

What is happening in the American The integrated circuit industry

Integrated circuits, which first went into production in 1961, are expected to reach sales of **\$750 million** in 1970.

Competition within the industry is **fierce**. Progress can **come** quickly **as manufacturers** chase market shares to secure their position and growth.

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UDK 338.972.621.3.049.7(73)

OO In the semiconductor industry, which is generally characterized by irritation, concern, and agitation, 1969 is considered a particularly decisive year for the industry. If the manufacture of integrated circuits—the focus of the semiconductor industry today—had not been started then, it would not be possible to compete in the global markets.

Integrated circuits, microelectronic components that combine multiple transistors, diodes, and other electronic elements on a single chip, have made their way into electronics on a broad front and threaten to take over the semiconductor industry. Although the first commercial integrated circuit was introduced in 1961, sales of this inconspicuous component exceeded \$364 million in the United States in 1968. In the first half of 1969, sales in the domestic market totaled \$232 million, and the Electronic Industries Association estimates that sales in 1970 will reach just over \$750 million.

Semiconductor companies estimate that sales will

The increase in value is expected to be at least 20% per year during the 1970s. No trend can be discerned. Texas Instruments Inc. (TI), the world's largest manufacturer of integrated circuits, reports that total sales for 1965 amounted to \$671 million. TI estimates that

sales will increase to \$3 billion in the latter part of the 1970s. The manufacture of integrated circuits accounts for most of this increase.

This means that integrated circuits will become even more important in electronics than transistors have been since their invention 20 years ago. What makes 1969 such an important year is that the industry clearly realizes that the circuits for the 1970s markets must be designed today by today's tube companies. And while the tube companies are fighting for the leading position, violent changes have shaken the industry. These have made themselves felt in the most obvious way

0 personnel

0 products

0 to effect

0 applications

- relationships between manufacturers and customers.

Many skilled engineers and senior executives are either changing jobs for higher salaries and priority rights to shares, or leaving industry to start their own businesses.

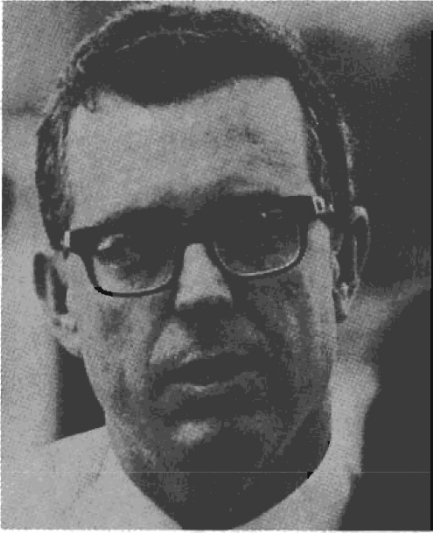
The integrated circuits available today vary greatly in terms of size, complexity, design, function, and application. Important new components are emerging every month.

The reason why the huge home electronics market has not yet embraced integrated circuits is that they are still very expensive. Semiconductor companies are therefore continuing to develop new manufacturing processes and new machines in order to reduce costs.

Integrated circuits were first used in military equipment and aircraft, as well as in some computers. Now they are flooding the market and are included in industrial and commercial equipment, as well as in home electronics products.

Some of those who use integrated circuits have not been able to obtain the special circuits they need from the semiconductor industry, which is geared towards mass production. Others are afraid to disclose too many details about their systems to the manufacturers of integrated circuits. This would reveal the specific design of that particular product. As a

result, some



J Fred Bucy vid Texas Instruments säger: "Det finns alltid plats för mindre företag."

of those who use integrated circuits in their products set up their own factories to meet their own needs. Some have also started to enter the market for integrated circuits.

THE HUNT FOR MARKETS

The leading industries involved in integrated circuits—Texas Instruments, Motorola, and Fairchild Camera & Instrument—will certainly survive the current crisis. However, the same cannot be said for their market competitors.

At Texas Instruments, they are confident that they will achieve their goal of a turnover of three billion dollars. Glen E. Peniston, Vice President of Planning and Technical Development within the Components Group, explains. Sales of integrated circuits were estimated at around \$100 million in 1968.

But even though Dal's future prospects look bright, this has not always been the case. After years of uninterrupted growth in pipe sales and profits, Ivc took a turn for the worse in 1967. Sales fell by \$11.8 million and net income by \$11 million, resulting in a profit margin of 4%. Last year, pipe sales rose again to \$102 million and profits rose again to \$11 million.



presentable 8%. Such ups and downs are characteristic of the semiconductor industry.

Motorola, Phoenix, Arizona, which was bigger than TI in its home market but significantly smaller abroad, followed a similar development curve. CEO Stephen L Levy says that sales in the semiconductor division increased by 30% in 1968. Fairchild in Mountain View, California, was once the leading company in the semiconductor industry, but declined three years ago. It only began to recover last year. Westinghouse, which once claimed to be one of the largest in the industry, never made a profit in the field of integrated circuits. Last year, it completely shut down production of these.

