5.5 PACKAGING EQUIPMENT

5.5.0 Packaging Equipment

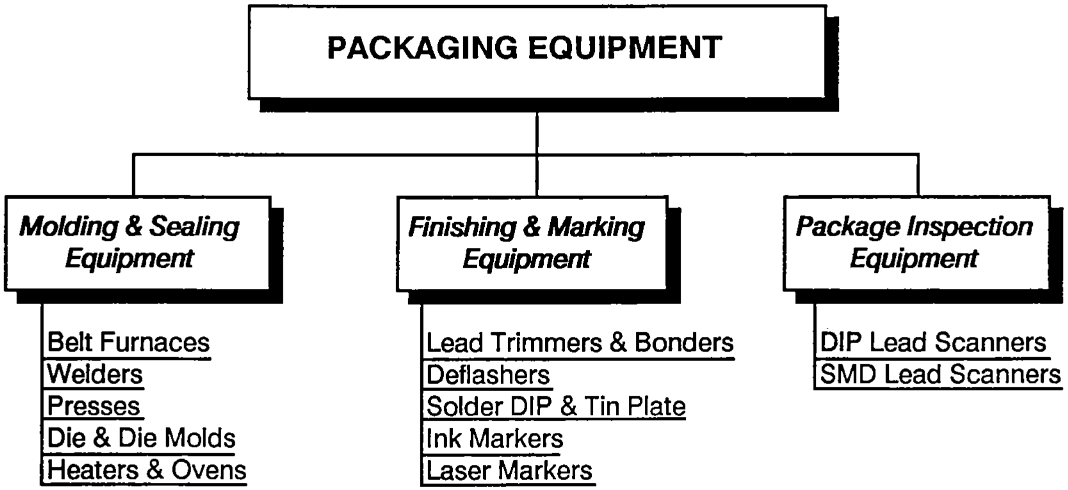
- **Surface mount technology has led to a renaissance in packaging equipment.**
- **Packaging equipment is the largest segment of the Assembly equipment market.**
- **Packaging equipment consists of three sub-segments: molding and sealing, finishing and marking, and package inspection.**

The early nineties, brought a renaissance to packaging due to a demand for more I/O, smaller sizes, higher power, faster speed and control of thermal properties. These demands drove the need for more sophisticated packaging equipment that could handle finer lead pitches, new package shapes, surface mount, greater thermal dissipation and even new materials.

The packaging equipment market is the largest single segment of the Assembly equipment market. Overall, it accounts for roughly 5% of the total semiconductor equipment market. This figure that has remained relatively unchanged during the last decade.

The packaging equipment market is made up of those processes and equipment used to encase and label dice in their protective cases, protect the dice from the environment and inspect the package for proper functionality. VLSI Research segments packaging equipment into three submarkets, as shown in Presentation 5.5.0-1.

Presentation 5.5.0-1



Source: VLSI RESEARCH INC
2254-68P

Molding and sealing equipment includes equipment used to encapsulate die into a package. Molding equipment consists of molding presses, molding die that go into the presses, heaters which preheat the leadframes, and cure ovens for final curing of molded packages. Sealing equipment consists of belt furnaces and other thermal reflow furnaces, as well as weld sealers. The latter is almost exclusively used for cap sealing of TO packages.

Finishing and marking equipment is used to finish and label the package. Finishing equipment consists of lead trimming, forming and solder dipping equipment. Marking equipment is segmented into ink marking with conventional or UV curing, and laser marking equipment. Finally, package inspection equipment consists of DIP and SMD lead scanners used to inspect for damaged leads.

5.5.1 CURRENT INDUSTRY CHARACTERISTICS

5.5.1 CURRENT INDUSTRY CHARACTERISTICS

- **The trend toward SMT is changing the face of packaging equipment.**
- **The packaging equipment industry is currently characterized by its diversity and its small size.**
- **Users want to be able to produce a wide variety of packages in smaller production runs.**
- **Fine pitch packages are driving the need for more sophisticated finishing equipment.**

Historically, IC packaging equipment has been somewhat of a neglected step-child of the semiconductor industry. Commonly referred to as the backend of assembly, it has taken a back seat not only to wafer fabrication equipment but also to dicing and bonding. This attitude results from the fact that sophistication in packaging methods does not matter if the IC cannot be made. However, the neglect that packaging equipment has endured has led to a condition where package technology is often a limiting factor to new product introductions.

Demand for more I/O, higher power, faster speed and better thermal management is placing new pressures on packaging. Consequently, some semiconductor manufacturers have begun to view packaging as a source of strategic differentiation.

Further, the trend towards a greater variety of surface mount packages is changing the face of the packaging equipment industry. The equipment can no longer be characterized as low-tech presses. Today's equipment is fully automated with sophisticated computer control.

Nevertheless, the packaging equipment market can be characterized by its diversity and its small size. Less than five percent of worldwide semiconductor equipment investment is made here.

5.5.1.1 Development of the Industry

Packaging equipment dates back to the 1950's. The first semiconductor packages were developed for transistors. These packages were 'top hat' cans with 2 to 3 leads. This design proved advantageous since it hermetically sealed the semiconductor from the environment and was highly reliable. These were important features since the first large consumer of devices was the military.

When the integrated circuit was developed, the industry expanded to 5 to 10 lead packages. As semiconductors began to be used for commercial applications, these packages were found to be technically limited for mass production. The top hat packaged devices had to be handled individually and put into a carrier so leads would not become entangled. The cost of this additional labor was too heavy a burden for the commercial market.

In the late fifties, the Dual In-line Package (DIP) was invented by Nathan Pritiken of Photonics. It originally developed in response to the semiconductor industry's need to reduce labor costs. DIP's provided stiffer leads that would not bend or entangle like TO's. Additionally, DIPs could ride down a rail, thus reducing labor costs associated with putting each package in an individual carrier. This represented one of the first automation efforts in assembly.

Fairchild is largely credited with commercializing DIP's after Bryant Rodgers joined the firm from Photonics in 1960. Fairchild was selling the first ceramic DIP packages by 1963. DIP's soon came to dominate the packaging market. They would hold this position for almost thirty years. Ceramic DIP packages came into existence due to military requirements. Ceramic packages hermetically sealed devices, which provided the best protection from environmental damage. These packages are also more durable. However, ceramic packages are more expensive than standard plastic DIPs because they are glazed and sealed with a gold frit (see Presentation 5.5.1.1-1).

It wasn't long before engineers began to encapsulate DIP's in plastic. This lowered costs dramatically. Plastic DIPs provided high volume at low cost and increased functionality of devices. This innovation proved a key factor in the success of the integrated circuit. Another alternative was the CERDIP.

The CERDIP is a cross between a ceramic and plastic package. It is a two layer package made out of alumina and it is solder glass sealed. When the CERDIP was introduced, it met most military applications and was heavily campaigned for by Fairchild and Texas Instruments. However, it never won favor over either plastic or ceramic DIPs because it did not meet all military applications and was more expensive than plastic.

By the early 1970's, portable consumer electronics was beginning to affect packaging. This led to the development of surface mount technology.

The term 'surface mount technology'—commonly called SMT—provides an accurate self-description. The leads of an SMT package are soldered to the surface of the Printed Circuit Board (PCB), in contrast with conventional DIP's, which are through-hole mounted. In surface mount terminology, DIP's are called THMs. The leads of a THM device are inserted through holes in the Printed Circuit Board (PCB) and then soldered. Both methodologies are depicted in Presentation 2. Unlike THM, the shape of an SMT's lead-bend can vary. The most common shapes are J-lead and gull-wing, as depicted in the figure. Lead shapes and pitch sizes tend to be the most critical feature that differentiate the various SMT package styles.

In its early years, SMT was viewed mostly as a technical curiosity. There was no infrastructure to allow a commitment by major users. Conflicting standards and unavailable equipment hampered SMT efforts. More importantly, lack of interest among users in the United States slowed growth considerably.

The development of SMT traces back to Europe. N.V. Philips developed the first SMT package. It was formally introduced as the Small Outline (SO) package style in 1971, originally designed for very dense packaging in consumer electronics.† Resis-

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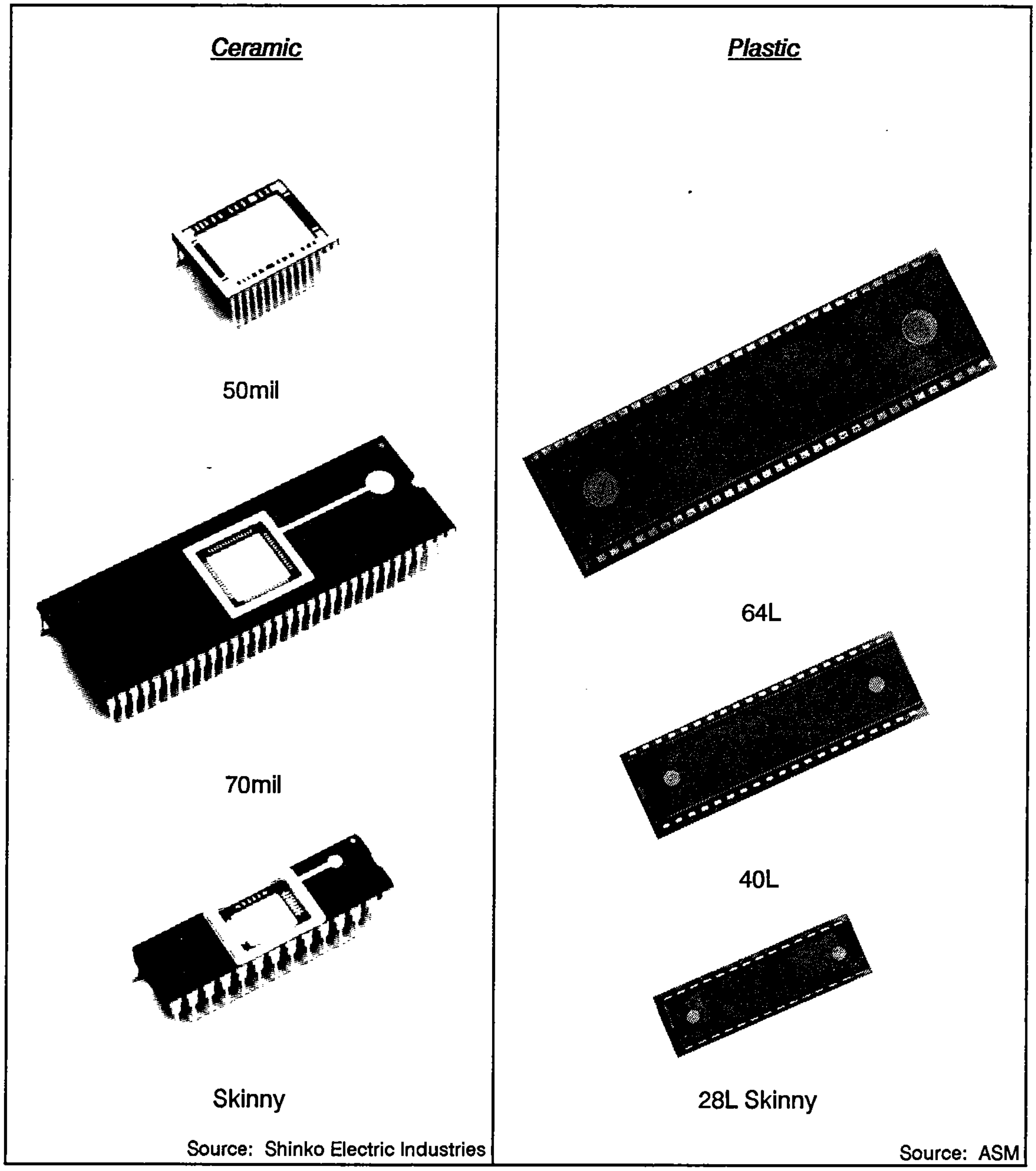
† It was also known in the United States as the Swiss Outline Package.



