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PACKAGING FOR THE 580-SERIES

AMDAHL COMPUTER

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TECHNICAL PAPER

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Presented at the 31st Electronic Components
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Abstract

The Amdahl 580 family of computers is the result of major evolutionary advancements in technology, packaging, and architecture beyond the fourth-generation 470V series. It features an air-cooled CPU with twice the performance of the top-of-the-line 470V/8 in half the floor space and at about the same overall price. This paper will discuss certain aspects of the packaging and cooling used in the 580.

Introduction

In November 1980, Amdahl Corporation announced a new series of mainframe computers, the "580 Series"; two versions were introduced initially. The first is the Model 5860, a uniprocessor; the second, the 5880, is a 2-way multi-processor. The Model 5860 has an average processing power in a typical commercial environment of twice the Amdahl 470V/8, while maintaining compatibility with Amdahl and IBM large-scale computer systems and preserving customer software investments.

The packaging of the Amdahl 580-Series is evolutionary in nature, continuing and extending the technology first introduced in the Amdahl 470-Series in the mid-70's[1]. It consists of a Power Distribution Unit (PDU); an Operator's console; and the mainframe itself. The mainframe, in turn, is made up of the LSI (Large Scale Integration) Unit, the Main Storage Unit (MSU), the Console/Channel Electronics Unit, and the Cable Entry panel. The units, and some of the technology and packaging employed, will be discussed in turn.

The design goals in packaging the 580 were to make the system as compact as possible; to eliminate most discrete wiring and harnessing; and to extend the technology developed for the 470V series.

The 5860 Floorplan

The 470V/8 and the 5860 floorplans are shown in figure 1. It is apparent that the 5860 occupies significantly less floor space, a result of improved packaging and denser LSI. The PDU's are of comparable size, although the 580 PDU can now control two 5860 systems where the earlier PDU controlled only one system. The mainframe itself is less than 50% the size of its predecessor, and the console is less than 33% as large. Such size reductions are driving the trend to more capability in smaller packages, as has been documented in recent articles[2].

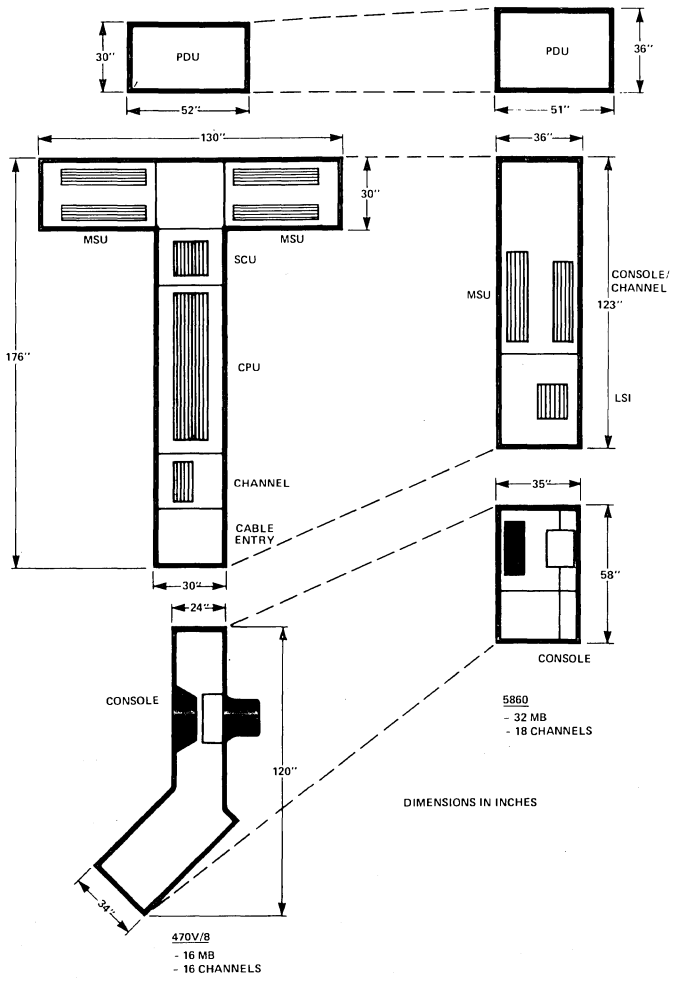

Figure 1. Comparative views of 470V/8 and 5860

The Power Distribution Unit (PDU)

The computer system requires 208V 400 Hz power for the computer logic power supplies, and 208V 50/60 Hz power for fans and console peripherals. The PDU conditions and controls this power, and distributes it among the other frames. It also controls power sequencing, and monitors power and thermal status for the whole system (or both systems, if two are connected). The new PDU (see figure 2) is partitioned by bulkheads into four sections: the load section, power conditioning section, contactor section, and logic section.

