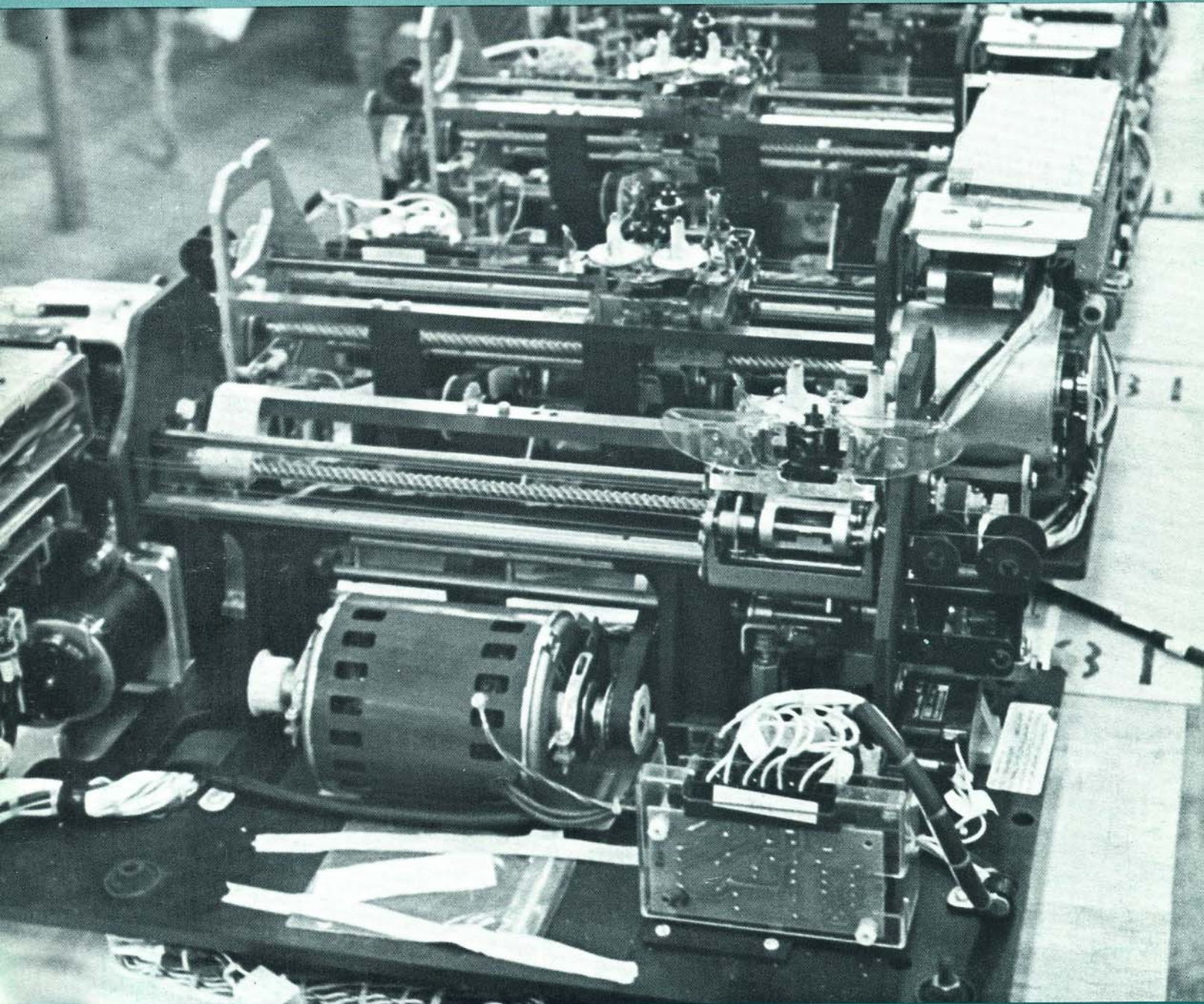# Real-Time Multiprogramming System
Boosts Productivity for NCR

Serial printer sub-assemblies await installation following checkout by NCR/Wichita Real-Time Multiprogramming System.

