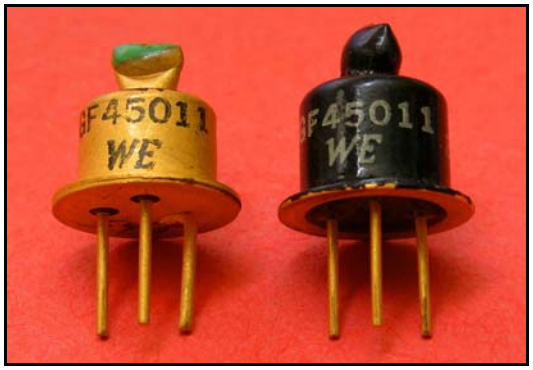
# TRANSISTOR MUSEUM™

## Historic Transistor Photo Gallery


**GA-53233 Handwritten Serial# 1061 (No date)**
**Gold GF-45011 Date Code 2-58**
**Black GF-45011 Date Code 3-59**

# Western Electric GA-53233 and GF-45011 Historic 1950s Vanguard Satellite Transistors

### TYPE
Germanium PNP Diffused Base

### USAGE
Vanguard I Satellite Radio Transmitters

### DATE INTRODUCED
Mid/Late 1950s

### CASE STYLES
Gold/Black Painted

### AVAILABILITY
Rare (Pre-production types)

## HISTORIC NOTES

The Vanguard I satellite was launched and entered earth orbit on March 17, 1958. At this time the U.S. government was in a space race to catch up with the Soviet Union, which had successfully launched the first satellite, the Sputnik I, on October 4, 1957. See reference [8] for a discussion of the Sputnik, Explorer I (launched on Jan 31, 1958) and Vanguard satellites. The success of the early U.S. satellites relied heavily on the newly emerging transistor technology that had begun with the June 30, 1948 public announcement by Western Electric of the invention of the first transistor at Bell Labs. The first transistors, known as point-contact, exhibited characteristics which prohibited their use in satellites - limitations such as very poor mechanical reliability and highly variable performance. In less than ten years, U.S. scientists had improved this initial transistor technology so substantially that satellite usage was feasible. This Photo Gallery article presents the story of the first high performance transistors that transmitted scientific data from the Vanguard I satellite. Also included are references for further review of this exciting milestone in transistor history.

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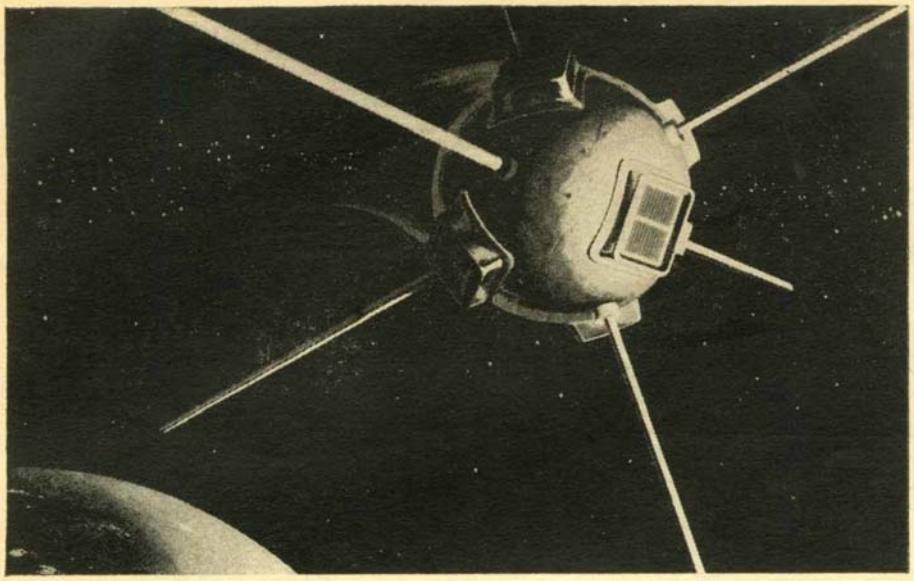
## Western Electric GA-53233 and GF-45011
## 1950s Vanguard Satellite Transistors



On the Vanguard the window-like Solar Batteries turn sunlight into power for a radio.

# What's the news from outer space?

Scientists want a lot of information from the Explorer and Vanguard space satellites—information about temperature, cosmic ray activity, meteorite density and other matters.

Radios in the satellites send back this useful "news" from outer space. Since every cubic inch and every ounce in a satellite is precious, these radio transmitters must be quite small. Bulky vacuum tubes, such as you find in most radios at home, would be too large and heavy for them.

So, instead of vacuum tubes, the radios use tiny transistors, an invention of the Bell System. These do the same job as vacuum tubes, but require much less power as well as room.

There's another Bell System invention in the Vanguards—the Solar Battery, which converts sunlight directly into power for a radio. Those in the satellites were made by Hoffman Electronics Corp., Evanston, Illinois.

