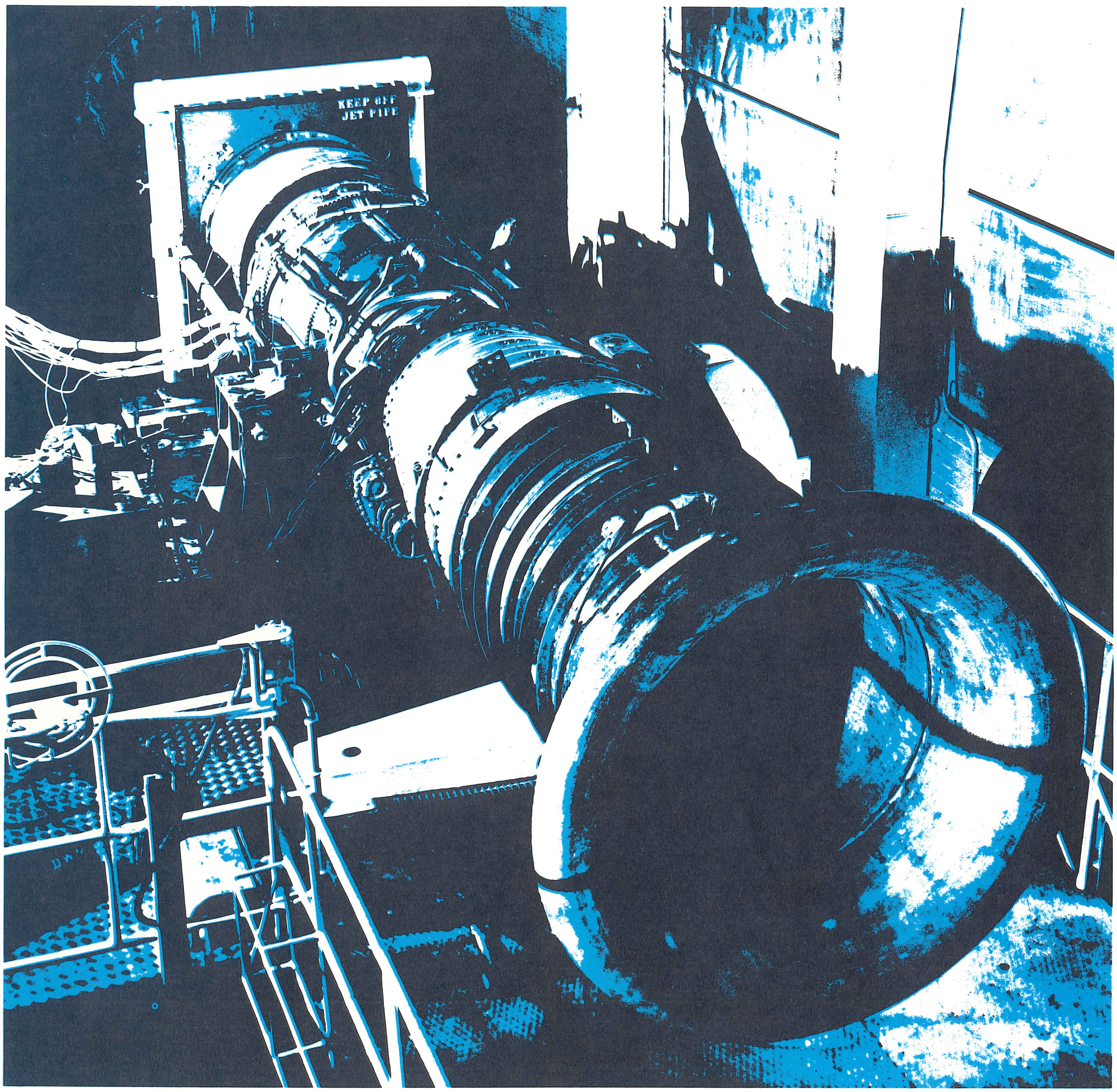
DIGITAL EQUIPMENT CORPORATION

decsystem10

APPLICATION NOTE

DECsystem-10 aids engine design at Rolls Royce Division



digital

AMOS

A computing facility called AMOS is the key to efficient operation at the Bristol Engine Division of Rolls Royce Ltd., Bristol, England. AMOS, "a multi-access on-line system" is a hierarchical computer network being implemented by BRISTOL to speed and simplify the complex tasks involved in jet engine design and development. Already the system has helped design many of the world's commercial and military jet engines as well as the engines for the Concorde supersonic transport.

