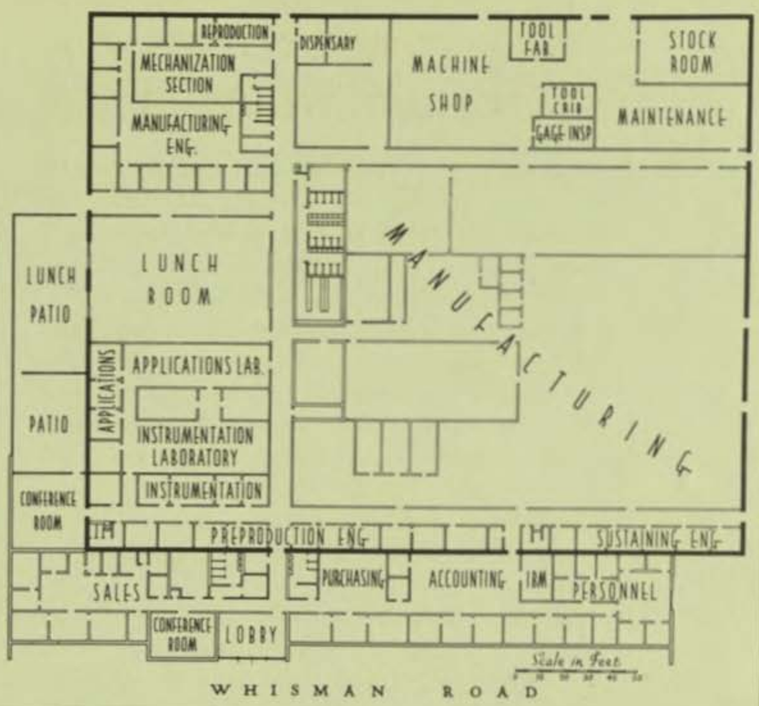
WELCOME
TO FAIRCHILD

THE PLANT



Built on a 10 acre site, Fairchild Semiconductor Corporation's new plant covers 68,000 square feet and houses complete facilities for crystal growing, device assembly, testing, circuit research, and applications engineering. Begun in December of 1958, the building and consequent move were part of our effort to provide better products and services to our customers. The plant is pressurized with filtered air, regulated in temperature and humidity. This system insures the clean conditions necessary for transistor manufacture and contributes to employee comfort. Other plant features include adequate parking space for 800 cars, musicasts in the production area and a large lunch room and employee patio. These excellent working conditions and facilities make Fairchild's new "home" one of the most functionally modern electronic component manufacturing plants in the nation.

THE STORY OF A FAIRCHILD TRANSISTOR

A transistor is an electronic device about the size of a green pea, usually having three wires protruding from its capsule. It is used as an electrical gate or valve to control the amount of electrical energy allowed to flow in a circuit.

Its function is much like that of a vacuum tube, but it performs its job in a smaller space, in a simpler circuit, in a more efficient manner, and with greater reliability than its vacuum tube predecessor.

The transistor's small size, high efficiency, and high reliability are the principal reasons for its popularity in the civilian market and its tremendous acceptance by the missile and defense industries.

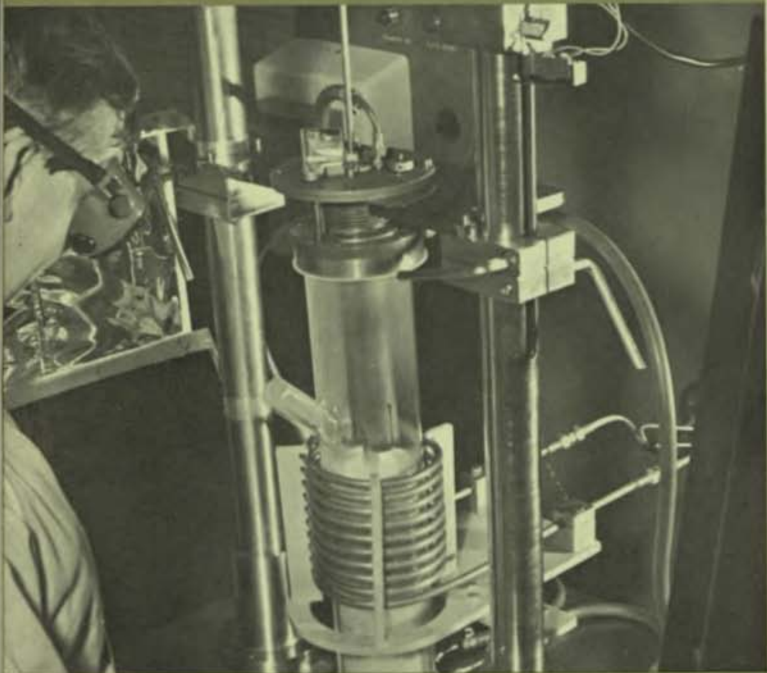
Fairchild's transistors are made from silicon, an element which, in its impure natural form, is the second most abundant material on the earth. Silicon is one of a number of chemical elements, including germanium, known as semiconductors. These elements differ from both metallic elements, which are electrical conductors, and non-metallic elements, which are nonconductors. Being neither fish-nor-fowl, silicon and germanium are among the semiconductors. Some of them are rather heavy and have a shiny luster like metals, but most of these elements conduct electricity rather poorly in their pure state as do the nonconductors. Carefully calculated amounts of other chemicals called