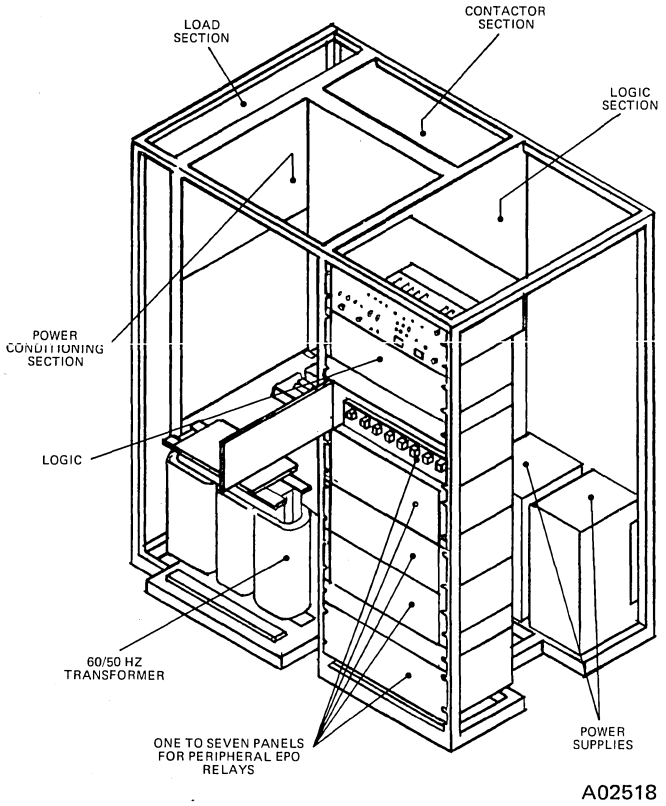

Figure 2. The 580 Power Distribution Unit

400 Hz Power. The primary power for the system is supplied by a 3-phase 400 Hz Motor-Generator (MG) or equivalent. It enters the PDU by way of the field wiring terminals in the load section, is distributed to a circuit breaker panel, then is fed through a shielded wiring trough into the contactor section. The contactors provide control of the power lines that then run to all system power supplies, located in the individual frames. When needed, the Power Factor on the 400 Hz line can be corrected using optional capacitors and a Power Factor controller, located in the power conditioning section.

50/60 Hz Power. The three-phase utility power (208V, 60 Hz in the USA and Canada; 380 or 415V, 50 Hz in Europe) enters the load section through a line filter and circuit breaker, and is routed to a built-in transformer in the power conditioning section to be converted to 208V. It is then routed (through the contactor section) out to the system, where it is used primarily for fan power and service outlets.

PDU Control. The PDU provides many monitoring and safety features, protecting both operators and the system itself. The state-driven controller is located in the logic section, where it verifies correct status and sequences the contactors and the frame power controllers (which in turn sequence on the power supplies). Also in the logic section is the logic needed to control power sequencing for the peripherals (tape and disk drives, printers, etc.) connected to the system.

Should there be a failure in the logic, it can be turned off, and the system power may be manually sequenced to turn the system on or off. In addition, there is an Immediate Power Off switch that, when pulled, removes all power from the system and also turns off the peripherals.

The PDU's internal DC power comes from a power supply that operates from both the 400 Hz and 50/60 Hz sources; if one source is lost, the supply continues to operate, providing interruption-free control.