Source: Shinko Electric Industries

Source: ASM

Presentation 5.5.1.1.-1

Dual In-Line Packages

tors and transistors were being made so small that they dwarfed conventional packages. SOIC's took up less than 70 percent of the area of an equivalent DIP. They weighed 90 percent less. Moreover, they were one-half the height of a DIP as well.

Japanese companies quickly adopted SOIC technology. At first, it was primarily used in small calculators and radios. With SMT, the limiting size factor became the display and the buttons. Consequently, a full calculator could be placed in a wrist watch by the mid-seventies.

The advantage that SMT brought to the consumer can clearly be seen by tracing the evolution of calculator thickness, as graphically portrayed in Presentation 3. In 1969, the first shirt-sized pocket calculator appeared from Sanyo. It was an inch thick, four-function calculator, which sold for about $700. It used standard DIP's. Sharp soon followed with its Micro Compet packaging technology that allowed for truly miniaturized consumer electronics.

In 1973, Sharp became the first company to introduce a Chip-On-Board (COB) mini-calculator. These were mass-produced on a fully automated 'lights out' production line, at a rate of one every four seconds. This provided the world with inexpensive, mass-produced, hand-held computing power. By that time, the price of a four function calculator had fallen to below ten dollars.

In 1975, the use of SMT allowed Sharp to further reduce the thickness of their calculators to 9mm. By 1976, this had edged down to 7mm. Pocket calculator thickness there-after consistently edged down in each succeeding year, to reach a low of 1.6mm by 1979. These were the credit card sized calculators of today.

The strategic effect of SMT upon the business of Japanese companies caused them to quickly push the Quad Flat Pack (QFP) in consumer products. QFP's came to be used in calculators, cameras, video cameras, VCR's, radios and TV's. A whole new wave of miniaturized consumer electronics began to hit United States shores by the late-seventies. Japan was well on its way to becoming the world's leader in electronics, with SMT playing a major role in this success.

By the late seventies, packages were reaching the lead count barriers. DIP's began to run into capacitance limits as pin counts exceeded 64. Packages such as leadless chip carriers and pin grid arrays were developed to accommodate higher lead counts.

Chip carriers first began to appear in the United States in 1977. At that time, industry forecasters were projecting phenomenal growth rates. Analysts expected worldwide market acceptance in a short period of time. Many prominent companies claimed surface mount technology (SMT) would be the panacea for all electronic architecture problems. It did not happen, and SMT did not show any signs of life in the United States for almost ten years after it was first developed. Over this time, many became discouraged because the booming forecasts never came to fruition. Several negative articles appeared in trade publications. Two key issues kept haunting SMT: Was it just a technical fad, and would it ever become a business reality? Consequently, the market for SMT in the United States did not develop in those early years, as senior management turned away from the recommendations of its packaging engineers.

TI and Signetics were the first pioneers to renew the push for SMT in the United States. Texas Instruments put massive resources into developing an American technical base for SMT. They published technical articles and books on SMT. They kept up-to-date listings of those vendors who offered equipment materials and contract services in SMT. They built an SMT technology development center in Houston, Texas whose sole purpose was to help customers through the initial learning phases.

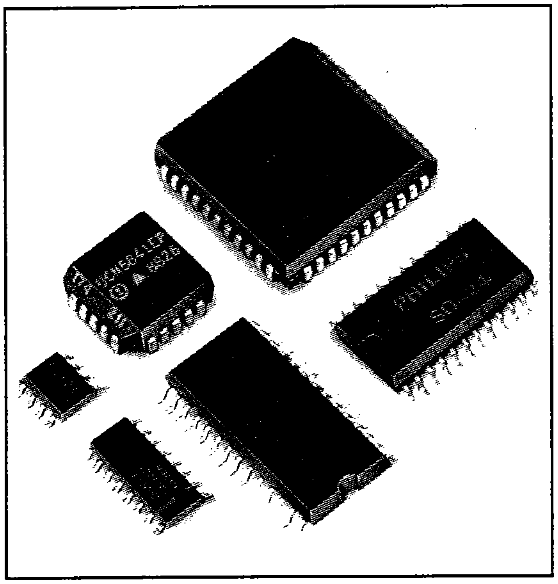
By the early eighties, the infrastructure for SMT use in the United States was coming together. AT&T, Hewlett-Packard, and Delco first began to actively use SMT. At that time, total United States SMT consumption was a mere 15 million units annually. In contrast, by 1987, Delco was consuming that many SMD's daily.

By 1985, large computer companies had also begun taking an active interest in SMT. Compaq, DEC, Honeywell, IBM, NCR and Unisys were beginning to focus heavily on SMT. Within two years time, they were to become heavy users of SMT. The industry moved quickly. At the time, a 0.05 inch pitch PLCC was considered state-of-the-art. By 1990, it was in use by virtually every device maker. Further, the majority of new Quad packages were being introduced with lead counts above 100.

Surface mount devices were developed in the late 70's, created by the need for flat packages used in calculators, smart cards, etc. (see Presentation 5.5.1.1-2). Currently, about 50% of the ICs are packaged as surface mount devices. By the mid-nineties, approximately 75% of integrated circuits will be packaged using surface mount technology (see Presentation 5.5.1.1-3).

The trend towards surface mount is changing the face of the packaging equipment industry. Successful packaging equipment vendors are making moves to take advantage of this growing market by manufacturing equipment flexible enough for easy changeover from DIP to surface mount devices (SMD) and from one SMD to another.

Another trend brought on by the increased complexity of packaging today's fine-pitch high-pin-count devices is the overwhelming use of statistical process control (SPC) data. The ability of the packaging equipment to provide SPC data has become a critical selling point to the users. Of particular interest is the collection of data on those parameters that have been shown to affect the quality of plastic packages. Some of these parameters include pre-heat time and temperature, compound transfer-time and overall cycle time.



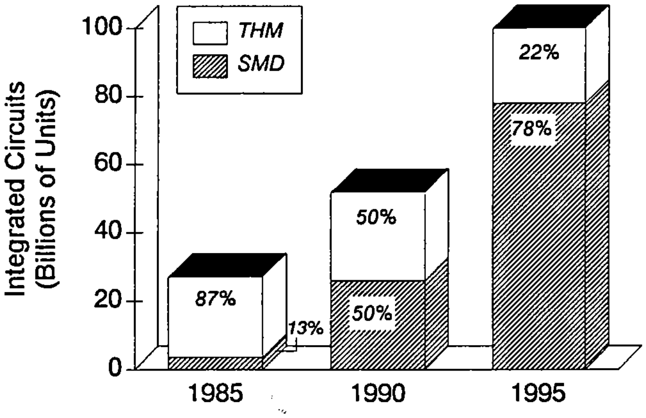
Source: ATM
2254-95

Presentation 5.5.1.1-2

Surface Mount Devices

Presentation 5.5.1.1-3

Packaging Technology Trends



Source: VLSI RESEARCH INC
2254-76G

5.5.1.1.1 Development of the Molding and Sealing Equipment Industry

Molding and sealing equipment have origins which are far older than this industry. Equipment has traditionally been generic to all industry. However, semiconductor specific equipment designs began to emerge in the mid-eighties.

Molding Equipment

Molding equipment was used for package assembly in the early 1960's when the first plastic DIP's began to be used. Molding required four pieces of capital equipment: a preheater, a press, a die form and a cure oven (see Presentation 5.5.1.1.1-1). Molding equipment involves placing dice mounted to a leadframe in the mold, heating the plastic and infusing it into the mold. The plastic seals and encapsulates the die.

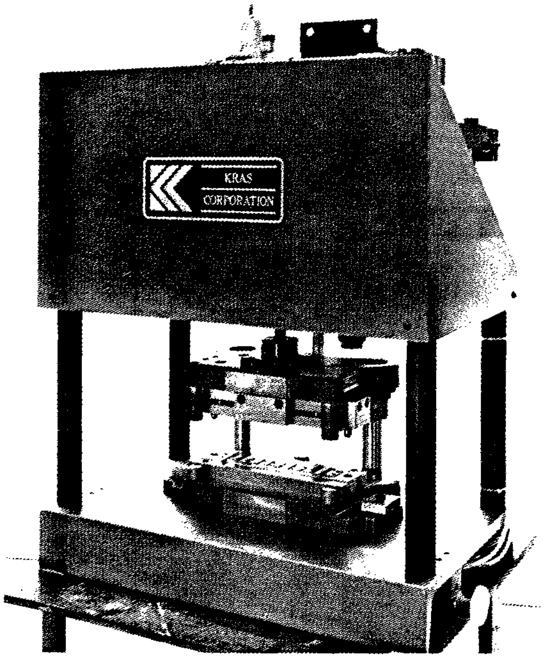
In the late 1970's, this market could be characterized by rapid advances in equipment throughputs without equivalent price rises. Advances in molding dies were the primary source of throughput improvements during this period. The thrust in molding equipment was continuously towards larger capacity molds. Few molds for 14 pin DIPS exceeded 200 cavities prior to 1977. But by 1979, 500-1000 cavity molds were coming into play. The first aperture plate molding die was invented by Dusan Slepcevic in 1979. These increased the number of cavities per mold by more than 50%. Consequently, Dusan's dies proved to be a major market success (see Presentation 5.5.1.1.1-2).

The primary factor which has drove the increase in mold capacity in the eighties was utilization of labor. Labor can be optimized when the unload, clean, and load time of any one press is approximately equal to the curing time in another. This optimized labor usage, since one operator can then continuously operate and monitor two or more molding presses. As a result, most of the technological developments continued to go into improving mold capacity.

However, technical research in the early eighties began to revolve around automating and simplifying the steps leading up to or following the cure step. The most difficult area to automate was curing. Consequently, curing remained essentially unchanged until the late eighties. Nevertheless, automation of the molding press forced change on this area as well as others. Towa and ASM-FICO were the first to successfully eliminate the need for separate postmold cure and deflashing equipment. These process steps are now incorporated into most modern systems. Consequently, automated molding equipment placed downward pressure on the curing oven and deflashing markets.

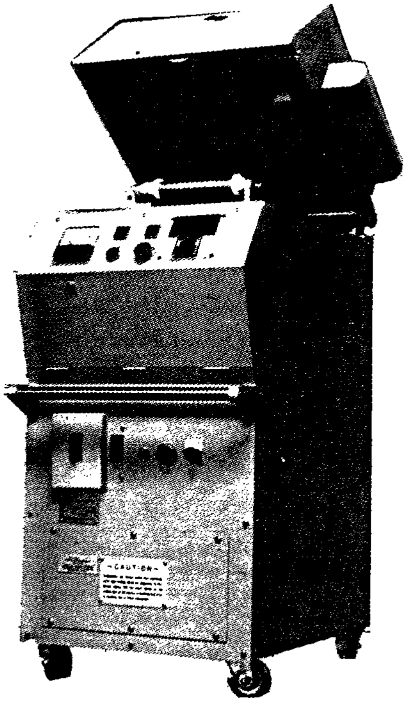
Packaging also benefitted from the trend toward smaller form factors and portability in electronics products during the eighties. Portability required smaller form factors and thus greater printed circuit board densities and smaller outlines for board components. Thus, surface mount technology (SMT) using small outline integrated circuits (SOIC) grew. The molding equipment market grew rapidly, since the technology required retooling of all molds. Moreover, SMT packages were harder to make and so new equipment developed as a result.