AMOS, which is operated by the Mathematical Services Department, uses a Digital Equipment Corporation PDP-10 to bring the facilities of the computing center to individual users and departments throughout the plant. The PDP-10 controls the computer network, providing input/output and scheduling for two English Electric 48-bit KDF9 batch processing computers, receiving data from up to 30 on-line satellite computers, and providing interactive computing services currently for some 50 terminals within the Bristol complex.

The satellite computers perform test bed data acquisition and reduction and vibration analysis, provide line printer and paper tape reader facilities, and preprocess numerical control tapes for the Bristol and Coventry plants via a remote communications system.

In the 3 to 5 year period it takes to develop an aircraft engine, an immense volume of performance and life history data is gathered. Engine profiles based on initial prototype data are used by performance engineers to calculate and specify engine performance. Development engineers then take over the long process of delineating tests which will ascertain performance, endurance, and other necessary engine characteristics. Modifications and retesting, especially during later procedures, are often extensive.

The departments involved in development use a moving window of data (about six months of accumulated data) for their current work. With information in a common data base, each department uses exactly the same data, which is easily accessible through remote terminals. If the same information were distributed in the form of computer listings, a department might not always be using the most current data. Time can also be saved if engine tests are properly scheduled. Then performance and development engineers can work in parallel. Since up to 2500 persons in 65 departments can be involved in these operations, efficiency is extremely important.

Gathering Engine Test Data

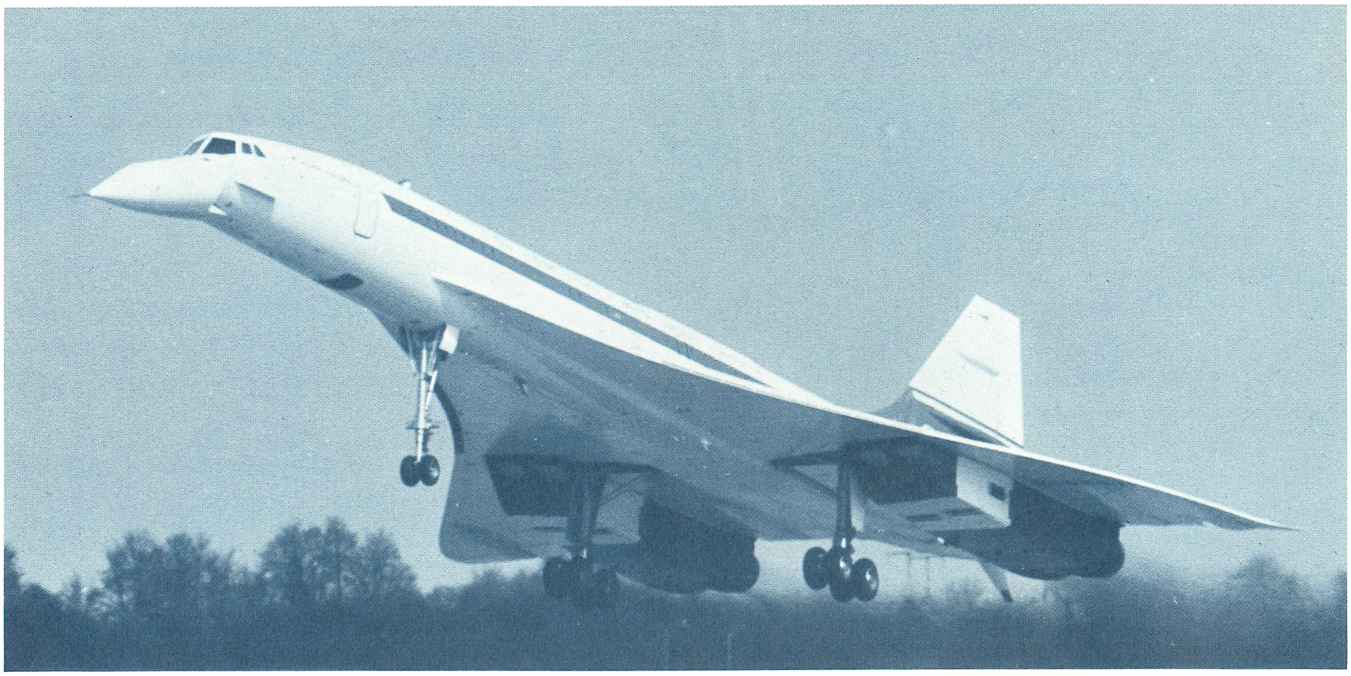
Prototype engines receive a battery of tests ranging from a 2 minute performance test to endurance runs of up to two weeks. During each test, from 30 to 300 points—temperatures, pressures, speeds, flows—are monitored and reduced by a PDP-8/I computer. The data is then fed to PDP-10 disk storage for access by engineers for use in programs scheduled for batch processing on the KDF9 computers.