Many challengers

Some of the smaller companies are taking on the giants. Signetics Corp, a subsidiary of Corning Glass Works in Sunnyvale, California, has increased its sales from \$1 million in 1964 to \$30 million in 1968. It expects sales for 1968 to reach approximately \$45 million. National Semiconductor Corp. in nearby Santa Clara sold \$7.2 million during the 1967 fiscal year. In 1968, it sold \$1 million, and in the 1969 fiscal year, which ended on June 30, 1969, it sold \$22.9 million. Both companies grew as larger companies declined.

Then there is a group of companies that entered the market in 1966. Some of these are acting to capture market share with the same energy that characterized the leading companies when they started in the early 1960s. Take Mostek Corp, for example, located a few kilometers from TI. Three TI employees, Richard L Petritz, L I Sei'in, and Louay E Sharif, founded Mostek last summer. Sevin and Sharif were the leading figures behind TI's venture into MOS circuits. "There's a real gold mine there," says Sevin. Total sales of MOS products were around \$16 million in 1968. Sevin predicts that total sales will reach \$1 billion in ten years, and he wants \$100 million of that.

Cooperation brings strength

The Mostek group had barely been formed when it sold a minority stake to Sprague Electric Co. The agreement, which gives Sprague the right to take control of Mostek, gives Sprague access to Mostek's know-how in the design of MOS circuits. For its part, Mostek gained access to Sprague's worldwide sales organization and, in return, was allowed to use

a factory in Worcester, Massachusetts.

This maneuver brought both companies higher up on the list of the 1970s' competitive companies. Before the agreement was signed, Spra-



Georg R Cogar at Cogar Corp is looking forward to sales of integrated circuits worth \$40 million by 1972.

The manufacture of integrated circuits has not posed any significant threat to the major players in the southwestern United States and on the San Francisco Peninsula. Sprague, an old family-owned company in the component industry, had enjoyed satisfactory returns for 26 consecutive years, but in 1968 it suffered its first loss.

TI has a management team and design capacity that can withstand the loss of a few good employees. This was demonstrated three years ago when National poached a four-man team that had specialized in a new product area that National had decided to add to its lineup.

TI normally does not care if a new competing company appears on the market. "There is always room for good small companies," says Fred Bucy, vice president and head of the component group. Of course, Hostec has ambitions to become much more than a small company.

Arrangements such as the one between Sprague and Mostek are not uncommon. IBM, like other computer companies, is expected to replace more and more of its core memory with faster and, if possible, cheaper components. Among the engineers appointed by the giant IBM to design the new memories were six people who eventually decided to form their own company in Phoenix, Semiconductor Electronic Memories Inc. (Semi). At about the same time, EL4M Corp. was founded in Huntington Beach, California.

— a leading manufacturer of core memory — that integrated circuits would be needed to maintain an adequate share of the market. When the former IBM team went to EMM Pör to get tO'd, they received a loan that could give them a majority stake in Semi in three years.

Like Mostek, Semi immediately gained access to its partner's sales organization. Semi also plans to become big. Arthur Mones, the company's vice president for technical development, says: " "

planning for annual growth of 30% through to 1974. We have gathered sufficient knowledge them to do this, provided that we don't ourselves."

THE HUNT FOR TALENT

Most of the companies that have been in the industry for more than a few years have had turnover among their top executives. This is particularly true of IBM and Fairchild. Several months before the six IBM engineers formed Semi, 66 men left IBM to join George R. Cogar, who founded Mohawk Data Sciences and is now president of Cogar Corp. The company started three years ago with an information services division. Then, towards the end of 1968, Cogar established a technical division for the manufacture of data memories. The group of 66 men from IBM provided the company with a well-trained staff. Cogar now forecasts a turnover of \$40 million around 1972. A factory is now being built in Wappinger, New York, about 8 km from IBM's component company in East Fishkill. IBM has filed a lawsuit against George Cogar, his company, and several former IBM employees who now work for Cogar, claiming that they are improperly using knowledge and experience that is the property of IBM.

Fairchild has lost dozens of top executives and middle management personnel over the past two years. Since the company acquired what became its semiconductor division in 1958, four executive directors have left. Among them is Robert N. Noyce, who now heads Intel.



Robert N Noyce once headed Fairchild's semiconductor division.

Corp in Mountain View, California, a powerful new challenger in the semiconductor memory market. Charles E Sporck. Noyce's successor as CEO, now heads National Semiconductor. Both took highly qualified Fairchild personnel with them. Emigrants from Fairchild hold top positions in every company that manufactures integrated circuits in the San Francisco Bay Area. Sjalva

A fresh start with new personnel

Some of the relocations took place when Fairchild itself conducted a raid. In August 1968

1 See ELEKTRON IK 1968, no. 1 1, p. 21: *Bitter sirid between Motorola and Fairchild.*

How to market high technical expertise

"There is a fair amount of mistrust within this industry," sighs William A. Dresser, Fairchild's sales director for the Chicago division. "Customers wait until the last minute to place their orders because they are busy trying to push down prices. When we ask them why we should lower the price, they say, 'Because that's how your industry works, right?'"