The Bell System is proud that its inventions are helping man to explore and understand outer space. We're equally proud, though, to serve you, your family and your community with good, dependable telephone service right here on earth!

Tiny Bell System transistors like this one help the satellites radio vital information back to earth.

BELL TELEPHONE SYSTEM

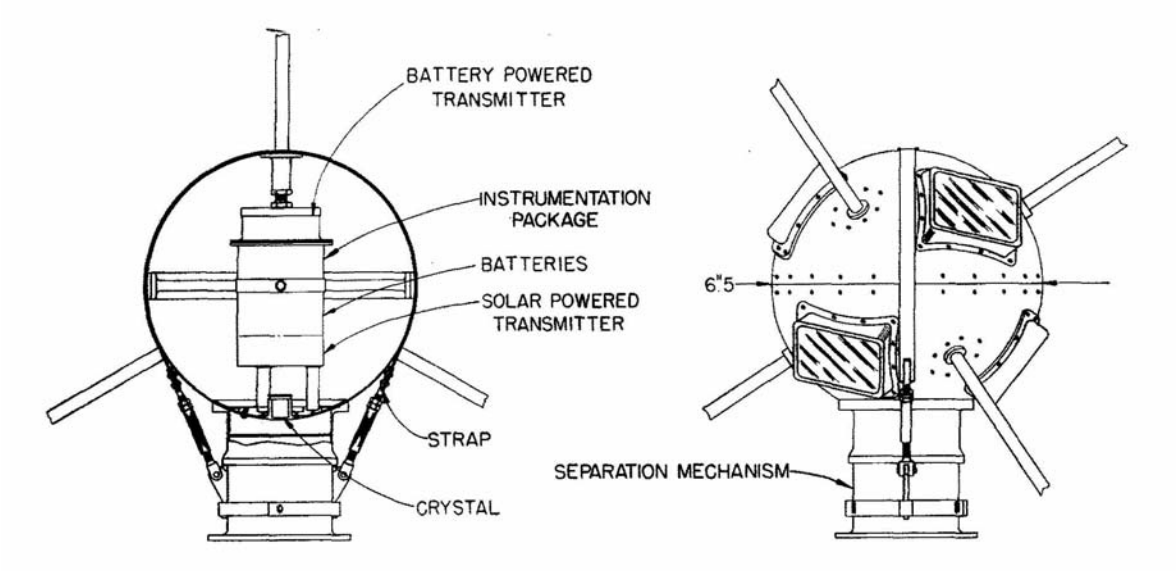
### 1958 Boy's Life

**At left is quite an exciting ad from a late 1950s Boy's Life magazine. By this time, the newly launched Vanguard I satellite was orbiting the earth and transmitting valuable data to scientists and engineers, who were listening to and recording the radio signals from space, powered by two tiny transistors developed at Bell Labs and manufactured at Western Electric. The Bell System was enthusiastic about promoting the new transistor technology to its phone customers, and the exciting use of transistors in the first U.S. satellites was surely an "attention getter. In addition to showcasing the revolutionary transistor technology, the Vanguard satellite also used solar batteries, another Bell Labs invention. The photo of the hand with the transistor is an accurate representation of the GA-53233 and GF-45011 transistors used in the Vanguard I satellite and the 53194 transistor used in Explorer I.**

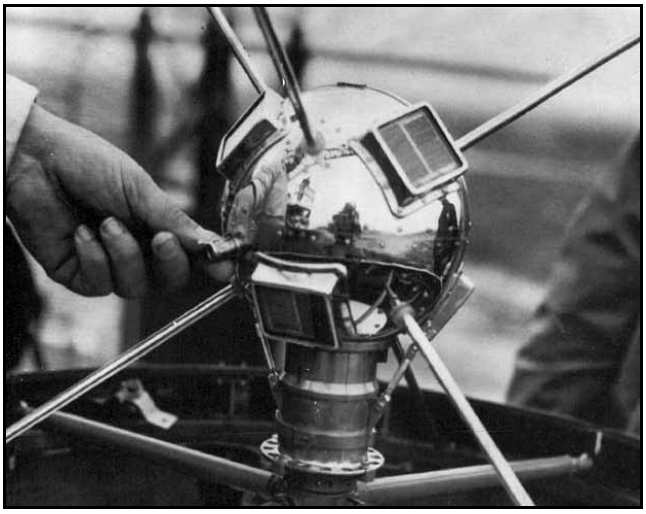
# TRANSISTOR MUSEUM™

## Historic Transistor Photo Gallery

## Western Electric GA-53233 and GF-45011 1950s Vanguard Satellite Transistors




| | |
|---|---|
| Time first in orbit | 7 hr 27 min 21.4 sec EST March 17, 1958 |
| Outer diameter | 6.46 in. |
| Shell material | Aluminum |
| Mass | 1456.7 g |
| Spin half-life | 143 days |
| Transmitters | (1) Battery powered, 108.00 Mc ±4 kc, measured internal package temperature; used type GA 53233 transistor; operated for 20 days |
| | (2) Solar powered 108.03 Mc ±4 kc, measures shell temperature; uses type WE 45011 transistor. Still operating with no deterioration discernible. |
| Antennas | (1) for battery-powered transmitter, 4 radiators in turnstile arrangement. |
| | (2) for solar-powered transmitter, 2 radiators arranged as a dipole. |
| Length of radiators | 12 in. |