Reduction performed by the small computers varies from the calculation of turbine inlet temperature—a variable which cannot be measured directly—to the simpler types of performance calculation.

Tests are controlled by a test engineer who can observe the engine in its test bed operation from his position in the control room. Through the control panel keyboards, the test engineer specifies the variables to be monitored and the number of samples or scans to be taken by the computer.

Results of each run appear immediately on the line printers; thus if a particular test is not satisfactory, it can be modified and run again. During all runs, the computer system automatically gathers life testing information, sampling 30 key points every 30 seconds.

Measurements are converted to digital form at the control site for transmission to the PDP-8/I, one quarter mile



away. Since the plant environment causes electrical noise, electro-optical isolation is used at the point where the signals enter the PDP-8/I. Altogether, four test beds are handled by two PDP-8/I computers. In addition to sea level testing each engine undergoes test flights during final testing operations. Data gathered in these flights helps to interpret the results of ground tests.

Preprocessing Numerical Control Tapes

The PDP-10 also contributes to production operations by preprocessing paper tapes for various numerical control machines. A program on the PDP-10 checks the tapes for format, character validity, syntax, and other possible error conditions before they are compiled on a large number-crunching computer at the Rolls Royce Derby plant.

In the future, the PDP-10 will be connected directly to the Derby plant via a remote communication link. The savings accrued through preprocessing will easily pay for the link.

Calculating Services

To aid in the design effort, the Mathematical Services group has written a language called CALC. Even easier to use than BASIC, this language allows an engineer or designer to sit at a terminal and start typing his calculations. No "log on" or "log off" is required and CALC programs are not stored; the system merely performs the desired operations and provides the answer. CALC can be used from the 50 terminals throughout the Bristol plant. In the drafting department, for example, the draftsman uses CALC to locate the positions of components in assembly drawings. The language is also used extensively in the engineering departments, since it includes special engineering functions.

Users that require more flexibility can use another BRISTOL-developed language called PROCAL. This more sophisticated language, much like BASIC, requires the user to have an approved password which is checked by the computer system each time he logs on.

PROCAL, which contains its own editor and print routine, lets the user develop and edit his program via his terminal and remotely enter it for processing on one of the KDF9's. PROCAL also permits the user to read programs and/or data which are input to the PDP-10 through a paper tape reader.

PROCAL is, in fact, a subset of a still more comprehensive BRISTOL-developed language, SCHEME C, which runs on the KDF9's. It is therefore possible to develop SCHEME C programs in a modular fashion, each module being created interactively in PROCAL and subsequently joined by EDIT commands. Runs on the resulting SCHEME C program can then be initiated by remote job entry commands for the terminals.

For system and application development, the Mathematical Services group has access not only to CALC, PROCAL and SCHEME C, but also all of the standard PDP-10 languages and programs. This PDP-10 software includes FORTRAN IV, COBOL, BASIC, AID, debugging, file copying, and many other utility programs.