The surface mount trend led the industry towards more fragile packages with greater numbers of leads. Users stressed the need for void free molding, with no warpage, less wire sweep, and flash free packages. In the early nineties, molding equipment was also driven by the demand for flexibility–the ability to mold a wider variety of packages in smaller production runs–and the ability to collect SPC data.



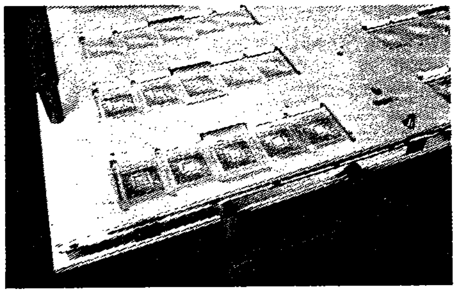
Press

Source: KRAS

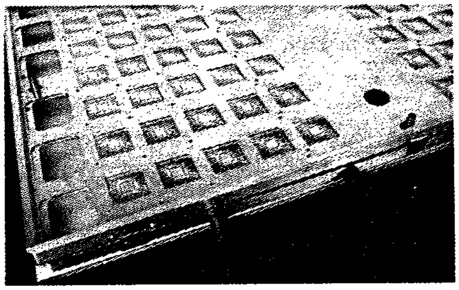


Preheater

Source: ESC/Fuji



Bottom aperture plate



Top aperture plate

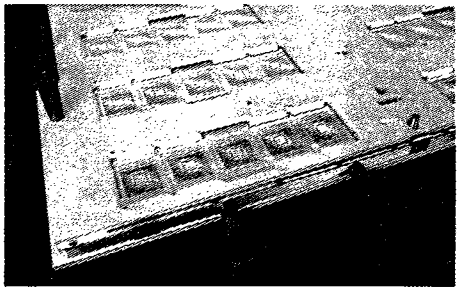
Source: Dusan Equipment
2254-77

Presentation 5.5.1.1.1-1

Early Versions of Molding & Sealing Equipment

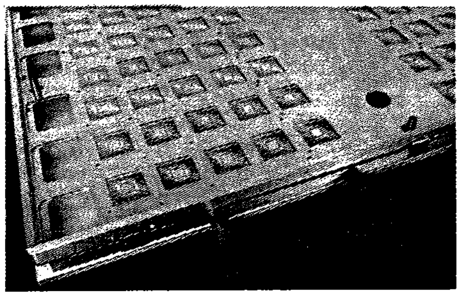
①

First, the bottom mold is placed on the alignment plate. The loading fixture is then set and aligned. Leadframes are loaded upside down.



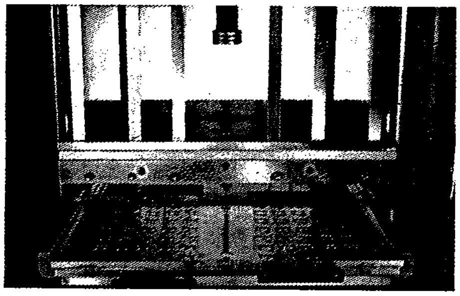
②

Next, the top mold is snapped into place, tightly securing the leadframes.



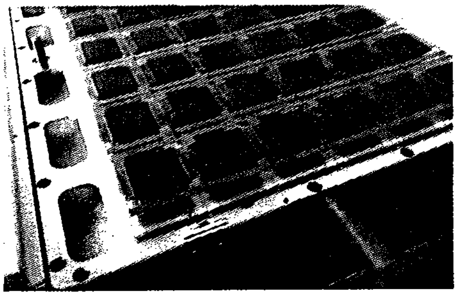
③

The plates are then slid into the press.



④

Finally, the plates are removed from the press. The molded packages then popped from the plates.



Source: Dusan Equipment
2254-112

Presentation 5.5.1.1.1-2

Molding and Sealing Stages Using Aperture Plate Die

This led to the introduction of molding processes with multiple plungers and small pots. Multiplunger systems essentially were several presses in one system. These systems handle fewer packages per mold at lower injection pressures. This minimized wire sweep and eliminated deflashing, resulting in better bleed and flash quality. In addition, these systems were easily convertible to different package types, in most cases automatically.

Sealing Equipment

Sealing equipment is one of the oldest processes of semiconductor equipment. It dates back to the earliest uses of semiconductors, when early as 1952, transistors were being made in standardized packages. During the sealing process, the device is bonded to the package and a 'cap' is sealed onto the package with a gold or glass frit. The package is then placed in an oven and sealed. Sealing equipment is used in the production of ceramic and CERDIP packages.

Sealing consists of belt furnaces and cap welders. Cap welders are used primarily for sealing transistors and some types of ceramic IC packages. Ceramic hybrid and ceramic IC packages are usually sealed by belt furnaces. The market for belt furnaces has grown substantially in the early to mid-eighties while that for cap welders had remained small. This growth occurred primarily as a result of a requirement of a transparent sealing lid which will pass the ultraviolet light; i.e. U.V. erasable PROM's.

An additional factor that has influenced the sealing market has been the use of Cerdip packages. Cerdip packages provide the semiconductor manufacturer with a large hermetic die cavity that can accommodate larger die than can be molded in plastic for the same package outline. Cerdips are an inexpensive counterparts to ceramic packages since they are made from alumina. Cerdips approach the low cost of a plastic package.

The use of Cerdips requires that leads be preformed at the time of package fabrication; the thin alumina walls cannot support the strains encountered in a conventional lead trim and form or elsewhere in the process. Cerdip sealing further mandates a sophisticated belt furnace, to reflow the lead-glass package. This requires a slow ramp-up, to work the peak temperatures of about 400 °C. A long anneal in a dry atmosphere is needed to obtain a proper seal. A typical furnace contains a minimum of four zones and a belt length of twenty feet.

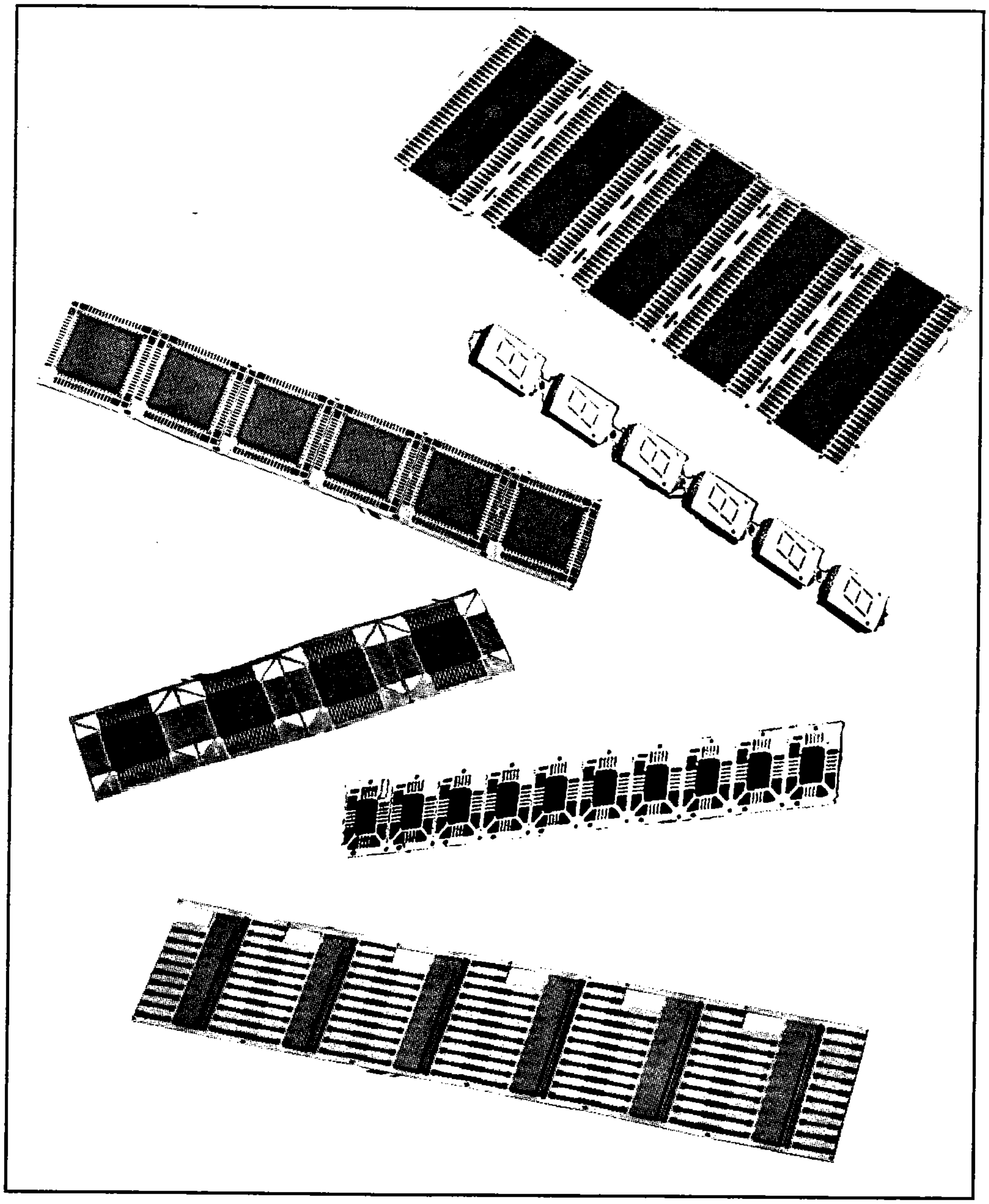
The thrust in sealing equipment has moved toward increasing throughputs. The growth in sales of sealing equipment was a result of rapid growth in the EPROM market. Until the mid-eighties, sealing equipment was used only for discrete, hybrid, and military applications. The latter two are only a small portion of the semiconductor business. The discrete market is growing at a relatively slow rate. Consequently, the growth of this market segment is closely tied to the market for EPROMs.

5.5.1.1.2 Development of the Finishing and Marking Equipment Industry

The finishing and marking equipment industry is segmented into two product types: finishing and marking equipment. Finishing is the final step in cosmetically preparing the package before their sale, leads are polished, trimmed and bent. Marking identifies the specific contents of each package.

