How to Get Your Money's Worth with Consultants

Hundreds of consulting firms and software companies stand ready to assist computer users in countless ways. Their services can be extremely valuable. Yet many companies, for various reasons, have had expensive and thoroughly unsatisfactory experiences with consultants. This report will help you select a fully qualified consulting firm, negotiate a suitable contract, and work harmoniously with the firm you select.

Independent data processing consulting firms offer an enormous variety of professional services to users and suppliers of EDP equipment and software. These services tend to be consistently high-priced, yet users' opinions of the value of these services are anything but consistent or uniform.

Some users of consultant services claim utter dissatisfaction with their hired consultants. Some say their consultants are excellent "brain pickers" who produce ponderous reports, but whose solutions are ridiculously impractical.

A more fortunate and less vocal group of users of independent consulting services recount entirely satisfactory experiences. The consultant may have contributed invaluable services during vital decision-making activities, critical technical projects, precarious periods of excessive workloads, and other such situations intimately affecting a company's success and profitability. And since several major computer suppliers have now "unbundled" (i.e., separately priced their support services, such as programming, systems analysis, training, software application packages, etc.), the appeal of such services offered by independent consultants has been considerably enhanced.

The contention of this Feature Report is simply that unsatisfactory consultant relationships can have their source not only in the consultant himself, but also in the user of the consultant's services. In other words, use of an independent consultant implies a two-way relationship which is subject to misuse and abuse by either party. For example, poorly defined problems presented to a consultant can yield poorly defined, inadequate, and ineffective solutions.

It seems a reasonable enough assumption that some consulting firms do indeed offer technical competence and professional integrity. Therefore, the remainder of this article offers some guidelines for detecting and selecting the qualified consultants, and also offers suggestions to the user which, if followed, should guarantee satisfactory and productive consultant relationships.

Consultant Services

Before describing how to use consultant services effectively, brief mention might be made of the types of services typically offered.

Services in the area of EDP technology include systems design, programming, documentation, personnel training, and usage of data processing equipment.

More comprehensive, integrated services include audit and evaluation of current operations and systems, design and implementation of new systems and procedures, integration of unlike systems, selection of new equipment, conversion to new equipment, and management of entire data processing installations.

And more management-oriented professional services include market research and planning, product research and planning, design of full-scale management information systems, and guidance in achieving the most effective use of currently available personnel and facilities.

Such services, if performed properly and economically, can obviously be of great value to any company. Therefore, the company must do all in its power to assure that the services it solicits will be provided fully, accurately, and at a fair price.

Necessary Preparations

The most important prerequisite to hiring a consultant lies in precisely defining the problem for which outside assistance might be required. Once the nature and extent of the problem or need is clearly defined, then it must be determined with certainty that the desired solutions and objectives cannot be feasibly achieved with current internal resources.

Some of the criteria which can be used to determine whether or not outside experts are required can be reduced to the following questions:

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- Are the required talent and experience currently on the payroll and available for use?

- Are the required talent and experience needed full-time and indefinitely? (If so, appropriate new staff members should probably be recruited.)

- Can the required talent and experience be afforded on a full-time basis? (If not, temporary use of a consultant may be an ideal solution.)

If it is decided that the use of independent consultants is necessary or desirable, then the evaluation and selection processes should begin at once in order to obtain the best qualified firm with the most attractive solution. These processes should begin immediately so that the selected consultant has the opportunity to participate in the project from the beginning and not only after the project has accumulated a staggering record of calamities. In fairness to these independent practitioners, it must be remembered that consultants offer brainpower, not miracles.

Preliminary Investigations

The prospective user of independent services should next determine the type of consulting firms that can best meet his needs, such as management consultants, general-purpose data processing consultants, software companies, computer service bureaus, etc.

A group of the appropriate type of firms should then be contacted to determine interest and willingness to participate in first-level interviews. During the interviews, a gross description of the project should be presented, followed by a careful probing into each firm's experience, capabilities, and resources—not in the abstract, but as related to the specific problem at hand.

Answers to specific questions, such as the following, should be diligently sought:

- How long has the company been in business?

- What is the background of the company and its key personnel?

- What is the financial and general business status of the company? (Use sources such as Dun and Bradstreet, Better Business Bureau, etc.)

- Is the company apparently easy to work with?

- Does the company appear to be imaginative and inventive?

- What user companies make up the satisfied client list?

- Does the company obtain a high percentage of "repeat" business?

- Are the company's experience and apparent strengths directly related to the specifics of the project at hand?

- Are the standard fee arrangements satisfactory, such as fixed price, time and materials, retainer fee, etc?

If possible, visits to the facilities of the interested consulting firms should be arranged to help determine whether their people and overall resources are adequate to the needs of the project. (The largest firms are not always the best, even though they generally have the best public relations departments; similarly, the smaller firms may not always provide the most personalized service, despite advertisements to the contrary.)

Any consulting company which has failed, or even marginally passed, any of the above preliminary tests should be eliminated from further consideration. The field should be narrowed to those companies which appear most qualified after these preliminary investigations.

Elaboration of Project Objectives

The qualifying firms should next be invited back (either jointly or separately, depending on the amount of time available) to discuss the project in more detail with a view toward submitting formal proposals of service.

All required project specifications should be released to the contending companies, probably in the form of a formal Request for Proposals (RFP). This document should clearly identify the nature of the problems and the objectives of the project, and should also state specific mandatory requirements and desired capabilities as related both to the qualifications of the company and to its proposed solutions.

For example, it can be requested that all proposals must contain the following information:

- Specific project objectives.
- Technical approach.

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- Professional staffing allocations (including commitments of specific personnel for various phases of the project).
- Time requirements and schedules.
- Cost factors, including method of billing.
- Methods of project control and status reporting.
- Specific areas of responsibility and non-responsibility.
- Specific required assistance from the hiring company.
- Contractual terms and conditions under which the services are offered.
- References from satisfied clients, especially those who have used the same kind of services.
- Detailed biographies of the specific individuals who will be assigned to the project.
- Indications of the company's financial stability.

Checking with Other Clients

The importance of the reference-checking phase of the consultant selection process cannot be overestimated. This exercise—which is all too frequently overlooked—can produce invaluable data on the company, its reliability, and its overall professionalism.

Such reference checking often proves to be a difficult, frustrating exercise, since many clients are unwilling to admit having made a very costly mistake in hiring the wrong consultant. Therefore, each such reference must be probed carefully, asking questions such as:

- What kind of work did the firm perform?
- Was it done completely, effectively, and on-time?
- Were the solutions appropriate, practical, and economical?
- Did the assigned personnel perform competently, objectively, and with integrity?
- Did the assigned personnel work constructively and efficaciously with client personnel?
- Did the project managers spend sufficient time in supervising and controlling the project?
- What is the client's summary evaluation of the firm's work?
- Would the client hire them again for further consulting work in similar or different technical endeavors?

All information obtained via these interviews should be summarized in some convenient, uniform manner for use during the final selection process.

Proposal Evaluation and Final Selection

Upon receipt of all proposals by the predetermined "due date," each proposal should be evaluated—and not simply in terms of price. The lowest price today may prove to be far and away the highest price later if the low-bidding consulting firm proceeds to fail in its contractual commitments and so cause the company unusally high expenses and aggravation while attempting to extricate the embroiled project.

The proposal evaluations should indeed measure the cost implications, but should not ignore other important factors such as the consulting firm's understanding of the problem, its technical approach, the benefits that will likely accrue to the company if the proposed problem solutions are approved, estimated project completion dates, methods of project control, pertinent experience levels and capabilities of assigned personnel, and contractual implications (such as guaranteed maintenance of a programming job for a fixed period of time).

Based on the results of the reference checking, proposal evaluations, and personal discussions, the final selection should be made with confidence. All efforts should now turn to ensuring that the selected firm will complete the project successfully.

Contract or Formal Agreement

After selection of the most qualified consulting firm, an attempt should be made to negotiate for the most favorable contract terms. If the impending contract is large enough, legal assistance should be secured to assist in these negotiations and to review all terms and conditions on the agreement.

Once again, it is vital that the written agreement specify the precise nature of the services to be rendered, the specific responsibilities of both client and consultant, the amount of the fee and all possible extra costs, the method of payment (such as one lump sum, progress payments, monthly reimbursement, etc.), the time limits involved, penalty clauses for non-delivery or incomplete delivery of promised service, and any other terms important to the specific project being negotiated.

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Post-Selection Activities

The client company hiring the consultant should not simply sign the formal agreement and then sit back and await results. A successful consulting engagement is always a joint undertaking, demanding mutual cooperation, involvement, and communications.

First of all, the client company should announce the selection of the consulting firm to all concerned company personnel. The precise role of the consultant should be made clear, and complete cooperation should be requested. Appropriate personnel should be informed of the rationale behind hiring the consultant and of the potential company benefits to be gained through his services. Any initial resentment to an outside consulting firm can usually be broken down and transformed into cooperation simply by communicating a few important, fear-dispersing facts.

As the consultant performs his work, the client should be continually reviewing the areas of mutual responsibility and checking to see if the consultant's progress could be materially improved by means of some timely assistance. Obviously, the project should be continually monitored in order to detect early in the proceedings any signs of faltering or poor progress. If initial difficulties are caught early and corrected immediately, then both the client and the consultant have the opportunity to reallocate resources and make whatever other adjustments are required to assure successful results before control is lost.

Toward the same end, the consultant should present periodic status reports in meetings with involved members of the management team. Concise written reports can serve to supplement these direct, personnel encounters.

Evaluation of Service Rendered

After the consultant has officially completed his services, the client company should take the time to prepare a formal report evaluating his performance.

This report can have a two-fold value. First, it can provide very useful information if the consulting firm should ever bid on another contract with the same company. Second, if another company which is contemplating using the same consulting firm should call as part of its reference checking, the performance report can be taken directly from the files. This report is not subject to the sometimes distorting interpretations of an individual summing up the consultant's performance from memory.

In evaluating the services rendered, the client should attempt to answer honestly and completely questions such as the following:

- Was the work carefully planned and accurately executed?
- Did the staff members conduct themselves professionally?
- Did they work diligently, with a minimum of disruption to in-house personnel?
- Were all involved consulting personnel technically competent within their assigned areas?
- Were the solutions complete, timely, and practical?
- Were the solutions capable of being economically implemented?
- Were the solutions feasible for implementation by current in-house personnel?
- Was the agreed-upon work performed within the time and fee limits?
- Were any required time or fee extensions reasonably and fully justified?
- Would a recommendation be made to use the services of the same consulting firm again?

To help ensure that the evaluation report will be objective and straightforward, management should see to it that the report is prepared by individuals other than those who participated in the consultant's selection. Those who helped make the decision to use independent consultants in general and this firm in particular will naturally tend to cover up any flaws in the consultant's performance in order to shield their decisions from management criticism.

Summary

Client companies can obviously obtain many valuable services from the great variety of independent consulting firms in existence today. The value of these services is often distorted and lessened by the company's inexperience in dealing with consultants. This inexperience can lead to expecting too much of the consulting firm and too little of the company's internal personnel.

If the consultant is left to work in a vacuum, the results of his work will probably reflect this isolation from reality. By contrast, mutual cooperation in clearly defined roles can go a long way toward assuring successfully completed projects at reasonable prices. □

How to Plan and Implement a New Computer Installation

The process of installing a new computer system can be incredibly complex. Unsuccessful and costly equipment installations generally result when companies underestimate or ignore the difficulties of this process. This report will help you during your next major equipment installation by identifying all vital conversion and installation activities and offering specific guidelines for performing these activities efficiently and economically.

If for any reason you feel a new computer system may be required in your installation, then you should make certain to spend the required time and money to evaluate the advantages and disadvantages of this new computer system, and to *plan* very carefully all of the many complex activities required to successfully install it.

In other words, a new computer installation must be carefully planned. Installing a new computer without the required planning and control is inviting trouble. This contention will hardly be disputed in data processing circles; in fact, it will be openly agreed with. And yet, computers are installed every day without the proper planning, leading to the inevitable disasters. Somehow, there never seems to be enough time to plan—only to struggle for survival.

This Feature Report not only discusses the problems associated with installing new computer systems, but also offers guidelines that should help you avert the pitfalls and pratfalls commonly encountered by your colleagues.

Why A New Computer?

If the conversion to a new computer system always tends to be trouble-prone, why should any of us disrupt relatively stable day-to-day data processing operations by even considering installation of a new computer system? Perhaps the correct answer in many cases is that we really should not consider new hardware and software until some very pressing production need or obvious economic benefit dictates such an interest.

However, as we all know, the decision to investigate new hardware and software will not always originate with ourselves. For example, it is not uncommon to have top management simply hand down an edict to upgrade the installation's current data processing equipment—for one reason or another. Top management's edict may not be based on the most solid technical foundations, but nonetheless, management has spoken.

More often than not, the reason a company will consider installing a new computer system will simply be that the increased volumes of data processed each day demand more computing capacity than is available with the current set of data processing equipment.

Still another valid reason for considering converting to a new computer system is the installation's desire to install a totally new and different application which demands equipment characteristics that are not available with the present hardware and software. For example, a new order entry system may demand use of remote terminals at many outlying locations. However, the present computer equipment may simply lack the capability to support remote data communications terminals.

Another common reason for considering a new computer is the phenomenon in which a totally new computer offering seems to offer a dramatically better price/performance ratio than our present computer system. When this situation is encountered, we certainly owe it to ourselves to investigate at some length the overall advantages and disadvantages of this new equipment as related to our present equipment. If the new equipment is reasonably compatible with our present equipment, or if the conversion of our current programs can be performed reasonably economically, then perhaps this new equipment does indeed deserve a close look.

In any event, you'll know when it's time for you to consider a new computer system. But remember, the process of investigating, selecting, and installing a new computer will be time-consuming and costly. Therefore, don't take on these activities lightly and casually. Especially, don't become involved in these activities simply because your colleagues in the next building or your friendly competitors across the city happen to be installing a new computer system. Your desire to investigate new computer equipment should instead be based on fundamental economic and technical considerations.

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Where Do You Start?

You can't begin to investigate new solutions to your data processing problems until your problems are well-defined and neatly summarized. Therefore, the first step in the process of investigating a new computer is to perform a careful audit of your existing installation and all the applications being processed therein.

One reasonable place to begin this audit is in your installation's system and program documentation. This documentation should be updated and carefully analyzed. You should attempt to summarize the characteristics of all current systems and programs in ways such as the following:

- Tabulate the file usage and machine usage by program and application.

- Identify all program interdependencies.

- Determine which systems or applications require resystematization. (This item is of extreme importance since it can be extremely shortsighted to convert directly a given application which has many known deficiencies. The process of installing a new computer system can be the most advantageous and reasonable time to dramatically re-style all important "bread and butter" programs and applications.)

- Identify the principal operating deficiences of all key programs. For example: Does the program require more main memory? Does the program badly need additional auxiliary storage? Are the currently available peripheral devices adequate to the real needs and objectives of this system? Is the current programming language adequate to efficiently perform the desired functions of this system? Is the program excessively patched, to the point that program maintenance has become a traumatic task? Does the program require excessive manual intervention and, therefore, is it excessively error-prone?

The results of this audit of the current data processing workload can be extremely valuable in several subsequent activities integral to the installation of a new computer system. It is essential to know not only how many programs currently make up a production program library, but also to know such facts as these: What are the limiting factors of these programs, and which files are used most extensively and across more than one application? Summary information such as this can lead to valuable conclusions related to the desired, if not necessary, capabilities of the new computer.

Install Your Pet Application

While investigating your current data processing workload is essential, it is by no means the only required activity during this period of fact gathering. Another very important element to investigate is the future data processing requirements of your company. In other words, it is not enough to study your present workload and to add some expansion factor to the summary results in order to determine required processing capabilities of the new system. You must also consider totally new and different applications which your company may have been unable to install to date simply because of lack of capability and capacity in your current system.

First of all, you should interview all "customers" of the computer center in order to determine their future data processing needs and desires. It's important to make sure that a clear distinction is made between those new applications which are absolutely required and those which are merely desirable. This distinction ultimately reduces itself to an economic consideration of which applications can benefit the company most by way of cost-saving operations and increased production.

Each department which is interviewed relative to its future data processing needs should be asked to perform an economic justification for its desired new applications. This is a very trustworthy technique which you can use to distinguish between a department's "pet" applications and those applications that can really save the company a considerable amount of money.

Another vital source of information in determining future data processing applications is that of top management's desires. Top management generally has some good ideas on how it would like to improve and expand the company's data processing activities, but it may not know precisely how to effect his expansion. Top management will generally come to you, therefore, with some sort of new application priority list which must be refined with your assistance.

How Many I/O Devices Can Your 407 Drive?

Now that you have reached the point where you have a clear knowledge of your present and future data processing workloads, you are in an excellent position to determine whether these needs can be met by your current equipment with hardware expansions and enhancements. With the aid of your computer vendor, you should learn all you can about what additional

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capabilities can be added to your current computer system and at what cost.

You may find that your current equipment can indeed be expanded considerably more than you may have thought, and yet the cost of this expansion may be prohibitively high in relation to the cost of similar configurations available with newer computer systems. But you may also find that by adding new equipment, such as disk pack drives to replace and supplement your current magnetic tape units, you may have all of the processing capabilities that you really need for the present and short-term future.

You should also consider at this point whether or not your present and future data processing needs can be met by installing multiple computer systems of the same or a similar type as your present equipment. If your present system simply cannot be expanded to the extent required by your projected needs, then it may be economical for you to consider this alternative.

One obvious advantage of installing another computer system of the same type as your present system is the fact that your current programs will run equally well on either machine. Therefore, you can immediately relieve the overworked initial computer. Also, your current programming staff is well trained in programming for your current computer system, so it will quickly be able to generate new programs and applications for the "new" computer system.

What's A 1401?

If you have decided that your present and future data processing needs can theoretically be met by installing another computer system of the same type as your present system, the next thing to do is investigate the availabiltiy of such "older" equipment in the used computer market, or from your current computer vendor.

If such equipment is available, you should at this point perform a cost analysis to determine the practicality and economics of obtaining such used equipment versus the benefits of installing new computer hardware and software.

As mentioned, you should consider the cost savings involved in eliminating or minimizing reprogramming. However, you should also estimate the length of time during which this used equipment is likely to be able to satisfy your company's data processing needs. Be sure to consider the fact that maintenance costs for older equipment tend to rise more rapidly than similar costs for new equipment, and that the availability of spare parts for older equipment declines every day.

After investigating the used computer market, you may be surprised and delighted to find out that you can install another computer system much like the one you now have for a fraction of its initial market value. For some installations there can be no better move, economically speaking, than to install quickly and smoothly a partner to the familiar and somewhat beloved computer system currently working its heart out. However, if you have by now come to the suspicion that you cannot meet your present and future data processing needs by expanding your current computer or by installing a mate for it, then you probably are ready to begin a formal feasibility study to determine the possibilities of your company installing a new computer system.

Will It Save Us More Than It Costs?

The feasibility study aims to determine whether or not it is economical and reasonable to install a new computer system at a given period in time. It involves a careful analysis of all the costs which are likely to be incurred during the process of converting to the new equipment. It also involves a careful analysis of the potential benefits that the company may gain by installing this new equipment. The feasibility study, then, attempts to measure the anticipated costs versus the potential savings in order to make the decision as to the most economical course of action for the company.

As part of the feasibility study, you should survey the available hardware and software from the computer vendors that are likely to satisfy your requirements. You should then roughly price this hardware and software as related to satisfying your general processing requirements. To your surprise, you may find out that of the many computer vendors offering data processing equipment today, only a handful are really interested in competing for the particular market that your class of needs represents. The object of this survey is to come up with a "ball park" price that you are likely to pay to satisfy your data processing needs.

You should also evaluate the costs which are likely to be incurred when you engage in formal equipment selection procedures. Evaluation and selection of a new computer system should be performed carefully and thoroughly, since a proper selection can represent savings of thousands of dollars per month to your company, and improper selection can severely handicap your company's operations.

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But a careful and thorough evaluation and selection process requires a substantial commitment of time and money, and it is precisely the extent of this commitment which should be estimated at this point. (We will shortly be discussing the major elements involved in evaluating and selecting a computer system.)

Another major element which must be measured with relation to its cost is the task involved in converting your programs, files, and documentation to the new computer system. Obviously, the cost of such conversions depends largely on the degree of general hardware and software compatibility offered by the various computer vendors competing for your data processing dollar. However, you should attempt to estimate the cost of this conversion based on the typical offerings of the most likely equipment suppliers.

Another important factor to be measured is that of personnel. Your current data processing staff will likely require expansion with the advent of the new computer system, both because of the additional tasks related to the conversion to the new computer, and also because of the new applications which will be added concurrently with your normal program maintenance requirements. Any additional personnel that may be required should be considered at this point, and their salaries and overhead allotments should be tabulated.

In summary, you should review all of the estimated costs involved in installing the new computer system and weigh these costs against the anticipated savings that will accrue to your company by reason of the new computer's installation. You should then complete the feasibility study by making a definitive go or no-go decision based on these anticipated costs and potential benefits.

If you find that the anticipated costs are far in excess of your company's data processing budget, then you may want to reconsider the alternatives discussed above, such as installing additional used data processing equipment.

What Makes Sammy Run?

If the facts and figures produced as part of your feasibility study indicate that a new computer system is probably best for your company, then you are ready to proceed with all due haste to the evaluation and selection of this new equipment.

The most effective way to begin the selection process is to send a formal Request For Proposals (RFP) to the computer manufacturers. The RFP should summarize your current and future data processing requirements. It should also specify other requirements which you will demand of your equipment, your software, and your supplying vendor.

The RFP should, therefore, be a fairly formal document summarizing your EDP requirements and soliciting proposals of equipment that will meet these requirements. The RFP should include the specifications for your major data processing applications, both current and prospective. These detailed specifications should have already been prepared as part of your earlier preparatory investigations.

In addition, your RFP should list specific mandatory requirements and desired capabilities that the proposed equipment must offer. You should also request specific and detailed information in the following areas: overall system concepts, system configuration, hardware components, software components, support commitments, support costs, procurement policies, overall cost data, delivery dates of both hardware and software, clear statements as to the quantity and quality of support personnel and other aids to assist in the conversion and installation activities, and specifications for benchmark tests (i.e., tests to demonstrate the relative capabilities of the products of competing computer vendors).

The more time you take to prepare the RFP clearly, concisely, and completely, the more likely it is that the computer manufacturers will bid systems which will satisfactorily meet your present and future requirements. Also, the better prepared your RFP, the easier it will be to evaluate the subsequent equipment proposals. The concise, rigidly structured RFP tends to influence the manufacturers to respond in the same highly structured manner.

Also, the fact that you have taken the time and effort to prepare a formal RFP cannot help but impress the computer vendors with your professionalism and your seriousness about procuring a new computer system. Sensing this professionalism and readiness to act, the computer vendors will respond enthusiastically with impressive and timely proposals.

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Proposal Evaluation Before Equipment Evaluation

After you have received the competitive proposals, you should evaluate each of them with four objectives in mind:

1. To determine whether the proposal is complete; i.e., whether it contains all of the information requested in the RFP.

2. To validate the information it contains; i.e., to determine that this information is accurate and otherwise reliable.

3. To compile lists of questions concerning any noted deviations from the RFP, any ambiguities, any major omissions, etc.

4. To summarize the technical content of the proposal in a standardized manner.

It's advisable to meet with each competing vendor at this point to discuss the proposals in their current state and to solicit any additional information required to bring the proposals up to the level of completeness which you initially requested in your RFP.

You should next attempt to narrow the field among the competiting vendors by eliminating from further consideration any vendors who simply have not been responsive to the requirements of the RFP, or whose proposed system is clearly and obviously non-competitive with the other proposed systems.

Who Makes The Tiniest Magnetic Cores?

Once having received the proposals from the competing computer vendors, you are now ready to begin evaluating the contents of these proposals. Evaluating and selecting as complex a device as a computer system is obviously a large and challenging project. Much has been written on this topic and much more still needs to be written. It is beyond the scope of this Feature Report to describe in detail the various techniques used in evaluating and selecting computer systems. However, an attempt will be made to discuss the various factors which should be evaluated—one way or another—when deciding on a new computer system.

In the first and second computer generations, an excessive amount of emphasis was placed on the raw speed of the computer's internal circuitry. Even today, it frequently happens that too much emphasis is placed on a given computer's magnetic core cycle time or its "add time."

In the current environment of the third generation, it has become clear that there are many other important factors which must be evaluated when selecting a computer system, above and beyond the raw speed of a computer's circuitry and its add time. Some of the additional factors which you should evaluate when measuring the relative merits of the vendors' proposals are:

- The operating system and other control programs available with the system. These programs can save your own programming staff a considerable amount of time and effort.

- The available programming languages as related to the skills and desires of your programming staff.

- All available application packages, whose presence may save you considerable amounts of development time and money.

- The new system's compatibility both with your current data processing equipment and with the more commonly used computer systems in the industry. Consider the significance of this compatibility or non-compatibility as related to both your present and future processing needs. Non-compatibility with the industry at large need not be a severe disadvantage, provided your company has no ambitious expansion plans which might necessitate converting to still another computer system within a relatively short period of time.

- The computer system's expansion potential, in order to determine just how far you can expect to grow with this system once it has been installed.

- The ease of use not only of the computer's hardware, but also, and most importantly perhaps, of its software. If the computer hardware is impressively powerful but the software defies comprehension by normal human beings, then the system can be economically impractical in terms of overall costs of the work processed.

- The quantity, quality, and prices of available system support in the areas of programming, general conversion assistance, training of your company's management, analysts, programmers, and operators,

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and hardware/software maintenance. The costs of these support items should be carefully evaluated, especially since most of the major computer manufacturers have "unbundled" these services in substantially different ways.

- The less striking but equally important factors of location and availability of back-up equipment, machine time provided for program testing prior to installation of your computer system, and the state of the system's hardware and software documentation.

- The various trade-offs involved in the lease/rental/purchase contract offerings. In this regard, you should consider the availability of capital, the length of the planned usage of the system, its disposibility if purchased, and various tax questions such as expected depreciation, sales taxes, investment tax credits, etc.

Thus, it is clear that there are truly significant factors that must be measured and evaluated above and beyond those of pure hardware speed. The relative importance of these various factors cannot be predetermined; it is directly related to the needs and desires of your particular installation.

Talking Turkey

Ideally, at this point in the equipment selection process, you are now dealing with only two or three manufacturers. By now these vendors are acutely aware that their proposed systems are under serious consideration. Thus, the stage is properly set for a serious discussion of contract terms and conditions with these prime contenders.

Most computer manufacturers will offer you their standard contracts for purchase, rental, or lease procurement situations. But frequently, these standard contracts may not be adequate to your needs and desires. You are about to make a significant financial investment, so you should make every effort possible to protect this investment through a favorable contract. Therefore, it will be well worth your while to negotiate with the computer manufacturers–making use of professional legal assistance, if necessary–to obtain contract terms that meet your requirements. You should strive to include contract provisions and stipulations such as: hardware and software delivery dates; the option to postpone delivery without penalty; the number and qualifications of promised support and maintenance personnel; free debugging time prior to equipment delivery; elimination of or reduced rental payments during first month's usage; discounts from list price or agreements to "buy back" computer time; acceptance test requirements; penalty clauses for inadequate or non-performance of hardware and software; and finally, penalty clauses for late or incomplete delivery of hardware and software.

What Can I Do To Salvage The Order?

You are probably ready at this point to make the final selection of the vendor who will supply your computer system. The act of finally selecting the vendor and his equipment configuration actually consists in most cases of a careful review and synthesis of the results of each major phase in the evaluation procedure which began after receipt of the manufacturers' proposals.

By now, you have already evaluated the content and quality of the original proposals and their supplementary information. You have also submitted the proposal material of the prime contenders to careful analysis using an evaluation technique that suits your specific needs, personnel capabilities, and evaluation budget. You have also evaluated the credentials and general qualifications of each manufacturer. You have probably obtained valuable information from user installations you have visited. And finally, you may have received certain contract concessions that satisfy your demands.

In most cases, you will now see a clear pattern of superiority emerging from the various evaluation phases. The best overall system for your present and future needs will begin to emerge. You should now make a firm and definitive system selection, documenting very clearly the factors that led you to select the number one system over the number two.

After having made your decision in what has hopefully been a most rational, objective, and painstaking manner, you should guard against any last-ditch attacks on your selected system by the non-selected vendors. Rather than allow your confidence to be undermined, you should remain steadfast in your decision and simply not entertain any frantic, last-hour negative selling tactics. You must now look beyond the equipment selection procedure and begin to prepare for the challenging task of equipment conversion that lies ahead.

Who's In Charge Here?

The time has now come to begin planning and scheduling the tasks related to converting all current systems and programs and installing the new computer system.

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A very important part of the early planning functions lies in determining the necessary roles required to carry out a successful system conversion and then determining—as specifically as possible—the personnel who will fill these roles. The underlying requirement is to affix clear responsibilities, authorities, and controls.

An excellent approach toward solving this problem of pinpointing authority and responsibility is to form a conversion and installation team composed of:

- Management personnel.
- Lead designers.
- Lead programmers.
- Key supervisors in operations.
- Independent consultants.

The size of this team is generally a function of the size and complexity of the sytem to be implemented. As a rule, however, you should try to keep the group as small as possible while still maintaining broad representation. One point is clear: if your company is large enough to install a computer system, it is large enough to direct this effort with a conversion team.

Teamwork is vital to insuring that all interests are considered and that all efforts work in coordinated fashion toward the same ends. Not only must the conversion team function smoothly and harmoniously as a unit, but each major data processing department (such as programming) must be so organized as to always operate in united fashion, bringing the overall system design to fruition while operating within the constraints and guidelines of the implementation team.

Why is a conversion team required? The answer to this question can be summarized by stating the following vital team functions:

- Establishing and enforcing conversion policies and procedures.
- Setting conversion objectives.
- Setting schedules.
- Monitoring progress.
- Solving major conversion problems and disputes.
- Coordinating the entire conversion and system installation effort.

The conversion team should be headed by at least one representative of high-level company management. Such participation is vital, because the team sets policies and objectives, and also ultimately assumes prime responsibility for the success or failure of the effort.

Team management should, early in the effort, decide the relative priorities and rules of precedence among the various discrete applications that will function on the same computer system. Team management should also solicit commitments of cooperation from all affected portions of the company. Resolving these two problems early in the implementation project will save you much time and aggravation as the project progresses.

Team management should also conduct periodic seminars with the other team members and with all other key personnel in the conversion project. These seminars can serve as a formal and direct means of communication of ideas, policies, status information, etc. The seminars can also contribute to morale by enabling all groups to visualize how their individual efforts are helping to accomplish a very complex task. These meetings can also stimulate ideas and suggestions for solving particularly difficult conversion problems.

You should also include lead system designers as members of the conversion team. Better than anyone else, these men know the capabilities and restrictions of the selected equipment and software. They also are generally familiar with the capabilities of the in-house design and programming staffs. Therefore, these men can serve to bridge the gap between management and implementation personnel. Their particular insights can be invaluable in the deliberations and decisions of the implementation team.

Lead programmers should also be members of the conversion team because almost every dicision made relative to system conversion and installation ultimately affects the programming department. The eventual success of the entire project may hinge largely on whether or not the programming department believes and understands that what it is being asked to do is indeed reasonable and feasible. These attitudes can be fostered through their realization that all programming tasks and policies have been approved by their own representative on the conversion team.

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If the conversion team and its ambitious undertakings are to be successful, the team should also include representation by supervisory personnel of the major company departments whose operations revolve about the computer's input and output data. A newly-installed computer system can often dramatically change the clerical and manual procedures throughout the company. Therefore, supervisory personnel in these departments should be consulted in those major decisions which will drastically change their way of doing business.

Once again, you can achieve the cooperation of individuals even down to the level of clerical personnel by providing their leaders with a voice in all key decisions relating to their work.

It is often desirable to engage the services of an independent consulting firm to advise in the design and management of a system conversion project. In addition, it can often be valuable to enlist an independent consultant as a permanent member of the conversion team.

The most valuable function of the consultant on the conversion team can be to provide an independent, objective viewpoint on all critical policy, design, and management decisions. He generally owes no allegiance to internal pressure groups and can disregard the pressures of internal politics. He is, in fact, paid to be his own man.

The consultant can also play an effective role in monitoring the progress of the overall implementation. Because of his fresh outlook, he may be able to detect potential bottlenecks, deviations, and problem areas long before such conditions might become evident to internal personnel.

He can also serve as a professional "gadfly," constantly prodding, stimulating, questioning, etc., and hopefully creating an atmosphere of continual alertness and awareness on the conversion team. For if the team itself should become smug and self-satisfied, then it will lose some of its effectiveness as control center and system monitor.

A Pert Chart Never Lies

You should next construct an overall schedule for the impending conversion and installation activities. Careful scheduling and project control are obviously of vital importance in complex endeavors such as installing a computer system, yet they frequently are given only token attention—especially in smaller data processing installations.

Among the many available techniques used to ai scheduling and project control are:

- Simple, single-level charts, which list each act and its scheduled and actual completion dates.
- Gantt (or bar) charts, which show the pla activities and their precedence relationships (time scale.
- Network techniques, such as PERT (Project Ev tion and Review Techniques) and CPM (Critical Method).

Single-level and Gantt charts are sometimes useful, they are generally inadequate for the task of schedu and controlling as complex an undertaking as a comp conversion project. Therefore, the scheduling techn most commonly used—especially in larger installation the PERT method.

Once the PERT network and its timing relationships l been defined, it can be relatively easy for the compute produce periodic management reports that clearly re the current implementation status relative to orig schedules. As milestones are reached, this information be easily entered into the computer system and refle in subsequent reports.

Most computer vendors offer packaged PERT progr ready for use. These programs are easy to use, inex sive, and productive of valuable scheduling informat They should not be ignored.

Regardless of aids used, scheduling and monitoring installation of a computer system can be a challen task. It is important to assign definite responsibility schedule maintenance and control. It is reasonable this individual should be a member of the implementa team.

Predetermined control procedures are vital to insure schedules become more than impressive wall-coverings make a schedule meaningful, you should set up ap priate checkpoints and milestones and demand reg progress reports. Equally important, you should estab a definite procedure for making changes to exis schedules for good and necessary reasons, such as mis important milestones. Rescheduling should, in most ca require the approval of the manager of the sys conversion team.

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When computer conversion schedules are being initially prepared, it is recommended that you seriously consider the following philosophy:

1. Schedule conversion of discrete functions, components, and subsystems one at a time.

2. Avoid "crash" conversions.

3. Estimate the time required to meet each scheduled milestone and then allocate considerably *more* time for its scheduled accomplishment.

4. Be conservative: assume the worst and provide enough time to handle that situation should it occur.

Missing deadlines can be most serious because of the close inter-relationships among the many conversion and installation activities.

Training for All—Even Your Boss

Before any new computer system is installed, you should institute a certain period of training to familiarize all concerned parties with the features and capabilities of the new equipment and software. Since the entire company is affected by installation of the computer system, the entire company should be trained in its use.

Since the conversion team will direct the entire effort, it is critically important that this team be thoroughly trained in every aspect of the new data processing system. They should take advantage of the instructional courses provided by the suppliers of the hardware and software. They should also consider attending pertinent courses offered by independent consulting firms. The team members must truly become experts in all aspects of the system.

The conversion team must then plan and coordinate the training program for all other concerned company personnel. The team itself should participate in the internal training programs to ensure general understanding of basic system policies, objectives, constraints, schedules, requirements, specifications, etc.

One of the first training tasks of the implementation team is to train company management in the general computer system concepts: system features, capabilities, and limitations; system uses in your particular company; system economics; and system future (expected life span, possible enhancements, next growth step,etc.).

Company management should also avail themselves of the executive orientation courses conducted by the suppliers of the computer system's hardware and software. Management can also be trained on a continuing basis by means of periodic seminars conducted by the manager of the conversion team.

The system designers and analysts are the key technical people involved in converting and installing the computer system. Therefore, their technical training must be extensive and in-depth.

The designers determine application and programming specifications that set the course for many man-years of ensuing work. It is vital that they have a thorough understanding of the hardware, software, and application areas for which they prepare specifications.

An obvious primary source of this technical training is the suppliers of your selected hardware and software. Also, your company should seriously consider sending lead analysts to specialized courses prepared by independent consultants. And finally, the designers should attend internal training sessions conducted by the company departments whose operations will be directly affected by the new computer system.

The programming personnel should naturally avail themselves of the programming courses conducted by the equipment and software vendors. They should become intimately familiar with:

- Principal programming languages.
- Any pertinent terminal-oriented languages.
- Pre-packaged application programs.
- Software aids for file conversions, program conversions, program debugging, system utility functions, etc.
- System supervisory programs and their functions.
- Operational aspects of all equipment.

The programmers must also be thoroughly trained by the lead systems analysts in the areas of programming standards, conventions, and restrictions; methods of writing detailed specifications; methods of preparing documentation; methods of program testing; procedures for initiating changes in specifications; and methods of preparing operator instructions.

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Training supervisory personnel from those departments which will be making use of the computer system can be of great importance. All required changes in their normal operations must be clearly explained and rationally justified.

You should train department heads and supervisors specifically for these reasons:

1. Psychologically, they will be more inclined to co-operate with the conversion efforts if they fully understand what is happening around them.

2. They are being asked to change their daily operating procedures to fit the functions and requirements of the new system. Therefore, they must know these new requirements.

3. They must assist the systems analysts in defining automated means of handling the department's business.

4. They must assist the analysts and documentalists in preparing new written operating procedures.

Operators of today's complex computer systems are required to perform involved and critical functions. As a result they must be intelligent and well-trained. They should receive training from the equipment suppliers and also from members or delegates of the conversion team. Not one, but a number of computer operators should be trained and made available for purposes of back-up, multiple-shift operations, and performing multiple concurrent operations during a single operation period.

Emulators? Translators? Simulators?

Converting all existing programs to a form which can be processed on the new equipment is obviously a vital system conversion activity. The difficulty of this activity will vary from one installation to another, and is directly related to the degree of compatibility between the old and the new computer systems. Therefore, one of the preparations for program conversion necessarily involves a study of the compatibility question relative to the two different computer systems.

Another preparation that you can make prior to converting your programs is to perform a survey of all available and pertinent program conversion aids such as hardware/software emulators, software language translators, software simulators, language conversion programs, file conversion programs, and automatic flowchart generator programs. All of these conversion aids should be studied carefully and reviewed as to their applicability to your particular program conversion requirements.

You should next attempt to classify all existing programs according to how they will be converted to the new computer equipment. For example, you should segregate those programs which can be emulated for the present and fully converted sometime in the future when time permits. (Emulation is really a temporary, "crutch" device and, therefore, should not be used indefinitely.) You should also segregate those programs which can be translated by automated means or be otherwise software-converted. If the computer vendor offers a program simulator, and you feel that there are a few programs that might be reasonably simulated for a short period of time, then you should segregate these programs also.

During this classification process, you should determine those programs which must be entirely re-written. For example, it is possible that some key programs have had serious operational deficiencies in them for some time. This period of program conversion offers you an excellent opportunity to completely redesign and rewrite all major production programs whose inefficiencies can represent serious operational losses to the company.

And to complete the classification process, you should try to identify all new programs that must be written. It is useful to examine the application packages offered by the computer supplier to determine which, if any, can form the foundation for your desired new programs. You should also examine the generalized application packages that are available from software houses, and determine whether or not they can satisfy your new application needs. As a result of these investigations, you will know which application packages can be obtained from external sources and which must be designed and written in-house.

Once all existing programs have been classified as to their probable means of conversion, you should make a firm decision as to those conversion aids which will be used. You should obtain the selected conversion aids from the computer manufacturers. If independent software vendors or other specialty suppliers offer useful conversion aids, then you should negotiate with these firms to obtain the required programs in time to fit your conversion schedule. You should also schedule the development of those software conversion aids which can best be written in-house.

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It is at this point that you should actually begin converting all programs in accordance with the overall conversion schedule. It is useful at this point to keep rigid accounting records of the various expenditures of manpower time, machine time, supplies, travel costs, etc., in order to detect as early as possible any potential problems in the program conversion process. It is possible that, quite early in the conversion process, an excessive amount of man and machine time expended to convert a given application might be an ominous indication that a particular selected conversion technique may really not be feasible. If so, early detection will permit you to select another more effective and economical conversion technique.

It is also at this time that you should begin the systems analysis and programming of all new and modified application programs. Obviously, this new design and programming work must also be coordinated with the overall conversion timetable.

Does the New Computer Speak ASCII?

Converting existing data files is a critically important task whose complexity and cost are nearly always underestimated. File conversions can be difficult technically and even more difficult logistically, i.e., relative to scheduling the conversion of live data which is continually in use.

For those files which are already in machine-readable form, i.e., those data files which are already being processed by your current data processing equipment, you must carefully evaluate differences between the kind of data acceptable to your current equipment and the kind acceptable to your new equipment. For example, you should carefully examine any differences in data codes, such as BCD, ASCII, EBCDIC, etc. You should also examine any differences in the data structure acceptable to the two classes of equipment, such as data recorded in binary words, packed decimal digits, alphanumeric characters, etc. Another key technical consideration to investigate is any differences in the data code collating sequences, which will be of critical importance in such operations as automated sorting and merging.

In addition to these potential problem areas related to how data is recorded in machine-readable form, you must also examine and evaluate all incompatibilities in the media itself upon which the data is recorded. For example, you must evaluate the differences in moving from seven-track magnetic tape units to nine-track units. Also, you must carefully investigate the problems involved in converting to a new computer system whose disk packs are recorded at different densities than the disk packs on the former computer.

These potential problem areas generally cause more difficulty than they should simply because sufficient attention is not given to them during the months of preparation for installing the new computer system. If these technical problems are evaluated early in the project and if solutions are determined in sufficient time, then the problems of file conversion can be considerably less difficult than the program conversion problems being solved concurrently.

Once you have carefully evaluated the nature and extent of your file conversion problems, you should determine the precise file conversion techniques which will be used for each class of data file. You should select any available and pertinent software aids which will assist in the file conversion process. You will probably also have to design some specialized software to convert specific files in your installation that represent unique problems.

You'll need to determine whether given files can be permanently converted once or whether they must be dynamically converted each time they are used on the new computer system. You must also examine the machine requirements to perform these file conversions. With this in mind, you should investigate the availability, prior to the installation of your new computer system, of the particular mix of hardware required to convert your files. You may find it necessary to deal with an independent service bureau to obtain the required hardware configuration to perform these file conversions. You will also discover at this time that there are certain file conversions that can best be performed only after your computer system has been delivered.

Scheduling the file conversions can be an extremely intricate process since most files need to be continually updated and maintained both before and after their conversion. Therefore, it frequently happens that it simply is not possible to pre-convert data files, but rather they can be converted only at the precise time when the programs that use these files are being cut over to the new computer system.

If the converted files are not kept up to date until they are put into regular use, they soon lose their value. A related problem can develop if the file conversion process is performed over a long period of time in order to reduce manpower requirements. What frequently happens in this case is that a large backlog of pertinent data for updating

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will build up and need to be added to the file before the file can actually be used with the converted programs.

In most cases, a rapid conversion of all data files just before cutting over programs to the new computer system will be most desirable. However, the logistics of converting files in this manner are generally impractical.

Therefore, the best advice that can be given in this area is to make suitable provisions for converting the files at a reasonable pace and then updating them—either on a periodic basis or just before they go into regular use on the new computer system.

In those cases in which a company is installing its first computer system, and also in those cases in which the new computer system will be performing considerably more work than the current computer system, there will be another class of file conversion problem involving converting data from manually-kept records to a form which is machine-readable.

You may find that these clerical records are not in the best possible condition, and that they may require an extensive amount of clean-up work prior to being converted to machine-readable form. This conversion will generally be performed by the manual operation of keying information from clerical records onto a keypunch machine, producing punched cards, or keying this data directly onto magnetic tape reels, using the many available key-to-tape data transcription devices. It may also be worthwhile at this point to consider the feasibility of transcribing typewritten and hand-written data to an automated form by means of an optical character reader. In the latter case, the economics of using these sometimes expensive devices must be carefully evaluated.

In most cases it is not possible to directly transcribe all data from the existing clerical records. Rather, it is often necessary to collect new and additional information, such as that normally found only in the heads of clerical supervisors, and to reduce this information to a format suitable for input to the computer system. Careful attention must be given at this point to purifying this data, with the objective in mind of locating and correcting errors and duplications in the existing records before they are transcribed to an automated medium.

The importance of carefully performing file conversions cannot be over-estimated. If the file conversions are performed completely and accurately prior to installation of the computer system, then you are insuring a relatively trouble-free cutover to the new computer system—provided, of course, that the program conversion procedures have also been performed effectively.

How to Write Unmaintainable Programs

With the advent of the new computer system, your programmers may find to their joy that the new computer system offers an enormous variety of computer instructions and a wide selection of programming techniques, file organizations, etc. The inventiveness of the programming breed stands challenged before this vast array. It is your job to channel this inventiveness to producing efficient programs in a minimal amount of programming time.

With this in mind, it is suggested that before any new programs are written for the new computer system, you should establish and promulgate a set of rigid programming standards for all to follow. These standards should include rules and restrictions for the selection of programming language for each type of application and for each level of programmer. (These rules will also help establish departmental compatibility and program exchangeability.)

You should also specify which discrete elements and features of the selected languages may and may not be used, and by whom. Similarly, you should specify which features of the operating system can be used and in what manner. Depending on the level of the programmer, you should specify the degree of direct interaction with the operating system that is permitted.

More specific standards can be set up in establishing rules for programmed error recovery, use of checkpoint/restart procedures, use of permanent disk storage, etc. At this time you should also identify common programming errors to be avoided.

These rules and restrictions should also be accompanied by conventions for file labels, program halts, control totals, etc. All such rules, restrictions, and standards should be promulgated to all design and programming personnel in a "Standards Manual".

If these suggestions are followed, you will avoid a common difficulty experienced by those who are installing a third generation computer system for the first time, for it can happen that the amount of time required to program a given class of problems for the new computer can considerably exceed that required if programmed for the old computer. This phenomenon can generally be avoided by use of carefully constructed programming standards that will direct the efforts of your programmers according to their levels of competence.

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Exterminating Gnats, Ants, and Termites

As all programs are converted and written anew, they must be fully tested and debugged. It can be very useful for the programmer who has converted and written each program to prepare a detailed test plan for each program. This test plan should include the schedule of when the various phases of testing should take place. For example, the individual program must be fully tested and debugged; it then must be debugged in conjunction with the debugging of other programs which form part of the same application; it must be debugged with test data; and finally, it must be debugged with live data.

The test plan might also state where the program testing will be done. It frequently happens that most program testing must be done on outside computer systems prior to delivery of the new computer system. In these cases, you will sometimes find that the test computer may have a somewhat different equipment configuration than the new computer, with the result that appropriate program adjustments may have to be made.

One of the most important elements of the program testing phase is the preparation of truly representative and reasonably exhaustive test data. Such test data should be prepared with the aid of the using department, if possible. The volume of the test data need not be large, but every type of transaction, exception condition, and error that can be anticipated should be included in order to thoroughly check out the resulting program behaviour.

You should verify the quality of the selected test data and also the test results with the supervisory personnel in the appropriate application area or department.

After the program and application tests are completed, the programmer should summarize and file the results of the tests. The test data (both input and output) should be saved as part of the overall program documentation package. Likewise, you should file several copies of the fully tested source and object programs and their related control cards.

It is advisable for you to keep close control over the amount of time spent for individual program testing. It is difficult to predetermine the amount of time required to test a given program, and yet, reasonable estimates must be made.

Control of program testing time can be necessary because given programmers may begin the testing process prior to completing the programming just to maintain the appearance of completing the programming on schedule. As a result, the program testing operation will tend to drag on for a long period of time as the programmer both tests what has been written and writes that which has not.

Eliminating the Mystery From Program Maintenance

Documenting systems and programs has never been an exciting or much appreciated job. It is generally considered as extra, non-essential work performed after all the exciting work has been completed and the new system or program is functioning as per the specifications.

Nonetheless, good documentation is vital for any data processing installation. In fact, a fairly high-level conversion group should be assigned to the area of system documentation almost as soon as the conversion project is inaugurated. The documentation, in this case no longer a mere afterthought, should continue throughout the duration of the conversion process. Even after successful cutover, the services of a documentation librarian should be utilized.