**The scan at top, with the Vanguard pictorial layout, and the chart above, identifying the two transistor types used in the transmitters, are from reference [6]. Note that two transmitters were used; the battery-powered transmitter operated for 20 days (when the batteries ran down), and the solar powered unit operated until May 1964 (more than six years after the launch date, March 17, 1958). The satellite is still in orbit!**

### The "Grapefruit Satellite"

**This 1957 photo shows the actual Vanguard I atop the launch vehicle. Weighting in at about 3 pounds, with a diameter of approximately 6.5", this tiny satellite was dwarfed by the 200 pound Soviet Sputnik I. You can find much useful info about the history of Vanguard I at the NRL site established to commemorate the 50th anniversary of the satellite – March 17, 2008. See reference [9] for additional information.**

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## Western Electric GA-53233 and GF-45011
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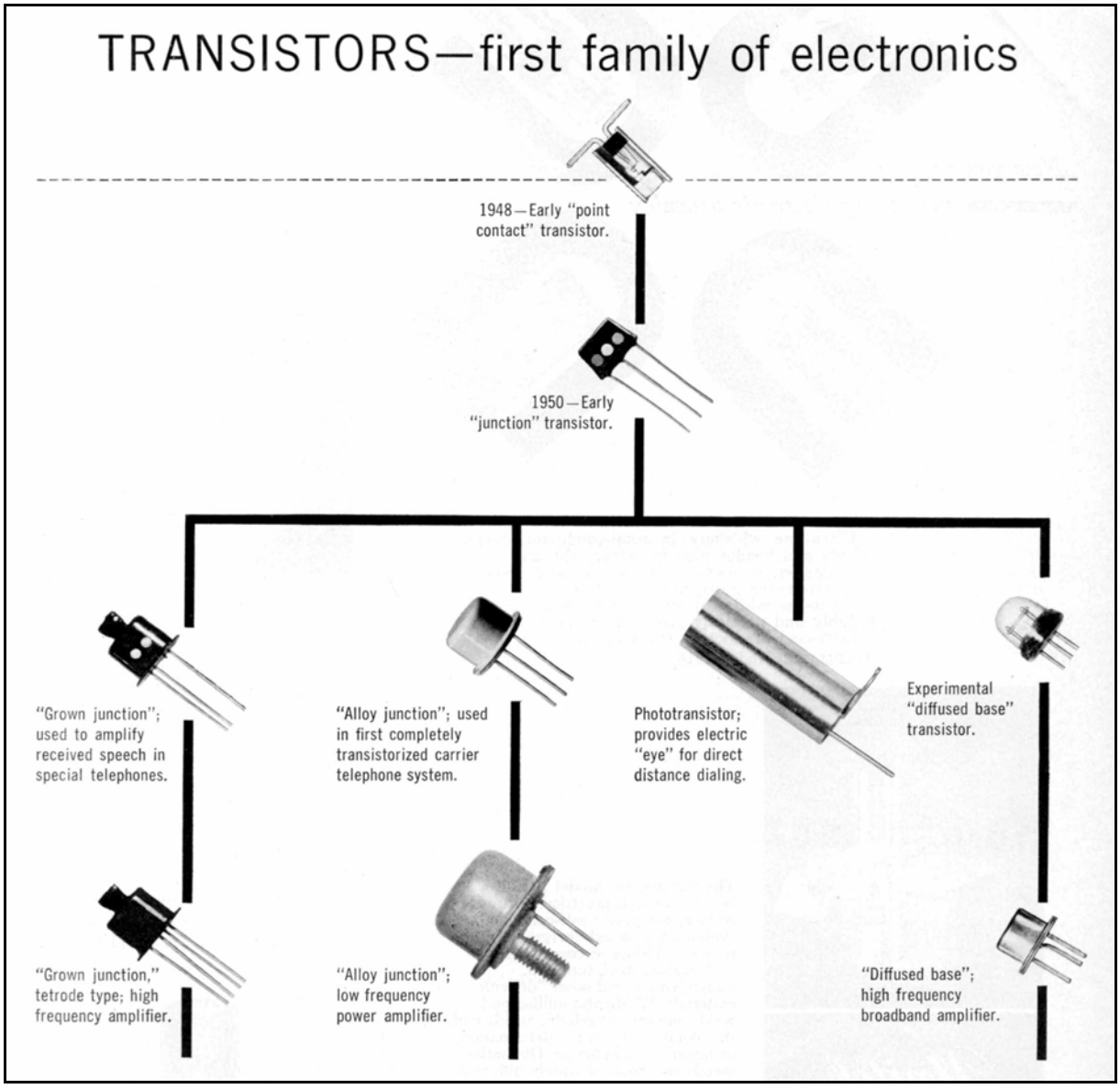



