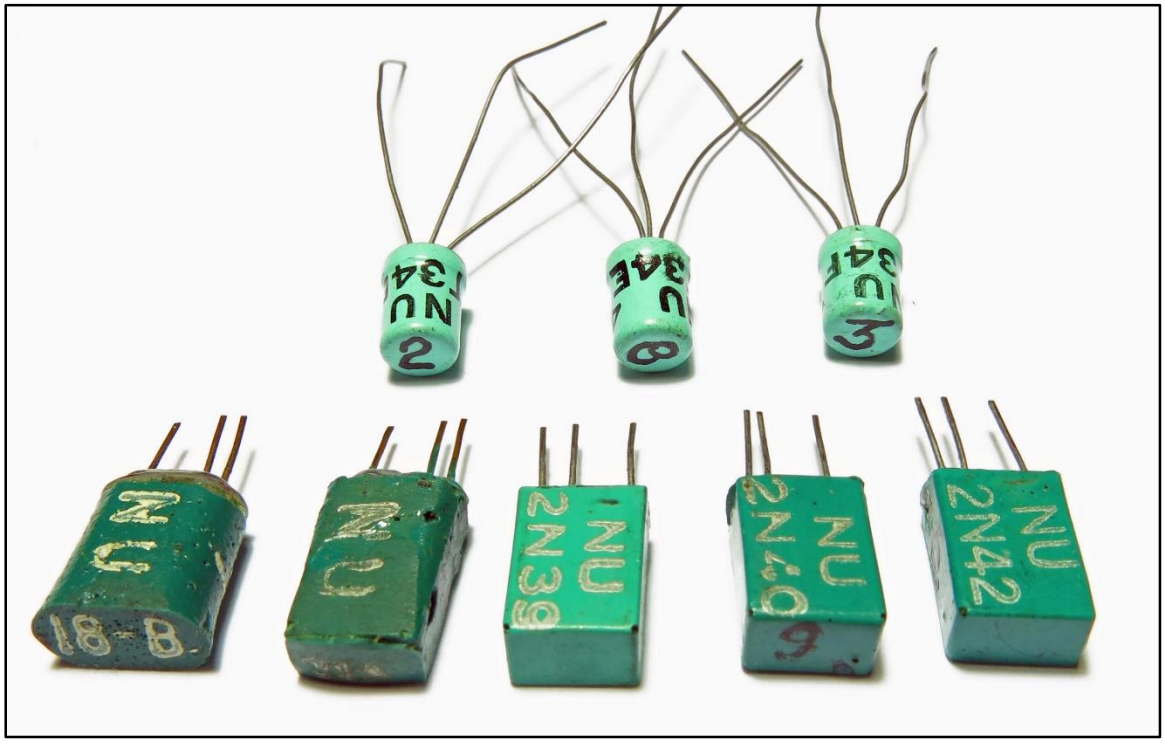

NATIONAL UNION JUNCTION AND POINT CONTACT TRANSISTORS

Top row left to right: T34D, T34E, T34F (Junction types)
Bottom row, left to right: 18-B (Point Contact type) 21-A, 2N39, 2N40 and 2N42 (Junction types)

National Union: The manufacture of both point contact and alloy junction transistors began at the National Union Radio Corp, Semiconductor Division, in Hatboro Pa. in 1952. This is very early in the timeframe of transistor development, and establishes National Union as a pioneer in the history of semiconductor technology. Production of NU transistors ceased in 1954, and the total number of units produced was quite small. Due to the early and brief period of manufacture, and the scarcity of documentation and remaining devices, National Union semiconductor transistors are quite historic.

The Transistors: These early NU transistors were very expensive, with, for example, the 1953/54 edition of the Radio Master catalog listing the T21A for a staggering $61.25, which is over $500 in 2014 value. The T34D, E and F units shown in the top row are T34 production units, selected and labeled based on gain. These smaller cased units were intended for the hearing aid market. The 2N39, 2N40 and 2N42 junction devices were available briefly and in limited quantities during this timeframe. These types were listed as general purpose amplifiers, and likely came from the same production line as the T21 series. The point contact types were manufactured in very low volumes, due to the limited market and the high level of production difficulties with the point contact technology The T18A was listed as an amplifier and the T18B was listed for switching applications.