Documentation conveys and communicates specifications. And specifications imply guidelines and restrictions that insure that the programs and systems will be implemented in accordance with the design plans.

Documentation also takes the mystery out of program modifications and maintenance. Frequently, the programmer who wrote a given program is no longer employed by the company at the time an extensive program modification must be made. Therefore, without adequate documentation the maintenance will be made only with the excessive expenditure of time and expense by another programmer who must, in essence, learn the entire program from the beginning by studying the original programmer's coding.

In large and complex data processing applications, a change to a given program should not be approved until its ramifications throughout the rest of the system are evaluated. It is only with the aid of complete documentation that this kind of total application analysis and evaluation can be readily made.

A principle requirement and duty of the lead system designers early in the conversion project is to prepare a complete set of documentation standards and requirements that apply to system designers, programmers, operators, and clerical personnel. (The documentation

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standards for clerical personnel generally take the form of rules and regulations for writing uniform manual procedures.)

It is the uniformity, consistency and completeness of documentation, as obtained through enforced documentation standards, that actually makes documentation have value. Non-uniform and disorganized information about systems and programs is really not documentation. It is merely raw data.

It is vital then, that an effective mechanism for enforcing documentation standards be installed at an early date.

A typical standardized documentation package that might be prepared for each program would include:

- Application (system) flowchart.
- Program description (verbal).
- Program macro and micro flowcharts. (You should consider use of automatic flowchart generators for micro-flowcharting.)
- Input/output record layouts.
- Any unusual processing requirements.
- Source program listing.
- Operating instructions.
- Control card layouts.
- Test data listing and test results.

The testing-related elements can later be filed apart from the working documentation package after the program has become operational.

Each program's documentation should be bound in some convenient manner for ease of reference, and should be filed in an accessible but controlled program documentation library.

Pre-Natal Preparations

Well in advance of the actual computer system's delivery, you should begin the physical site preparations and should concurrently order all required supplies for the conversion process and the functioning of the new system. With regard to preparing the physical site, you should work closely with the computer manufacturer so that no equipment peculiarities or environmental requirements are overlooked. You should evaluate competitive construction bids for site preparations and, once having selected the contractor, you should establish rigid work schedules for the construction work.

Several firms now specialize in the physical planning and construction of computer facilities. You may find their services preferable to the use of separate contractors for room construction, flooring, air-conditioning, power supplies, etc., which has up to this time been the usual practice.

With regard to computer room supplies, you should order these supplies as soon as possible after their need has been identified. You should also include on the conversion master time schedule the promised delivery dates for each key supply item. Any slippages in the delivery schedules should be acted upon immediately.

Supplies to be considered in this regard include magnetic tape reels, disk packs, specialized forms (many of which you will have to design to fit your own conversion and processing needs), storage cabinets, keypunch equipment (or perhaps keyboard-to-tape equipment), general office equipment, etc. Since unusually long lead times are often required for the delivery of computer supplies, it is well to order early. Whatever costs are involved in receiving delivery prior to actual need will be far outweighed by the comforting assurance that your programs, applications, and equipment—in which you have made truly large investments—will not be prevented from becoming operational due to the unavailability of relatively inexpensive and unsophisticated supply items.

All physical site preparation work should be completed and all facilities tested at least one week before the computer equipment is delivered. When the equipment is actually delivered, you should monitor the installation carefully. You should make sure that the hardware and software perform as contractually specified through the use of acceptance tests, and you should not hesitate to invoke contractual penalty clauses or to withhold monthly rental payments in cases of non-performance or non-delivery.

The Showdown

Now that the computer equipment and related hardware have been delivered and installed, you are ready to begin the crucial work of cutting over (or converting) the new

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and converted programs and files to the new equipment. All prior study, design, and implementation work in this conversion and installation project culminate in the act of cutting over to the new equipment. In relation to all other aspects of the project, you may find this cutover period to be not only the most important and critical, but also the most error-prone, frustrating, and costly.

For it is during cutover that all hertofore hidden problems are forced out into the open. For example, despite everyone's best efforts at estimating and simulating required processing power, it may quickly become clear that the available processing power falls considerably below the target plans and expectations. Great disappointment may be experienced when the new computer processes a given job not much faster than the original, "outdated" computer system.

For these reasons, great expenditures are made, and must be made, in attempting to anticipate in advance all possible weak spots in the system long before the actual cutover date. Much money is spent in monitoring the progress of the conversion effort, trying to sense potential trouble areas and bottlenecks before the time of system cutover. Personnel and equipment performance analyses are made continually to provide against unpleasant surprises at time of cutover. All of these things, planning, monitoring, studying, scheduling, and evaluting, must be done at great lengths to minimize the disruption that is likely to occur at this critical period of system implementation.

Perhaps the most important guideline in the cutover operation is this: cutover one system function at a time. The smaller the function, the better. You can then build up the cutover on a staged or phased basis.

For example, first decide what application should be cutover initially. This application can be chosen for a variety of reasons, such as ease of implementation, amount of productive work that it will generate on the new computer system, or successful testing record. You may elect that application which is most comprehensive in nature, and therefore, tends to exercise the system components the most.

Next, within the selected application, decide upon the one or two functions that are most feasible to cutover initially. After these functions have been successfully cutover and evaluated, additional functions can be gradually converted until the entire application is running.

Only after the first selected application is substantially cutover can this phased cutover plan begin with another application. Certainly, however, there will be some situations in which it will be reasonable to overlap the staged cutover of more than one application.

Another perhaps less desirable approach to cutting over to a new computer system is to first convert experimental application prototypes rather than "live" applications.

An experimental prototype is a specially designed application which has no reason for existence other than to serve as a test vehicle for the real application. The prototype is constructed more simply but along the same lines as the actual application being designed and implemented. When tested, the prototype is run with artificial test data. The prototype can then be monitored and tested easily and extensively, and design improvements can be made without much difficulty because the size of the prototype permits easy manipulation and modification.

The just-cited features of this approach are clear. But the major disadvantage lies in the fact that this approach is merely an elegant extension of the program and application testing phase which has presumably been already completed. The validity of the results of exercising a prototype are still subject to question until the actual application is cutover using live transactions and data files.

Another disadvantage to this approach is that it tends to be costly, for the same kind of programming work tends to be done in duplicate: once for the actual system and once for its prototype.

Another cutover technique commonly used when installing a new computer system is that of parallel operations. Running "in parallel" generally means running the new system side-by-side with the old one, comparing the results, investigating all variances, and correcting the causes of these variances until a clear pattern of consistency and accuracy emerges.

Two advantages of the parallel operations method are: (1) the new system can be fully tested under actual conditions without endangering the company's operation, and (2) the accuracy and integrity of critically important file information can be assured.

Several disadvantages of the parallel operations technique are that it is expensive, and that the old and the new systems frequently differ so much in their functions, inputs, and outputs that it is almost impossible to make meaningful direct comparisons.

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Still another technique used in converting to a new data processing application is the so-called "burned bridges" method. Using this method, the conversion takes place abruptly, with the new system completely replacing the old one at some fixed point in time. An advantage of this technique is that its very crucial nature tends to provide a strong incentive for all concerned personnel to make sure that the new system works properly from the very beginning. Obvious disadvantages are that extremely careful and comprehensive planning is required and that the company can experience major disasters if anything does not function as planned during the conversion process.

System cutovers normally take a substantial amount of time, not only because of staged or phased cutovers, but also because of the unforeseen difficulties that can arise when the "moment of truth" arrives and all system functions are put on-line. Serious problems, such as design flaws, system overloads, defective hardware, not fully debugged system control software, etc., can virtually destroy the original cutover schedule.

Somehow, these contingencies must be provided for in the conversion schedule, and alternate courses of action decided upon should any of these serious problems arise.

In summary, it is strongly recommended that gradual conversion methods, where feasible, be employed as opposed to "crash" methods, such as the burned-bridges approach. Cutovers of individual applications should, therefore, be scheduled to take place on a comfortable, sequential basis if possible. It is foolish to try to convert everything at once.

Post-Mortem

After several applications have been cutover and are functioning reasonably well for a certain period of time, a number of facts will suggest themselves, such as:

- Certain applications or programs should function more quickly and more efficiently.
- Certain applications or programs should have additional functions added to them.
- Certain applications and programs include some characteristics and peculiarities which do not lend themselves to smooth and efficient equipment operation.

In short, system changes begin to suggest themselves.

This is a normal and reasonable situation. In fact, discovering the need for system changes should not be allowed to occur merely by accident, but rather, specific individuals should be assigned the responsibility of monitoring the installed system's performance on an on-going basis, evaluating, scheduling, and documenting all required system changes.

Another important aspect of the post-conversion evaluations is the analysis of the performance of the new hardware and software. Periodic reports should be prepared on the system's performance and all system failures or deficiencies should be reported to the equipment manufacturer or software supplier, requesting corrective action as quickly as possible.

One suggested approach to enhancing or improving installed applications is the "model" approach. This means that the first application, as cutover, is considered Model 1. Substantial changes should not be permitted to this model during the cutover operations. In effect, Model 1 is "frozen" until the cutover is virtually complete.

After closely and carefully evaluating the performance of Model 1 and learning from its operational experiences, you can schedule a second model for implementation. Model 2, then, incorporates all the accumulated enhancements required or desired after observing Model 1 in action. In like manner, Model 3 can follow at some later date.

The important points implicit in this approach are:

1. A controlled mechanism for making system changes is established.
2. Changes are not made casually, but only after proper evaluation.
3. Changes are not made continuously, but only on well-defined, widely-spaced dates when a new "model" is scheduled for cutover.
4. Optimized system performance remains an objective continually sought and worked for.

When the time comes to install the second model of a given application, you will find that this installation will be considerably easier than the installation of the first model. This is so because the environment in which the

How to Plan and Implement a New Computer Installation

installation will take place has become considerably more stable then it was when the first model was installed. For example, the control software is working, the file security mechanisms are working, the hardware has become reliable, the operating personnel are now trained, etc. For these reasons, the "model approach" to refining installed applications is again quite attractive.

Bring on the Fourth Generation

It is certainly clear by now that the process of converting to and installing a new computer system is a complex and challenging task. However, it should be similarly clear that there are ways to bring these activities to successful conclusions. Activities such as designing, planning, and scheduling all aspects of the conversion in detail cannot be over-emphasized. Also, the need for the institution and enforcement of effective controls throughout all conversion and installation activities is vitally important.

You will find, in general, that the process of installing your computer will be a productive and successful exercise if you have followed the principles contained in this report, and if you are prepared for the substantial investments required in time and money.

In short, there are computer conversions which require substantial investments of time and money, and there are those which result in disaster.

If you have carefully followed the recommendations and guidelines included in this report, you will find that not only will your computer installation be successful, but that the conversion to your next computer system will be even more efficient and less costly than the current one, because you have taken the opportunities during this installation to carefully organize and control your entire data processing operation. ☐

All About Disk and Drum Storage

This report surveys the broad range of disk and drum storage units currently available to computer users (or suppliers) who choose to customize their systems. You'll find comparison charts covering 93 disk and drum units from 36 suppliers, plus an enlightening guide to evaluating their performance.

To a fresh and unjaded observer of data processing activities, it may seem today that a major criterion of whether a computer application is worthwhile is whether or not it employs disk storage. If an application uses disk storage, then it seems as if it almost has to be good. Spooling is good (it uses disk storage). Multiprogramming is better (it uses a lost of disk storage). Time-sharing is better still (it uses even more disk storage). And how about on-line data entry, and data communications, and random processing, and data base management, and information retrieval? In short, most of the modern concepts of information handling and processing that are permitting ever wider application of the computer stem from the presence of disk storage units.

Does this seem too sweeping a statement? Consider the fact that the vast majority of IBM System/360 and System/370 computer systems in operation employ disk-based systems software. Consider the fact that over half of the IBM System/3's (IBM's smallest business-oriented computer system) in use include disk storage units. Consider the fact that virtually all of the new computer systems from all of the major mainframe manufacturers are based on operating systems using disk storage. Consider the fact that the estimated value of disk storage units shipped in 1972 will represent about 20 percent of all data processing shipments, compared to a figure of under 10 percent in 1966.

Are you impressed? Does it kind of make you want to build your own disk unit and get into this lucrative market? Well, these facts have impressed numerous companies—who have in turn gotten into the market. The number of manufacturers and system builders involved in the production of disk storage units has indeed burgeoned in recent years.

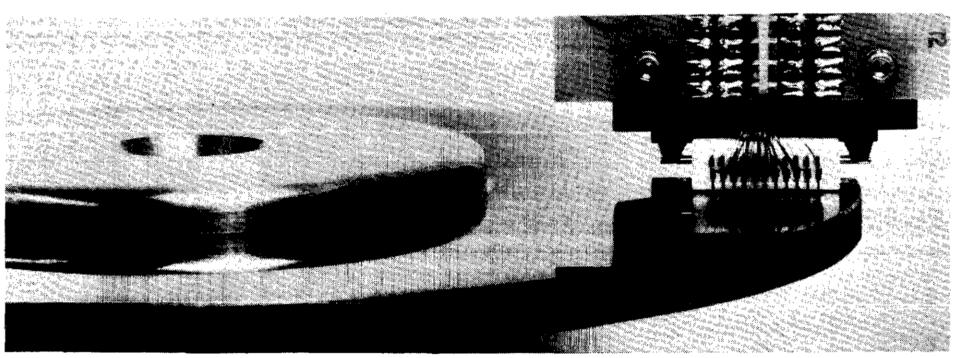
This report explores the world of disk and drum storage. It presents the facts about what these units can do for you, and what they cannot. Detailed comparison charts describe the salient characteristics of 93 devices and families of devices from 36 vendors. Not included in this report, however, are the many disk and drum units available from the mainframe vendors, nor the many plug-compatible disk units on the market, since these devices are covered in individual reports within the Computers and Peripherals sections.

Why Disk Storage?

The key to the importance that disk (and drum) storage units have assumed in the application of computers to real problems can be quickly summarized in one word—flexibility. With other types of computer peripherals, the logical behavior of the unit is intimately tied to the mechanical behavior of the unit. With disk units, the logical behavior can be separated from the mechanical behavior.

These are weighty words which mean simply that one disk unit can perform the logical functions of several devices, and that it can do this in one of several operational modes. For example, sorting a data file absolutely requires a minimum of three magnetic tape drives—assuming, of course, that you don't have a main memory sufficiently large to contain the whole data file. A single disk drive can assume the logical identity of three—or more—devices to permit sorting with a single drive. As another example, consider an application that requires several files to be on-line simultaneously during the course of execution of a program. The only practical way to do this with magnetic tape is to assign each file to a separate unit. With a disk unit, multiple files can be contained within the same unit and are equally accessible.

This flexibility was first used advantageously by employing drum units as the main memories of computers. The



The exacting specifications for flatness and smoothness of disk recording surfaces are exemplified by the mirror-like surface of this newly announced disk unit from Omron Systems.

All About Disk and Drum Storage

great speed advantages inherent in non-mechanical devices—along with the fantastic reductions in the prices of electronic devices and the fact that they are even more flexible than drums or disks—prevented drums and disks from exerting any long-term influence as main memory components for computers. However, at least one popular low-priced computer family (the Burroughs L/TC family) still uses a disk unit as the main memory component.

When Is a Disk A Drum?

Disks and drums fall into a generic category called rotating memories. Three principal features serve to categorize this class of equipment: media, head arrangement, and media arrangement.

The medium is the component on which the magnetic patterns are recorded. It can be a round, flat disk with one or both surfaces used for recording. Or it can be a drum-shaped (cylindrical) component with a single surface available for recording. (No one has seriously considered using the inside surface of a drum for recording because of obvious mechanical conflicts between providing support for the rotating drum and providing support for the head assemblies required to record on that surface.)

Drums came first, because machining a cylindrical shape was a well-known procedure. Learning to make disks flat enough to allow the required level of performance took longer. To help explain why, let's consider a brief analogy. One of the manual skills that has just about been lost due to encroaching technology is the art of making the large circular blades used in a saw mill. Making the blades flat was highly desirable to reduce the amount of power required and to reduce waste due to the saw cuts. When first manufactured, the blades contained residual stresses that caused warpage because the thinness of the blade provided very little resistance to bending. This was removed by judiciously applied hammer blows. However, these blows caused the blade to stretch which, often introduced additional waviness if the blows were not struck in exactly the correct place.

While disks for computer peripherals are not made by hand and the ratio of diameter to thickness is not as severe, the saw-blade problem typifies the problems of making disks flat. The problems were worthwhile to overcome because of the greatly increased ratio of surface area to overall volume when comparing a disk to a drum. Compensating for this to some extent is the fact that all of the drum's outer surface is usable, while only a small portion of the disk surface is usable. This situation arises because the recording density on a disk must vary across the diameter if the bit rate is to be constant, a desirable property.

Typically, a band only an inch or so wide is used for data recording on the disk surface, to keep the recording density within reasonable bounds. If a reasonable density were used for recording near the center of the disk, then the density at the outer areas would be so low as to make it not worthwhile. As a matter of fact, it can be shown, for fixed radial and transverse recording densities, that the maximum storage capacity is achieved when the inner diameter of the recording band is half the outer diameter. Disk units using a modest track-to-track recording density approach this, but units with higher lateral densities seldom do, probably because of the added expense for the head mechanisms.

Having established a surface for recording the magnetic patterns for storing information, we need a component to generate the patterns. As with magnetic tape units, these components are called *heads.* There are two basic physical arrangements for the heads: fixed and moving. In a fixed-head arrangement, each head records on a single track. In a moving-head arrangement, the heads can be moved to record on more than one track each. In general, moving-head units are cheaper and slower for the same storage capacity, or have more capacity for the same cost, than fixed-head arrangements. Obviously, head assemblies are expensive. Fixed-head units appear to have an advantage in performance because no time is spent in mechanical motion of the heads to start reading or writing. However, this is not always the case, as we will see under Performance.

The third characteristic is *media arrangement.* This refers to whether the disk or drum is fixed in place or contained in a removable cartridge (or pack). Fixed-media units are less expensive for the same performance and capacity than removable-media units. However, the use of a removable storage medium greatly increases the flexibility and is the principal development that has made disk units so very popular. With disk packs (or cartridges), the same unlimited off-line storage is available through disk units as is present with magnetic tape units and their removable reels.

Thus, there are eight possible combinations of the three basic characteristics. Of these, only two (drums with removable media and either fixed or moving heads) have not been implemented commercially. Of the other six possibilities, only moving-head drum units are not common. (The one principal example is UNIVAC's Fastrand units, available with the company's larger computer systems.)

There are no logical differences between equivalent disk and drum configurations. Indeed, at one time, some people called a fixed-head disk unit a "logical drum." In those days, drum was synonomous with high speed, low capacity, and high cost, with disk units being diametrically opposite. Today, the distinctions are more blurred, but UNIVAC remains the only major computer manufacturer that is actively marketing a wide range of drum units. And

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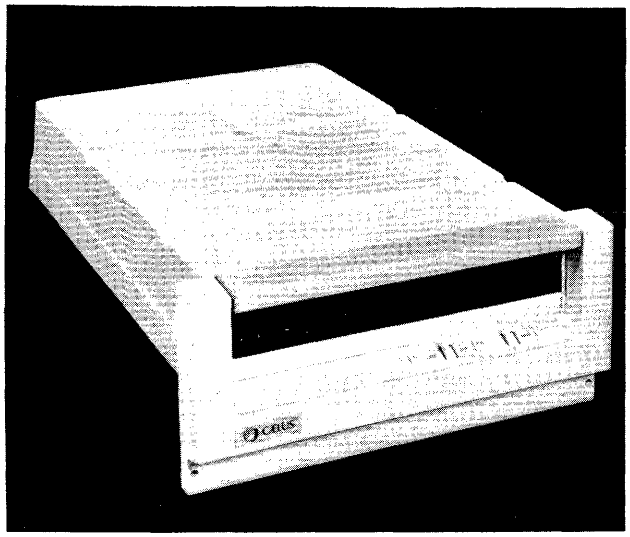

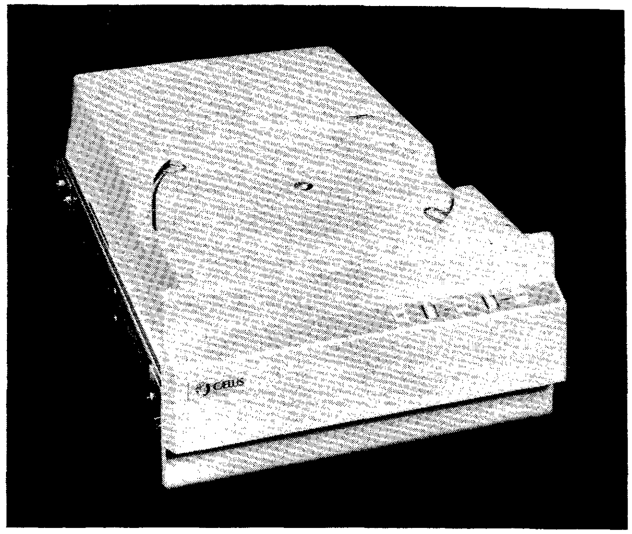

Among other choices you have concerning the specifications of disk units, these two Caelus models give you a choice of front-loading or top-loading cartridges. The front-loading 203 on the left uses an IBM 2315-type cartridge, while the top-loading 303 on the right uses an IBM 5440-type cartridge. Either model is available in the now-popular style of one removable cartridge and one fixed cartridge mounted on a common drive, as pioneered by IBM with the System/3.

these are offered only for the larger UNIVAC computer systems. For special situations, such as very high transfer rates or very fast access times or very severe environments in terms of physical shocks, drum units possess advantages. But it is disk units that have captured the fancy of the data processing community for ordinary applications.

In summary, all other factors being equal,

- Disks have the advantage in terms of capacity per unit volume.
- Drums have the advantage for speed and shock resistance.
- Fixed-head arrangements have the advantage of speed.
- Moving-head arrangements have the advantage of cost and capacity.
- Removable-media units have the advantage of unlimited off-line storage capacity.
- Fixed-media units have the advantage of simplicity of design.
- Rotating memories (all types) have the key advantage of flexibility.

They Do It With Mirrors, Right?

Evaluation of the performance of a disk/drum unit is relatively straightforward in theory, but something else again in practice. Part of this is due to confusion in the nomenclature, and part is due to confusing the elements defining the performance with the performance itself. There are three principal elements that affect performance:

- Head movement time (if any).
- Rotational speed.
- Recording density.

The above applies to a single unit. If multiple units are engaged in the same program, then the additional element of overlapped or simultaneous operations must be considered. Simultaneity is primarily a function of the control electronics and control software in most installations.

Before we discuss the effects of each of the elements, let's talk about performance itself. As an analog to clarify the differentiation between performance and the parameters performance depends upon, we can draw upon a more common topic, automobiles. The horsepower of an engine can be computed from a knowledge of the pressure curve inside the cylinders during burning, rotating speed, stroke, and cylinder diameter. The horsepower, however, is not the performance of the car. The horsepower, together with gear ratios, frontal area of the car, rolling resistance, etc., is just one of numerous elements needed to calculate the car's performance.

In a similar manner, the performance of a disk/drum unit must be evaluated in terms of the work it can do in specific applications. In this fashion, the elements contributing to the performance are blended into meaningful relationships. And there are some surprises in store when

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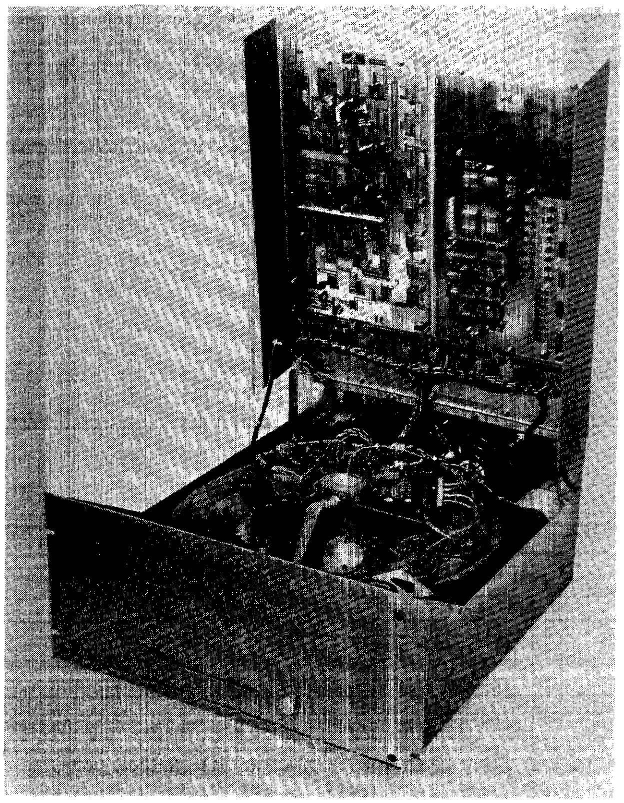


The technique of magnetic recording is vital to the efficient use of computers, but its implementation is vastly more complicated than one might expect. This fixed-head disk unit from Applied Magnetics Corporation illustrates the complex circuitry required to control and shape the electronic pulses used to record magnetic patterns and to interpret them when regenerating (reading) the recorded data.

you talk in terms of actual performance rather than limiting your evaluation to access time, etc. But what is the application-oriented performance term that has now been alluded to several times? Basically, it is *the number of operations per second* that can be performed. An operation can be the retrieval of a record, processing it, and rewriting it back in place. Or an operation can be the retrieval of a record in answer to an inquiry, with no record processing required. Or an operation can be the transfer of a large data block, such as a systems program (e.g., a compiler) to main memory. In short, an operation is the complete task that a disk or drum unit is called upon to do.

Each of the three basic elements–head movement time, rotational speed, and recording density–plays a distinct, but inter-related, role in the evaluation of performance.

Head movement time is just what it says: the time to move the head mechanism from its starting point to its destination. Once the destination is reached, it takes a short while for the heads to settle down and become still enough for reliable reading or writing. This settling time is normally included in the head positioning times quoted by the manufacturers, but it is always worthwhile to check to make sure. Of late, the trend seems to be for manufacturers to quote positioning time as "access time." Others, particularly mainframe vendors, include latency, discussed in the next paragraph, with positioning time to arrive at an access time. Be careful to check.

Much has been written in the literature about positioning time. Most of it is accurate but misleading. The basic difficulty in dealing with positioning time is reducing it to simple enough terms for convenient calculation. There is, of course, a different time associated with each different movement possible, and the relationships are by no means linear; e.g. seldom does a move across 50 tracks take 5 times as long as a move across 10 tracks. A solution, then, is to derive an average time, a single number that can be applied with the expectation that things will even out over the course of many operations. Assuming a random position to begin with and a random destination, then, on the average, the movement will be across one-third of the tracks. (Over a small number of tracks, it will vary slightly from one-third, but not enough to worry about.) It is one-third rather than one-half because the head mechanism can move in either direction. If the heads moved in a linear time relationship, then an average time would be one-third of the maximum. In practice, it works out to be about one-half of the maximum time in most cases. This is because short moves typically take more than a proportionate length of time compared to long moves and there are many more possible short moves than long ones.

If you haven't quite followed the above discussion, don't worry. Vendors normally quote an average positioning time in their literature. However, this time is normally applied to the whole range of movement. If your application confines the data being accessed to less than the total capacity, then a downward adjustment in the average positioning time will have to be made.

The *rotational speed* is involved in a parameter called average rotational delay, or "latency." This is the length of time from when the head positioning is completed to when the required data is under the heads. On the average, latency is one-half of a revolution. (The one-half factor works here because the movement is uni-directional.)

The *recording density* comes into play in determining how many revolutions (or what fraction of a revolution) is required to transfer data. The most convenient unit to work with is the data capacity per track, which is normally constant.

Thus, the three elements are the time to bring the heads to the correct position, the time for the right data to come under the heads, and the time to transfer data.

To see how these times work together to determine the number of operations per second that can be performed,

All About Disk and Drum Storage

we will consider a hypothetical moving-head disk unit and some typical types of operations.

The disk unit has the following parameters: average positioning time is 60 milliseconds; the time for one rotation is 40 milliseconds; and the capacity of one track is 3125 16-bit words. (If this looks like a typical unit using the IBM 5440 cartridge to you, credit yourself with sharp powers of observation.)

For the operation of transferring a randomly located large block of data, say 4096 words, the operation consists of an average positioning, an average rotational delay, and 1.3 revolutions to transfer the data. This adds up to 132 milliseconds, or a rate of 7.6 operations per second.

For the retrieval application of accessing a randomly located 64-word record, the operation is essentially the same as before with a shorter transfer period. This adds up to about 81 milliseconds, or a rate of 12 operations per second.

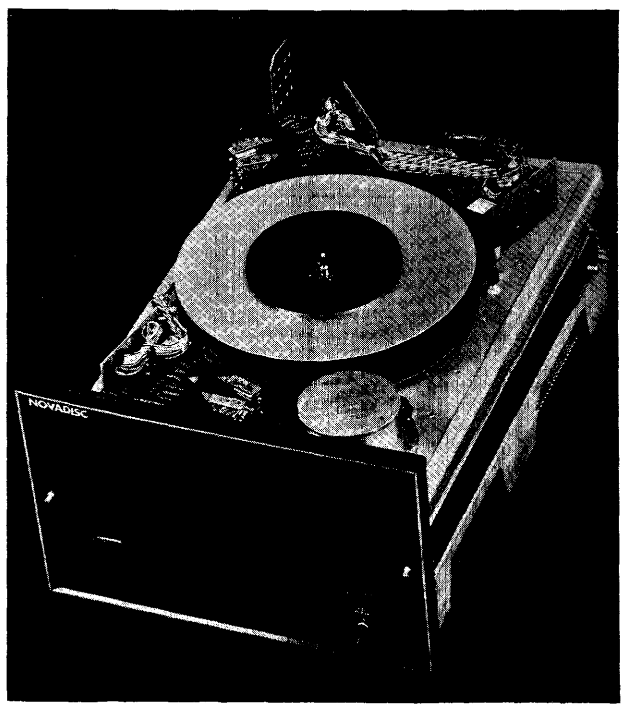
Neither of the above operations involved processing of the record, at least in a way that would affect the disk performance. How about a traditional operation of reading a record, processing it, and rewriting it in place. In addition to the factors already considered, at least one full revolution must pass before the disk is again in position for the record to be written. Assuming that processing can be completed in this time and that only one revolution goes by, the operation time adds up to 121 milliseconds, or slightly over 8 records processed per second. If you wish to reread the record to verify recording accuracy, it costs another revolution and the rate drops to just over 6 records per second. (Few disk units employ the read-after-write checking that is so familiar in magnetic tape units, but most do allow for recording check bits of one kind or another.)

For a fixed-head disk or drum, you would naturally delete the positioning time. But don't make the mistake of assuming that fixed-head units are always faster than moving-head units. A full comparison of elements is required to make a complete evaluation. For example, some years ago one of the Datapro staff became involved in a lengthy and somewhat heated discussion with representatives from a mainframe vendor concerning an evaluation of that vendor's fixed-head disk unit. They were most unwilling to concede that their unit was slower in actual performance than IBM's then-hot 2311 Disk Storage Drive, a moving-head unit. The catch was that the fixed-head unit had a rotational speed only half that of the 2311. If the same criterion were applied to the preceding example (half the rotational speed) and the most unfavorable case were selected (the update processing with read-back), the operation rate would decrease from 6 to 5 operations per second. In all fairness, we must note that for the other operation types cited, the performance of the fixed-head unit would be faster.

The above calculations assume random locations of the data accessed. Any distributional patterns can shift the rates up or down. For example, if you are accessing a customer file which shows a predominant activity within a small group of records which are closely spaced on the disk, the rates could be substantially higher. On the other hand, if you locate several files on one disk and use them in the same processing application, rates could be significantly lower. Adjust the calculations with whatever information you have about your application.

The above discussion is confined to a single unit. If multiple disk units are used to hold a sinlge file, the situation is somewhat different. Each unit taken by itself will follow the calculations outlined above. The question is, what is the distribution of requests among the units holding the file? If all requests go to one unit, then the operation rate will be that of the unit. If the requests are distributed among the units, then there is an opportunity to overlap some of the elements and increase the overall rate. The element most frequently subject to overlapping is the positioning or seek time. A full discussion of the possibilities of overlapped operations is beyond the scope of this report, for it involves the characteristics of the computer I/O structure, including interrupts, and the available software.

One major element has not yet been mentioned. It is the distribution of data on the disk. Stated in other words, how do you know the disk address of a particular record



The more prosperous minicomputer manufacturers are beginning to enter the potentially lucrative field of peripheral building. This Novadisc unit from Data General features head mechanisms that swing out when the disk is stopped to prevent any contact of the heads with the disk surfaces.

or block of data you want to access? This is what separates the men from the boys. With simple data organizations, it is sometimes possible to relate the disk address to a field in the record (e.g., to the customer or invoice number) through a simple arithmetic expression. In this case the individual user program can calculate disk addresses directly as it goes. This approach will not get you very far in disk processing activities. More complex situations are the rule of the day. In addition, we have become spoiled by higher-level languages, and we expect to be able to reference things by a symbolic name rather than a hexadecimal number. The amount of coding required for this sort of thing can become very high. A full discussion is beyond the scope of this report. For an insight into this area, you can reference the following DATAPRO 70 reports: Amigos (70E-242-02), Total (70E-132-01), and System 2000 (70E-652-01). They are all in the Software section.

Disk Packs and Six Packs

In the area of removable-media disk units, IBM has set the patterns. The company has offered a number of different units over the years. Because of the wide availability of disk packs or cartridges for these units, many of the independent peripheral manufacturers have built units around the IBM packs/cartridges and their equivalents produced by other vendors. The following is a tabulation of the various IBM disk packs and cartridges in use. The capacities that IBM obtains with these packs are listed for comparative purposes. Keep in mind, though, that these are formatted capacities as defined under *Capacity per Spindle* in the discussion of the Comparison Charts later in this report. Incidentally, current terminology seems to indicate that a "disk cartridge" contains one disk and a "disk pack" contains more than one disk.

IBM Disk Pack or Cartridge	For IBM Disk Drive	Recording Surfaces	Cylinders*	Capacity, megabits*
2315	1131, 2310	2	200	8.19
5440	5444	2	100 or 200	9.8 or 19.6
1316	2311	10	100 or 200	21.6 or 43.2
2316	2314	20	200	233
3336	3330	19	404	800
23FD-II	**	1	32	0.653

*As formatted by IBM for use on the drives indicated; note that the capacity is expressed in bits rather than the usual bytes.

**This is the so called "floppy disk" used by IBM to load control memory on the System/370 Models 135 and 145.

Where To Find Information

Within the pages of DATAPRO 70, you will find perhaps the most comprehensive presentation of information on commercially available disk drives ever collected. But not all of this information is in this report. To keep the length of the comparison charts within reasonable limits, information found in other parts of DATAPRO 70 was not keted by the computer mainframe vendors are covered in the individual reports on computer systems found in the Computers section. The IBM plug-compatible disk drives produced by the independent peripheral manufacturers are covered in individual reports within the Peripherals section; you can find these most easily by looking in the Index under the generic headings of "disk drives (IBM-compatible)." For the same reason, each disk or drum unit marketed by a minicomputer manufacturer for use with its own computers is not listed in the charts except in the rare cases where the minicomputer vendor actually manufactures the disk or drum unit itself (e.g., some of the DEC, Data General, and Hewlett-Packard units). Virtually all of the drives marketed for use with minicomputers are, however, listed in the charts under their original manufacturer.

The Comparison Charts

The principal characteristics of 93 disk and drum units and families from 36 manufacturers are presented in the accompanying comparison charts. All information in the charts was furnished by the suppliers in May, June, and July 1972. The cooperation of these companies with the Datapro Research staff in the preparation of these charts is greatly appreciated.

The comparison chart entries and their significance are explained in the following paragraphs, together with additional discussions of terminology and guidelines for equipment selection.

Manufacturer and Model identifies the subject device. For your convenience, a list of all manufacturers along with their addresses and telephone numbers precedes the comparison charts.

Under *Physical Arrangement,* the configuration of the unit is delineated.

The *Type* identifies the style of recording medium used; i.e., disk or drum. The entry under *Heads* tells whether a moving or a fixed head arrangement is employed. The *Media* entry identifies the type and sometimes the style of the disk or drum employed. Possible entries include fixed, cartridge, fixed/cartridge, or an IBM disk pack or cartridge number. The "fixed/cartridge" entry designates the IBM 5444 type of unit, which includes one fixed and one removable cartridge. If an IBM cartridge or pack number designation appears, it normally signifies a removable-media unit; in those few cases where it does not, this fact is clearly indicated in the Comments entry.

If the vendor provides a specific device for taking command strings in computer words and converting these into the signals necessary to control the unit, the device is identified under *Controller.* When such a device is available, the configuration rule is stated under *Drives per Controller.* In a few cases, the entry under *Comments* is

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used to clarify configuration details. To accommodate variations in packaging, the term "spindle" is used. It refers to one drive arrangement; in a few cases, multiple spindles are combined into a single package. Basing our entries on a spindle permits more direct comparisons. The number of *Recording Surfaces per Spindle* is a more reliable indicator than the number of disks, for example, and permits disks and drums to be covered in the same format.

Storage Arrangement describes the layout of data in the unit. Again, spindle is used as the basis.

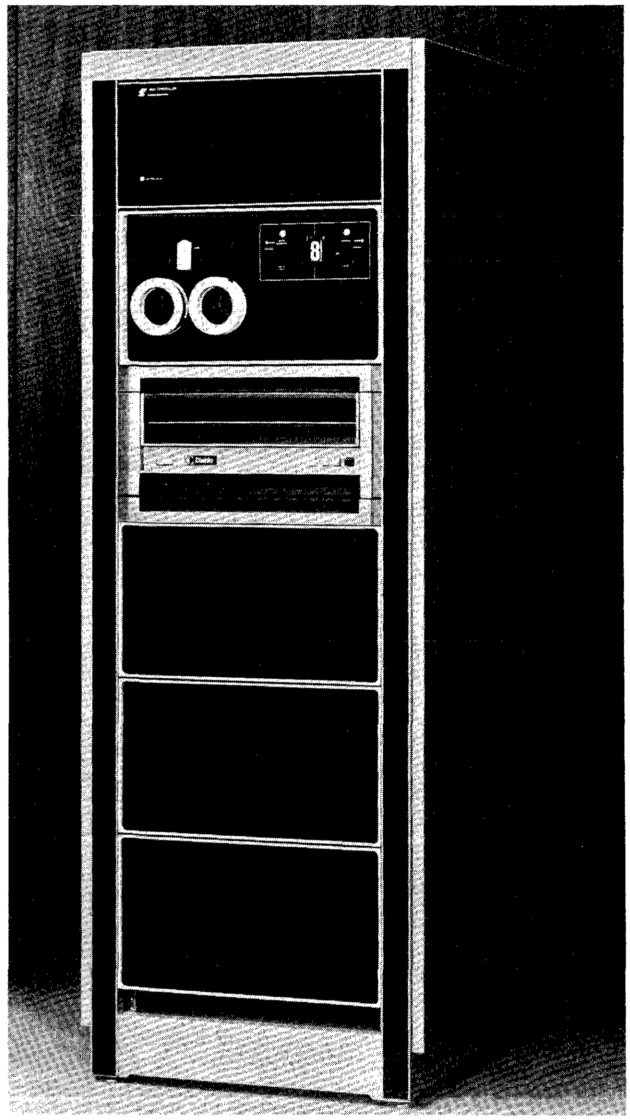
The *Capacity per Spindle* states the total capacity of the unit in an unformatted mode. Formatting is the separation of the disk or drum surface into sectors. To ensure reliability of reading and writing of just portions of the surface, some space must be left between the sectors. Sectoring is usually desirable to allow a finer addressing level than a whole track. Depending on the precision of the technique and the number of sectors per track, a substantial amount of storage space can be lost. For example, the IBM 2315 cartridge uses mechanical sensing of slots to pick up sector references. The 5440 cartridge has only one index slot, and an electronic clock is used to generate sector references. Electronic sectoring permits greater storage space utilization.

The *Format* entry identifies the grouping of bits on the recording surface. Almost universally, a bit-serial technique is used. Some units do allow linking two or more tracks in parallel to increase the data transfer rate by reading multiple tracks simultaneously in the fashion of conventional magnetic tape drives. Multi-track heads (as in magnetic tape units) are not used in disks and drums. The chief reason is that the lateral track density is so high as to make such heads either impossible or prohibitively expensive. Track-to-track spacing in a tape drive is on the order of 20 tracks per inch; the corresponding figure for disks and drums to 5 to 10 times as high.

The term *Cylinders* refers to the number of discrete positions in which a moving-head access mechanism can be positioned. Obviously, for a fixed-head unit, there is only one cylinder. The *Number of Tracks per Cylinder* provides a measure of the amount of data that can be accessed without moving the heads. Again, for fixed-head units this figure corresponds to the number of tracks per spindle.

Average Positioning Time applies of course, to a moving-head unit only. Some manufacturers refer to this factor as "access time." For a fuller discussion of positioning time and its significance, see the earlier paragraphs in this report that discuss performance.

Average Rotational Delay, or latency, is usually one-half of the time required for one revolution of the disk or drum. See the earlier discussion of performance.



The range of peripheral equipment available to minicomputer users is being constantly expanded by the availability of new subsystems such as this one from System Industries. It combines a specialized magnetic tape unit (DECtape) along with a Diablo disk unit and the company's controller to form a complete storage subsystem for a PDP-8 minicomputer.

The previous two parameters tell how long it takes, on the average, to get ready for a data transfer. The *Data Transfer Rate* tells how fast data is transferred once it gets going. For the few units that can be arranged to read and write multiple tracks in parallel, a serial rate is entered and identified. To calculate the transfer rate when operating in a parallel mode, simply multiply the serial rate by the number of tracks in parallel.

The entries under *Interface* identify the computer systems for which the vendor supplies components that permit direct connection. En entry of "none" means that the vendor does not supply interfacing components and implies that the unit is normally sold on an OEM basis.

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▷ The entries under *Pricing and Availability* are self-explanatory. Prices stated are for unit quantities, and typically do not include options or expanded capacities mentioned in the other comparison chart entries. Under the heading *Serviced By,* the various entries have subtle shades of meaning which are more hints than outright statements. An entry naming a company usually signifies a network of service offices. The term "factory" implies that servicing is performed at the factory of the manufacturer listed in the first chart entry. The term "customer" is usually associated with an OEM unit and indicates that the buyer–who is the person who sells it to the end user–is responsible for service. The equipment makers provide varying levels of support to these "middle men", who can in turn add a great deal of value to the units by developing appropriate controllers and software.

Disk and Drum Unit Manufacturers

Listed below, for your convenience in obtaining additional information, are the names, addresses, and telephone numbers of the 36 vendors represented in the comparison charts.

Alpha Data Incorporated, 8759 Remmet Avenue, Canoga Park, California 91304. Telephone (213) 882-6500.

Applied Magnetics Corporation, 75 Robin Hill Road, Goleta, California 93017. Telephone (805) 964-4881.

Caelus Memories, Inc. (a subsidiary of Electronic Memories & Magnetics Corporation), P.O. Box 6297, San Jose, California 95150. Telephone (408) 298-7080.

California Computer Products, Inc. (CalComp), 2411 West La Palma, Anaheim, California 92801. Telephone (714) 821-2011.

California Electro Mechanisms, 22519 South Normandie Avenue, Torrance, California 90501. Telephone (213) 328-2151.

Century Data Systems, Inc., (a subsidiary of California Computer Products, Inc.), 1270 North Kramer Avenue, Anaheim, California 92806. Telephone (714) 632-7111.

Control Data Corporation, Box 0, Minneapolis, Minnesota 55440. Telephone (612) 853-8100.

Data Disc, Inc., 686 West Maude Avenue, Sunnyvale, California 94086. Telephone (408) 732-7330.

Data General Corporation, Southboro, Massachusetts 01772. Telephone (617) 485-9100.

Data Systems Design, 1122 University Avenue, Berkeley, California 94702. Telephone (415) 849-1102.

Datum Inc., Peripheral Equipment Division, 170 East Liberty Avenue, Anaheim, California 92801. Telephone (714) 879-3070.

Decision, Inc., 5601 College Avenue, Oakland, California 94618. Telephone (415) 654-8626.

Diablo Systems Inc., 24500 Industrial Blvd., Hayward, California 94545. Telephone (415) 783-3910.

Digital Development Corporation, 5575 Kearny Villa Rd., San Diego, California 92123. Telephone (714) 278-9920.

Digital Equipment Corporation, 146 Main Street, Maynard, Massachusetts 01754. Telephone (617) 897-5111.

Diva Associates Inc., 58 Maple Avenue, Red Bank, New Jersey 07701. (201) 842-6500.

Eclectic Corporation, 2830 Walnut Hill Lane, Dallas, Texas 75229. Telephone (214) 358-1307.

Hewlett-Packard, Data Systems, 11000 Wolfe Road, Cupertino, California 95014. Telephone (406) 257-7000.

Information Data Systems Inc., 7550 Walnut Lake Road, Walled Lake, Michigan 48088. Telephone (313) 624-5525.

Intercomp, 68 Rogers Street, Cambridge, Massachusetts 02142. Telephone (617) 864-4700.

International Memory Systems, 7315 East Evans Road, Scottsdale, Arizona 85254. Telephone (602) 948-2120.

IOMEC Inc., 345 Mathew Street, Santa Clara, California 95050. Telephone (408) 246-2950.

Librascope (Division of The Singer Company), 808 Western Avenue, Glendale, California 91201. (213) 245-8711 (Ext. 1847).

Omron Systems, Inc., 440 East Middlefield Road, Mountain View, California 94040. Telephone (415) 964-2266.

Pacific Micronetics Inc., 5037 Ruffner Street, San Diego, California 92111. Telephone (714) 279-7500.

Per Data (Peripheral Data Machines, Inc.), 102 New South Road, Hicksville, N.Y. 11801. Telephone (516) 938-2851.

PERTEC, 9600 Irondale Avenue, Chatsworth, California 91311. Telephone (213) 882-0030.

Potter Instrument Co., Inc., 532 Broad Hollow Road, Melville, New York 11746. Telephone (516) 694-9000.

Sagem Corp., 35 South Main Street, Derry, New Hampshire 03038. Telephone (603) 432-2013.

System Industries, 535 Del Rey Avenue, Sunnyvale, California 94086. Telephone (408) 732-1650.

Systematics/Magne-Head (Division of General Instrument Corporation), 13040 South Cerise Avenue, Hawthorne, California 90250. Telephone (213) 679-3377.

Tally Corporation, 8301 So. 180th Street, Kent, Washington 98031. Telephone (206) 251-5500.

Vermont Research Corporation, Precision Park, North Springfield, Vermont 05150. Telephone (802) 886-2256.

Wabash Computer Corporation., Equipment Division, 10202 N. 19th Avenue, Phoenix, Arizona 85021. Telephone (602) 943-2311.

Xebec Systems, Inc., 566 San Xavier Avenue, Sunnyvale, California 94086. Telephone (408) 732-9444.

