The Development of a Dual-In-Line Package Microcircuit Card and Card Cage Assembly

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An improved Dual-In-Line Package Microcircuit Card and Card Cage Assembly have been developed. The external dimensions and the basic configuration of a previously developed card have been essentially maintained. However, the number of microcircuit socket locations has been increased from 106 to 126 by compressing dimensions, and the number of interface plug connections has been raised from 82 to 240 by using a new high-density connector. Also the physical size of the filtering capacitors has been reduced by selecting a miniaturized version. All wire-wrap terminals have been placed on 2.5-mm (0.100-in.) centers, with the exception of the capacitor terminals, to allow the card to be wired on an automated wire-wrap machine for potential savings of time, effort, and cost.

I. Introduction

This article discusses the development of an improved Dual-In-Line Package Card and Card Cage Assembly for use in DSN digital systems. A microcircuit card and associated cage assembly had previously been designed and developed; however, both units possessed certain inherent limitations which restricted their use for specific digital subsystem applications. The purpose of this article is to describe the manner in which this card and cage were re-designed to accept the imposed restraints.

II. The Dual-In-Line Package Microcircuit Card

The Dual-In-Line Package (DIP) Microcircuit Card is a high-density packaging panel designed to accommodate a wiring process referred to as automated wire-wrapping. It is a universal card of modular construction which provides flexibility in integrated microcircuit packaging and prototyping. The card is designed to accept either 14- or 16-lead plug-in integrated microcircuits. The front and rear views of the card are illustrated in Figs. 1 and 2, respectively.

The card is composed of the following basic material and hardware: (1) a copper clad epoxy glass laminate, (2) wire-wrap socket terminals, (3) interconnect plugs with guide pins, (4) insertion/withdrawal pressure levers, and (5) spring pins. The characteristics of these parts along with their functional applications will be discussed.

The primary board material is a flame retardant composite which consists of a laminate base of continuous-filament-type glass fabric impregnated with an impigmented epoxy resin binder in the form of a sheet. The sheet is over-laid and bonded with copper on both sides. The technical designation for the composite is FR-4 glass epoxy NEMA grade-type FL-GE 125 C2/2 AIIB per MIL-P-13949. The material covering the copper is an Electro Tin Plate of 0.005-mm (0.0002-in.) minimum thickness per MIL-T-10727.

The tin-plated copper surfaces on either side of the card form the power distribution and ground planes which connect to each DIP pattern. On the ground plane, centered within each pattern, is a unique numbering system which is silk screened in black epoxy ink. Ground is typically provided at socket terminal No. 7 for both 14- and 16-lead DIPs. Socket No. 16 only supplies power for a 16-lead microcircuit; however, power may be provided to a 14-lead DIP by jumping terminal 16 to 14. The character configuration may be observed in Fig. 2.

There are 126 DIP patterns located on the 34.8 cm (13.70 in.) wide × 14 cm (5.50 in.) high × 3.17 mm (0.125 in.) thick microcircuit card. Each pattern contains 16 wide-angle tapered entry socket terminals (P/N LSG-1FG-1) manufactured by Augat Inc. in Massachusetts. This device, which extends through and anchors into the board, performs two functions. It serves as a socket on the component side and a wire-wrap terminal on the opposite side. The body (or "sleeve") of the socket terminal is retained in the laminate by means of a "barbed" design shown in Fig. 3. Tests have indicated that this "barb" will maintain its locking function when a maximum force of 5.4 kg (12 pounds) is applied. If there should be a requirement to replace the socket terminal, because of contact or terminal damage, it may be removed simply by means of a special extraction tool (P/N 8136-23G1) made by Augat. It is advisable to insert the new one by using a swaging tool designed to accommodate the form of the sleeve. Note that the removal and insertion processes do no significant damage to the board material. The socket terminal sleeve is made of hard F.C. yellow brass per QQ-B-626 which is gold-plated over nickel per MIL-G-45204. The wire-wrap terminal portion is 13 mm (0.510 in.) long and 0.63 mm ±0.08 mm (0.025 in. ±0.003 in.) square with 0.08 mm (0.003 in.) maximum radii on corners. A wide tapered entry has been designed into the socket portion for ease of DIP lead insertion. The socket contact is a 4-fingered closed-entry device made of beryllium copper per QQ-C-530, heat-treated to maximum tensile strength. The contact finish is gold-plated per MIL-G-45204, 0.001 mm (0.00004 in.) thick over stress-free nickel 0.002 mm (0.00008 in.) thick per QQ-N-29. The socket is designed to accept a DIP lead diameter of from 0.41 mm (0.016 in.) to 0.48 mm (0.019 in.). To avoid potential contact damage, it is advised that the diagonal measurement of the DIP lead should not exceed 0.48 mm (0.019 in.).