1 *Emitter lead*

2 *Base lead*

3 *Header*

4 *Die*



Growing a silicon crystal

dopants can be added to the pure semiconductor elements to increase their conductivity as required.

Early transistors were fabricated from germanium chiefly because it could be handled easily and at relatively low temperatures. However, its limitation as a transistor material is that it cannot stand high operating temperatures. Until recently silicon has been more difficult to handle than germanium, but it produces transistors with vastly superior performance. Since the beginning, Fairchild's operation has been predicated upon the use of silicon as a raw material.

Our silicon is produced by a process which culminates in the growth of a solid single crystal about the size of a fat cigar.

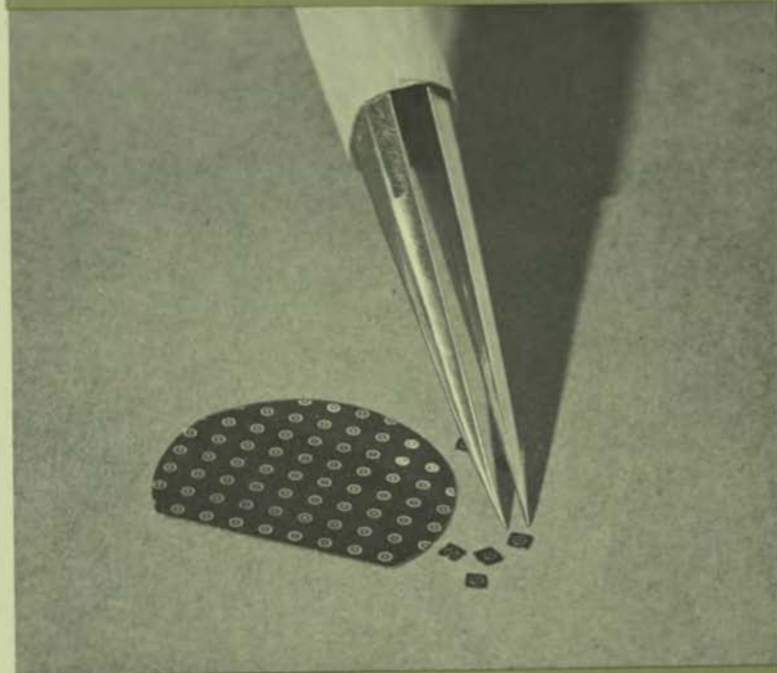
This cigar-shaped crystal is sliced with a diamond cutting wheel into wafers the size of a nickel only much thinner. Polished to a finish approaching optical flatness, the wafers are then treated by a process called diffusion. In diffusion, the wafers are placed in a quartz "boat" and loaded into a furnace maintained at a temperture above 2000 degrees Fahrenheit. A gas containing a known amount of a certain chemical dopant is then passed over the wafers so that some atoms of the dopant diffuse into the silicon wafer. The concentration and depth of this penetration determine the electrical characteristics of the transistor.

Certain metals are evaporated onto or alloyed with the silicon wafer to make the electrical contacts. The wafer is next etched apart into several hundred "dice." Each "die" then becomes a transistor.

When you look at a finished transistor you see the "header" to which the die is mounted. After mounting, wires are attached to the transistor's active areas, and the device becomes electrically complete. The addition of a protective "can" over the header seals air out and completes the unit.

The reasons for Fairchild's spectacular success and rapid growth are dual. The scientists and engineers who founded FSC had the aim of bringing the solid state diffusion process under closer control than had been previously done anywhere in the industry. Concurrent with this was the aim to put out a transistor having the greatest performance and reliability possible. The solid state diffusion process is better adapted to closely controlled volume production than are earlier methods of transistor manufacture. Hence, although former production procedures depended heavily on hand assembly, we can now produce premium quality units in large quantities at prices competitive with standard units made by less advanced methods.