A Solution to Production Test Problems for NCR ACCOUNTING COMPUTER DIVISION, Wichita, Kansas
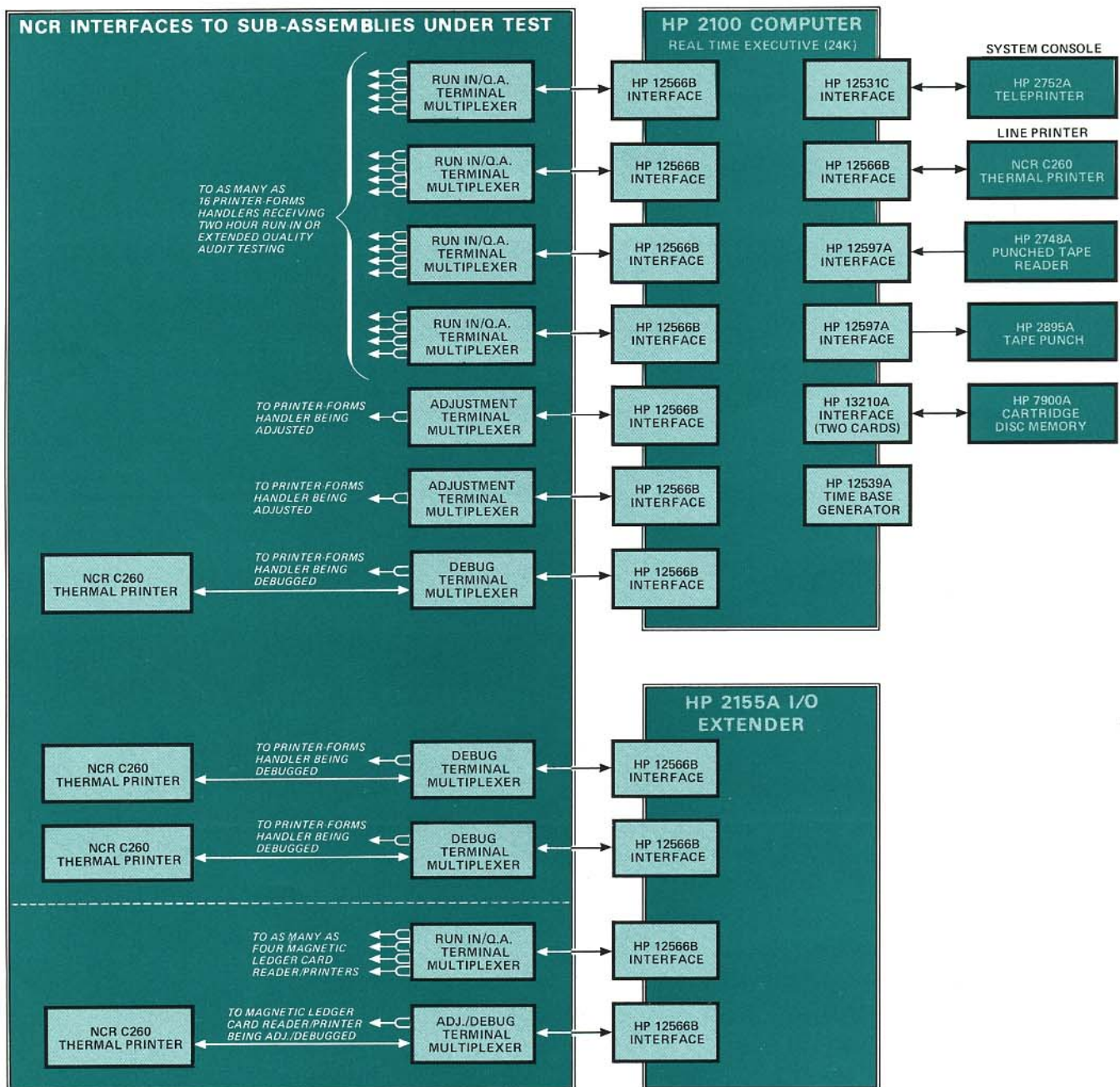
Real-Time Multiprogramming System Boosts Productivity for NCR