Augat Inc. has performed extensive life testing of the socket terminal contact. Their main concern was to develop a contact that would maintain its prescribed retention force after one or more pin insertions. To measure the insertion and withdrawal forces in grams, Augat used a Hunter Spring Gauge Model No. 1-10000M. A selected number of socket contacts were probed 5000 times, first with a 0.41-mm (0.016-in.) and second with a 0.48-mm (0.019-in.) diameter round head test probe attached to the gauge. The results of the tests indicate that the contact pressure does decrease slightly with probing, but that the contact establishes a set relatively early in the probing cycle. In the first experiment, the average insertion force was 88 grams and withdrawal was 61 grams. Using the 0.48-mm (0.019-in.) probe, the average insertion registered 650 grams and the withdrawal force 260 grams. The requirement established was for insertion and withdrawal forces to be no less than 50 grams. Due to improved control of their manufacturing process, Augat exceeded our requirement by a wide margin.

There are a total of 2368 wire-wrap terminals on the back side of the board. With the exception of 96, which are designated for capacitors, all terminals are spaced on 2.5-mm (0.100-in.) centers to accommodate automatic wire-wrapping. To insure that the terminal hole positions are held within the required ±0.06-mm (±0.002-in.) tolerance, an automatic tape-controlled drilling machine should be employed. All board tolerances must be held tightly because of the critical nature of the automatic wire-wrapping process.

Two high-density right-angle connectors, secured to the bottom of the board, provide a potential of 240 interconnect contacts. The connector is manufactured by Viking Industries (part number 000240-0003). The plug is composed of 3 rows of 40-blade contacts with 2.5-mm (0.100-in.) centers to accommodate automatic rows. Diallyl Phthalate per MIL-P-19833, Type GD1-30, constitutes the insulation material. The contact material is phosphor bronze per MIL-QQ-8-750, which is gold-over-nickel-plated. The contacts bend on a 90-deg angle within the connector body and protrude on the side as wire-wrap terminals. The current-carrying capacity of each contact is limited to 3 amperes. Because of close tolerance mating problems, a precision guide pin assembly was fabricated which fits into holes provided on each side of the connector body. To prevent misalignment damage, these pins assist in guiding the plug contacts directly into their receptacle contacts. It might be noteworthy to mention that after extensive research into the connector field, it was found that this was the only high-density, right-angle, wire-wrap connector that could meet our specific stringent requirements.

There are two insertion/withdrawal pressure levers mounted at the top on each side of the card. This unique device is shown in Fig. 2. The lever is fabricated from 3.17-mm (0.125-in.) stainless steel for strength and rigidity. Through the lever is mounted a 19-mm (0.750-in.) long spring pin, which is used both as a handle and a board locking device. The lever serves a three-fold function. It inserts the card plug into its receptacle, locks the card in, and releases the card from the mating grip of the connectors. The lever was designed to produce the force required to insert and release the card with a very moderate amount of finger pressure. A spring pin is mounted in the board as a stop to prevent the lever from possibly shorting the wiring terminals. This unique type of hardware was selected because it has the capability of retaining a tight fit when subjected to external pressures.

There are 48 socket locations provided on the card for the installation of filtering capacitors. These locations, constituting the topmost and bottommost rows of sockets, are patterned to accommodate capacitors with either 5-mm (0.200-in.) or 8-mm (0.300-in.) spaced leads. Because of limited packing density, it was imperative that a capacitor of miniature size be selected. A study and survey of the miniature capacitor market was accomplished, which yielded the monolithic-type CY30 produced by the U.S. Capacitor Corp. It is basically a radial lead, epoxy-coated, ceramic capacitor with a rated value of 1.0 μF at 50 Vdc. The physical size is $8 \times 8 \times 3.8$ mm ($0.300 \times 0.300 \times 0.150$ in.) with a lead center spacing of 5 mm (0.200 in.). The lead diameter is 0.5 mm (0.020 in.), which allows the capacitor to be held firmly in its socket.

III. The DIP Microcircuit Card Cage Assembly

The DIP Microcircuit Card Cage is basically an angled-metal structure which serves as a facility for mounting 10 DIP cards. The cage may be observed in Figs. 4 and 5. The cage is composed of 12 individual pieces of angled aluminum, 20 aluminum card guides, an aluminum conductor plate, and 20 connector receptacles. The parts of the cage are fabricated from No. 2024-T4 aluminum alloy per QQA-A-225/6. The basic purposes for using the angled-aluminum approach are for strength, rigidity, and prevention of warpage. This design concept was necessary because great stress is exerted on the entire framework as the microcircuit cards are inserted into their respective sockets.

The base plate provides the surface in which to mount the connector receptacles. It was necessary for the plate to be 6.3 mm (0.250 in.) thick because of pressures incurred while inserting the card plug into the cage receptacle. The plate is perforated to permit an unobstructed flow of air onto the DIP cards for cooling purposes.

The connector that mounts in the base plate is a Viking receptacle No. 00241-0021 with the same technical specifications as its mating counterpart. The receptacle contacts are commonly referred to as "fork contacts." These fork contacts terminate into wire-wrap terminals on the opposite side of the connector body. All connector terminals are placed on 2.5-mm (0.100-in.) centers to allow automatic wire-wrapping of the entire bottom plane. Two guide bushing receptacles were developed and installed into each connector body. These bushings mate with the card connector guide pins to prevent misalignment of the connectors upon initial contact.