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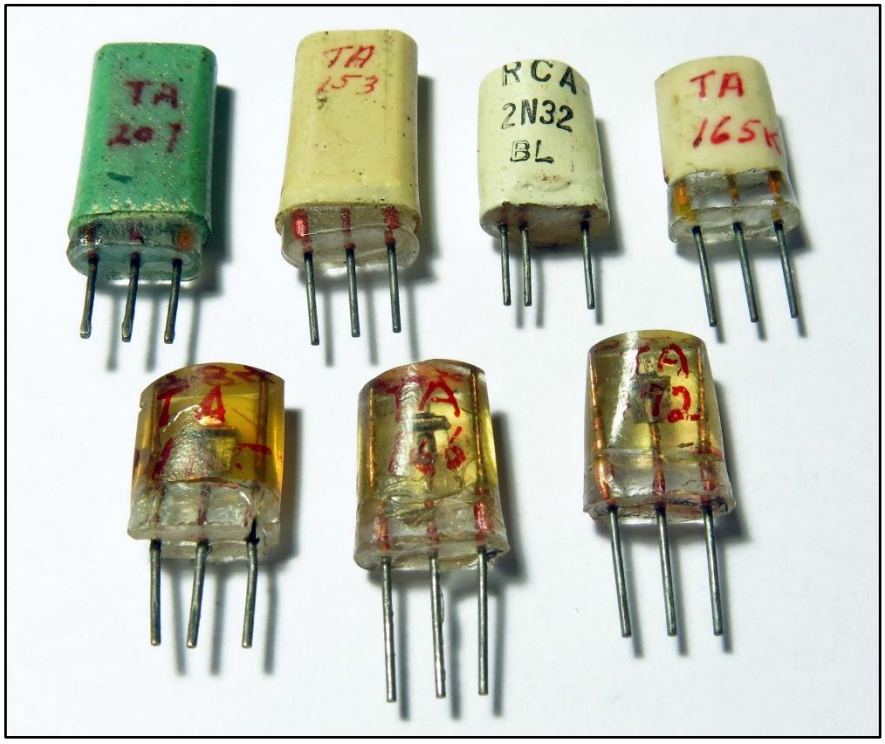

RCA JUNCTION AND POINT CONTACT TRANSISTORS

Top row left to right: TA207, TA153 (Junction types) 2N32, TA165K (Point Contact types)
Bottom row, left to right: TA165, TA166, TA172 (Point Contact types)

RCA: Beginning in 1948, RCA became actively involved in primary transistor research, and introduced commercial versions of both point contact and junction types by 1953. RCA's early transistor patent profile was second only to BTL/Western Electric. Because of this substantial commitment to 1950s transistor research and development, remaining RCA transistors from this timeframe provide a technologically important view into transistor history.

The Transistors: Preproduction/developmental transistors, provided to industry for purposes of further evaluation, were typically designated by RCA as "TA", or Transistor Amplifier. All the above devices fall into this category, except the commercialized "2N32". All the above devices were hand-assembled, and individually tested and/or adjusted. The cases were made from plastic epoxy, and the early molds were medicinal "pill" capsules. The two junction devices (TA207 and TA153) were the basis for the later commercial 2N35 and 2N34 and similar types - green case color was used by RCA to denote NPN types, such as the TA207. The 2N32 shown above is from 1953, very early for a commercial device, and was based on the TA165/66 technology. The remaining units shown above (TA165, TA165K, TA166, and TA172) are all from 1952/53 and are developmental point contact types. RCA used these types in the first experimental all-transistor television set, which was developed at the Sarnoff labs in 1954. These types were also used in experimental digital and computer circuits.