NCR, known world wide for more than 80 years as an outstanding manufacturer of cash registers and other business accounting and data processing systems, is today a corporation decidedly on the move. Directed by dynamic new leadership from its corporate headquarters in Dayton, Ohio, NCR is on an all-important thrust upward, toward higher levels of efficiency, contribution, and profitability. One highly-effective way of raising productivity and profitability without compromising product quality and reliability is through automation of testing. This approach is exemplified at NCR's Accounting Computer Division in Wichita, Kansas by a sub-assemblies test system which is being implemented by T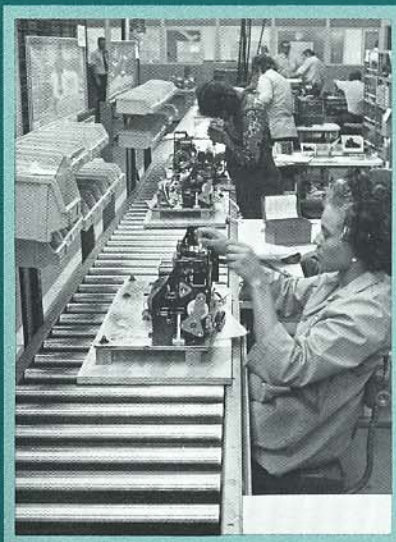est Systems Manager, Jim Richardson, around a Hewlett-Packard disc-based Real-Time Executive (RTE) System. Electromechanical sub-assemblies currently manufactured and tested using the system include a high-speed serial printer and split-platen forms handlers used in the new NCR C-399 Accounting Computer System as well as the serial printer for the NCR C-270 bank teller's terminal. Testing of magnetic ledger card reader/printers will soon be added to the system's accomplishments.

Operations conducted by the system under the direction of NCR-written test programs comprise run-in, adjustment, quality audit checking, life test, and debugging and rework of units that fail to meet NCR quality standards.
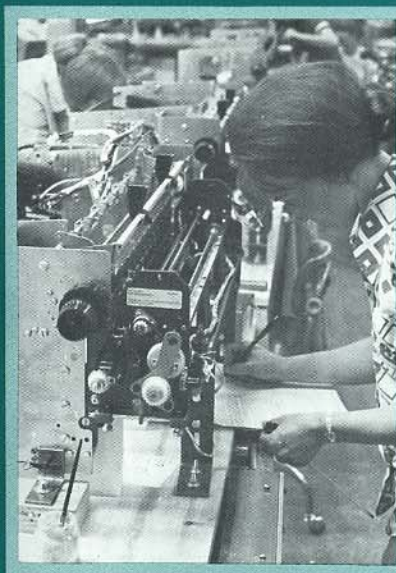
NCR INTERFACES TO SUB-ASSEMBLIES UNDER TEST

TO AS MANY AS 16 PRINTER-FORMS HANDLERS RECEIVING TWO HOUR RUN IN OR EXTENDED QUALITY AUDIT TESTING

- RUN IN/Q.A. TERMINAL MULTIPLEXER → HP 12566B INTERFACE
- RUN IN/Q.A. TERMINAL MULTIPLEXER → HP 12566B INTERFACE
- RUN IN/Q.A. TERMINAL MULTIPLEXER → HP 12566B INTERFACE
- RUN IN/Q.A. TERMINAL MULTIPLEXER → HP 12566B INTERFACE

TO PRINTER-FORMS HANDLER BEING ADJUSTED → ADJUSTMENT TERMINAL MULTIPLEXER → HP 12566B INTERFACE

TO PRINTER-FORMS HANDLER BEING ADJUSTED → ADJUSTMENT TERMINAL MULTIPLEXER → HP 12566B INTERFACE

NCR C260 THERMAL PRINTER ↔ TO PRINTER-FORMS HANDLER BEING DEBUGGED → DEBUG TERMINAL MULTIPLEXER → HP 12566B INTERFACE

HP 2100 COMPUTER
REAL TIME EXECUTIVE (24K)

