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COMPUTER DESIGN/APRIL 1966
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The Datastrobe subsystem employs a new concept of data display that offers you precisely registered, reliable readouts and simple, flexible installations—at very low cost.

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Reduced number of components increases reliability. The time-sharing feature reduces the number of components. Self-contained Datastrobe subsystem wires directly to logic without buffers or drivers. There are no signal amplifiers, mechanical switches or relays. One 6-digit Datastrobe subsystem can replace as many as 66 incandescent bulbs or 6 electromechanical readouts! No complementary input or 8-line to 4-line converter is required.

Self-decoding eliminates wrong readouts. A self-decoding feature incorporated into the Datastrobe subsystem uses direct logic comparison to eliminate erroneous or ambiguous readouts. The conventional white-on-black displays are bright, steady, and provide high contrast and easy recognition.

Wide range of design options. Datastrobe subsystem display screens can be integral or separate. Standard models are available with up to 12 digits; floating decimal point is optional. Models with more digits and combinations of alphanumeric characters or symbols are available. Additional readout locations are accommodated with simplified wiring. Codes other than BCD, such as 2-out-of-5 code, are available as options.

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CIRCLE NO. 5 ON INQUIRY CARD
Datavue® Numerical Indicator Tubes in 
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selected symbols such as + and -
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glow lamp. And their life expectancies 
range upward of 200,000 hours in dynam-
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They’re also easily read in high ambient 
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out. Erroneous readouts due to segment 
failure do not occur because the charac-
ters are fully formed.

Side-view Datavue tubes cost less be-
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manufacturing economies. They’re also 
economical to install because the bezel 
and filter assembly can be eliminated,
and their mating 11-pin sockets are less 
expensive than for end-view types.

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input/output cathode ray storage de-
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delay, and stop motion. Types include 
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immediate readout capabilities. Information 
can be written and stored by se-
quential techniques or by random writ-
ing. Complete, partial, or selective 
erase is possible. Many other types of 
recording storage tubes are available, 
covering a wide range of requirements 
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ation.

Symbolray® CRT Tube. The new Ray-
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in sequence to form the readout on a 
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100 characters are available.

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are available for writing alphanumeric 
characters while raster scanning. All 
standard phosphors are available and 
specific design requirements can be 
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plate” types include CK1395P (24” re-
tangular tube), CK1400P (21” rectangu-
lar), and CK1406P (17” rectangular).

Send the Reader Service Card for Liter-
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and catalogs—
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Cathode Ray Tubes Data Sheets
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CIRCLE NO. 5 ON INQUIRY CARD
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**MODEL QF PRINTER**

**12-COLUMN CAPACITY**

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Editorial Notes

CD REFRESHER SERIES

This month COMPUTER DESIGN inaugurates a new department which will provide a continuing series of review tutorials on basic analytical techniques used, at one time or another, by all professionals in the field of computer design.

The first series of articles under this new department has been named Mathematics Revisited: Selected Topics in Probability and Statistics. This series has a two-fold purpose: first, to serve as a review for those readers whose skills in the area of interest have become dulled through disuse; second, to provide a primer for those readers who may never have been formally exposed to the subject material.

To these ends, the articles are result-and-application oriented. Rigorous mathematical development of equations, proof of theorems, and mathematician's jargon are left to the textbooks. Prolific footnoted references and bibliographies are not provided; the reader who wishes to pursue the subject matter in greater depth will find detailed treatment of nearly all of the topics discussed in these articles, in any of a number of excellent texts.

Mathematical background material is briefly presented, in tabular form, whenever a review is required for understanding of the manipulations used in the text. No mathematics beyond undergraduate level will be encountered.

Each article will contain a complete topic, and will therefore stand as nearly independently of the others as is possible. This month's subject covers basic probability concepts, the next issue will explore the principal rules for manipulating probabilities.

DAN M. BOWERS,
Contributing Editor
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The ULTIMATE DIODE

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**Electrical Specifications for H100 Series at 25°C**

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>PRV</td>
<td>90 V @ 10 µA</td>
</tr>
<tr>
<td>IL</td>
<td>40 mA @ 1 V</td>
</tr>
<tr>
<td>IS</td>
<td>2 nA @ -40 V</td>
</tr>
<tr>
<td>C0</td>
<td>2.4 µF @ 0 V</td>
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<tr>
<td>τr</td>
<td>4 ns @ Ip = 10 mA to VR = -40 V</td>
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But—don't be misled by its low, low cost. It's all NIXIE tube—in name, in design, in construction, in performance, in quality, in long, trouble-free life.