Finishing Equipment

Early finishing systems required single pieces of equipment at each step to deflash, trim, form and solder dip leads. After molding, plastic packages were still on a lead frame strip. This strip contained several packages in which the leads to each individual package were still interconnected (see Presentation 5.5.1.1.2-1). In order to complete these devices, the leads had to be deflashed by one piece of equipment, cut



Source: Tool & Die Masters
2254-78

Presentation 5.5.1.1.2-1

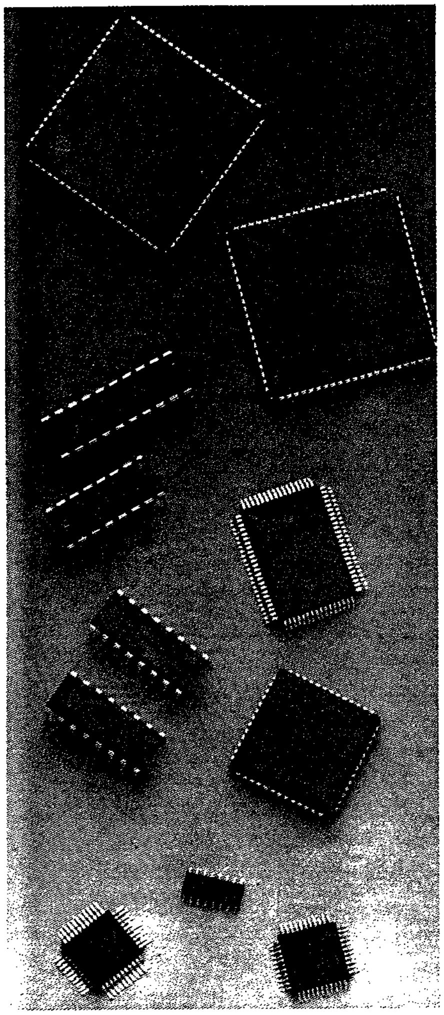
Various Packages Connected to the Lead Frames

and trimmed by another and then formed into their final shape by even another system (see Presentation 5.5.1.1.2-2). In some cases, leads were then either solder dipped, or, tin plated by a fourth system. Plating occurred after deflashing, but prior to trimming and bending. Early versions of trimming and forming equipment are shown in Presentation 5.5.1.1.2-3.

The major issue that has confronted suppliers of finishing and marking equipment is increasing equipment throughput. Prior to 1976, most finishing equipment was manually operated. However, 1977 and 1978 brought equipment that provided handling capability.

Automation in the eighties had a definite impact on lead trimming and forming and deflashing equipment, by integrating them into molding equipment. Furthermore, automated finishing equipment has been linked to automated marking equipment. Thus, two handling steps have been eliminated. This was a major step for a discrete lines, since almost a million parts per hour are processed on typical discrete assembly lines.

Today, finishing systems are being challenged by the increased use of surface mountable packages. In many cases, the fine-pitch leads on small outline packages are so fine that the process of bending them at solder dipping can induce stress that leads to cracking. In addition, today's trend for tighter-specified smaller-lead packages is also requiring higher accuracy in tooling and transport mechanisms used with trim-and-form equipment. This is leading to process monitoring on trim-and-form equipment for monitoring parameters such as tip-to-tip dimensions and coplanarity.

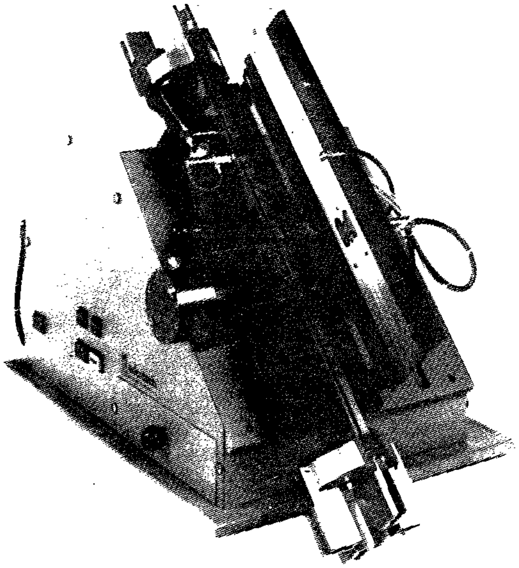


Source: Yamada

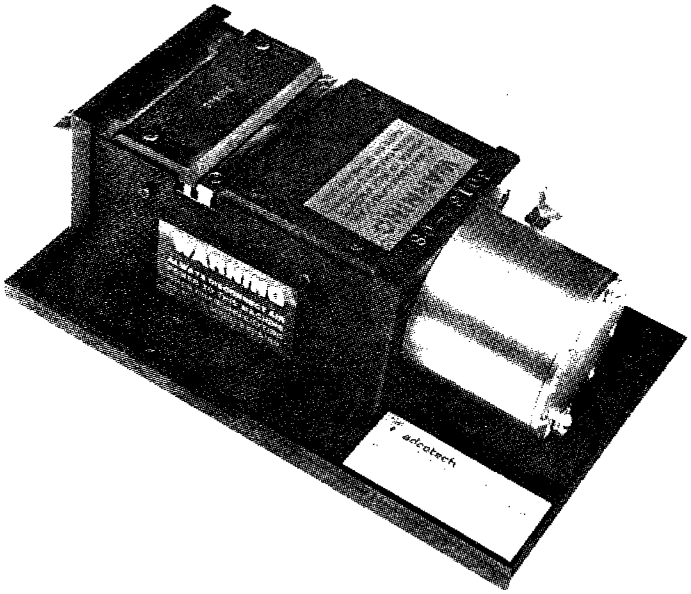
2254-79

Presentation 5.5.1.1.2-2

Various Packages Trimmed and Formed

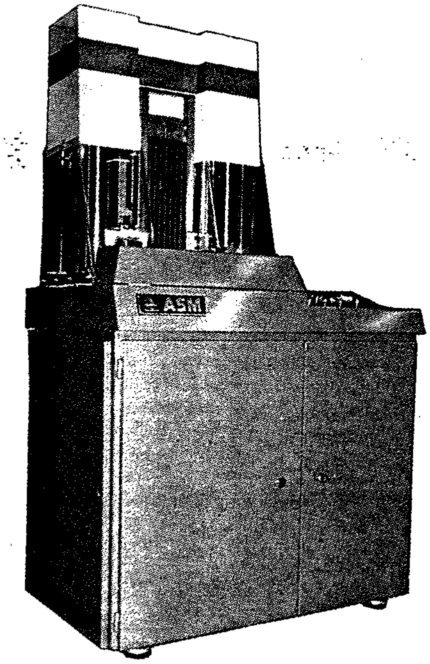


Auto Lead Forming Machine

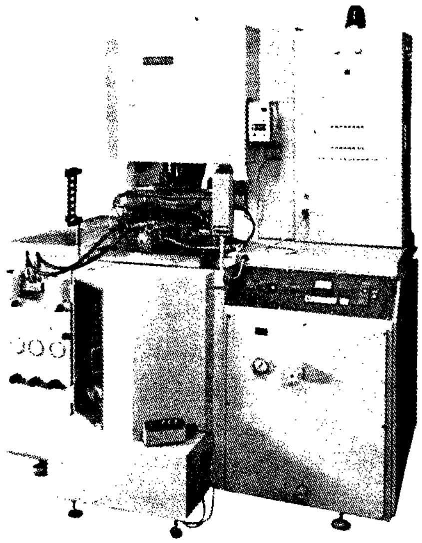


Trim Machine

Source: Adcotech



Automatic Deflash System



Auto Cutting and Bending Machine

Source: ASM

2254-80

Presentation 5.5.1.1.2-3

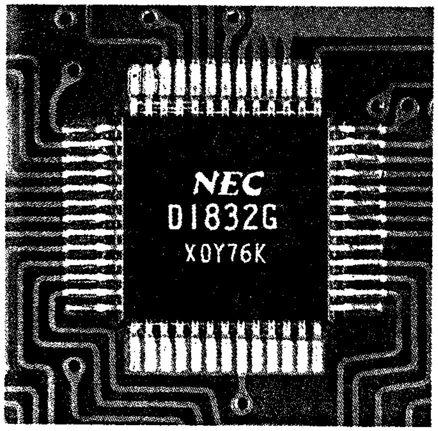
Early Trimming and Forming Equipment

Marking Equipment

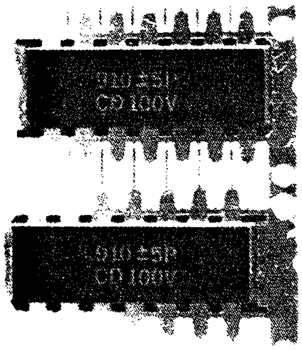
The marking step identifies the part number, the manufacturer and the date of manufacture (see Presentation 5.5.1.1.2-4). It is usually done following test since part identification varies with the grade level. For discrete devices, however, the marking step sometimes precedes testing. This is a result of the low price of transistors and diodes. Yields are high but labor content is low.

In the marking segment, throughputs were increased by automation and by the development of faster marking methods. In 1977, UV curing inks were used on some production lines, and soon became widely used because they offered throughput advantages over conventional inks. At about this time, the first laser marking systems also began to appear on the market.

Laser marking had several advantages. First, it did not require curing, thus lowering the total marking time. Typical throughputs for a laser system were about eighteen thousand units per hour. However, laser marking systems were typically sold for over $100K. Nevertheless, laser marking was convenient. No ready-made printing die was required. It also eliminated messy inks. However, marks were not very bright. The use of laser markers became popular in the mid-eighties as part numbers exploded. Laser markers have been used extensively for ASICs. ASIC manufacturers have small lots and they do not normally remark products. The number of unique product types is quite high in a given ASIC product line. Product identification, tracking and routing are critical to these product lines. So, establishing identification early in the process is desirable. Laser marking has been favored for this application. This is due to their direct writing capability.



Source: NEC



Source: Adcotech
2254-81

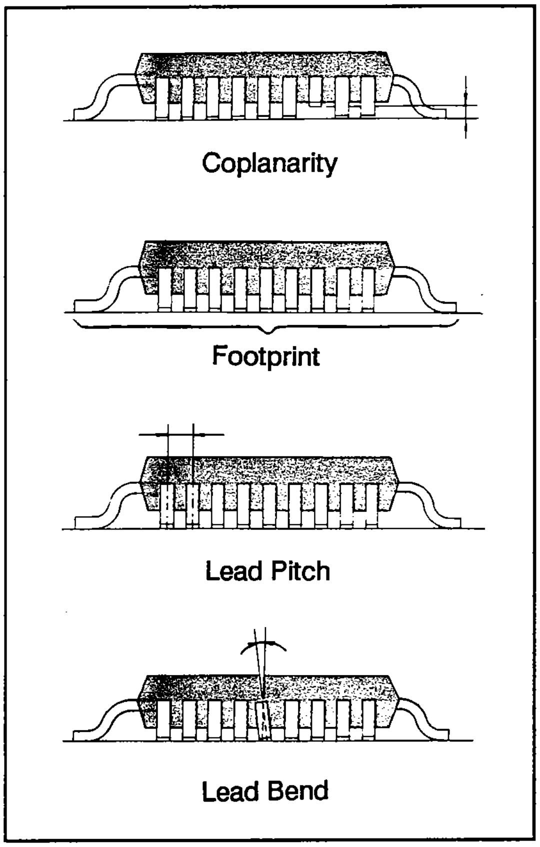
Presentation 5.5.1.1.2-4

Typical Marks on ICs

As the assembly line continues to grow, more automated manufacturers continue to demand the elimination of unnecessary handling steps. Some manufacturers incorporated laser marking systems into the component handling step at final test. This eliminated two more manufacturing steps.

5.5.1.1.3 Development of the Package Inspection Equipment Market

The package inspection equipment segment is the youngest of the packaging markets. This market developed in the mid-eighties as the result of the continued trend toward surface mount devices. Package inspection equipment became necessary because of problems that surrounded the use of surface mount packages. Chief among these is the need to assure the coplanarity of the leads. Unlike through-hole-mount, all leads of surface mount devices must be planar in order to make proper contact. In addition, leads on surface mount devices are not as robust as leads on DIP packages. This makes surface mount leads susceptible to bending and breaking. The market for package inspection grew out of the need to check for lead coplanarity, correct footprint and spacing straightness (see Presentation 5.5.1.1.3-1). Once developed, these systems were also used to inspect DIP leads.