Are customers really that short-sighted? **Dresser, whose company has been forced to** postpone deliveries significantly more often than is customary in the industry, shakes his head and pulls out a couple of excerpts from letters from

the company's customers. "I have been trying to do business with Fairchild for over eight years," begins one letter. "If it weren't for the fact that they say I am buying your patent, I would tear out the 'F' page from my phone book."

Dresser is concerned, but it is a universal problem for him. "We have solved some of our delivery problems, but I think deliveries are a serious problem for the entire industry," he says. "And I don't think you can just blame the industry. The customer plays a big part in this because he doesn't want to say what he wants over a long period of time. He expects the semiconductor industry to keep large quantities in stock for him. We have to realize that this costs a lot of money."

Dresser brings up another major problem for integrated circuit sellers. "Manufacturers are afraid to design equipment with overly advanced components because there is probably only one supplier for them. And nobody wants that."

However, there is hope

Despite certain reservations, Dresser does not see

C Lester Hogan, then president of Motorola's semiconductor division, was recruited by Fairchild's chairman Sherman M Fairchild to become president of Fairchild Camera. Hogan installed himself as acting director of the semiconductor division, bringing with him seven of the nine Motorola men who had worked under him and also recruiting a 20-man group from Sprague. From International Telephone & Telegraph, he took F. Joseph Van Poppelen Jr., whom he then made CEO. The industry calls the new additions to Fairchild "Hogan's Heroes."

Such talent raids annoyed some directors, such as Richard E Lee, president of Siliconix Inc, a small but solid Sun-ny wafer company, which primarily focuses on the military market. Lee, who

is optimistic about the future of integrated circuits. "I haven't met anyone who isn't interested in integrated circuits," he says.

Dresser has eight salespeople under him—all engineers—, who handle 40 accounts, all of them major customers. The sales representatives take care of smaller buyers or those who are not regular customers. "Unfortunately, I would say that 20% of our accounts account for about 80% of our revenue. This is a rather unhealthy situation," says Dresser.

"Anyone can get an order," he says. "A salesperson's work begins after he gets it — then he has to make sure we take care of it and that we deliver it. It's a difficult job."

Order fulfillment

Dresser believes that many deals fall through because of a lack of good old-fashioned sales techniques—the ability to know when to ask for an order and how to close the deal. "I've seen too many cases where a sales engineer has done an excellent job of customer support and taken it for granted that everything will then go through the normal channels and that the prospective customer's purchasing manager will sign off on it," he says. "But he has lost the initiative, and in the meantime, a competitor who was also able to solve the problem has come in and gotten the order. Many of our deals fall through because we don't follow up on them. As a result," says Dresser, "salespeople spend 60 to 70% of their time developing sales techniques, while the rest of their time is devoted to technical training." O

former sales director at TI, says that the semiconductor industry is characterized by "immature management, people-stealing, industrial espionage, and unsophisticated pricing."

Sporck at National takes a more liberal stance, which is probably considered the norm in the industry. "I wouldn't refuse to pay well to get a good power to change," he says. Harry M Lu hrs, sales director for integrated circuits at Sy Ivania Electric Products, Inc, adds that if a company lacks expertise in a production area in which it is trying to cut costs, it can cost the company a million dollars to try to find a solution. "On the other hand

you know that if you can hire the right person, you get the problem solved for free."

The usual incentives are high salaries and the right to subscribe for shares. Sporck is now well and truly a millionaire thanks to the terms he was offered when National Chairman Peter J Sprague persuaded him to leave Fairchild together with a highly qualified team in February 1967. Hogan's contract includes an interest-free loan from Sherman Fairchild to purchase priority rights to 90,000 shares, which were sold for \$60 a couple of years ago. In September 1969, the share price was around \$80. The agreement can be said to have set a precedent.

The director of a medium-sized company that operates in integrated circuits says that a director at a company she worked for offered her "half a Hogan" to switch companies.

THAT'S how MOS began

Some smaller companies—both start-ups and "newly born" ones such as Signetics and National—have succeeded by jumping into a "void" in the market that others have been too slow or too hindered to exploit. Motor Oil and Fairchild have only now turned their attention to the manufacture of MOS circuits. The semiconductor group at General Instrument Corp. GI, Hicksville, New York, is the undisputed leader among MOS manufacturers. However, GI has never been able to show a profit or build up a reliable high production rate. Another MOS specialist, General Microelectronics in Santa Clara, reported one loss after another. The company was acquired by Philco-Ford Corp three years ago, moved to Philadelphia, and has since continued to decline. In what appears to be a last-ditch effort

Despite all attempts to continue with integrated circuits, Philco-Ford reduced its product range and lowered its prices.