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Use the reply card for full information on the new NIXIE tube and complete readout-application assistance.

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For more information on the M4000, write or call Ralph P. Bohn, Digital Tape Products Division, P. O. Box 1526, Tulsa, Oklahoma 74101. Our phone number is 918-627-1116.
Under operational conditions, MTBF for a typical \(2^{11}\) full word Litton encoder is 30,000 hours (very conservatively rated) compared with 5,000 hours experienced under equivalent conditions for an encoder using tungsten bulbs.

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PART 1 — BASIC PROBABILITY

Dan M. Bowers, Contributing Editor

An understanding of Probability is most easily and thoroughly acquired if one first develops a feel for three fundamental concepts: "randomness," "independent trials," and "in the long run."

"Randomness" is a property which describes the unpredictability, haphazardness, "chance," or uncertainty in the result of a particular operation. If a balanced die is repeatedly (and honestly) rolled, "randomness" describes the sequence in which the six possible numbers appear. If a balanced coin is repeatedly flipped, "randomness" describes the sequence in which heads and tails appear. If 5000 ticket stubs are placed into a drum and stirred, and five stubs are drawn to award door prizes, "randomness" describes the sequence of the numbers drawn, and their relation to the original set of 5000 numbers. If 99 black balls and one white ball are placed into a tub, shaken, and are drawn out (without peeking), "randomness" describes the fact that, in any given draw, the ball may be either black or white, even though we intuitively expect that this operation will nearly always result in the drawing of a black ball.

"Independent trials" is a concept which is expressed by James Bond as "the wheel has no memory." If the property of randomness is assumed, then the roll of a die or the toss of a coin is completely unaffected by the result of the preceding roll or toss, or, for that matter, by the result of the subsequent or any other roll or toss. Each roll or toss is an "independent trial." Provided the five ticket stubs are returned to the drum and the contents stirred (to assure randomness), a second draw of five stubs is unaffected by the first draw. Provided the ball drawn is returned to the tub, the tub shaken, and another ball drawn, its color is unaffected by the color of the first ball. In James Bond's example, each spin of a roulette wheel is an "independent trial."

"In the long run" relates to the familiar "law of large numbers"; through Probability theory we can predict that out of a large number (strictly speaking, an infinite number) of independent trials of a given random operation, a certain result will occur a certain percentage of the time. Thus we can say that "in the long run," one-sixth of the rolls of a die will result in a four, half the coin tosses will result in a head, a given ticket will be drawn once every 1000 5-stub draws, and a white ball will result one percent of the time.

Applying these concepts, we can see that if nine consecutive coin tosses have all resulted in heads (an unlikely sequence of events), the outcome of the tenth toss is still equally likely to be a head as a tail, since it is an independent random trial, and heads and tails are equally likely in the long run. The weatherman's statement that the probability of snow on a given day is 70% means that in the long run — i.e., out of a large number of days (independent trials) which exhibit certain meteorological characteristics, as evaluated by the forecasting techniques used in this case — snow will result on 70% of the days; further, the 70% snowy days are randomly selected from those showing the meteorological characteristics of interest. (Note that the forecaster seemingly cannot be wrong, since the occurrence of snow on a particular day has the property of randomness; if, however, it remains clear on 90 out of 100 days on which the forecaster predicts 70% for snow, he may — quietly — re-examine his forecasting techniques. We shall see in a later article of this series how one may determine whether the 10% occurrence of snow in the face of 70% prediction for snow may reasonably be attributed to chance; we shall, for example, be able to state that we are more than 99% certain that the 70% prediction was wrong, based on the 10% snow in 100 observations.) If 99 draws have resulted in a black
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COMMUNICATIONS
equipment for on-line,
real-time processing

features you can take-for-granted

There are many features on Teletype sets that assure you of the most reliable, efficient, and least costly terminal equipment for your data communications systems. Take these features for granted...since they are standard on new model Teletype machines.