PDU Packaging Features. The 5860 PDU was divided into sections in order to suppress conducted and radiated noise that otherwise tends to be transmitted from the primary AC lines into the AC being distributed throughout the system, and from both of these areas into the more sensitive logic section. Interference radiated by contactors is contained by the steel bulkheads. This separation has provided internal immunity to radiation, as well as helping the system to meet the requirements of the FCC's recent Docket 20780 for maximum levels of radiated interference.

DC Power Supplies. All low-voltage direct current in the 580 mainframe is provided by two basic versions of DC power supply, used singly or as master-plus-slaves to give the current required. One supply is rated at 380 Amps, the other at 125 Amps, and both can be set for any voltage between 2.0 and 6.0 volts. By using just two versatile supplies, the field logistics costs are reduced and servicing is made easier. These custom-designed units sense under-voltage, over-voltage, over-current, under-current, and over-temperature, and report such conditions to the PDU. They are optimized for highly reliable operation and are typically run at much less than their rated current. For added servicability, both supplies use the same replaceable printed circuit board for their internal electronics.

The Operator's Console

The 470V/8 console consisted of a minicomputer, head-per-track disk drive, two floppy drives, the CRT/monitor and keyboard, a modem (for remote servicing), and various controllers and power supplies.

The 5860 console (see figure 3) takes advantage of several factors to achieve a significant reduction in size.

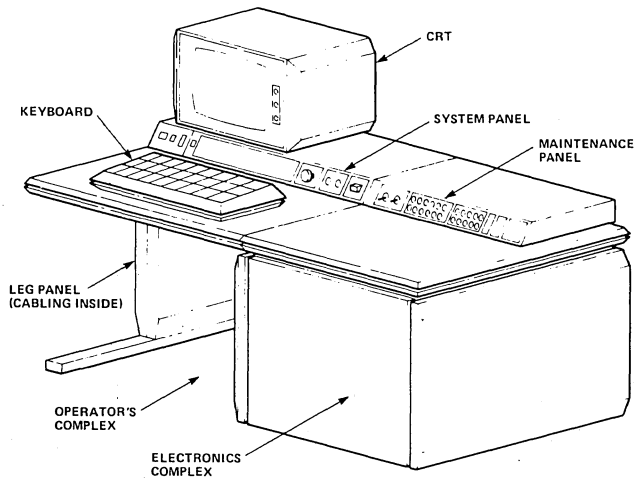

Figure 3. The 580 Main Operator's Console

Processor Relocation. Taking advantage of the high density and greater reliability of the gate-array IC's used in the mainframe, the total console processor has been implemented in Large Scale Intergration (LSI) and placed in the LSI Unit. A support microprocessor and its memory are located in the Console/Channel Electronics Unit. The basic Operator's Console (or Terminal Station), containing a keyboard, CRT/monitor, and optional printer, has only a single PC board to handle the Terminal Station functions. By removing all processing functions from the console, its susceptability to electrostatic discharge and other operator-induced problems is greatly reduced.

Terminal Station Packaging. The CRT can both tilt and rotate; this, in conjunction with the moveable keyboard enclosure, allows the operator to select the position best suited for comfort, and to vary that position to ease monotony and reduce strain. The etched CRT faceplate reduces glare, and a P42 phosphor eliminates flicker. Different contrasts and brightnesses can be selected by keying in selected codes on the keyboard, to optimize viewing characteristics.

The CRT and keyboard enclosures are made from either fiberglass, or by low-pressure molding out of thermoplastic sheet. For either enclosure, the inside has a zinc coating; this provides excellent shielding for eliminating interactions from external noise and for giving the electromagnetic suppression needed to meet the FCC requirements. Power and signal harnesses are routed inside channels in the table and leg, and cables to the system (and to the printer) attach at the bottom of the leg. The composite video for the display is sent via a triaxial cable, and digital signals are transmitted to and from the rest of the system over twisted-pair wires in a round jacketed cable. Up to four Terminal Stations may be attached to a 5860.