Fairchild transistors are technically unsurpassed even in today's rapidly moving and highly competitive industry. The increasing acceptance of our products by governmental agencies is a further endorsement of the unexcelled quality of Fairchild transistors.



Closeup of finished wafer and dice

Research and Development Laboratories

HISTORY

In October, 1957, eight scientists and engineers, who had previously worked together in semiconductor research and development, combined their talents to form the Fairchild Semiconductor Corporation.

Uniquely qualified in every phase of semiconductor technology, the men consequently attracted other select people from science and industry who added an abundant fund of specialized knowledge. Forming a company with well defined goals, they obtained the backing of the Fairchild Camera and Instrument Corporation. The growing firm began an accelerated program of research, equipment design, and pilot production.

In the short period of two years, the Fairchild Semiconductor Corporation has grown from eight persons to a staff of over 600 qualified personnel, carefully selected and trained for specialized jobs. This rapid internal growth is matched by an outstanding record of leadership not only in research and development but in volume production of premium grade semiconductor products.

FAIRCHILD SEMICONDUCTOR CORPORATION • MOUNTAIN VIEW, CALIFORNIA

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RESEARCH AND DEVELOPMENT LABORATORIES • 844 CHARLESTON ROAD • PALO ALTO, CALIFORNIA

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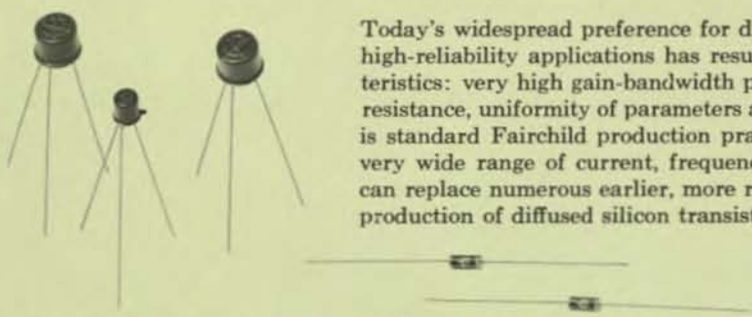
FAIRCHILD
CONDENSED CATALOG

FAIRCHILD DIFFUSED SILICON TRANSISTORS AND DIODES

Providing an unmatched combination of speed, power and reliability in computer switching and in RF and video amplifiers and oscillators



Today's widespread preference for diffused silicon transistors in high-performance, high-reliability applications has resulted from their unique combination of characteristics: very high gain-bandwidth product, large power dissipation, low saturation resistance, uniformity of parameters and outstanding reliability (300° C stabilization is standard Fairchild production practice). Their high performance applies over a very wide range of current, frequency and temperature, hence one Fairchild type can replace numerous earlier, more restricted types. Fairchild pioneered large-scale production of diffused silicon transistors and today offers the broadest line.

TRANSISTORS—Fairchild Diffused Silicon Types

Types	Description	JEDEC Outline	f_t Typical	P_c @ 25°C Case Temp.	h_{FE} (Min.)	h_{FE} (Max.)	V_{CER}	V_{CBO}	V_{BE} SAT (Max.)	V_{CE} SAT (Max.)	I_{CBO}† @ 25°C (Max.)
2N696 & 2N697	General purpose types for switching, RF and DC applications over a wide current range	TO-5	90 mc	2 watts	20	60	40 V	60 V	1.3 V	1.5 V	1.0 μA
			120 mc	2 watts	40	120	40 V	60 V	1.3 V	1.5 V	1.0 μA
2N698 & 2N699	High voltage types particularly suited to video amplifiers and RF oscillators	TO-5	90 mc	2 watts	20	—	80 V	120 V	1.3 V	5 V	2.0 μA
			120 mc	2 watts	40	120	80 V	120 V	1.3 V	5 V	2.0 μA
2N706	Logic transistor for very high speed switching in low current saturated circuits	TO-18	400 mc	1 watt	20	—	20 V	25 V	0.9 V	0.6 V	0.5 μA
2N707	VHF oscillator type	TO-18	45% @ 100 mc*	1 watt	9	—	28 V	56 V	0.9 V	0.6 V	5 μA
2N1131 & 2N1132	PNP complements to the 2N696 and 2N697 suitable for identical uses in opposite polarity	TO-5	50 mc	2 watts	15	45	−30 V	−40 V	−1.5 V	−1.5 V	1.0 μA
			60 mc	2 watts	30	90	−30 V	−40 V	−1.5 V	−1.5 V	1.0 μA
2N1252 & 2N1253	Low storage types optimized for high current saturated switching circuitry	TO-5	80 mc	2 watts	15	45	20 V	30 V	1.3 V	1.5 V	10 μA
			100 mc	2 watts	30	90	20 V	30 V	1.3 V	1.5 V	10 μA
2N717 & 2N718	General purpose types for switching, RF and DC applications over a wide current range	TO-18	90 mc	1.5 watts	20	–	40 V	60 V	1.3 V	1.5 V	1.0 μA
			120 mc	1.5 watts	40	120	40 V	60 V	1.3 V	1.5 V	1.0 μA
2N1613	A UNIVERSAL TYPE: Fast switching (logic and high current) Amplifiers (low level, low noise, wideband, VHF power)	TO-5	100 mc	3 watts	30	—	40 V	75 V	1.3 V	1.5 V	25 mμA††