**Ad from Electronics Magazine – August 1956**

**The Bell System was very proud to promote the phenomenal progress in transistor development that occurred in just a few short years after the 1948 announcement of the invention of the transistor. The above Bell Labs transistor "family tree" illustrates the various types of transistors available from Western Electric in 1956. Of all these early types, the 'diffused base" represented the most important improvement in performance and set the stage for the development of modern transistors.**

# TRANSISTOR MUSEUM™

# Historic Transistor Photo Gallery
# Western Electric GA-53233 and GF-45011
# 1950s Vanguard Satellite Transistors

## THE TRANSISTOR
*that smashed a frequency barrier*

A new transistor invented at Bell Telephone Laboratories can provide broadband, high-frequency amplification never before possible with transistors. The big leap in frequency is made possible by a diffusion process that earlier enabled Laboratories scientists to create the Bell Solar Battery.

This transistor is a three-layer semiconductor "sandwich." High-frequency operation is obtained by making the central layer exceedingly thin. This had previously been difficult to do economically.

The new diffusion process, however, easily produces microscopic layers of controllable thickness. Thus it opens the way to the broad application of high-frequency transistors for use in telephony, FM, TV, guided missiles, electronic brains and computers.

The new transistor shows once again how Bell Laboratories creates significant advances and then develops them into ever more useful tools for telephony and the nation.

Scientist checks temperature as arsenic vapor diffuses into germanium, creating 4/100,000-in. layer.

**Ad from Bell Laboratories Record – February 1956**

**A major breakthrough in early transistor technology was accomplished by Bell Labs in 1954/55 with the development of diffused base transistors – see reference [2]. Using chemical diffusion to fabricate a very thin transistor base layer (50 millionths of a inch), very high operating frequencies could be achieved reliably. High frequency capability, low power requirements and the reliability of diffused transistors meant that these devices would be ideally suited for use as earth satellite transmitters. Production units were available in 1957 to support the Vanguard and Explorer programs.**

# TRANSISTOR MUSEUM™

## Historic Transistor Photo Gallery

## Western Electric GA-53233 and GF-45011

## 1950s Vanguard Satellite Transistors

# Berks Beep

## *Transistor Made by Western Electric at Laureldale Sends Scientific Data to Earth From the Explorer*

By MOYLAN C. MILLS
Eagle Staff Writer

FROM 200 to 1,700 miles above the earth, traveling at more than 18,000 miles per hour, a tiny transistor made at the Western Electric Co.'s Laureldale plant is sending out a constant "beep" signal from the nation's first earth satellite, the Explorer.

The ¼-inch square diffused base germanium transistor is the only one of its kind now being manufactured in the United States with the high power and high frequency capable of transmitting messages from the satellite to receiving stations in the United States.

According to Leslie C. Jarvis, manager of the plant located at Marion and Vine streets, Laureldale, the transistor has the unique capacity of being able to transmit signals on the high 108.3 megacycle frequency being used by the Explorer transmission system.

### *Cites Transistor's Value*

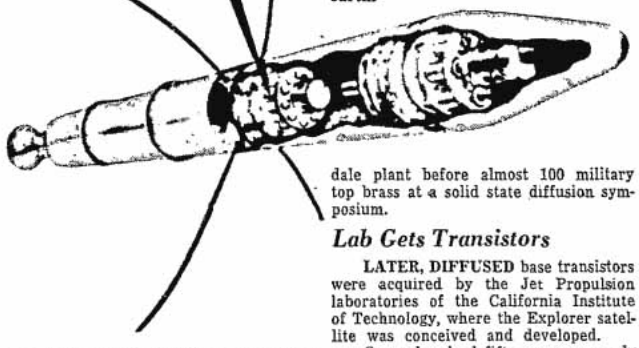
**JARVIS EXPLAINS,** however, that other manufacturers probably are developing similar high frequency transistors.

He points out that the values of the diffused base germanium transistor are its ability to transmit data at high frequencies and its high standard of reliability. Also, the transistor is subject to easy oscillation rate control.

All of these attributes count for its use in the Explorer's high power transmitter, Jarvis notes.

In the Explorer, the diffused base transistor transmits the following data: Pressure, temperature and densities of matter in outer space; the strength of the earth's magnetic field and information concerning the ultraviolet spectrum of the sun and cosmic radiation.

Transmitter contains transistor made in plant at Laureldale.