Source: VLSI RESEARCH INC
2254-82

Presentation 5.5.1.1.3-1

Inspection Points for Package Inspection Equipment

The first package inspection systems were built by semiconductor manufacturers who were looking for a way to inspect leads on surface mount devices. These were nothing more than modified optical recognition systems. Since that time, dedicated systems have been developed. Today, lead scanners are used throughout the semiconductor industry. In addition, the systems are used by the electronics industry for incoming inspection and inspection during production.

5.5.1.2 Technology

- **Many of trim and form machines supplied today are interchangeable for various package types.**
- **Modern DIP and SMD scanners are fully automatic and can handle differing package widths and lead counts.**

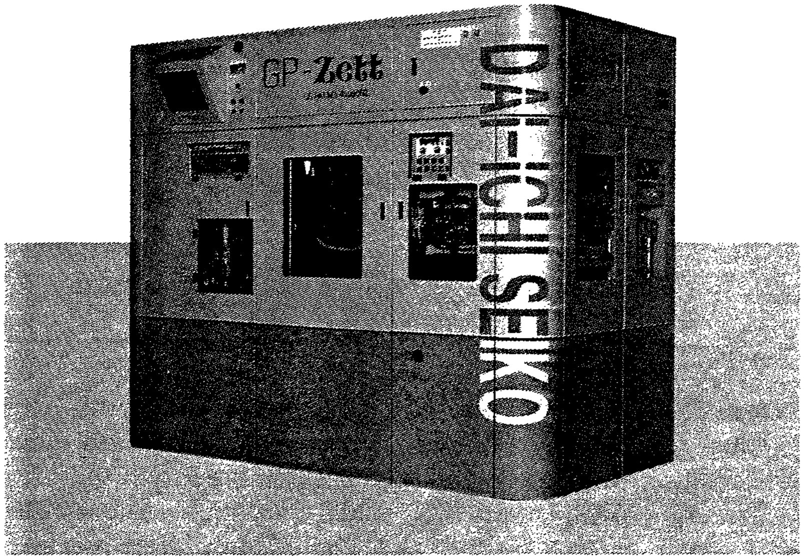
This section contains descriptions of the applications and technologies used by molding & sealing, finishing & trimming and package inspection equipment.

5.5.1.2.1 Molding and Sealing Technology

As the variety of different shapes and sizes of surface mount packages exploded onto the market, the molding and sealing equipment market went through drastic changes to meet the demands of this new technology. Contemporary molding and sealing systems are fully automatic and have integrated preheaters, multiplunger presses, interchangeable molding die forms and cure ovens into automatic molding systems (see Presentation 5.5.1.2.1-1). These systems have the ability to quickly and easily convert to different package types automatically. They are also designed to prevent wire sweep. In addition, many of these modern systems have incorporated a flash-free mold design, eliminating the deflashing step altogether.

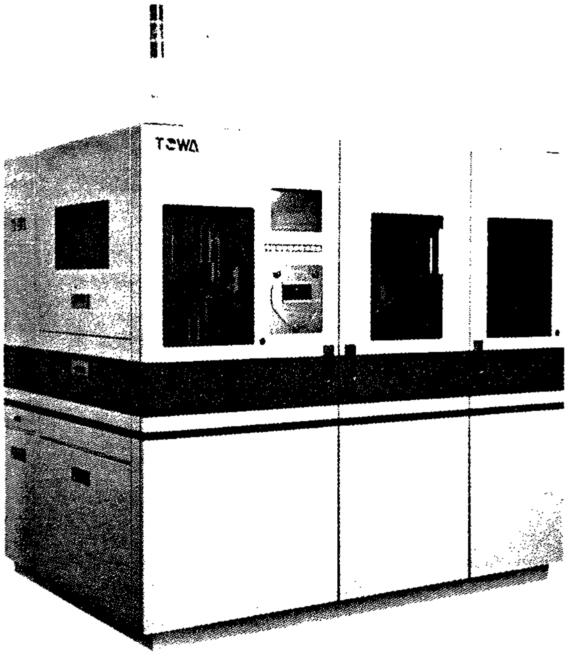
The general mechanics of these systems are fairly simple (see Presentation 5.5.1.2.1-2). First, lead frames are loaded, one by one, from the loading magazine onto a turntable. The turntable is heated to provide for preheating lead frames (lead frames are heated in order to expand to molding dimensions). Next, a tablet loader positions lead frame strips into the bottom mold. Then, the bottom mold and top mold are united. At this point, epoxy is quickly injected into the mold cavities. The curing process follows immediately there after. After sufficient time has elapsed for the curing process, the bottom mold is separated from the top mold. Then, an unloader lifts the molded lead frames up and takes them to the degating station. After unloading, the top and bottom mold are automatically cleaned. When cleaning is complete, the cycle is repeated. Back at the degator, molded lead frames are separated from gates, culls and runners. They are then stacked into a magazine conveyor. CRT monitors are utilized throughout the whole process in order to supervise every procedure (see Presentation 5.5.1.2.1-3). These molding systems are fully enclosed and placed in the clean room in order to eliminate as much foreign substances and contamination as possible. Also, all molding and sealing steps are insulated to eliminate noise pollution in the factory.

Productivity has increased through the automation and integration of the molding and sealing equipment, but mold warpage has yet to be conquered. Mold warpage is a constant issue and is continually being addressed by decreasing the stress level during curing, eliminating water cooling, and including a dehumidifier or desiccation controller.



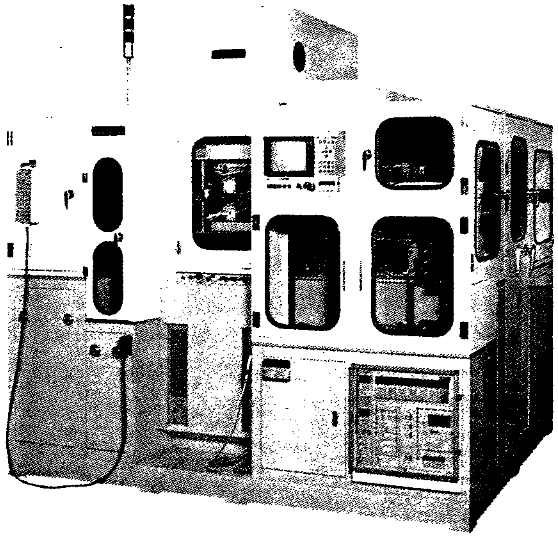
GP-Zett

Source: Dai-Ichi Seiko



UPS-80N Automatic Multi-Plunger Molding System

Source: TOWA



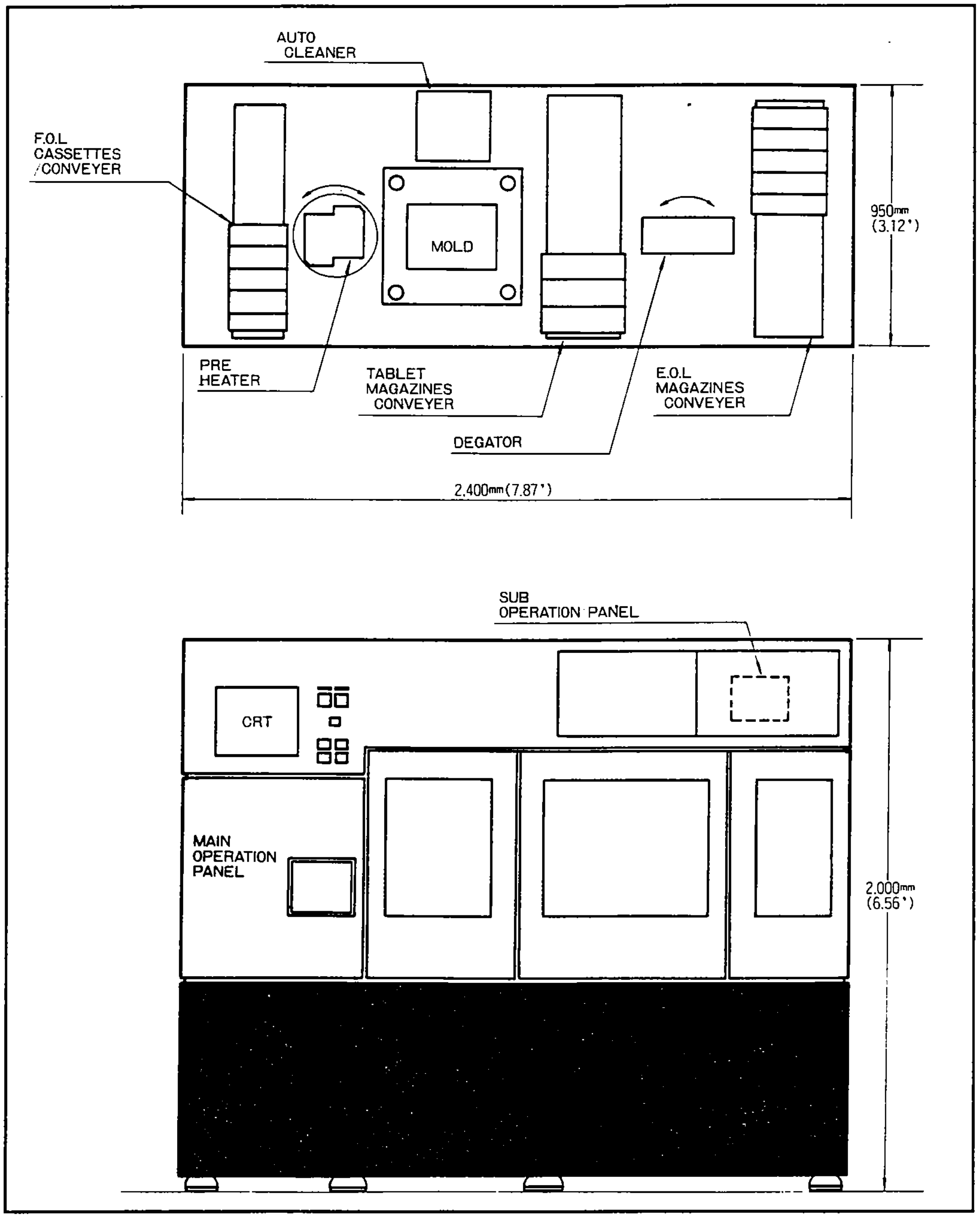
Flexible Auto Molding System, TAMS-IV

Source: Takara Tool & Die Co., Ltd.