*Oscillator efficiency †I_{CBO} measured at 50% of V_{CBO}. ††I_{CBO} measured at 60 V.

DIODES—Fairchild Diffused Silicon Types

Type	Description	Reverse recovery time (Max.)	Maximum power dissipation (Max.)	Capacitance at 0 volts bias (Max.)	Breakdown voltage (Min.)	Reverse current (Max.)	Forward voltage drop at I_F=10 ma (Max.)
FD-100	Ultra-fast computer diode	4 mμs	200 mW	2 μμf	75 V	.100 μA	1 V

A number of additional high performance types are scheduled for announcement subsequent to date of this printing.

Specification sheets available with comprehensive data on all types shown and on additional types announced subsequent to this printing.

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FAIRCHILD SILICON TRANSISTORS

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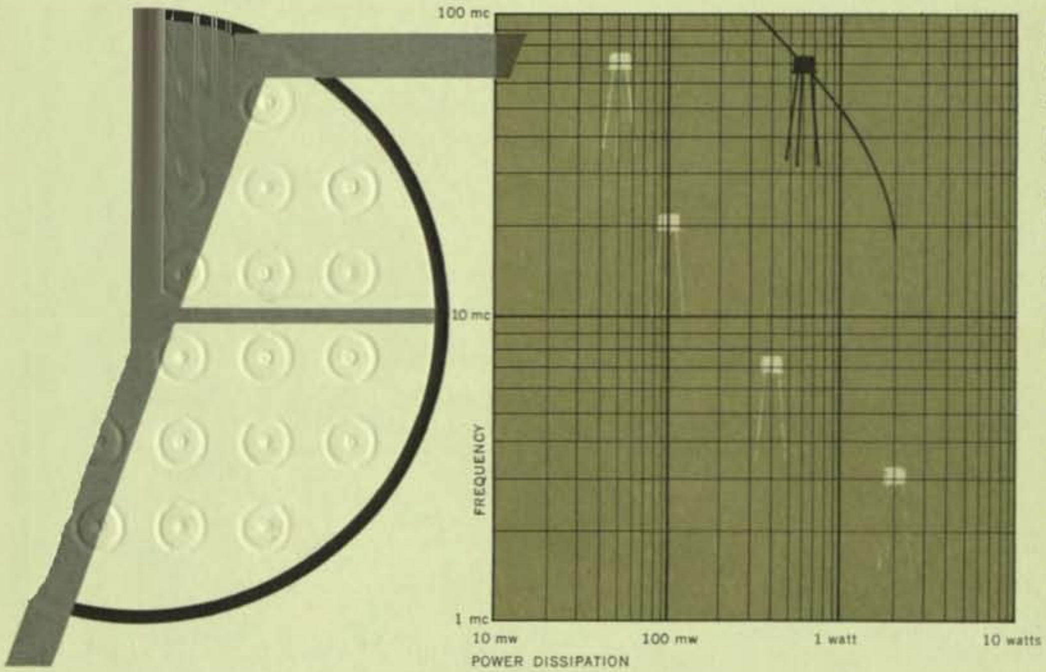
FAIRCHILD SILICON TRANSISTORS

New performance, uniformity and reliability achieved by th



A higher order of magnitude in silicon-transistor performance is now available. It is a direct and logical result of Fairchild's quantity production by the solid-state diffusion process.

To the circuit designer and systems engineer, the resulting performance parameters can upgrade overall electronic-system capabilities, further reduce equipment size and improve its ability to cope with severe environments.