This drawing shows the location of the high power transmitter in the Explorer. A Western Electric transistor in the transmitter sends signals to the earth.

**THE LAURELDALE** transistors also have been installed in the U.S. Navy's satellite hope, the Vanguard, which has not yet been orbited.

It all began back in 1947 when technicians at the Bell Telephone Research Laboratories invented and patented the first transistor.

In October 1955 the initial engineering effort on the diffused base germanium transistor was started at the Laureldale plant. The transistor was researched and designed at the Bell Laboratories in Murray Hill, N.J. The manufacturing research was accomplished at the Laureldale plant.

On Jan. 12, 1956, the diffused base transistor was unveiled at the Laureldale plant before almost 100 military top brass at a solid state diffusion symposium.

### *Lab Gets Transistors*

**LATER, DIFFUSED** base transistors were acquired by the Jet Propulsion laboratories of the California Institute of Technology, where the Explorer satellite was conceived and developed.

Seven hundred fifty persons, nearly 700 of them from Berks County, are assisting in the manufacture of members of the transistor family at the plant. Recently a Bell Laboratory group was located on the premises, facilitating liaison between research and manufacturing groups.

Future diffused base transistors will be one-fourth the size of the Explorer transistors capable of even higher power and higher frequency than the one now orbiting the earth approximately every 114 minutes.

**JARVIS, WHO** is the guiding light of the plant operation, resides at 1427 Van Steffy Ave., Wyomissing. He was associated with Western Electric's Allentown facility before he was transferred to Laureldale in 1953.

John N. Garber, plant comptroller, who is second in command, came to Laureldale when the plant was established in June 1952 in the former Rosedale Hosiery Mill buildings. Garber resides at 50 Wyomissing Hills Blvd., Wyomissing Hills.

Directly connected with the success of the diffused base transistor are assistant superintendents of engineering, Frank P. Lyons, 708 Warren St., and Glenn L. Prudhon, 1215 Cleveland Ave., Wyomissing. Lyons has been associated with the plant since it was established in 1952, and Prudhon has been with the firm since 1955.

### *Sponsored by Signal Corps*

**ALTHOUGHT THE LAURELDALE** plant manufactures several thousand members of the transistor family each month, it produces none for commercial purposes. The plant is a Western Electric facility sponsored by the U.S. Signal Corp. to manufacture items for the Defense Department.

The sole purpose of the plant is to turn out transistor items for military use. In addition to military installations, its customers include other firms doing military work, such as Douglas Aircraft Co. and the Chrysler Corp., and schools involved in military research, such as the Massachusetts Institute of Technology and the Universities of California, Alaska and Illinois.

**LAST MAY, THE FIRM** leased the half-block long, three-story building owned by Karl Lieberknecht, Inc., at Marion and Vine streets and is renovating the premises to provide facilities for a considerable increase in production.

Even though Western Electric employes are accustomed to producing transistors for military projects, such as high speed missile systems, a subdued feeling of exultation was evident in the plant after the first U.S. satellite started beaming a signal toward earth nine days ago through its transistor made in Berks County.

**Reading Eagle Newspaper Article - Feb 9, 1958**

**The above article from the Reading Eagle newspaper proudly describes the accomplishments of the Western Electric transistor manufacturing facility located in nearby Laureldale (in Berks County, Pa.) The Laureldale plant was established in 1952 with funding from the Army Signal Corps for the sole purpose of semiconductor manufacturing for the U.S. government and military contractors. Note the reference to both the Explorer and Vanguard satellites. The GA-53233 and the GF-45011 transistors used in Vanguard I and the F-53192 used in Explorer I were manufactured at the Laureldale facility.**

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# Western Electric GA-53233 and GF-45011
# 1950s Vanguard Satellite Transistors