2254-83

Presentation 5.5.1.2.1-1

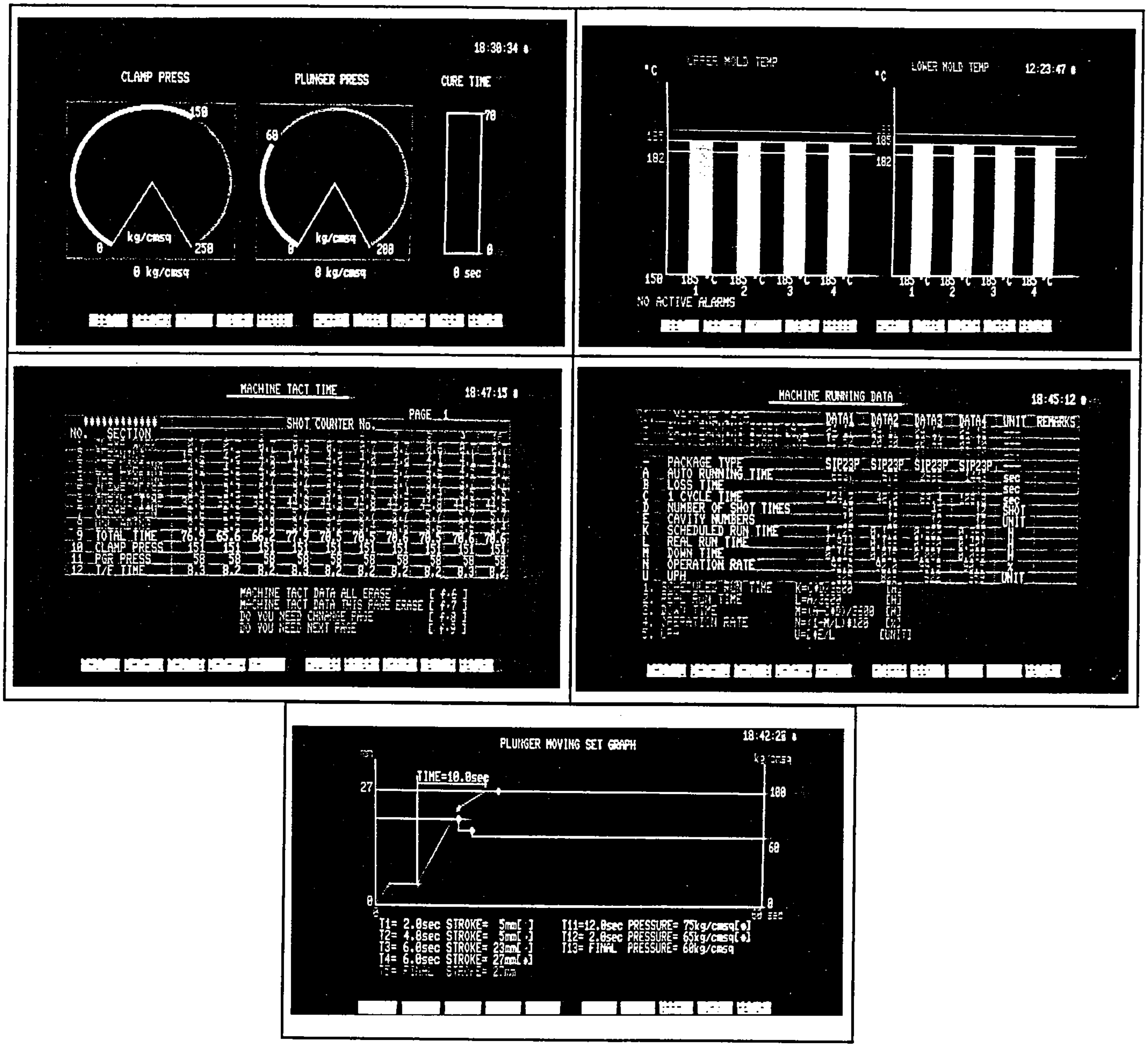
Modern Day Automatic Molding Systems



Source: Dai-Ichi Seiko
2254-84

Presentation 5.5.1.2.1-2

Lay-out of an Automatic Molding System



```
T1= 2.0sec STROKE=  5mm[ ]     T11=12.0sec PRESSURE= 75kg/cmsq[•]
T2= 4.0sec STROKE=  5mm[ ]     T12= 2.0sec PRESSURE= 65kg/cmsq[•]
T3= 6.0sec STROKE= 23mm[ ]     T13= FINAL  PRESSURE= 60kg/cmsq
T4= 6.0sec STROKE= 27mm[•]
T5= FINAL  STROKE= 27mm
```

Source: Dai-Ichi Seiko
2254-85

Presentation 5.5.1.2.1-3

Sample Displays of a CRT Monitor

5.5.1.2.2 Finishing & Marking Technology

After the lead frames go through the molding and sealing process, the molds are finished and marked, i.e. cutting the molds from the lead frame strips, forming and tinning the leads, and marking the package.

The finishing step begins with the lead frame strips taken one by one from a magazine off loader and placed onto a conveyor plate. The conveyor moves the lead frame through the trimming and forming tool (see Presentation 5.5.1.2.2-1). Depending on whether the package is through hole or surface mount depends on the type of trimming and forming tool used. This tool cuts the molds from the lead frames and forms the leads accordingly. The separated and formed die are then loaded into plastic tubes or trays. The whole process is fully automatic. Many of the trim and form machines supplied today are interchangeable for various package types (see Presentation 5.5.1.2.2-2). There are still some machines made specifically for DIP or QFP (see Presentation 5.5.1.2.2-3).

The next step is tinning the leads. During this phase, the package is removed from the tube or tray and the leads are precleaned and fluxed. Then, the leads are preheated and passed through a wave of solder (see Presentation 5.5.1.2.2-4). The leads are cooled, cleaned and dried (see Presentation 5.5.1.2.2-5). The package is then reloaded into tubes or trays.

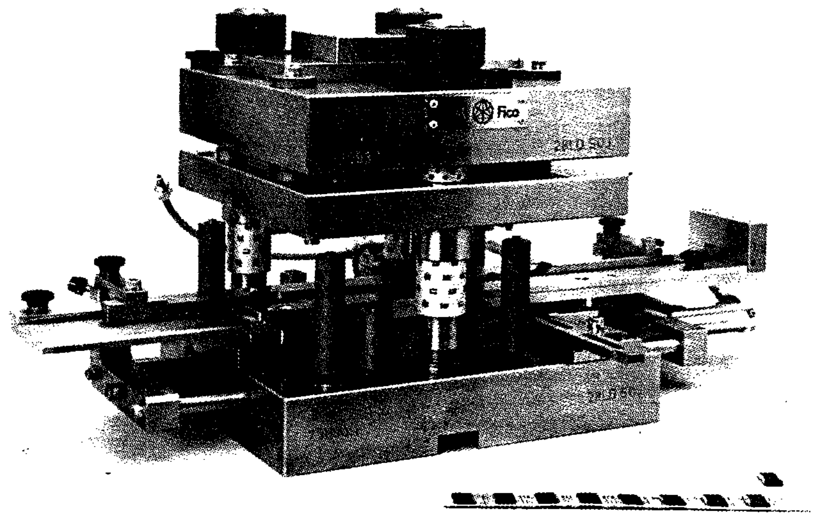
At this point the individual packages are marked or branded. Two different methods are used for marking the packages, i.e., ink and laser marking. During the marking operation, the IC package is transferred from a tube, tray or tape to the printing unit. The printing method is either by ink or CO2 pulse laser. If the ink is used, the IC proceeds to the drying zone to be dried by UV or hot air. When dry, it is loaded back into a tube, tray or tape. Marks made by laser markers do not need drying since the laser burns characters into the surface. The benefits of laser over ink marking is that normal abrasion will not obliterate the mark, and no pressure is applied during marking, so the package has no chance of becoming damaged. In addition, laser marking tends to be faster than ink marking. The disadvantages are that laser marks are not as visible and they are difficult to remove for remarking. Presentation 5.5.1.-2.2-6 illustrates various laser marker machines.

5.5.1.2.3 Package Inspection Technology

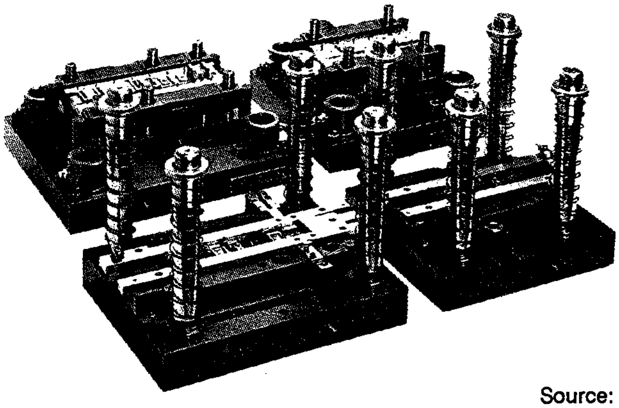
Inspecting the IC package for defects is the final stage of manufacturing a semiconductor. Particular concern is taken in inspecting the leads for bent or missing leads, coplanarity, and incorrect spacing. Two lead inspection systems predominate; they are DIP lead scanners and SMD lead scanners (see Presentation 5.5.1.2.3-1). There is also an automated package inspection system which inspects both IC leads and printed marks (see Presentation 5.5.1.2.3-2). Modern DIP and SMD scanners are fully automatic and can handle differing package widths and various lead counts. Both of these systems scan, sort and reform DIP and some SMDs' bent, misaligned and mangled leads. A majority of DIP leads can be reformed. But many of the SMD leads are too fragile to be reformed, so in these cases, the IC package is discarded.

The operating sequences for scanning DIP and SMD leads are fairly similar. For DIP lead scanning the DIP packages travels from a tube down a trackway to the forming station. Here a pair of feed wheels drive the IC through the former, restoring twisted leads. Then the DIP travels through the scanner station where the IC is determined 'pass', 'straighten' or 'fail' by a photo-scanner (see Presentation 5.5.1.2.3-3). If the DIP passes or fails, it proceeds down the trackway into the 'pass' or 'fail' tube, respectively. If it requires straightening, it is sent down the trackway to the straightener station. Here the DIP is aligned over a pair of separator blades and straightened (see Presentation 5.5.1.2.3-4). The straightened DIP then continues down the trackway into the 'straighten' tube.

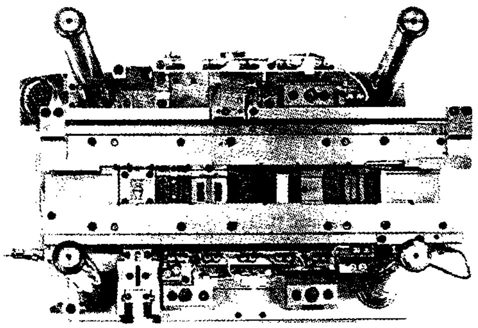
SMD scanners, comparable to DIP, test surface mount ICs for irregular pitch, pin-to-pin sweep, coplanarity, incorrect spacing, and bent and missing leads. They also sort for good, reworkable and reject leads. All the re-workable leads undergo corrective forming and reinspection. These scanners use both tube and tray loaders.