XLO Computer Products, 850 Ladd Road, Walled Lake, Michigan 48088. Telephone (313) 624-4571. (Or try the OEM sales office in Fort Washington, Pennsylvania. Telephone (215) 646-7417.) □

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MANUFACTURER & MODEL	Alpha Data Series 10	Alpha Data Series 16	Applied Magnetics M200D	Applied Magnetics M200DX	Caelus 103
PHYSICAL ARRANGEMENT					
Type	Disk	Disk	Disk	Disk	Disk
Heads	Fixed	Fixed	Fixed	Fixed	Moving
Media	Fixed	Fixed	Fixed	Fixed	Fixed
Controller	Available	Available	Available	Available	Available
Drives per Controller	Up to 8	Up to 8	Up to 4	Up to 4	Up to 4
Spindles per Drive	1	1	1	1	1
Recording Surfaces per Spindle	1 to 4	1 to 4	2	2	2
STORAGE ARRANGEMENT					
Capacity per Spindle, millions of bits	0.5 to 8	4 to 20	6.4	9	24
Format	Bit serial	Bit serial	Bit serial	Bit serial	Bit serial
Cylinders per Spindle	1	1	1	1	204
Tracks per Cylinder	16 to 256	64 to 384	128	128	2
AVERAGE POSITIONING TIME, msec.	–	–	–	–	75
AVERAGE ROTATIONAL DELAY, msec.	8.4 or 16.8	16.8 or 8.4	8.7	12.5	20 or 13
DATA TRANSFER RATE, megabits per sec.	2 or 1	2 or 4	3.4	3.4	1.59 or 2.5
INTERFACE	Popular minicomputers	Popular minicomputers	DEC PDP-8, -11; Data General Nova; Honeywell; CAI; most others	DEC PDP-8, -11; Data General Nova; Honeywell; CAI; most others	Universal interface permits connection to most controllers
PRICING AND AVAILABILITY					
Purchase Price:					
Controller, $	2,000 average	2,000 average	3,000 to 5,000	3,000 to 5,000	Contact vendor
Drive, $	4,000 average	4,000 average	5,000	5,000	2,200
First Delivery	1968	1968	April 1971	October 1971	May 1972
Availability, days ARO	56	56	45	45	60
Number Installed to Date	500	500	Over 100	Over 100	INA
Serviced By	Factory	Factory	Independent reps. and factory	Independent reps. and factory	Factory
COMMENTS	Series number represents disk size; 10-inch disk has 35K bits/track; 16-inch disk has 70K bits/track; parallel track data arrangements available; head lifters; prices include power supplies and rack mounting		European sales and service available	European sales and service available	Plug-compatible with Caelus 203 and 303; OEM unit

MANUFACTURER & MODEL	Caelus 203	Caelus 303	Caelus CD-11/CDD-22	Caelus CD-22/CDD-44	CalComp AS12
PHYSICAL ARRANGEMENT					
Type	Disk	Disk	Disk	Disk	Disk
Heads	Moving	Moving	Moving	Moving	Moving
Media	Fixed/cartridge	Fixed/cartridge	Cartridge	Cartridge	IBM 2316
Controller	Available	Available	Available	Available	Integral
Drives per Controller	Up to 4	Up to 4	1 or 2	1 or 2	1
Spindles per Drive	1	1	1	1	1
Recording Surfaces per Spindle	2 or 4	2 or 4	2	2	20
STORAGE ARRANGEMENT					
Capacity per Spindle, millions of bits	24 or 48	24 or 48	11	22	163.8
Format	Bit serial	Bit serial	Bit serial	Bit serial	Bit serial
Cylinders per Spindle	204	204	203	203	200
Tracks per Cylinder	2 or 4	2 or 4	2	2	20
AVERAGE POSITIONING TIME, msec.	60	60	60	60	35
AVERAGE ROTATIONAL DELAY, msec.	20 or 13	20 or 13	20	20	12.5
DATA TRANSFER RATE, megabits per sec.	1.59 or 2.5	1.59 or 2.5	0.72	1.55	2.5
INTERFACE	Universal interface permits connection to most controllers	Universal interface permits connection to most controllers	Data General Nova series	Data General Nova Series	IBM 1130 SAC; Digital Scientific Meta 4
PRICING AND AVAILABILITY					
Purchase Price:					
Controller, $	Contact vendor	Contact vendor	Contact vendor	Contact vendor	–
Drive, $	4,275 (203/1); 4,575 (203/2)	4,275 (303/1); 4,575 (303/2)	4,500 (CD-11); 8,000 (CDD-22)	4,500 (CD-22); 8,000 (CDD-44)	20,000
First Delivery	June 1972	Fall 1971	1970	1970	1971
Availability, days ARO	60	60	60	60	30
Number Installed to Date	INA	INA	See Comments	See Comments	INA
Serviced By	Factory	Factory	Factory	Factory	CalComp
COMMENTS	203/1 and 303/1 have one cartridge; 203/2 and 303/2 have one cartridge and one fixed disk; 200's use front-load, CMI-HD (IBM 2315-type) cartridge; 300's use top-load CMIII (IBM 5440) cartridge; 103's, 203's, and 303's are plug-compatible; OEM units		CD Models have one drive; CDD models are twin drives sharing same power supply electronics; low-density drives use CMI-LD cartridge; high-density drives use CMI-HD; OEM units. Caelus has delivered over 2000 disk drives since June 1969		Company markets several other IBM plug-compatible drives (see Index)

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MANUFACTURER & MODEL	California Electro Mechanisms DRGE-xxA	California Electro Mechanisms DRGE-xxB/C	California Electro Mechanisms DR10S-60/288	California Electro Mechanisms DR6S-108/160	California Electro Mechanisms DR12S/15S
PHYSICAL ARRANGEMENT					
Type	Drum	Drum	Drum	Drum	Drum
Heads	Fixed	Fixed	Fixed	Fixed	Fixed
Media	Fixed	Fixed	Fixed	Fixed	Fixed
Controller	Optional	Optional	Optional	Optional	Optional
Drives per Controller	–	–	–	–	–
Spindles per Drive	1	1	1	1	1
Recording Surfaces per Spindle	1	1	1	1	1
STORAGE ARRANGEMENT					
Capacity per Spindle, millions of bits	0.72, 1.56, or 2.16	0.5, 1.04, or 1.44	4 or 25.6	5.4 or 7.68	21 or 38
Format	Bit serial	Bit serial	Bit serial	Bit serial	Bit serial
Cylinders per Spindle	1	1	1	1	1
Tracks per Cylinder	12, 26, or 36	12, 26, or 36	40 or 256	90 or 128	180 or 256
AVERAGE POSITIONING TIME, msec.	–	–	–	–	–
AVERAGE ROTATIONAL DELAY, msec.	8.5	8.5	8.5	8.5	17.5
DATA TRANSFER RATE, megabits per sec.	3.5	2.4	6	3.6	3.6 or 4.5
INTERFACE	Interfaces are available for a variety of mini-computers and special-purpose applications	Interfaces are available for a variety of mini-computers and special-purpose applications	Interfaces are available for a variety of mini-computers and special-purpose applications	Interfaces are available for a variety of mini-computers and special-purpose applications	Interfaces are available for a variety of mini-computers and special-purpose applications
PRICING AND AVAILABILITY					
Purchase Price: Controller, $	Contact vendor	Contact vendor	Contact vendor	Contact vendor	Contact vendor
Drive, $	790 ro 1,345	775 to 1,330	3,400 or 16,500	6,800 or 7,800	13,500 or 18,500
First Delivery	May 1971	May 1971	October 1971	October 1971	October 1971
Availability, days ARO	30 to 45	30 to 45	45 or 90	60 or 90	90
Number Installed to Date	INA	INA	INA	INA	INA
Serviced By	Factory	Factory	Factory	Factory	Factory
COMMENTS	xx in model number indicates number of tracks; field expandable		Field expandable; these models are representative; many options for coatings, heads, and motors; the "S" series units are designed for extreme environments, for military and process control applications		

MANUFACTURER & MODEL	Century Data Systems CDS-100/110	Control Data 9425	Control Data 9427	Control Data 9795	Data Disc 5200 Series
PHYSICAL ARRANGEMENT					
Type	Disk	Disk	Disk	Drum	Disk
Heads	Moving	Moving	Moving	Fixed	Fixed
Media	IBM 23FD-II	IBM 5440	Cartridge	Fixed	Fixed
Controller	None supplied	None supplied	None supplied	None supplied	6501 or 6601
Drives per Controller	–	–	–	–	1
Spindles per Drive	1	1	1	1	1
Recording Surfaces per Spindle	1	2 or 4	2 or 4	1	1 or 2
STORAGE ARRANGEMENT					
Capacity per Spindle, millions of bits	0.653 or 1.306	25 or 50	50 or 100	Up to 4.33	0.8 to 8
Format	Bit serial	Bit serial	Bit serial	Bit serial or parallel	Up to 72 bit parallel
Cylinders per Spindle	32 or 64	200	200	1	1
Tracks per Cylinder	1	2 or 4	2 or 4	Up to 64	8 to 72
AVERAGE POSITIONING TIME, msec.	Appx. 10,000 or 400	35	35	–	–
AVERAGE ROTATIONAL DELAY, msec.	333	12.5	12.5	8.3	18.7
DATA TRANSFER RATE, megabits per sec.	0.0333	2.5	2.5	0.5 to 4	3 (serial)
INTERFACE	None	Per customer requirement	Per customer requirement	Per customer requirement	Most minicomputers
PRICING AND AVAILABILITY					
Purchase Price: Controller, $	–	–	–	–	Contact vendor
Drive, $	500	3,280	4,100	3,285	9,920 to 27,720
Frist Delivery	Fall 1972	1971	1971	1970	1968
Availability, days ARO	INA	120	120	120	90
Number Installed to Date	0	150	50	INA	150
Serviced By	Customer	Customer	Customer	Customer	Data Disc
COMMENTS	OEM units, read-after-write checking available on 64-track model	OEM units; Control Data also markets models of its plug-compatible drives on an OEM basis; see Index for references to Control Data's end-user plug-compatible drives			Designed for digital television refresh application; high precision speed control optional

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MANUFACTURER & MODEL	Data Disc 7200 Series	Data General Novadisc	Data Systems Design Series 130	DATUM 144/244	DATUM 288/388/688
PHYSICAL ARRANGEMENT					
Type	Disk	Disk	Disk	Disk	Drum
Heads	Fixed	Fixed	Moving	Moving	Fixed
Media	Fixed	IBM 1316	IBM 2315	IBM 5440	Fixed
Controller	Available	Model 4019	240 Series	7000	6000
Drives per Controller	1	2.05 megawords	Up to 4	1 or 2	Up to 4
Spindles per Drive	1	1	1 or 2	1	1
Recording Surfaces per Spindle	1 or 2	8	2	2 or 4	1
STORAGE ARRANGEMENT					
Capacity per Spindle, millions of bits	0.8 to 12.8 or 1.1 to 17.7	2.1 to 12.6	12 or 24	24 or 48	0.56 to 2.24
Format	Bit serial	Bit serial; sectors of 256 16-bit words	Bit serial	Bit serial	Bit serial
Cylinders per Spindle	1	1	203	204	1
Tracks per Cylinder	8 to 128	64, 128, 256, or 384	2	2 or 4	8, 16, or 32
AVERAGE POSITIONING TIME, msec.	–	–	70	60	–
AVERAGE ROTATIONAL DELAY, msec.	16.7	8.4	20	20	16.6 or 8.3
DATA TRANSFER RATE, megabits per sec.	3 or 4	2	0.781 or 1.562	2.4	2.1 or 2.4
INTERFACE	Most minicomputers, including those from DEC, Data General, Honeywell, Interdata, etc.	Data General Nova series	DEC PDP-8, -11	Data General Nova; DEC PDP-11	Data General Nova; DEC PDP-11; Honeywell H-316, H-516; Hewlett-Packard 2100 series
PRICING AND AVAILABILITY					
Purchase Price:					
Controller, $	7,340 to 27,540 (includes drive)	3,000	About 5,000	4,000	3,000
Drive, $	–	5,200 to 12,560	5,200 to 7,780	4,500	2,550 to 4,050
First Delivery	1969	July 1972	INA	September 1972	1970/1971
Availability, days ARO	90 to 120	90	90	90	30
Number Installed to Date	Over 1300	–	INA	–	About 300
Serviced By	Data Disc	Data General	DEC	DATUM	DATUM
COMMENTS	Prices include interface and installation; system is marketed as 1700; severe environment option	Full DOS and RDOS software for Nova series; head retractors; 2-level sector interleave; unit is currently marketed in a fixed-disk configuration	Systems use Diablo 31 or 33 units; Diablo 40 series or other drives available	144 is single-cartridge unit; 244 is dual-cartridge unit	Any model available for operation at 1800 rpm, 70K bits/track, or 3600 rpm, 40K bits/track; can be gas-sealed for hostile environment

MANUFACTURER & MODEL	DATUM 788/488/888	DATUM Series 55A	DATUM Series 55B	DECISION 3150	DECISION 3160
PHYSICAL ARRANGEMENT					
Type	Drum	Drum	Drum	Disk	Disk
Heads	Fixed	Fixed	Fixed	Moving	Moving
Media	Fixed	Fixed	Fixed	IBM 2315	IBM 2316
Controller	6000	None supplied	None supplied	3150	3160
Drives per Controller	Up to 4	–	–	Up to 4	Up to 8
Spindles per Drive	1	1	1	1	1
Recording Surfaces per Spindle	1	1	1	2	20
STORAGE ARRANGEMENT					
Capacity per Spindle, millions of bits	4.48 to 17.92	0.36, 0.72, or 0.144	0.72 to 2.24	23	230 or 460
Format	Bit serial	Bit serial	Bit serial	Bit serial	Bit serial
Cylinders per Spindle	1	1	1	203	203 or 406
Tracks per Cylinder	64, 128, or 256	2, 4, or 8	2, 4, 8, 16, 32, or 64	2	20
AVERAGE POSITIONING TIME, msec.	–	–	–	20	37
AVERAGE ROTATIONAL DELAY, msec.	17.5 or 8.7	8.3	19.5	20	12.5
DATA TRANSFER RATE, megabits per sec.	2.1 or 2.4	1	1	1.6	2.7
INTERFACE	Data General Nova; DEC PDD-11; Honeywell H-316, H-516; Hewlett-Packard 2100 series	None	None	Data General Nova; DCC 116	Date General Nova; DCC 116
PRICING AND AVAILABILITY					
Purchase Price:					
Controller, $	3,000	–	–	3,600 to 4,250	8,000 to 8,800
Drive, $	6,050 to 15,050	650 to 950	650 to 1,750	3,000 to 5,000	10,000
First Delivery	1970/1971	1969	1969/1970	October 1970	March 1972
Availability, days ARO	30 to 60	30	30	30	45
Number Installed to Date	About 250	About 850	About 975	200	12
Serviced By	DATUM	DATUM	DATUM	DECISION	DECISION
COMMENTS	Any model available for operation at 1800 rpm, 70K bits/track, or 3600 rpm, 40K bits/track; can be gas-sealed for hostile environment	OEM units	OEM units. Model 655B, the 64-track model included in the chart, will be delivered in August 1972; price has not been determined to date	Software available; fixed or cartridge drives available; system uses Diablo Model 31133 drives	Software available; system includes single or dual-density IBM 2314-style drives from Century Data Systems

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MANUFACTURER & MODEL	Diablo Model 31	Diablo Model 33	Diablo Model 41	Diablo Model 43	Digital Development Corp. 7300 Series
PHYSICAL ARRANGEMENT					
Type	Disk	Disk	Disk	Disk	Disk
Heads	Moving	Moving	Moving	Moving	Fixed
Media	IBM 2315	IBM 2315	IBM 5440	IBM 5440	Fixed
Controller	None supplied	None supplied	None supplied	None supplied	None supplied
Drives per Controller	–	–	–	–	–
Spindles per Drive	1	2	1	1	1
Recording Surfaces per Spindle	2	2	2	4	4, 8, or 16
STORAGE ARRANGEMENT					
Capacity per Spindle, millions of bits	12 or 24	12 or 24	24	48	8.96 to 35.84
Format	Bit serial	Bit serial	Bit serial	Bit serial	Bit serial or parallel
Cylinders per Spindle	203	203	200	200	1
Tracks per Cylinder	2	2	2	4	256 to 1024 (serial)
AVERAGE POSITIONING TIME, msec.	70	70	38	38	–
AVERAGE ROTATIONAL DELAY, msec.	20	20	12.5 or 20	12.5 or 20	8.5
DATA TRANSFER RATE, megabits per sec.	0.781 or 1.562	0.781 or 1.562	2.5 or 1.562	2.5 or 1.562	2 (serial)
INTERFACE	None	None	None	None	Custom
PRICING AND AVAILABILITY					
Purchase Price:					
Controller, $	–	–	–	–	–
Drive, $	3,625 to 4,245	5,395 to 6,165	4,175	4,575	15,980 to 44,960
First Delivery	August 1970	August 1970	March 1972	March 1972	1965
Availability, days ARO	90	90	90	90	90
Number Installed to Date	See Comments	See Comments	See Comments	See Comments	1000
Serviced By	Customer	Customer	Customer	Customer	DDC
COMMENTS	OEM units; Model 33 includes 1 removable and 1 fixed cartridge mounted on separate spindles; about 2500 of the 30 series drives have been delivered		OEM units; Model 43 includes 1 removable and 1 fixed cartridge on common spindle; about 25 to 50 of the 40 series drives have been delivered		Sealed unit; no maintenance required over 10-year design life; parallel formats available up to number of surfaces per word

MANUFACTURER & MODEL	Digital Development Corp. 7310 Series	Digital Development Corp. 7613	Digital Development Corp. 6100 Series	Digital Development Corp. 6200 Series	Digital Equipment Corp. RK05 DECpack
PHYSICAL ARRANGEMENT					
Type	Disk	Disk	Disk	Disk	Disk
Heads	Fixed	Fixed	Fixed	Fixed	Moving
Media	Fixed	Fixed	Fixed	Fixed	IBM 2315
Controller	DMS-11, -16	None supplied	DMS-11, -16	DMS-11, -16	RK8/E or 11
Drives per Controller	Up to 4	–	Up to 4	Up to 4	4 or 8
Spindles per Drive	1	1	1	1	1
Recording Surfaces per Spindle	2, 4, 8, or 16	16	1	2	2
STORAGE ARRANGEMENT					
Capacity per Spindle, millions of bits	9.6 to 76.8	76.8	1.15 to 4.6	1.15 to 9.2	24
Format	Bit serial or parallel	Bit serial or 2-16 parallel	Bit serial	Bit serial	Bit serial
Cylinders per Spindle	1	1	1	1	203
Tracks per Cylinder	180 to 1024 (serial)	1024 (serial)	16, 32, or 64	16, 32, 64, 80, 96, or 128	2
AVERAGE POSITIONING TIME, msec.	–	–	–	–	50
AVERAGE ROTATIONAL DELAY, msec.	8.5	5.2	8.7	8.7	20
DATA TRANSFER RATE, megabits per sec.	4.4 (serial)	7.2 (serial)	4.14	4.14	1.44
INTERFACE	DEC PDP-11; Data General Nova series; custom	Custom	DEC PDP-11; Data General Nova series; custom	DEC PDP-11; Data General Nova series; custom	DEC PDP-8/E, -11, -12
PRICING AND AVAILABILITY					
Purchase Price:					
Controller, $	3,500 to 5,860	–	2,500 to 5,860	2,500 to 5,860	2,800 or 5,900
Drive, $	11,900 to 49,000	89,000	4,695 to 5,595	4,995 to 7,345	5,100
First Delivery	May 1971	June 1972	August 1971	August 1971	March 1972
Availability, days ARO	90	120	90	90	INA
Number Installed to Date	220	20 (on order)	60	125	INA
Serviced By	DCC	DCC	DCC	DCC	DEC
COMMENTS	Sealed units; no maintenance required over 10-year design life; parallel formats available with up to the number of disk surfaces per word		Sealed units; no maintenance required over 10-year design life		Manufactured by DEC

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MANUFACTURER & MODEL	DIVA DD-10	DIVA DD-10A	DIVA DD-11	DIVA DD-14, -18, -25	DIVA DD-30
PHYSICAL ARRANGEMENT					
Type	Disk	Disk	Disk	Disk	Disk
Heads	Moving	Moving	Moving	Moving	Moving
Media	IBM 2315	IBM 5440	IBM 1316	IBM 2316	IBM 3336
Controller	DIVA MMMC	DIVA MMMC	DIVA MMMC	DIVA MMMC	DIVA MMMC
Drives per Controller	Up to 4	Up to 4	Up to 4	Up to 2 or 4	Up to 2
Spindles per Drive	1	1	1	1 or 2	2
Recording Surfaces per Spindle	2	2	10	20	19
STORAGE ARRANGEMENT					
Capacity per Spindle, millions of bits	24	48	58	233 or 466	800
Format	Bit serial	Bit serial	Bit serial	Bit serial	Bit serial
Cylinders per Spindle	203	203	203	203	404
Tracks per Cylinder	2	2	20	20	19
AVERAGE POSITIONING TIME, msec.	70	60	30	28 or 35	28
AVERAGE ROTATIONAL DELAY, msec.	20	20	12.5	12.5	8.3
DATA TRANSFER RATE, megabits per sec.	1.2	1.2	1.248	2.5	6.45
INTERFACE	DEC PDP-8E, -11; Data General Nova; Interdata 70, 80; DCC 116; GE-PAC 3010/2; IBM 1130; others	DEC PDP-8E, -11; Data General Nova; Interdata 70, 80; DCC 116; GE-PAC 3010/2; IBM 1130; others	DEC PDP-8E, -11, Data General Nova; Interdata 70, 80; DCC 116; GE-PAC 3010/2; IBM 1130; others	DEC PDP-8E, -11; Data General Nova; Interdata 70, 80; DCC 116; GE-PAC 3010/2; IBM 1130; others	DEC PDP-8E, -11; Data General Nova; Interdata 70, 80; DCC 116; GE-PAC 3010/2; IBM 1130; others
PRICING AND AVAILABILITY					
Purchase Price:					
Controller, $	11,700 (includes 1 drive)	12,700 (includes 1 drive)	16,500 (includes 1 drive)	17,500 to 33,500 (includes 1 drive)	49,900 (includes 1 drive)
Drive, $	5,700	8,500	10,275	10,475 to 24,975	37,875
First Delivery	July 1971	January 1972	November 1971	January 1972	November 1972
Availability, days ARO	30 to 45	30 to 45	30 to 45	30 to 45	90 to 120
Number Installed to Data	See Comments	See Comments	See Comments	See Comments	See Comments
Serviced By	Customer	Customer	Customer	Customer	Customer
COMMENTS	DIVA manufactures controllers; disk units are obtained from Century Data Systems; units are OEM; typical customers are companies installing specialized systems such as point-of-sale data collection and processing for retail stores. To date, DIVA has delivered about 20 disk systems and an additional 30 to 35 controllers. DD-14 is single-spindle, single-density 2314-type unit; DD-18 is dual-spindle, single-density; DD-25 is dual-spindle, dual-density. Prices include interface. IBM-compatible format optional.				

MANUFACTURER & MODEL	Eclectic Model 840	Hewlett-Packard HP 7900A	Hewlett-Packard HP 7901A	Information Data Systems 7000 Series	Information Data Systems 7700 Series
PHYSICAL ARRANGEMENT					
Type	Disk	Disk	Disk	Disk	Disk
Heads	Moving	Moving	Moving	Fixed	Fixed
Media	IBM 1316	IBM 2315	IBM 2315	Fixed	Fixed
Controller	Included	HP 13210A	HP 13210A	Available	Available
Drives per Controller	Up to 8	Up to 4	Up to 4	Up to 4	Up to 4
Spindles per Drive	1	1	1	1	1
Recording Surfaces per Spindle	10	4	2	1	1
STORAGE ARRANGEMENT					
Capacity per Spindle, millions of bits	48	48	24	0.4 to 6.4	0.57 to 4.6
Format	Bit serial	Bit serial	Bit serial	Bit serial	Bit serial
Cylinders per Spindle	200	200	200	1	1
Tracks per Cylinder	10	4	2	8 to 128	8 to 64
AVERAGE POSITIONING TIME, msec.	30	30	35	–	–
AVERAGE ROTATIONAL DELAY, msec.	12.5	12.5	12.5	8.3 or 16.7	8.3 or 16.7
DATA TRANSFER RATE, megabits per sec.	1.25	2.5	2.5	3 or 1	4.6 or 2.3
INTERFACE	DEC PDP-8, PDP-11	HP 2100 series	HP 2100 series	None	None
PRICING AND AVAILABILITY					
Purchase Price:					
Controller, $	13,000 (includes 1 drive)	16,000 (includes 1 drive)	11,800 (includes 1 drive)	–	–
Drive, $	7,950	–	–	2,400 to 8,100	2,900 to 6,500
Frist Delivery	INA	November 1971	March 1972	INA	INA
Availability, days ARO	90	56	56	45 to 60	45 to 60
Number Installed to Date	INA	INA	INA	Over 400	About 100
Serviced By	INA	Hewlett-Packard	Hewlett-Packard	Independent reps.	Independent reps.
COMMENTS		Manufactured by Hewlett-Packard; drive includes 1 removable cartridge and 1 fixed disk	Manufactured by Hewlett-Packard	Prices do not include power supply; disk retracts when stopped	Prices do not include power supply; disk retracts when stopped

All About Disk and Drum Storage

MANUFACTURER & MODEL	Information Data Systems 8200 Series	Information Data Systems 10,000 Series	Intercomp Model 111	Intercomp Model 114	International Memory Systems Disk Systems
PHYSICAL ARRANGEMENT					
Type	Disk	Disk	Disk	Disk	Disk
Heads	Fixed	Fixed	Moving	Moving	Moving
Media	Fixed	Fixed	IBM 1316	IBM 2316	Fixed/Cartridge
Controller	Available	Available	Model 112	Model 115	IMS
Drives per Controller	Up to 4	Up to 4	1	1	Up to 4
Spindles per Drive	1	1	1	1	1
Recording Surfaces per Spindle	1	1	10	20	2 or 4
STORAGE ARRANGEMENT					
Capacity per Spindle, millions of bits	0.145 or 0.290	6.4 to 25.6	49.152	204.8	24 or 48
Format	Bit serial	Bit serial	Bit serial; 16-bit words	Bit serial; 16-bit words	Bit serial; 16-bit words
Cylinders per Spindle	1	1	203	203	204
Tracks per Cylinder	8 or 16	64 to 256	10	20	2 or 4
AVERAGE POSITIONING TIME, msec.	–	–	30	35	75 or 60
AVERAGE ROTATIONAL DELAY, msec.	8.3	25	12.5	12.5	20
DATA TRANSFER RATE, megabits per sec.	1.09	2	1.25	2.496	1.59
INTERFACE	None	None	IBM 1130	IBM 1130	DEC PDP-11
PRICING AND AVAILABILITY					
Purchase Price:					
Controller, $	–	–	9,600	11,600	7,800 to 8,400 (includes 1 drive)
Drive, $	1,815 to 2,150	8,285 to 19,470	7,200	8,200	4,850 to 5,450
First Delivery	INA	INA	January 1970	July 1972	INA
Availability, days ARO	45 to 60	60	30	90	INA
Number Installed to Date	About 50	About 50	60	–	INA
Serviced By	Independent reps.	Independent reps.	Intercomp	Intercomp	IMS
COMMENTS	Prices do not include power supply; disk retracts when stopped	Prices do not include power supply; disk retracts when stopped	Software-compatible with IBM 2310	Software-compatible with IBM 2310	IMS builds controllers and incorporates Caelus 103, 203, and 303 disk drives

MANUFACTURER & MODEL	IOMEC IODISC Series ONE	IOMEC IODISC Model 2001	IOMEC IODISC Model 2002	Librascope (Singer) Series L107	OMRON 3000
PHYSICAL ARRANGEMENT					
Type	Disk	Disk	Disk	Disk	Disk
Heads	Moving	Moving	Moving	Fixed	Fixed
Media	Cartridge	IBM 2315	Fixed/Cartridge	Fixed	Fixed
Controller	Integral	2,800	2,800	None supplied	None standard
Drives per Controller	Up to 8	Up to 4	Up to 4	–	–
Spindles per Drive	1	1	1	1	1
Recording Surfaces per Spindle	1	2	4	2	1
STORAGE ARRANGEMENT					
Capacity per Spindle, millions of bits	2.2	24	48	7 or 18 max.	24
Format	Bit serial	Bit serial	Bit serial	Bit serial	Bit serial
Cylinders per Spindle	64	203	203	1	1
Tracks per Cylinder	1	2	4	10 to 100 (A & MA); 128 or 256 (B)	160
AVERAGE POSITIONING TIME, msec.	60	75	95	–	–
AVERAGE ROTATIONAL DELAY, msec.	16.7	20	20	8.5 or 1.7	10
DATA TRANSFER RATE, megabits per sec.	1.23	1.56	1.56	2.1 to 2.4	7.5
INTERFACE	Data General Nova; DEC PDP-8E, -8L/I, -11; Hewlett-Packard HP 2100 series; Varian 620	Data General Nova; DEC PDP-8E, 8L/I, -11, -12; HP 2100 series; Varian 620; Microdata 800/1600; others	Data General Nova; DEC PDP-8E, -8L/I, -11, -12; HP 2100 series; Varian 620; Microdata 800/1600; others	Custom	Flexible policy for providing interfaces for most minicomputers
PRICING AND AVAILABLE					
Purchase Price:					
Controller, $	4,400 to 5,500 (includes 1 or 2 drives)	1,980	1,980	–	–
Drive, $	–	4,560	5,545	2,320 to 11,400	7,000
First Delivery	February 1972	INA	INA	October 1971	May 1972
Availability, days ARO	45	45	45	90 to 120	Under 60
Number Installed to Date	25	10	500	112	1 (May 1972)
Serviced By	Factory and third party	Factory and third party	Factory and third party	Librascope	Third party
COMMENTS	Units available as OEM or complete systems; Cartridisc uses flexible disk; Model 10 is a single drive; Model 20 is a dual drive		Removable cartridge is IBM 2315-type	All models available for operation at 1800 or 3600 rpm; L107A is minaturized; L107MA is for hostile environments	OEM unit

All About Disk and Drum Storage

MANUFACTURER & MODEL	OMRON 6000	Pacific Microtechnics 010 Series	Pacific Microtechnics 100 Series	Per Data Series D	Per Data Series DP
PHYSICAL ARRANGEMENT					
Type	Disk	Disk	Disk	Disk	Disk
Heads	Fixed	Fixed	Fixed	Fixed	Moving
Media	Fixed	Fixed	Fixed	Fixed	IBM 2315
Controller	None standard	IMS	IMS	Integral	Integral
Drives per Controller	–	Up to 4	Up to 4	Up to 8	Up to 8
Spindles per Drive	1	1	1	1	1
Recording Surfaces per Spindle	1	1	2	2	2
STORAGE ARRANGEMENT					
Capacity per Spindle, millions of bits	7.5	Up to 19.2 to 9.6	Up to 76.8	6.464	22
Format	Bit serial	Bit serial	Bit serial; 2, 4, or 8 track parallel	Bit serial; 128 16-bit words/block	Bit serial; block or 16-bit word
Cylinders per Spindle	100	1	1	1	203
Tracks per Cylinder	1	16 to 128	256 to 1,024 (serial)	128	2
AVERAGE POSITIONING TIME, msec.	–	–	–	–	75
AVERAGE ROTATIONAL DELAY, msec.	5	16.7 or 8.3	16.7 or 8.3	8.3	20
DATA TRANSFER RATE, megabits per sec.	7.5	4.5	4.5 (serial)	3.4	1.56
INTERFACE	Flexible policy for providing interfaces for most minicomputers	DEC PDP-8, -11; Honeywell H-316	DEC PDP-8, -11; Honeywell H-316	DEC PDP-8, -11; Data General Nova; HP 2100 series; Honeywell H-316; Varian 620	DEC PDP-8, -11; Data General Nova; HP 2100 series; Honeywell H-316; Varian 620
PRICING AND AVAILABILITY					
Purchase Price:					
Controller, $	–	–	–	12,500 (includes 1 drive)	11,000 (includes 1 drive)
Drive, $	4,900	4,000 to 7,200	17,800 to 44,400	INA	INA
First Delivery	May 1972	November 1971	January 1970	INA	INA
Availability, days ARO	Under 60	90	90 to 120	60	30
Number Installed to Date	2 (May 1972)	Over 10	Over 30	INA	INA
Serviced By	Third party	PMI	PMI	Per Data	Per Data
COMMENTS	OEM unit	A model is also available with a transfer rate of 6.375 megabits per second	A model is also available with a transfer rate of 6.375 megabits per second	Models available with up to 9.024 megabits per drive	Also available with 1 fixed disk in addition to removable cartridge for a total of 44 megabits per drive

MANUFACTURER & MODEL	Pertec D3300 Series	Pertec D3400 Series	Pertec D5100 Series	Pertec D5200 Series	Potter DD 480
PHYSICAL ARRANGEMENT					
Type	Disk	Disk	Disk	Disk	Disk
Heads	Moving	Moving	Moving	Moving	Moving
Media	IBM 2315/5440	IBM 2315/5440	IBM 2315	IBM 2315	IBM 23FD-II
Controller	F3000 Formatter	F3000 Formatter	F3000 Formatter	F3000 Formatter	None supplied
Drives per Controller	Up to 4	Up to 4	Up to 4	Up to 4	–
Spindles per Drive	1	1	1	1	1
Recording Surfaces per Spindle	2 or 4	2 or 4	2 or 4	2 or 4	1
STORAGE ARRANGEMENT					
Capacity per Spindle, millions of bits	25 or 50	50 or 100	12 or 24	25 or 50	0.653
Format	Bit serial	Bit serial	Bit serial	Bit serial	Bit serial; 8 sectors/ track
Cylinders per Spindle	203	203	203	203	32
Tracks per Cylinder	2 or 4	2 or 4	2 or 4	2 or 4	1
AVERAGE POSITIONING TIME, msec.	35	35	60	60	853
AVERAGE ROTATIONAL DELAY, msec.	20; 12.5 optional	20; 12.5 optional	20	20	333
DATA TRANSFER RATE, megabits per sec.	1.562; 2.5 optional	1.562; 2.5 optional	0.72	1.562	0.0333
INTERFACE	None	None	None	None	None
PRICING AND AVAILABILITY					
Purchase Price:					
Controller, $	2,300	2,300	2,300	2,300	–
Drive, $	3,800 to 4,600	4,600 to 5,400	3,500 to 4,100	3,800 to 4,400	Under 500 (large quantities)
First Delivery	July 1972	November 1972	March 1971	March 1971	INA
Availability, days ARO	60	–	45	45	INA
Number Installed to Date	–	–	See Comments	See Comments	0
Serviced By	Pertec and customer	Pertec and customer	Pertec and customer	Pertec and customer	INA
COMMENTS	OEM units; models are available using either IBM 2315-type or 5440-type cartridge; models are available with 1 removable or with 1 removable and 1 fixed cartridge		OEM units; models are available with 1 removable or with 1 removable and 1 fixed cartridge; about 500 D5000 series drives have been delivered		

All About Disk and Drum Storage

MANUFACTURER & MODEL	Sagem Series MS 400	System Industrie's 3500	System Industrie's 3400	Systematics/ Magne-Head SA7000 Series	Systematics/ Magne-Head SA8000 Series
PHYSICAL ARRANGEMENT					
Type	Disk	Disk	Disk	Drum	Drum
Heads	Fixed	Moving	Moving	Fixed	Fixed
Media	Fixed	IBM 2315	Fixed	Fixed	Fixed
Controller	None supplied	3010	3010	SA7100 Series	SA8100 Series
Drives per Controller	–	Up to 8	Up to 4	INA	INA
Spindles per Drive	1	1	1	1	1
Recording Surfaces per Spindle	1	2	2	1	1
STORAGE ARRANGEMENT					
Capacity per Spindle, millions of bits	1.072 to 17.152	24	6	10 to 300	5 to 150
Format	Bit serial	Bit serial	Bit serial	Bit serial or parallel	Bit serial or parallel
Cylinders per Spindle	1	203	64	1	1
Tracks per Cylinder	16 to 256	2	2	Up to 2,048	Up to 1,536
AVERAGE POSITIONING TIME, msec.	–	60	–	–	–
AVERAGE ROTATIONAL DELAY, msec.	8	20	8.7	8.7	4.3
DATA TRANSFER RATE, megabits per sec.	4	1.56	3.3	7.2 (serial)	7.2 (serial)
INTERFACE	Custom	DEC PDP-8, -11, -12; Data General Nova; Varian 620; Microdata 800/1600	DEC PDP-8, -11, -12; Data General Nova; Varian 620; Microdata 800/1600	Custom	Custom
PRICING AND AVAILABILITY					
Purchase Price:					
Controller, $	Contact vendor	3,000 to 4,000	3,000 to 4,000	Contact vendor	Contact vendor
Drive, $	Contact vendor	3,000 to 5,000	4,000 to 8,000	Contact vendor	Contact vendor
First Delivery	INA	INA	INA	1967	1969
Availability, days ARO	INA	14	56	120	150
Number Installed to Date	0 (U.S.)	100	Over 10	700	200
Serviced By	INA	Systems Industrie's	Systems Industrie's	Magne-Head	Magne-Head
COMMENTS	OEM units; drives are built in France	The two series can be intermixed on the same controller; much of I/O handler logic is hard-wired in controller; disk drives used are Diablo and Applied Magnetic's Corp.			

MANUFACTURER & MODEL	Systematics/ Magne-Head DisCstor 500	Tally 2000	Tally 3000	Tally 4000	Vermont Research 3002
PHYSICAL ARRANGEMENT					
Type	Disk	Disk	Disk	Disk	Drum
Heads	Fixed	Fixed	Fixed	Fixed	Fixed
Media	Fixed/Cartridge	Fixed	Fixed	Fixed	Fixed
Controller	Integral	None supplied	None supplied	None supplied	None supplied
Drives per Controller	1	–	–	–	–
Spindles per Drive	1	1	1	1	1
Recording Surfaces per Spindle	2	2	2	2	1
STORAGE ARRANGEMENT					
Capacity per Spindle, millions of bits	1 to 16	0.4 to 6	0.4 to 8.96	0.68 to 5.4	4.6 max.
Format	Bit serial or parallel	Bit serial	Bit serial	Bit serial	Bit serial
Cylinders per Spindle	1	1	1	1	1
Tracks per Cylinder	Up to 256	8 to 120	8 to 128	8 to 64	128 max.
AVERAGE POSITIONING TIME, msec.	–	–	–	–	–
AVERAGE ROTATIONAL DELAY, msec.	8.7	8.5	17	17	8.7
DATA TRANSFER RATE, megabits per sec.	3.7 (serial)	3	1.5 or 2.1	2.54	2.1
INTERFACE	Custom	None	None	None	None
PRICING AND AVAILABILITY					
Purchase Price:					
Controller, $	Contact vendor	–	–	–	–
Drive, $	Contact vendor	3,300	3,300	4,400	6,150 max.
First Delivery	1970	1968	1968	1968	INA
Availability, days ARO	60	30	30	30	INA
Number Installed to Date	100	INA	INA	INA	See Comments
Serviced By	Magne-Head	Tally	Tally	Tally	Vermont Research
COMMENTS	Unit uses special cartridge, which is fixed or removable, depending on model				See Comments at bottom of next page

All About Disk and Drum Storage

MANUFACTURER & MODEL	Vermont Research 3008	Vermont Research 3102	Vermont Research 1004	Vermont Research 1016
PHYSICAL ARRANGEMENT				
Type	Drum	Drum	Drum	Drum
Heads	Fixed	Fixed	Fixed	Fixed
Media	Fixed	Fixed	Fixed	Fixed
Controller	None supplied	None supplied	6100	6100
Drives per Controller	–	–	Up to 8	Up to 8
Spindles per Drive	1	1	1	1
Recording Surfaces per Spindle	1	1	1	1
STORAGE ARRANGEMENT				
Capacity per Spindle, millions of bits	18.4 max.	1.05, 2.1, or 4.19	4.48 or 2.56 max.	17.92 or 10.24 max.
Format	Bit serial	Bit serial	Bit serial	Bit serial
Cylinders per Spindle	1	1	1	1
Tracks per Cylinder	512 max.	32, 64, or 128	128 max.	512 max.
AVERAGE POSITIONING TIME, msec.	–	–	–	–
AVERAGE ROTATIONAL DELAY, msec.	8.7	8.7	8.7	8.7
DATA TRANSFER RATE, megabits per sec.	2.1	1.76; interlace of 2, 4, or 8 opt.	2.0 or 1.2	2.0 or 1.2
INTERFACE	None	None	None	None
PRICING AND AVAILABILITY				
Purchase Price:				
Controller, $	–	–	Contact vendor	Contact vendor
Drive, $	Contact vendor	Contact vendor	Contact vendor	Contact vendor
First Delivery	INA	INA	INA	INA
Availability, days ARO	INA	INA	INA	INA
Number Installed to Date	See Comments	See Comments	See Comments	See Comments
Serviced By	Vermont Research	Vermont Research	Vermont Research	Vermont Research
COMMENTS	Models 1004H and 1016H are sealed versions of 1004 and 1016; special models are available with 4 or 8 times the capacity of the 1016. To date Vermont has delivered over 3000 drum memory units			

MANUFACTURER & MODEL	Wabash Disc Memo	Xebec XMD 8224	Xebec XMD 7224	Xebec XMSD-3000 MEGA-STOR
PHYSICAL ARRANGEMENT				
Type	Disk	Disk	Disk	Disk
Heads	Fixed	Moving	Moving	Moving
Media	Fixed	IBM 2315	IBM 5440	Fixed
Controller	DMC-600	XDC 200	XDC 200	XDC 200
Drives per Controller	Up to 4	Up to 4	Up to 4	Up to 4
Spindles per Drive	1	1	1	1
Recording Surfaces per Spindle	2	4	4	2
STORAGE ARRANGEMENT				
Capacity per Spindle, millions of bits	0.25 to 15	52.8	52.8	19.2
Format	Bit serial	Bit serial	Bit serial	Bit serial
Cylinders per Spindle	1	406	406	203
Tracks per Cylinder	8 to 128	2	2	2
AVERAGE POSITIONING TIME, msec.	–	35	60	75
AVERAGE ROTATIONAL DELAY, msec.	8.3 or 16.7	20	20	20
DATA TRANSFER RATE, megabits per sec.	2.5	1.562	1.59	1.59
INTERFACE	DEC PDP-8, -8E, -8L, -11, -12; GRI-909; Interdata 70	DEC PDP-8I, -8L, -8E, -11, -12, -9, -15; MAC-16; Data General Nova; Varian 620; others	DCC 112, 116; HP 2100 series Interdata 3,4,5,70	DCC 112, 116; HP 2100 series; Interdata 3, 4, 5, 70
PRICING AND AVAILABILITY				
Purchase Price:				
Controller, $	2,770	9,450 to 12,500 (includes 1 drive)	9,450 to 12,500 (includes 1 drive)	5,125 to 7,125 (includes 1 drive)
Drive, $	4,770 to 6,400	INA	INA	INA
First Delivery	INA	October 1970	October 1970	June 1972
Availability, days ARO	90	45	45	60
Number Installed to Date	10	INA	INA	INA
Serviced by	Factory	Factory and independent reps.	Factory and independent reps.	Factory and independent reps.
COMMENTS	Unit can be tailored to fit customers' needs	Includes basic software; has two cartridges per drive	Includes basic software; has 2 cartridges per drive	Uses non-removable IBM 2315-type cartridge; includes basic software

All About Disk and Drum Storage

MANUFACTURER & MODEL	XLO 3301	XLO 3322-1	XLO 3322-2	XLO CD Series AUTO-LIFT	XLO AB Series AUTO-LIFT
PHYSICAL ARRANGEMENT					
Type	Disk	Disk	Disk	Drum	Drum
Heads	Fixed	Moving	Moving	Fixed	Fixed
Media	Fixed	Cartridge	Fixed/cartridge	Fixed	Fixed
Controller	Available	Available	Available	Available	Available
Drives per Controller	1	Up to 4	Up to 4	–	–
Spindles per Drive	1	1	1	1	1
Recording Surfaces per Spindle	2	2	4	1	1
STORAGE ARRANGEMENT					
Capacity per Spindle, millions of bits	1.33 to 10.64	75	150	9.6 to 154.3	4.8 to 77.2
Format	Bit serial	Bit serial	Bit serial	Bit serial; 2, 4, or 8-bit parallel	Bit serial; 2, 4, or 8-bit parallel
Cylinders per Spindle	1	357 (6 spares)	357 (6 spares)	1	1
Tracks per Cylinder	16 to 128	2	4	128 to 1024	128 to 1024
AVERAGE POSITIONING TIME, msec.	–	30	30	–	–
AVERAGE ROTATIONAL DELAY, msec.	16.7, 12.5, or 8.3	8.3	8.3	8.3 or 16.7	8.3 or 16.7
DATA TRANSFER RATE, megabits per sec.	2.49, 3.32, or 4.97	6.45	6.45	4.52 (serial)	2.26 (serial)
INTERFACE	None	None	None	None	None
PRICING AND AVAILABILITY					
Purchase Price:					
Controller, $	Contact vendor	Contact vendor	Contact vendor	Contact vendor	Contact vendor
Drive, $	5,500 (max.)	6,100	6,600	Contact vendor	Contact vendor
First Delivery	June 1972	June 1972	June 1972	December 1970	December 1969
Availability, days ARO	30	60	60	120	120
Number Installed to Date	–	–	–	INA	INA
Serviced By	XLO	XLO	XLO	XLO	XLO
COMMENTS	OEM unit	OEM unit; uses IBM 3336-type disk in a 5440-type cartridge; lower speeds available.	OEM unit; uses same cartridge as 3322-1 plus 1 fixed IBM 3336-type disk	OEM units; both series include models with 10-inch drums (512 tracks max.) and 18.5-inch drums (256 tracks min.); larger drum has twice the bits/track of smaller drum. These units also known under Bryant name	

All About Magnetic Tape Units

Magnetic tape is a curious thing. Unconfined by the high flanges of a reel, it becomes a writhing mass, seemingly immune to any possibility of order. Yet, when wound onto the reel, it becomes a useful means of both storing information and transferring it to a computer when needed.

This report surveys the broad range of magnetic tape equipment currently available to computer users (or suppliers) who choose to customize their systems. You'll find comparison charts covering 95 reel-to-reel, cassette, and cartridge drives from 42 manufacturers, plus an informative review of magnetic tape technology.

Magnetic tape, in common with magnetic disks and drums, possesses one property that made it worthwhile to go through the ardous process of perfecting the production and use of magnetic materials – a technological achievement not to be underestimated. That property is the capability for information to be erased and rewritten without damaging or changing the original medium. This capability makes the use of magnetic media economical.

The niche in the arena of data processing peripherals that is reserved for magnetic tape can be simply defined. Magnetic disks and drums are available with higher performance than that of tape units. Punched tape is unrivaled in the low cost of the devices for handling it. Photographic processes take the prize for information storage density. Magnetic tape represents an attractive compromise among these three characteristics that make it suitable for a wide range of data processing applications. In itself, magnetic tape is not a suitable medium for direct manipulation of information by a person. However, with the advent of low-cost processing circuitry and CRT display devices, it is not difficult to adapt it even for direct manipulation.

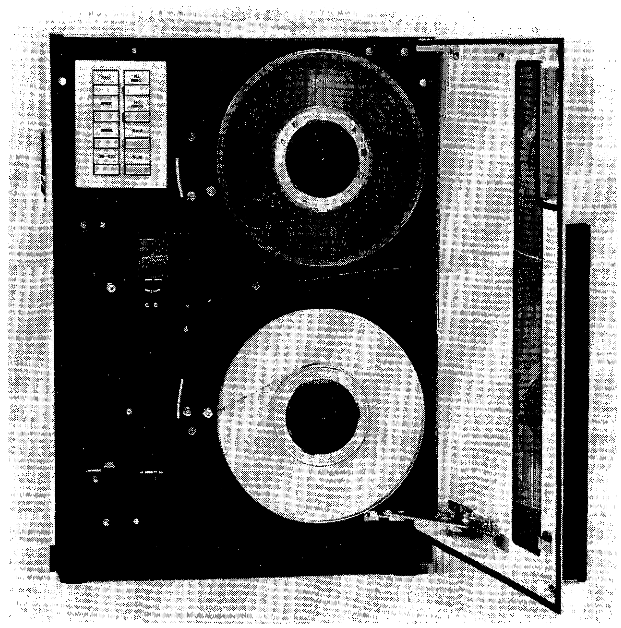
A Brief History

The development of magnetic tape was slow until plastics were developed that had the necessary combination of flexibility, stability, and strength. This began in the mid-1940's. The original need that spurred development was for scientific and engineering purposes. UNIVAC is credited with the design of the both first tape and the first practical tape for use with computers. The first was solid metal; the first practical computer tape was also solid metal, but the magnetic material was contained in a coating. The big push for a cheap, easy-to-handle tape came from the consumer market for tape recorders for home and studio use. The production of tape for high-density, high-speed tape units came about directly because of the need for faster ways to store and transfer large amounts of data.