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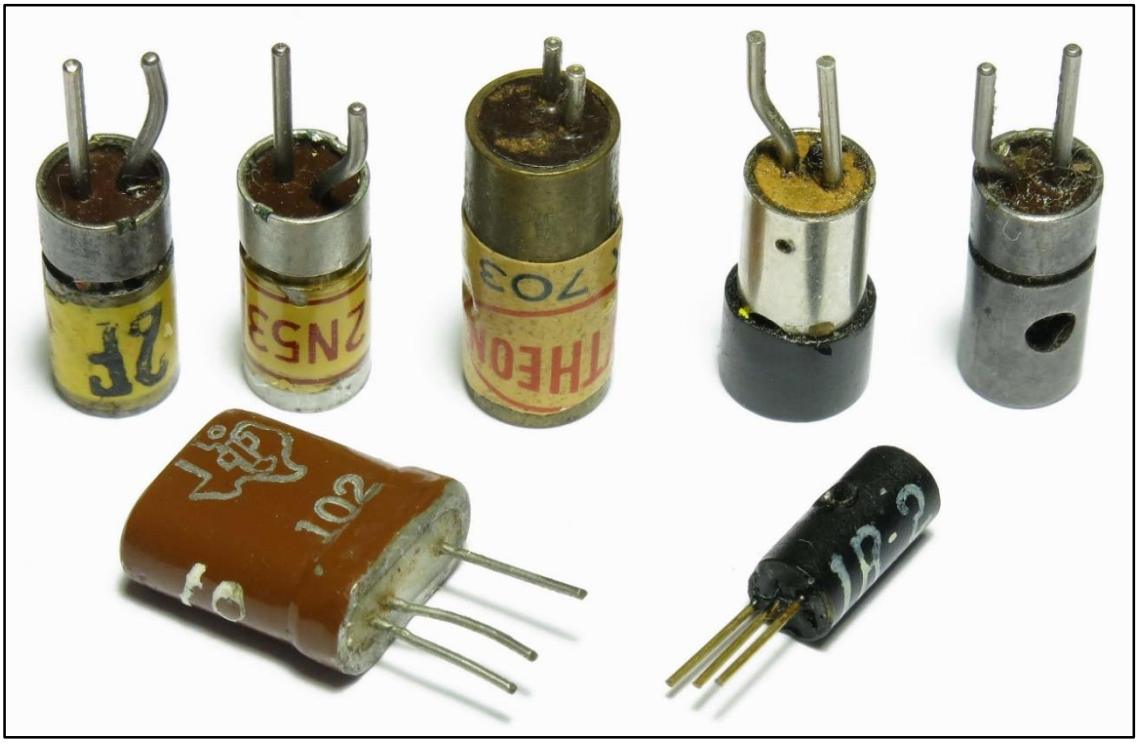


POINT CONTACT TRANSISTORS

Top row left to right: 2F, 2N53 (Clevite Transistor Products), CK703 (Raytheon), 2 unmarked
Bottom row, left to right: 102 (Texas Instruments), G11/11A (General Electric)

Clevite Transistor Products types 2F and 2N53: The two units above are based on the "cartridge type" point contact case design, developed at Bell Labs in 1951 for the first transistor production lines at the Western Electric transistor facility in Allentown. CTP manufactured these types for a very brief period in the early 1950s.

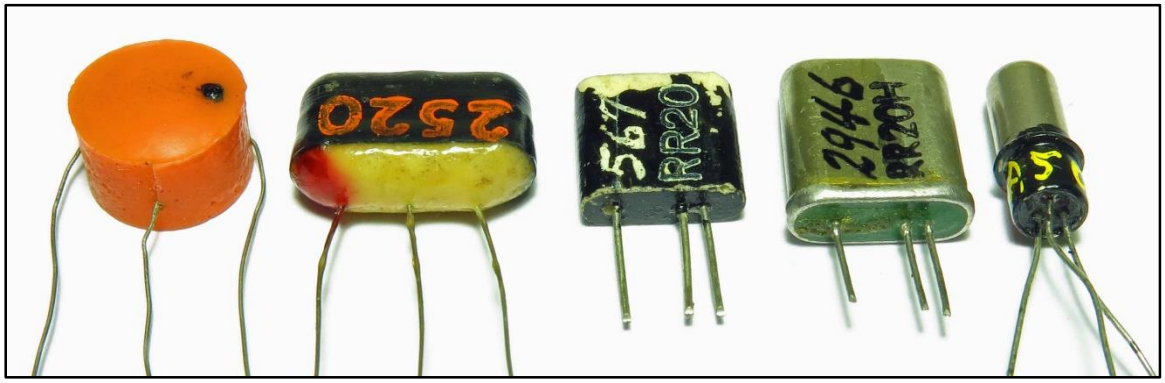
Raytheon type CK703: This is a very historic transistor, as Raytheon was the first company to commercialize transistor technology. The CK703 became available in 1948/49, less than one year after the June 1948 public announcement of the invention of the transistor by BTL/Western electric.