When Philco-Ford took over General Microelectronics, several leading figures left the company and formed American Micro Systems. Ami. This company turned a profit after six months. It manufactured nothing but MOS components. Ami had sales of \$1 million in 1967, \$3.5 million in 1968, and \$3.4 million in the first half of 1969.

Charles E Sporck succeeded Noyce, then moved to National Semiconductor.



Kommande marknader för integrerade kretsar

Integrerade kretsar var en gång små dyrbara, tekniskt högt utvecklade produkter, som påskyndade utvecklingen av små och tillförlitliga satelliter och missiler. I dag är integrerade kretsar små, mycket billiga, tekniskt högt utvecklade produkter, som börjar att tränga in på mycket större och mycket mer vardagsbetonade marknader.

"Vi har nyckelprodukterna för många industrier", säger J Fred Bucy, vicepresident i Texas Instruments-koncernen och direktör för komponentgruppen. "Vi har inriktat oss på att göra dem allmänt tillgängliga." James R Riley, president vid Signetics Corp, tillägger: "Marknaden begränsas bara av marknadsförings- och konstruktionsfolkets fantasi."

De integrerade kretsarna börjar ta överhanden i datorerna, i synnerhet i den senaste modellen i IBM:s 360-serie. Men de kommer också i andra änden av datormarknaden — i de små bordskalkylatorerna och i minidatorerna. Friden, som utgör kalkylatordivisionen inom Singer Co, använder kretsarna överallt i en ny serie om fem kalkylatortyper. Vicepresidenten för Singers grupp för kontorsutrustning, Lyman Fink, räknar sig som en av Texas Instruments största kunder.

Monroe, som hör till Litton-koncernen, introducerade under förra året en datamaskin för 895 dollar, som är bestyckad med integrerade kretsar. Den väger bara ca 7 kg och kan räkna med 14-siffriga tal. Monroe-presidenten Donald A MacMahon uppger att bara två komplexa MOS-kretsar används för alla minnesoperationer i maskinen. Kretsarna kommer från American Micro-systems. Datamaskinen innehåller också 160 bipolära integrerade kretsar från Signetics.

Hemelektroniken

Integrerade kretsar håller sakta men säkert att bereda sig plats i radio- och TV-apparater, bandspelare och stereoutrustningar. Ett par integrerade kretsar finns redan i nästan alla nya färg-TV-mottagare. H H Scott Inc introducerade förra året en FM-

stereomottagare, där en enda integrerad krets från Motorola ersätter 40 transistorer.

Integrerade kretsar börjar också tränga in på bilmarknaden. Priset på dem har hittills i hög grad hållit dem borta därifrån, säger Stephen L Levy, vicepresident och VD i Motorolas halvledardivision. "Bilföretagen bryr sig inte om ifall en komponent är en integrerad krets eller inte", säger han. "De vill ha bättre egenskaper till lägre pris än de kan få på något annat sätt. Med ett pris på integrerade kretsar, som sjunker med 28 % per år, kommer dessa att om två eller tre år kunna konkurrera med de komponenter, som de skulle ersätta i bilarna."

Motorola säljer redan bilradiomottagare och bandspelare, som innehåller upp till fyra integrerade kretsar per enhet. Många tillverkare av integrerade kretsar har börjat arbeta på andra funktioner för integrerade kretsar i bilar, bl a antislirutrustningar.

Priset på integrerade kretsar hindrar också deras användning på andra områden. Harry Neil, produktdirektör hos Fairchild, säger att företaget har konstruerat en styrenhet för tvättmaskiner, som han i dag skulle vara tvungen att ta 30 dollar för. "Vi måste kunna sälja den för 3,5 dollar", säger han.

Motorola håller på och arbetar på en mätare för avläsning av el, gas och vatten i hemmen under kontrakt med McGraw-Edison. "Energileverantörerna", säger Levy, "vill eliminera de uniformsklädda mätaravläsarna med block och ficklampa. Denna personal borde kunna ersättas med en integrerad krets, som skulle monteras in i mätaren för att tillåta fjärravläsning av en dator."

Goda framtidsutsikter

Marknaden för tunga industriutrustningar, som är koncentrerad till Mellanvästern, är en annan oåtkomlig bransch. Några företag, i synnerhet de som gör eller använder numeriskt styrda verktygsmaskiner, känner väl till integrerade kretsar, men är än så länge skeptiska mot värdet av dem.

inte ut och köper hjulen, motorn och kraftöverföringen och bara sätter ihop alltsammans själv", säger han och förklarar att det är på det sättet som datorföretagen sätter samman sina minnen. Taren säger att Cogar vill sälja kompletta minnessystem och också ta ansvaret för utförandet av dessa. Han uppskattar att marknaden för datorminnen kommer att bli värd 4,1 miljarder dollar under 1975.