For each card there are two guides, which are simply slotted square bars with a pivot pin inserted near the top edge. The card guides serve four distinct functions: (1) they align the card plug with the plate receptacle, (2) they add vertical strength to the cage structure, (3) they provide a spring pin on which the insertion lever pivots to insert the card, and (4) they serve as a platform on which the withdrawal lever presses against to release the mated connectors.

The entire card cage assembly is gold-plated, with the exception of the card guides, for the vital purpose of ground integrity. Listed in Table 1 is a unique plating process developed to prevent tarnishing of the cage members.

All of the aforementioned parts, along with all 10 cards installed, constitute the total assembled Integrated

DIP Microcircuit Card and Cage Package, which is illustrated in Fig. 6.

IV. The Card Cage Mounting Enclosure

In order to mount the card cage into a rack assembly, an enclosure was developed that serves as a medium for securing the cage, the drawer slide assemblies, the system interface connectors, and the front panel assembly. The enclosure is easily fabricated from an inexpensive 43-cm × 43-cm × 10-cm × 1.6-mm (17.00-in. × 17.00-in. × 4.00-in. × 0.0625-in.) universal Bud radio chassis.

V. The Extender Card

A device was needed to remotely interface a DIP card with its mating connector for check-out or modification purposes. Therefore, a piece of hardware referred to as an *extender card* was developed which elevates the DIP card above the others to permit unobstructed access to all electrical points. This extender card, into which is plugged a standard card, is illustrated in Fig. 7. The device is simply an epoxy glass board on which is mounted card guides, 2 mating plugs, and 2 mating receptacles which are wired in consecutive order.

VI. Wire-Wrapping Procedures

There are three basic methods used at this time for the wire-wrapping of card terminals: (1) the manually operated portable hand tool method, (2) the semi-automatic machine process, and (3) the procedure involving the use of a totally automated wire-wrapping machine.

Extensive use has been made of a Model 14R2 Gardner Denver battery-operated hand tool which accepts various sizes of bits and sleeves for different wire and insulation diameters. The wire generally used is described as a No. 30 solid conductor with Kynar insulation, P/N KN-30-130-6, MIL-UL-1423. A bit (No. 507063) and a sleeve (No. 500350) are required for the installation of this particular wire on 0.63-mm (0.025-in.) wire-wrap terminals spaced on 2.5-mm (0.100-in.) centers. On each Augat socket terminal, it is possible to make 3 connections of 8 wraps each using a No. 30 gauge wire. If a connection should necessitate removal, it is easily accomplished by the use of a Gardner Denver unwrapping tool No. 505244.

The semi-automatic method is achieved by employing a computer-fed manually controlled wiring machine. The automated wire-wrapping procedure is typically accomplished by the use of a computer-controlled Gardner Denver machine.

VII. Conclusion

The design characteristics of the DIP Microcircuit Card and Card Cage Assembly provide a wide latitude of flexibility and versatility in their application. There are numerous distinguishing features included in the design philosophy which contribute to freedom in application procedures.

The DIP microcircuit card has several universal applications. It may be used simply as a breadboard, as a prototype model, or as a sophisticated piece of hardware around which to design the most complex of systems. The general approach allows any combination of logic and or analog microcircuitry to be inserted and interconnected for any desired function.

The attributes of this unique design, versus the widely accepted printed circuit (PC) approach, allow the engineer to considerably reduce his design and development time. PC boards possess distinctive problems which make them impractical for general application purposes. If a circuit change should occur, an entirely new PC layout is required which is both costly and time consuming. In addition, PC boards have proven to be very difficult to change or repair in the field. Where sophisticated logic or frequent design changes exist, economic and time factors favor the plug-in wire-wrapped card approach.

The elements that comprise the DIP card produce several significant advantages for design applications. For instance, the power and ground planes, covering each side of the board, improve high-frequency performance and reduce electrostatic coupling between each microcircuit. Power and ground are supplied to each DIP, which eliminates the need for additional wiring. The use of Augat-type wide-entry socket terminals allows any dual-in-line package to be easily plugged in and removed without the cumbersome task of soldering and unsoldering leads. The closed-entry socket will indefinitely maintain a secure retention force on the DIP leads by nature of their inherent design. If for any reason a socket terminal requires replacement, it may simply be removed and a new one installed without damage to the board material. At times, situations arise that prevent the use of DIP circuits. When this occurs, discrete components may be mounted on an adaptor plug which may be inserted into any of the card socket patterns.

The wire-wrap approach also provides several distinct advantages. The solderless wrap termination technique produced such favorable application results that it is currently considered the most preferred method by many electronic system manufacturers. Extensive use by the aerospace industry, the military, computer manufacturers, and the Bell System has proven that the wire-wrap process is much higher in reliability, less time consuming in application, and less costly than other established techniques for wiring. Wire-wrap's initial and most consistent advantage has been the significant cost savings inherent to the process.