- HP 12531C INTERFACE ↔ **SYSTEM CONSOLE** HP 2752A TELEPRINTER
- HP 12566B INTERFACE ↔ **LINE PRINTER** NCR C260 THERMAL PRINTER
- HP 12597A INTERFACE ↔ HP 2748A PUNCHED TAPE READER
- HP 12597A INTERFACE ↔ HP 2895A TAPE PUNCH
- HP 13210A INTERFACE (TWO CARDS) ↔ HP 7900A CARTRIDGE DISC MEMORY
- HP 12539A TIME BASE GENERATOR

HP 2155A I/O EXTENDER

NCR C260 THERMAL PRINTER ↔ TO PRINTER-FORMS HANDLER BEING DEBUGGED → DEBUG TERMINAL MULTIPLEXER → HP 12566B INTERFACE

NCR C260 THERMAL PRINTER ↔ TO PRINTER-FORMS HANDLER BEING DEBUGGED → DEBUG TERMINAL MULTIPLEXER → HP 12566B INTERFACE

TO AS MANY AS FOUR MAGNETIC LEDGER CARD READER/PRINTERS → RUN IN/Q.A. TERMINAL MULTIPLEXER → HP 12566B INTERFACE

NCR C260 THERMAL PRINTER ↔ TO MAGNETIC LEDGER CARD READER/PRINTER BEING ADJ./DEBUGGED → ADJ./DEBUG TERMINAL MULTIPLEXER → HP 12566B INTERFACE

Real-Time System for Testing NCR C-399 and C-270 Sub-assemblies

ASSEMBLY AND STATIC TEST AND ADJUSTMENT

TWO-HOUR RUN-IN

DYNAMIC TEST AND ADJUSTMENT

DEBUG AND REWORK

DELIVERY TO NCR C-270 & C-399 ASSEMBLY LINES FOR INSTALLATION

One C-270 Printer-Forms Handler

C-270 Printer Assembly

Up to four C-270 Printer-Forms Handlers

Up to eight Printer-Forms Handlers

Up to three Printer-Forms Handlers

NCR C-270 Printer Assemblies Awaiting Shipment

QUALITY AUDIT (EXTENDED RUN-IN)

C-399 Printer-Forms Handler Assembly
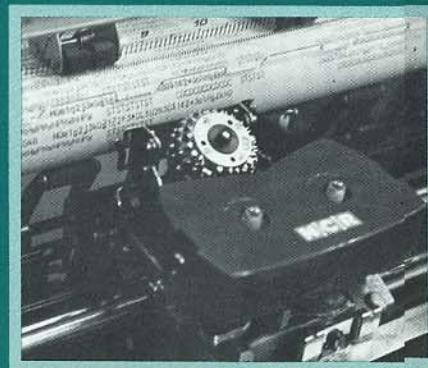
Up to four C-399 Printer-Forms Handlers

One C-399 Printer-Forms Handler
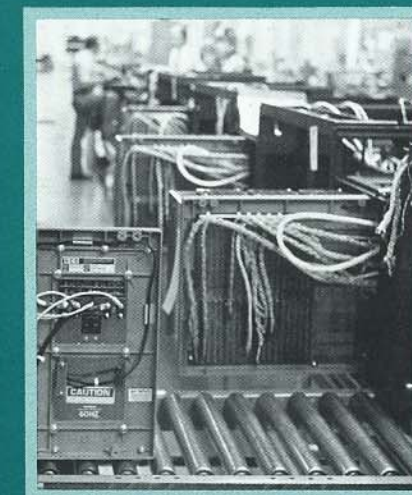
NCR C-399 Computer Assembly Line

A Sensible System Design

In the test system design, Jim Richardson has sought to maximize flexibility, to minimize total investment, and to maximize NCR's return on the investment. By using the general-purpose HP RTE system in conjunction with NCR-built terminal multiplexers, Jim has maximized NCR's ability to respond rapidly to product changes, some of which could be unexpectedly forced by new product introductions of competitors. The use of the general-purpose RTE system has minimized the special engineering content of the over-

all system, holding down the usually high costs associated with special engineering. Because of its flexibility, the RTE system can be expected to have a long useful life, extending and increasing the return on NCR's investment in the system.