Source: ASM/FICO



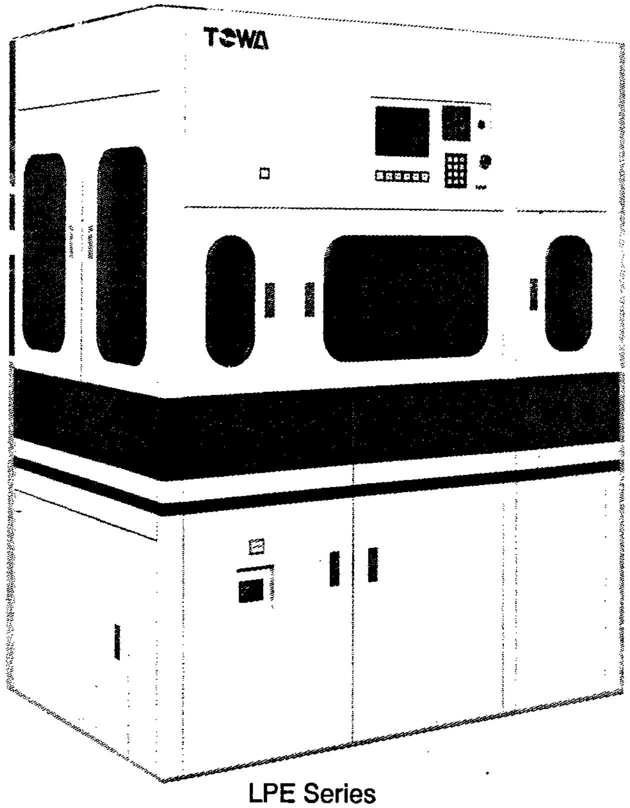
Source: TOWA



Source: NEC
2254-86

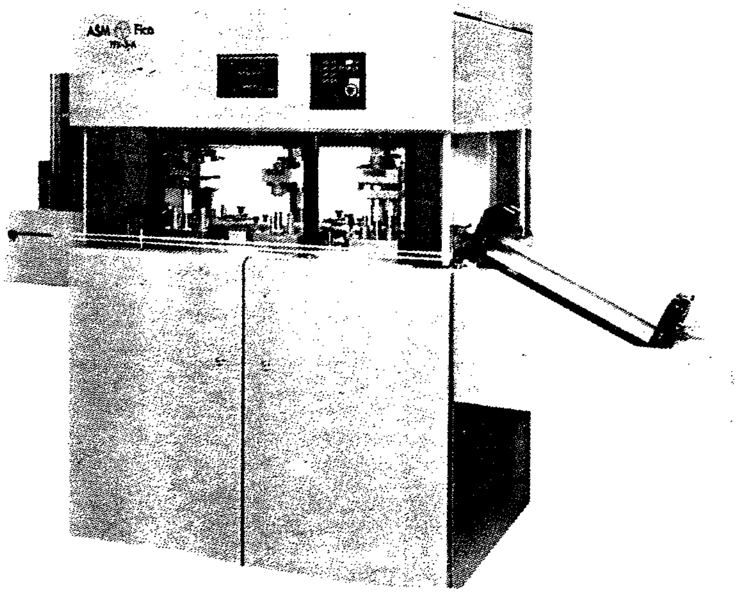
Presentation 5.5.1.2.2-1

Various Trim & Forming Apparatus



LPE Series

Source: TOWA



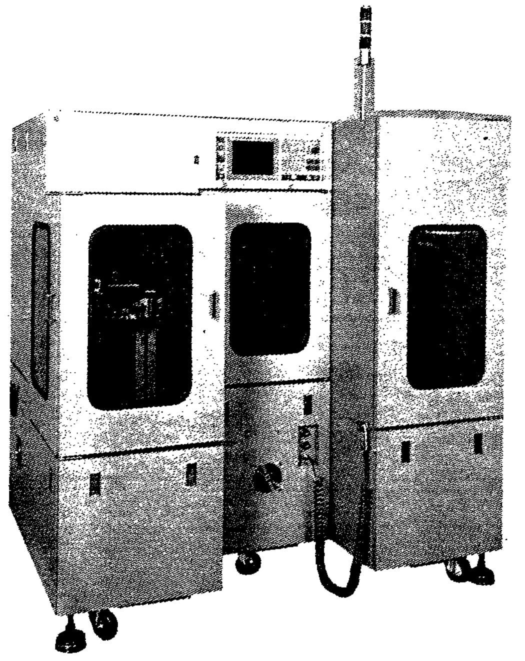
TFX-3-A

Source: ASM/FICO

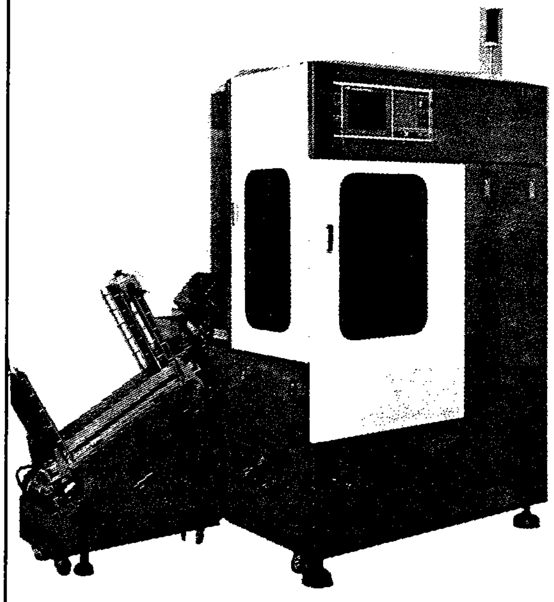
2254-87

Presentation 5.5.1.2.2-2

Trim & forming machines for a variety of packages.



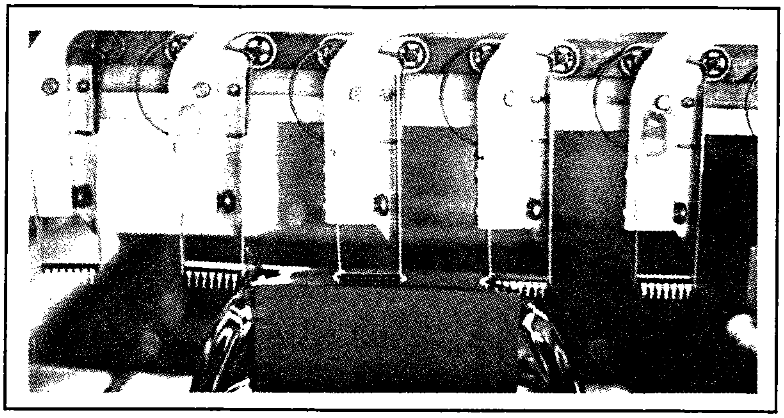
Trimming & Forming Machine for QFP



Trimming & Forming Machine for P-DIP

Source: Yamada
2254-88

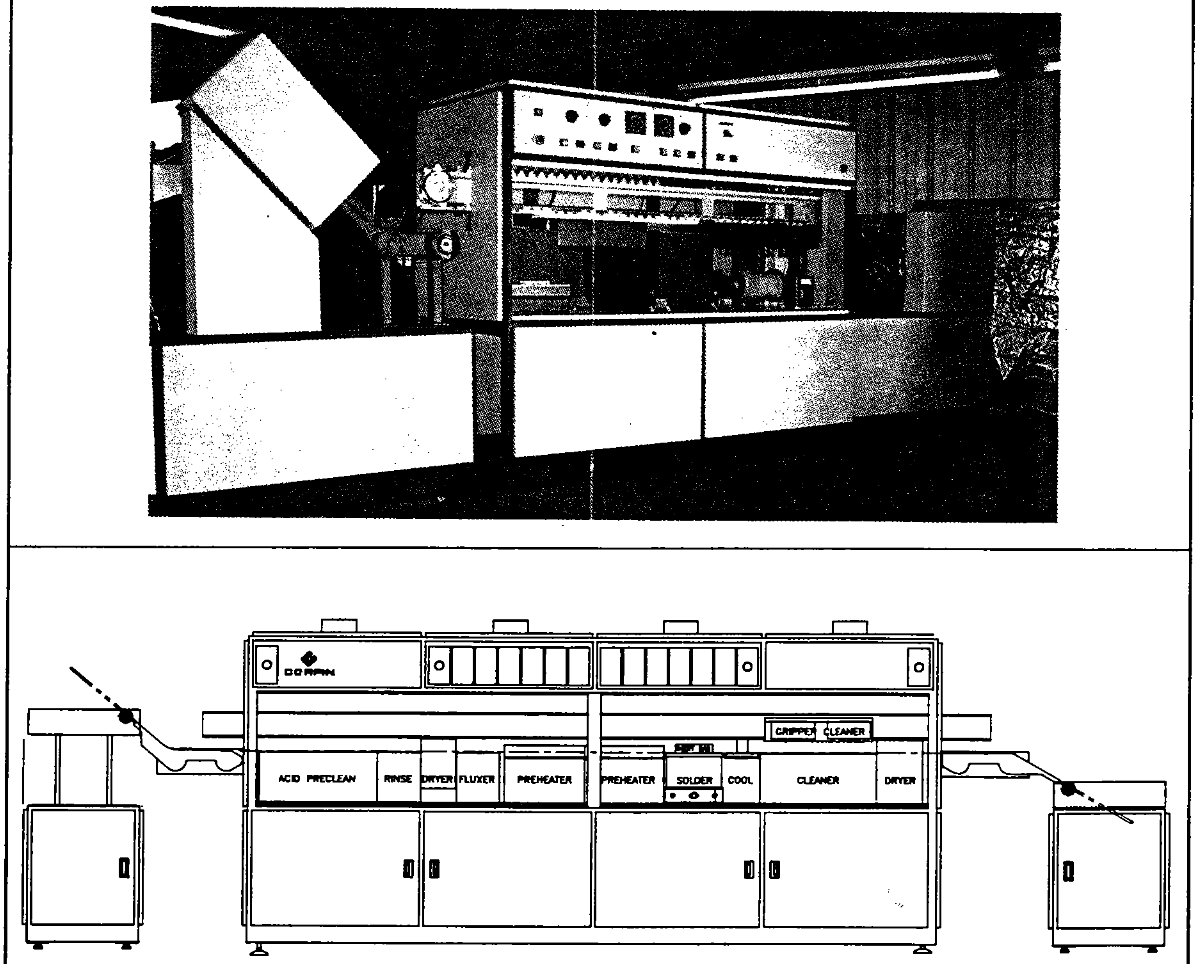
Presentation 5.5.1.2.2-3



Source: CORFIN
2254-89

Passing the leads through a wave of solder.