Electronics Complex. The Main Operator's Console (MOC) includes the Terminal Station described above, plus a pedestal containing embedded console peripherals. An 8" Winchester-technology disk drive is used to store the console operating programs and the system diagnostics, and a pair of 8" floppy drives are used to load any non-resident programs or diagnostics, and also to load field updates. These three drives are mounted side-by-side on slides, to allow easy access for repair or replacement. Beneath the drives are two drawers: one for the storage of floppy diskettes; and the second for a modem to connect a field-installed system to one of the Amdahl diagnostic centers. Behind the drives is located an electronics card cage containing the drive controllers. A system operation and maintenance panel is built into the top-rear of the pedestal; mechanical switches have been replaced with a membrane switch panel, with light-emitting diodes (LED's) as indicators, for greater reliability and ease of manufacturing.

The pedestal can be located on the left or on the right of the Terminal Station, or it can be free-standing. In addition, multiple terminal stations can be connected together to form larger work stations. For example, the two consoles for the 5880 2-way multiprocessor can be integrated into a single-table-top station.

The pedestal electronics receives power from the PDU, and twisted-pair wires in a jacketed cable are used for the interface to the Console/Channel Electronics Unit.

The LSI Unit

The "heart" of the 5860 is the LSI Unit, shown in figure 4. The Unit Power Controller (upper-left in figure) controls sequencing of the power supplies, located in the bottom of the frame; it also monitors voltage, thermal and air flow status, and reports this back to the PDU.

The MCC. The Multi-Chip Carrier (MCC) boards are located in the center of the frame. Each board can accommodate up to 121 LSI chip carriers, in contrast to the 470V/8 MCC which had up to 42 such carriers. By scaling up the size of the MCC and quadrupling the gate density of the LSI chips, it was now possible to integrate the complete CPU and Buffer memory onto 5 MCC's; the Input/Output (I/O) Processor, Console Processor, and Memory Bus Controller fit on one MCC each. Thus, 8 MCC's in a 5.6 cubic foot package give twice the performance of the 470V/8, with its 79 cubic feet of LSI volume. In fact, the 5860 can accommodate up to 13 MCC's, one of which can be a second I/O Processor to expand Channel capacity from 18 to 34 channels.

Cooling the LSI Unit. The 580 uses the chilled air provided from under the computer room's raised floor to do all the system cooling. The LSI Unit uses only one-half the amount of DC power as the 470V/8's LSI (about 5kW, including the Console Processor, compared to 10kW for the V/8) and thus needs less cooling than its predecessor. There is no need for a chilled-water or Freon system, and the added complexity of liquid distribution is avoided. No compressors or heat-transfer devices are needed beyond those required for supplying cool air to peripherals and controllers already present.

Chilled air is drawn from under the floor and routed through a plenum to the MCC's; two half-horsepower blowers draw the air across the MCC's, cooling the LSI chips with an air velocity of 1800 feet per minute. The air is exhausted through an expansion chamber (to suppress noise) and then out through the top of the frame. For access during servicing, the plenum in front of the MCC's is swung out of the way, and room-temperature air is then drawn through the MCC's while individual circuits are probed.

Chip-to-chip temperature differences are reduced, since each MCC gets chilled air directly; in the 470V/8, with three rows of MCC's, the upper MCC received air after it had cooled lower MCC's. The reduced chip temperature variation increases the margins for reliable operation.

The five power supplies in the base of the frame also draw underfloor air for cooling purposes. Their exhaust air is routed up the frame next to the outer doors, and then out the top of the unit, so as not to add heat to the LSI.

MCC Interconnection. To get the high numbers of interconnects needed for data transfer between MCC's, a Zero Insertion Force (ZIF) connector on the two side edges of the MCC provide a total of 1152 I/O pins; 768 are used for signals, and the balance are for power and ground. The mating connectors are mounted in two "side panels", which are printed circuit boards containing the etched interconnections between MCC's. This is a major improvement in producibility, reliability, and signal propagation time over the 470V/8 interconnections, which were individual coaxial wires routed between the MCC edge connectors. One side panel can be seen in figure 4; the other is on the opposite side.