**TABLE I—Commercially Available Transistors Operating Above 300 Mc**

| | | | Absolute Max Ratings at 25 C | | | | | Typical Parameters at 25 C | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Type and Mfr. | $f_{\alpha b}$ in mc | Max Coll. Diss. in free air in mw | $BV_{cb}$ in v | $I_c$ in ma | $BV_{eb}$ in v | Derate in Free Air in deg C/mw | Max $I_{cbo}$ at max $V_{cb}$ in $\mu$a | Bias $V_{cb}$ in v | Bias $I_e$ in ma | $h_{fe}$ $\beta^{ab}$ | $C_{ob}$ in $\mu\mu f$ | $r'_{bb}\times C_{ob}$ in $\mu\mu$sec | Max Temp |
| 2N499[j,k] Philco | 320[g] | 30 | 30 | 50 | 0.50 | 0.80 | 15 | 10 | 3 | 8.5 | 1.3 | 40 | 85 |
| 2N1143[a] Texas Instruments | 480 | 750[d] | 25 | 100 | 0.50 | 0.10 | | 10 | 10[f] | 32 | 1.5 | 113 | 100 |
| GA53233[c,b] Western Electric | 500 | 200 | 20 | 10 | | | | 20 | 10 | 3 | | 5.0 | 90[m] |
| 2N700[f] Motorola | 600[g] | 50 | 30 | | 0.50 | 1 | 10 | 6.0[e] | 2.0[f] | 10 | 0.80 | 40 | 100 |
| 2N1142[a] Texas Instruments | 600 | 750[d] | 30 | 100 | 0.70 | 0.10 | | 10 | 10[f] | 32 | 1.5 | 113 | 100 |
| GA53194[c] Western Electric | 600 | 100 | 30 | 30 | | 1.0 | 5 | 9.0 | 10 | 19 | 2.5 | 125 | 100 |
| 2N509[b] Western Electric | 750 | 200 | 30 | 40 | 2 | 0.50 | 5 | 10 | 10 | 49 | 2.5 | 135 | 100 |
| 2N1141[a] Texas Instruments | 750 | 750[d] | 35 | 100 | 1 | 0.10 | | 10 | 10[f] | 32 | 1.5 | 105 | 100 |

a. Tentative data b. Military use only c. Tentative data and military use only d. Infinite sink e. $V_{ce}$ f. $I_e$ g. Max frequency of oscillation in mc $=(\alpha f_{ab}/8\pi r'_b C_c)^{1/2}$ h. $t_r$ in $\mu$sec at 25 C $=0.03$ j. Max noise factor in db at 25 C $=10$ k. Gain in db at 25 C $=10$ l. Gain in db at 25 C $=12$ m. Storage temperature rather than junction temperature as in other units

## 1959 Diffused Transistors Comparison Chart

**Limited high frequency performance was a major issue for 1950s transistor technology. Several competing transistor types were capable of operating up to 300 Mc, but only the diffused methodology developed at Bell Labs combined high frequency performance with electrical and mechanical reliability. The above comparison chart of diffused transistors from different manufacturers appeared in the March 6, 1959 issue of Electronics magazine. Note the different transistors from Western Electric – of interest for satellite transmitter applications are the GA-53233 (Vanguard I) and the 53194 (Explorer I).**

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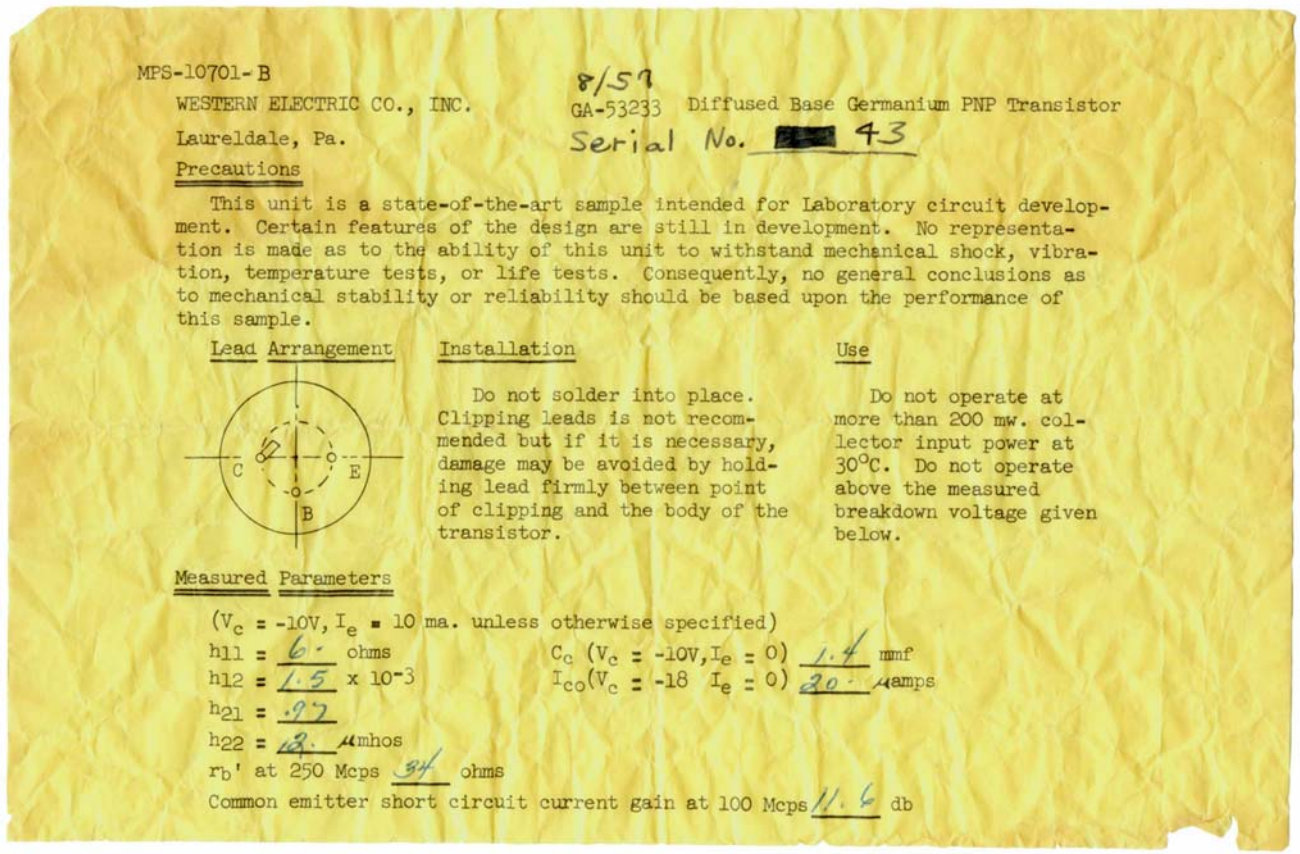
# Historic Transistor Photo Gallery