With the design concepts described throughout this article, the design engineer is provided with the potential to develop any digital or analog system whether it be simple or highly sophisticated. It was the basic intent of this article to describe a new design approach that can be used to replace other packaging techniques which previously created rigid restraints in the design of DSN digital systems.

Table 1. Gold-plating procedure for the Card Cage Assembly[a]

Sequence	Procedure
1	Polish each piece carefully.
2	Mask all tapped holes.
3	Treat all parts with zincate.
4	Electroless nickel plate surfaces to 0.254-mm (0.001-in.) thickness.
5	Bake all parts at 149°C (300°F) for 1 hour.
6	Repolish all pieces as necessary to obtain smooth surface.
7	Expose each part to "gold strike" process.
8	"Sel-Rex" hard gold plate to all surfaces to minimum of 0.0254-mm (0.0001-in.) thickness.
9	Alodine tapped holes.
10	Buff all surfaces to mirror-bright finish.

[a]For all cage parts except card guides.

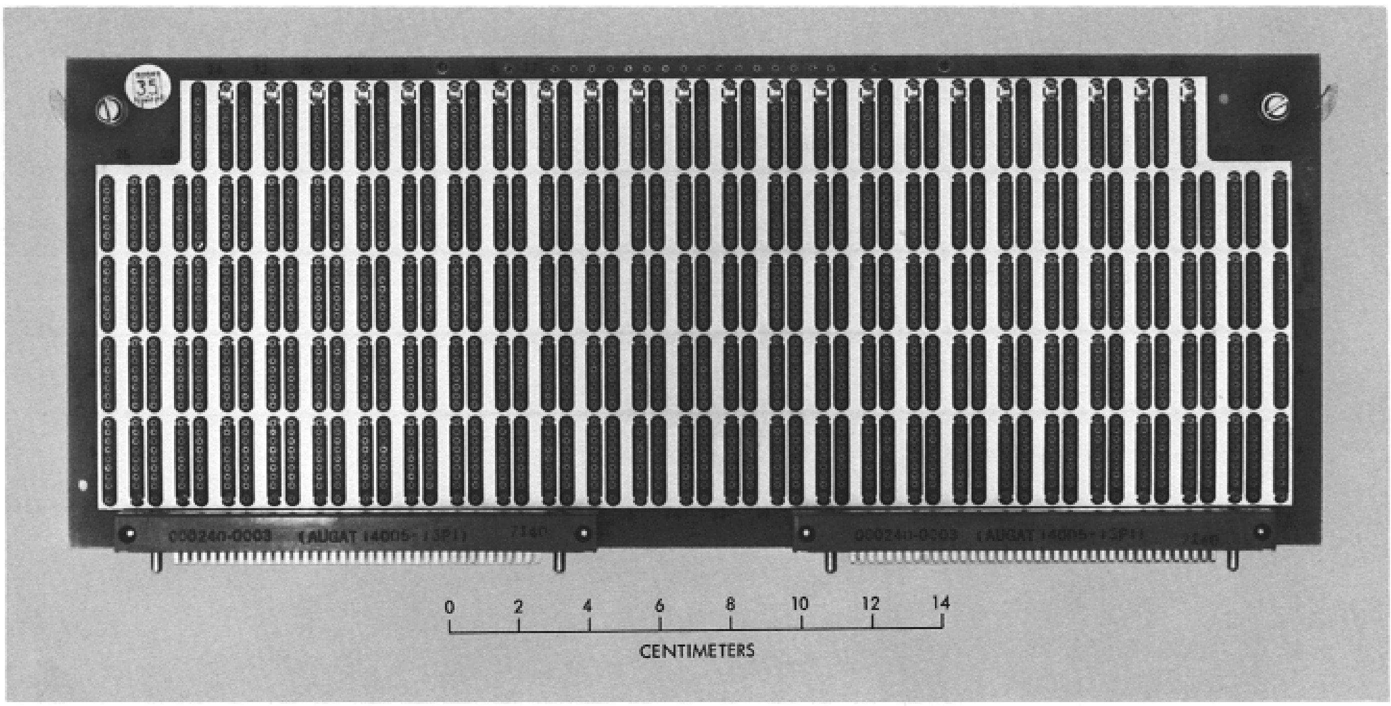

Fig. 1. DIP Microcircuit Card—microcircuit plane

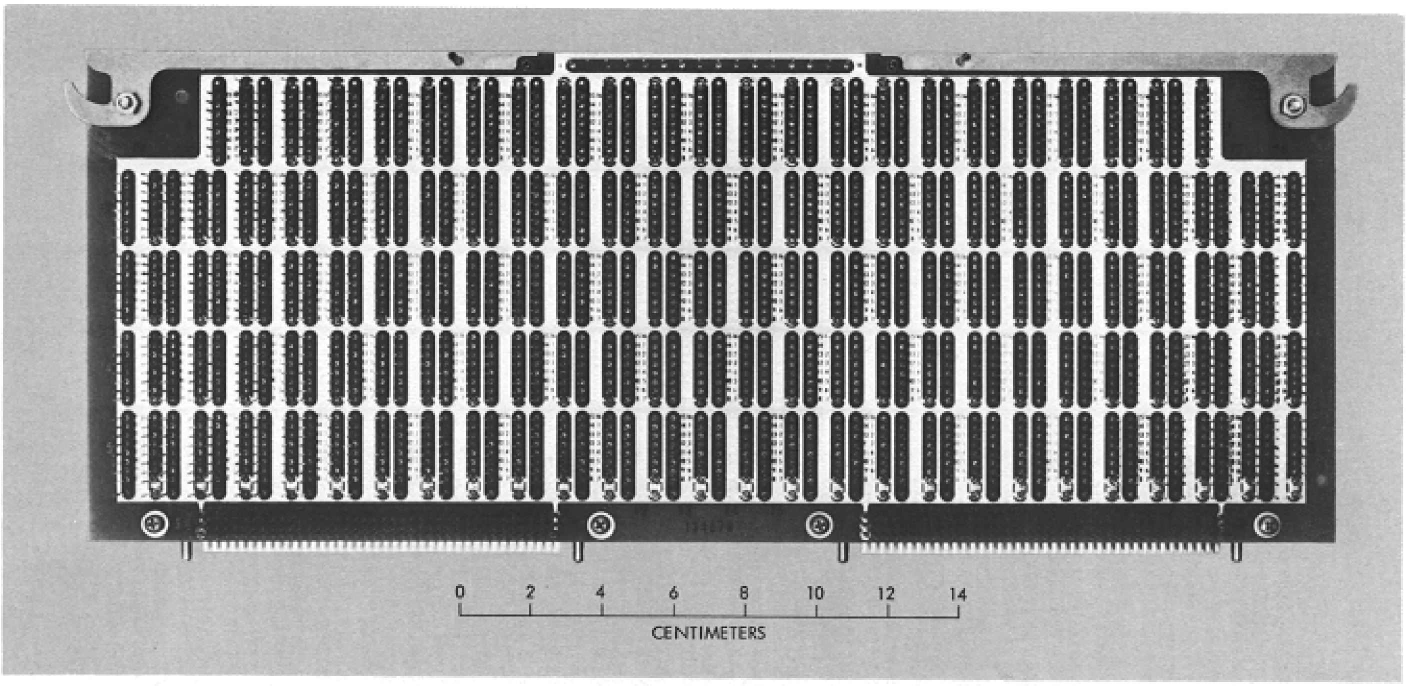

Fig. 2. DIP Microcircuit Card — wire-wrap plane

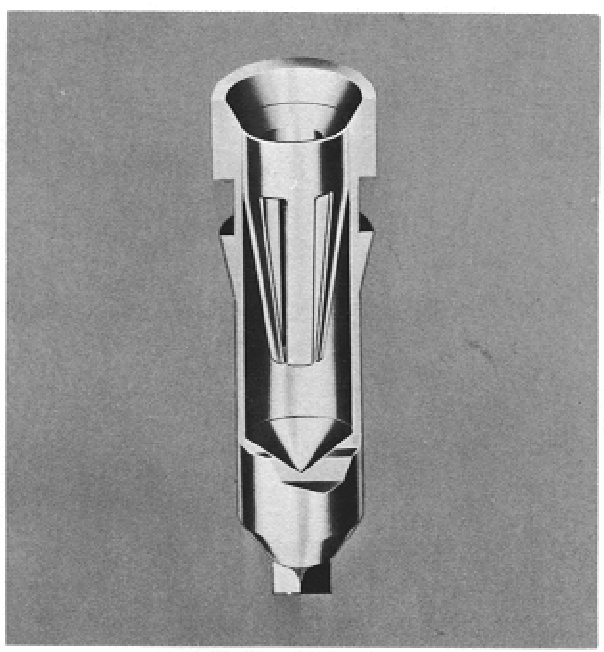

Fig. 3. Cut-away view exposing contact configuration of Augat wide-angle tapered entry socket terminal