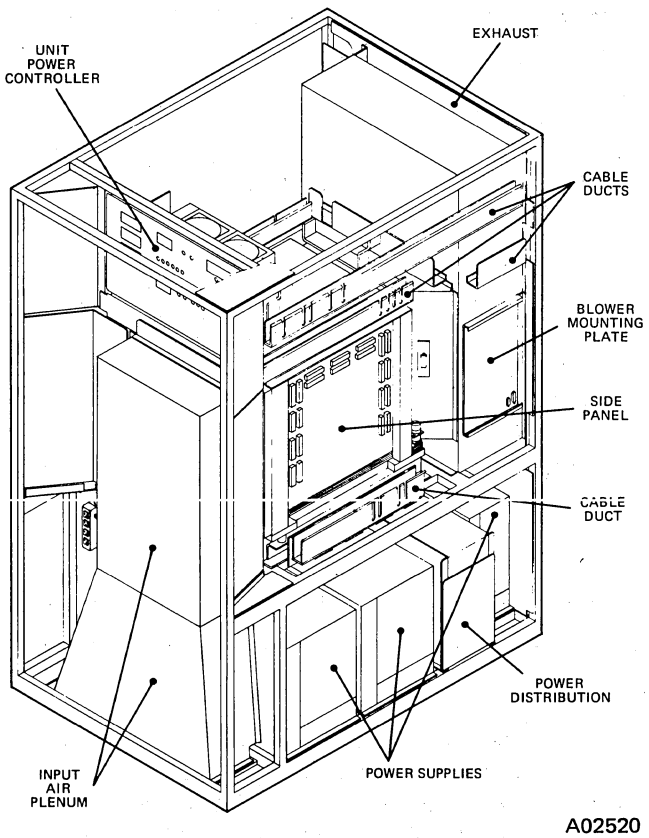

Figure 4. The 5860 LSI Unit

Interconnections from the LSI Unit. Commands and data are routed over 50-conductor coaxial ribbon cables that are mass-terminated into connector headers (see figure 5). They originate on the side-panel and terminate on the MSU and Console/Channel backplanes. Spare lines are available in each cable in case rework is required.

The Main Storage Unit (MSU)

The MSU is a swing-out gate that fits in one side of the second frame of the main computer unit (see figure 6). By using low-profile components and connectors, and metal stiffeners on the front and rear, the Main Store boards have been placed on 0.5" centers. The 4-layer boards are 11.2" x 9.2", with 128 memory chips (using a 16K device) and about 40

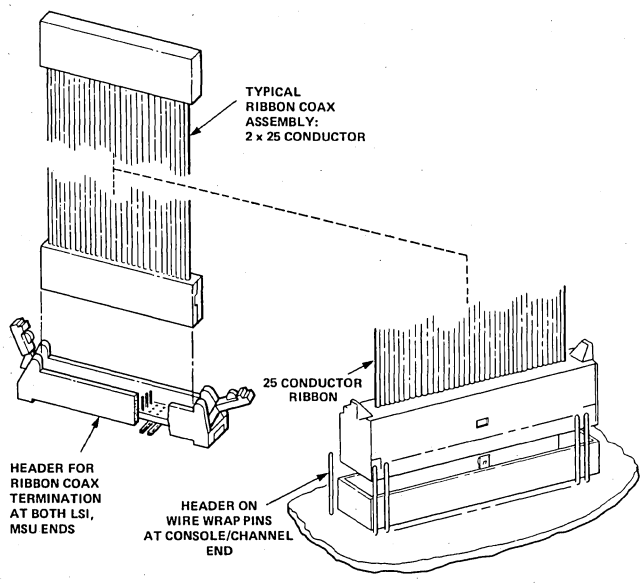

Figure 5. Coaxial Ribbon Cable from the LSI Unit to the MSU and Console/Channel Unit