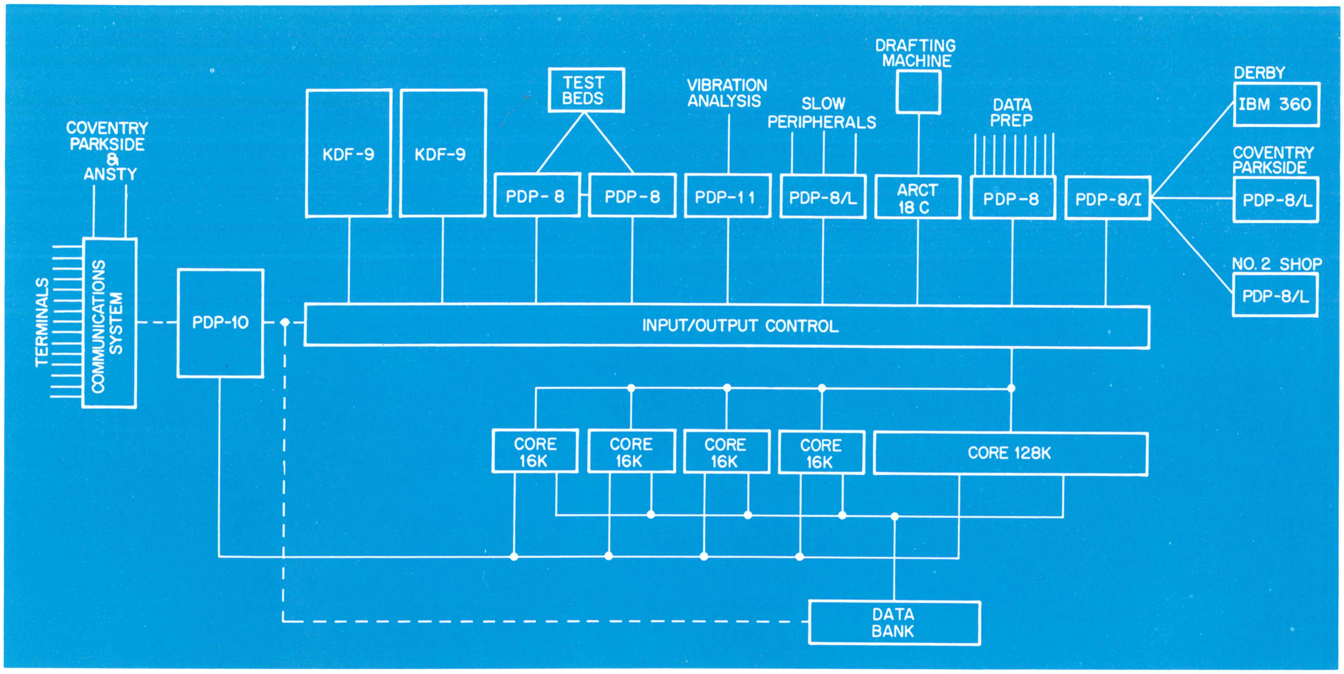
Optimizing Batch Processor Operation

By scheduling the operation of the two KDF9 computers, the PDP-10 has been able to greatly increase batch processing throughput.

The KDF9 computer in its original form executed one program at a time, yielding a processor utilization of about 25 percent. In contrast, the PDP-10, which is designed for multiprogramming, operates at 95 percent efficiency. To improve KDF9 operation, one of the batch processors was upgraded to multiprogram four parallel batch streams.

On this machine turnaround improved and processor utilization increased to 60 percent.

To improve utilization even further, Mathematical Services has modified the KDF9 for attachment to the PDP-10, which schedules and performs input/output for the



KDF9's, making it possible to increase processor utilization to 70-80 percent. When both KDF9's operate in this manner, their work capacity will be much greater than in their former stand-alone configuration.

Each KDF9 program receives a time slice and if the program is not completed during that time, it is suspended pending the next free time slice. Since the duration of a time slice is constant, both large and small programs are executed efficiently, and without usurping the processor.

The PDP-10 also simplifies KDF9 operation. In the stand-alone mode, a single KDF9 requires 12-15 operators for three-shift operation. For two multiprogramming KDF9's, some 22 persons would be required.

With the PDP-10 coordinating the network, 10 operators can cope with the entire network for three shifts, no operators being necessary for the KDF9's. Programs run by the batch processors are initiated in response to satellite computer requests or are initiated directly by terminal users. To run a program on the KDF9, a terminal user "logs on" to the PDP-10, specifying the name of the program, the location of the program and data, and the desired location for the results. He then logs off. In response, the PDP-10 schedules the operation, transferring the data and the program from its disk library to the KDF9, and initiating program execution. When the program has been executed, results are transferred to PDP-10 disk storage. The user can request a program called PRINT to output his results on the system line printer.