# Western Electric GA-53233 and GF-45011 1950s Vanguard Satellite Transistors



MPS-10701-B

WESTERN ELECTRIC CO., INC.
Laureldale, Pa.

8/57
GA-53233 Diffused Base Germanium PNP Transistor
Serial No. [redacted] 43

Precautions

This unit is a state-of-the-art sample intended for Laboratory circuit development. Certain features of the design are still in development. No representation is made as to the ability of this unit to withstand mechanical shock, vibration, temperature tests, or life tests. Consequently, no general conclusions as to mechanical stability or reliability should be based upon the performance of this sample.

Lead Arrangement



Installation

Do not solder into place. Clipping leads is not recommended but if it is necessary, damage may be avoided by holding lead firmly between point of clipping and the body of the transistor.

Use

Do not operate at more than 200 mw. collector input power at 30°C. Do not operate above the measured breakdown voltage given below.

Measured Parameters

($V_c$ = -10V, $I_e$ = 10 ma. unless otherwise specified)

$h_{11}$ = 6. ohms
$h_{12}$ = 1.5 x $10^{-3}$
$h_{21}$ = .97
$h_{22}$ = 2. μmhos
$r_b'$ at 250 Mcps 34 ohms
Common emitter short circuit current gain at 100 Mcps 11.6 db

$C_c$ ($V_c$ = -10V, $I_e$ = 0) 1.4 mmf
$I_{co}$ ($V_c$ = -18 $I_e$ = 0) 20. μamps

## GA-53233 Data Sheet

**Many of the GA-53233 transistors were individually serialized and tested, and the identifying data sheet was supplied with the transistor to the purchaser. Unlike modern transistors, the manufacturing processes used with these 1950s devices were poorly understood and the resultant transistors exhibited quite a wide range of performance characteristics. This means that "hand-selection" of GA-53233 transistors was required for many applications. The transistor identified in the above data sheet is a very early device, with the low serial number "43". An unknown number of serialized GA-53233 transistors were manufactured – see reference [5] for information on serial number "851". These low serial numbers correspond to a 1956 or 1957 timeframe – note the data sheet above has an 8/57 date. These individually serialized GA-53233 are very historic and represent a major milestone in the development of transistor technology and satellite electronics.**

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# Historic Transistor Photo Gallery
# Western Electric GA-53233 and GF-45011
# 1950s Vanguard Satellite Transistors

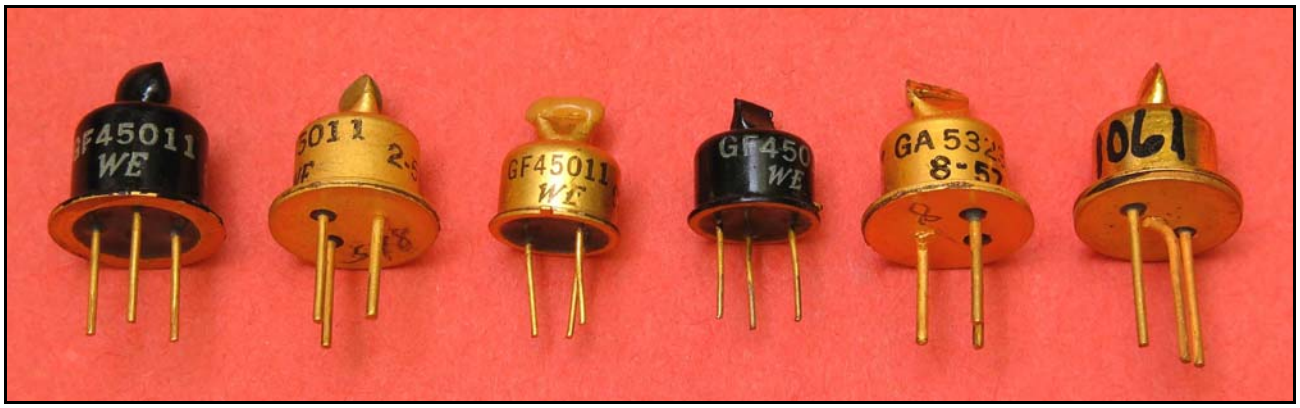
**Purchases Authorized**

| | | | |
|---|---|---|---|
| 5,000 Western Electric type GF-45011 transistors | Digital Computer Laboratory | Western Electric Co., Inc., New York, N.Y. | 102 500 00 f.o.b. Laurel-dale, Pa. |