Two versions of terminal multiplexers are used. One of these exercises all functions of serial printers and forms handlers during run-in and quality audit testing. It can operate four printer-forms handler sub-assemblies simultaneously and in-

dependently. The other terminal multiplex configuration is used for adjustment and debugging. It works with one sub-assembly at a time.

Part of the terminal multiplexer interfacing includes a modification, by Jim Richardson, of the Real-Time Input/Output Control (RTIOC) section of the HP RTE software. This provides for multiplexing communications with multiple devices under test to the RTE system and the NCR-written

test programs via a single computer I/O channel. Each transfer to/from one of the NCR terminal multiplexers is 32 bits, or two successive computer words. The four most significant bits identify the device which is transferring data to/receiving data from the system. The remaining 28 bits are used for data and control or status signals. With the RTIOC modification, a hardware interrupt from an interface card associated with a terminal multiplexer is routed to an NCR-written program that determines which device interrupted and then services the interrupt.

Interactive Operation

A key feature of the system is provision for debugging and adjustment as well as automatic run-in and checkout. Via each of the three debugging terminal multiplexers and individual NCR C-260 Thermal Printers, the system provides interactive programs to the technician. He can use these with great flexibility to generate tests and operating cycles that quickly localize mechanical and electrical problems, facilitating rework and final adjustment. The system provides both printed information and appropriate control and excitation signals to cycle the unit being debugged. Previously, the technician had to make many time-consuming multiple adjustments to manually-controlled test equipment, distracting from observation of the faulty performance of the sub-assembly. Now his attention is undivided, increasing his effectiveness and speeding the debugging process.

Adjustment actions, which do not require the flexibility of response needed in debugging, are keyed by test numbers to a test adjustments manual, which is quickly mastered by production people working with the adjustment program.

Incorporating the adjustment and debug procedures in the system makes them easy to update. It takes only 20 minutes to change procedures. Moreover, the system provides ample memory space for saving particular operating cycle sequences that individual technicians have developed for debugging faulty units. These can be stored or modified by the technician, on-line.
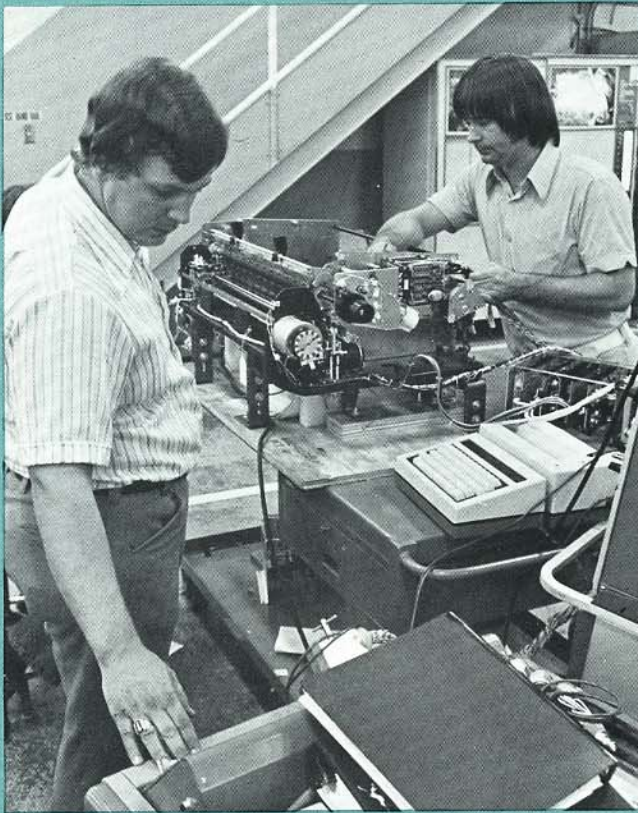
Capacity to Spare