COPY VIEWING AREA
All Teletype RO (receive-only), KSR (keyboard send-receive), and ASR (automatic send-receive) sets have a convenient window that provides the typist with a clear view of the copy as it is being typed. The rear edge of this window has a tearing surface to facilitate removal of the printed copy.
The upper cover of these sets is hinged, allowing easy access to the equipment for changing the paper supply and typing ribbon. On ASR sets, the paper tape chad from the punch head is conveniently collected in a chad container.

CHARACTER COUNTER
The standard Teletype Model 35 ASR set has many additional versatile features, such as: a character counter that enables the typist to see at a glance how many spaces have been typed from the left margin of the page; a utility tray to conveniently hold papers or forms; a clear plastic bubble on top of the upper cover for viewing the paper supply and observing the operation of the typing unit; and an end-of-line indicator that glows red as the type box nears the end of the line.
Other features of the Model 35 ASR include: a window for viewing the paper tape and the punching operation; a low paper alarm that operates when the paper supply is nearly exhausted;

a copyholder and line guide to hold short messages the typist is sending; as well as illuminating lamps for the typing unit and reperforator areas.

BREAK BUTTON
When the paper supply is running low, you merely depress an illuminating "BREAK" button on the Teletype machines to "break off" communication in the middle of transmission. After the paper has been changed, the line is easily restored by depressing the BREAK-RELEASE key—without losing any portion of the text.

These standard features are another reason why this equipment is made for the Bell System and others who require reliable communications at the lowest possible cost. For more information on Teletype machines, write for our new brochure "ALL ABOUT TELETYPE EQUIPMENT." Teletype Corporation, Dept. 71D, 5555 Touhy Avenue, Skokie, Illinois 60076.

machines that make data move
ball, the 100th ball is still very likely to be black, even though in the long run (which might be 3000 draws in this case), an average of one out of every hundred draws will result in a white ball.

**PROBABILITY**

In the long run, a given result of a random operation will occur with a frequency equal to the product of its Probability and the number of times the operation is performed. Conversely put, we are defining Probability as the ratio, "in the long run," between the frequency of occurrence of a particular result, and the number of times the operation is performed. Mathematically stated, if \( \alpha_1, \alpha_2, \ldots, \alpha_n \) are the possible results of an operation, \( f(\alpha_i) \) is the number of occurrences of the \( i \)th result, and \( k \) is the number of times the operation is performed, then \( P(\alpha_i) \), the Probability of the \( i \)th result, is

\[
P(\alpha_i) = \lim_{k \to \infty} \frac{f(\alpha_i)}{k}
\]

We see that "in the long run" is implemented by defining the Probability, as \( k \) becomes very large.

Since one can never perform any operation an infinite number of times, a Probability can be only approximated by experimental means. For example, one actual coin toss experiment (performed during a quiet midwatch) of 1000 tosses resulted in 490 heads and 510 tails; we could therefore calculate \( P(\text{heads}) \) of 0.49 compared to the well-known \( P(\text{heads}) \) of 0.50. Fortunately, Probabilities of many events of interest can be calculated without recourse to experimental trials, and the Probabilities of other events can in general be estimated — to within a predictable amount of error — on the basis of relatively few trials. These techniques will be discussed.

Examining the definition of Probability, we can

**TABLE 1**

**PERMUTATION AND COMBINATION RULES**

**RULE 1:** If \( X \) and \( Y \) are two independent operations (i.e., the result of \( X \) has no relation to the result of \( Y \) and vice versa), and if there are \( x \) different results of operation \( X \), and \( y \) different results of operation \( Y \), then there are \( xy \) different results of the operation of performing \( X \) and \( Y \) together. (Example: a roll of die 1 has 6 possible results, and a roll of die 2 has 6 possible results, therefore, the roll of die 1 and die 2 together has 36 possible results, as shown in the text.)

**RULE 2:** Permutations within a set: A set of \( n \) different objects can be arranged in \( n! \) different ways, where \( n! = n(n-1)(n-2)\ldots(3)(2)(1) \). (Example: four persons at a bridge table can be seated in \( 4! = 24 \) different ways; let the persons be numbered 1, 2, 3, 4, and the places a, b, c, d; then if person 1 is at place a, person 2 can be at b, c, or d, with persons 3 and 4 at c and d or d and c, b and d or d and b, b and c, or c and b, respectively, giving 6 possible arrangements for person 1 at seat a; the 18 other arrangements result from person 1 being at seats b, c, and d.)