Input/Output Subsystem

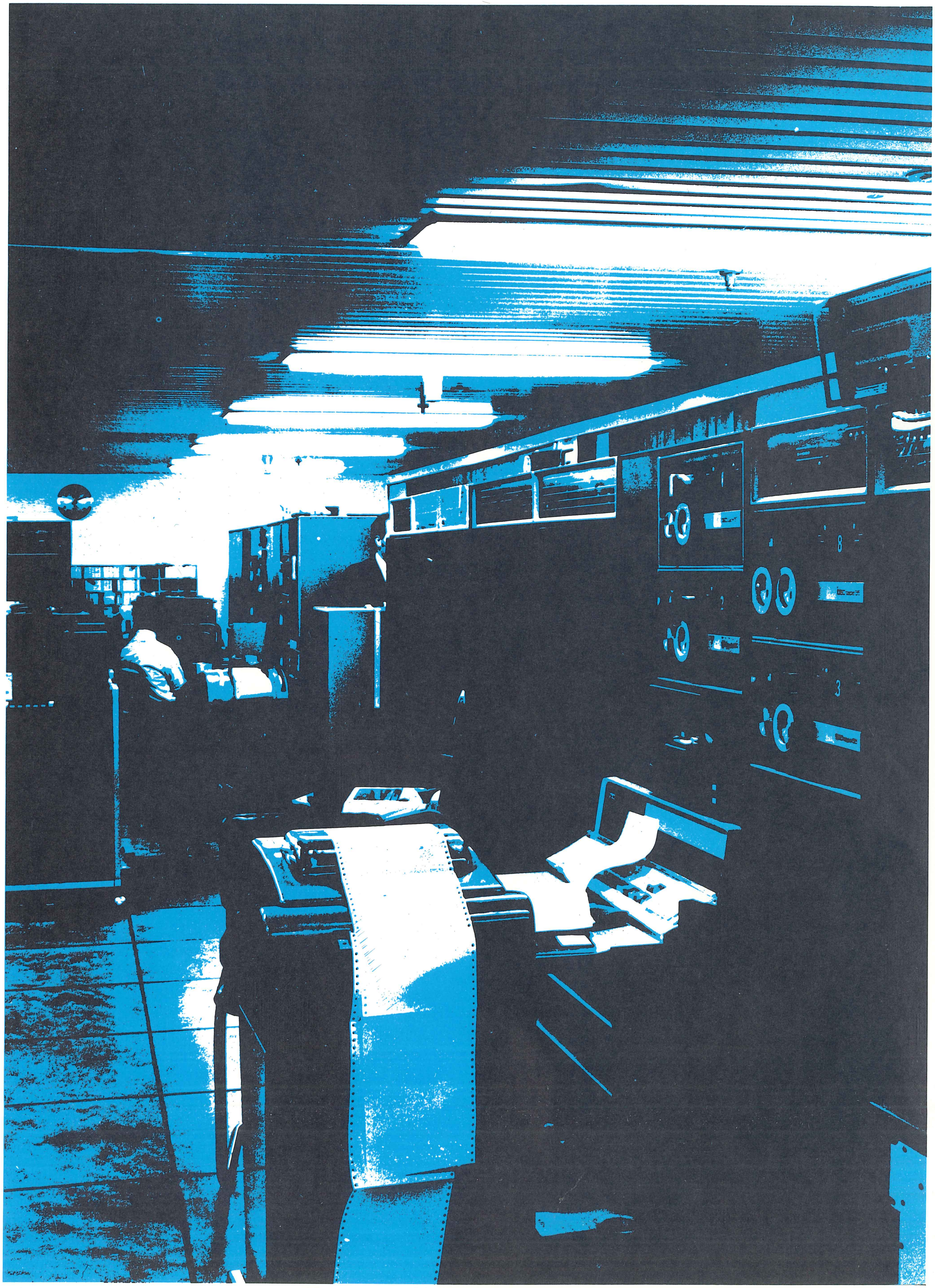
Connections to all the small computers and to the two KDF9's are provided by a control subsystem designed by the Mathematical Services group. The controller, which is connected directly to the PDP-10 memory bus, multiplexes data blocks from all 32 sources, the PDP-10 I/O bus having only to initiate a transfer. For example, the controller assembles small computer words (three 12-bit bytes or two 16-bit bytes) for transmission to the PDP-10, or disassembles PDP-10 words for transmission to the smaller computers. Transmission to the KDF9 is via a 144-bit buffer which contains four PDP-10 words or three KDF9 words.

The controller is capable of handling up to thirty 12-bit or 16-bit computers and two KDF9's, since the channel to PDP-10 memory can transfer up to 24 million bits per second, and the KDF9's each operate at a maximum rate of 8 million bps. Due to the PDP-10's asynchronous nature, transfers can also be taking place from magnetic tape and disks packs to PDP-10 memory through two additional channels.

More Progress

Bristol's AMOS has grown from two large, independant batch processing machines to an integrated computer complex coordinated by the PDP-10. According to plan, each system addition is studied, implemented experimentally where possible, then fully implemented to assure maximum results. The AMOS configuration affords great growth potential. Plans continue for extending the scope of the computing services still further. In the immediate future AMOS will have more terminals, perform on-line vibration testing with a PDP-11, drive drafting machines and graphic displays, and service test rigs and machine shop equipment. As the present system uses only a portion of the PDP-10's servicing capacity, hardware extensions in the form of more memory, bulk storage or satellite computers can be added without disruption, as the rising work load dictates.

To ensure that Rolls Royce personnel obtain full benefit from the facilities available, AMOS education forms part of the curriculum of the company's Engineering Training College, which plays an important role in educating the staff. Needless to say the College terminal equipment is also on-line to AMOS.



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