Switching speeds in millimicroseconds from silicon transistors make possible the design of compact computing machines with higher switching rates than heretofore.

Cut-off frequencies in the 100-megacycle range become readily attainable in silicon transistors allowing the further transistorization of communications equipment intended for severe environments.

Power dissipation as high as 2 watts in the Jetec 30 case. Also saturation resistance is lower resulting in higher current capability at any power level. These characteristics afford opportunities to simplify high-performance circuitry.

N-P-N or P-N-P silicon transistors can be made with similar characteristics such as current gain, rise times, leakage current and general performance. After nominal development time, this choice can be offered wherever it is warranted by sufficient demand.

Uniformity is inherently superior because of the simplified crystal-growing requirements and controllable means by which the junctions are created and connections made.

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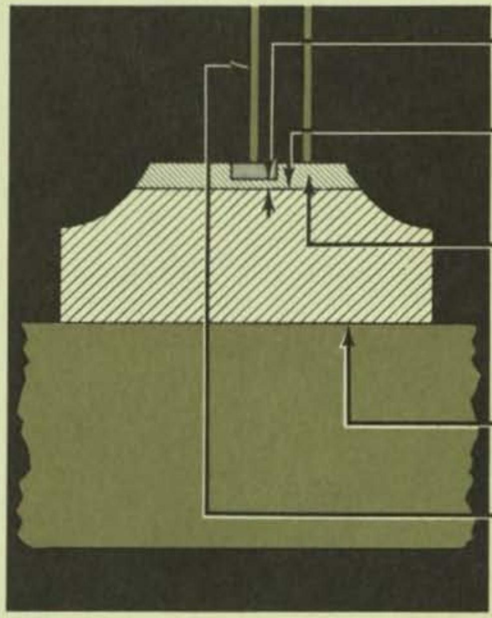
he solid-state diffusion process

INSIDE REASONS FOR A TREND

The solid-state diffused silicon transistor has superior performance because it is a distinct departure in construction. The diffusion process has little in common with other processes used in the manufacture of silicon transistors. Yet the resulting characteristics are so rewarding that every major manufacturer of silicon transistors is engaged either in laboratory exploration or preliminary production of diffused transistors—regardless of which techniques have been used for the prior units in their product lines. By offering diffused transistors in production quantities, Fairchild is a leader in a growing trend.

As the accompanying cross section shows, each performance parameter of Fairchild's silicon transistors relates to the controllability of dimensions and impurity distribution in the diffused silicon die:



ELECTRICAL ADVANTAGES

High-frequency capability • *Frequencies of the order of 100 megacycles require a graded base and a base width of less than 1/10,000th inch. The only way this has been done successfully in silicon is by the solid-state diffusion process.*

Lower capacitance • *At the base-collector junction, a low impurity gradient occurs as a result of diffusion. The effect is the same as spreading the plates of a condenser. The reduced capacitance achieved this way further improves high-frequency characteristics.*

Lower base spreading resistance • *A high impurity density near the surface reduces base resistivity exactly where such a reduction has the most effect on total base spreading resistance. The impurity gradient results in high base resistivity at the collector junction where it has a favorable effect on capacitance and adds little to total resistance.*

MECHANICAL ADVANTAGES

Lower thermal resistance • *The diffused transistor's structural configuration permits the collector to be soldered directly to the case. Thus the heat generated by power dissipation is readily conducted to the heat sink.*

Ruggedness • *Another advantage in soldering the transistor die directly to the header, under shock and vibration nothing but the tiny masses of base and emitter leads can exert any forces on the connections. The favorable configuration of the diffusion transistor keeps these well within safe limits.*

THE DIFFUSION PRINCIPLE

When statistical probability takes place at a molecular level, the results are a certainty

A glass of water and a drop of ink
tell half the story

Molecular movement diffuses the ink with statistical uniformity throughout the water. But this takes place far too quickly to permit a controlled arresting of any intermediate stage.