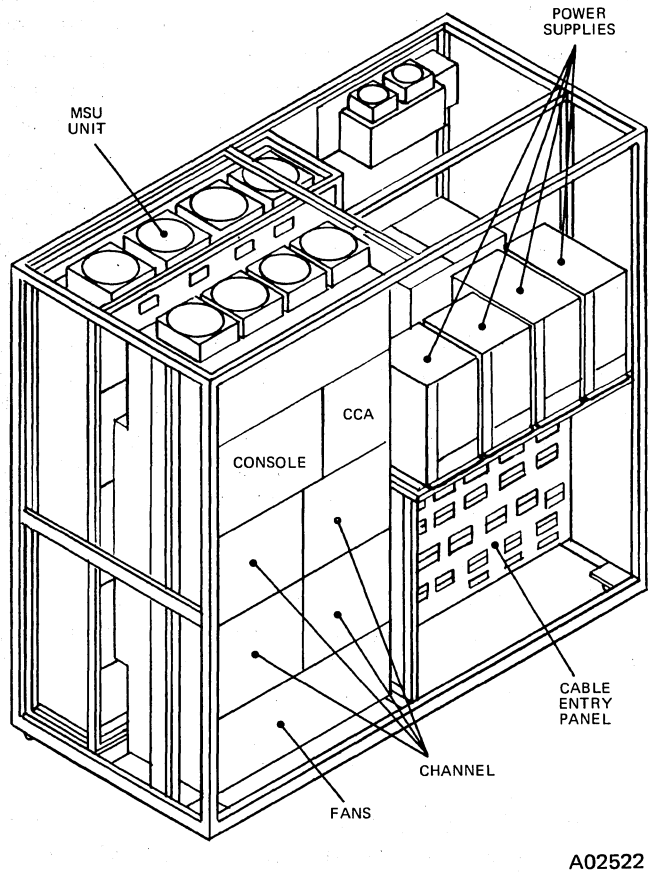

Figure 6. Non-LSI Frame, with Main Storage Unit, Console/Channel Unit, and Cable Entry Panel

additional support chips on each board. A fully populated MSU contains 144 such boards in three card-cage rows; an additional eleven boards in each row handle driving, terminating, and key storage tasks. Interconnection to the backpanel is through a 180-position connector; the backplane contains four signal layers and four voltage/ground layers, as well as wire-wrap pins for overflow wiring. The coaxial ribbon cables from the LSI Unit mate with headers on the MSU backplane.

This packaging scheme provides a very compact MSU, containing up to 32 megabytes; this is contrasted to earlier computers, such as the 470V series, that provided one-fourth to one-half the memory in twice the volume.

Cooling the MSU. Chilled air is drawn from under the floor and forced up the MSU by four fans at the bottom of the MSU gate; another row of four fans at the top of the gate helps draw air up the column. This "push-pull" arrangement provides the best airflow for the fan-power investment, and also allows the MSU to run without the sheet-metal gate covers in place, with little loss of cooling performance.

Power for the MSU. The two power supplies for the MSU are mounted on the swing-out frame along with the gate itself. The heavy DC cables can thus be quite short, reducing voltage drop on the supply busses.

The Channel/Console Unit

The other gate in the second frame contains the boards for running the console, for a channel-to-channel adaptor (CCA), and for the channel driver/receiver cards (called "Interface Handlers") for up to 34 channels. The boards are 11.2" x 8", with 4 to 10 layers.

The Interface Handler board. The mainframe's interface to the various types of peripherals is through 18 (and up to 34) independent channels. In the 580 series, the Interface Handlers perform the data transfer operations, including data buffering. In past designs, this function has taken extensive logic; this new design uses custom Emitter-Coupled Logic (ECL) chips and high-speed ECL memory chips to reduce chip count and improve performance and reliability. Data transfer can be as high as 6 megabytes per second, and future channel protocols can be implemented by changing the Interface Handler, rather than requiring a re-design to the Input/Output Processor MCC.

The Interface Handler contains 15 LSI and memory devices plus 24 resistor networks. Because of the

height of the cooling towers on the LSI chip carriers, and the provision for overflow wiring and engineering updates on the back of the board, the boards are placed on 1.2" centers. Each board's backpanel connector contains 180 pins, for communication to other boards and to the LSI Unit; the Channel Bus and Tag connections are made from the front edge of the board through three 50-position headers. Ribbon cable runs from these connectors, through cabling troughs, to the cable-entry area of the frame, where the system's peripheral cables are connected (see figure 7).