Texas Instruments type 102: TI was selling point contact transistors as early as 1953, with the cartridge types 100 and 101, and the oval case style, type 102 shown above. TI also manufactured germanium junction transistors and became a major industry presence with the first commercial silicon transistors in 1954.

General Electric type G11/11A: GE established an active transistor research program, as early as 1950. The first GE commercial transistors were similar to the type shown above, with early prototypes labeled as SX-4 and Z2, G11/11A and commercialized as 2N30 and 2N31. The above unit is a hand-labeled prototype.

Unmarked types: These units date from the early 1950s, and were likely manufactured by one of the few companies known to have manufactured "cartridge type" devices. This list of companies includes Bell Labs, Western Electric, Clevite Transistor Products, Radio Receptor and Texas Instruments

Historic 1950s Germanium Computer Transistors



JUNCTION TRANSISTORS

Left to right: Unmarked prototype (Westinghouse), 2520 (Germanium Products Corporation), RR20 and RR20H (Radio Receptor), and unmarked (Philco)

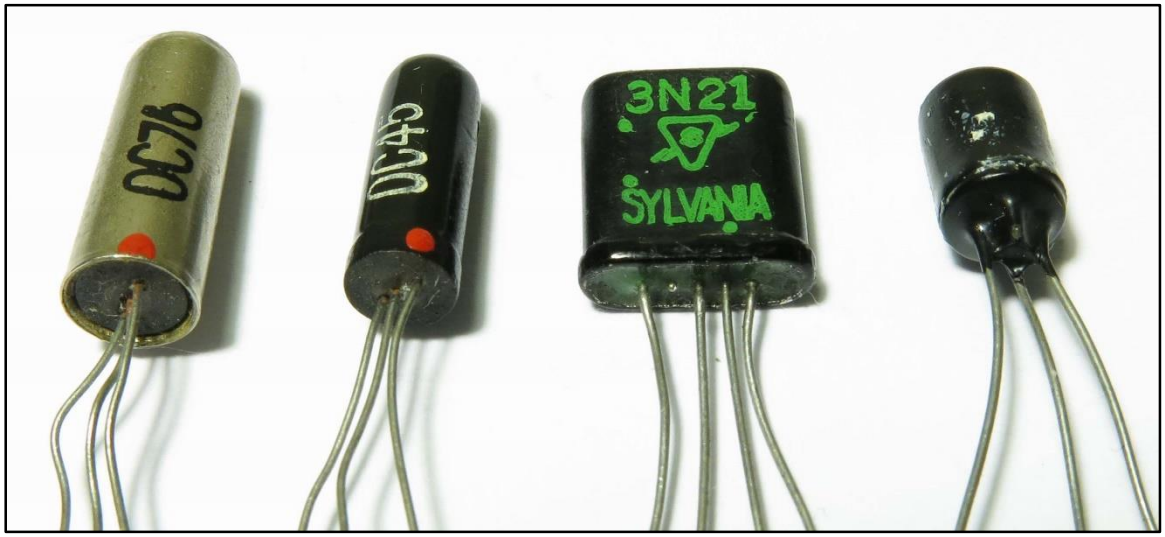
Westinghouse unmarked prototype: Westinghouse developed experimental point contact and junction transistors in the early 1950s. The orange epoxy unit above is from 1953 and was the prototype for the commercialized type 2N54.