The Magnetic Phenomenon

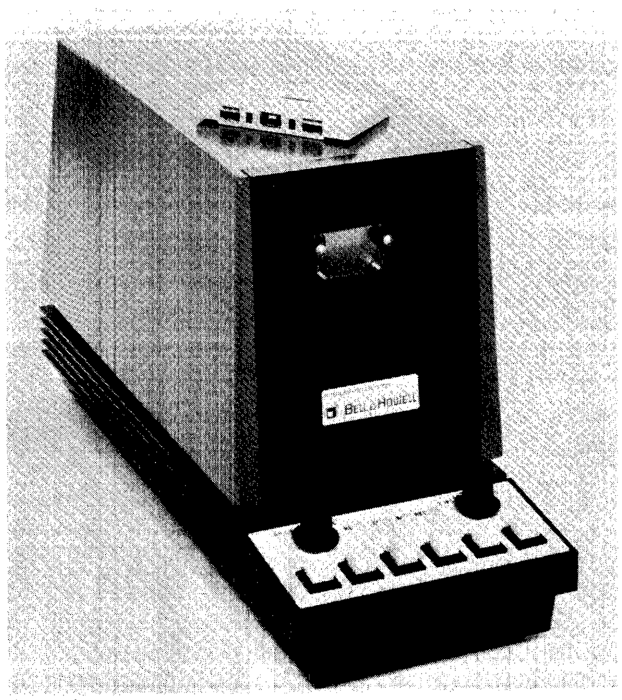
Magnetism has been known for hundreds of years. Natural magnets, called lodestones, served as compasses and made navigation in all weather possible, if risky. The discovery of electricity, and the equally important discovery that magnetism could be induced in some metals through the use of electricity, opened a whole new era in mechanical design. Flexible connections of almost any length could connect an energy source with a mechanical transducer for producing motion.

Magnetic recording depends not on the forces caused on a metallic object by a magnetic field, as in motors and loudspeakers, but on two facts that were actually hindrances in the early application of electromagnetism. One is that electric currents could be used to produce permanent magnetism (or to leave a residual magnetism). The second is that a magnetic field could induce a current when a metallic object was moved through it. The second fact contains the essence of magnetic recording devices – relative motion between the magnetic field and the sensing apparatus. In the case of magnetic tape, the magnetic fields, representing individual data bits, are contained on the tape which moves relative to the read/write head.



The Ampex TMZ tape unit features single-capstan drive (wheel at lower left), tension arms, and speeds up to 60,000 bytes per second. The tape path looks particularly complex; but, when loading, the tension arms move to the center so that threading in and around the guides is not necessary.

All About Magnetic Tape Units



Although you can't tell by looking, when you load a cassette into the Bell & Howell Model 240, fingers automatically hook the tape and draw it out over a single-capstan drive. This allows a tape speed of 20 inches per second writing and 80 inches per second searching. The new ANSI/ECMA standard cassette recording format is used. Another unusual feature is the strain gages that provide the signals for tension control.

It is possible to sense the magnetic state of a static object; core memories do this, but sensing apparatus is required for each and every bit position. With magnetic tape, the use of motion permits the use of only one sensing device, which reduces the cost of the unit. Unfortunately, this motion also introduces mechanical design difficulties. In addition, the magnetization process is decidedly non-linear, introducing electronic circuit difficulties. Both of these problem areas are sizable.

In retrospect, it is doubtful that progress in magnetic tape and transport design would have been nearly so rapid without the spur of a large consumer market in a parallel field. (Perhaps it will help you live with the raucous, inane, and sometimes even musical sound of rock if you realize that it, or the equivalent of a few years ago, helped to make your profession in computers possible.) However, there are many design differences between digital tape transports for computers and analog recorders for music. If commercial tape recorders for the home seem crude beside your bright and shiny computer drives, compare their costs. And remember that as crude as the home recorders are, they still record reasonably faithfully a much greater information density than computer tape transports. We have yet to find a way to make use of this capability, though. As inefficient as digital processes are in terms of space, they are the only ones we have mastered, so they will have to do for the time being.

Tape Versus the World

Before you decide which type of tape unit and which brand and which model, you must decide whether or not magnetic tape is suitable for your needs. Modern disk units can compete with tape units under certain circumstances in terms of cost, performance, and storage space. The traditional forte of magentic tape has been for sequential processing. Another way of saying this that relates better to some applications, is that tape is particularly well suited for applications where all of the information stored is to the processed in the sequence in which it was recorded. The latter statement explains why tape is being used for buffer units in communications terminals (when the information stored between transmissions is large) and probably why direct key-to-disk techniques are not being widely promoted.

It is difficult to relate the use of magnetic tape to specific data processing applications because it serves normally as an intermediate storage medium. The source of information, its use, and its destination are of little significance except where it is necessary to exchange data among several computers. In this case, tape does present a convenient, high-density means of physically carrying it from place to place.

If it comes down to a question between magnetic tape and disk, a decision can normally be based on the frequency and sequence of use of the recorded information. Heavy reference to many different data sets in no predictable order favors disk. Heavy reference to a few data sets in a known sequence favors tape. As always, there is room for discussion where the two conditions overlap. Historically, computer installations have found it easier to do without disk than without tape, except for holding systems programs and data bases which are frequently and randomly referenced.

Recent Developments

Never in the history of computers have the independent manufacturers of peripheral equipment been so active. Many things contribute to this activity. The growth of the minicomputer has opened new opportunities because very few of the manufacturers have found it economically feasible to manufacture their own peripherals at their present stage of company development. The maturing of computer technology means that more and more people are capable of designing and building effective equipment.

Of the total equipment cost of a computer installation, from half to three-quarters or more of the cost is generally devoted to peripheral gear. (The smaller the system, the larger the percentage.) The large amount of money being spent on peripherals led many to build devices that could be substituted directly for the ones supplied by IBM, which still has by far the largest portion of the business.

All About Magnetic Tape Units

The most active area in magnetic tape units is cassettes. This area started out using the Philips cassette, which quickly achieved worldwide popularity for use in home recorders because of its compact size and convenience of use. It has progressed to the point where a European standard has been adopted and an American standard is expected shortly for computer-grade cassettes, which are already on the market. These are not toys. They are highly precise, low-cost, low-performance units that are receiving widespread acceptance by manufacturers and users of minicomputers and terminals.

Where to Find Information

Contained in this report are comparison charts of magnetic tape devices other than those marketed by the mainframe vendors as part of their systems. For the mainframe tape units, you can refer to the individual reports on computer systems behind the Computers tab in DATAPRO 70. For much the same reason, tape drives that are plug-compatible with the IBM family of computers are also omitted from the charts; for detailed information on these devices, consult the DATAPRO 70 Index under the heading "tape drives (IBM-compatible)."

Both OEM and end-user tape units are included in this survey. The distinction between OEM sales to manufacturers of systems and end-user sales is becoming a little vague as the popularity of minicomputers grows. A large company intending to install several units to function as terminals may elect to build the systems itself and, in effect, become an OEM. The principal difference between OEM and end-user purchases is the determination of who does routine maintenance. Typically, an OEM vendor's service does not extend beyond a warranty.

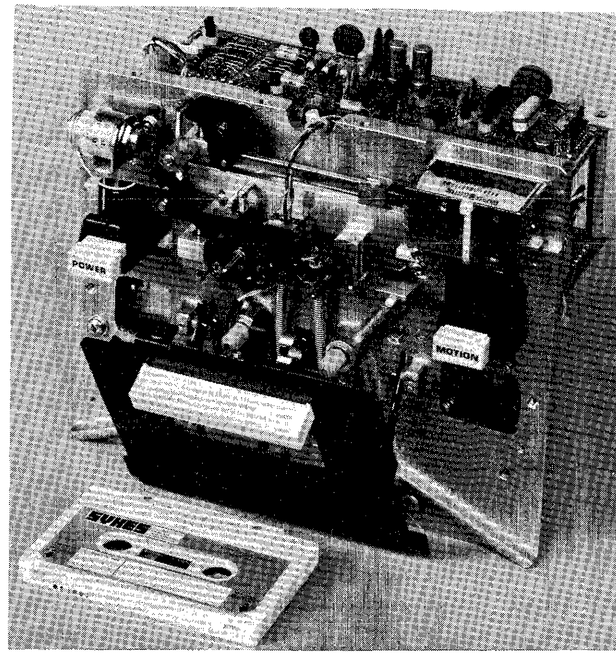
Putting It All Together

There is a significant amount of glamour associated with putting together your own system. The price of components has decreased to the point where you can almost indulge your fancy for tinkering. It is Datapro's recommendation that you do not try to put together a whole system at once from components purchased from a number of different vendors unless you are prepared to spend a great deal of time and effort in this pursuit; treat it like a hobby if you simply have to do it.

However, if you want to install a tape unit of different performance than the standard units available with your minicomputer system, then with care it can work out. Many of the vendors offer specific hardware interface logic and software support for many of the popular minicomputer models.

Characteristics of Tape Units

The salient characteristics of 95 commercially available magnetic tape units from 42 manufacturers are presented



The insides of a Sykes CompuCorder. The cassette is inserted in a vertical position. The pinch roller drive, read/write head, and tape guides are at the top. Note the plugs at the extreme left and right of the cassette; these knock-outs provide for protection against writing on either "side" of the cassette, allowing permanent data or programs to be maintained safely.

in the accompanying comparison charts. All information in the charts was supplied by the manufacturers during May and June 1972; their close cooperation with the Datapro Research staff in the preparation of these charts is greatly appreciated.

The chart entries and their significance are explained in the following paragraphs.

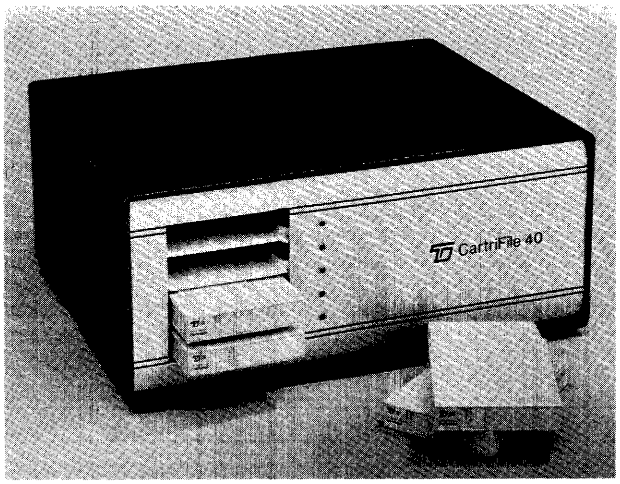
Type

The *reel-to-reel* tape unit is the one seen in most computer installations. The removable portion is a single reel; when loaded, the tape is transferred to another reel that is usually permanently mounted.

Another basic type of tape unit also uses two reels for handling the tape, but both reels are mounted in a removable cartridge. Several types of cartridges are used. The most common is an adaptation of the *Philips cassette* used for home recording. Where the type of cartridge is unique to one manufacturer, it is noted as a *proprietary cartridge.*

The Philips cassette achieved greatly enhanced stature when the European Computer Manufacturers Association (ECMA) adopted a standard pertaining to the cassette and how it is recorded. The standard is very complete. It details all dimensions of the cassette and tape, as well as specifying the exact recording method. Included are speci-

All About Magnetic Tape Units



Tri-Data was one the pioneers in the use of cartridge tape units for minicomputers. Shown here are the CartriFile 40 and Tri-Data's own endless-loop cartridges. A slide on the front edge provides file protection. All four cartridges are driven independently from one capstan and four sets of pinch rollers.

fications concerning the forces required to move the tape. The American National Standards Institute is in the process of adopting this standard as well. The purpose of the standard is to enable the interchange of information among different locations using tape units made by various manufacturers. If cartridges and tape units are manufactured to these standards, it will be great; but the Datapro staff has reservations about just how well the standards will be met by devices advertising ANSI/ECMA compatibility because of the extent of the standard. Compatibility among units produced by the same manufacturer can be achieved without necessarily achieving compatibility with other manufacturers' units.

There are three common *tape widths* in use today. Conventional tape units use 0.5-inch-wide tape. The width of the tape in Philips cassettes is 0.15 inch, though some refer to this as 1/8-inch tape. Manufacturers of proprietary cartridges commonly use 0.25-inch tape.

Tape length that is usable for data recording varies with the size of the reel for reel-to-reel units and with the thickness of the tape for computer-grade Philips cassettes.

Three reel diameters are common for reel-to-reel units. The 10.5-inch reel is most familiar and holds 2400 feet of tape. An 8.5-inch reel holds 1200 feet, and a 7-inch reel holds 600 feet.

The ECMA standard for 0.15-inch tape specifies tape length to be between 282 feet and 295 feet. Computer-grade Philips cassettes come in various lengths up to 600 feet.

The *drive mechanism* is the heart of a tape unit. It is the means for moving the tape. The design problem for engineering the drive mechanism involves moving the tape in a repeatable manner so that the recorded patterns can be read by the same unit or by another unit. The principal drive methods are by capstan and motor-driven reels, with many variations in the mechanical linkage between the motors and the drive and in the method for controlling the speed of the motors.

The term *capstan* is taken from naval usage. Basically it is a constantly rotating cylinder; movement is accomplished by increasing the friction between it and the thing to be moved – in this case, tape. There are several ways to accomplish this. A pinch roller is a free-turning wheel used to push the tape against the capstan to generate the necessary friction. A single-capstan drive uses tension in the tape to create the friction. A dual capstan uses two capstans turning in opposite directions for bidirectional movement. Bidirectional movement can also be accomplished by reversing the rotation of the capstan. A vacuum capstan is hollow with vents on the surface; when the capstan is connected to a vacuum source, external air pressure forces the tape against the capstan. The techniques just described were mentioned in the order of increasing "goodness" of operation. High-speed transports normally use vacuum capstans, which minimize tape wear and tear; low-speed ones normally use pinch roller drives for the sake of economy.

Motor-driven reel mechanisms are used only in cassette or cartridge drives. For these units, the rotational inertia of the reel and tape is low enough to control directly; i.e., the speed of the motor varies to keep the tape speed constant. In some units, the speed of the motor is constant and the tape speed varies in a prescribed manner from beginning to end; in these cases, the recording density varies but is repeatable.

Many innovations have been developed to control motor speed for reels and capstans, not only to control the speed of the tape passing the head, but also to control tape tension in some cases.

There is another major difference in drive mechanisms. Some are synchronous, some are incremental, and some can be operated in either mode.

Synchronous drives are designed to record data in blocks. Upon completion of a block, the tape stops. The distance required for the tape to slow down and stop, added to the distance required for it to get up to speed again for the next block, is the inter-record gap.

Incremental drives, on the other hand, are designed to record one character at a time; the advantage of this method is that it eliminates inter-record gaps when the data is coming in slowly and an intermediate buffer is not desired. It is not unusual for incremental drives to play back at a higher rate than their maximum recording rate. The nature of some of the motors employed in drives is

All About Magnetic Tape Units

> stepwise to permit speed control, so that incremental operation is assumed but continuous speed is possible. A true incremental unit records at the specified density and can start or stop on a single character. When recording to a particular format standard, there is no advantage of incremental operation over synchronous operation. Synchronous drives, however, can operate at much higher speeds.

Control of the tension in the tape in the area of the read/write head becomes more important as the speed of the drive increases. Tension affects speed control, durability of the tape, and the recording properties of the tape. This is more critical in reel-to-reel drives because of the larger inertia of the reels and consequent slow response and high power requirements if tension control were attempted by the reel motors directly. It can be done, but it is seldom worthwhile. A *tape buffer* is an arrangement for maintaining constant tension in the tape. Two frequently used methods are tension arms and vacuum columns.

Tension arms employ a loop of tape around a spring-loaded privoted or sliding arm that moves in response to tape tension. This mechanism also usually controls the motors driving the supply and takeup reels.

Vacuum columns employ loops of tape in a column with multiple ports. The differential pressure between the vacuum and the atmosphere regulates tape tension. As the tape moves, the position of the loop moves in the column, and this is sensed to drive the reel motors. This technique is used for high-speed tape movement.

Most cassette and cartridge transports control tape tension through control of the reel motors, but some employ tension arms by extracting the tape from the cassette and automatically filling the tape path. One even uses a vacuum column method. Tape buffers are generally not required because the inertia of the tape and reels is low enough to make it practical to control them directly.

The *controller* is the device that decodes the digital commands from the computer, buffers data characters as needed, performs error checking, and sends the proper control and data signals to the tape drive. The innards of a controller can become very complex if several drives are to be accommodated with different speeds, different formats, and the possibility for simultaneous reading and writing (on different drives, of course). For conventional computer configurations, it is not unusual for the controller to cost as much or more than one tape drive of high performance. Several of the independent manufacturers produce a unit called a "formatter" which includes many of the functions of a controller, missing most notably the command decoding logic.

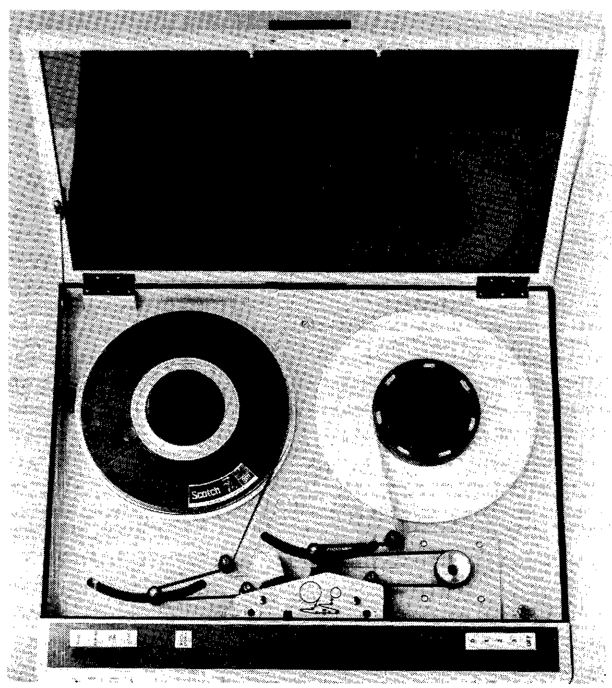
Recording Arrangement

The *density, format,* and *method* describe the arrangement of magnetic patterns on the tape. While the same reel of tape can be used on transports of widely varying drive design, unless these three characteristics are the same from unit to unit, data cannot be swapped.

Density refers to the spacing of bits along the longitudinal dimension of the tape. The actual pattern density will vary according to the recording method.

Format refers to the arrangement of bits to make up characters or words. Some formats record several tracks in parallel to increase the information density. Others record only one track, or "bit serial." For conventional drives, two formats are almost universal: ANSI 7-track and ANSI 9-track. For cassettes, the ANSI/ECMA standard specifies 2-track recording, but allows the second track to be used for any purpose; some manufacturers use it for a second bit-serial data track, some for clocking information, and some for redundant recording. (What is standard about that?) The format also includes the size of the inter-record gap for synchronous recorders.

The *method* of recording gets into the technique for inducing the magnetic patterns and the style of the patterns, so to speak. Two methods are commonly used: NRZI and Phase Encoding (PE). ▷



Hewlett-Packard is one minicomputer manufacturer that makes many of its own peripheral units. Shown here is one of the H-P Series 7970 tape units, which feature speeds up to 72,000 bytes per second.

All About Magnetic Tape Units

Discussion of recording techniques tends to get pretty complex pretty fast. Elements of information theory creep in when explaining why one technique is better than another in the sense that redundancy of information becomes involved, though usually not in a manner that permits easy error checking.

The basic element of magnetic recording is a flux transition. (Flux is the magnetic field itself; a flux transition is a change in the direction of magnetization. "Flux reversal" is also used in this manner.) The number and pattern of flux transitions used for a "1" or "0" bit or for certain combination of bits (a "0" followed by a "1", for example) are determined by the recording method. Fortunately, the recording method is covered by the various standards that have been adopted and seldom really becomes important in and of itself because recourse can be made to "Is it ANSI 9-track 800-bpi compatible?" However, we will have a go at putting the more common methods into words. (Again, fortunately, this subject is well covered in the literature for those who want to delve deeper.)

The simplest method is *return to zero (RZ).* A "1" is generated by a positive pulse of current through the coil in the write head; a "0" is represented by a negative current pulse. These pulses produce magnetic patterns of opposite polarity; i.e., when moving the tape past the read head, a positive or negative current will be induced. The name comes from the fact that between pulses, the current flowing through the head is zero. This technique does not permit high recording densities, but it does have the advantage of simplifying the required circuitry.

A slight modification of the above gives the *return to bias (RB)* method. A pulse is recorded for a "1" but not for a "0". If timing information is available, "0's" are detected by the absence of a pulse in a bit position.

A couple of methods have current flowing in the write head at all times and impart bit information by changing the direction of the current. This does nice things for the engineers trying to increase bit density. The *non-return to zero (NRZ)* method reverses current whenever a different bit comes along. In plain words, a string of "1's" or "0's" would result in a continuous current flow with no reversals; then when the other type of bit came along, the current would reverse. This is an efficient method, but has one big drawback; if a bit is missed, all the succeeding bits will be read wrong (or until another bit is missed). If you are interested in information theory, this is a case where a poor mechanism (many errors) would be correct more often than a very good one (one error).

The *NRZI* method eliminates this problem by always reversing current on a "1" and never on a "0", at the cost of a slightly decreased efficiency– which seems a small price to pay for the increased reading realiability. The disadvantage of the NRZI (and NRZ) method is that it is not self-clocking; i.e., there is not enough information in a single track to convey both what the bit is and where it is. For multi-track recording, the problem is handled by using odd-parity to ensure that there is at least one "1" bit in each frame. This method is sensitive to skew (i.e., passing the tape past the head at other that a right angle). What skew does is to mix the bits from different frames. (And this is definitely *not* what is meant by "random processing.")

The closest thing to a perfect recording method used so far is *phase encoding (PE).* This method uses the direction of flux transitions to indicate "1's" and "0's". To do this, insignificant reversals have to be inserted in between bit positions so that the proper direction can be recorded. This method is self-clocking and much less sensitive to speed fluctuations and skew (for multi-track recording). The disadvantage of this method, or group of methods to be more precise, is that it requires twice the bandwith required by the NRZI method. This translates directly into reduced bit density. Wait a minute, you say? Didn't IBM double the density when it announced the PE format? The answer is yes. The secret is simply that a new, and much better, tape was also introduced.

The following table represents the various standard combinations adopted over the years:

Density, bpi	Tracks	Method	Standard	Inter-Record Gap, inches
200	7	NRZI	ANSI	0.75
556	7	NRZI	ANSI	0.75
800	7	NRZI	ANSI	0.75
800	9	NRZI	ANSI	0.6
1600	9	PE	ANSI	0.6
800	1 or 2	PE	ECMA/ANSI (cassette)	0.7

In the comparison chart, entries for the various standard formats, when many options are available, are intended more to guide you to the appropriate entries in the above table than to attempt to rigorously identify each and every combination, which sometimes run into the dozens. Normally, all three or any two 7-track formats can be included in the same reel-to-reel tape unit. In the same manner, the 7-track and 9-track 800-bpi formats can often be combined, as can the 9-track 800-bpi and 1600-bpi formats. In addition, it is not unusual for a manufacturer to supply format combinations which are not a part of his standard product line.

Read-after-write checking refers to the type of head used. A dual-gap head combines a logically separate read head and write head into one mechanical unit. The advantage is the capability for immediate checking to see if a valid bit ∑

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pattern has actually been written. (In audio recording, they call this "monitoring.") Magnetic tape is almost unique in providing this capability. A few card readers have dual read stations which can accomplish the same thing, but the capability is not implemented in magnetic disks, for example. Some vendors say it is unnecessary for disk recording. Some cynics point out that head crash detection is more important than read-after-write checking for disk drives.

The real situation is that dual-gap heads are expensive, and disk drives use a lot of heads. In addition, tapes are usually more abused in typical installations than disk packs are. Tapes are frequently used beyond their useful life, giving rise to many bad areas on the tape. Automatic retry and erase/skip routines can keep an installation in ignorance of the condition of a tape until it gets really bad. Read-after-write checking at least ensures that the data will be readable.

Tape Speed

This parameter measures the speed of the tape moving past the head. For synchronous drives, the speed is given in inches per second. For the purely incremental drives, it is given in steps (usually bits or characters) per second. Where a range is given, this means that several options are available within that range. In a couple of instances, the speed is variable and can be set by the user, or the speed is not constant; these instances are noted directly.

Tape speed usually has nothing to do with compatibility. As long as one of the standards is used, and *adhered* to, the tape speed is immaterial.

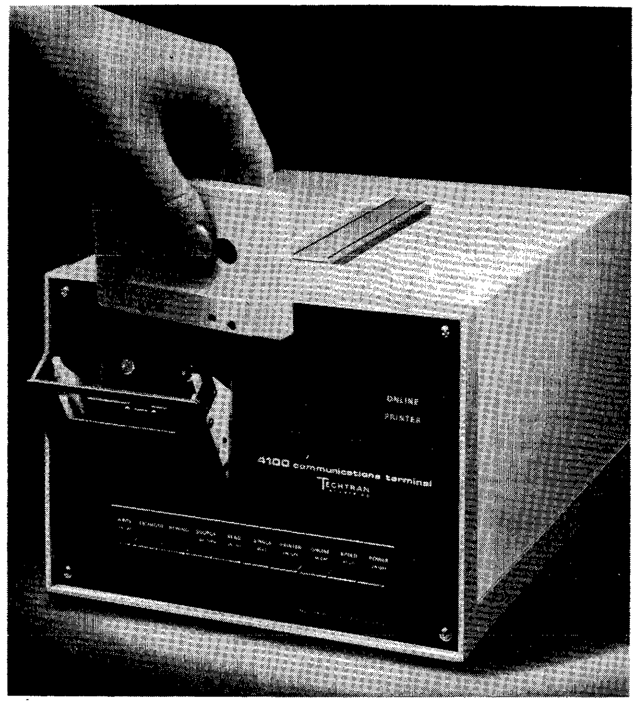
Data Transfer Rate

This characteristic is the product of the tape speed and the recording density adjusted for any parallel (multi-track) recording. Abbreviations used in the comparison charts include KCS (thousands of 6-bit characters per second), KBS (thousands of 8-bit bytes per second), and bps (bits per second).

Interface

This component is the actual physical connection between the computer and the tape subsystem. The entry identifies specific computers for which the vendor will supply a suitable interface. This, of course, determines the ease with which you can connect a particular tape unit to your computer. Where no interface is available, the type of interface required, bit serial or bit parallel, is noted when different than expected. For example, a 9-track reel-to-reel unit would normally have a 9-bit parallel interface.

Some entries specify an RS-232 interface. This is the standard EAI interface for modems and communications lines.



The Techtran 4100 is designed to serve as a buffer in a communications environment. It can be substituted between a terminal and the communications line or connected to a minicomputer; in the latter case it provides an RS-232 interface for the minicomputer – a neat way to get an intelligent terminal.

Pricing and Availability

Purchase prices only are given because outright purchase is the only way the great majority of these units can be obtained. If a single price is listed for a tape drive, it normally includes the tape transport mechanism along with motion control and read/write electronics. Any feature specified as an option is not reflected in the price. When available, pricing information concerning interfaces is included under Comments. Deviations from these rules are noted.

First Delivery identifies the date of initial delivery of a commercial unit.

Availability specifies the length of time following receipt of order required for delivery.

The *number installed to date* is self-explanatory. Note, however, that the same unit may appear more than once in the charts – once as an OEM unit and one or more times as a subsystem sold to end-users. The first delivery date and the number installed taken together give an idea of the acceptance of the unit by users.

The entry under *serviced by* tells what arrangements have been made for service. For some OEM units, service is confined to warranty. Others require a return to the factory. Some have made arrangements with one of the

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independent service companies, such as Honeywell or SirVess.

Under *Comments*, any additional information that may help you get a feel for the unit is included.

Tape Unit Manufacturers

Listed below for your convenience in obtaining additional information, are the full names, addresses, and telephone numbers of the 42 manufacturers whose products are summarized in the comparison charts.

Ampex Corp., Computer Products Division, 13031 West Jefferson Boulevard, Marina delRey, California 90291. Telephone (213) 821-8933.

Anderson Jacobson Inc., 1065 Morse Avenue, Sunnyvale, California 94086. Telephone (408) 734-4030.

Astro-Science Corporation, 9700 Factorial Way, So. El Monte, California 91734. Telephone (213) 443-3211.

Auricord Division, Conrac Corporation, Old Saybrook, Connecticut 06475. Telephone (203) 388-3574.

Bell & Howell, Electronics and Instruments Group, 360 Sierra Madre Villa, Pasadena, California 91109. Telephone (213) 681-8421.

Canberra Industries, 45 Gracey Avenue, Meriden, Connecticut 06450. Telephone (203) 238-2351.

Cipher Data Products, Inc., 7655 Convoy Court, San Diego, California 92111. Telephone (714) 277-8070.

Computer Access Systems, 2645 East Buckeye Road, Phoenix, Arizona 85034. Telephone (602) 267-1444.

Computer Operations, Inc., 10774 Tucker Street, Beltsville, Maryland 20705. Telephone (301) 937-5377.

Datacom, Inc. P.O. Box 278, 40 Lincoln Drive, Fort Walton Beach, Florida 32548. Telephone (904) 242-3113.

Decision Inc., 5601 College Avenue, Oakland, California 94618. Telephone (415) 654-8626.

Dicom Industries, 715 North Pastoria Avenue, Sunnyvale, California 94086. Telephone (408) 732-1060.

Digi-Data Corporation, 4315 Balitmore Avenue, Bladensburg, Maryland 20710.Telephone (301) 277-9378.

Digitronics Corporation, Route 9, Southboro, Massachusetts 01772. Telephone (617) 481-2500.

Electric Corporation, 2830 Walnut Hill Lane, Dallas, Texas, 75229. Telephone (214) 358-1307.

Hewlett Packard Co., Data Systems, 11000 Wolfe Road, Cupertino, California 95014. Telephone (408) 257-7000.

Infotec, 70 Newtown Road, Plainview, New York 11803. Telephone (516) 694-9633.

Interdyne, 14761 Califa Street, Van Nuys, California 91401. Telephone (213) 787-6800.

International Computers Limited, 839 Stewart Avenue, Garden City, New York 11530. Telephone (516) 248-5656.

International Computer Products, Inc., P.O. Box 34484, Dallas, Texas 75234. Telephone (214) 239-5381.

Kennedy Company, 540 West Woodbury Road, Altadena, California 91001. Telephone (213) 798-0953.

Kybe Corporation, 132 Calvary Street, Waltham, Massachusetts 02154. Telephone (617) 899-0012.

Memodyne Corporation, 369 Elliot Street, Newton Upper Falls, Massachusetts 02164. Telephone (617) 527-6600.

Mobark Instruments Corporation, 1080 East Duane Avenue, Sunnyvale, California 94086. Telephone (408) 736-8540.

Per Data (Peripheral Data Machines, Inc.), 102 New South Road, Hicksville, New York 11801. Telephone (516) 938-2851.

Peripheral Dynamics Corporation (subsidiary of Datum, Inc.), 170 East Liberty Avenue, Anaheim, California 92801. Telephone (714) 879-3070.

PERTEC Peripheral Equipment, 9600 Irondale Avenue, Chatsworth, California 91311. Telephone (213) 882-0030.

Precision Instrument Company, 3170 Porter Drive, Palo Alto, California 94304. Telephone (415) 493-2222.

Raymond Precision Industries, Inc., 217 Smith Street, Middletown, Connecticut 06457. Telephone (203) 347-5611.

Redactron Corporation, 100 Parkway Drive South, Hauppauge, New York 11787. Telephone (516) 543-8700.

Remex (a unit of Ex-Cell-O Corporation), 1733 Alton Street, Santa Ana, California 92705. Telephone (714) 557-6860.

Sycor Inc., 100 Phoenix Drive, Ann Arbor, Michigan 48104. Telephone (313) 971-0900.

Sykes Datatronics Inc., 375 Orchard Street, Rochester, New York 14606. . Telephone (716) 458-8000.

Teac Corporation of America, 7733 Telegraph Road, Montebello, California 90640. Telephone (213) 726-0303.

Techtran Industries, 580 Jefferson Road, Rochester, New York 14623. Telephone (716) 271-7953.

Texas Instruments, Inc., Digital Systems Division, P.O. Box 1444, Houston, Texas 77006. Telephone (713) 494-5115.

3M Company, Data Products Division, 300 So. Lewis Road, Camarillo, California 93010. Telephone (805) 482-1911.

Tri-Data Corporation, 800 Maude Avenue, Mountain View, California 94040. Telephone (415) 969-3700.

Wangco, Inc., 2400 Broadway, Santa Monica, California 90404. Telephone (213) 828-5565.

Willard Laboratories, Inc., 4221 Redwood Avenue, Los Angeles, California 90066. Telephone (213) 821-8026.

Wiltek, Inc., 59 Danbury Road, Wilton, Connecticut 06897. Telephone (203) 762-5521.

Xebec Systems Incorporated, 566 San Xavier Avenue, Sunnyvale, California 94086. Telephone (408 732-9444. □

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MANUFACTURER AND MODEL	Ampex TMC	Ampex TMA	Ampex TM-16	Ampex TMX	Ampex TMY
PHYSICAL ARRANGEMENT					
Type	Philips cassette	Reel-to-reel	Reel-to-reel	Reel-to-reel	Reel-to-reel
Tape Width, inches	0.15	0.5	0.5	0.5	0.5
Tape Length, feet	300	2400	2400	1200	600
Drive Mechanism	Single capstan	Single capstan	Single capstan	Single capstan	Single capstan
Tape Buffer	None	Vacuum columns	Vacuum columns	Tension arms	Tension arms
Controller	None supplied	None supplied	TC-38	None supplied	None supplied
RECORDING ARRANGEMENT					
Density, bpi	800	800/1600	800/1600	800	800
Format and Method	ANSI 1- or 2-track; PE	ANSI 7- or 9-track; NRZI/PE	ANSI 7- or 9-track; NRZI/PE	ANSI 7- or 9-track; NRZI	ANSI 7- or 9-track; NRZI
Read-After-Write Checking	Yes	Yes	Yes	Yes	Yes
TAPE SPEED, inches per second	3, 6, or 12	37.5 to 125	75 to 150	7 to 12.5	5 to 12.5
DATA TRANSFER RATE	9600 bps	30 KCS to 200 KBS	60 KCS to 240 KBS	5.6 to 10 KCS	4 to 10 KCS
INTERFACE	None	Data General Nova series	IBM 360; Data General Nova series; Interdata	Data General, Novar, Computer Terminal Corp., Mitron	Datacraft
PRICING AND AVAILABILITY					
Purchase Price					
Controller, $	–	–	26,000	–	–
Drive, $	1,250	5,450	14,600	2,780	2,295
First Delivery	1970	1971	1968	1970	1971
Availability, days ARO	30	30	30	30	30
Number Installed to Date	INA	INA	INA	INA	INA
Serviced By	Ampex	Ampex	Ampex	Ampex	Ampex
COMMENTS					

MANUFACTURER AND MODEL	Ampex TMZ	Ampex ATM-13 Mk II	Anderson Jacobson AJ-700	Astro-Science Corp. ADIR-1093	Auricord Div., Conrac Corp. CAS-101-20
PHYSICAL ARRANGEMENT					
Type	Reel-to-reel	Reel-to-reel	Philips cassette	Reel-to-reel	ANSI Philips cassette
Tape Width, inches	0.5	0.5	0.15	0.5	0.15
Tape Length, feet	2400	2400	300	2400	150 to 450
Drive Mechanism	Single capstan	Twin, servoed capstans	Pinch rollers, bi-directional	Single capstan	Pinch rollers; bi-directional (CAS-10)
Tape Buffer	Tension arms	Vacuum columns	Tension arms	Tension arms	None
Controller	None supplied	None supplied	None supplied	None supplied	None supplied
RECORDING ARRANGEMENT					
Density, bpi	800/1600	200, 556, or 800	See Comments	200/556/800	800
Format and Method	ANSI 7- or 9-track; NRZI/PE	ANSI 7- or 9-track; NRZI	See Comments	ANSI 7- or 9-track; NRZI	2-channel, 4-track; NRZI or PE
Read-After-Write Checking	Yes	Yes	Yes	Yes	Yes
TAPE SPEED, inches per second	10 to 37.5	75	Up to 15	12.5 to 75	1.5 to 15; 240 (search)
DATA TRANSFER RATE	8 KCS to 60 KBS	60 KBS	Up to 12,000 bps	2.5 KCS to 60 KBS	1,200 to 12,000 bps
INTERFACE	Data General, Singer System Ten, Varian, Milgo, Raytheon	None	None	Varied	None
PRICING AND AVAILABILITY					
Purchase Price					
Controller, $	–	–	–	–	–
Drive, $	4,200	23,000 to 25,000	INA	10,000	245 (100)
First Delivery	1969	1970	INA	August 1970	INA
Availability, days ARO	30	60	INA	90	30 to 40
Number Installed to Date	INA	INA	INA	50	4,000
Serviced By	Ampex	Ampex Service (OEM)	Customer	Customer	Conrac Corp.
COMMENTS		OEM ruggedized for airborne and related usage	OEM unit; customer supplies all electronics; ECMA head or others available	Ruggedized for military shipboard, airborne, and mobile van applications	OEM unit; motor control electronics optional

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MANUFACTURER AND MODEL	Auricord Div., Conrac Corp. CAS-3A	Auricord Div., Conrac Corp. CAS-1	Bell & Howell Model 240-204	Bell & Howell Model 240-205	Canberra Industries Model 2020
PHYSICAL ARRANGEMENT					
Type	ANSI Philips cassette	ANSI Philips cassette	Philips cassette	Philips cassette	Philips cassette
Tape Width, inches	0.15	0.15	0.15	0.15	0.15
Tape Length, feet	300 to 600	300 to 600	300	300	300
Drive Mechanism	Pinch roller	Pinch roller	Single, external capstan	Single external capstan	Pinch roller
Tape Buffer	None	None	None	None	None
Controller	None supplied	None supplied	None supplied	None supplied	Integral
RECORDING ARRANGEMENT					
Density, bpi	800	800	800	800	750
Format and Method	2-channel, 4-track; NRZI or PE	2-channel, 4-track; NRZI or PE	ANSI 1- or 2 track; PE	ANSI 1- or 2-track; PE	Bit serial; 2-track redundant; PE
Read-After-Write Checking	Yes	Optional	No	Yes	No
TAPE SPEED, inches per second	1 to 6; 100 (search)	1 to 6; 100 (search)	Up to 20; 50 (search)	Up to 20; 50 (search)	8; 80 to 140 (search)
DATA TRANSFER RATE	800 to 4,800 bps	800 to 4,800 bps	Up to 16,000 bps	Up to 16,000 bps	667 char/sec
INTERFACE	None	None	Teletype; RS-232; custom	Teletype; RS-232; custom	DEC PDP-11, PDP-8; Data General Nova
PRICING AND AVAILABILITY					
Purchase Price					
Controller, $	–	–	–	–	Included in drive
Drive, $	84 (100)	74 (100)	1,070	1,140	5,900 (3 drives)
First Delivery	INA	INA	December 1971	December 1971	November 1971
Availability, days ARO	30 to 40	30 to 40	30	30	30 to 60
Number Installed to Date	10,000	18,000	INA	INA	40
Serviced By	Conrac Corp.	Conrac Corp.	Bell & Howell	Bell & Howell	Canberra
COMMENTS	OEM unit; motor control electronics optional; remotely controllable	OEM unit; motor control electronics optional; remotely controllable	Mechanism extracts tape from cassette for external capstan drive	Mechanism extracts tape from cassette for external capstan drive	System includes 3 drives; interface, including software, costs $1,000 extra

MANUFACTURER AND MODEL	Cipher Mini-cette 2000	Cipher Mark II	Cipher Mark II	Computer Access Systems 260 C-Drive	Computer Access Systems 250 C-Drive
PHYSICAL ARRANGEMENT					
Type	Philips cassette	Reel-to-reel	Reel-to-reel	Philips cassette	Philips cassette
Tape Width, inches	0.15	0.5	0.5	0.15	0.15
Tape Length, feet	300	600	2400	300	300
Drive Mechanism	Dual, differential capstan	Single capstan	Single capstan	Servo motors, bi-directional	Servo motors, bi-directional
Tape Buffer	None	Tension arms	Tension arms	None	None
Controller	Included	Integral	MTC-4000	None supplied	None supplied
RECORDING ARRANGEMENT					
Density, bpi	800	800	800 or 1600	50 to 800	50 to 800
Format and Method	ANSI 2-track; PE	ANSI 7- or 9-track; NRZI	ANSI 7- or 9-track; NRZI or PE	1-track; PE	1-track; PE
Read-After-Write Checking	Yes	No	Yes	Yes	Yes
TAPE SPEED, inches per second	6;24 (load)	12.5 to 25	12.5 to 75	10 to 40	5 to 40 (user set)
DATA TRANSFER RATE	4,800 or 19,600 bps	10 to 20 KCS	10 KCS to 120 KBS	Up to 9,600 bps	Up to 8,000 or 9,600 bps
INTERFACE	DEC PDP-8, PDP-11; Honeywell H-316, H-516; Hewlett-Packard 2100; Data General Nova	Data General Nova; DEC PDP-8/E	DEC PDP-8; PDP-11; Honeywell H-316, H-516; Hewett-Packard 2100; Data General Noval; Interdata, Varian	None	None
PRICING AND AVAILABILITY					
Purchase Price					
Controller, $	2,450 (includes one drive)	4,500 (includes one drive)	3,650 (NRZI); 5,700 (PE)	–	–
Drive, $	1,100 (additional drives)	–	3,600 to 4,500	565	515
First Delivery	June 1972	March 1971	June 1971	INA	INA
Availability, days ARO	30 to 60	30 to 60	30 to 60	30	14
Number Installed to Date	20	Over 100	50	50	550
Serviced By	Honeywell, GTEIS	Honeywell	Honeywell	Customer	Customer
COMMENTS	Includes backspace command; based on C-200 drive, first delivered in January 1970; approximately, 1200 C-200 drives have been delivered	For programmed I/O (not DMA)	Controller handles 1 to 4 drives	OEM unit; basic unit includes read/write and motion control electronics	OEM unit; basic unit includes read/write and motion control electronics; drive uses pre-recorded timing track

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MANUFACTURER AND MODEL	Computer Operations CO-600	Computer Operations CO-500	Datacom Models TU-xx	Decision 3120 Series A-F	Decision 3120G
PHYSICAL ARRANGEMENT					
Type	Reel-to-reel	Reel-to-reel	Reel-to-reel	Reel-to-reel	Reel-to-reel
Tape Width, inches	0.75	0.75	0.5	0.5	0.5
Tape Length, feet	150	150	2400	2400	2400
Drive Mechanism	Motor-driven reels; bi-directional	Motor-driven reels; bi-directional	Any	Pinch roller	Pinch roller
Tape Buffer	None	None	Any	Tension arms	Vacuum column
Controller	Integral	Integral	TC8	3120	3120
RECORDING ARRANGEMENT					
Density, bpi	400	400	200, 556, 800	200, 556, 800	200, 556, 800
Format and Method	10-track, PE, full redundancy; block addressable (normally 256 16-bit-word blocks)	10-track, PE, full redundancy; block addressable (normally 256 16-bit-word blocks)	ANSI 7- or 9-track; NRZI	ANSI 7- or 9-track; NRZI	ANSI 7- or 9-track; NRZI
Read-After-Write Checking	No	No	Optional	Yes	Yes
TAPE SPEED, inches per second	60	60	6.2 to 150	12.5, 25, 37.5, 45	75
DATA TRANSFER RATE	8400 bytes/sec	8400 bytes/sec	Varies	2.5 KCS to 36 KBS	15 KCS to 60 KBS
INTERFACE	Minicomputers by Data General, Varian, Honeywell, General Automation, EPI, Microdata, Lockheed, Rolm, Hewlett-Packard, Computer-Automation	Minicomputers by Data General, Varian, Honeywell, General Automation, EPI, Microdata, Lockheed, Rolm, Hewlett-Packard, Computer Automation	DEC PDP-8I, PDP-11, PDP-15; Data General Nova series; Honeywell H-116, H-316, H-516; SEL 810A/B; others	Digital Computer Controls 116	Digital Computer Controls 116
PRICING AND AVAILABILITY					
Purchase Price					
Controller, $	7,350 (includes 2 drives)	3,950 (includes 1 drive)	Typically under 6,000	3,900	3,900
Drive, $	–	–	From 4,500	3,400 to 4,500	7,500
First Delivery	1968	1970	1970	August 1970	August 1970
Availability, days ARO	60	60	60 to 70	60	60
Number Installed to Date	100	40	INA	INA	INA
Serviced By	Computer Operations	Computer Operations	Datacom	Decision	Decision
COMMENTS	Systems include software; can be connected to programmed I/O or DMA (optional) channel; pre-sectored tapes are available from Computer Operations for $12.50 in unit quantities; units known as LINC Tape		Datacom builds controller and OEM's tape drives; models of the controller handle 2 to 8 7- and/or 9-track drives; xx in model number is tape speed	Decision builds controller and OEM's tape drive; controller occupies 1 slot; diagnostic and I/O software included	

MANUFACTURER AND MODEL	Dicom Industries Model 344	Dicom Industries 172	Dicom Industries 440	Digi-Data 1100 MINIDEK	Digi-Data 1600 MINIDEK
PHYSICAL ARRANGEMENT					
Type	Philips-cassette	Philips-cassette	Philips-cassette	Reel-to-reel	Reel-to-reel
Tape Width, inches	0.15	0.15	0.15	0.5	0.5
Tape Length, feet	300	300	300	600	1200
Drive Mechanism	Pinch roller	Pinch roller	Pinch roller; bi-directional	Capstan	Capstan
Tape Buffer	Tension arm	None	Vacuum columns	Tension arms	Tension arms
Controller	Integral	Optional	Optional	Optional	Optional
RECORDING ARRANGEMENT					
Density, bpi	556	800	800	200, 556, 800, or 1600	200, 556, 800, or 1600
Format and Method	2-track; PE	2-track; PE or NRZ	2-track; PE or NRZ	ANSI 7- or 9-track; NRZI or PE	ANSI 7- or 9-track; NRZI or PE
Read-After-Write Checking	No	Optional	Optional	Yes	Yes
TAPE SPEED, inches per second	10.6	1.5/15/40 (selectable)	2/20/80 (selectable)	12.5	25
DATA TRANSFER RATE	500 bytes/sec	Up to 32,000 bps	Up to 64,000 bps	2.5 KCS to 10 KBS	5 KCS to 20 KBS
INTERFACE	Minicomputers by Hewlett-Packard, DEC, Data General, Varian, Computer Automation, others	Optional	Optional	DEC PDP-8, PDP-11; Data General Nova	DEC PDP-8, PDP-11; Data General Nova
PRICING AND AVAILABILITY					
Purchase Price					
Controller, $	2,750 (1 drive) to 4,550 (3 drives)	500	1,000	700	700
Drive, $	–	495	950	1,950	2,350
First Delivery	January 1970	Fall 1972	Fall 1972	INA	INA
Availability, days ARO	40	–	–	60	75
Number Installed to Date	500	–	–	INA	INA
Serviced By	Dicom and Sirvess	–	–	Digi-Data	Digi-Data
COMMENTS					

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MANUFACTURER AND MODEL	Digi-Data 1700 MAXIDEK	Digi-Data 1300	Digi-Data 1500	Digi-Data 1400	Digitronics MCT-7
PHYSICAL ARRANGEMENT					
Type	Reel-to-reel	Reel-to-reel	Reel-to-reel	Reel-to-reel	Proprietary cartridge
Tape Width, inches	0.5	0.5	0.5	0.5	0.15
Tape Length, feet	2400	1200	2400	2400	190
Drive Mechanism	Capstan	Capstan, asynchronous	Capstan, asynchronous	Capstan, asynchronous	Single capstan
Tape Buffer	Tension arms	Tension arms	Tension arms	Tension arms	None
Controller	Optional	Integral	Integral	Integral	MTD7
RECORDING ARRANGEMENT					
Density, bpi	200, 556, 800, or 1600	200, 556, or 800	200, 556, or 800	200, 556, or 800	400 or 800
Format and Method	ANSI 7- or 9-track; NRZI or PE	7- or 9-track; NRZI	7- or 9-track; NRZI	7- or 9-track; NRZI	1-track; PE
Read-After-Write Checking	Yes	No	No	No	Optional
TAPE SPEED, inches per second	45	10	7.5	7.5	7; 18 (search)
DATA TRANSFER RATE	9 KCS to 36 KBS	Up to 8 KCS	Up to 6 KCS	Up to 6 KCS	2,800 or 5,600 bps
INTERFACE	DEC PDP-8, PDP-11; Data General Nova	None	None	None	DEC PDP-8/E; Data General Nova
PRICING AND AVAILABILITY					
Purchase Price					
Controller, $	700	—	—	—	INA
Drive, $	2,750	2,100	2,600	3,600	450
First Delivery	INA	INA	INA	INA	January 1972
Availability, days ARO	75	60	60	60	Stock
Number Installed to Date	INA	INA	INA	INA	About 50
Serviced By	Digi-Data	Digi-Data	Digi-Data	Digi-Data	Digitronics
COMMENTS				Available in horizontal or vertical mount; portable; low power consumption	Proprietary cartridge uses two reels mounted coacially; i.e., one on top of the other; OEM unit; cartridges cost $10 each in small quantities