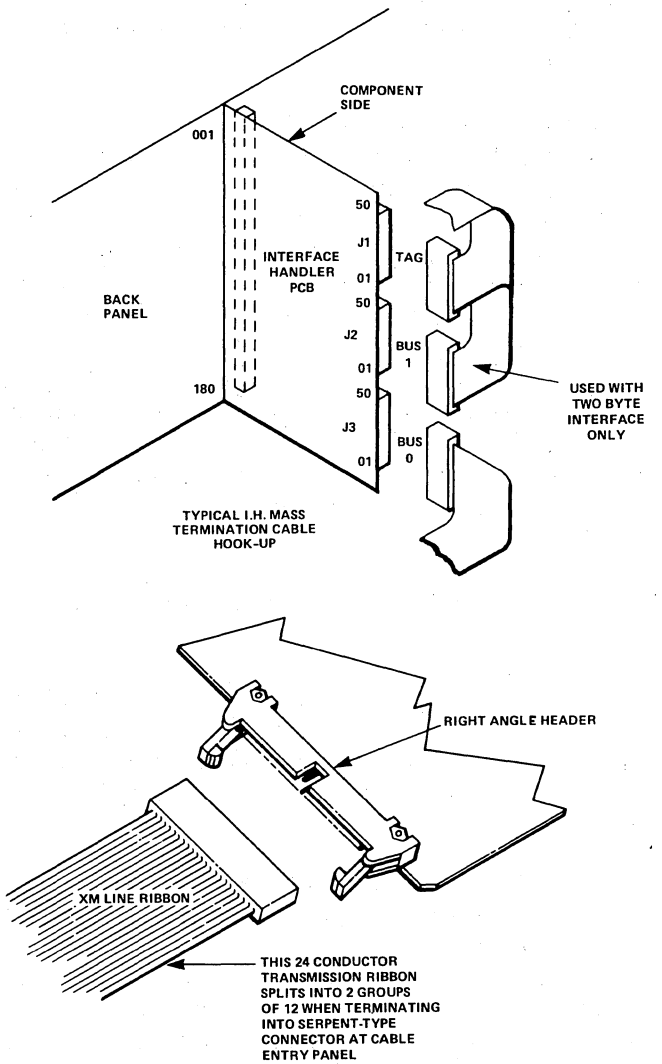

Figure 7. Transmission-Line Ribbon Cable from the Channel Interface Handler to the Cable Entry Panel

The Cable Entry Panel. The system's channel cables are plugged onto standard Bus and Tag connectors on a shielded panel within the second frame. Once the cables are in place, a steel door fitted with RFI gasketing completes the enclosure. This panel can handle cables for the first 18 channels; when the system is expanded to 34 channels, an additional 24" x 33" frame is added for connecting the balance.

The Console and CCA boards. These boards use a combination of ECL and TTL family logic, plus both bipolar and MOS microprocessors, to implement the operation and maintenance functions of the console, and to provide a loosely coupled link to another mainframe computer through the Channel-to-Channel Adaptor (CCA). As a part of the console section, there is a 2 megabyte memory array on 10 boards.

Most of these boards are laid out on one of two basic grid and voltage/ground plane implementations; only the signal layers are customized for each individual board. This commonality allows speedier assembly and test and creates some economies of scale because of the "family" relationship.

Access to Boards and Backplanes. Although so much electronics is packaged into the second frame, the access is quite good. The MSU boards are accessible by opening the outer doors and removing a sheet metal cover over each row of boards. By swinging the MSU gate out from the frame, the backpanels are available for probing or updates. With this gate swung out, the console and channel boards may be removed from the fixed gate; the Interface Handler's ribbon cables run in the space between the card rack levels so they need not be removed to unplug a board. The console and channel backplanes are accessible by opening the external doors on the other side of the frame.

Cooling the Console/Channel Unit. Airflow through the Console/Channel Unit is identical to that for the MSU. A push-pull fan arrangement is used, with four fans below the gate and four above. The same fan is used in this unit and in the MSU, so only one fan type needs to be stocked in the field to service either unit.

There are six additional power supplies associated with this unit (in addition to the 2 MSU supplies). They are located on a shelf above the Cable Entry panel, to allow more space for the cable routing.

Summary

The 580 computer is an example of how system function and capability have been increased several-fold, while at the same time the size and power requirements have been reduced. Features of the 580 packaging include improved accessability for servicing, better RFI suppression, and simplicity of implementa-

tion. Substantial gains in reliability are attributed to greater use of higher-density LSI chips, reduced quantity of discrete wiring in favor of etched backplanes and mass-terminated ribbon cables, and reduced operating temperatures.

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Acknowledgements

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