Germanium Products Corporation type 2520: The Germanium Products Corporation was one of the first companies to commercialize junction transistors, and has a place in history as supplying the transistors (type 25XX, as shown above) to the Sonotone company to be incorporated in the first commercial device using transistors – the Sonotone 1010 hearing aid.

Radio Receptor types RR20/RR20H: The Radio Receptor company developed and commercialized both point contact and junction transistors in the early 1950s. The units shown above were available in 1953 and were advertised for use as audio or servo amplifiers. The RR20 is plastic cased and the RR20H is hermetically sealed in a metal enclosure.

Philco unmarked prototype: Philco was a major manufacturer of electron tubes when transistor technology first appeared in the late 1940s. Philco invested heavily in transistor research and production, and became one of the largest semiconductor manufacturers of the 1950s. A Philco invention of note is the surface barrier transistor, and related types which were characterized by very high frequency performance and switching speeds. These Philco types were used extensively in early digital computers. The unit above is from the early 1950s and is a surface barrier type.

Historic 1950s Germanium Computer Transistors



JUNCTION TRANSISTORS

Left to right: *OC76*, *OC45* (Amperex), 3N21 (Sylvania), and unmarked

Amperex types *OC76* and *OC45*: Amperex was the US subsidiary of the Dutch company Phillips, and began manufacture of transistors in the US in the early 1950s. The initial Amperex devices used the European device numbering system ("*OC*" instead of "2N"). The Amperex devices shown above are from the 1953/54 timeframe. The *OC76* is the equivalent of the US 2N284 type.

Sylvania type 3N21: Most early transistor types were known as triodes, which meant that the device had three connections or leads (typically identified as collector, base and emitter). The fourth lead was usually identified as "base 2". Early high speed digital circuits sometimes employed tetrodes, as the base 2 lead could be biased in such a manner as to achieve high switching speed performance. The Sylvania 3N21 shown above is a tetrode from this timeframe. These devices are very rare.

Unmarked type: There are no markings on the unlabeled device shown above. The case style is similar, but not identical, to early Clevite Transistor Products junction devices. This device is a PNP germanium transistor, and is still functional.

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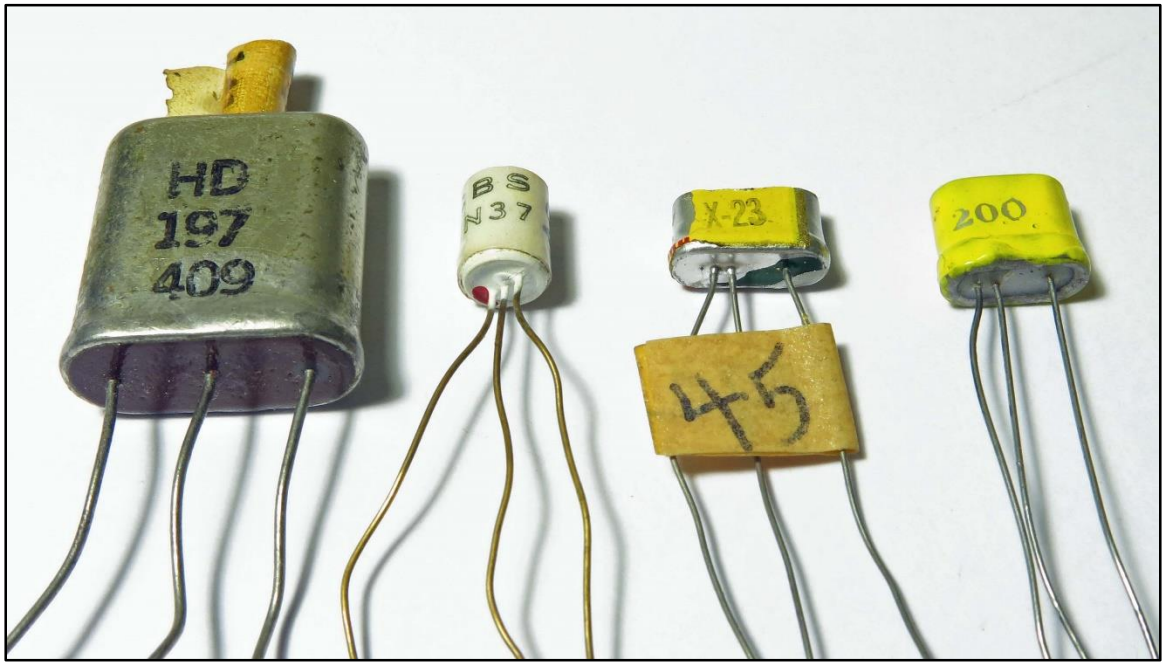