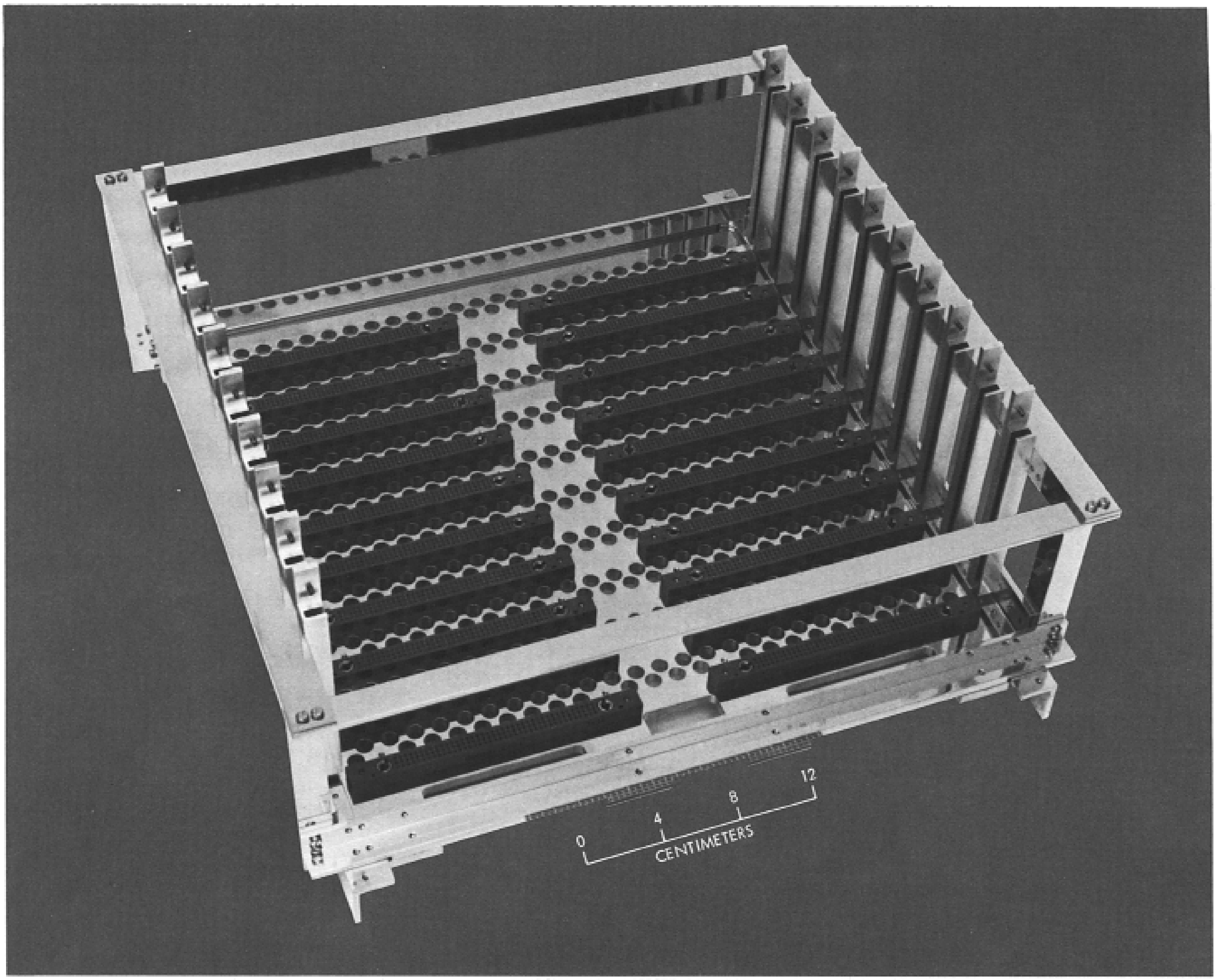

Fig. 4. Top view of Card Cage Assembly

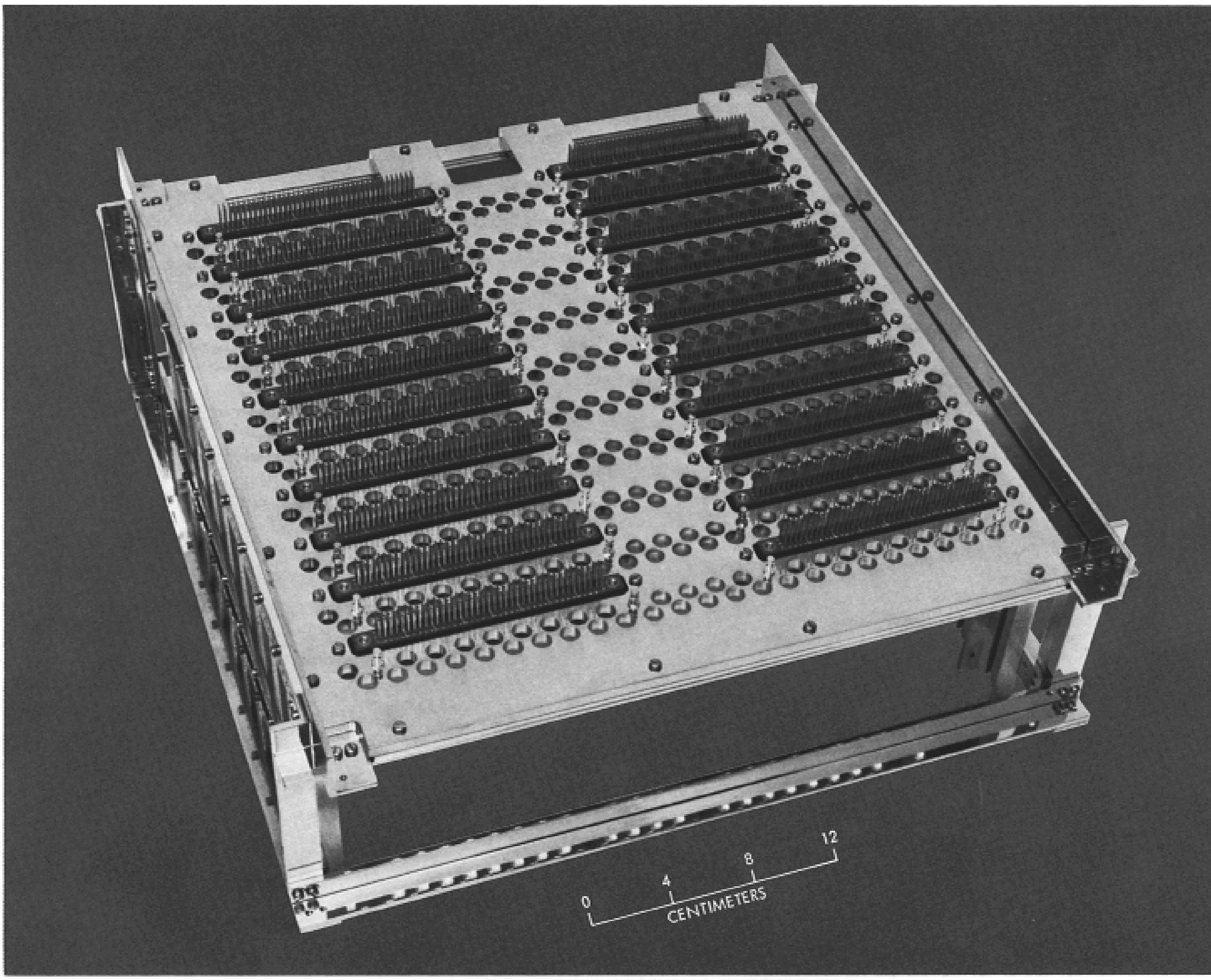