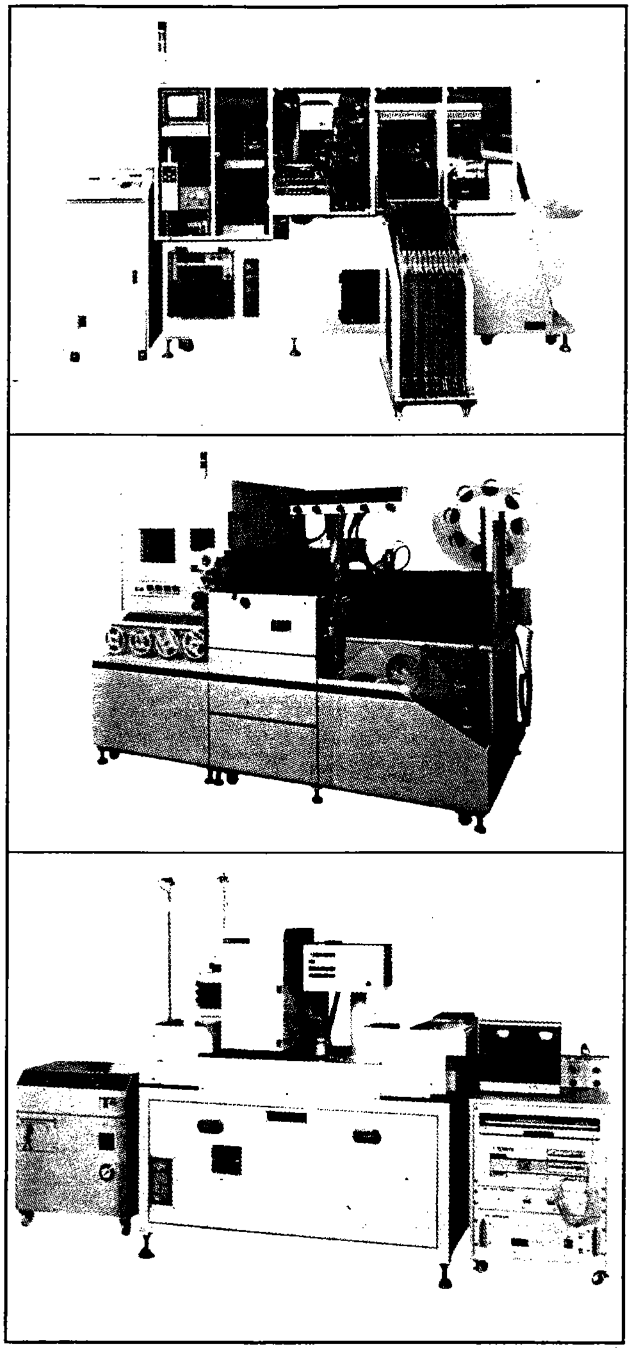
Presentation 5.5.1.2.2-4



Presentation 5.5.1.2.2-5

Source: CORFIN
2254-90

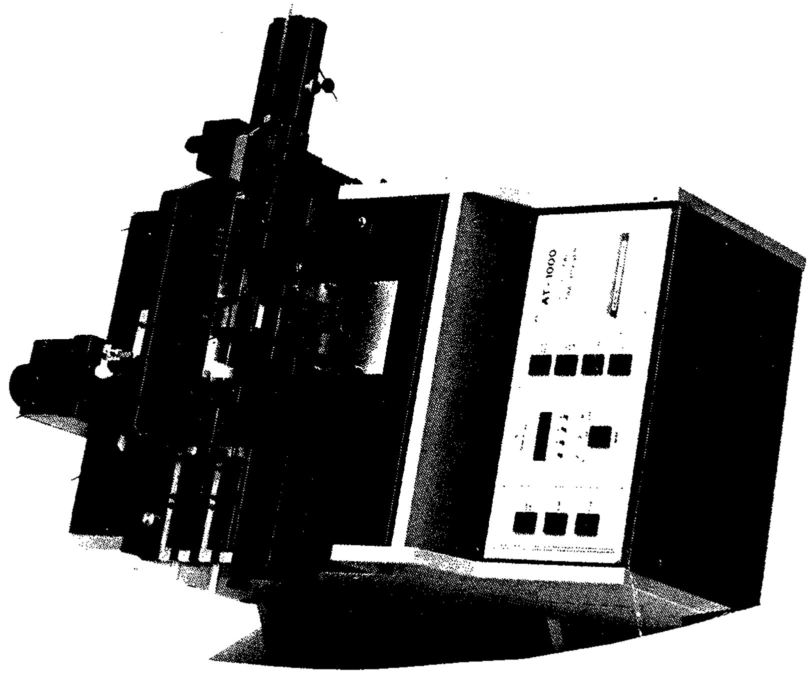
Corfin's DTS-330LL Tinning System



Source: NEC
2254-91

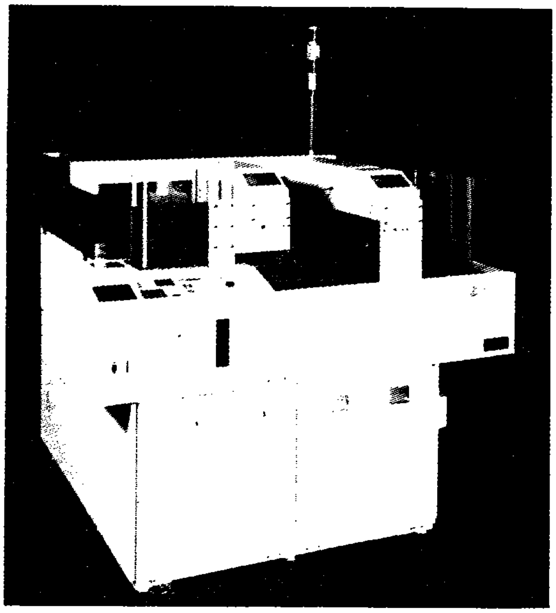
Presentation 5.5.1.2.2-6

Laser Markers



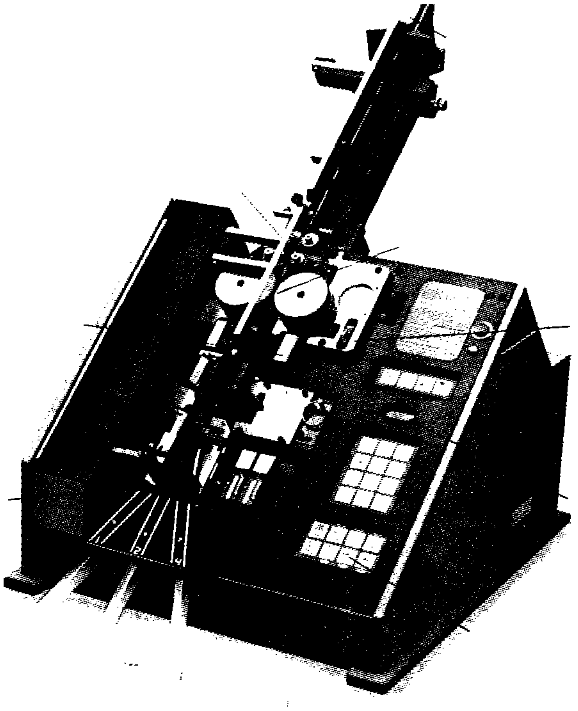
SMD Lead Scanner

Source: American Tech Manufacturing



Source: Kanematsu

SMD Lead Scanner



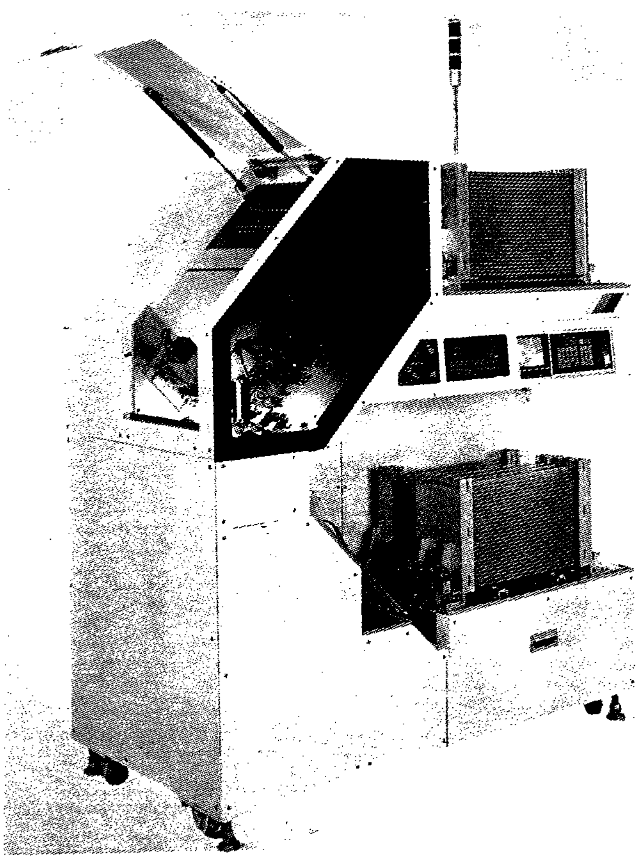
DIP Lead Scanner

Source: American Tech Manufacturing

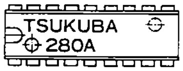
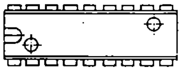
2254-92

Presentation 5.5.1.2.3-1

Lead Scanners



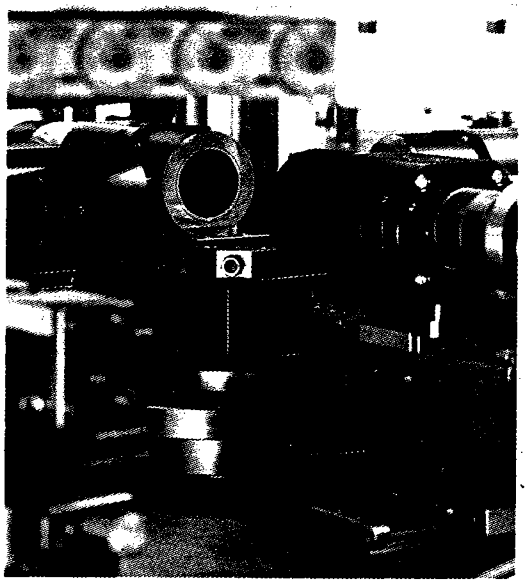
Mark Inspections:

項　目 Items	印 刷 不 良 例 Samples of Inferior Mark
文字切れ Broken Character	 TSJKUBA 280A
にじみ Blurred Imprint	 TSUKUBA 280A
位置ずれ Off-center Imprint	 TSUKUBA 280A
逆マーク Improper Orientation	 TSUKUBA 280A
混　入 Improper Characters	 TSUKUBA 270B
マーク無し No Imprint	

Source: Tsukuba Seikoh
2254-96

Presentation 5.5.1.2.3-2

Automated IC Lead Scanner/Mark Checking Machine



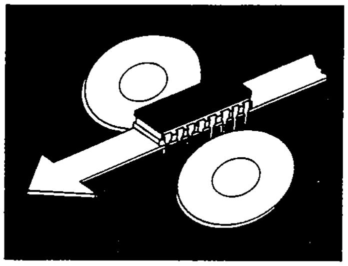
Source: TOWA
2254-93

Presentation 5.5.1.2.3-3

Photo Scanner for SMD

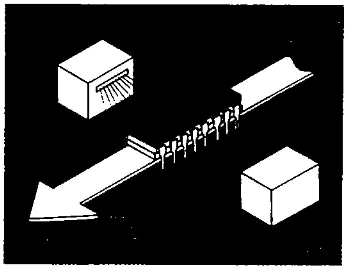
①

Forming Station



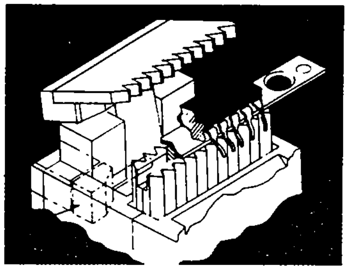
②

Scanner Station



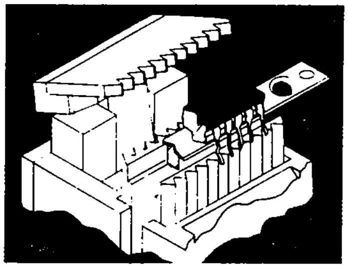
③

Straightener Station



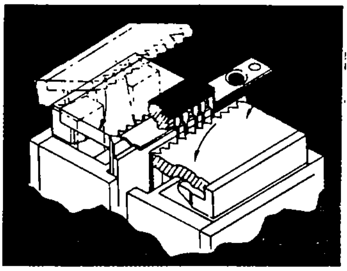
④

The separator blades open to position both rows of leads into V-type grooves.



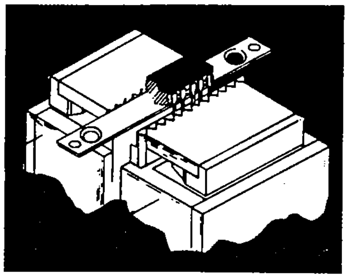
⑤

Two matched dies then come down to comb the leads into the grooves.



⑥

While both rows of leads are sealed in the V-grooves, the right and left assemblies oscillate in opposing directions.



Source: American Tech Manufacturing

2254-94

Presentation 5.5.1.2.3-4

DIP Lead Scanning Operating Sequence