JUNCTION TRANSISTORS

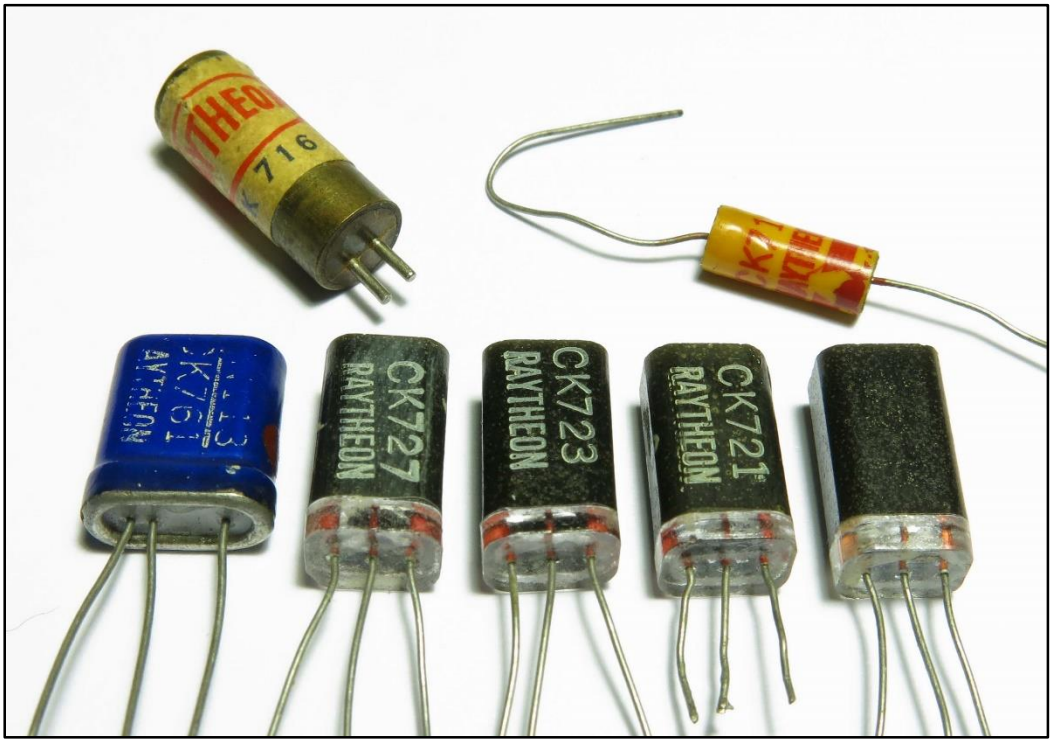
Left to right: HD197, 2N37 (CBS), X-23 (Clevite Transistor Products), 200 (Texas Instruments)

CBS types HD197 and 2N37: CBS was a major manufacturer of germanium power transistors in the 1950s. Widely used CBS power transistor types from this timeframe included the 2N158 and 2N255. The above HD197 is an early CBS power prototype from early 1954. The CBS 2N37 is an alloy PNP low power audio type, similar to CBS transistors used in hearing aids.

Transistor Products type X-23: This device is one of the first junction transistor types developed by "Transistor Products, Inc." and was available in limited quantities most likely for device evaluation purposes. The X-23 type is documented in several industry publications, beginning in 1953, as a junction transistor and was produced for only a year or so. It is an NPN unit, which suggests it was manufactured by the grown junction process developed at Bell Labs in this timeframe. The label on this unit reads "TPI" indicating the device was manufactured prior to the 1953/54 buyout of TPI by Clevite. Any device manufactured by TPI is considered rare and historic, since this small company produced only limited quantities of commercial germanium devices using very early semiconductor technology.