MANUFACTURER AND MODEL	Digitronics 1600 Series	Eclectic Model 640	Hewlett-Packard HP 7970B	Hewlett-Packard HP 7970E	Infotec TD Series
PHYSICAL ARRANGEMENT					
Type	Reel-to-reel	Reel-to-reel	Reel-to-reel	Reel-to-reel	Reel-to-reel
Tape Width, inches	0.5	0.5	0.5	0.5	0.5
Tape Length, feet	2400	2400	2400	2400	Up to 2400
Drive Mechanism	Single capstan	Single capstan	Single capstan	Single capstan	Dual capstan
Tape Buffer	Tension arms	Tension arms	Tension arms	Tension arms	Tension arms
Controller	1608E	Integral	HP 13181A or 13182A	HP 13183A	Optional
RECORDING ARRANGEMENT					
Density, bpi	556, 800, or 1600	200, 556, 800, or 1600	200, 556, or 800	200, 556, 800, or 1600	200, 556, 800
Format and Method	ANSI 7- or 9-track; NRZI or PE	ANSI 7- or 9-track; NRZI or PE	ANSI 7- or 9-track; NRZI	ANSI 7- or 9-track; NRZI or PE	ANSI 7- or 9-track; NRZI
Read-After-Write Checking	Yes	Yes	Yes	Yes	Yes
TAPE SPEED, inches per second	12.5 to 45	24 (10 to 75 optional)	10 to 45	10 to 45	25, 37.5, 45, or 75
DATA TRANSFER RATE	7 KCS to 36 KBS	4.8 KCS to 19.2 KBS	2 KCS to 36 KBS	2 KCS to 72 KBS	5 KCS to 60 KBS
INTERFACE	DEC PDP-8/E, PDP-11; Data General Nova; Hewlett-Packard HP2100 Series	DEC PDP-8, PDP-11	HP 2100 Series	HP 2100 Series	DEC PDP-8, PDP-11; Honeywell H-316; Data General Nova; IBM 1130
PRICING AND AVAILABILITY					
Purchase Price					
Controller, $	2,500	7,750 (one drive; for PDP-8)	INA	INA	Contact vendor
Drive, $	3,580	5,000	3,910	6,885	3,500 (75 ips)
First Delivery	June 1971	INA	July 1970	August 1971	June 1972
Availability, days ARO	30	30	70 to 85	70 to 85	60 to 90
Number Installed to Date	150	INA	INA	INA	0
Serviced By	Digitronics	INA	HP Worldwide Service	HP Worldwide Service	Honeywell
COMMENTS	Diagnostic routines available	System includes interface and software; system for PDP-11 costs $1,000 more; controller can handle up to 4 drives	OEM unit	OEM unit	Also available as OEM unit

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MANUFACTURER AND MODEL	Interdyne IC 2500	International Computers Ltd. ICL Model II	International Computer Prod. Digicorder 170 & 270	International Computer Prod. TermiCette Series 3000	International Computer Prod. PTR 700 & 720
PHYSICAL ARRANGEMENT					
Type	Philips cassette	Real-to-reel	Philips cassette	Philips cassette	Philips cassette
Tape Width, inches	0.15	0.5	0.15	0.15	0.15
Tape Length, feet	300	Up to 2400	300	300	300
Drive Mechanism	Direct-drive capstan	Single capstan	Servo-driven reels	Servo-driven reels	Servo-driven reels
Tape Buffer	None	Vacuum columns	None	None	None
Controller	None supplied	None supplied	Available	Integral	Available
RECORDING ARRANGEMENT					
Density, bpi	800	556, 800, 1600	550	550	550
Format and Method	ANSI 1-track; PE	ANSI 7- or 9- track; NRZI or PE	2-track, BMS, incremental	BMS, incremental	BMS, incremental
Read-After-Write Checking	Yes	Yes	No	No	No
TAPE SPEED, inches per second	2 to 12	18.75, 25, 37.5, 50, or 75	6	2 to 10	2 to 14
DATA TRANSFER RATE	1,600 to 9600 bps	10.4 KCS to 120 KBS	300 bytes/sec	110 to 2400 bps	Up to 40 (700) or 350 (720) bytes/sec
INTERFACE	None	None; read/write and motion control electronics included	Data General Nova and others	RS-232	Plug-compatible with many minicomputer paper tape reader/ punch interfaces
PRICING AND AVAILABILITY					
Purchase Price					
Controller, $	–	–	750	–	275 (if needed)
Drive, $	995	From 3,200	1,990 (1 drive); 2,990 (2 drives)	1,600	2,285
First Delivery	September 1971	January 1972	May 1969	May 1971	August 1972
Availability, days ARO	45	INA	60	30 to 45	60 to 90
Number Installed to Date	INA	INA	100	250	0
Serviced By	Customer	Customer	ICP and independent representatives	ICP and independent representatives	ICP and independent representatives
COMMENTS	OEM unit	OEM unit; automatic threading optional	BMS recording method stands for Bit Mark Sensing, a modification of the return to bias method; OEM versions of these units are also available for $525 to $1,015 per unit; the company has delivered about 5,000 OEM units		

MANUFACTURER AND MODEL	Kennedy 8109	Kennedy 8108	Kennedy 8107	Kennedy 8709	Kennedy 8707
PHYSICAL ARRANGEMENT					
Type	Reel-to-reel	Reel-to-reel	Reel-to-reel	Reel-to-reel	Reel-to-reel
Tape Width, inches	0.5	0.5	0.5	0.5	0.5
Tape Length, feet	2400	2400	2400	600	600
Drive Mechanism	Single capstan	Single capstan	Single capstan	Single capstan	Single capstan
Tape Buffer	Tension arms	Tension arms	Tension arms	Tension arms	Tension arms
Controller	8208/8216 Formatter	8208 Formatter	8208 Formatter	Formatter	Formatter
RECORDING ARRANGEMENT					
Density, bpi	800, 1600	800	200, 556, 800	800, 1600	800
Format and Method	ANSI 9-track; NRZI or PE	ANSI 9-track; NRZI	ANSI 7-track; NRZI	ANSI 9-track; NRZI or PE	ANSI 7-track; NRZI
Read-After-Write Checking	Yes	Yes	Yes	Yes	Yes
TAPE SPEED, inches per second	10 to 45	10 to 45	10 to 45	10 to 18.75	10 to 18.75
DATA TRANSFER RATE	8 KCS to 72 KBS	8 KCS to 36 KCS	2 KCS to 36 KCS	8 KCS to 30 KBS	8 KCS to 30 KCS
INTERFACE	None	None	None	None	None
PRICING AND AVAILABILITY					
Purchase Price					
Controller, $	–	–	–	–	–
Drive, $	2,800 (100)	2,500 (100)	2,500 (100)	INA	INA
First Delivery	November 1970	November 1970	November 1970	May 1971	May 1971
Availability, days ARO	30	30	30	30	30
Number Installed to Date	See Comments	See Comments	See Comments	See Comments	See Comments
Serviced By	Kennedy	Kennedy	Kennedy	Kennedy	Kennedy
COMMENTS	These units are OEM devices; about 700 of the 8100 series and 150 of the 8700 series units have been delivered. Combinations of these units are available with formatters in a complete subsystem as the System 8000.				

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MANUFACTURER AND MODEL	Kybe Kydek System	Memodyne 113	Memodyne 103	Memodyne 201	Mobark 300, 400, 400T
PHYSICAL ARRANGEMENT					
Type	Philips cassette	Philips cassette	Philips cassette	Philips cassette	Philips cassette
Tape Width, inches	0.15	0.15	0.15	0.15	0.15
Tape Length, feet	150 or 300	300	300	300	300
Drive Mechanism	Pinch roller	Pinch roller capstan	Pinch roller capstan	Pinch roller capstan	Pinch rollers, dual capstan
Tape Buffer	None	None	None	None	None
Controller	Integral	Integral	904 Formatter	906 Formatter	Integral
RECORDING ARRANGEMENT					
Density, bpi	800	120	120	615	333
Format and Method	2-track fully redundant; PE	Modified NRZI, incremental by character	Modified NRZI, incremental by bit	Modified NRZI, incremental by bit; write only	NRZI, fully redundant, incremental by bit
Read-After-Write Checking	No	No	No	No	No
TAPE SPEED, inches per second	7.5	2.7	0 to 2.7	0 to 1	Up to 2400 steps per sec.
DATA TRANSFER RATE	6000 bps	25 char/sec	0-300 bps write; 300-330 bps read	0 to 180 bps	To 1200 bps (write); to 2400 bps (read)
INTERFACE	DEC PDP-8, PDP-11; Data General Nova; Hewlett-Packard 2100	None; 8-bit parallel I/O	None; bit serial I/O	None; bit serial input	RS-232
PRICING AND AVAILABILITY					
Purchase Price					
Controller, $	3,495 (includes 2 drives)	700 (includes drive)	525	425	1,050 to 2,070 (includes drive)
Drive, $	—	225	225	225	—
First Delivery	June 1972	April 1972	February 1972	February 1972	June 1970
Availability, days ARO	45	20 to 30	20 to 30	20 to 30	30
Number Installed to Date	—	10	30	60	165
Serviced By	SirVess	Memodyne	Memodyne	Memodyne	Mobark
COMMENTS		OEM unit	OEM unit	OEM unit	300 Series are read-only or write-only units; 400 Series are read/write units

MANUFACTURER AND MODEL	Mobark 305, 400P, 405	Mobark 325, 425	Per Data D-600 Series	Peripheral Dynamics Corp. 4200	Peripheral Dynamics Corp. 4250
PHYSICAL ARRANGEMENT					
Type	Philips cassette	Philips cassette	Reel-to-reel	Philips cassette	Philips cassette
Tape Width, inches	0.15	0.15	0.5	0.15	0.15
Tape Length, feet	Up to 600	Up to 600	2400	300	300
Drive Mechanism	Pinch rollers, dual capstan	Pinch rollers, dual capstan	Dual capstan	Motor-driven reels	Motor-driven reels
Tape Buffer	None	None	Tension arms	None	None
Controller	Integral	Integral	C-9-8	None supplied	Integral
RECORDING ARRANGEMENT					
Density, bpi	333	333	200, 556, 800, 1600	800 or 1600	800
Format and Method	NRZI, fully redundant, incremental by 8-bit character	Saturation NRZ, incremental by 16-, 24-, or 32-bit black; 4 tracks	ANSI 70 or 9-track; NRZI or PE	ANSI 1-track, PE, or customer option	NRZI
Read-After-Write Checking	No	No	Yes	Yes	Yes
TAPE SPEED, inches per second	Up to 2400 steps per sec.	Up to 2400 steps per sec.	25 to 75	Up to 75	37.5
DATA TRANSFER RATE	To 1200 bps (write); to 2400 bps (read)	To 1200 bps (write); to 2400 bps (read)	5 KCS to 120 KBS	Up to 120,000 bps	30,000 bps
INTERFACE	None; 8-bit parallel I/O	None; 16-, 24-, or 32-bit parallel I/O	DEC PDP-8, PDP-11; Data General Nova; Hewlett Packard 2100 series; Honeywell H-316; Varian 620	None	Compatible with Dicom 344
PRICING AND AVAILABILITY					
Purchase Price					
Controller, $	950 to 2,070 (includes drive)	1,150 to 1,750 (includes drive)	4,300	—	3,800 (includes 3 drives)
Drive, $	—	—	3,995	1600	—
First Delivery	November 1970	October 1970	INA	January 1972	June 1972
Availability, days ARO	30	45	30	60	60
Number Installed to Date	180	16	INA	5	1
Serviced By	Mobark	Mobark	Per Data	Datum	Datum
COMMENTS	300 Series are read-only or write-only units; 400 Series are read/write units		Complete systems with software also available	OEM unit	

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MANUFACTURER AND MODEL	PERTEC 5000 Series	PERTEC 6000 Series	PERTEC 7000 Series	PERTEC T8000 Series	Precision Instrument Company PI-1400
PHYSICAL ARRANGEMENT					
Type	Reel-to-reel	Reel-to-reel	Reel-to-reel	Reel-to-reel	Reel-to-reel
Tape Width, inches	0.5	0.5	0.5	0.5	0.5
Tape Length, feet	1200	2400	600	2400	2400
Drive Mechanism	Single capstan; bi-directional	Single capstan; bi-directional	Single capstan	Single capstan	Single capstan
Tape Buffer	Tension arms	Tension arms	Tension arms	Tension arms	Tension arms
Controller	Available	Available	Available	Available	Integral or separate
RECORDING ARRANGEMENT					
Density, bpi	200, 556, 800, or 1600	200, 556, 800, or 1600	200, 556, 800, or 1600	200, 556, 800, or 1600	1600 and two of 200, 556, 800
Format and Method	ANSI 7- or 9-track; NRZI or PE	ANSI 7- or 9-track; NRZI or PE	ANSI 7- or 9-track; NRZI or PE	ANSI 7- or 9-track; NRZI or PE	ANSI 7- or 9-track; NRZI or PE
Read-After-Write Checking	Some models	Some models	Some models	Some models	Yes
TAPE SPEED, inches per second	12.5 to 37.5	12.5 to 75	6.25 to 25	12.5 to 45	12.5 to 45
DATA TRANSFER RATE	5 KCS to 60 KBS	5 KCS to 120 KBS	1.25 KCS to 40 KBS	2.5 KCS to 72 KBS	2.5 KCS to 72 KBS
INTERFACE	None	None	None	None	Minicomputers from DEC, Data General, Xerox, Honeywell, EMR, Varian, Tempo, Hewlett-Packard, and others
PRICING AND AVAILABILITY					
Purchase Price Controller, $	—	—	—	—	3,950 or less
Drive, $	2,545	3,150	2,100	3,150	4,000 or less
First Delivery	January 1972	June 1969	August 1969	August 1972	INA
Availability, days ARO	45	45	45	—	30
Number Installed to Date	See Comments	See Comments	See Comments	0	100
Serviced By	Customer and PERTEC	Customer and PERTEC	Customer and PERTEC	Customer and PERTEC	Precision and independent reps.
COMMENTS	Within each family, except the 7000 series, 3 groups of drives are available; read-only, read/write, and read-after-write. Many models are available in various combinations of format and density. All of these models are synchronous units. A wide range of incremental drives is also available. BMTT System includes 5000, 6000, and/or 7000 Series drives, a controller, and up to two 1K or one 2K buffers. Prices above are for read/write drives; read-after-write models cost about $500 more. These units are OEM devices. PERTEC has delivered about 50,000 drives; many were delivered under the company's former name, PEC.				Other models available

MANUFACTURER AND MODEL	Raymond 6406 Raycorder	Redactron Model 100	Remex RCP Series	Remex RCE Series	Sycor Model 125E
PHYSICAL ARRANGEMENT					
Type	Philips cassette	Philips cassette	Philips cassette	Philips cassette	Philips cassette
Tape Width, inches	0.15	0.15	0.15	0.15	0.15
Tape Length, feet	300	200	282	282	285
Drive Mechanism	Pinch roller	Motor-driven reels	Pinch roller; bi-directional	Pinch roller; bi-directional	Pinch roller
Tape Buffer	None	None	None	None	None
Controller	None supplied	MOS chip	Included	None supplied	None supplied
RECORDING ARRANGEMENT					
Density, bpi	800	430 avg. (555 to 350)	800	800	800
Format and Method	PE, 2-track or 1-track with full redundancy	Proprietary, ratio detection	PE, fully redundant	Customer selected; 1- or 2-track	ANSI 1-track; PE
Read-After-Write Checking	Optional	Yes	Optional	Optional	Yes
TAPE SPEED, inches per second	3 to 15	30 avg. (24 to 38)	7.5 (10 optional)	7.5 (10 optional)	12.5
DATA TRANSFER RATE	2400 to 12,000 bps	8,333 or 12,000 bps	5,000 bps	5,000 bps	10,000 bps
INTERFACE	None, bit serial I/O	None; bit serial I/O	DEC PDP-8/E, PDP-11; Data General Nova; Hewlett-Packard	None; bit serial I/O	None
PRICING AND AVAILABILITY					
Purchase Price Controller, $	—	60	1,870 (1 drive) to 2,995 (3 drives)	1,245 (1 drive) to 2,650 (3 drives)	—
Drive, $	375 (100)	325	—	—	990
First Delivery	September 1970	1969	June 1971	June 1971	1968
Availability, days ARO	30	30	Stock	56	30
Number Installed to Date	300	800	INA	INA	6,000
Serviced By	Customer or factory	Customer	Remex and independent representatives	Remex and independent representatives	Customer
COMMENTS	OEM unit	OEM unit; company also offers a device for reading and writing on IBM magnetic typewriter cards	Interface with diagnostic and driver software for RCP Series costs $1,600. RCP Series do and RCE Series do not have error detection/correction capabilities; Partial systems with just drive or drive and basic electronics also available		OEM unit

All About Magnetic Tape Units

MANUFACTURER AND MODEL	Sykes Compu/Coder 100 & 200	Sykes Tape Transport TT100 & TT120	Teac DATAPAK MT-5	Teac DATAPAK MT-6	Techtran 4100/4120/4130
PHYSICAL ARRANGEMENT					
Type	Philips cassette	Philips cassette	Philips cassette	Philips cassette	Philips cassette
Tape Width, inches	0.15	0.15	0.15	0.15	0.15
Tape Length, feet	300	300	Up to 300	Up to 300	300
Drive Mechanism	Pinch roller; bi-directional	Pinch roller; bi-directional	Capstan	Dual capstans	Motor-driven reels
Tape Buffer	None	None	None	None	None
Controller	Integral	None supplied	None supplied	None supplied	Integral
RECORDING ARRANGEMENT					
Density, bpi	1000	1000	800	800	800
Format and Method	PE, 2-track	PE, 2-track	PE, 2-track	PE, 2-track	Modified NRZ, 2-track
Read-After-Write Checking	No	Optional	No	Yes	No
TAPE SPEED, inches per second	5, 6, or 12; 120 (search)	5, 6, or 12; 120 (search)	7.5	7.5	6
DATA TRANSFER RATE	Up to 12,000 bps	Up to 12,000 bps	6,000 bps	6,000 bps	110 to 2,400 bps
INTERFACE	DEC PDP-8, PDP-11; Data General Nova; Varian 620; Hewlett-Packard 2100 series; others	None	None	None	Designed to fit between terminal and line or mini-computer; RS-232 on one side and RS-232 or custom on the other
PRICING AND AVAILABILITY					
Purchase Price					
Controller, $	About 3,000 (includes drive)	–	–	–	1,650 to 2,265 (includes drive)
Drive, $	–	784 to 985	595	1,025	–
First Delivery	February 1970	Feb. 1970/June 1971	INA	INA	January 1971
Availability, days ARO	15 to 30	15 to 30	INA	INA	30
Number Installed to Date	1,000	500	See Comments	See Comments	450
Serviced By	Sykes	Sykes	Customer	Customer	Techtron
COMMENTS	Interface costs $150 to $1,000. Systems available with up to 4 drives. Software is included	OEM unit; controller is available for 1 to 4 drives with RS-232 interface	OEM units; MT-5 available as read-only or write-only model; MT-6 is a read/write device. About 50,000 have been sold in U.S.		4100 is for ASCII terminals; 4120 is for IBM 2741 or equivalent; 4130 is for minicomputers

MANUFACTURER AND MODEL	Texas Instruments Model 951	Texas Instruments Model 959	Texas Instruments Model 979	3M Company Model 3 Data Cartridge Drive	3M Company DPC-202
PHYSICAL ARRANGEMENT					
Type	Reel-to-reel	Reel-to-reel	Reel-to-reel	Proprietary cartridge	Philips cassette
Tape Width, inches	0.5	0.5	0.5	0.25	0.15
Tape Length, feet	2400	2400	2400	300	300
Drive Mechanism	Single capstan	Single capstan	Single capstan	Band-driven reels; bi-directional	Pinch roller
Tape Buffer	Vacuum column	Vacuum column	Vacuum column	None	None
Controller	None supplied	959	TIU	None supplied	None supplied
RECORDING ARRANGEMENT					
Density, bpi	800/1600	200, 556, or 800	200/556/800, 800, or 1600	1600	800
Format and Method	9-track	ANSI 7- or 9-track; NRZI	ANSI 7- or 9-track; NRZI or PE	1-, 2-, or 4-track; PE	1- or 2-track; PE
Read-After-Write Checking	Yes	Yes	Yes	Optional	Optional
TAPE SPEED, inches per second	75/37.5	60 to 120	15 to 45	30; 90 (search)	6, 8, or 12
DATA TRANSFER RATE	60 KBS	12 KCS to 96 KBS	3 KCS to 72 KBS	48,000 bps	Up to 9,600 bps
INTERFACE	None	None	TI 960	None	None
PRICING AND AVAILABILITY					
Purchase Price					
Controller, $	–	INA	3,000	–	–
Drive, $	Contact vendor	11,100 (7-track); 11,750 (9-track)	4,100	600 up	811 up
First Delivery	INA	INA	INA	September 1972	January 1971
Availability, days ARO	120 to 180	120 to 180	60 to 90	INA	30 to 60
Number Installed to Date	INA	INA	INA	0	1200
Serviced By	Texas Instruments	Texas Instruments	Texas Instruments	3M	3M
COMMENTS		7-track models are dual density (any two)		OEM unit; cartridge includes all tape-handling mechanism, requiring only an external capstan to drive band	OEM unit

All About Magnetic Tape Units

MANUFACTURER AND MODEL	Tri-Data CartriFile 20/40	Tri-Data CartriFile 4196	Tri-Data CartriFile 4096	Wangco Mod 7	Wangco Mod 8
PHYSICAL ARRANGEMENT					
Type	Proprietary cartridge; endless loop	Proprietary cartridge; endless loop	Proprietary cartridge; endless loop	Reel-to-reel	Reel-to-reel
Tape Width, inches	0.25	0.25	0.25	0.5	0.5
Tape Length, feet	10 to 150	10 to 150	10 to 150	600	1200
Drive Mechanism	Pinch roller	Pinch roller	Pinch roller	Single capstan	Single capstan
Tape Buffer	None	None	None	Tension arms	Tension arms
Controller	Integral	Integral	Integral	Formatter	Formatter
RECORDING ARRANGEMENT					
Density, bpi	900	900	600	800 or 1600	800 or 1600
Format and Method	Bit serial, 2 parallel tracks; PE	Bit serial, 2 parallel tracks; PE	Bit serial, fully redundant; PE	ANSI, 7- or 9-track; NRZI or PE	ANSI 7- or 9-track; NRZI or PE
Read-After-Write Checking	No	No	No	Optional	Optional
TAPE SPEED, inches per second	10	10	10	12.5	12.5, 25, or 37.5
DATA TRANSFER RATE	18,000 bps	18,000 bps	6,000 bps	10 KCS or 20 KBS	10 KCS to 60 KBS
INTERFACE	DEC PDP-8, PDP-11; Data General Nova; Honeywell H-316, H-416, H-516; Varian; Interdata; others	DEC PDP-8, PDP-11; Data General Nova; Honeywell H-316, H-416, H-516; Varian; Interdata; others	DEC PDP-8, PDP-11; Data General Nova; Honeywell H-316, H-416, H-516; Varian; Interdata; others	None; compatible with Ampex TMY/TMZ and PERTEC 7800 series drives	None; compatible with Ampex TMY/TMZ and PERTEC 5000 series drives
PRICING AND AVAILABILITY					
Purchase Price					
Controller, $	4,150 (4 drives); 2,850 (2 drives)	5,200 (4 drives)	5,200 (4 drives)	1,150 (NRZI); 2,400 (PE)	1,150 (NRZI); 2,400 (PE)
Drive, $	—	—	—	2,025	2,400 to 2,750
First Delivery	September 1971	November 1970	December 1968	INA	INA
Availability, days ARO	30	30	30	30	30
Number Installed to Date	145	400	500	400	About 800
Serviced By	Tri-Data	Tri-Data	Tri-Data	SirVess	SirVess
COMMENTS	Interface, including diagnostic and driver software, costs about $800. Cartridges are arranged flat in a vertical stack; all are driven independently by a single capstan. Version of 2-drive model with tape motion and read/write electronics is available for $1,200				

MANUFACTURER AND MODEL	Wangco Mod 10	Wangco Mod 1075	Wangco Mod 1100	Willard Laboratories 719, 719F	Willard Laboratories 8, 8F
PHYSICAL ARRANGEMENT					
Type	Reel-to-reel	Reel-to-reel	Reel-to-reel	Reel-to-reel	Reel-to-reel
Tape Width, inches	0.5	0.5	0.5	0.5	0.5
Tape Length, feet	2400	2400	2400	600	1200
Drive Mechanism	Single capstan	Vacuum capstan	Vacuum capstan	Single capstan	Single capstan
Tape Buffer	Tension arms	Vacuum column	Vacuum column	Tension arms	Tension arms
Controller	Formatter	Formatter	Formatter	Mod 5091	Mod 5091
RECORDING ARRANGEMENT					
Density, bpi	800 or 1600	800 or 1600	800 or 1600	200, 556, 800, or 1600	200, 556, 800, or 1600
Format and Method	ANSI 7- or 9-track; NRZI or PE	ANSI, 7- or 9-track; NRZI or PE	ANSI 7- or 9-track; NRZI or PE	ANSI 7- or 9-track; NRZI or PE	ANSI 7- or 9-track; NRZI or PE
Read-After-Write Checking	Optional	Optional	Optional	Yes	Yes
TAPE SPEED, inches per second	25, 37.5, or 45	75	100	12.5 or 25	12.5 or 25
DATA TRANSFER RATE	20 KCS to 72 KBS	60 KCS or 120 KBS	80 KCS or 160 KBS	2.5 KCS to 40 KBS	2.5 KCS to 40 KBS
INTERFACE	None; compatible with Ampex TMZ and PERTEC 6800 series drives	None; compatible with PERTEC 6840-75 drive	None; compatible with PERTEC 6840-75 drive	Available for all major minicomputers; custom	Available for all major minicomputers; custom
PRICING AND AVAILABILITY					
Purchase Price					
Controller, $	1,150 (NRZI); 2,400 (PE)	1,150 (NRZI); 2,400 (PE)	1,150 (NRZI); 2,400 (PE)	Contact vendor	Contact vendor
Drive, $	2,625 to 2,700	4,200	4,500	Contact vendor	Contact vendor
First Delivery	INA	INA	August 1972	INA	INA
Availability, days ARO	30	30	—	INA	INA
Number Installed to Date	850	25	—	INA	INA
Serviced By	SirVess	SirVess	SirVess	Willard	Willard
COMMENTS				OEM unit	OEM unit

All About Magnetic Tape Units

MANUFACTURER AND MODEL	Willard Laboratories 10	Wiltek DS-3	Xebec Systems XTS 1000	Xebec Systems XTS 7000	Xebec Systems XTS 8000
PHYSICAL ARRANGEMENT					
Type	Reel-to-reel	Built-in tape loop	Reel-to-reel	Reel-to-reel	Reel-to-reel
Tape Width, inches	0.5	0.63	0.5	0.5	0.5
Tape Length, feet	2400	50	2400	2400	2400
Drive Mechanism	Single capstan	Separate read and write sprocket drives	Capstan	Capstan	Capstan
Tape Buffer	Tension arms	None	Tension arms	Tension arms	Tension arms
Controller	Mod 5091	Integral	XTC 300	XTC 300	XTC 300
RECORDING ARRANGEMENT					
Density, bpi	200, 556, 800, or 1600	83	200, 556, 800	200, 556, 800	200, 556, 800
Format and Method	ANSI 7- or 9-track; NRZI or PE	1 to 8 track; RB	ANSI 7- or 9-track; NRZI	ANSI 7- or 9-track; NRZI	ANSI 7- or 9-track; NRZI
Read-After-Write Checking	Yes	No	Yes	Yes	Yes
TAPE SPEED, inches per second	12.5 to 45	Up to 4	10 to 75	10 to 25	10 to 37.5
DATA TRANSFER RATE	2.5 KCS to 72 KBS	Up to 333 char. per second	2 KCS to 60 KBS	2 KCS to 20 KBS	2 KCS to 30 KBS
INTERFACE	Available for all major minicomputers; custom	Teletype; RS 232; MIL-188; custom	DEC PDP-8, -11, -12, -9, -15; Data General Nova; Varian 620i; MAC; DCC; Honeywell	DEC PDP-8, -11, -12, -9, -15; Data General Nova; Varian 620i; MAC; DCC; Honeywell	DEC PDP-8, -11, -12, -9, -15; Data General Nova; Varian 620i; MAC; DCC; Honeywell
PRICING AND AVAILABILITY					
Purchase Price					
Controller, $	Contact vendor	Contact vendor	7,500 to 10,250 (includes drive)	6,500 to 8,500 (includes drive)	6,900 to 8,900 (includes drive)
Drive, $	Contact vendor	Contact vendor	—	—	—
First Delivery	INA	1968	June 1971	June 1971	June 1971
Availability, days ARO	INA	INA	30 to 45	30 to 45	30 to 45
Number Installed to Date	INA	INA	INA	INA	INA
Serviced By	Willard	Wiltek	Xebec and indep. reps.	Xebec and indep. reps.	Xebec and indep. reps.
COMMENTS		Unit designed for in-line buffer for communications terminal			

All About Printers

Of all the types of peripheral devices in modern computer systems, the printer comes closest to being indispensable, since it converts the results of computer processing into a form that can be understood by people. This comprehensive survey covers 109 printers marketed by 47 vendors and highlights the inventiveness that has been shown by the manufacturers in solving the eternal problems of speed versus cost.

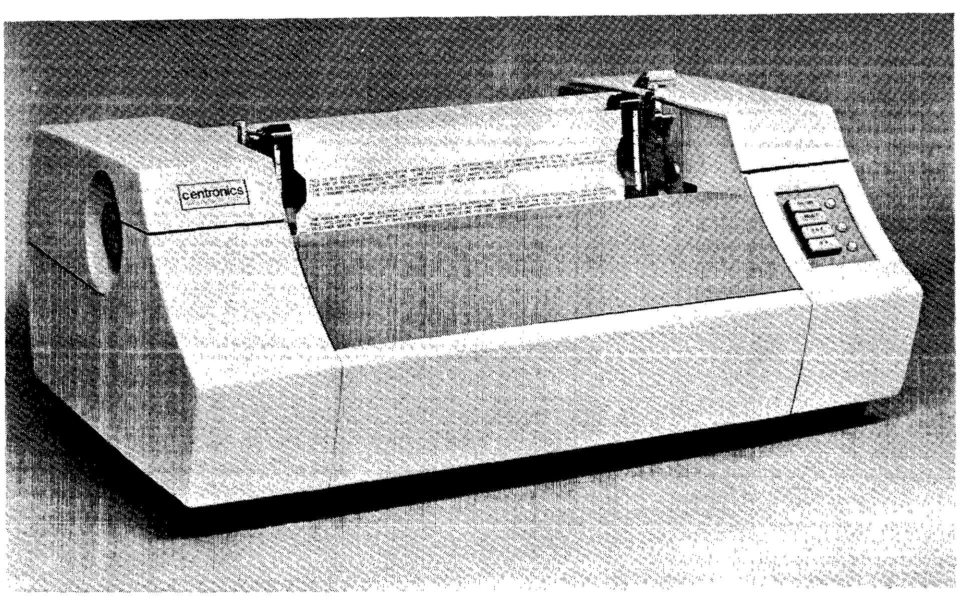
The words to a song in a well-known musical go something like this: Pool begins with a "P" which rhymes with "T" which stands for Trouble. Well, the word Printer also begins with the letter "P". More than any other computer peripheral, the printer has been cursed and cajoled.

It's too slow. It's too expensive. It's always down. In these familiar remarks overheard in many a computer room or data processing manager's office, nobody needs to ask what it is—everyone knows it's the printer. And now, with the advent of minicomputers, data communications, information retrieval, etc., we are being asked to use these recalcitrant beasts just about everywhere. (Forgive us, but when you spend much of your adult life working in a field, it's almost impossible not to anthropomorphize the equipment you encounter.)

Conceptually, a printer is a simple device. The basic specifications can be jotted down almost offhand by anybody involved in data processing. But when you go to implement the specifications at a price people are willing to pay, the problems begin to multiply. Nevertheless, more originality and innovation have been shown in developing printers than any other type of peripheral device. We have come a long way since the days when your choice of printers was restricted to a slow Teletype unit for under $1,000 or a high-speed line printer for over $50,000. The middle ground between these two extremes has been fruitful ground for numerous enterprising innovators. And, in all fairness, printers today are much more reliable than they used to be.

The printer is the most visible of the computer peripherals. The vast majority of computer applications use printed output as the final stage in massaging information for use. Soft-copy output—as represented by CRT displays—has made a few inroads in specialized applications. But even in these cases, there is usually a demand for hard copy (i.e., printed output) to capture a permanent record of the displayed information. Let's face it. Our society is paper-oriented. And it will be for some time to come.

The share of the cost of a typical data processing installation grabbed by printers has been declining due to the increased usage of relatively expensive disk units. There are two factors at work—one old and one new—that may well tend to increase the market for printers. First, the continuing growth of data communications represents a large potential increase in the number of printers, both low- and high-speed, in everyday use. Second, IBM's recent announcement of software and hardware for virtual memory permits more effective multiprogramming in small and medium-size installations and generates a potential for multiple printers operating on-line in parallel to compress the time span for printing out the results of program execution. (Note that it is IBM's endorsement and support of virtual memory that is new, not the concept itself.)



This is the Centronics wire-matrix printer that has been a major cause of the strong current interest in faster-than-Teletype printers. Centronics has delivered more than 3000 of the Models 101 and 101A (an upgraded 101) in the last year. Inside the housing, a circular pattern of large solenoids fires pins that come out in a vertical pattern of 7 dots. The 101 uses 5 columns of these dots to form characters, while the 101A uses 9; the wider-than-high arrangement of the dot matrix pattern for the 101A is unusual. For a look at the print quality produced by the 101A, check the copy sample on the following page.

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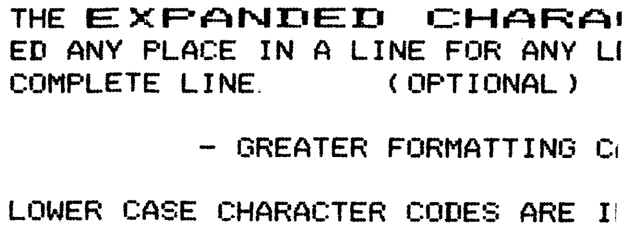
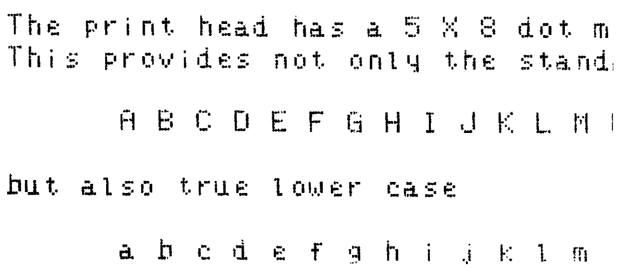
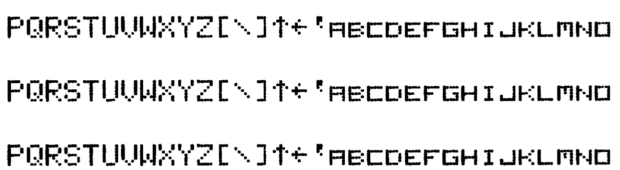


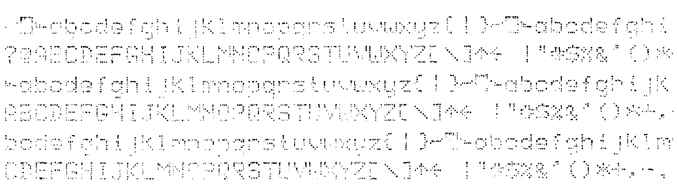
Centronics 101A (9 x 7)



Anderson-Jacobson AJ630 (5 x 8)



NCR 260 (5 x 7)



Versatec 1100 (7 x 11)

Great diversity and individuality marks the many dot-matrix patterns used to print characters. A selection of four, each with a different makeup, is shown here. The basic pattern size is shown in parentheses, with width followed by height. In the example shown for Versatec, each character is actually formed within a 7x9 matrix, but the overall size, including the risers and descenders for the lower-case letters, makes the full pattern 7x11. The phantom appearance of some letters compared to the solid appearance of others is shown most clearly in the sample for the NCR 260. Letters with only straight lines appear very solid, while letters with curved or slanting strokes have a phantom appearance.

A Printer By Any Other Name

At first glance, the difficulties of producing printers for computer usage may seem overstated. After all, high-speed printing presses have been available for many years. Surely it is just a matter of adapting existing technology.

In truth, press technology is of almost no value in computer printer design. The reason is simple. The printing press is designed to produce many copies of existing pages of information; because of the large number of copies, it is of small importance that several hours are required to produce the master pages that are used to print the copies. The overall turnaround time is measured in hours or days. The task of the computer printer is diametrically opposite. The need is to produce a single copy, or at most a few copies, of information in a much shorter time, usually measured in seconds or minutes. A two-step process (master and copy) is too expensive in terms of time. In addition, the information exists in non-graphic form, as stored magnetic patterns in main memory or perhaps on a disk or tape.

We can break the functions of a computer printer into three processes: (1) decode the information from the computer; (2) create the graphic image (i.e., print the characters); and (3) move the paper as needed. As mentioned before, manufacturers have been most innovative in finding solutions for these three processes.

The inventiveness of the manufacturers has been directed toward one major goal: producing faster printers at lower costs. Until recently, there have been large gaps in the capabilities of commercially available printers because the intermediate-speed units could not be produced much cheaper than the corresponding higher-speed units. And it is speed of operation that is the overriding criterion for printer selection. All over characteristics, such as size of forms that can be handled, capabilities for making multiple copies, etc., are secondary to the speed of printing.

Speed is in the Eye of the Beholder

Because speed is the first consideration, it is unfortunate that printer speed can be difficult to evaluate because it frequently depends on factors that are difficult to assign values to. It can depend on the distribution of characters in the text to be printed, the number of characters in a line, and the layout of the form being printed (i.e., the number of lines skipped, and when).

A complete discussion of the factors involved in evaluating the speed of printing devices is beyond the scope of this report. Indeed, it may well be beyond the patience of any one man, particularly for line printers; these units require extensive manipulation of integer mathematics, a neglected branch of mathematics that involves discrete Σ

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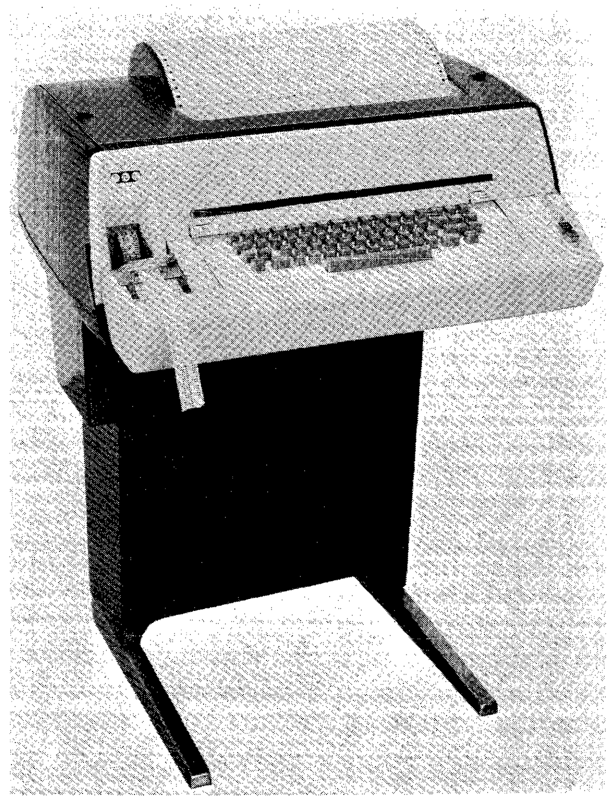
jumps from value to value rather than a smooth variation as found in common mathematical processes. However, we will highlight the factors involved.

The usual approach to evaluating the performance of mechanical devices is to determine the basic cycles, or repetitive actions, and go from there. Here we encounter our first problem. The logical cycle (i.e., print a line and space to the next line) may not agree with the basic machine cycle (e.g., one revolution of the drum or one circulation of the print train). But it is still a better starting place than most.

The elements of the print cycle for a character-at-a-time printer include: print a character, space to the next position, and return the print mechanism and space a line when the end of a printed line is reached. Depending on the arrangement of the printing mechanism, the time required to print a character may be constant for all characters or it may vary depending on the location of the character to be printed on the printing element (wheel, ball, cylinder, etc.). Usually, a character printer is run at the speed of the "slowest character" to achieve a uniform printing rate. Thus, the quoted printing rate in characters per second is usually reasonably believable. The factor that pulls down the average printing rate is the time required to return the carriage and the time required to space a line. The average characters per second for a highly formatted form could be substantially less than the quoted peak speed. On the other hand, substantial time savings can be realized for short lines, so that the speed in lines per minute could be quite respectable. As a rule of thumb, frequent short lines make a character printer look good and frequent line-spacing operations tend to make it look bad. Some of the faster character printers include special provision for high-speed skips to reduce this limitation.

The elements of the print cycle for a line printer are fewer: print a line and space to the next line. The design and execution of a line printer is somewhat more complex, however. During the "print a line" phase, logic within the printer continuously compares the contents of the buffer with the character coming into position for each print column. And the printing is usually done while the paper is moving. This last factor creates some critical timing problems if the printed result is to look decent. It is in this area that train and chain printers excel the drum printers. Any misalignment on a chain or train printer will be horizontal, resulting in slight variations in the spacing between letters. For a drum printer, the misalignment is vertical, resulting in the familiar wavy lines. But the alignment problem doesn't affect speed, just appearance, unless the printer has to be slowed down to achieve good alignment.

The basic factors affecting the average speed of a line printer are the number of different symbols printed in a line and the size of the skips between lines. Most line printers can start scanning the buffer for printable characters immediately after the spacing operation has been completed. If any one of the characters to be printed in the line is the one that passed the print hammers just before the spacing operation terminated, a full cycle of the drum must pass or a full set of train characters must pass before the line can be completely printed. No advantage can be taken of the non-printing segment of characters to space to the next line.



The newest version of the old reliable Teletype. The Model 38 ASR shown here is equipped with keyboard and punched tape reader and punch. With its 132-character print line, the Model 38 is a natural for minicomputer applications. And the price of a print-only version is still under $1,000 (but just).

Usually, there is sufficient time to allow printing at the full rated speed at single spacing and still print a useful subset of characters. The most typical example is printing a a 48-character subset of a 63-character font. The arrangement of the characters on the drum or in the train, compared to the distribution of characters in the data being printed, controls whether spacing and the print cycle can be overlapped. Because of the integer nature of the timings, accurate predictions of average speeds are very difficult. However, the variations are not great and most models of the same rated speed will show similar degredations of performance, so this factor is seldom a decision point. Repeating certain characters in the set, such as numerics, helps to an extent that is difficult to predict for the same reason.

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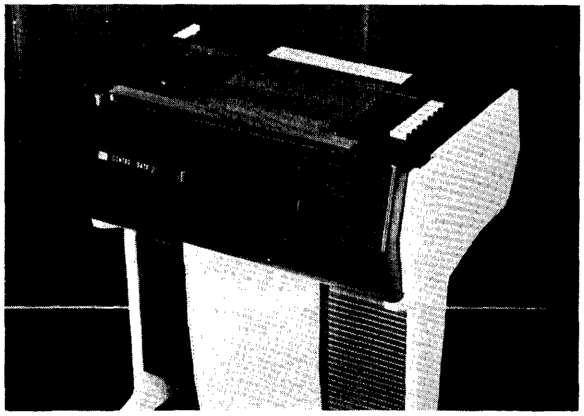

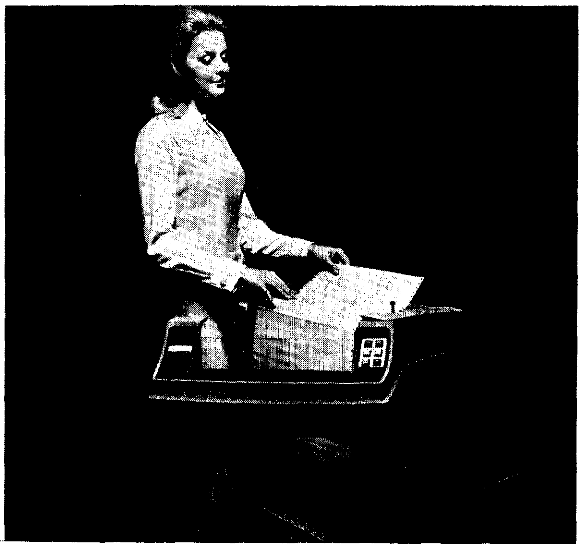

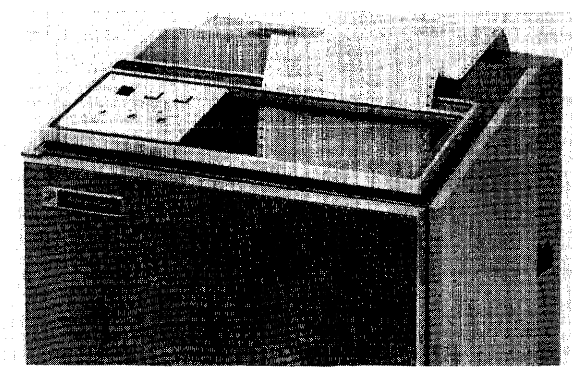

On the outside .... You may not see these three companies' names on the cabinets, but their products are likely to show up in many places in different covers. From the top, you see the Control Data 9320, the Digitronics 200, and the Data Products 2310, all designed for the OEM market. The Control Data model is a "conventional" drum printer that operates at a peak rate of 200 lines per minute. The Digitronics model also prints at 200 lines per minute, but uses a belt to carry the characters from column to column to be printed. The Data Products model will operate at 1100 lines per minute—as long as you're not printing more than 20 columns. It uses a quarter-line buffer to reduce the cost of the electronics; to print a full 80-character line, four print cycles are required and the speed drops to 365 lines per minute.

⊳ Where To Find Information

Within the pages of DATAPRO 70, you will find a very comprehensive collection of information about printers. But not all of the information is in this report. To keep the length of the comparison charts within reasonable limits, information found in other parts of DATAPRO 70 has not been included in this report. Printers marketed by the computer mainframe vendors are covered in the individual reports on computer systems, found in the Computers section. IBM plug-compatible printers produced by independent peripheral manufacturers are covered in individual reports within the Peripherals section; you can find these reports most easily by looking in the Index under the generic heading of "printers (IBM-compatible)." Printers marketed by minicomputer manufacturers for use with their own computers are not listed in the charts under the minicomputer makers' names, but virtually all of these printers are listed in the charts under their original manufacturers.

The Comparison Charts

The principal characteristics of 109 printers from 47 vendors are presented in the accompanying comparison charts. All information in the charts was furnished by the suppliers in June, July, and August 1972. The cooperation of these companies with the Datapro Research staff in the preparation of these charts is greatly appreciated.

The comparison chart entries and their significance are explained in the following paragraphs.

Manufacturer and Model identifies the subject device. For your convenience, a list of all the suppliers along with their addresses and telephone numbers precedes the comparison charts.