| *Item* | *Department* | *Vendor* | *Cost* |
|---|---|---|---|
| 250 Western Electric type GA-53233 transistors | Digital Computer Laboratory | Western Electric Co., New York, N.Y. | $10 000 00 f.o.b. Laureldale, Pa. |

## 1958 Prices for Western Electric Diffused Base Transistors

**Pricing information for Western Electric transistors is difficult to document, since these devices were not sold commercially but only to the U.S. government, the military, and approved contractors. The scans above are excerpts from a 1958 University of Illinois reference, which provide detailed pricing information for these transistors. 5000 GF-45011 transistors for a total of $102,500 = $20.50 for each device. Similarly, 250 GA-53233 transistors for $10,000 = $40 for each device. (That's over $300 in 2013 dollars!)**




## Different Case Styles

**The above photo illustrates some of the various case styles that were used for the early Western Electric diffused base transistors. The two rightmost units are GA-53233 types, and the four units to the left are all different GF-45011 case styles. Some general observations about the evolving case styles: (1) The larger gold units appear to be the earliest style, dated 1957 and 1958, (2) The smaller case sizes appear to be the latest dates codes, 1959 and later and (3) There are a variety of header constructions and pin-outs, including metal or glass headers and in-line or triangular lead pin-outs. By the mid 1960s, the case styles and pin-outs became more standardized. For example, the 2N1195 was one of the production versions of these pre-production germanium PNP diffused base Western Electric transistors. It was registered with JEDEC in 1959 and was manufactured in a TO-5 case style.**

# TRANSISTOR MUSEUM™

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# Western Electric GA-53233 and GF-45011
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## LIST OF REFERENCES WITH LINKS


1. Michael Rainey – Vanguard 1 Satellite Transmitter Project

Michael Rainey, a highly inventive and historically-minded ham radio operator (call sign AA1TJ) has researched the technical details of the transmitter circuits used in the Vanguard 1 satellite and has constructed a modern day replica. Use the link above to view Mike's transmitter in operation.

2. Mark Burgess – Western Electric Transistor History

Visit Mark's well researched and enjoyable website on early transistor history, and learn about the "Diffusion Technologies at Bell Labs". This article provides excellent background for the pioneering work at Bell Labs that was the basis for diffused transistors used in the Vanguard satellite.

3. Joe Knight – Bell Labs and Western Electric Power Transistors

Joe Knight is the author of the most comprehensive and often-referenced web series on early power transistor technology. This link will direct you to his 28 page presentation with details and photos of early Bell Labs/Western Electric transistors, including the first diffused devices from the 1950s.

4. George Ludwig – Transistor Museum Oral History

Dr. George Ludwig was the principle designer of the transistor-based cosmic ray instrumentation package for the Explorer 1 satellite, and worked extensively on early satellite electronics at JPL. This informative 2004 Transistor Museum interview with Dr. Ludwig contains a wealth of information about the first transistors used in Vanguard and Explorer.

5. Vanguard Progress Report No. 10 – October 15 1956

Many of the early progress reports on the Vanguard satellite program are currently available on the web. The specific link above references a 1956 report which contains an interesting discussion on vibration test results of the GA 53233 transistor, serial #851. Other reports are also available with additional information on the early transistors.

6. Vanguard I Satellite - 1959 IGY Research Paper

This very informative paper, published in the Feb 1959 "Review of Scientific Instruments" describes the instrumentation used in the Vanguard I satellite, including details of the GA-53233 and GF-45017 transistors. Written by R.L. Easton and M.J. Votaw at the U.S. Navy Research Lab.

7. 1962 Production Engineering Report on Diffused Transistors at Laureldale

The U.S. Army Signal Corps funded much of the diffused transistor research and production at the Western Electric semiconductor facility at Laureldale Pa. This report provides an excellent overview of this work from 1962, including a discussion of diffused transistors in the Nike missile program.

8. JPL History of the Sputnik, Vanguard and Explorer Satellites

This is an excellent article by JPL/Cal Tech which documents the exciting history of the early U.S. satellite program, including both Vanguard and Explorer. There is much technical detail and solid background material presented.

9. NRL 50th Anniversary Legacy of Vanguard I

The Naval Research Lab, a major contributor to the success of the Vanguard I satellite, established this excellent website to commemorate the 50th anniversary of the launch.