Texas Instruments type 200: Before introducing commercial silicon transistors in 1954, TI manufactured various types of germanium transistors for use in radios and as general purpose amplifiers. The type 200 is an NPN grown junction device from 1953 and was used by various hearing aid companies such as Sonotone.

Historic 1950s Germanium Computer Transistors



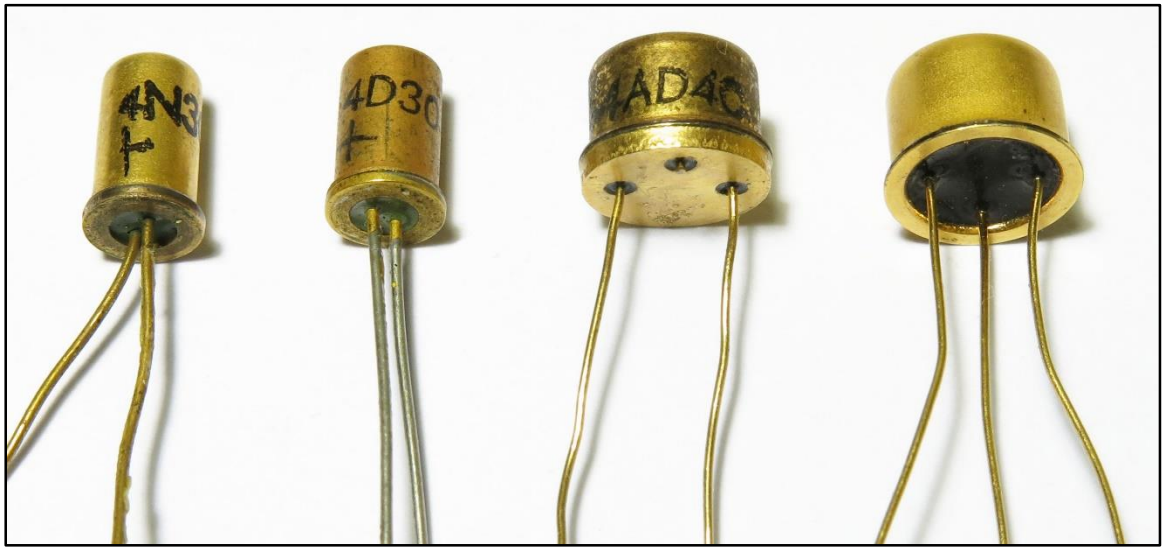
RAYTHEON JUNCTION AND POINT CONTACT TRANSISTORS

Top row left to right: CK716 (Point Contact) CK713 (Germanium diode)
Bottom row, left to right: CK761/2N113, CK727, CK723, CK721, unmarked (Junction types)

RAYTHEON: Raytheon was the early leader in commercializing transistor technology. First with commercial point transistors (in 1948 with the CK703) and the first commercial manufacturer to achieve 1,000,000 transistors shipped (in 1954 with the CK7XX line of junction transistors). Raytheon's early transistor production was largely destined for use in hearing aids, which was a ready-made market for this company - Raytheon miniature and subminiature vacuum tubes had been the market leader for this application beginning in the 1940s.

The Transistors: The CK716 point contact transistor was the second commercial transistor type developed by Raytheon, and was available as early as 1951. The Raytheon CK703 (shown on a previous page) was the first commercial transistor available from any company – the CK716 was marketed as an improved version of the CK703. The four black epoxy cased units all are dated 1954. This style represents the first commercial junction type available from Raytheon, and was used in many hearing aids. These black units were from the same production lines, with the different model numbers (CK721, for example) determined by testing the units individually to measure performance. Unmarked units typically were units that did not meet commercial performance levels, and these were often labeled as CK722, which is well remembered 1950s hobbyist transistor. The blue cased metal unit is from the mid-1950s and represents an improved junction type which achieved higher switching speeds than the early hearing aid type transistors. At upper right is a CK713 germanium diode, dated 1952. Raytheon diodes were manufactured in large quantities for use in radios and tv tuners.