Basic Imprinting Technique specifices whether the printer is an impact or non-impact device. The chief functional difference between the two is in the capability to make multiple copies. In general, non-impact devices cannot make "carbon" copies, while impact printers can. An alternative to making multiple copies with the printer is to use an office copier to duplicate the original. In many cases, this must be done anyway because the application requires more than the four to six copies that can be produced by an impact printer.

Frequently heard criticisms of non-impact printers are that special paper is required and that print quality is low. Not all non-impact printers require a special paper. In addition, if you are using only one type of printer, you will have to stock forms for it anyhow; using a special paper adds only a little to the cost, but it does reduce the number of sources of supply. If you are using a number of printers at one location, consideration of special paper needs becomes more important. Print quality is a very subjective matter. The criticism of non-impatc print ⊳

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quality is usually based on the fact that the special papers frequently provide a low contrast between the printed material and the paper, and on the fact that almost all non-impact printers use some form of dot matrix character formation.

You will have to look at actual samples to tell whether the output of a particular printer will suffice for your needs. One thing to keep in mind however, is that multiple copies printed on a line printer invariably show a marked degradation of print quality. (This is virtually impossible to avoid because the multiple thicknesses of paper tend to cushion and spread the printing impact, blurring the carbon copies.)

Printing Mechanism includes entries describing the physical layout and performance of the printer.

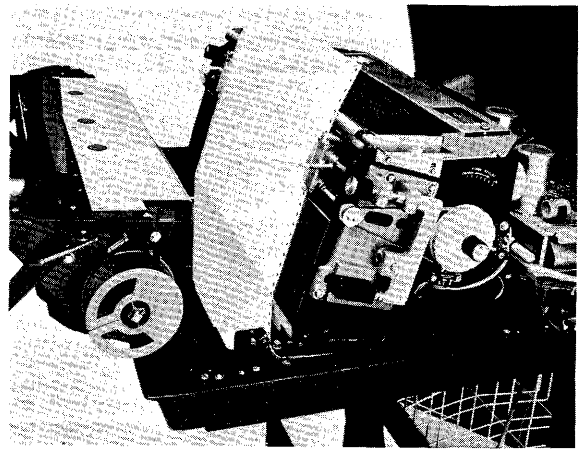
Under *Type,* the printer is identified as being a character or line printer. This refers to the unit of information printed during a basic cycle. Line printers achieve their high information rate by printing all columns in parallel, during one print cycle. Some character printers also double up a bit by printing two or three characters per cycle to achieve higher print rates.

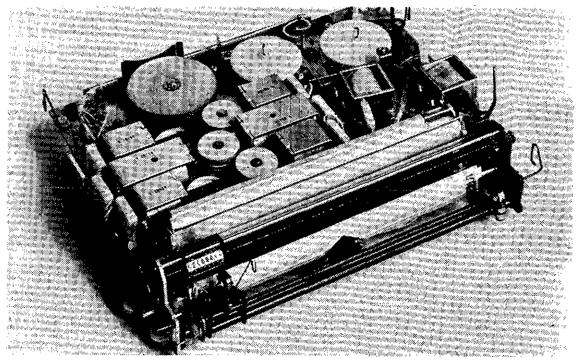
The printing process is identified under *Arrangement.* At one time or another, virtually every method for creating legible marks has been incorporated into a printer. The entries are largely self-descriptive when taken with other entries in the chart. Entries such as drum, chain, train, etc. normally are associated with an impact printer and refer to the shape of the component that carries the engraved images of the characters to be printed. A wheel is a single-column drum, if you will, that is moved across the paper column by column. The basic difference between a chain and a train printer is whether the type slugs carrying the engraved images are linked or not. The advantage of train printers is that it is normally easy to change the set of characters being used. Associated with non-impact printers are entries such as "electrothermal", which uses heat to create a visible mark on special paper, and "ink-jet", which uses controlled stream of ink particles to form the characters.

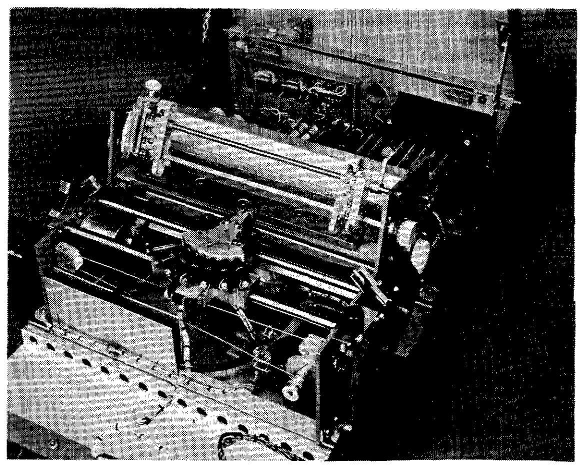
Character Formation refers to the appearance of the printed characters. Two general entries appear: full and dot matrix. The illustrations accompanying this report show what typical examples of each technique look like. Associated with the entry "dot matrix" is the size of the array employed. The first digit is the width of the array, and the second digit is the height.

If conventional printer forms cannot be used, but a special type of paper is required instead, you will find a "Yes" under the heading *Special Paper Required.*

Forms Feed identifies the method used to advance the paper during printing. There are three general methods:







And on the inside .... Open up an Odec 1300 series line printer and you get the view at the top. The yoke at left conceals the character belt. The print hammers are concealed on the right by the paper. The yoke swings to the right, the cover swings down, and you're ready to print at 180 to 310 lines per minute, depending on the model. The tractor mechanism is clearly visible at the sides of the forms. Open up a Mite 123P printer and you get the view in the middle. The printer cylinder is visible at the lower left; it rotates and translates to bring the correct character into position for the column being printed. The wheels, belts, and other contrivances are necessary to control the various kinds of motions going on. You have to remove the cover from a Di-An 9030 to get the view at the bottom. The "gun carriage" includes seven solenoids that "fire" pins to form seven vertical dots; five columns of these form a character. Again, the tractors for forms movement are clearly visible.

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$$a_{11}x + a_{12}y + a_{13}z = q_1^2$$
$$a_{21}x + a_{22}y + a_{23}z = q_2^2$$
$$a_{31}x + a_{32}y + a_{33}z = q_3^2$$

The Diablo Model 1200 Serial Printer caught the attention of many people at the 1972 Spring Joint Computer Conference. One of the reasons is illustrated above. All functions are independently controlled by servos. For instance, the superscripts and subscripts for the q's were printed without having to backspace. Very fine control of both vertical and horizontal pitch (48 increments per inch horizontally and 60 vertically), coupled with the separate control of all motion functions, greatly enhances the printing speed for complex layouts. Proportional spacing is even possible–if you have the software to do it.

friction, pin, and tractors. Friction feed is what typewriters use. Pin feed employs sprockets at one or both ends of the paper feed mechanism. Tractors are sprocket feeds that can be adjusted for width. Both pin and tractor feed mechanisms provide accurate alignment of multi-part forms. Trying to feed a long run of multi-part forms through a friction feed device usually results in slippage so that the various parts lose alignment. Occasionally you may see a pin feed with sharpened teeth on the sprockets; this is normally referred to as a prick-pin feed and is designed to eliminate the requirement for forms with sprocket holes already punched. In general, pin or tractor mechanisms are recommended when pre-printed forms are used or when multi-part forms are used.

Special provisions are sometimes included or are optionally available for positioning the forms vertically. Such provisions are noted under *Vertical Format Control.* The basic capability is, of course, single spacing, or advancing the form one line at a time. To simplify programming of multi-line skips, a device called a vertical format unit (VFU) is incorporated. A VFU is usually a device for reading a continuous paper or Mylar tape loop that is separated into several channels. Punches in the channels are used to sense and control the positioning of the form. Occasionally, an electronic VFU device is employed; this is a set of automatic line counters that accomplishes the same result as the tape VFU. For preprinted forms or highly formatted output, a VFU is a very helpful feature.

The width of forms that can be accommodated by the printer is indicated under *Forms Width.* For units with tractor feed, the minimum and maximum widths are stated. The width of the print line is smaller than the forms width. The entry under *Characters per Line* indicates the print line width.

The number of different symbols that can be printed is indicated under *Font.* A font of about 88 symbols is the minimum size that would include lower-case alphabetic letters.

The vertical spacing of lines is indicated by *Lines per Inch.*

A line printer requires a *Buffer* of some sort to function. Usually, a buffer is provided that will hold a full line, but on some low-cost units, less than a full-line buffer is provided. In this case, only a segment of the line corresponding to the size of the buffer can be printed in one print cycle; multiple cycles are required to print a full line because the one-segment buffer is shared among all line segments. For these units, speed will vary widely with the number of columns printed. Character printers may incorporate a buffer to simplify the physical and software interface between the printer and the computer.

The *Controller* is the component that decodes the stream of control characters and translates them into signals that actuate the various functions of the printer.

Peak Speed is an indication of the performance of the printer. The abbreviation "lpm" is used for "lines per minute." See also the discussion on performance earlier in the report.

Paper Advance Speed is the rate at which paper can be moved through the printer without printing; this performance characteristic becomes important when a great deal of skipping is performed to print highly formatted output.

The entries under *Interface* identify the computer systems for which the vendor supplies components that permit direct connection. An entry of "none" means that the vendor does not supply interfacing components and implies that the unit is normally sold on an OEM basis. Some OEM manufacturers do supply interfaces. An entry of "RS-232" or "current" indicates a data communications interface. Sometimes "ASCII" or another code will appear in this entry; this indicates the code recognized by the printer, including control codes for printer functions.

The entries under *Pricing and Availability* are self-explanatory. Prices stated are for unit quantities, unless otherwise specified, and typically do not include options indicated in other comparison chart entries.

WITH THE VIDEOJET PRINTER. REPORT
132 COLUMNS PER LINE AT 10 CHARAC
MORE INFORMATION PER LINE IS NEED

THE PRESENT ME
DATA PROCESSING

The Videojet 9600 printer from A.B. Dick is a most versatile unit. These two examples were printed on the same unit. Mechanical adjustments permit varying the character height and horizontal pitch. The top example was printed at 10 characters per inch; the bottom at 5.

All About Printers

Printer Suppliers

Listed below for your convenience in obtaining additional information, are the names, addresses, and telephone numbers of the 47 vendors represented in the comparison charts.

Anderson-Jacobson, Inc., 1065 Morse Avenue, Sunnyvale, California 94086. Telephone (408) 734-4030.

Centronics Data Computer Corporation, One Wall Street, Hudson, New Hampshire 03051. Telephone (603) 883-0111.

Clary Corporation, 404 Junipero Serra Drive, San Gabriel, California 91776. Telephone (213) 283-9485.

Computer Devices, Inc., 9 Ray Avenue, Burlington, Massachusetts 01803. Telephone (617) 273-1550.

Computer Terminal Systems, Inc., 52 Newtown Plaza, Plainview, New York 11803. Telephone (516) 293-6611.

Computer Transceiver Systems, Inc., East 66 Midland Avenue, Paramus, New Jersey 07652. Telephone (201) 261-6800.

Control Data Corporation, Box O, Minneapolis, Minnesota 55440. Telephone (612) 853-8100.

Datadyne Corporation, Building 37A, Valley Forge Center, King of Prussia, Pennsylvania 19406. Telephone (215) 265-1793.

Data Interface Associates, 4 West Kenosia Avenue, Danbury, Connecticut 06810. Telephone (203) 792-0290.

Data Printer Corporation, 201 Vassar Street, Cambridge, Massachusetts 02139. Telephone (617) 492-7484.

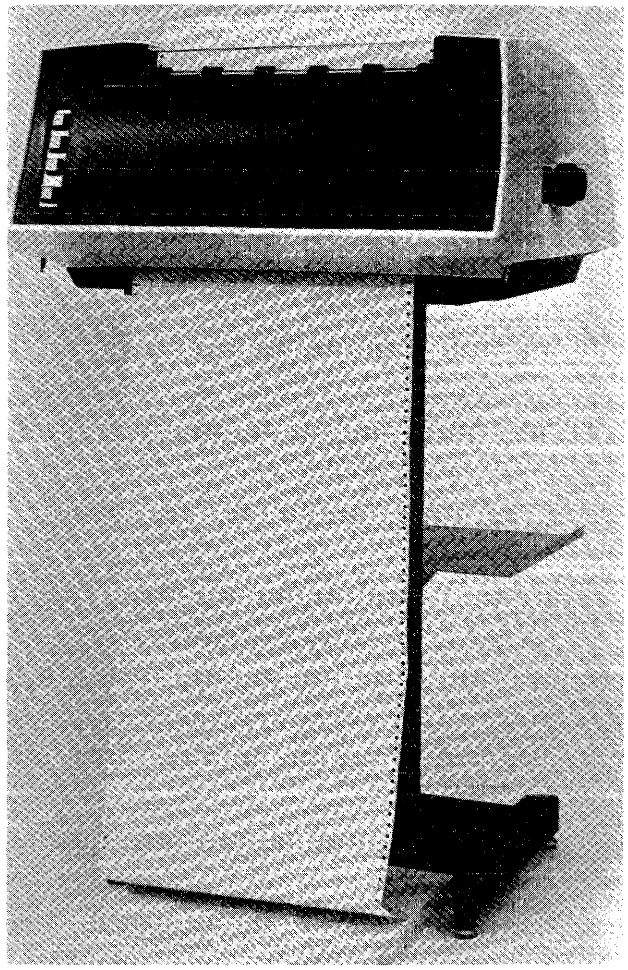
Data Products Corporation, OEM Marketing, 16055 Ventura Boulevard, Suite 419, Encino, California 91316. Telephone (213) 981-9600.

Datum, Inc., Peripheral Equipment Division, 170 East Liberty Avenue, Anaheim, California 92801. Telephone (714) 879-3070.

Decision, Inc., 5601 College Avenue, Oakland, California 94618. Telephone (415) 654-8626.

Diablo Systems, Inc. (subsidiary of Xerox Corporation), 24500 Industrial Boulevard, Hayward, California 94545. Telephone (415) 783-3910.

Di-An Controls, Inc., 944 Dorchester Avenue, Boston, Massachusetts 02125. Telephone (617) 288-7700.



Printer Technology has staked a claim to the high-speed, character-at-a-time, impact, fully-formed-character printer market. Citing the capability for multiple copies and for generating OCR-legible copy as strong selling points, the company has made a 100-character-per-second printer out of a 30-character-per-second printer by wrapping three rows of characters around a wheel in a helical pattern. The whole mechanism, including six print hammers, moves along the carriage to print a line of output. If that seems a lot to move, take a look at the typical gun carriage of a wire-matrix printer shown earlier in this report; however, some matrix printers do print faster than the Printec 100 shown above.

A.B. Dick Company, 5700 West Touhy Avenue, Chicago, Illinois 60648. Telephone (312) 763-1900.

Digitronics Corporation, Route 9, Southboro, Massachusetts 01772. Telephone 617-481-2500.

Dytro Corporation, 63 TEC Street, Hicksville, New York 11801. Telephone (516) 822-2130.

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Eclectic Corporation, 2830 Walnut Hill Lane, Dallas, Texas 75229. Telephone (214) 358-1307.

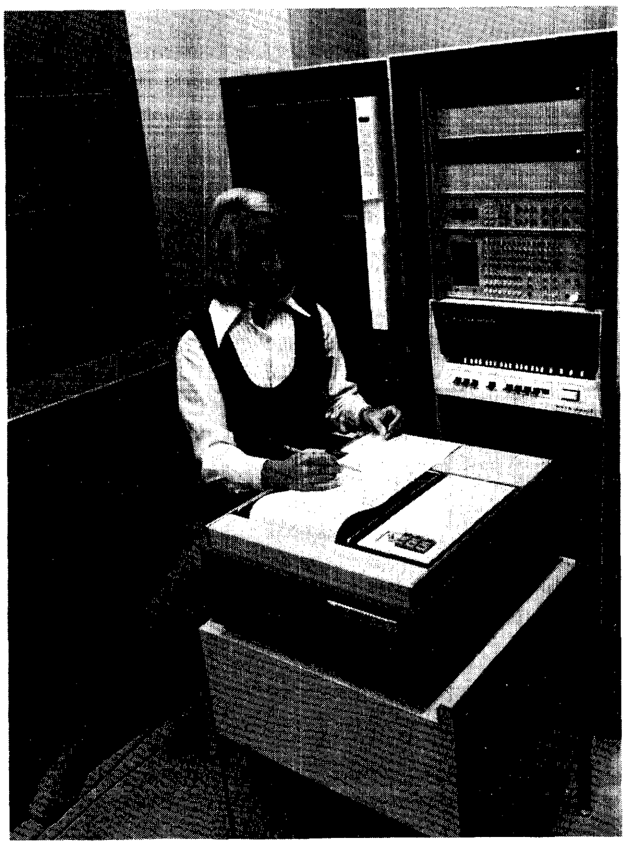
Esterline Angus, Division of Esterline Corporation, Box 24000, Indianapolis, Indiana 46224. Telephone (317) 244-7611.

Facit-Odhner, Inc., 501 Winsor Drive, Secaucus, New Jersey 07094. Telephone (201) 806-5111.

Gould, Inc., Data Systems Division, 20 Ossipee Road, Newton, Massachusetts 02164. Telephone (617) 969-6510.

Infotec, 70 Newtown Road, Plainview, New York 11803. Telephone (516) 694-9633.

Intercomp, 68 Rogers Street, Cambridge, Massachusetts 02142. Telephone (617) 864-4700.



The Varian Data Machines Statos printers/plotters equip a minicomputer for prosaic and/or exotic hard-copy output. Available in two models with different resolution capability, these units are available with a wide range of interfaces for popular minicomputers in addition to Varian's own. Someday the business community will appreciate the value of graphic information as a working tool, and units like this may become commonplace. Until then, they will be used primarily by engineers and scientists.

International Computers Limited, 839 Stewart Avenue, Garden City, New York 11530. Telephone (516) 248-5656.

ITT, General Controls Division, 1838 Flower Street, Glendale, California 91201. Telephone (213) 842-6131.

International Teleprinter Corporation, 493 Washington Avenue, Carlstadt, New Jersey 07072. Telephone (201) 438-1770.

I/O Devices, Inc., 100 Route 46, Mountain Lakes, New Jersey 07046. Telephone (201) 335-2935.

Kleinschmidt (Division of SCM Corporation), Lake-Cook Road, Deerfield, Illinois 60015. Telephone (312) 945-1000.

Litton Systems, Inc., Datalog Division, 1770 Walt Whitman Road, Melville, New York 11746. Telephone (516) 694-8300.

Macro Products Corporation, 14403 Crenshaw Boulevard, Gardena, California 90249. Telephone (213) 675-7151.

Mite Corporation, 446 Blake Street, New Haven, Connecticut 06515. Telephone (203) 387-2572.

NCR, Dayton, Ohio 45409. Telephone (513) 449-2000.

ODEC Computer Systems, Inc., 25 Graystone Street, Warwick, Rhode Island 02886. Telephone (401) 738-9500.

Per Data (Peripheral Data Machines, Inc.), 102 New South Road, Hicksville, New York 11801. Telephone (516) 938-2851.

Photophysics, Inc., 1601 Stierlin Road, Mountain View, California 94040. Telephone (415) 969-9500.

Printer Technology, Inc., Sixth Road, Woburn Industrial Park, Woburn, Massachusetts 01801. Telephone (617) 935-4246.

Repco, Inc., 1940 Lockwood Way, P.O. Box 7065, Orlando, Florida 32804. Telephone (305) 843-8484.

Tally Corporation, 8301 South 180th Street, Kent, Washington 98031. Telephone (206) 251-5500.

Teletype Corporation, 5555 Touhy Avenue, Skokie, Illinois 60076. Telephone (312) 982-2000.

Terminal Equipment Corporation, 750 Hamburg Turnpike, Pompton Lakes, New Jersey 07442. Telephone (201) 839-3000.

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> *Texas Instruments, Inc.,* Digital Systems Division, P.O. Box 1444, Houston, Texas 77001. Telephone (713) 494-5115.

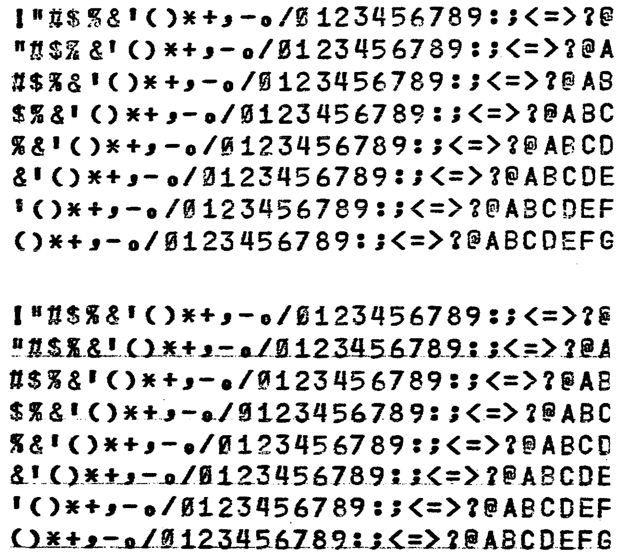
Typagraph Corporation, 7547 Convoy Court, P.O. Box 586, San Diego, California 92112. Telephone (714) 279-5690.

Uppster Corporation, 73 Southfield Avenue, Stamford, Connecticut 06902. Telephone (203) 359-4841.

Varian Data Machines, 611 Hansen Way, Palo Alto, California 94303. Telephone (415) 493-4000.

Versatec, 10100 Bubb Road, Cupertino, California 95014. Telephone (408) 257-9900.

Vogue Instrument Corporation, Shepard Division, 131st Street at Jamaica Avenue, Richmond Hill, New York 11418. Telephone (212) 641-8800. □



Much is said by the vendors of impact printers about their capabilities for printing multi-part forms. This example compares the first and last copies of a six-part form printed on a medium-speed printer. The last copy is still readable, but is far from pretty. Some printers can do better—some worse.

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MANUFACTURER & MODEL	Anderson Jacobson AJ630	Anderson Jacobson AJ841	Centronics 101	Centronics 101A	Centronics 101D
BASIC IMPRINTING TECHNIQUE	Non-impact	Impact	Impact	Impact	Impact
PRINTING MECHANISM					
Type	Character	Character	Character	Character	Character
Arrangement	Electrothermal	Ball	Wire matrix	Wire matrix	Wire matrix
Character Formation	5x8 dot matrix	Full	5x7 dot matrix	9x7 dot matrix	dot matrix
Special Paper Required	Yes	No	No	No	No
Forms Feed	Friction	Friction or pin	Pin	Pin	Pin
Vertical Format Control	Single spacing	Single spacing	Tab	Tab	Tab
Forms Width, inches	15	15.5	14.875	14.875	14.875
Font, characters	95	88	63	64	64
Characters per Line	140	130 or 156	132	132	132
Lines per Inch	6	6	6	6	6
BUFFER	None	None	Full line	Full line	Full line
CONTROLLER	Integral	Integral	None supplied	None supplied	None supplied
PEAK SPEED	30 char/sec	15.1 char/sec	165 char/sec	165 char/sec	165 char/sec
PAPER ADVANCE SPEED, inches/sec.	INA	INA	INA	INA	INA
INTERFACE	RS-232C; DAA; acoustic; ASCII	RS-232C; DAA; acoustic; ASCII	RS-232; popular minicomputers; ASCII	RS-232; popular minicomputers; ASCII	RS-232; popular minicomputers; ASCII
PRICING AND AVAILABILITY					
Purchase Price, $	2,500 (RO)	4,100 (inc. keyboard)	3,935	4,130	Contact vendor
First Delivery	INA	INA	Summer 1971	Early 1972	Early 1973
Availability	INA	INA	45 to 60	45 to 60	–
Number Installed to Date	INA	INA	Over 2000	Over 1000	–
Serviced By	Anderson Jacobson	Anderson Jacobson	Syntonics	Syntonics	Syntonics
COMMENTS	These units are sold in terminal configurations. The AJ841 is based on the IBM Selectric Typewriter.		Lines of double-width characters can be printed; also available as OEM.	Double-width characters can be interspersed anywhere; also available as OEM.	Includes graphics mode for complete control of matrix points printed; also OEM.

MANUFACTURER & MODEL	Centronics 102A	Centronics 306	Clary Corp. SP-20	Clary Corp. LP321	Clary Corp. 7000
BASIC IMPRINTING TECHNIQUE	Impact	Impact	Impact	Impact	Impact
PRINTING MECHANISM					
Type	Character	Character	Character	Line	Line
Arrangement	Wire matrix	Wire matrix	Wheel	Drum	Drum
Character Formation	9x7 dot matrix	9x7 dot matrix	Full	Full	Full
Special Paper Required	No	No	No	No	No
Forms Feed	Pin	Pin	Friction	Friction	Friction
Vertical Format Control	Tab	Tab	Single spacing	Single spacing	Single spacing
Forms Width	14.875	11	INA	3.5	3.5
Font	64	64	64	16	11
Characters per Line	132	80	INA	21	20
Lines per Inch	6	6	INA	5	6
BUFFER	Full line	Full line	None	None	None
CONTROLLER	None supplied	None supplied	None supplied	None supplied	None supplied
PEAK SPEED	330 char/sec	120 char/sec	20 char/sec	63 char/sec	600 lpm
PAPER ADVANCE SPEED, inches/sec.	INA	INA	2	0.6	INA
INTERFACE	RS-232; popular minicomputers; ASCII	RS-232; popular minicomputers; ASCII	None; 6-bit parallel input	None; 4-bit parallel input	None; parallel input
PRICING AND AVAILABILITY					
Purchase Price, $	5,195	1,495	460 (50)	870 (50)	1,575 (50)
First Delivery	September 1972	Fall 1972	INA	INA	INA
Availability	45 to 60	45 to 60	30	45	60
Number Installed to Date	–	–	INA	INA	INA
Serviced By	Syntonics	Syntonics	Clary	Clary	Clary
COMMENTS	Two print heads operate simultaneously forward and backward; also OEM.	Also available as OEM.	Military version available as Model AN-16	Available with 5 to 21 columns	Ruggedized; similar military version (Model 2000) operates at 900 lpm.

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MANUFACTURER & MODEL	Computer Devices 930 Teleterm	Computer Terminal Systems Model 444	Computer Transceiver Systems Execuport 1200	Control Data 9300	Control Data 9310
BASIC IMPRINTING TECHNIQUE	Non-impact	Impact	Impact	Impact	Impact
PRINTING MECHANISM					
Type	Character	Character	Character	Column	Column
Arrangement	Electrothermal	Wheel	Wire matrix	Drum	Drum
Character Formation	5x7 dot matrix	Full	5x7 dot matrix	Full	Full
Special Paper Required	Yes	Yes	No	No	No
Forms Feed	Friction	Friction	Tractors	Friction	Tractors
Vertical Format Control	Single or double spacing	–	Optional	–	–
Forms Width, inches	8.75	Strip printer	14.875	2 (high)	5.3
Font	96	64	120	42	64 or 96
Characters per Line	80	–	132	Unlimited	Unlimited
Lines per Inch	6	–	6	4	6
BUFFER	None	None	Full line optional	None	None
CONTROLLER	Intergal	None supplied	None supplied	None supplied	None supplied
PEAK SPEED	30 char/sec	30 char/sec	120 char/sec	20 columns/sec	15 columns/sec
PAPER ADVANCE SPEED, inches/sec.	5 or 10	–	6.5	6.7	3.8
INTERFACE	RS-232C; Serial or parallel logic; current	Custom	Serial or parallel logic	Custom	Custom
PRICING AND AVAILABILITY					
Purchase Price $	2,700	500	2,800 to 5,300	3,000 (10)	3,900 (10)
First Delivery	May 1972	June 70	September 1972	1966	1966
Availability	15	30	90	180	180
Number Installed to Date	See Comments	800	–	Over 3000	Under 100
Serviced By	Honeywell	Computer Terminal Systems	Honeywell	Per customer requirement	Per customer requirement
COMMENTS	Teletype replacement. Over 500 portable versions (1030) have been installed, beginning in 1970	Uses carbonless paper; no inking required; many variations for special applications		OEM units. Print up to 7 (9300) or 26 (9310) lines simultaneously, one column at a time; paper feed is in the direction of the print line	

MANUFACTURER & MODEL	Control Data 9320	Control Data 9340	Control Data 9350	Control Data 9360	Datadyne 722
BASIC IMPRINTING TECHNIQUE	Impact	Impact	Impact	Impact	Impact
PRINTING MECHANISM					
Type	Line	Line	Line	Line	Line
Arrangement	Drum	Drum	Drum	Train	Drum
Character Formation	Full	Full	Full	Full	Full
Special Paper Required	No	No	No	No	No
Forms Feed	Pin	Tractors	Tractors	Tractors	Friction
Vertical Format Control	12-channel VFU	12-channel VFU	12-channel VFU	12-channel VFU	Single spacing
Forms Width, inches	3.5 to 20.5	4 to 20.5	4 to 20.5	4 to 21	2.5
Font	64	64	64	47 to 63	16 or 64
Characters per Line	136	136	136	136	22
Lines per Inch	6 or 8	6 or 8	6 or 8	6 or 8	6
BUFFER	Optional	Optional	Optional	Optional	Yes
CONTROLLER	9322	9342	9352	9362	None supplied
PEAK SPEED	200 lpm	400 lpm	600 lpm	1200 lpm	1200 or 2400 lpm
PAPER ADVANCE SPEED, inches/sec.	15	20	20	70	6.5 or 3.3
INTERFACE	Custom	Custom	Custom	Custom	Logic level
PRICING AND AVAILABILITY					
Purchase Price $	6,000 (10)	9,500 (10)	15,000 (10)	27,000 (10)	1,700 to 2,900
First Delivery	1972	1965	1969	1968	INA
Availability	180	180	180	180	30
Number Installed to Date	Over 10	Over 3000	Over 250	Over 1000	Over 200
Serviced By	Per customer requirement	Per customer requirement	Per customer requirement	Per customer requirement	Datadyne
COMMENTS	OEM units; available as print mechanism only (except 9360), print mechanism with drive electronics, or complete with controller; prices above are for the second arrangement				Peak speed is 2400 lpm for numeric and 1200 lpm for alphanumeric printing

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MANUFACTURER & MODEL	Data Interface 240	Data Printer F80-C	Data Printer V-132-C	Data Printer V-236	Data Printer V-306
BASIC IMPRINTING TECHNIQUE	Non-impact	Impact	Impact	Impact	Impact
PRINTING MECHANISM					
Type	Line	Line	Line	Line	Line
Arrangement	Magnetic ink transfer	Drum	Drum	Drum	Drum
Character Formation	10x12 dot matrix	Full	Full	Full	Full
Special Paper Required	No	No	No	No	No
Forms Feed	Friction	Tractors	Tractors	Tractors	Tractors
Vertical Format Control	Single spacing	8 or 12-channel VFU	8 or 12-channel VFU	8 or 12-channel VFU	8 or 12-channel VFU
Forms Width, inches	8.5	9.875	3.5 to 19.5	3.5 to 19.5	3.5 to 19.5
Font	96	64	64	64	64
Characters per Line	80	80	132	132	132
Lines per Inch	6	6 or 8	6 or 8	6 or 8	6 or 8
BUFFER	Yes	Yes	Yes	Yes	Yes
CONTROLLER	Integral	Third party	Third party	Third party	Third party
PEAK SPEED	240 char/sec	600 lpm	600 lpm	200 to 600 lpm	300 to 600 lpm
PAPER ADVANCE SPEED, inches/sec.	1.25	27.5	27.5	27.5	27.5
INTERFACE	RS-232 or parallel logic level	Most popular minicomputers via third-party controllers	Most popular minicomputers via third-party controllers	Most popular minicomputers via third-party controllers	Most popular minicomputers via third-party controllers
PRICING AND AVAILABILITY					
Purchase Price, $	4,100	7,665	9,960	8,275	8,875
First Delivery	July 1972	Fall 1969	Fall 1969	May 1972	May 1972
Availability	60	60 to 90	60 to 90	60 to 90	60 to 90
Number Installed to Date	1	See Comments	See Comments	INA	INA
Serviced By	INA	Third party	Third party	Third party	Third party
COMMENTS	Matrix patterns magnetically recorded on belt; adhering toner particles are pressed onto paper, then fused	OEM units. About 800 have been installed. Model F-132-C also available for fixed-width forms		OEM units. Higher speeds are attained when printing less than full-width lines	

MANUFACTURER & MODEL	Data Products 2310	Data Products 2410	Data Products 2420	Data Products 2440	Data Products 2470
BASIC IMPRINTING TECHNIQUE	Impact	Impact	Impact	Impact	Impact
PRINTING MECHANISM					
Type	Line	Line	Line	Line	Line
Arrangement	Drum	Drum	Drum	Drum	Drum
Character Formation	Full	Full	Full	Full	Full
Special Paper Required	No	No	No	No	No
Forms Feed	Tractors	Tractors	Tractors	Tractors	Tractors
Vertical Format Control	Single spacing; top-of-form	8 or 12-channel VFU	8 or 12-channel VFU	8 or 12-channel VFU	8 or 12-channel VFU
Forms Width, inches	4 to 9.875	4 to 19.875	4 to 19	4 to 19	4 to 19
Font	48, 64, 86, or 96	48, 64, 86, or 96	48, 64, 86, or 96	48, 64, 86, or 96	48, 64, 86, or 96
Characters per Line	80	132 or 136	132 or 136	132 or 136	132 or 136
Lines per Inch	6	6 or 8	6 or 8	6 or 8	6 or 8
BUFFER	20 char.	24 char.	Full line	Full line	Full line
CONTROLLER	None supplied	None supplied	None supplied	None supplied	None supplied
PEAK SPEED	350 to 1100 lpm	245 to 1100 lpm	245 to 1100 lpm	700 to 1800 lpm	1250 to 1800 lpm
PAPER ADVANCE SPEED, inches/sec.	13	13	20	35	35
INTERFACE	Logic level	Logic level	Logic level	Logic level	Logic level
PRICING AND AVAILABILITY					
Purchase Price, $	Contact vendor	Contact vendor	Contact vendor	Contact vendor	Contact vendor
First Delivery	1969	1969	1971	1971	1971
Availability	60	60	90	90	90
Number Installed to Date	2000	1000	250	250	300
Serviced By	OEM support	OEM support	OEM support	OEM support	OEM support
COMMENTS	OEM units. These printers are noted for producing copy with unusually good vertical alignment for drum units. Variations in print speed are due to character set and separation of print line into logical segments to reduce logic required; reading across, the number of segments is 4, 6, 6, 21. Quick-change drum is optional for character set changes				

All About Printers

MANUFACTURER & MODEL	Data Products 4300	Datum 5096	Decision 3140	Decision 3141	Decision 3142
BASIC IMPRINTING TECHNIQUE	Impact	Impact	Non-impact	Impact	Impact
PRINTING MECHANISM					
Type	Line	Character	Line	Character	Line
Arrangement	Drum	Wheel	Electrostatic	Wire Matrix	Wire matrix
Character Formation	Full	Full	5x7 dot matrix	5x7 dot matrix	5x7 dot matrix
Special Paper Required	No	No	Yes	No	No
Forms Feed	Tractors	Pin	Friction	Tractors	Tractors
Vertical Format Control	8 or 12-channel VFU	2, 8, or 12-channel VFU	Single spacing	2-channel VFU	4 or 12-channel VFU
Forms Width, inches	4.5 to 19	Up to 15.94	8	Up to 14	4 to 8 or 14.875
Font	48, 64, 86, 96, 128	64	64	64	64
Characters per Line	132 or 136	132	80 or 132	132	80 or 132
Lines per Inch	6 or 8	6 or 8	6	6	6
BUFFER	Full line	Yes	Full line	None	None
CONTROLLER	None supplied	Integral	Integral	Integral	Integral
PEAK SPEED	1000 lpm	100 char/sec	300 or 600 lpm	135 char/sec	135 or 300 lpm
PAPER ADVANCE SPEED, inches/sec.	35	5.5	1 or 2	4	8.5
INTERFACE	Logic level	DEC PDP-8, -8/E,-11; Data General Nova	Data General Nova; DCC 116	Data General Nova; DCC 116	Data General Nova; DCC 116
PRICING AND AVAILABILITY					
Purchase Price, $	Contact vendor	2,960 to 4,960	8,500 or 11,000	5,400	8,300 or 8,700
First Delivery	1966	February 1972	1970	January 1972	April 1972
Availability	90	60	60	60	60
Number Installed to Date	1200	5	INA	INA	INA
Serviced By	OEM support	Datum	Decision	Decision	Decision
COMMENTS		Includes output software; based on Printer Technology PRINTEC 100	Includes output and diagnostic software; based on Versatec printers	Includes output and diagnostic software; based on Centronics printer	Based on Potter printers

MANUFACTURER & MODEL	Decision 3143	Diablo HyType I	Di-An Controls Series N	Di-An Controls Series DL	Di-An Controls Ticket Printers
BASIC IMPRINTING TECHNIQUE	Impact	Impact	Impact	Impact	Impact
PRINTING MECHANISM					
Type	Character	Character	Line	Line	Column
Arrangement	Chain	Daisy disk	Drum	Drum	Drum
Character Formation	Full	Full	Full	Full	Full
Special Paper Required	No	No	No	No	No
Forms Feed	Tractors	Friction	Friction or tractors	Friction	Friction or tractor
Vertical Format Control	8-channel VFU	Up or down, 48 increments per inch	Single spacing	Single spacing	Single spacing
Forms Width, inches	Up to 14.875	Up to 15	3.75	2	1 to 4 (high)
Font, characters	64	96	16, 48, or 64	16, 48, or 64	16, 48, or 64
Characters per Line	132	132	32	16	Unlimited
Lines per Inch	6	Variable	6	6	6
BUFFER	None	None	Yes	Yes	Yes
CONTROLLER	Integral	None supplied	None supplied	None supplied	None supplied
PEAK SPEED	600 lpm	30 char/sec average	1200 lpm	1200 lpm	20 columns/sec
PAPER ADVANCE SPEED, inches/sec.	15	4	25	25	10
INTERFACE	Data General Nova; DCC 116	None	Custom	Custom	Custom
PRICING AND AVAILABILITY					
Purchase Price, $	12,500	1,825	3,525 to 8,000	2,100 to 5,500	3,290
First Delivery	July 1972	Summer 1972	1962	1965	1967
Availability	60	90	90	90	30
Number Installed to Date	INA	200	600	400	2500
Serviced By	Decision	Diablo	Di-An	Di-An	Di-An
COMMENTS	Based on Vogue printer	OEM unit. Horizontal spacing variable, 60 positions per inch; all functions independently controlled by servos			Ticket cutter; can imprint OCR bar codes; can record on magnetic stripe

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MANUFACTURER & MODEL	Di-An Controls 9030	Di-An Controls Series S	A.B. Dick 9600 Videojet	A.B. Dick 9500 Videojet	Digitronics 200
BASIC IMPRINTING TECHNIQUE	Impact	Impact	Non-impact	Non-impact	Impact
PRINTING MECHANISM					
Type	Character	Character	Character	Character	Line
Arrangement	Wire matrix	Wheel	Inkjet matrix	Inkjet matrix	Belt
Character Formation	7x9 matrix	Full	9x11 matrix	5x7 matrix	Full
Special Paper Required	No	No	No	No	No
Forms Feed	Tractors	Friction	Pin	Pin	Tractors
Vertical Format Control	Single spacing	Strip printer	12-channel VFU	12-channel VFU	8-channel VFU
Forms Width, inches	Up to 11	15/32 (high)	3.5 to 14.875	3.5 to 14.875	Up to 14.875
Font	96	63	64	64	64 or 96
Characters per Line	80 or 132	Unlimited	Variable	Variable	132
Lines per Inch	6	–	6 or 8	6 or 8	6 or 8
BUFFER	None	None	200 or 400 char. optional	200 or 400 char. optional	Yes
CONTROLLER	Integral	None supplied	Optional	Optional	200 CI
PEAK SPEED	30 char/sec	20 char/sec	300 char/sec	750 char/sec	200 lpm
PAPER ADVANCE SPEED, inches/sec.	5	2	5.95	5.95	10
INTERFACE	RS-232C; acoustic; parallel or serial logic level; ASCII	RS-232B; ASCII or Baudot	RS-232; DEC PDP-8, -11; Data General Nova; Hewlett-Packard Varian 620/i; others	RS-232; IBM 2260/2848; Teletype	Data General Nova; DEC PDP-8/E, -11; Honeywell 316, 516; HP 2100 Series
PRICING AND AVAILABILITY					
Purchase Price, $	2,660	295	6,250	7,500	8,500
First Delivery	March 1972	1968	November 1969	June 1972	January 1971
Availability	30	30	60 to 90	60 to 90	45 to 60
Number Installed to Date	15	350	325	1	INA
Serviced By	Di-An	Di-An	A.B. Dick	A.B. Dick	Digitronics
COMMENTS	Price above includes keyboard; RO model available; matrix is dot addressable		9600 can simulate lowercase printing by use of a reduced 5x7 matrix for small capitals. Both models can vary horizontal pitch from 5 to 20 characters per inch		OEM unit

MANUFACTURER & MODEL	Dytro 1100/1020/1223	Eclectic 760	Eclectic 770	Esterline Angus P-500	Facit-Odhner 3841-4
BASIC IMPRINTING TECHNIQUE	Impact	Impact	Impact	Impact	Impact
PRINTING MECHANISM					
Type	Line	Character	Line	Line	Character
Arrangement	Wheel	Matrix	Drum	Drum	Type bars
Character Formation	Full	5x7 dot matrix	Full	Full	Full
Special Paper Required	No/Yes/No	No	No	No	No
Forms Feed	Friction	Pin	Pin	Friction	Friction
Vertical Format Control	Single spacing	Vertical tab; top of form	Top of form; single spacing	Single spacing	Single spacing
Forms Width, inches	2.5 or custom	3.5 to 14.875	4 to 9.875	3.5	Up to 17
Font	12	63	63	16	92
Characters per Line	10/10/16	132	80	21	Up to 200
Lines per Inch	4.5/4.5/3 to 6	6	6	4.9	6, 4.5, or 3
BUFFER	Available	Full line	Full line	None	None
CONTROLLER	None supplied	Integral	Integral	None supplied	Available
PEAK SPEED	150 lpm	165 char/sec	600 lpm	2.5	12 char/sec
PAPER ADVANCE SPEED, inches/sec.	2	4	13	0.5	INA
INTERFACE	Custom	DEC PDP-8, -11	DEC PDP-8, -11	6-bit, parallel logic level	Teletype; RS-232; ASCII 7-bit
PRICING AND AVAILABILITY					
Purchase Price, $	175 up	3,925	9,875	1,095	1,130
First Delivery	INA	INA	INA	INA	1969
Availability	15	45	90	15	Stock
Number Installed to Date	2100	INA	INA	50	INA
Serviced By	Dytro	INA	INA	Esterline	Company Service centers
COMMENTS	Model 1020 requires special carbonless paper				OEM unit. Also available as input-only or input/output unit

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MANUFACTURER & MODEL	Facit-Odhner 4552	Facit-Odhner 4501	Gould 4800	Infotec PS-1130	Intercomp 143
BASIC IMPRINTING TECHNIQUE	Impact	Impact	Non-impact	Impact	Impact
PRINTING MECHANISM					
Type	Character	Character	Line	Line	Line
Arrangement	Wire matrix	Type segment	Electrostatic	Drum	Chain
Character Formation	5x7 dot matrix	Full	5x7 dot matrix	Full	Full
Special Paper Required	Yes	No	Yes	No	No
Forms Feed	Friction	Friction	Friction	Pin	Tractors
Vertical Format Control	Strip printer	Single spacing	Single spacing	12-channel VFU	12-channel VFU
Forms Width	—	INA	11	3.5 to 19.5	6 to 18
Font	64	10	64	64	48 or 96
Characters per Line	Unlimited	20	132	132	120 or 136
Lines per Inch	—	6	8	6 or 8	6 or 8
BUFFER	No	No	Yes	Yes	Yes
CONTROLLER	Integral	None supplied	Available	Integral	Integral
PEAK SPEED	15 char/sec	180 lpm	3000 lpm	600 lpm	450 lpm
PAPER ADVANCE SPEED, inches/sec.	INA	0.5	7	27.5	17
INTERFACE	ASCII, 6-bit parallel	None	Most popular computers	IBM 1130	IBM 1130
PRICING AND AVAILABILITY					
Purchase Price, $	395	185	10,900	Contact vendor	18,800
First Delivery	1971	1971	December 1969	January 1972	September 1970
Availability	Stock	Stock	60	60 to 90	60
Number Installed to Date	INA	INA	200	4	25
Serviced By	Facit-Odhner	Facit-Odhner	Gould	Honeywell	Intercomp
COMMENTS	OEM unit. Also available with interface to accept data by matrix column or by matrix dot	OEM unit	Unit provides extensive graphic capabilities	Replaces IBM 1403	Replaces IBM 1403

MANUFACTURER & MODEL	International Computers Ltd. ICL TP 1500	International Computers Ltd. ICL 667	ITT/General Controls Model CP	ITT/General Controls Model EP	International Teleprinter TELEREX-30
BASIC IMPRINTING TECHNIQUE	Impact	Impact	Impact	Impact	Impact
PRINTING MECHANISM					
Type	Line	Line	Line	Line	Character
Arrangement	Train	Drum	Wheel	Wheel	Wire matrix
Character Formation	Full	Full	Full	Full	5x7 or 7x9 dot
Special Paper Required	No	No	Yes	Yes	No
Forms Feed	Tractors	Tractors	Friction	Friction	Friction & pin
Vertical Format Control	Electronic or 8-channel VFU	8-channel VFU	Single spacing	Single spacing	Single spacing top-of-form
Forms Width	4 to 20	4 to 15.313	Variable	Variable	8.5 or 12.84
Font	16 to 192	64	10 or 12	10 or 12	64 or 96
Characters per Line	132 to 160	80 to 136	1 to 30	8, 12, or 16	80 or 132
Lines per Inch	6 or 8	6 or 8	4.5	4.5	6
BUFFER	Optional	None	None	None	None
CONTROLLER	Optional	None supplied	None supplied	None supplied	None supplied
PEAK SPEED	1500 lpm	875 lpm	300 lpm	300 lpm	30 char/sec
PAPER ADVANCE SPEED, inches/sec.	30 and 75	22	2.2	2.2	5.5
INTERFACE	ICL 1900; custom	None	Custom	Custom	RS-232C; Teletype current; serial or parallel logic level
PRICING AND AVAILABILITY					
Purchase Price, $	25,474	5,256	350 (8 col.)	290 (8 col.)	1,650
First Delivery	INA	1970	INA	INA	August 1972
Availability	INA	INA	45-60	Stock	INA
Number Installed to Date	INA	INA	Several thousand	Several thousand	—
Serviced By	Customer	Customer	Customer	Customer	Customer
COMMENTS	OEM unit. Price does not include controller	OEM unit			OEM unit. Ro, KSR, and ASR terminals also available

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MANUFACTURER & MODEL	I/O Devices Model 200	Kleinschmidt Model 311	Kleinschmidt SYCOM	Litton Datalog 1100	Litton Datalog MC 1000
BASIC IMPRINTING TECHNIQUE	Impact	Impact	Impact	Non-impact	Non-impact
PRINTING MECHANISM					
Type	Character	Character	Line	Line	Character
Arrangement	Print cylinder	Drum	Drum	Electrolytic	Electrolytic
Character Formation	Full	Full	Full	5x7 dot matrix	5x7 dot matrix
Special Paper Required	No	No	No	Yes	Yes
Forms Feed	Frict./pin/tractors	Friction/pin	Tractors	Friction	Friction
Vertical Format Control	Tab; up/down, ½ or 1 line	2-channel VFU	Yes	Single spacing	Strip printer
Forms Width, inches	14.375 to 27	8.5 or 9	Up to 14.5	11	3/8 (high)
Font, characters	96	64	64 or 96	64	64
Characters per Line	132 to 256	80	132	128	Unlimited
Lines per Inch	6 or 12	6	6 or 8	5 to 9	–
BUFFER	Optional	No	Yes	Two lines	None
CONTROLLER	None supplied	None supplied	None supplied	Integral	None supplied
PEAK SPEED	35 to 50 char/sec	40 char/sec	200, 400, or 600 lpm	200 lpm	65 char/sec
PAPER ADVANCE SPEED, inches/sec.	3.3	INA	16	0.9	8
INTERFACE	DEC PDP-8; Data General Nova; others on request	Serial or parallel	RS-232; DEC PDP-8; Texas Instruments 960 A; Data General Nova; IBM System/3	DEC PDP-8, -11, -9, -15; Data General Nova; Hewlett-Packard; Interdata; Varian	None
PRICING AND AVAILABILITY					
Purchase Price, $	3,210 (inc. keyboard)	1,975	9,500	6,000	1,995
First Delivery	November 1971	1965	August 1972	June 1971	INA
Availability	30	30	INA	60	30
Number Installed to Date	120	About 3000	–	25	INA
Serviced By	GTE	Kleinschmidt	Kleinschmidt	Litton Datalog	Litton Datalog
COMMENTS	Many forms handling features available	Acoustical enclosure available	Plugboard vertical format control	Manufactured by Leigh Instruments, Ltd., Ottawa, Canada. Extensive graphic capabilities	Meets military specifications; portable unit