Fig. 5. Bottom view of Card Cage Assembly

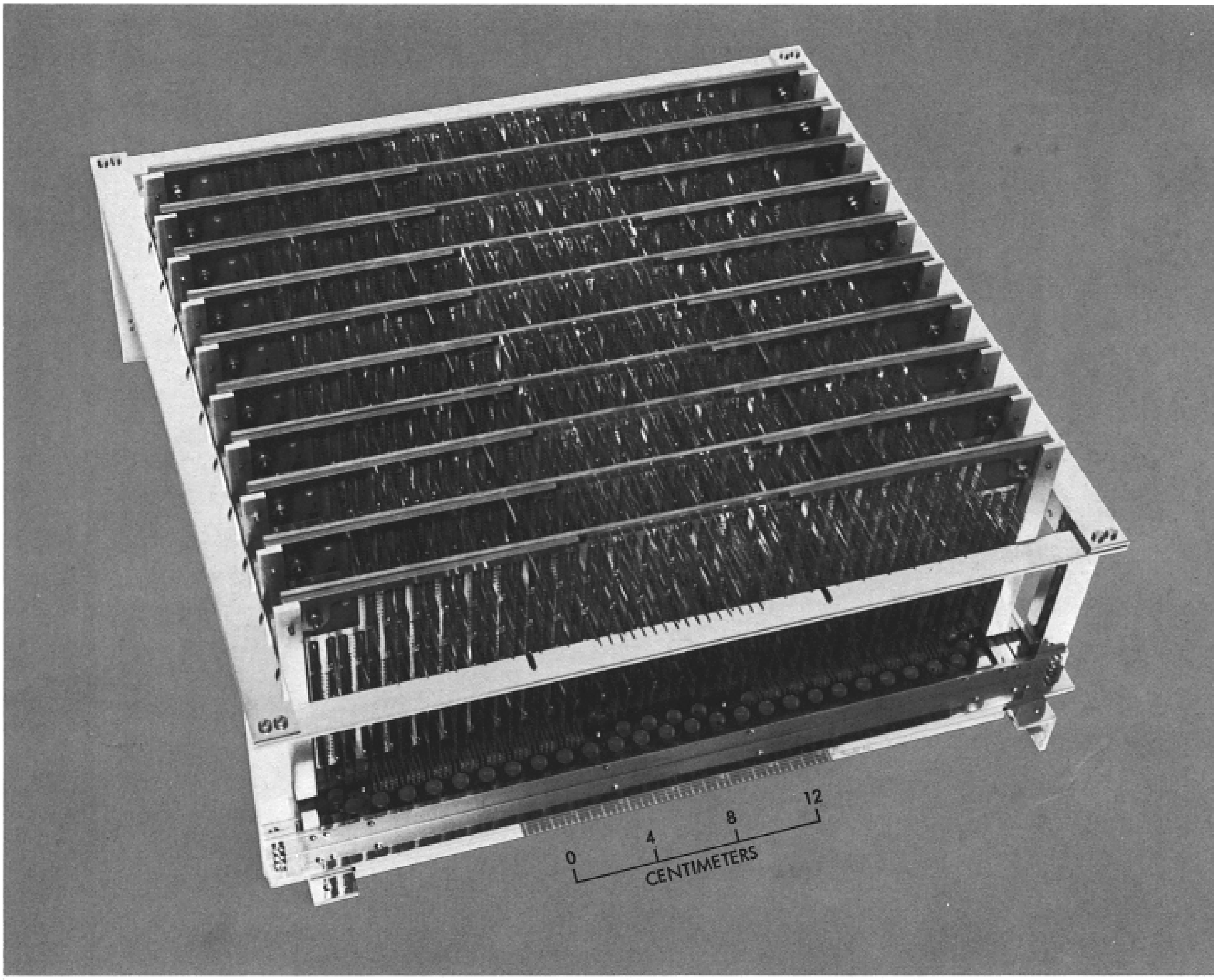

Fig. 6. Total Integrated