Historic 1950s Germanium Computer Transistors



SHOCKLEY TRANSISTOR 4-LAYER DIODES

Left to right: 4N30D-50, 4D30, 4AD40, unmarked

SHOCKLEY TRANSISTOR CORPORATION: Founded in 1956 as Shockley Semiconductor Laboratory by William Shockley, this historic company is often credited with a number of wide-ranging achievements in early transistor development – for example, this company is often cited as the birthplace of Silicon Valley. See the text *Crystal Fire* by Riordan and Hoddeson for an excellent account of the many historic aspects of Shockley's company. Shockley was one of the three recipients of the 1956 Nobel Prize for the invention of the transistor in 1947 at Bell Labs. The primary product developed and sold by Shockley Transistor Corporation (STC) was a device known as the 4-layer or Shockley diode. This device was intended to replace the millions of switching relays used by Western Electric in the nation's phone system. STC was not successful commercially and the company was sold to Clevite in the early 1960s.

The 4-Layer Diodes: The 4-layer, or Shockley, diode, is a silicon switching device with two leads attached to the two outermost layers of silicon. The primary performance characteristic of the Shockley diode is negative resistance, which is a unique switching function of the device that allows the use of fewer components in a computer switching circuit or oscillator. Silicon technology in the late 1950s was not well developed and as a result, the STC diodes were very difficult to manufacture, with low yields and inconsistent performance. STC used various case styles, as shown above. The two leftmost units are low current devices and were listed as available for approximately $8 each in the 1958 STC price list. The third unit from left is a higher power device. Most unusual is the rightmost unmarked unit. The center lead is not connected to the internal silicon layers, but instead it is connected to the metal case. This configuration is likely an experimental approach to achieve shielding and possibly higher switching speeds. All four units shown above are heavily gold plated, and represent very early production or prototype devices, from 1957 or 1958. Due to the unique historic importance of Shockley Transistor Corporation, and the low number of STC devices actually manufactured, these four units are quite rare and historic.

Historic 1950s Germanium Computer Transistors
Concluding Remarks

Mr. Hoppe's generous donation of samples of the many transistor types evaluated by his grandfather over 60 years ago as a Co-op assignment for the Burroughs Corporation is a "time capsule" that provides an unmatched view into the first days of transistor technology. Most of the transistor companies represented by these devices were in business for only a few years and represent a "who's who" of the first pioneering semiconductor startups that appeared soon after the invention of the transistor at Bell Labs. In a similar manner, the transistor types illustrated by the devices in this collection represent historical types that were produced only as prototypes or in limited production quantities – many of these types are very rare and have not been well documented in the past. The photos and commentary provided in the preceding pages only begins to adequately archive the Hoppe collection. The Transistor Museum will continue to update this material as additional devices and information from this collection become available. The links below have been included to provide Museum visitors with useful references to some of the companies and devices discussed above.

USE THESE LINKS FOR FURTHER INFORMATION REGARDING EARLY TRANSISTOR COMPANIES AND DEVICE TYPES

1. Transistor Museum Photo Gallery: National Union T18-B
2. Transistor Museum Photo Gallery: National Union T21-A
3. Transistor Museum Oral History RCA Bob Slade
4. Transistor Museum Photo Gallery: RCA TA153
5. Transistor Museum Photo Gallery: RCA TA166
6. RCA Transistor History by Mark PD Burgess
7. Texas Instruments Transistor History by Mark PD Burgess
8. General Electric Transistor History by Mark PD Burgess
9. Raytheon Transistor History by Mark PD Burgess
10. Transistor Museum Photo Gallery
11. Transistor Museum Survey of Early Power Transistors by Joe A. Knight
12. Computer History Museum: Invention of the Point Contact Transistor

Check back often to the Transistor Museum website to follow updates to this material and for other important topics relating to transistor history.

Note: Mr. Hoppe maintains a WordPress site to document his wide ranging professional archiving and collecting interests. You can visit his site at this address: hoppejl.wordpress.com