MANUFACTURER & MODEL	Litton Datalog MC 2000	Litton Datalog MC 3000	Litton Datalog MC 4600	Macro Products M310	Macro Products M410
BASIC IMPRINTING TECHNIQUE	Non-impact	Non-impact	Non-impact	Impact	Impact
PRINTING MECHANISM					
Type	Line	Line	Line	Line	Line
Arrangement	Electrolytic	Electrolytic	Electrolytic	Drum	Drum
Character Formation	5x7 dot matrix	5x7 dot matrix	5x7 dot matrix	Full	Full
Special Paper Required	Yes	Yes	Yes	No	No
Forms Feed	INA	INA	INA	Tractors	Tractors
Vertical Format Control	INA	INA	INA	Single spacing; Top of form	8 or 12-channel VFU
Forms Width, inches	INA	INA	INA	4 to 9.875	4 to 14.875
Font, characters	64	64	64	64 or 96	64 or 96
Characters per Line	32	80	32	80	132
Lines per Inch	6	6	6	6	6 or 8
BUFFER	Yes	Yes	Yes	Yes	Yes
CONTROLLER	None supplied	None supplied	None supplied	Integral	Integral
PEAK SPEED	1800 lpm	3000 lpm	6000 lpm	356 to 1100 lpm	245 to 1110 lpm
PAPER ADVANCE SPEED, inches/sec.	2.22	8	16	13	13
INTERFACE	None	None	None	All minicomputers; most general-purpose computers	All minicomputers; most general-purpose computers
PRICING AND AVAILABILITY					
Purchase Price, $	7,250	11,500	6,500 to 7,000	10,750	13,125
First Delivery	INA	November 1969	INA	Ann. June 1972	Ann. June 1972
Availability	30	30	30	30 to 60	60 to 90
Number Installed to Date	INA	INA	INA	–	–
Serviced By	Litton Datalog	Litton Datalog	Litton Datalog	Third party	Third party
COMMENTS	Meets military specifications; cockpit mounted	Meets military specifications; table-top unit	Meets military specifications; table-top unit	Systems include Data Products printer and interface. Prices include complete system, installation, documentation, and CE training	

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MANUFACTURER & MODEL	Macro Products M420	Macro Products M440	Macro Products M470	Mite 123P	Mite 150P
BASIC IMPRINTING TECHNIQUE	Impact	Impact	Impact	Impact	Impact
PRINTING MECHANISM					
Type	Line	Line	Line	Character	Character
Arrangement	Drum	Drum	Drum	Cylinder	Cylinder
Character Formation	Full	Full	Full	Full	Full
Special Paper Required	No	No	No	No	No
Forms Feed	Tractors	Tractors	Tractors	Friction, pin	Friction, pin
Vertical Format Control	8 or 12-channel VFU	8 or 12-channel VFU	8 or 12-channel VFU	Single spacing	Single spacing
Forms Width, inches	4 to 19	4 to 19	4 to 19	8.5	8.5
Font, characters	64, 86, or 96	64, 86, or 96	64, 86, or 96	64	64
Characters per Line	132	132	132	75 or 80	75 or 80
Lines per Inch	6 or 8	6 or 8	6 or 8	6	6
BUFFER	Yes	Yes	Yes	None	None
CONTROLLER	Integral	Integral	Integral	None supplied	None supplied
PEAK SPEED	245 to 1120 lpm	700 to 1800 lpm	1250 to 1800 lpm	10 char/sec	15 char/sec
PAPER ADVANCE SPEED, inches/sec.	20	35	35	1.7	2.5
INTERFACE	All minicomputers; most general-purpose computers	All minicomputers; most general-purpose computers	All minicomputers; most general-purpose computers	None	None
PRICING AND AVAILABILITY					
Purchase Price, $	14,875	17,625	21,325	500	550
First Delivery	Ann. June 1972	Ann. June 1972	Ann. June 1972	July 1969	January 1972
Availability	90 to 120	90 to 120	90 to 120	15	15
Number Installed to Date	–	–	–	4000	200
Serviced By	Third party	Third party	Third party	Worldcom and factory	Worldcom and factory
COMMENTS	Systems include Data Products printer and interface. Prices include complete system, installation, documentation, and customer engineer training			OEM units with no electronics. Mite also produces a line of terminals built around these printers	

MANUFACTURER & MODEL	Mite 123/150RO	NCR 260-100	ODEC 1321	ODEC 1322	ODEC 1323
BASIC IMPRINTING TECHNIQUE	Impact	Non-impact	Impact	Impact	Impact
PRINTING MECHANISM					
Type	Character	Character	Line	Line	Line
Arrangement	Drum	Electrothermal	Belt	Belt	Belt
Character Formation	Full	5x7 dot matrix	Full	Full	Full
Special Paper Required	No	Yes	No	No	No
Forms Feed	Friction, pin	Friction	Tractors	Tractors	Tractors
Vertical Format Control	Single spacing	Single spacing	2, 8, or 12-channel VFU	2, 8, or 12-channel VFU	2, 8, or 12-channel VFU
Forms Width	8.5	8.5	16	16	16
Font	64	94	96	96	96
Characters per Line	75 or 80	80	80 or 132	132	80 or 132
Lines per Inch	6	6	6	6	6
BUFFER	None	None	Yes	Yes	Yes
CONTROLLER	Integral	Integral	Integral	Integral	Integral
PEAK SPEED	15 char/sec	30 char/sec	180 lpm	250 lpm	310 lpm
PAPER ADVANCE SPEED, inches/sec.	2.5	5	8.33	8.33	8.33
INTERFACE	RS-232; Teletype; acoustic; ASCII	RS-232; current; acoustic; ASCII	DEC PDP-8, -11, -12; Data General Nova Series; Hewlett-Packard 2100A; Honeywell 316; Varian 620/i; RS-232C		
PRICING AND AVAILABILITY					
Purchase Price, $	1,275	2,450	7,900	7,900	8,400
First Delivery	May 1972	July 1971	January 1971	January 1971	January 1971
Availability	30	INA	60	60	60
Number Installed to Date	INA	INA	INA	INA	INA
Serviced By	Worldcom and factory	NCR	SirVess	SirVess	SirVess
COMMENTS		Print-only terminal; keyboard version also available; OEM version available from different division	Printing belt operates like a chain and has individually replacable characters. Prices are for 132-column models; 80-column models cost about $1,400 less		

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MANUFACTURER & MODEL	Per Data Series LP	Photophysics Model 01	Photophysics Model 100	Printer Technology PRINTEC-100	Repco Model 120
BASIC IMPRINTING TECHNIQUE	Impact	Non-impact	Non-impact	Impact	Non-impact
PRINTING MECHANISM					
Type	Line	Page	Page	Character	Character
Arrangement	Drum	Electrographic	Electrographic	Multiple helical wheel	Electrosensitive paper
Character Formation	Full	Image	Image	Full	5x7 dot matrix
Special Paper Required	No	Yes	Yes	No	Yes
Forms Feed	Tractors	Friction	Friction	Tractors	Friction
Vertical Format Control	8 or 12-channel VFU	–	–	2 or 8-channel VFU	Single spacing
Forms Width	Variable	5.75	8.5	Up to 16	8.5
Font	64	Image	Image	64	64
Characters per Line	132	Image	Image	Up to 136	80
Lines per Inch	6	Image	Image	6	5 or 6
BUFFER	Yes	No	No	Yes	Optional
CONTROLLER	Integral	None supplied	None supplied	None supplied	Integral
PEAK SPEED	600 lpm	30 pages/min	30 pages/min	100 char/sec	120 char/sec
PAPER ADVANCE SPEED, inches/sec.	27.5	–	–	INA	0.2
INTERFACE	DEC PDP-8, -11; Data General Nova; Hewlett-Packard. 2100; Honeywell 316; Varian 620/i	EIA RS 170 video or other	EIA RS 170 video or other	Custom; RS-232C	RS-232B Serial; parallel logic level; ASCII
PRICING AND AVAILABILITY					
Purchase Price, $	12,790	Contact vendor	Contact vendor	2,200	1,500
First Delivery	INA	December 1970	November 1971	October 1971	May 1970
Availability	30	60	60	60	30
Number Installed to Date	INA	INA	INA	INA	Over 1000
Serviced By	Per Data	Honeywell	Honeywell	Honeywell	Raytheon
COMMENTS		OEM units designed as copier for CRT display or microfiche reader, Model 01 has a 4.75 x 3.25 copy field; Model 100, 8 x 10			Leased and OEM units available; keyboard available

MANUFACTURER & MODEL	Tally T-132	Tally 2100	Tally 2200	Teletype Model 33 RO	Teletype Model 35 RO
BASIC IMPRINTING TECHNIQUE	Impact	Impact	Impact	Impact	Impact
PRINTING MECHANISM					
Type	Line	Line	Line	Character	Character
Arrangement	Cross-point	Cross-point	Cross-point	Cylinder	Type box
Character Formation	7x8 dot matrix	5x7 dot matrix	5x7 dot matrix	Full	Full
Special Paper Required	No	No	No	No	No
Forms Feed	Pin	Pin	Pin	Friction or pin	Friction or pin
Vertical Format Control	1 and 2 line space; top of form	8-channel VFU	8-channel VFU	Single spacing	Single spacing
Forms Width, inches	4 to 14.875	4 to 14.875	4 to 14.875	8.5	Up to 9.5
Font, characters	63	63	63	63	63
Characters per Line	132	132	132	80	90
Lines per Inch	6	6 or 8	6 or 8	6	6
BUFFER	Two lines	Two lines	Two lines	None	None
CONTROLLER	Integral	Integral	Integral	Integral	Integral
PEAK SPEED	100 lpm	100 lpm	200 lpm	10 char/sec	10 char/sec
PAPER ADVANCE SPEED, inches/sec.	2.7	4	4	INA	INA
INTERFACE	RS-232 serial	DEC PDP-8, -11; Data General Nova	DEC PDP-8, -11; Data General Nova	RS-232; current; ASCII	RS-232; current; ASCII
PRICING AND AVAILABILITY					
Purchase Price, $	5,900	5,900	Contact vendor	575 to 700	1,525 to 1,650
First Delivery	January 1971	September 1972	September 1972	INA	INA
Availability	30	60	60	90	90
Number Installed to Date	60	–	–	Many	INA
Serviced By	Tally	Tally	Tally	Teletype or third party	Teletype or third party
COMMENTS		Lower case optional	Lower case optional		Rated for heavy-duty usage

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MANUFACTURER & MODEL	Teletype Model 37 RO	Teletype Model 38 RO	Teletype Inktronic RO	Terminal Equipment Corp. TYCOM 735	Terminal Equipment Corp. TYCOM Buffered Applique
BASIC IMPRINTING TECHNIQUE	Impact	Impact	Non-impact	Impact	Impact
PRINTING MECHANISM					
Type	Character	Character	Character	Character	Character
Arrangement	Type box	Wheel	Inkjet matrix	Ball	Ball
Character Formation	Full	Full	7x9 dot matrix	Full	Full
Special Paper Required	No	No	No	No	No
Forms Feed	Friction or pin	Pin	Friction	Friction or pin	Friction or pin
Vertical Format Control	Tab; ½ or 1 line up or down	Single spacing	Single spacing	Single spacing	Single spacing
Forms Width, inches	Up to 9.5	14.875	8.5	11, 13, or 15	11, 13, or 15
Font, characters	94	94	63 or 96	88	88
Characters per Line	90	132	80	Up to 132 or 156	Up to 132 or 156
Lines per Inch	6	6	6	6	6
BUFFER	None	None	None	None	Yes
CONTROLLER	Integral	Integral	Integral	None supplied	Integral
PEAK SPEED	15 char/sec	10 char/sec	120 char/sec	15 char/sec	15 char/sec
PAPER ADVANCE SPEED, inches/sec.	INA	INA	INA	INA	INA
INTERFACE	RS-232; ASCII	RS-232; current; ASCII	RS-232; ASCII; Baudot; parallel	DEC PDP-8; Data General Nova; IBM Correspondence code	8-bit parallel ASCII
PRICING AND AVAILABILITY					
Purchase Price, $	2,125 to 2,550	905 to 974	5,650 to 6,450	1,350	2,095
First Delivery	INA	INA	INA	September 1970	May 1972
Availability	120 to 180	90	90 to 150	30	60
Number Installed to Date	INA	INA	INA	500	2
Serviced By	Teletype or third party	Teletype or third party	Teletype or third party	TEC	TEC
COMMENTS	Limited graphic capability	Friction feed for 8.5-inch paper roll available		Printers are IBM Selectric Typewriters with a special addition; no modifications are required and the addition can be quickly removed; IBM maintenance available for typewriter	

MANUFACTURER & MODEL	Texas Instruments 700 Series	Typagraph DP-30	Uppster 1200-1	Uppster 1200-2	Varian Statos 21
BASIC IMPRINTING TECHNIQUE	Non-impact	Impact	Non-impact	Non-impact	Non-impact
PRINTING MECHANISM					
Type	Character	Character	Line	Line	Line
Arrangement	Electrothermal	Wheel	Electrographic	Electrographic	Electrostatic
Character Formation	5x7 dot matrix	Full	Full	Full	5x7 dot matrix
Special Paper Required	Yes	No	No	No	Yes
Forms Feed	Friction	Pin	Friction	Pin	Friction
Vertical Format Control	Single spacing	Tab	Variable spacing	Electronic VFU	Incremental spacing
Forms Width, inches	8.5	4 to 15	8.5	3.5 to 9.5	8.5
Font, characters	94	94	96	96	64
Characters per Line	80	Up to 132	80	44 to 160	80
Lines per Inch	6	6	6	6 or 8.25	8
BUFFER	No	Yes	Yes	Yes	Full line
CONTROLLER	Integral	Integral	Integral	Integral	Integral
PEAK SPEED	30 char/sec	60 char/sec	1200 lpm	4400 lpm	5000 lpm
PAPER ADVANCE SPEED, inches/sec.	5	6.7	3.3	3.3	11
INTERFACE	RS-232B; current; ASCII	RS-232; current; ASCII	DEC PDP-8, -11; Data General Nova; custom	DEC PDP-8, -11; Data General Nova; IBM System/360 & 370; custom	Varian 620; HP 2000; DEC PDP-8, -11, -12, -9, -15; Data General Nova; Honeywell 316, 516
PRICING AND AVAILABILITY					
Purchase Price, $	2,165 to 2,480	3,500	15,000	20,600	12,950
First Delivery	1970	January 1972	January 1971	September 1972	INA
Availability	7 to 30	30 to 45	90	90	60
Number Installed to Date	INA	INA	6	–	60
Serviced By	TI	Third party	Uppster; indep. representatives	Uppster; indep. representatives	Varian
COMMENTS	Available with built-in modem and with keyboard	Price includes keyboard		Can make up to 99 copies; multiple fonts	Can plot to a resolution of 80 lines/inch; complete on-or off-line software available

All About Printers

MANUFACTURER & MODEL	Varian Statos 31	Versatec Matrix LP860	Versatec Matrix 200A	Versatec Matrix LP1150	Versatec Matrix 1100A
BASIC IMPRINTING TECHNIQUE	Non-impact	Non-impact	Non-impact	Non-impact	Non-impact
PRINTING MECHANISM					
Type	Line	Line	Line	Line	Line
Arrangement	Electrostatic	Electrostatic	Electrostatic	Electrostatic	Electrostatic
Character Formation	7x11 dot matrix	5x7 dot matrix	5x7 dot matrix	7x9 dot matrix	7x9 dot matrix
Special Paper Required	Yes	Yes	Yes	Yes	Yes
Forms Feed	Friction	Friction	Friction	Friction	Friction
Vertical Format Control	Incremental spacing	Single spacing; top-of-form	Incremental spacing	Single spacing; top-of-form	Incremental spacing
Forms Width, inches	14.875	8.5	8.5	11	11
Font, characters	123	64 or 96	64 or 96	64 or 96	64 or 96
Characters per Line	132 or 140	80	80	132	132
Lines per Inch	6 or 8	6	6	6.7	6.7
BUFFER	One or two lines	Yes	Yes	Yes	Yes
CONTROLLER	Integral	Available	Available	Available	Available
PEAK SPEED	1000 lpm	600 lpm	600 lpm	500 lpm	500 lpm
PAPER ADVANCE SPEED, inches/sec.	2.2	1.2	1.2	1.2	1.2
INTERFACE	Varian 620; DEC PDP-8, -11, -12, -9, -15; Data General Nova; IBM 1130; Interdata 70; others	DEC PDP-8, -9, -11, -12, -15; Data General Nova; HP 2100 Series; Varian 620; XDS Sigma Series; Honeywell 316, 516	DEC PDP-8, -9, -11, -12, -15; Data General Nova; HP 2100 Series; Varian 620; XDS Sigma Series; Honeywell	DEC PDP-8, -9, -11, -12, -15; Data General Nova; HP 2100 Series; Varian 620; XDS Sigma Series; Honeywell 316, 516	DEC PDP-8, -9, -11, -12, -15; Data General Nova; HP 2100 Series; Varian 620; XDS Sigma Series; Honeywell 316, 516
PRICING AND AVAILABILITY					
Purchase Price, $	9,250	3,900	6,900	4,300	7,900
First Delivery	September 1972	May 1972	August 1970	May 1972	May 1971
Availability	90	45 to 60	45 to 60	45 to 60	45 to 60
Number Installed to Date	–	20	150	20	150
Serviced By	Varian	Versatec	Versatec	Versatec	Versatec
COMMENTS	Can plot to a resolution of 100 lines/inch; complete on- or off-line software available		Extensive plotting capabilities; resolution is 72.5 points per inch. Includes software for plotting		Extensive plotting capabilities; resolution is 100 points per inch. Includes software for plotting

MANUFACTURER & MODEL	Vogue 400C	Vogue 880E	Vogue 810	Vogue 828
BASIC IMPRINTING TECHNIQUE	Impact	Impact	Impact	Impact
PRINTING MECHANISM				
Type	Line	Line	Line	Line
Arrangement	Drum	Drum	Drum	Drum
Character Formation	Full	Full	Full	Full
Special Paper Required	No	No	No	No
Forms Feed	Tractors	Tractors	Tractors	Tractors
Vertical Format Control	8-channel VFU	Single spacing; top-of-form	Single spacing; top-of-form	Single spacing; top-of-form
Forms Width, inches	4 to 15	4 to 9.625	4.25 (high)	2 to 9.625
Font, characters	64 or 96	64	64	50
Characters per Line	132	80	17 col.	28
Lines per Inch	6 or 8	6	6	4
BUFFER	Yes	Yes	Yes	Yes
CONTROLLER	Integral	Integral	Integral	Integral
PEAK SPEED	600 lpm	400 lpm	600 col/min	600 lpm
PAPER ADVANCE SPEED, inches/sec.	13	13	13	13
INTERFACE	DEC PDP-8, -11, -15; Data General Nova; HP 2100; Interdata 4,70; H-316, H-516; EMR 6130; Varian 620	DEC PDP-8, -11, -15; Data General Nova; HP 2100; Interdata 4,70; H-316, H-516; EMR 6130; Varian 620	DEC PDP-8, -11; Data General Nova; H-316, H-516; HP2100; Interdata 4,70; Varian 620; Incoterm SPD 10/20	RS-232C; IBM PTTC (2740/2741)
PRICING AND AVAILABILITY				
Purchase Price, $	9,800	7,000	4,100	12,500
First Delivery	INA	INA	November 1972	INA
Availability	30	30	120	30
Number Installed to Date	INA	INA	–	INA
Serviced By	GTE	GTE	GTE	GTE
COMMENTS	Also available as communications terminal for $13,800 with 500-character buffer	Also available as communications terminal for $11,000 with 500-character buffer	Ticket printer	Designed to print order tickets for securities exchanges

All About Punched Card Units

In addition to surveying the characteristics of 51 card readers, punches, and reader/punches from 13 vendors, this report raises—and answers—the question of why the punched card refuses to die.

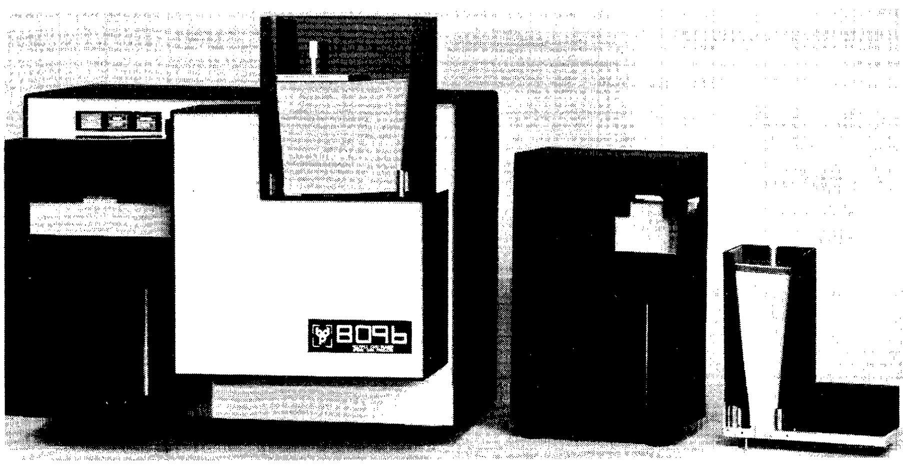
The year is 1964. Punched cards are on the way out. IBM no longer trains new systems people on unit record equipment, but starts them directly on computers. Mohawk introduces the replacement for punched cards—equipment for keying data directly to magnetic tape. The year is 1968. Punched cards are on the way out. Multistation key entry systems using disk storage as an intermediate stage reduce the cost of data recording. On-line, random-access processing is the way to collect data directly from the source. CRT display systems are great for entering data directly. The year is 1970. OCR has finally come of age, and punched cards are on the way out. The year is 1972. Somewhere around one-half million keypunches are being used—and that is more than ever before. It has become clear that cards are harder to kill than the many-headed Hydra.

The above is a short synopsis of comments made by sincere, qualified observers of the data processing scene. Seldom in the history of technology has one concept weathered the onslaught of so many talented inventors who seemed determined to stamp it out. But punched cards are still with us. With IBM's announcement of the System/3 in mid-1969, punched cards even regained momentum. Why have so many experts been wrong? Why hasn't the advent of small, cheap tapes, disks, and optical readers eliminated punched cards once and for all?

Punched cards are only one of the many media available for recording data in a form that can be read by a machine. Others include magnetic tape, punched tape, magnetic disks and drums, printed characters (OCR), and probably others. Punched cards are the least attractive of any of these methods in terms of equipment cost, storage density, and performance (though in some situations, punched cards do compete well with punched tape). What is it, then, about punched cards that so many experts seem to miss when evaluating their potential for computer applications? We will attempt to answer these questions and, in so doing, clarify for you the place that punched cards can assume in your operations.

Perhaps the key word underlying the tenacity of punched cards is understandability. Think for a second about the complexities of fully documenting even a simple tape or disk oriented data processing project. Between the input data and the final output, there is the job of describing how the data looks within each of the components where it is stored before, during, and after the processing run. "No big thing," you may say. "It's a simple matter of setting up the logical relationships among the various pieces of data and the physical medium on which they are stored." You hit the key—logical relationships. Throughout the computation and file handling process, identification and handling of the logical relationships are required to successfully complete the project.

Punched cards are so successful as a medium for storing and handling information largely because there is a much closer relationship between the logical considerations and the physical medium itself than with any other widely used medium. (Printed material also shows a high degree of agreement between the logical and the physical—but OCR, in spite of its many supporters, has not reached this level of usefulness yet.) Because of this closeness, procedures involving handling information via punched cards are more understandable than when other media are used.



This reader from Bridge Data Products is a tabletop unit with a change. As set up in the picture, it will read 300 to 400 80-column cards per minute. Install the alternate input hopper and stacker shown on the right, a procedure that takes about 15 minutes, and it will read 600 to 800 96-column cards per minute. The increase in speed is due to the shorter length of the 96-column card and the fact that the transport runs at a constant speed.

All About Punched Card Units

The Joys of Youth

To illustrate this idea more thoroughly, let us briefly revert back to the 1940's and 1950's, during the heyday of punched card processing. "Data processing" then meant accounting machines and calculators and interpreters and sorters and gangpunches.

To plan an application meant to identify the entry point of each item of data into the system and to plan the sequence of machine operations required to manipulate the data. To run an installation meant to plan the utilization of each machine so that the minimum number of holdups occurred. (This was no mean feat, as some of you will surely remember.) Each procedure was clearly identifiable in terms of the physical residing place of the data and the machines needed to perform the procedure. (To those of you who never were involved in such operations, the joy of successfully wiring a plugboard panel for an IBM 403 Accounting Machine for multi-line printing or wiring a 602 Calculator without getting short circuits is fully comparable with anything offered by today's sophisticated equipment and applications.)

The advent of the general-purpose programmable computer centralized the many diverse data manipulation functions, aside from the original key entry of the data itself. However, there remained the close link between the logical use of data and its physical storage. Punched card files were well adapted to meeting the needs of early data processing users. It was easy to insert and remove data elements through a clerical operation. Related data elements could be prestored on cards and brought together at transaction time. (Remember tub files?) In addition, the slow speed of operations made it a simple matter to take care of exceptions by manual handling; the process was not delayed too much. By contrast, today's EDP environment precludes very much manual manipulation because of the much larger difference between processing speeds and manual efforts and because procedures tend to be more monolithic, without as many pauses between parts that would provide opportunities to interfere. (Conversational techniques, however, are now tending to restore the number of options available to interact with the automated procedures.)

Also spelling out the demise of punched cards as an adequate medium for file storage was the need for greater performance. The development of magnetic media was the answer. Not only did these permit faster reading and recording; storage space and costs were greatly reduced.

The role that punched cards assumed in medium to large-scale computer systems was that of the medium on which new information was recorded for feeding to the computers. This is the position punched cards occupy today—and will occupy for a long time to come. Other media may be cheaper, but the convenience of being able to manually manipulate the data outside the computer is a strong factor indeed.

Two Big Boosts for Cards

The two principal recent happenings affecting the use of punched cards in data processing were the development of the minicomputer and the introduction of the IBM System/3.

The minicomputer opened the door for the widescale development of small, specialized, free-standing processing systems and for batch terminals. The first area opened up because cost was brought down to a region that made these applications feasible. The second area opened up because of the flexibility of the minicomputer for imitating other popular terminals and interfacing with various central computers. In both cases, the need arose for getting data into and out of the minicomputer's mainframe. Due to habit or familiarity (or perhaps to the position of the stars), users readily accepted the use of punched cards with minicomputers. Underlying this acceptance is, of course, the ease with which data contained on cards can be manipulated.

This ready market for low-cost card units of low and medium performance, in turn, provided the impetus for the additional development of card equipment. No longer is the card punch as large and power-hungry as the main computer. Today there is a crop of tabletop-sized units available for your selection.

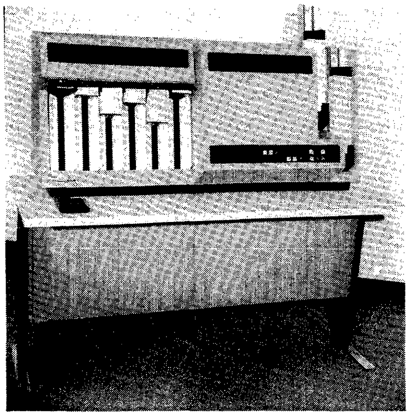
The introduction of the IBM System/3 represents a completely different dimension. It forms the bottom end of the business computer line offered by IBM. As such, a whole new generation of computer users is being introduced to data processing through the punched card—but not to the traditional 80-column card that has stood for so long as a symbol of data processing to the lay public. Most System/3 installations use IBM's new 96-column card, which represents a major advance over the 80-column card in storage density.

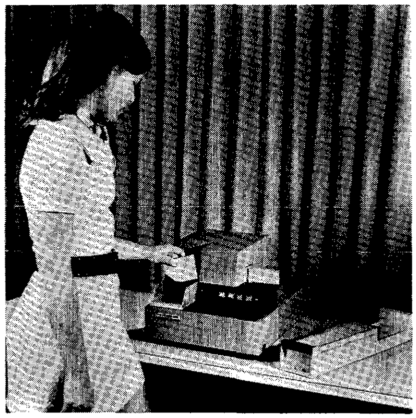
It is strange that after successfully competing with and eliminating the 90-column card format long advocated by UNIVAC, IBM has introduced a new format that is quite reminiscent of the old UNIVAC format. The 96-column card is substantially smaller than UNIVAC's 90-column card, which was identical in size with the 80-column card, but there are many points of similarity, including multiple punched sections stacked vertically and the use of round holes. The main advantages of the 96-column card are the increased storage density, which allows you to store about 2.5 times as much data in the same physical volume, and the longer record length possible on a single physical item.

Punched Cards Today

Throughout the preceding material, the use of punched cards has been referred to historically. Now the question is how can they be used today? The answer is anywhere you need to store information in a form that can be accessed manually as well as through a machine. Σ

All About Punched Card Units





The Decision Data product line spans the range from basic to deluxe, all oriented toward the 96-column card. Above, the 9625 (middle) represents the basic card reader. On the right, the 9645 includes the functions of reading, punching, and interpreting (printing) in the same unit. On the left is the big gun, the 9650 Multi-Function Card Unit. It provides dual input feeds and six output stackers; it can read, punch, and/or interpret cards. IBM introduced this kind of device for the System/360 Model 20 (80-column cards) and continued the concept on the System/3 (96-column cards). It can keep you awake at night trying to think up ways to best utilize its versatility.

Program development is a good example. Having individual source statements on individual cards makes program modifications easy. But once the program is finished, there is no major advantage to having it on cards. Indeed, it would be better to have it on another medium, such as magnetic tape or even punched tape; spilling a tray of cards can be very troublesome if you do not have a sorter on the premises.

Another convenient, and traditional, use for punched cards is the maintenance of a library of fixed information that is frequently used in the preparation of transactions. For example, parts descriptions, unit pricing, etc., can be maintained on individual cards for use in preparing invoices. The increasing availability and use of small disk storage units, however, may do away with the widespread utilization of punched cards in this application.

A third prominent application area for punched cards is the so-called turnaround document. This technique is frequently used for billing by companies dealing with the general public, such as telephone companies, public utility companies, and book clubs. In this application, a punched card prepunched with the account identification and billed amount is either enclosed with the bill or serves as the bill itself. When returned with payment, the card is keypunched with the amount paid and fed into the computer's accounts receivable system. Many efforts have been made to replace the punched card with OCR devices for this application, particularly since it became technologically practical to recognize handwritten numbers; this eliminates the keypunching operation, but the results obtained to date have been mixed.

In summary, the punched card is anything but dead. The three application areas described above would be enough by themselves to keep punched cards active for a long time to come. In addition, there are applications where it is convenient to manually manipulate or access the data contained in a file; for this purpose, there is nothing more convenient than punched cards short of an on-line interactive system. As costs come down, the punched card will probably lose out in this type of application. Eventually the punched card will probably expire—but it is clear that this won't happen for many years to come.

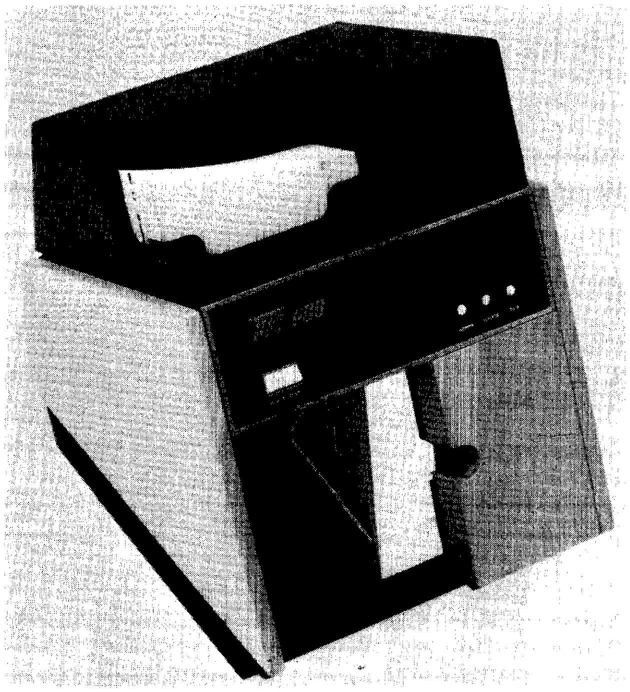
Where to Find Information

We have talked about history and use of punched cards. All that is left is to discuss the card input and output units themselves. In this report, space requirements make it impractical to include the units marketed as part of computer systems. As you would expect, the card units marketed with all the major general-purpose computers are included within the reports on the individual computer systems contained in the Computers section in Binder 1. The availability of punched card devices for each minicomputer is summarized in our Feature Report on minicomputers (Report 70F-400-01). Included in this report are the products manufactured and marketed outside the framework of complete computer systems. You'll find that many of the devices marketed with complete computer systems, particularly with minicomputers, are covered in this report under the names of their original manufacturers.

Comparison Charts

The accompanying comparison charts contain the salient characteristics of 51 devices marketed by 13 companies. The information for these charts was collected from the companies during July, August, and September 1972. The Datapro staff extends its appreciation to those companies for their cooperation.

All About Punched Card Units



A recent entry in punched card circles, True Data Corporation has announced its first two models built around a similar mechanism that it claims is particularly good for handling misused cards. The Model 600 above has a reading rate of 600 cards per minute; the second model, also a tabletop version but with a different orientation of the card path, reads 1000 cards per minute.

The following paragraphs contain a discussion of each element of the comparison charts and relate them to anticipated usage.

The entry in *Manufacturer and Model* identifies each unit.

Entries under *Physical Arrangement* characterize each unit.

The *Function* identifies each unit as a reader, punch, or combination reader/punch. In general, a reader/punch moves cards along a single card path, past first a read station and then a punch station. It is usually possible to read information from a card and then punch other information into the same card. Special format considerations are required to produce a compiler or assembler in which the reader/punch is used for both input and output. Usually, the source statement and resulting object statement are contained in the same card. If multiple, selectable stackers are available, it is possible to work with independent input and output card streams, but blank cards must first be interspersed in the input deck; needless to say, performance suffers when both input and output files must be fed sequentially. Reader/punches are seldom a good choice as the only peripheral devices in a system.

The *Format* entry distinguishes between units capable of reading/punching 80-column and 96-column cards. In a few cases, both formats can be accommodated by physically changing the input hopper and stacker mechanisms; this usually requires a few minutes to do. Some readers are able to accept so-called stub cards. These are portions of full-size cards and are usually used as part of a turnaround document. There are several sizes in common use, up to 51 columns in length for 80-column cards. The equivalent 96-column card form is the "topless" format, which is so named for the obvious reason.

Orientation refers to whether the cards are read and/or punched in column by column or row by row fashion. The latter orientation was once popular for card punches to improve performance without raising the linear speed at which the cards moved; this technique requires either a full card-image buffer or a very large number of data transfers per card. Nearly all of the current units are column-oriented, since this greatly reduces the logic required to interpret data signals. For 96-column equipment, the "column" orientation implies that three characters are handled at a time.

The *pick* and *transport mechanisms* describe the methods used for picking one card from the input stack and transporting it past the read and/or punch stations into the stacker. Of the three common methods–knife, friction, and vacuum–friction is the most commonly used in the class of equipment shown in this report. Basically, this technique involves moving the bottom plate holding the cards down a short distance. This causes the cards to fan slightly and also brings the bottom card into contact with a revolving roller. The slight fanning allows the bottom card to be moved out without disturbing the other cards. Usually the card passes through a throat to insure that two cards have not been picked up. Of course, there are many variations of this basic approach. Sets of power-driven rollers are most commonly used to move the cards along.

The pick and transport mechanisms form the heart of a punched card unit, whether it is a reader or punch. The most reliable method for checking out a particular unit is to observe it running. The things to look for are the frequency of card jams and how the unit treats the edges of the cards. Frayed edges after just a few passes indicate that frequently used card decks will have to be replaced often. A secondary level of checking concerns the number of adjustment points; a large number is sometimes indicative of a unit that requires frequent adjustment, a bothersome exercise.

The *Code* entry refers to the exchange of data between the unit and the computer. Almost universally, data is exchanged as a binary image of the holes in the card; thus, the entry "12-bit (or 18-bit) binary image" is frequently used. Note, however, that for 80-column equipment, this ∑

All About Punched Card Units

refers to one character, while for 96-column equipment, this refers to the three characters which are read and transferred in parallel.

The *input hopper capacity* is significant because it indicates how often an operator must put in more cards. In most cases, cards can be added without stopping the unit. But if a card weight must be used to insure reliable feeding, then this is a dead giveaway that the unit must be stopped to add more cards.

The number and capacity of the *stackers* tells a great deal about a unit's flexibility. Most commonly, one stacker is provided with a capacity commensurate with that of the input hopper. Multiple stackers on a reader permit breaking apart decks made up of several components, such as master and transaction cards or subroutines and main program source cards. Two stackers are not uncommon in card punches when a checking arrangement is included to detect mispunched cards and direct them into a reject stacker. Reject stackers normally have a much smaller capacity than the main stacker.

The importance of a *buffer* is measured in terms of the amount of flexibility it adds. A full card-image buffer requires only a single multi-character data transfer operation for each card. This permits the processor more freedom in the timing of data transfers in regard to program points. A single-character buffer provides primarily a simpler interface, but doesn't add to processing flexibility. Lack of a buffer ties the processor to the unit for each character read or punched.

The *Controller* is the component that transforms the computer's binary-oriented input/output commands into signals to activate the various parts of the mechanism. A controller for a punched card unit is much simpler than one for a multi-unit subsystem such as a group of magnetic tape drives. It is not uncommon for vendors to market card units that work from the native controller for particular minicomputers.

Speed is largely self-obvious, but there are a few wrinkles worth noting. Most notable is the difference between continuous operation and asynchronous or demand operation. In the latter case, a new command is given for each card in an unpredictable manner. Usually, demand reading is slower than continuous reading. Some units operate only asynchronously. Where a speed range is given, the lower limit is for demand operation and the higher limit is for continuous operation.

Interface entries identify specific computers, if any, for which directly compatible circuitry is available from the supplier of the punched card unit.

The entries under *Pricing and Availability* are mostly self-explanatory. *Purchase prices* are given for a single unit and typically do not include options mentioned elsewhere. *First delivery* refers to the date when the first commercial delivery was made. In some cases, an early delivery date really does not mean "elderly" equipment because design changes have been included in later models without a model number change. Under *Availability*, ARO means "after receipt of order." The *Number Installed to Date* is given in all cases where the information was available. The entry under *Serviced By* identifies the source for repair and maintenance tasks. An entry of "customer" clearly identifies an OEM unit for which the servicing is arranged by the vendor of the equipment that includes this card unit. Under any of these headings, an entry of INA means "information not available."

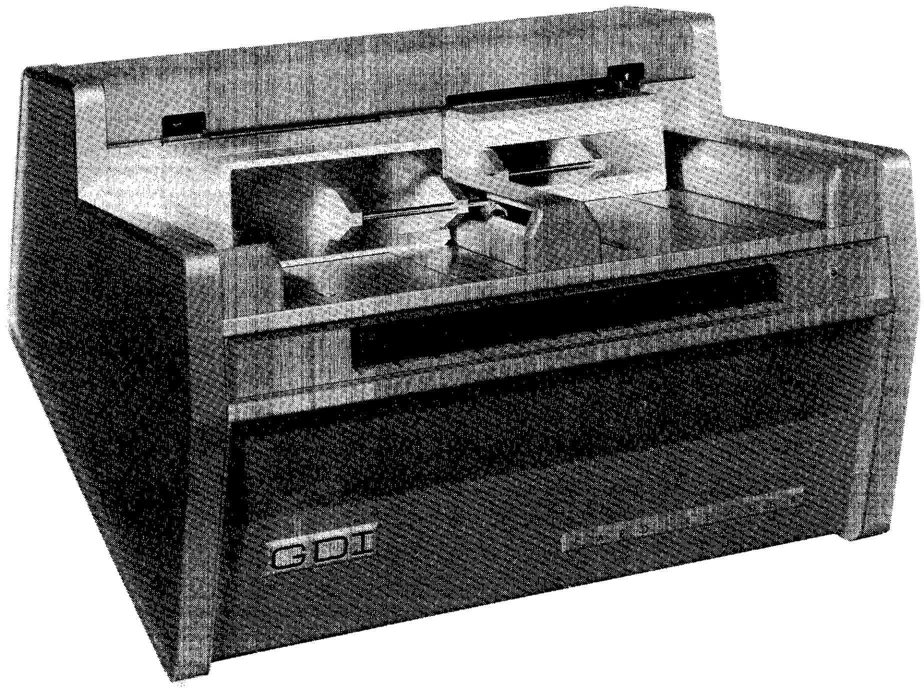
Entries in the *Comments* block summarize information unique to each device that helps to clarify other entries or adds information about special capabilities.

Card Unit Suppliers

Listed below for your convenience in obtaining additional information, are the names, addresses, and telephone numbers of the 13 vendors represented in the comparison charts.

This neat model from Data Products (the 8330) shows the size of the current crop of tabletop card readers. It can read cards at over 300 cards per minute, which puts it at the low end of the line, and is one of the few units to use a picker knife mechanism.

All About Punched Card Units



The GDI name is well known among card reader enthusiasts, but the supplier turned out to be hard to find. We finally tracked it down; EAI bought the product line and name in September 1972. This Model CR-600 reads 80-column cards at 600 cards per minute.

▷ *Bridge Data Products, Inc.,* 738 South 42nd Street, Philadelphia, Pennsylvania 19104. Telephone (215) 382-8700.

Control Data Corporation. Box O, Minneapolis, Minnesota 55440. Telephone (612) 853-8100.

Data Products Corporation, OEM Marketing, 16055 Ventura Boulevard, Suite 419, Encino, California 91316. Telephone (213) 981-9600.

Decision Data Computer Corporation, 100 Witmer Road, Horsham, Pennsylvania 19044. Telephone (215) 674-3300.

Decision, Inc., 5601 College Avenue, Oakland, California 94618. Telephone (415) 654-8626.

Documation, Inc., P.O. Box 1240, Melbourne, Florida 32901. Telephone (305) 724-1111.

Eclectic Corporation, 2830 Walnut Hill Lane, Dallas, Texas 75229. Telephone (214) 358-1307.

Electronic Associates, Inc. (EAI), 185 Monmouth Parkway, West Long Branch, New Jersey 07764. Telephone (201) 229-1100.

GDI (see Electronics Associates, Inc.)

Hewlett-Packard Co., Data Systems, 11000 Wolfe Road, Cupertino, California 95014. Telephone (408) 257-7000.

International Computers Limited (ICL), 839 Stewart Avenue, Garden City, New York 11530. Telephone (516) 248-5656.

Peripheral Dynamics, Inc., East Norriton Industrial Park, 1030 W. Germantown Pike, Norristown, Pennsylvania 19401. Telephone (215) 539-5500.

True Data Corporation, 17905 Skypark Boulevard, Suite G, Irvine, California 92707. Telephone (714) 979-4842.