Hur stor del av minnesmarknaden Cogar tar beror till stor del på företagets produktionsförmåga. "För att lyckas med tillverkningen", säger en av de ledande krafterna hos Ami, "är det nödvändigt att strunta i tekniska exklusiviteter." Ami,

"Uppriktigt sagt använder vi integrerade kretsar bara för att visa att vi är moderna", säger en representant för Sundstrand Corp, maskintillverkare i Rockford, Illinois. "Det är magiska ord. Visst är det bra att kunna säga att man har dem, men de gör ingenting, som inte transistorer kan göra utom det att de miniatyriserar utrustningarna."

Telekommunikationsindustrin kommer troligen att absorbera lika många integrerade kretsar som datorindustrin, fastän inte så snabbt. "Telefonindustrin har just börjat gå över till integrerade kretsar", säger C Robert Castor, vicepresident och VD i Sylvania's halvledardivision. "Den kommer inte att bli någon större förbrukare förrän 1974 eller 1975."

De flesta tillverkarna av telefonväxlar använder varken rör, transistorer eller integrerade kretsar, utan elektromekaniska komponenter — reläer och väljare — av vilka många har varit i tjänst i mer än 30 år. AT & T-ordföranden H J Romnes talade om för säkerhetsanalytikerna att 70 av 80 000 växlar har utrustats med halvledare och att fem stycken per fjortondagarsperiod kommer att utrustas på samma sätt under 1970-talet. Var och en kommer att kosta en miljon dollar.

Inom industrin för tillverkning av integrerade kretsar är man oerhört säker på att det inte kommer att dyka upp någon annan teknik, som skulle kunna hindra deras utveckling på marknader som de ännu inte dominerar.

Riley vid Signetics blir hänryckt över användningsmöjligheterna för integrerade kretsar inom bilindustrin. "Vi gör tio miljoner bilar per år", säger han. "Om fem år kommer man att använda 20 integrerade kretsar per bil." Om priset för en typisk integrerad krets för bilar sjunker till ca 1 dollar till 1974 jämfört med det dubbla eller fyrdubbla i dag, skulle bilmarknaden ensamt ta hand om mer än hälften av den totala försäljningen av integrerade kretsar under 1968. □

Satsning på säkra kort

MOS-kretsarna håller nu på att etableras som konkurrenter till de bipolära. Dessa dominerar marknaden och det är osannolikt att de kommer att slås ut av MOS-kretsarna. I några tillämpningar konkurrerar de två komponenttyperna med varandra, i andra kompletterar de varandra. Cogar och Semi har valt att inrikta sig på båda typerna för att kunna ta så stor del som möjligt av den framtida marknaden på halvledarminnen för datorer.

Cogars marknadsförings- och försäljningschef William Taren jämför sättet att se på marknadsföringen av halvledarminnen med hur man bygger bilar. "Man går

liksom Motorola, Signetics och National, är kända för att låta andra företag göra innovationerna. De tar hand om det fåtal nya produkter som ser ut att kunna lyckas och koncentrerar sig på en säker produktion. Målsättningen då Ami startades var att hålla sig ifrån "exklusiviteter" och att "komma i gång med tillverkningen och leverera när vi sagt att vi skulle leverera".

Fairchild, General Instrument och Sylvania räknas som ledarna vad avser tekniskt kunnande och som efterslätrarna vad gäller produktionsstyrning. För några år sedan kom Sylvania, som är dotterbolag till General Telephone & Telegraph, ut med en sorts snabba bipolära TTL-kretsar, som

marketed under the name Suhl (Sylvania ultra-high-speed logic). The Suhl components were technically the best available at the time.

their kind. Computer companies fought over them, and Sylvania received more orders than it could handle. "We found ourselves in a situation where we couldn't expand enough to meet demand," says C Robert Castor, CEO of the company's electronics component division. , marketing director, adds: "What really hurt us was that we had customers who believed in us, but we didn't have enough resources. This gave Texas Instruments a real advantage, which they also took advantage of."

Texas Instruments had developed a comparable product. Sylvania began to turn around delivery times and, at the same time, launched a huge sales campaign. Customers flocked to Dallas. The first n sped away even further, says Deryl Foster, marketing director for integrated circuits, where the company assembled its TTL circuits in plastic.

capsules instead of the more expensive ceramic or metal caps, which were common at the time. Foster says that TI now leads the industry in the TTL field, a statement that can hardly be disputed.

Sylvania is back where it started. The company operates its Suhl line, but has also become a supplier to TI. Castor reports that bottlenecks in production have been eliminated and that production volume has doubled in one year. Fairchild says that it is still holding on and fighting successfully. Fairchild's Van Poppelen says: "A year ago, Fairchild was able to keep its delivery times at 60%. Now we are up to 85%."