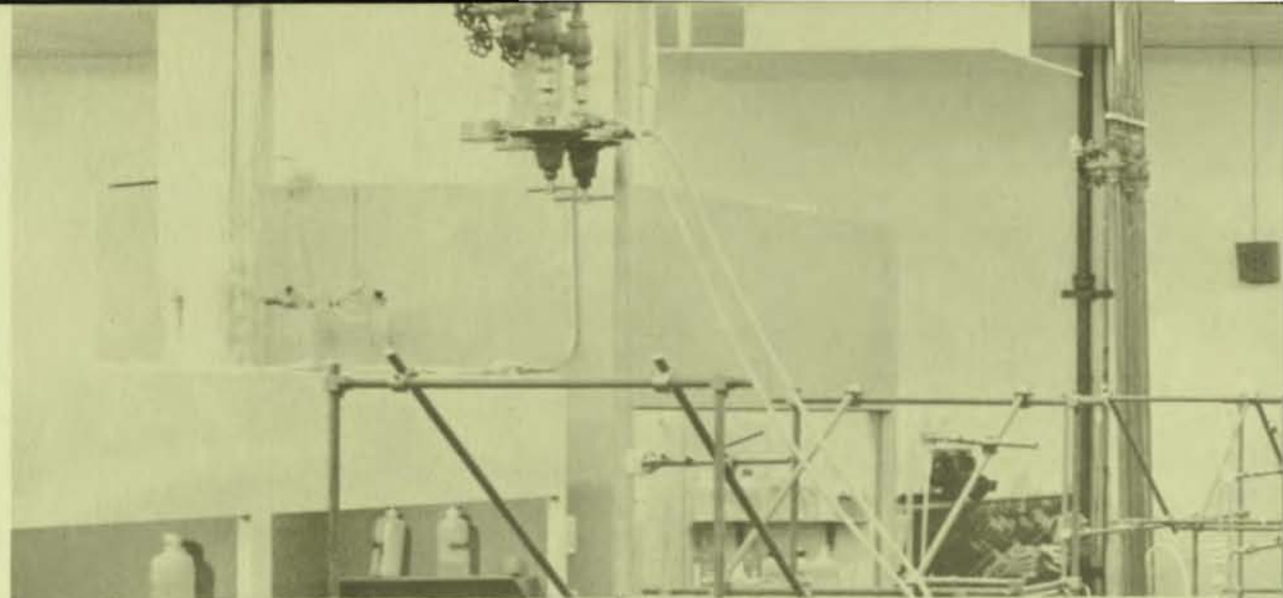
In a block of ice
diffusion takes place slowly...

So slowly in fact that it might take a million years for the drop of ink to diffuse throughout. At any stage in time, the distribution of the diffused ink would for practical purposes be completely fixed and stable.

In a silicon transistor
diffusion can be rapid, controlled, and then stable

Silicon is heated to as much as 1000° Centigrade higher than its ultimate operating temperature as a transistor. Though it is still a solid, diffusion takes place rapidly. The desired impurities for a semiconductor have appreciable vapor pressure at this temperature. They impinge on the silicon surface as gas molecules and diffuse into the crystalline lattice with statistical uniformity and a known rate of inward travel.

Reducing the temperature by only 100° C. virtually stops further impurity movement. The maximum operating temperature is 1000° C. below diffusion temperature. Impurity movement is completely stopped. The silicon is like the block of ice.



APPLICATION TO A MANUFACTURING PROCESS

Though simple in principle, the solid-state diffusion process has numerous variables when applied to transistor manufacture. A large body of accumulated knowledge is required. An ultimate in cleanliness is needed. However, once the process variables have been fixed for a particular device, they are readily repeatable to manufacture quantity lots with excellent uniformity.

CRYSTAL GROWING

The solid-state diffusion process somewhat simplifies the problem of crystal growing. It allows the crystal pulling to be done at constant rate and without making additions to the melt. Desired impurities are present at the beginning. By growing its own crystals, Fairchild is able to exercise a degree of care that is producing an unequalled level of crystalline perfection. And with this first vital step done in our own plant, it is kept under close observation both for production and for continuing research.

CUTTING AND LAPPING

This step too is more subject to good control in the diffusion process. Wafers are rough cut from the crystal with diamond saws and are lapped to finished thickness and smoothness. Though impurity density and orientation of the crystalline lattice are critical, the problems of laying out the transistor dice on the wafers are much reduced by comparison with older processes.

DIFFUSION

This key operation takes place in several stages, each controlled by the three variables, time, temperature and furnace atmosphere.

At the beginning the crystal wafer has a uniform distribution of the collector impurity. The portion not reached by the diffused impurities ultimately becomes the collector body of each die.

The base is diffused first. In an N-P-N device, the "P" impurity is introduced into the diffusion-furnace atmosphere as a gas in a continuous flow. Temperature and time determine very precisely the distance of penetration, hence the depth of the base-collector junction. Desired variations in the impurity density through this layer can be achieved by variations in the time-temperature programming of the diffusion run and impurity concentration in the furnace. Since the times involved are relatively long, they permit a high degree of control.