Vogue Instrument Corporation, 131st Street at Jamaica Avenue, Richmond Hill, New York 11418. Telephone (212) 641-8800. □

All About Punched Card Units

MANUFACTURER & MODEL	Bridge Data Model 8060	Bridge Data Model 8600	Bridge Data Model 8800	Bridge Data Model 8000	Bridge Data Model 9600
PHYSICAL ARRANGEMENT					
Function	Reader	Reader	Reader	Reader	Reader
Format	80 column	96 column	80/96 column	80 column	96 column
Orientation	Column	Column	Column	Column	Column
Input Hopper Capacity	1000	1000	1000	1000	1000
Stackers	1-1000	1-1000	1-1000	1-1000	1-1000
Pick Mechanism	Friction	Friction	Friction	Friction	Friction
Transport Mechanism	Rollers, positive drive	Rollers, positive drive	Rollers, positive drive	Rollers, positive drive	Rollers, positive drive
Buffer	Special order	Special order	Special order	Special order	Special order
Controller	Special order	Special order	Special order	Special order	Special order
CODE	12-bit binary image out	18-bit binary image out	12/18-bit binary image out	12-bit binary image out	18-bit binary image out
SPEED, cards/minute	600 to 800	1000 to 1200	600 to 800 (80 col); 1000 to 1200 (96 col)	300 to 400	600 to 800
INTERFACE	Many available on special order	Many available on special order	Many available on special order	Many available on special order	Many available on special order
PRICING AND AVAILABILITY					
Purchase Price, $	2,195	2,570	2,840	1,850	2,050
First Delivery	January 1971	January 1971	January 1971	August 1970	August 1970
Availability, days ARO	30	30	30	30	30
Number Installed to Date	INA	INA	INA	INA	INA
Serviced By	Bridge Data or Sorbus	Bridge Data or Sorbus	Bridge Data or Sorbus	Bridge Data or Sorbus	Bridge Data or Sorbus
COMMENTS	Can also read stub cards; table-top unit	Can also read topless cards; table-top unit	Changing from 96 to 80 column cards involves changing hopper and stacker; table-top unit	Can also read stub cards; table-top unit	Can also read topless cards; table-top unit

MANUFACTURER & MODEL	Bridge Data Model 8096	Control Data 9200	Control Data 9240	Control Data 9250	Control Data 9280
PHYSICAL ARRANGEMENT					
Function	Reader	Reader	Punch	Punch	Reader/Punch
Format	80/96 column	80 column	80 column	80 column	80 column
Orientation	Column	Column	Column	Row	Row
Input Hopper Capacity	1000	4000	1200	1200	1200
Stackers	1-1000	2-4000 and 240	1-1300 with offset	1-1500 with offset	1-1300 with offset
Pick Mechanism	Friction	Vacuum capstan	Knife	Knife	Knife
Transport Mechanism	Rollers, positive drive	Latches to drum	Rollers	Rollers	Rollers
Buffer	Special order	No	1 column	No	1 column
Controller	Special order	None supplied	None supplied	None supplied	None supplied
CODE	12/18-bit binary image out	12-bit binary image	INA	INA	INA
SPEED, cards/minute	300 to 400 (80 col); 600 to 800 (96 col)	1200	100 (80 col) to 460 (1 col)	250	Reads 500; punches 100 (80 col) to 460 (1 col)
INTERFACE	Many available on special order	None	None	None	None
PRICING AND AVAILABILITY					
Purchase Price, $	2,195	12,000	14,300	13,600	16,000
First Delivery	August 1970	1962	1969	1964	1968
Availability, days ARO	30	180	180	180	180
Number Installed to Date	INA	Appx. 2000	Over 100	1200	Over 300
Serviced By	Bridge Date or Sorbus	Control Data	Control Data	Control Data	Control Data
COMMENTS	Changing from 96 to 80 column cards involves changing hopper and stacker; table-top unit	OEM unit; read/compare check	OEM unit; punch echo check	OEM unit; punch read check	OEM unit; punch echo check

All About Punched Card Units

MANUFACTURER & MODEL	Data Products SR 300	Data Products 8330	Data Products 8340	Data Products 8360	Data Products SR 1500
PHYSICAL ARRANGEMENT					
Function	Reader	Reader	Reader	Reader	Reader
Format	80 column	80 column	80 column	80 column	80 column
Orientation	Column	Column	Column	Column	Column
Input Hopper Capacity	600	600	1000	1000	2500
Stackers	1-600 with offset	1-600 with offset	1-600 with offset	1-600 with offset	2-2000 each
Pick Mechanism	Knife	Knife	Knife	Knife	Friction roller
Transport Mechanism	Rollers	Rollers	Rollers	Rollers	Rollers
Buffer	None	None	None	None	Optional
Controller	None supplied	None supplied	None supplied	None supplied	None supplied
CODE	12-bit binary image	12-bit binary image	12-bit binary image	12-bit binary image	12-bit binary image
SPEED, cards/minute	300	318	318	600	1500 to 2200
INTERFACE	None	None	None	None	None
PRICING AND AVAILABILITY					
Purchase Price, $	Contact vendor	Contact vendor	Contact vendor	Contact vendor	Contact vendor
First Delivery	1969	1972	October 1972	October 1972	1962
Availability, days ARO	45	45	45	45	90
Number Installed to Date	1500	30	–	–	600
Serviced By	OEM support	OEM support	OEM support	OEM support	OEM support
COMMENTS	OEM unit; can read 51 column stub cards; table-top unit	OEM unit; IBM-compatible mark sensing optional; table-top unit	OEM unit; IBM-compatible mark sensing optional; table-top unit	OEM unit; table-top unit	OEM unit; can read most stub cards; also available in 90 column format

MANUFACTURER & MODEL	Data Products SR 120	Decision Data 9601	Decision Data 9610	Decision Data 9660	Decision Data 9625
PHYSICAL ARRANGEMENT					
Function	Punch	Reader/punch	Reader/punch/ interpreter	Reader/punch/ interpreter/sorter	Reader
Format	80 column	96 column	96 column	96 column	96 column
Orientation	Column	Column	Column	Column	Column
Input Hopper Capacity	1000	2-600 and 400	2-600 and 400	2-600 and 400	600
Stackers	1-1000 with offset	2-400 each	2-400 each	6-400 each	1-600
Pick Mechanism	Friction roller	Capstan	Capstan	Capstan	Capstan
Transport Mechanism	Incremental drive	Rollers and flat belt	Rollers and flat belt	Rollers and flat belt	Rollers and flat belt
Buffer	None	Card image	Card image	Card image	Card image
Controller	None supplied	None supplied	None supplied	None supplied	None supplied
CODE	12-bit binary image	6-bit BCD	6-bit BCD	6-bit BCD	6-bit BCD
SPEED, cards/minute	100 to 300	Reads 300; punches 60 to 120	Reading: 300; punching: 60 to 120	Reading: 300; punching: 60 to 120	400
INTERFACE	None	Standard Decision Data interface common to all models	Standard Decision Data interface common to all models	Standard Decision Data interface common to all models	Standard Decision Data interface common to all models
PRICING AND AVAILABILITY					
Purchase Price, $	Contact vendor	5,885	7,785	8,785	1,200
First Delivery	1965	INA	INA	INA	INA
Availability, days ARO	60	60 to 90	60 to 90	60 to 90	60 to 90
Number Installed to Date	450	INA	INA	INA	INA
Serviced By	OEM support	Decision Data	Decision Data	Decision Data	Customer
COMMENTS	OEM unit	All units include keyboard and dual feeds. Units can be used off-line for keypunching, verifying, reproducing, and gang punching. Model 9660 can be used off-line for sorting. Interpreter models print 3 rows of 32 characters across top of card. Keyboard can be used on-line.			OEM unit; table-top unit

All About Punched Card Units

MANUFACTURER & MODEL	Decision Data 9630	Decision Data 9640	Decision Data 9635	Decision Data 9645	Decision Data 9650
PHYSICAL ARRANGEMENT					
Function	Reader	Reader/punch or punch	Reader/punch	Reader/punch	Reader/punch
Format	96 column	96 column	96 column	96 column	96 column
Orientation	Column	Column	Column	Column	Column
Input Hopper Capacity	600	2000	2-600 and 400	2-600 and 400	2-2000 each
Stackers	1-600	3-1200 each	2-400 each	2-400 each	6-1200 each
Pick Mechanism	Capstan	Capstan	Capstan	Capstan	Capstan
Transport Mechanism	Rollers and flat belt	Rollers and flat belt	Rollers and flat belt	Rollers and flat belt	Rollers and flat belt
Buffer	Card image	Card image	Card image	Card image	Card image
Controller	None supplied	None supplied	None supplied	None supplied	None supplied
CODE	6-bit BCD	6-bit BCD	6-bit BCD	6-bit BCD	6-bit BCD
SPEED, cards/minute	1200	Reads 1000 (optional); punches and/or prints 120 to 240	Reads 300; punches 60 to 120	Reads 300; punches and/or prints 60 to 120	Reads 1000; punches and/or prints 120 to 240
INTERFACE	Standard Decision Data interface common to all models	Standard Decision Data interface common to all models	Standard Decision Data interface common to all models	Standard Decision Data interface common to all models	Standard Decision Data interface common to all models
PRICING AND AVAILABILITY					
Purchase Price, $	2,800	7,750	4,350	5,850	11,600
First Delivery	INA	Fourth quarter 1972	INA	INA	July 1972
Availability, days ARO	60 to 90	150 to 180	60 to 90	60 to 90	150 to 180
Number Installed to Date	INA	—	INA	INA	INA
Serviced By	Customer	Customer	Customer	Customer	Customer
COMMENTS	OEM unit. Model with IBM System/360/370 interface available for $5,800	OEM unit. Prints 3 rows of 32 characters across top of card. Available without reading capability for $6,900	OEM unit. Dual feed	OEM unit. Prints 3 rows of 32 characters across top of card; dual feed	OEM unit. Prints 4 rows of 32 characters across top of card; dual feed

MANUFACTURER & MODEL	Decision, Inc. 3130A	Decision, Inc. 3130B	Documation, Inc. D150	Documation, Inc. M200	Documation, Inc. M300L
PHYSICAL ARRANGEMENT					
Function	Reader	Reader	Reader	Reader	Reader
Format	80 column	80 column	80 column	80 column	80 column
Orientation	Column	Column	Column	Column	Column
Input Hopper Capacity	400	400	400	500	400
Stackers	1-400	1-400	1-400	1-500	1-1000
Pick Mechanism	Friction roller	Friction roller	Friction	Vacuum	Vacuum
Transport Mechanism	Rollers	Rollers	Rollers	Rollers	Rollers
Buffer	None	None	None	None	None
Controller	Integral	Integral	None supplied	None supplied	None supplied
CODE	12-bit binary image	12-bit binary image	12-bit binary image	12-bit binary image	12-bit binary image
SPEED, cards/minute	300	600	150	300	300
INTERFACE	Data General Nova; DCC 116	Data General Nova; DCC 116	Compatible with most controllers; RS-232C (ASCII code) available	Compatible with most controllers; RS-232C (ASCII code) available	Compatible with most controllers; RS-232C (ASCII code) available
PRICING AND AVAILABILITY					
Purchase Price, $	3,500	4,100	1,350	1,950	2,595
First Delivery	April 1971	May 1971	July 1972	December 1970	October 1970
Availability, days ARO	60	60	60	60	60
Number Installed to Date	INA	INA	INA	Appx. 400	Appx. 400
Serviced By	Decision, Inc.	Decision, Inc.	Documation	Documation	Documation
COMMENTS	Diagnostic and input routine software included. Units use readers from Peripheral Dynamics, Inc.; table-top units		Mark reading model available; table-top unit	Mark reading model available; table-top unit	Mark reading model available; table-top unit

All About Punched Card Units

MANUFACTURER & MODEL	Documation, Inc. M600L	Documation, Inc. M600C	Documation, Inc. M1000L	Documation, Inc. M1000C	Documation, Inc. M1200
PHYSICAL ARRANGEMENT					
Function	Reader	Reader	Reader	Reader	Reader
Format	80 column	80 column	80 column	80 column	80 column
Orientation	Column	Column	Column	Column	Column
Input Hopper Capacity	1000	1500	1000	1000	2250
Stackers	1-1000	1-1500	1-1000	1-1000	1-2250
Pick Mechanism	Vacuum	Vacuum	Vacuum	Vacuum	Vacuum
Transport Mechanism	Rollers	Rollers	Rollers	Rollers	Rollers
Buffer	None	None	None	None	None
Controller	None supplied	None supplied	None supplied	None supplied	None supplied
CODE	12-bit binary image	12-bit binary image	12-bit binary image	12-bit binary image	12-bit binary image
SPEED, cards/minute	600	600	1000	1000	1000
INTERFACE	Compatible with most controllers; RS-232C (ASCII code) available	Compatible with most controllers; RS-232C (ASCII code) available	Compatible with most controllers	Compatible with most controllers	Compatible with most controllers
PRICING AND AVAILABILITY					
Purchase Price, $	2,995	3,995	3,495	4,495	7,800
First Delivery	October 1970	April 1971	October 1970	April 1971	June 1971
Availability, days ARO	60	60	60	60	60
Number Installed to Date	Appx. 500	Appx. 50	Appx. 250	Appx. 10	Appx. 40
Serviced By	Documation	Documation	Documation	Documation	Documation
COMMENTS	Mark reading model available; table-top unit	Mark reading model available	Mark reading model available; table-top unit	Mark reading model available	Mark reading model available

MANUFACTURER & MODEL	Documation, Inc.	Documation, Inc.	EAI MR300	EAI CR300
PHYSICAL ARRANGEMENT				
Function	Punch	Reader/punch	Reader	Reader
Format	80 column	80 column	80 column	80 column
Orientation	Column	Column	Column	Column
Input Hopper Capacity	1000	1000	500	500
Stackers	2-1000 and reject	2-1000 and reject	1-600	1-600
Pick Mechanism	Friction	Friction	Vacuum	Vacuum
Transport Mechanism	Rollers	Rollers	Rollers	Rollers
Buffer	Optional	Optional	1 column	1 column
Controller	None supplied	None supplied	None supplied	None supplied
CODE	12-bit binary image	12-bit binary image	12-bit binary image	12-bit binary image
SPEED, cards/minute	100	Reads 400; punches 100	200 to 300	300
INTERFACE	Compatible with most controllers	Compatible with most controllers	DEC PDP-8, -11, Data General Nova; custom	DEC PDP-8, -11; Data General Nova; custom
PRICING AND AVAILABILITY				
Purchase Price, $	Contact vendor	Contact vendor	2,800	1,890
First Delivery	January 1973	January 1973	May 1970	December 1970
Availability, days ARO	60	60	30	30
Number Installed to Date	—	—	INA	INA
Serviced By	Documation	Documation	EAI or customer	EIA or customer
COMMENTS	Echo check; high-speed eject	Echo check; high-speed eject	OEM units. These units were formerly known under the name GDI Corp., which EAI bought from United Business Communications, Inc. in September 1972	

All About Punched Card Units

MANUFACTURER & MODEL	EAI CR600	EAI CP60	Eclectic Model 560	Hewlett-Packard 2761A-007
PHYSICAL ARRANGEMENT				
Function	Reader	Punch	Reader	Reader
Format	80 column	80 column	80 column	80 column
Orientation	Column	Column pair	Column	Column
Input Hopper Capacity	1000	1000	500	300
Stackers	1-1000	1-1000	1-500	1-300
Pick Mechanism	Vacuum	Friction	Friction	Friction
Transport Mechanism	Rollers	Rollers	Rollers	Rollers
Buffer	1 column	4 columns; 80 optional	None	None
Controller	None supplied	None supplied	Integral	Available
CODE	12-bit binary image	12-bit binary image	ASCII	12-bit binary image
SPEED, cards/minute	600	60	200	200 to 250
INTERFACE	DEC PDP-8, -11; Data General Nova; custom	DEC PDP-8, -11; Data General Nova; custom	DEC PDP-8, -11	Hewlett-Packard 2100 Series
PRICING AND AVAILABILITY				
Purchase Price, $	2,990	8,200	2,750	2,750
First Delivery	March 1971	January 1972	INA	INA
Availability, days ARO	30	30	60	14
Number Installed to Date	INA	INA	INA	INA
Serviced By	EIA or customer	EIA or customer	INA	Hewlett-Packard
COMMENTS	OEM units. These units were formerly known under the name GDI Corp., which EAI bought from United Business Communications, Inc. in September 1972			Reads marks also

MANUFACTURER & MODEL	International Computers, Ltd. ICL 640/4	International Computers, Ltd. ICL 2101	Peripheral Dynamics, Inc. C301	Peripheral Dynamics, Inc. C451
PHYSICAL ARRANGEMENT				
Function	Reader	Reader	Reader	Reader
Format	80 column	80 column	80 column	80 column
Orientation	Column	Column	Column	Column
Input Hopper Capacity	400	3000	500	1000
Stackers	1-400	1-3000	1-500	1-1000
Pick Mechanism	Knife	Vacuum and feed wheel	Friction roller	Friction roller
Transport Mechanism	Rollers	Rollers	Rollers	Rollers
Buffer	None	1 column	None	None
Controller	None supplied	Integral	None supplied	None supplied
CODE	12-bit binary image	ICL 1900 Series	12-bit binary image	12-bit binary image
SPEED, cards/minute	300	2000	300	450
INTERFACE	None	ICL 1900	DEC PDP-8E; Honeywell 316/516	DEC PDP-8E; Honeywell 316/516
PRICING AND AVAILABILITY				
Purchase Price, $	2,400 (100)	20,240	1,545	1,795
First Delivery	1972	1969	December 1970	July 1971
Availability, days ARO	INA	INA	30	30
Number Installed to Date	INA	INA	500	100
Serviced By	Customer	Customer	Peripheral Dynamics	Peripheral Dynamics
COMMENTS	OEM unit; table-top unit; mechanics-only version available	Mechanics-only version available	Table-top unit; rack-mounted version available	Table-top unit; rack-mounted version available

All About Punched Card Units

MANUFACTURER & MODEL	Peripheral Dynamics, Inc. C601	True Data 600	True Data 1000	Vogue Model 8000
PHYSICAL ARRANGEMENT				
Function	Reader	Reader	Reader	Reader
Format	80 column	80 column	80 column	80 column
Orientation	Column	Column	Column	Column
Input Hopper Capacity	1000	600	1500	1000
Stackers	1-1000	1-1000	1-1500	1-1000
Pick Mechanism	Friction roller	Band latches card to drum	Band latches card to drum	Friction
Transport Mechanism	Rollers	Drum	Drum	Rollers
Buffer	None	Card image	Card image	None
Controller	None supplied	Included	Included	Integral
CODE	12-bit binary image	12-bit binary image	12-bit binary image	12-bit binary image
SPEED, cards/minute	600	600 or 400	1000 or 800	300 to 400
INTERFACE	DEC PDP-8E; Honeywell 316/516	DEC PDP-8E, -8I, -8L; Data General Nova; Honeywell 316, 516; HP 2100 series	DEC PDP-8E, -8I, -8L; Data General Nova; Honeywell 316, 516; HP 2100 series	DEC PDP-8; HP 2116; Honeywell 316, 516; Data General Nova; Varian 620i
PRICING AND AVAILABILITY				
Purchase Price, $	2,040	1,495	1,995	3,600 to 4,500
First Delivery	July 1971	April 1972	October 1972	April 1971
Availability, days ARO	30	Stock	30	60
Number Installed to Date	100	125	—	INA
Serviced By	Peripheral Dynamics	SirVess	SirVess	GTE
COMMENTS	Table-top unit; rack-mounted version available	OEM units. Table-top units. Mark reader version of Model 600 available. True Data designed and is marketing these units; they are being built by Beckman Instruments, Inc.		Unit uses Bridge 8096 reader; can be easily modified to read 96 column cards by changing hopper and stacker; table-top unit

All About Punched Tape Units

Of all devices used to record information in a machine-readable form, the most numerous may well be the lowly punched tape punches–or paper tape punches, if you prefer. Their popularity is almost, but not entirely, confined to data communications uses rather than as peripheral units for computers. Two exceptions come to mind: minicomputers and NCR.

The Teletype Model 33 ASR includes a printer, reader, and punch within the same cabinet and at an attractively low price, making it a natural for use with a minicomputer as the entire complement of peripheral equipment.

NCR has long promoted the use of punched tape by providing computing services for merchants who collect data on punched tape in connection with their cash registers.

Both cases point up the outstanding characteristic of punched tape: data can be handled conveniently only in integral blocks.

For data communications, this represents no restriction because punched tape units are used primarily as buffer units. Prepunched data is sent when the line is available; prepunching allows the operator to be doing other things instead of waiting around for the line to clear or until the line is polled. Similarly, received data can be printed out when convenient. In any case, the text of the data transmission has an integrity; seldom is there a need to break it apart and accumulate subgroups.

The most common use of punched tape with minicomputers is as a source for storing programs. Again, there is usually no need to separate the parts of a particular program.

A day's or week's transactions on punched tape form a journal, which should be saved in one lump anyway, so the NCR application also displays the prime characteristic.

Punched tape, like anything else, can be cajoled into doing things that it was never intended for. If it is all you have to work with, as in many minicomputer installations, then your ingenuity is really challenged. However, the key phrase–data in integral blocks–pretty well sums up the application areas for punched tape. And for those applications, punched tape devices are hard to beat for simplicity and low cost.

The remaining discussion of punched tape is best done in connection with actual equipment and practices, so we will proceed forthwith to the comparison charts.

When you've said that punched tape is a low-cost way of handling data in integral blocks, you've just about said it all. In this report, we survey 55 punched tape readers, punches, and combination units from 14 vendors.

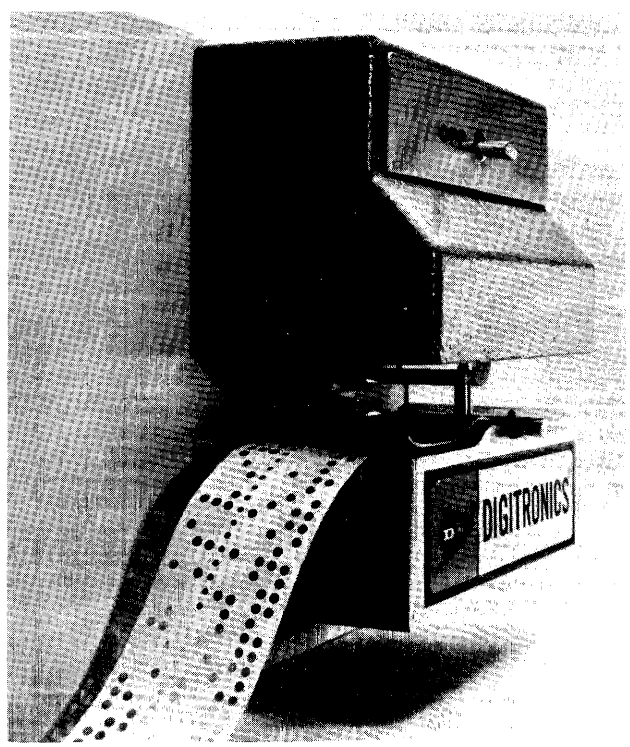
The Comparison Charts

The information in the following comparison charts was gathered during July, August, and September 1972. The Datapro staff extends its appreciation for the cooperation of the 14 manufacturers represented. A total of 55 devices are shown.

The following paragraphs explain the meaning of each element of the comparison charts and provide an overview of punched tape technology.

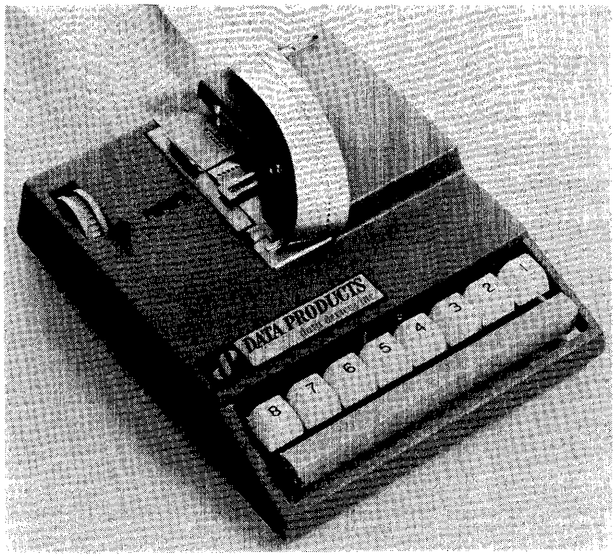
Each device is identified under the head *Manufacturer and Model*.

Under *Physical Arrangement*, the distinguishing mechanical and electronic characteristics are shown.



The Digitronics 2015 is one of the newest models in a long line of punched tape equipment. This unit reads at speeds up to 150 characters per second. Can you imagine anything more simple and basic to use as a computer peripheral? That simplicity–and the resulting low equipment cost–is a major part of punched tape's appeal to system designers.

All About Punched Tape Units



Not an on-line device, this Data Products unit is included to show the punched tape equivalent of the portable keypunch. (The punched tape equivalent of the full-size keypunch is a Teletype Model 33 ASR or similar unit.) Note that the holes for the sprocket feed are already punched. To make them, you would have had to pass this tape through a tape punch first; on-line tape punches normally punch their own feed holes.

The entry under *Function* identifies the device as a reader or punch. One manufacturer, Remex, is marketing a line of readers and punches housed in the same cabinet under a single model number.

Media deals with what is perhaps the most confusing aspect of punched tape devices: the material composition of the tape and the way it is moved through the unit. These units have been referred to as "paper tape" units long after paper ceased to be the only form of tape used. Unlike other computer-related peripheral devices, punched tape units generally give you a choice of media composition. Tapes can be made of paper, oiled paper, mylar, and various "sandwiches" or laminations of paper, mylar, and aluminum. The principal differences among the various types are in the energy required for punching and the transparency of the tape.

Mylar is a very tough material that requires considerably more oomph to punch through than paper. On the other hand, it is considerably more durable than paper. Most current punches can punch mylar, but it is always worthwhile to make sure, particularly if you plan to store frequently used data sets, such as programs, on punched tape. The trouble with pure mylar is that it is not very opaque and may cause trouble in photoelectric readers. The various laminates are compromises oriented toward providing both durability and opacity.

Another dissimilarity between punched tape units and other computer peripherals is the frequent separation between the reader or punch units themselves and the mechanisms for transporting the tape. There are four basic methods for handling the tape: strip, roll, fanfold, and reel.

A strip is a short piece of tape that is handled by itself without any equipment except the basic tape movement mechanism in the reader/punch itself. A special form of strip is a loop or closed strip. Usually, a strip reader can also accommodate loops, but there may be some restrictions on how the splice is made that joins the two ends of a strip into a loop. You use loops just where you would expect to: any time you want to repeat the same data over and over.

A roll is a loosely coiled long strip. Some sort of holder is provided to hold the roll and keep it from uncoiling all over the room and creating snarls that end up in torn tape. Usually, what to do with the tape as it comes out of the reader is your problem.

Fanfold tape has been quite popular with minicomputer users. It is relatively inexpensive to implement while still being convenient to handle. Digital Equipment Corporation, among others, provides program libraries on fanfold tape and a neat, flat case for storing them. Basically, tape is fanfolded by folding it back and forth in the same manner in which most computer forms are folded.

We all know what a reel is. Most punches use a reel for supplying the tape to the punch. For some, a spooling device is also available to wind the tape as it is punched. The spooler is also called a takeup reel. The term spooler is a carry-over from the terminology used in punched tape communications devices. Readers are usually equipped with both a supply reel and a takeup reel, if any.

The entries under *media* take two forms, depending on whether the unit is a reader or punch. For a reader, the basic tape handling technique is listed. For a punch, the types of tape it can accommodate are added.

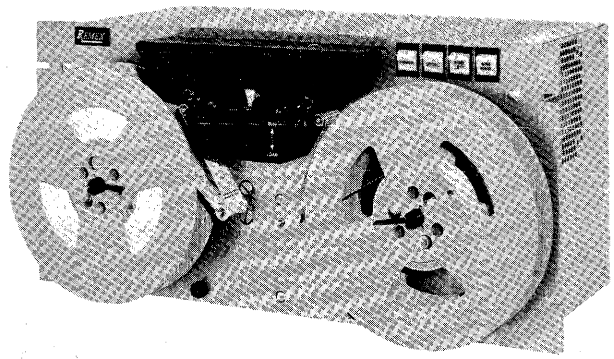
Tape width and *code levels* are closely related. There are three commonly used tape widths and four standard code levels. The tape widths are 11/16-inch, 7/8-inch, and 1-inch. The code levels are 5, 6, 7, and 8.

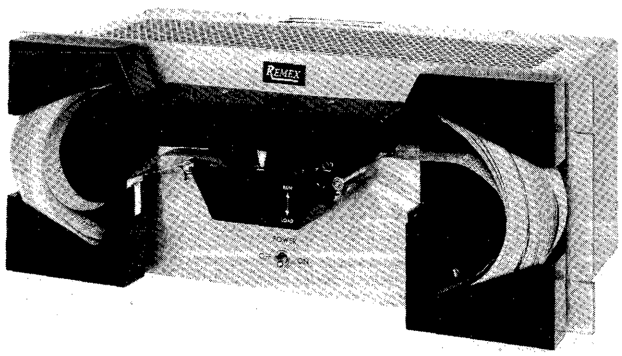
Five-level code is associated with the narrowest of the three tape widths. It appears only on data communications devices using the Baudot code, such as the Teletype Model 28 and earlier units.

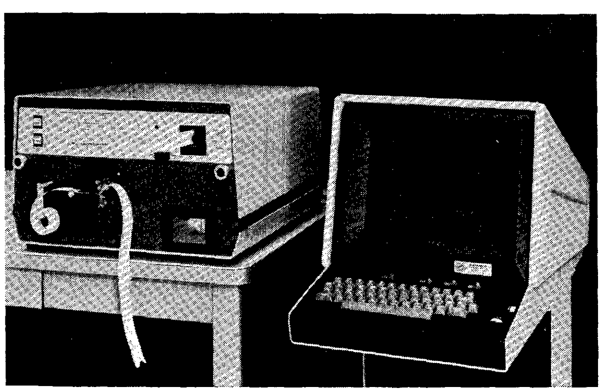
Six- and seven-level codes are associated with the in-between 7/8-inch tape size. Six-level codes are used almost exclusively in typesetting equipment, and seven-level codes are used in Europe.

The most common format for computer usage is the eight-level code associated with one-inch tape.

All About Punched Tape Units







This stack of three units is from the expansive Remex product line. At the top is a reader equipped with a reel-to-reel tape transport. In the middle is the same basic reader equipped with fanfold tape handlers. At the bottom is one of Remex's combination readers and punches—two independent units contained in the same cabinet. It is shown as a companion to a Tektronix graphic display terminal. The Remex unit is set up to handle a roll (coil) of tape for input (bottom left); the supply reel for the punch (top right) is concealed, but you can see the conveniently located chad box at the bottom right.

Many punched tape devices provide the capability for adjustments that permit reading more than one tape width and code level. This is convenient if you have input from or are generating output for any of the specialized equipment mentioned above.

Buffers are not normally available with punched tape units because of the low-cost orientation, though they would provide the same performance benefits as they do with other types of computer peripherals.

The *Controller* is the component that transforms the binary-oriented input/output commands into signals to activate the various parts of the reader or punch mechanism. A controller for a punched tape unit is much simpler than one for a multi-unit subsystem such as a group of magnetic tape drives. It is not uncommon for vendors to market punched tape units that work from the native controller for particular minicomputers.

Speed is a largely self-evident entry. Where there is a range of speeds given, it shows the difference between demand (asynchronous) and continuous operation. Operation is asynchronous when a new command is given for each character in a non-predictable manner. Some units operate only asynchronously.

Interface entries identify specific computers, if any, for which directly compatible circuitry is available from the supplier of the punched tape equipment.

The entries under *Pricing and Availability* are mostly self-explanatory. *Purchase Prices* are given for a single unit and typically do not include options mentioned elsewhere. *First delivery* refers to the date when the first commercial delivery was made. Under *Availability*, ARO means "after receipt of order." *The Number Installed to Date* is given in all cases where the information was available. The entry under *Serviced By* identifies the source for repair and maintenance tasks. Under any of these headings, an entry of INA means "information not available."

Entries in the *Comments* block summarize information unique to each device that helps to clarify other entries or adds information about special capabilities.

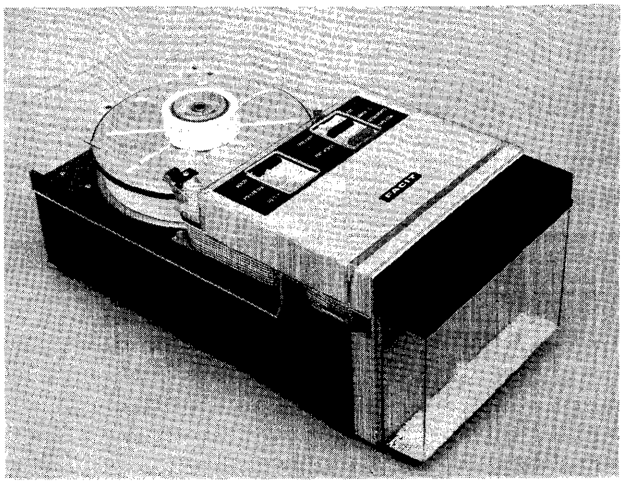
Punched Tape Unit Suppliers

Listed below, for your convenience in obtaining additional information, are the names, addresses, and telephone numbers of the 14 vendors represented in the comparison charts.

Adtrol, 700 Abbot Drive, Broomall, Pennsylvania 19008. Telephone (215) 544-6900.

Datascan, Inc., 1111 Paulison Avenue, Clifton, New Jersey 07013. Telephone (201) 478-2800.

All About Punched Tape Units



This Facit Model 4070 punch makes a neat, attractive package. Concealed in the front is a supply reel; at the back is the take-up reel or spooler. Conveniently located at the front is the chad box, a problem with some units in terms of its capacity and location.

Data Specialties, Inc., 1548 Old Skokie Road, Highland Park, Illinois 60035. Telephone (312) 831-3750.

Decision, Inc., 5601 College Avenue, Okland, California 94618. (415) 654-8626.

Decitek, a division of Jamesbury Corporation, 15 Sagamore Road, Worcester, Massachusetts 01605.

Digitronics Corporation, Route 9, Southboro, Massachusetts 01772. Telephone (617) 481-2500.

Eclectic Corporation, 2830 Walnut Hill Lane, Dallas, Texas 75229. Telephone (214) 358-1307.

Facit-Odhner, Inc., 501 Winsor Drive, Secaucus, New Jersey 07094. Telephone (201) 866-5111.

International Teleprinter Corporation, 493 Washington Avenue, Carlstadt, New Jersey 07072. Telephone (201) 438-1770.

Pivan Data Systems, 6955 Hamlin Avenue, Lincolnwood, Illinois 60645. Telephone (312) 676-0790.

Remex, a unit of Ex-Cell-O Corporation, 1733 Alton Street, Santa Ana, California 92705. Telephone (714) 557-6860.

Superior Electric Co., 484 Middle Street, Bristol, Connecticut 06010. Telephone (203) 582-9561.

Tally Corporation, 8301 South 180th Street, Kent, Washington 98031. Telephone (206) 251-5500.

Teletype Corporation, 5555 Touhy Avenue, Skokie, Illinois 60076. Telephone (312) 982-2000. □

All About Punched Tape Units

MANUFACTURER & MODEL	Adtrol AR20	Adtrol AR21	Adtrol AR31	Data Products RPR1075	Data Products RPS1075
PHYSICAL ARRANGEMENT					
Function	Reader	Reader	Reader	Punch	Punch
Media	Strip; reel or fanfold optional	Strip; reel or fanfold optional	Strip; fanfold optional	Reel; paper, mylar, laminates	Reel; paper, mylar, laminates
Tape Width, inches	11/16 to 1	11/16 to 1	11/16 to 1	11/16 to 1	11/16 to 1
Code Levels	5 to 8	5 to 8	5 to 8	5 to 8	5 to 8
Buffer	Yes	Yes	Yes	None	None
Controller	Integral	Integral	Integral	Integral	Integral
SPEED, char./second	150	250	300	75	75
INTERFACE	DEC PDP-8; Data General Nova; custom	DEC PDP-8; Data General Nova; custom	DEC PDP-8; Data General Nova; custom	DEC PDP-8E, -11; Data General Nova; HP 2100	DEC PDP-8E, -11; Data General Nova; HP 2100
PRICING AND AVAILABILITY					
Purchase Price, $	350	550	565	1,515	1,690
First Delivery	October 1971	October 1971	March 1972	February 1971	February 1971
Availability, days ARO	Stock	Stock	Stock	Stock	Stock
Number Installed to Date	INA	INA	INA	INA	INA
Serviced By	Factory	Factory	Factory	Data Products and independent reps.	Data Products and independent reps.
COMMENTS	Spooler or fanfold handler available for $300 or $120, respectively; incremental drive	Spooler or fanfold handler available for $400 or $120, respectively; incremental drive	Fanfold handler available for $120; unidirectional drive	No spooler	Includes spooler

MANUFACTURER & MODEL	Datascan, Inc.	Data Specialties R-60	Data Specialties R-120	Data Specialties DSI-120	Data Specialties PER-820
PHYSICAL ARRANGEMENT					
Function	Reader	Reader	Reader	Reader	Punch
Media	Strip; reel or fanfold optional	Strip, reel	Strip, reel	Fanfold, reel	Reel; paper, mylar
Tape Width, inches	11/16 to 1	11/16 to 1	11/16 to 1	11/16 to 1	1
Code Levels	5 to 8	5 to 8	5 to 8	5 to 8	8
Buffer	Yes	No	No	No	No
Controller	None supplied	None supplied	None supplied	None supplied	None supplied
SPEED, char./second	175 to 500	60	120	120	20
INTERFACE	DEC PDP-81, -8L, -11; HP 2100	DEC PDP-8; Data General Nova	DEC PDP-8; Data General Nova	DEC PDP-8; Data General Nova	None; logic level
PRICING AND AVAILABILITY					
Purchase Price, $	890	310 to 1,000	350 to 1,000	910	1,050
First Delivery	INA	1971	1972	1972	1969
Availability, days ARO	Stock	30	30	60	30
Number Installed to Date	500	INA	INA	INA	INA
Serviced By	Datascan	Data Specialties	Data Specialties	Data Specialties	Data Specialties
COMMENTS	Spooler costs $1,100; fanfold container costs $75; interfaces cost $265 to $481	Spooler optional	Spooler optional		Unit based on Teletype mechanism; includes spooler

All About Punched Tape Units

MANUFACTURER & MODEL	Data Specialties PEF-820	Decision, Inc. 3110B	Decision, Inc. 3110A	Decitek 241 Series	Decitek 242 Series
PHYSICAL ARRANGEMENT					
Function	Punch	Reader	Reader and punch	Reader	Reader
Media	Fanfold; paper, mylar	Fanfold	Fanfold; paper, mylar	Strip; fanfold, reel optional	Strip; fanfold, reel optional
Tape Width, inches	1	1	1	11/16 to 1	11/16 to 1
Code Levels	8	8	8	5 to 8	5 to 8
Buffer	No	No	No	No	Yes
Controller	None supplied	Included	Included	None supplied	None supplied
SPEED, char./second	20	650	Reads 650; punches 65	150	300
INTERFACE	None; logic level	Data General Nova; DCC 116	Data General Nova; DCC 116	None; logic level	None; logic level
PRICING AND AVAILABILITY					
Purchase Price, $	1,025	2,600	4,200	351 to 991	351 to 1,063
First Delivery	1971	February 1971	February 1971	1970	1970
Availability, days ARO	30	60	60	21	21
Number Installed to Date	INA	INA	INA	INA	INA
Serviced By	Data Specialties	Decision, Inc.	Decision, Inc.	Decitek	Decitek
COMMENTS	Unit based on Teletype mechanism; includes spooler	Includes read and diagnostic routines	Includes read/write and diagnostic routines	Price range covers reader only to reader with electronics and spooler or fanfold handler	Price range covers reader only to reader with electronics and spooler or fanfold handler

MANUFACTURER & MODEL	Decitek 243 Series	Digitronics 2015 EP/T	Digitronics 2031	Digitronics 2060	Digitronics 2540
PHYSICAL ARRANGEMENT					
Function	Reader	Reader	Reader	Reader	Reader
Media	Strip	Strip; reel optional	Strip; fanfold, reel	Reel	Strip, reel, fanfold
Tape Width, inches	11/16 to 1	11/16 to 1	11/16 to 1	11/16 to 1	11/16 to 1
Code Levels	5 to 8	5 to 8	5 to 8	5 to 8	5 to 8
Buffer	Yes	No	No	No	No
Controller	None supplied	None supplied	None supplied	None supplied	None supplied
SPEED, char./second	600	150	300	60	150 to 600
INTERFACE	None; logic level	None; logic level	None; logic level	None; logic level	None; logic level
PRICING AND AVAILABILITY					
Purchase Price, $	351 to 845	295 to 845	680 to 924	195 to 620	Contact vendor
First Delivery	1971	INA	INA	INA	1968
Availability, days ARO	21	60	45	60	60
Number Installed to Date	INA	25	25	3000	6000
Serviced By	Decitek	Digitronics	Digitronics	Digitronics	Digitronics
COMMENTS	Price range covers reader only to reader with electronics	OEM unit. Price range covers reader only to reader with electronics and spooler	OEM unit. Price range covers unidirectional reader with electronics to bidirectional reader with electronics and fanfold handler	OEM unit. Unidirectional reader. Price range covers basic reader to reader with electronics and spooler	OEM unit. Available as unidirectional or bidirectional reader

All About Punched Tape Units

MANUFACTURER & MODEL	Digitronics P135-20	Digitronics P135-35	Eclectic 540	Eclectic 545	Facit-Odhner 4001
PHYSICAL ARRANGEMENT					
Function	Punch	Punch	Reader	Punch	Reader
Media	Strip, fanfold, reel; paper, mylar, aluminized mylar		Strip, fanfold	Strip, reel	Reel
Tape Width, inches	11/16 to 1	11/16 to 1	11/16 to 1	1	11/16 to 1
Code Levels	5, 6, or 8	5, 6, or 8	5 to 8	8	5 to 8
Buffer	No	No	No	No	No
Controller	None supplied	None supplied	Integral	Integral	Integral
SPEED, char./second	20	35	400	75	1,000
INTERFACE	Standard interfaces available	Standard interfaces available	DEC PDP-8, -11	DEC PDP-8, -11	
PRICING AND AVAILABILITY					
Purchase Price, $	525 to 860	555 to 890	1,500 to 1,750	2,950	2,190
First Delivery	INA	INA	INA	INA	1960
Availability, days ARO	40 to 60	40 to 60	30 to 60	30 to 60	Stock
Number Installed to Date	Over 1,000	Over 1,000	INA	INA	INA
Serviced By	Digitronics	Digitronics	INA	INA	Facit
COMMENTS	OEM units. Price range covers basic punch to punch with electronics, backspace, and supply and take up reels or fanfold handler		Unidirectional reader	Includes spooler	OEM unit. Unidirectional reader; spooler available for $1,440

MANUFACTURER & MODEL	Facit-Odhner 4060	Facit Odhner 4070	International Teleprinter Corp. Series 18	International Teleprinter Corp. Series 08	International Teleprinter Corp. Series 60
PHYSICAL ARRANGEMENT					
Function	Punch	Punch	Reader	Reader	Reader
Media	Reel; paper, mylar	Reel; paper, mylar	Strip; reel optional	Strip; reel optional	Strip; reel optional
Tape Width, inches	11/16, 1, or 7/8	11/16, 1, or 7/8	1	1	1
Code Levels	5, 7, 8 or 6	5, 7, 8 or 6	5 to 8	5 to 8	5 to 8
Buffer	1 character	1 or 2 characters	No	No	No
Controller	Model 5107	Integral	None supplied	None supplied	None supplied
SPEED, char./second	150	75	30	200	60 or 72
INTERFACE	None; logic level	None; logic level	None; dry contacts	None; dry contacts	None; dry contacts
PRICING AND AVAILABILITY					
Purchase Price, $	1,990 (punch); 1,145 (controller)	1,590	215	155	345
First Delivery	1960	1969	1968	1968	1968
Availability, days ARO	Stock	Stock	Stock	Stock	30
Number Installed to Date	INA	INA	5000	3000	1000
Serviced By	Facit	Facit	Customer	Customer	Customer
COMMENTS	OEM unit	OEM unit. Includes spooler	OEM unit. Unidirectional reading	OEM unit. Price is for basic read head without drive motor	OEM unit. Versions available to read up to 120 char/sec

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MANUFACTURER & MODEL	Pivan N101	Pivan N105	Remex RR-4001 Series	Remex RR-3000 Series	Remex RRS-3401
PHYSICAL ARRANGEMENT					
Function	Reader	Reader	Reader	Reader	
Media	Reel	Reel or fanfold	Strip, roll	Strip or fanfold and roll	Reel, roll
Tape Width, inches	11/16 to 1	11/16 to 1	11/16 to 1	11/16 to 1	1
Code Levels	5 to 8	5 to 8	5 to 8	5 to 8	8
Buffer	No	No	No	No	No
Controller	Included	Included	Integral	Integral	Integral
SPEED, char./second	50	300 to 500; 1200 (search)	1,000	400	400
INTERFACE	Data General Nova	Data General Nova	DEC PDP-8E, -11; Data General Nova; HP 2100	DEC PDP-8E, -11; Data General Nova; HP 2100	DEC PDP-8E, -11; Data General Nova; HP 2100
PRICING AND AVAILABILITY					
Purchase Price, $	1,675	2,495 (reel) 2,195 (fanfold)	2,030 (inc. interface)	1,530 (inc. interface)	2,350 (inc. interface)
First Delivery	August 1971	October 1971	1966	1966	Early 1971
Availability, days ARO	45 to 60	60 to 90	Stock	Stock	Stock
Number Installed to Date	35	20	Over 5,000	Over 11,000	INA
Serviced By	Pivan or SirVess	Pivan or SirVess	Remex and indep. reps.	Remex and indep. reps.	Remex and indep. reps.
COMMENTS	Spooler included; based on Tally R-50	Spooler or fanfold handler included; based on Tally R-5000	Spooler available for $990 to $1,365; bi-directional model available for $145 more	3401 includes spooler for 7.5-inch reels; bidirectional models available for $110 more; separate spooler available for 3000 for 8 or 10.5-inch reels for $990 to $1,365; fanfold model of 3000 available for $120 more	

MANUFACTURER & MODEL	Remex RR-0305 Series	Remex RR-1150 Series	Remex RR-6300 Series	Remex RPR 1075	Remex RA-2075 Series
PHYSICAL ARRANGEMENT					
Function	Reader	Reader	Reader	Punch	Reader and punch
Media	Strip, fanfold, or reel and roll	Strip, fanfold, or reel and roll	Strip or fanfold and roll	Reel or fanfold; paper, mylar, laminates	Strip or fanfold (reader); roll (punch)
Tape Width, inches	11/16 to 1	11/16, 7/8, 1 (any 2)	11/16, 7/8, 1 (any 2)	11/16 to 1	11/16 to 1 (any 2)
Code Levels	5 to 8	5 to 8	5 to 8	5 to 8	5 to 8
Buffer	No	No	No	No	No
Controller	Integral	Integral	Integral	Integral	Integral
SPEED, char./second	300	150 to 200	300 to 400	75	Reads 200; punches 75
INTERFACE	DEC PDP-8E, -11; Data General Nova; HP 2100	DEC PDP-8E, -11; Data General Nova; HP 2100	DEC PDP-8E, -11; Data General Nova; HP 2100	DEC PDP-8E, -11; Data General Nova; HP 2100	DEC PDP-8E, -11; Data General Nova; HP 2100
PRICING AND AVAILABILITY					
Purchase Price, $	1,560 to 1,895 (inc. interface)	1,195 to 1,717 (inc. interface)	1,295 (inc. interface)	2,290 (inc. interface)	2,995 to 3,095 (inc. interface)
First Delivery	1961	1969	New	INA	1971
Availability, days ARO	Stock	Stock to 30	INA	INA	Stock
Number Installed to Date	Over 31,000	INA	INA	INA	INA
Serviced By	Remex and indep. reps.	Remex and indep. reps.	Remex and indep. reps.	Remex and indep. reps.	Remex and indep. reps.
COMMENTS	Model available with spooler for 5.25-inch reels or separate spooler (same as for 3,000 series) available; uni-directional reading	Models available with spooler for 6 or 8.5-inch reel or separate spooler (same as 3000 series)	Fanfold model costs $100 more	Include spooler for 7.5, 8, or 8.5-inch reels; fanfold model $95 less; model without spooler $185 less	Punches paper, mylar, and laminated tape

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MANUFACTURER & MODEL	Remex RR-3075 Series	Superior Electric TRP 500	Superior Electric TRP 125-5	Superior Electric 6TRP 125-5	Tally R-50
PHYSICAL ARRANGEMENT					
Function	Reader and punch	Reader	Reader	Reader	Reader
Media	Strip or fanfold (reader); roll (punch)	Strip	Strip	Reel	Strip
Tape Width, inches	11/16, 7/8, 1 (any 2)	1	1	1	11/16 to 1
Code Levels	5 to 8	8	8	8	5 to 8
Buffer	No	No	No	No	No
Controller	Integral	None supplied	None supplied	None supplied	None supplied
SPEED, char./second	Reads 300; punches 75	500	125	125	50
INTERFACE	DEC PDP-8E, -11; Data General Nova; HP 2100	None	None	None	None
PRICING AND AVAILABILITY					
Purchase Price, $	3,095 to 3,145 (inc. interface)	980	650	820	330
First Delivery	1971	INA	INA	INA	1967
Availability, days ARO	Stock	60	60	60	30
Number Installed to Date	INA	INA	INA	INA	INA
Serviced By	Remex and indep. reps.	Superior	Superior	Superior	Tally
COMMENTS	Punches paper, mylar, and laminated tape			Includes spooler	Unidirectional reading

MANUFACTURER & MODEL	Tally 424	Tally R-2000	Tally R-5000	Tally BP-30	Tally 420
PHYSICAL ARRANGEMENT					
Function	Reader	Reader	Reader	Punch	Punch
Media	Strip, reel	Strip, reel	Strip, reel	Strip; paper	Reel; paper, polyester
Tape Width, inches	11/16 to 1	11/16 to 1	11/16 to 1	11/16 to 1	11/16 to 1
Code Levels	5 to 8	5 to 8	5 to 8	5 to 8	5 to 8
Buffer	No	No	No	Yes	Yes
Controller	None supplied	Integral	Integral	Optional	Optional
SPEED, char./second	60	200 to 300	300 to 1,200	30	60
INTERFACE	None	Data General Nova	Data General Nova	Data General Nova	Data General Nova
PRICING AND AVAILABILITY					
Purchase Price, $	500	520	1,385	395	1,270
First Delivery	1958	1971	1970	1971	1958
Availability, days ARO	30	30	30	30	30
Number Installed to Date	INA	INA	INA	INA	INA
Serviced By	Tally	Tally	Tally	Tally	Tally
COMMENTS	Rack mounted; includes spooler	Rack mounted; includes spooler; fanfold handler available	Rack mounted; includes spooler; fanfold handler available	Rack mount with tape handling optional	Rack mounted; spooler included

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MANUFACTURER & MODEL	Tally P-1200	Teletype CX	Teletype DX	Teletype BRPE	Teletype DRPE
PHYSICAL ARRANGEMENT					
Function	Punch	Reader	Reader	Punch	Punch
Media	Reel; paper, polyester	Strip	Strip	Reel; paper	Reel; paper
Tape Width, inches	11/16 to 1	11/16 to 1	11/16 to 1	11/16 to 1	11/16 to 1
Code Levels	5 to 8	5 to 8	5 to 8	5 to 8	5 to 8
Buffer	Yes	No	No	No	No
Controller	Optional	None supplied	None supplied	None supplied	None supplied
SPEED, char./second	120	107	360	110	240
INTERFACE	Data General Nova	None	None; logic level parallel or serial; RS-232C	None	None
PRICING AND AVAILABILITY					
Purchase Price, $	1,500	296 to 529	Contact vendor	546 to 1,057	871 to 2,615
First Delivery	1965	INA	INA	INA	INA
Availability, days ARO	30	120 to 180	180	120 to 180	180
Number Installed to Date	INA	INA	INA	INA	INA
Serviced By	Tally	Teletype or customer	Teletype or customer	Teletype or customer	Teletype or customer
COMMENTS	Rack mounted; spooler included; error checking optional	Price range covers basic reader to full package with electronics, drive motor, and covers		Price range covers basic punch to full package with electronics, drive motor, and covers	Price range covers basic punch with motors to full package with electronics and takeup reel