Low yield for complex integrated circuits

Some of the factors that are hindering the growth of companies are difficult to control. For example, shortages of raw materials are detrimental to manufacturers of integrated circuits as well as to users. Deliveries of purified silicon, the base material for all semiconductors, declined alarmingly in 1969. The reason: no one had foreseen the rapid growth of the market for integrated circuits. The availability of capsules for mounting the circuits is also reported to be generally scarce. Ami states that the growth may slow down in the coming years as suppliers of silicon and capsules are expected to increase their capacity.

It seems ironic that a mass-produced item such as a half-wired component requires so much manual handling. The industry measures efficiency in terms of yield or the percentage distribution of approved and rejected products. Yield can decline anywhere along the production chain, but defects cannot be detected until the finished circuit is tested in measuring equipment.

The outcome of the case concerning transistors is

throughout at close to 100% run length. The heart of a transistor, like that of an integrated circuit, consists of a silicon chip. But unlike the chips in integrated circuits, transistor chips are only one circuit component. A single chip for an integrated circuit can contain several entire circuits. For simple integrated circuits, the failure rate often exceeds 50%, but for the more complex ones, it is rarely more than 5%. As the failure rate drops and costs rise, the more complex integrated circuits that pass the test must pay for the 95% that do not. Low rejection rates have been one of Fairchild's biggest problems. "Things are starting to get better," says Van Poppe-len, "but we are still below a competitive level."

Many opportunities for error

A dominant cause of poor results is human error. People intervene at many stages in the manufacturing process. They make extremely accurate patterns, which ciler alt ha reducerad i storlek. blir den exposure mask. This is used to place the circuits in rows on the silicon wafer. These are then cut down to wafers. If there is a fault in the mask, the entire wafer with all its circuits will be ruined.

Human labor is also used to encapsulate the finished tray. The work is semi-automatic and is performed under a microscope.

A tray with 14 tilted areas, a common configuration, contains 28 welds, each of which poses a risk from a reliability standpoint. Each weld also represents a high cost factor in the manufacture of integrated circuits. Mic-



John L. Sprague

Rotek Electronics, Inc., a manufacturer of welding equipment, estimates that a good welding machine, operated by a skilled operator, can produce a maximum of 4,000 welds per hour. This is one-fifth to one-tenth of what the industry expects to achieve in the future. in the future.

Important for factories outside the US

One solution to these production problems is "one-pass bonding," a process in which all soldered joints are soldered simultaneously. Several methods for "one-pass bonding" have been developed and are now being tested in pilot production. Levy at Motorola, however, assures us that "one-pass bonding" will be used in a large part of their production by the end of 1970.

I think there is another reason why automatic bonding has not been introduced more quickly. Namely, the cheap labor available abroad. Almost all leading companies operate factories in Korea, Hong Kong, Singapore, Formosa, and Mexico, after Curaçao, where girls earn 20 to 30 cents an hour for welding and encapsulating bricks. Companies usually pay customs duties only on the value of the components shipped out and returned, but this situation may change. President Nixon has given the Tariff Commission i **tasked with investigating more American** manufacturers outside the country and submit a report to him at the beginning of this year. The changes that the investigation could lead to would almost certainly force companies to seek to reduce labor costs at home through automation.

Competitors as secondary suppliers

Some companies stick to and, in certain cases, also use other production methods alongside "one-pass bonding." For example, they use computers to design the more complex circuits and to draw up the masks. This saves time and reduces the risk of errors caused by the human factor. Computers are also used to increase the speed of testing the circuits.

The situation is difficult to control, and companies are reluctant to expose themselves to customer criticism when the exchange rate falls so low that deliveries are halted. Therefore, they hire competitors as "second-tier suppliers," which gives them the opportunity to save face and, they hope, future orders. General Instrument recently did this when they appointed Signetics as a second-tier supplier for MOS circuits. Fairchild's secondary suppliers include Motorola, Philco-Ford, ITT, and Raytheon. The latter company, which is also a secondary supplier to , and , has become one of the top ten companies almost entirely by being a good secondary supplier.

COMPETITION FOR NEW PRODUCTS

In the electronics industry, which is characterized by rapid innovation, new semiconductor products are being introduced at a pace that is otherwise only seen in the racing industry. Electronic News, the industry's weekly magazine, proclaims Intel Corp. "Pick Another Winner. We did." The new

Another winner" is one of the newly launched products. Both were introduced in August 1969.

In fact, several companies, such as Fairchild and Sylvania, admit that they previously launched advertising campaigns for products that later proved to be misguided. Nowadays, however, one can count on the products advertised actually being available.

"But the advertisements can mislead us," says Harry Luhrs at Sylvania. "People advertise new products and pretend that what actually drives the industry has become outdated. In reality, very little has changed." The integrated circuits have not yet reached their full potential.

The transistors did not knock out the tubes, nor did the transistors knock out the tubes. The supply of transistors in 1965 fell by 6% in value to \$379 million compared to the previous year, but was still greater than sales of integrated circuits. In terms of volume, transistors increased by 16% according to the Electronic Industries Ass. Receivers, the only ones really threatened by semiconductors, sold for \$196 million

in 1968, a decrease of only \$14 million compared to 1967. While sales of transistors and tubes will undoubtedly decline, integrated circuits will more than make up for the gap. The question today is not whether to manufacture integrated circuits, but which ones and when.