The emitter is a second diffusion performed after a necessary masking operation that shields all but the correct emitter location. Control of this second diffusion is similarly precise, making it practical to control base thicknesses of two microns with a variation of less than 10%.

FURTHER STEPS

Beyond diffusion there are many further operations necessary to produce a finished, packaged transistor. Contacts are plated on the wafer. The wafer is separated into individual dice. These are soldered to the header. Fluxless solder used in this step is a vital precaution against contamination. Leads are then affixed. A washing step and a vacuum bakeout remove any loose or volatile impurities. Finally the can is welded to the header permanently sealing the transistor.

CRYSTAL GROWING

CUTTING CRYSTAL INTO WAFERS

FINISHED WAFER AND DICE

TRANSISTOR BEFORE CAPPING

DIFFUSION FURNACES AT FAIRCHILD

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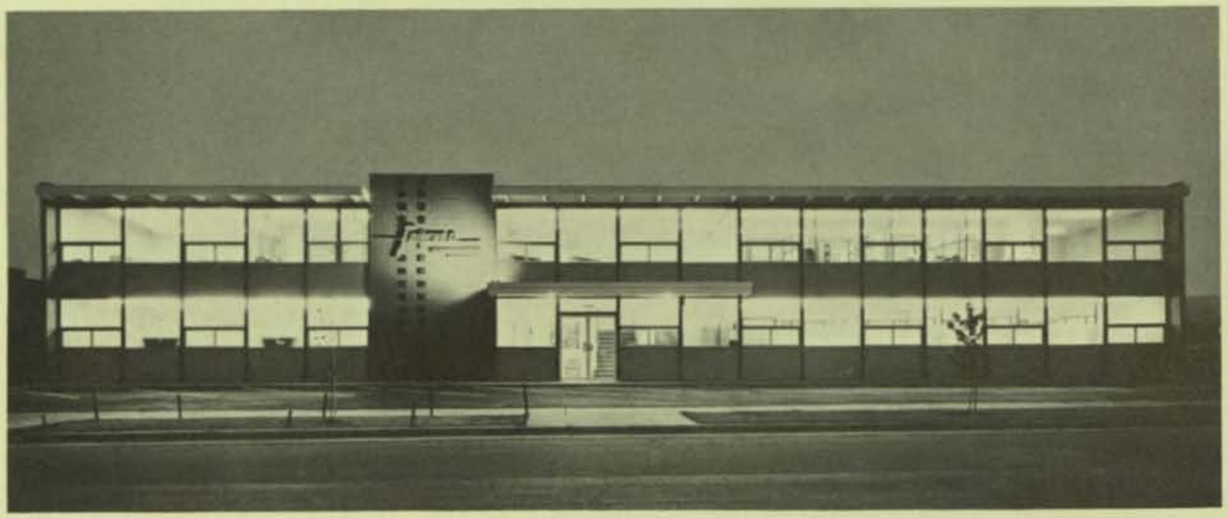
THOMAS H. BAY, BS.
Marketing Manager