DIP Microcircuit Card and Cage Packaging Assembly

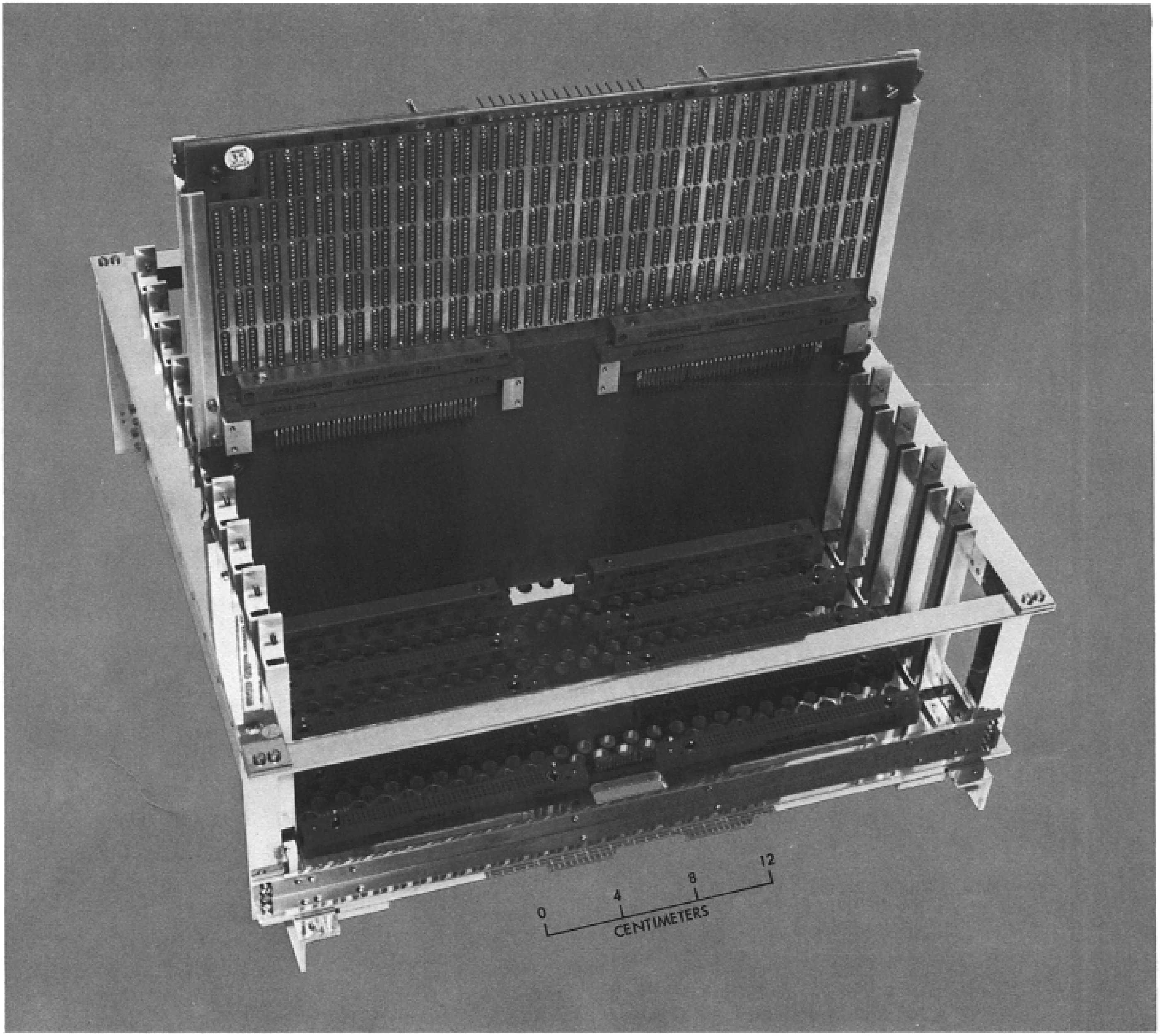

Fig. 7. Extender Card