Misjudging which circuits to recognize and when to start manufacturing them can cause some damage, as General Instrument and General Microelectronics learned through the MOS circuit. These were slow to catch on because the component was slow and could not directly cooperate with bipolar circuits. Faster MOS components appeared later, and among these were some that could work together with some

bipolar circuits.

Although MOS circuits are still slower than bipolar components, they cost less and are therefore attractive to the cost-conscious, highly competitive calculator and office machine industry. MOS components can also be packed much more densely on silicon wafers. In

åratari re ekte Cieneral Instrument förö-ä-

ves ate r computer manufacturers to methods but also use MOS circuits throughout their

The machines themselves are also becoming increasingly complex. For machines, MOS circuits could not describe the degrees of complexity, they have collaborated with the bipolar kret sama industry has expanded its technical vocabulary.

Now there is 'Nu'. says Lewis Solomon, the company's

the SS I for "small scale integration," which is the same as DIC, for "discrete integration." the same as DIC, for "discrete integration circuit." Then there is MSI for integrated circuits, which allows customers to integrate circuits by giving them the opportunity to sell.

integrated circuits." Then there is MSI for circuits by giving customers the opportunity "medium scale integration" and LSI for mixing them.

"large scale integration." Designers TTS circuits account for the largest share of sales and sellers of integrated circuits build the construction share

ay the bipolar logic their special vocabulary, but are "families" whose identities are determined by how do not always agree on how to define

components are arranged on the boards. their concepts.

EC L circuits belong to a different family. The SSI circuit is generally described as a

Although ECL circuits are far more expensive, they are circuits with 12 or fewer gates built on the fastest, they are the most expensive to manufacture and a chip. Some engineers believe that MSI circuits are the most expensive. be Lonstrueras circuits have 12 to 50 gates. Others say almost exclusively for large computers. that they have up to 100

grinders: if you go Foster x'id Texas Instrument asks to LS I sales of EC L circuits will rise sharply. circuits. MOS circuits bring the whole

resolution. In 1967, sales were 19.2 in disarray. One can pack millions of dollars, and in 1968 it rose to 25.9 MOS circuits are denser than bipolar

components. million . Is 1969. said Foster. nents, which makes it unrealistic to compare

sales will reach 30 million

dollars. In 1973, she estimates sales

a couple of hundred million dollars.

addition to digital integrated circuits

which has been mentioned so far, linear

Deras marknad ar mycket

smaller than the ru di ;tata components —

60 million dollars versus 304 million dollars measuring stick they had back then—it was 1968— but it's stable and looks like what it looked like back then." Jack A Mor-grow significantly. N Air the integrated circuits— ton, vice president for electrical components at Bell Telephone Laboratories. radio and TV receivers, they will be used says that companies should focus on the right scale of integration for analog circuits for special functions in xml-ph-0007. Furthermore, "RSI... the right scale of integration" is needed for analog circuits for special functions in to arrive at the most economical solution. The solution.

Pure integrated circuits are called monolithic circuits. The circuits are becoming increasingly complex. Nothing else but conductors and capacitors because that is what customers want. The resistors are then assembled after the chip has been manufactured. The following applies: The more circuits on the same chip, the fewer external connections are needed and the lower the risk of errors due to human factors. Companies make hybrid components by placing an extra component on the chip after the main production process.

The process. Hybrid circuits can also be made by spreading monolithic bricks over a substrate. The bricks offer a cost compromise in terms of the required production volume of monolithic circuits.

The need for a sufficiently large production volume of monolithic circuits.

Designations with

Uncertain meaning

Not only did they develop manufacturing

Many people make them themselves.

As larger markets open up for integrated circuits, the semiconductor industry faces an uncertain future: more and more companies are starting their own production. Among computer companies, IBM has for several years manufactured many of its own components. Smaller companies such as Control Data and Honeywell have followed suit or will do so soon. Singer Co. supplies many of the circuits that its subsidiary Friden uses in its calculators. Tektronix and Hewlett-Packard put their own specially manufactured hybrid circuits in their instruments along with components purchased from manufacturers from integrated circuits. Hewlett-Packard and Collins Radio have also put what they have learned to good use and entered the open market.

Why are some companies willing to invest in their own semiconductor factories? Some have no other choice. Texas Instruments and Hewlett-Packard purchase the integrated circuits they need from suppliers. But they also need special circuits for expensive instruments, of which they may only sell a dozen or so. Manufacturers of integrated circuits are geared toward mass production. Instrument companies are therefore forced to set up a small department for the manufacture of hybrid circuits and make their own components. Then another company may find that it needs a similar circuit. It is not available in the semiconductor industry. So they buy it from Hewlett-Packard.