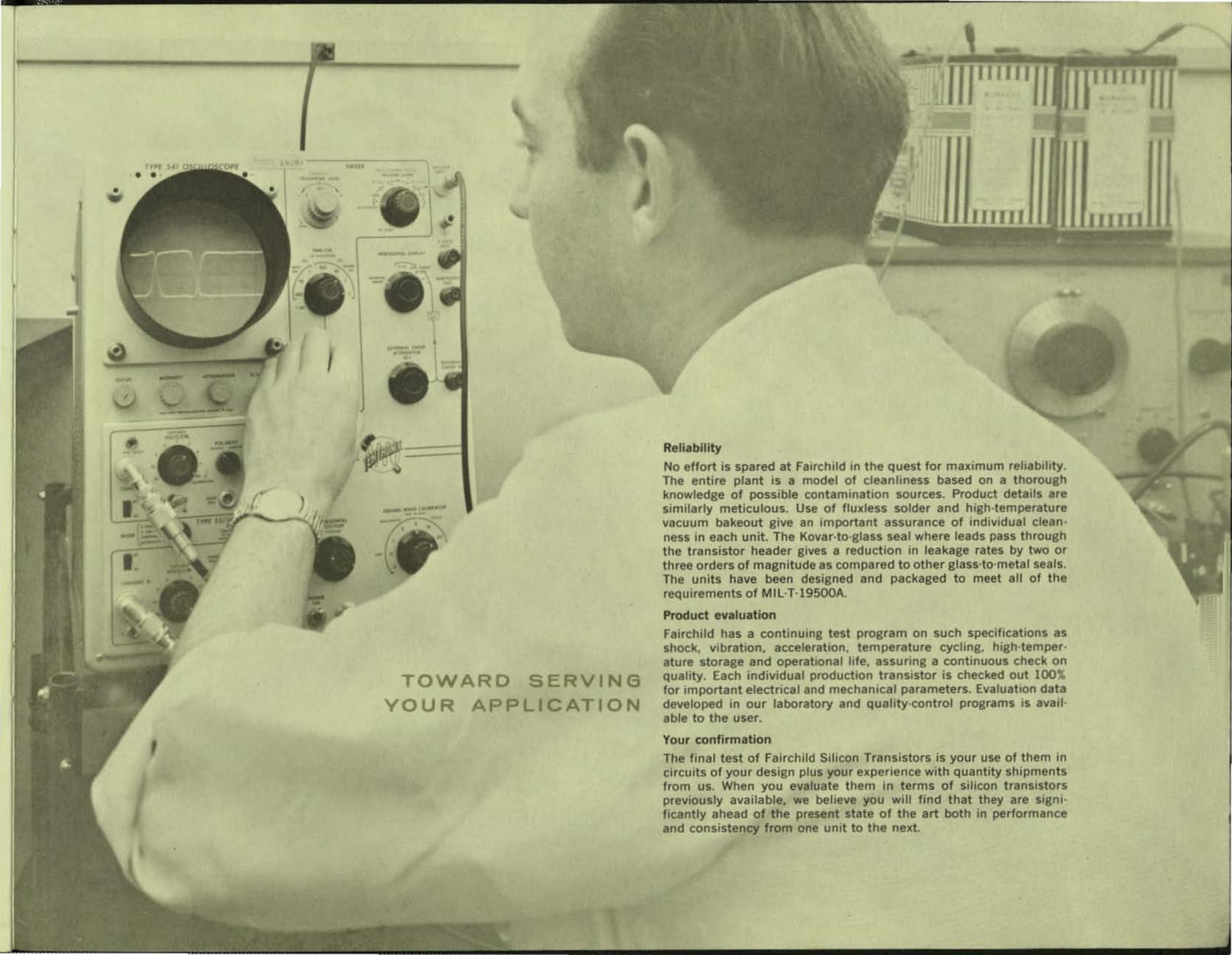
EUGENE KLEINER, BME, MIE.
Production Manager

JULIUS BLANK, BME.
Chief Engrg. Services

HISTORY

The Fairchild Semiconductor Corporation was organized by a team of scientists, engineers and production specialists uniquely qualified in every phase of semiconductor work. They had previously worked together for 1½ years. The company was formed with a well defined goal and a large fund of specialized knowledge. The diffusion process for silicon-transistor manufacture had been slow to get started elsewhere — perhaps because Germanium transistors had preceded silicon and had not been amenable to practical diffusion techniques. Here was an opportunity. To make an all out assault on the problem, the group obtained backing and affiliation with the Fairchild Camera and Instrument Corporation. This permitted an ample period of further research, equipment design and pilot production. The result was a finished product and a capacity to meet delivery schedules at the time of the first product announcement.





TOWARD SERVING YOUR APPLICATION

Reliability

No effort is spared at Fairchild in the quest for maximum reliability. The entire plant is a model of cleanliness based on a thorough knowledge of possible contamination sources. Product details are similarly meticulous. Use of fluxless solder and high-temperature vacuum bakeout give an important assurance of individual cleanness in each unit. The Kovar-to-glass seal where leads pass through the transistor header gives a reduction in leakage rates by two or three orders of magnitude as compared to other glass-to-metal seals. The units have been designed and packaged to meet all of the requirements of MIL-T-19500A.

Product evaluation

Fairchild has a continuing test program on such specifications as shock, vibration, acceleration, temperature cycling, high-temperature storage and operational life, assuring a continuous check on quality. Each individual production transistor is checked out 100% for important electrical and mechanical parameters. Evaluation data developed in our laboratory and quality-control programs is available to the user.

Your confirmation

The final test of Fairchild Silicon Transistors is your use of them in circuits of your design plus your experience with quantity shipments from us. When you evaluate them in terms of silicon transistors previously available, we believe you will find that they are significantly ahead of the present state of the art both in performance and consistency from one unit to the next.

Products of the Fairchild Semiconductor Corporation are sold through representatives covering all of the United States. Technical inquiries will also be served by correspondence from the Palo Alto main office.

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