Via the nine terminal multiplexers currently being used for printer-forms handler sub-assembly checkout, the system can control various stages of testing for up to 42 different sub-assemblies simultaneously (up to 16 printers and 16 forms handlers in run-in and quality audit testing and up to 5 printers and 5 forms handlers in adjustment and debugging operations). This uses less than 25% of the available CPU operating time of the RTE system and leaves ample time for program development in the system's background mode concurrently with real-time testing operations. Jim Richardson estimates that addition of magnetic ledger card reader/printer sub-assemblies (photo below) to the testing load will still leave approximately half of the RTE system's CPU time and 27 computer I/O channels available for further extension of testing operations.
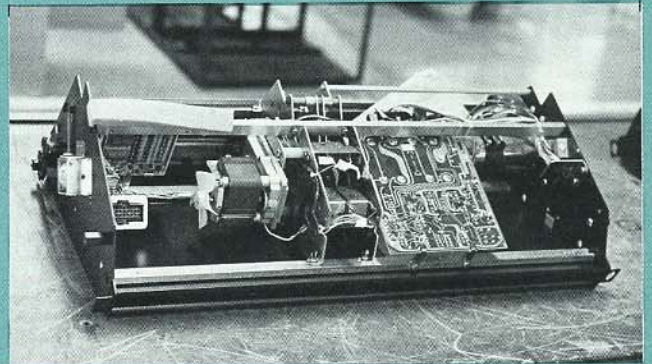
Magnetic Ledger Card Reader/Printer Sub-assembly. Soon to be Added to System's Test Load.

Benefits of the System

The use of the system has reduced mechanical and electrical adjustment times and costs. For example, technicians using manual techniques and manually-controlled test equipment require four hours to align, adjust, and check out a serial printer. With the system controlling all equipment and working interactively *with a non-technical operator,* the process takes only about 28 minutes, a time reduction of better than 8 to 1. Overall, the system has cut the total labor time for making the serial printer in half, as shown in the comparison below, while reducing the skill requirement. This represents a doubling of productivity without any sacrifice of the thorough testing which assures that each unit meets NCR quality standards.

Technician Debugging Printer-Forms Handler Sub-assembly at One of Three Debug Stations.

Labor Content Comparison
for NCR C-399 Serial Printer

STAGE OF MANUFACTURE	WITH MANUAL TEST & ADJ.	TEST & ADJ. WITH SYSTEM
Assembly	1 hour	1 hour
All adjustment and checkout	4 hours	½ hour
Run-in	2 hours	2 hours
Total	7 hours	3½ hours

In addition to doubling productivity, the system is providing a data base of Quality Audit information that is being used to help direct product design and production improvements.

The success of the NCR/Wichita system has encouraged NCR to provide similar systems for its manufacturing facilities in Scotland and Japan.

System Selection

The HP RTE system was chosen as the heart of the NCR/Wichita sub-assembly test system because Jim Richardson, the test systems manager, was familiar with, and realized the time and cost savings inherent in using it. Jim estimates that preparing a suitable real-time operating system in-house instead of using the user-proven HP RTE software would have nearly doubled the NCR engineering manhour investment in the overall system. This additional time was not available.

Another important factor was the excellent environmental specifications of the HP hardware. Reliable performance under adverse conditions has been proven thoroughly at the NCR/Wichita plant no. 1, an interim facility. There the system has operated for more than ten months without any system failure in a dusty environment above the ground level factory floor, without special air conditioning, in ambient temperatures often reaching as high as 95°F.

In the present interim facility, power failures are fairly frequent, so the system's power fail interrupt and restart capability is quite valuable. This capability, implemented by NCR-written routines tailored to the specific needs of the installation, returns the system to active service within 30 to 45 seconds after power is restored, minimizing the impact of power failures on the system's productivity.

Jim Richardson, NCR/Wichita's Test Systems Manager Working on Extension of the Sub-assemblies Test System. (The temporary operating site shown here is less than 15 feet away from the furnace that heats the entire plant.)

HEWLETT PACKARD