There are other reasons why companies manufacture their own semiconductors. In the fierce competition within the industries for the manufacture of instruments, calculators, microcomputers, and home electronics products, the arrangement of circuit components is of particular importance for the cost and performance of the end product. Under the design, which is carried out using monolithic technology by large manufacturers, companies are increasingly afraid of losing control of the individuality and competitiveness of their products.

The CEO of a company that manufactures integrated circuits has found widespread paranoia within the TV industry. "We have to prove to them that we can visit Zenith one day and Riolola the next without spilling the beans," he says. Users seem to be afraid of what might happen even if nothing happens. But the fear has been enough to persuade some to build their own design and manufacturing departments. Several others are doing so because they are afraid of losing sales due to delayed deliveries of circuits.

This was the basis for Stromberg-Carlson's decision in 1969 to build a semiconductor factory—and not just a temporary facility for manufacturing hybrid circuits. Company president Dause L. Bibby says he wants to start with hybrid circuits and then move on to complex MOS circuits and bipolar circuits.

"We want to have oversight of every factor that

"It is crucial for the quality, cost, or functionality of our products," he says. functionality of our products," he says.

Sporck at National Semiconductor believes that some companies are right to establish internal factories for the manufacture of integrated "But there is a "Own departments tend to tend to become uneconomical. They are not exposed for the beneficial effects of competition."

FUTURE OPPORTUNITIES

If competition were the only criterion for success in integrated circuits, Collins Radio would have made it. Four years ago, the company decided to meet its own needs for components for military equipment and aircraft equipment, and later also for computers. In August last year, Collins announced that it would launch its semiconductor including manufacturing on the open market.

Collins says that the most advanced computer design technology and assembly methodology should be used to ensure a total delivery time of 60 days from order to delivery. This is 30 to 60 days less than the delivery time that manufacturers of integrated circuits can currently offer for the design and manufacture of customer circuits.

Collins intends to install data terminals at its customers' design offices. This will allow Collins to participate in the design of circuits without wasting time on travel and will facilitate communication between customers and Collins' new factory for the manufacture of MOS components.

The manufacturers of integrated circuits do not believe that Collins will cause them much trouble, but hope to be able to prevent similar initiatives from other former customers. "We believe that companies that manufacture integrated circuits tend to forget one fundamental thing—that the customer is always right," says John L. Sprague, senior vice president at Sprague Electric. "In the past, we let the companies know that we know how to design integrated circuits better than they do. Now," he says, "the industry has changed its approach. The customer must be involved in the design process."

Consumers of integrated circuits have There are differing opinions about what the ideal relationship between users and manufacturers should be. Some focus on close collaboration with semiconductor manufacturers, while others reserve the right to design their own circuit patterns without the manufacturer's involvement. The manufacturer then takes over the masks and makes the circuits. Some simply purchase large quantities of stock items, just as they used to buy transistors and tubes, in order to get below the cost of custom circuits. Some purchase chips that they encapsulate themselves, sometimes as hybrid circuits.

Signetics has established itself within the industry reputation for customer satisfaction. "At Signetics," says President James F. Riley, "customer service is considered as important as sales, marketing, and distribution, so the customer service department is directly

that he has a firm grasp of his field." Riley has become known for turning down attractive orders when there is a risk that he will not be able to deliver on time. But he admits that even Signetics gets stuck from time to time. How do you treat the customer when that happens? "Tell him the truth," he says.

Many in the industry believe that the larger companies will continue as before, while some of the newcomers, such as Mostek, Intel, Ami, Cogar, and Semi, will creep up to the top ranks in the mid-1970s. There is a tendency to dismiss the less publicized production of integrated circuits by companies such as RCA, General Electric, General Telephone, and ITT. But don't be so quick to do so, warns Thomas H. Bay, former CEO of Fairchild and now head of Central Data Systems, a new computer company in Sunnyvale, California. Bay believes that computer companies will follow JBM's lead and cover their own semiconductor needs, either by starting their own manufacturing operations or through acquisitions. For example, both RCA and General Electric manufacture computers. In order to satisfy their own demand for semiconductor-equipped telephone exchanges, communications companies could become major users of integrated circuits. Philco-Ford, ITT, and Sylvania manufacture both semiconductors and communications systems.

Morton at Bell Laboratories believes that companies with broad resources in all areas of integrated circuits will lead the industry in the long run. Those who focus on a specific technology, such as MOS memory, only have a temporary market advantage, he says. William Sick, director of strategic planning at Texas Instruments, adds: "You have to have all design methods available so that you can develop the optimal method for a particular customer's system." On the other hand, the figures presented by some of the newcomers show that, at least for now, there are other ways.

"It's a competitive industry," says Howard Bobb, who works at Amim•n and was also involved in founding General Microelectronics. A typical example of a failed business venture. But why not then? decide to make, say, tea bricks instead? "People love this technology," says Bobb. "Because it's fun," says Robert Noyce at Intel. D