**RULE 3:** Permutations of groups from a set: if a group of \( p \) objects is taken from a set of \( n \) (\( n > p \)), the number of different arrangements of the group is:

\[
n(n-1)(n-2)\ldots(n-p+1)
\]

(Example: If a 3-desk office is available to seat three of the 5 men assigned to a project, there are 60 different arrangements possible; if the men are designated a, b, c, d, and e, and the desks 1, 2, and 3, then any of the five men can be assigned to desk 1, combined with any of the remaining four at desk 2, combined with any of the remaining three at desk 3.)

This can also be written \( \frac{n!}{(n-p)!} \), where \( n! \) is the number of arrangements of the set of \( n \), and \( (n-p)! \) is the number of arrangements of the "leftover" items.

**RULE 4:** Combinations: (permutations describe the number of different arrangements of objects within a set; combinations refer only to the number of different objects in the set, regardless of their arrangement. Example: there is only one combination of cards in an ace-high straight heart flush, but there are, by Rule 2, \( 5! = 120 \) permutations, or arrangements of the cards.) The number of combinations of \( p \) objects taken from a set of \( n \) (\( n > p \)) is

\[
\frac{n(n-1)(n-2)\ldots(n-p+1)}{p!}
\]

This is seen to be the number of permutations of \( p \) objects taken from a set of \( n \) (from Rule 3), divided by the number of permutations within the set of \( p \) (from Rule 2). Using the second notation shown in Rule 3, this can be written as:

\[
\frac{n!}{p!(n-p)!}
\]

which is usually written \( \binom{n}{p} \).

To re-emphasize: the number of combinations of \( n \) objects taken \( p \) at a time is:

\[
\binom{n}{p} = \frac{n!}{p!(n-p)!}
\]
If your data communications system requires a Teletype set with vertical or horizontal tabulation, we've got it. If you need a Teletype machine that prints on multiple copy business forms with form-out and line-feed features, we've got it.

Teletype research and development engineers have created these optional features and the ones described below to provide the versatility you need in your data communications systems.

AUTOMATIC CONTROL
Teletype Model 33 and 35 ASR (automatic send-receive) sets can be equipped for automatic unattended operation with the following controls:

Automatic Reader Control allows taped data to be transmitted automatically by the reader of an unattended ASR set when called in by a remote Teletype machine.

Automatic Punch Control allows data to be transmitted to the reperforator of an unattended set when called in by a remote Teletype machine.

Automatic Printer Control allows printed data to be transmitted to the printer of an unattended set when called in by a remote Teletype machine.

When these three features are used on the same set, you can separate the tape punch, tape reader, and printer operations, enabling you to tape data without printing page copy, or print the copy without punching a duplicate tape.

AUTOMATIC DATA PREPARATION
Teletype R&D engineers have developed a Push Button Data Generator to simplify and speed the flow of fixed data. By preprogramming fixed data (such as addresses and identification numbers) into the PBDG, you can automatically print as many as 24 alphanumeric characters and other symbols by depressing a single button.

Operating on either a 5 or 8-level code, the basic Teletype PBDG unit consists of 12 pushbuttons that are capable of generating a total of 288 characters. The PBDG can be used as a self-contained unit or combined with Teletype KSR (keyboard send-receive) or ASR sets.

The PBDG has wide application wherever there is a need for automatic handling of repetitive data or information. For instance, in a computer time-sharing system, the intricate instructions needed to activate the computer for a particular user can be programmed into the PBDG, and transmitted automatically to the computer merely by pressing the appropriate buttons.

AND MORE FEATURES
There are many additional features that are available on Teletype machines, such as a variety of different width platens, and automatic carriage return-line feed. That's why this equipment is made for the Bell System and others who require reliable communications at the lowest possible cost.

Additional information on the Push Button Data Generator and our other features can be obtained by writing: Teletype Corporation, Dept. 71D, 5555 Touhy Avenue, Skokie, Illinois 60076.
deduce five important properties.

1. $0 \leq P(\alpha_i) \leq 1$; $P(\alpha_i)$ is non-negative, and can assume any value between zero and one.

2. The Probability of a certain result (e.g., the Probabilities of death and taxes) is unity, since every performance of the operation results in the specified result $\alpha_i$, therefore $P(\alpha_i) = k$. Note, however, that the reverse is not necessarily true, i.e., a Probability of unity does not necessarily describe a certain result. For example, if there are a million balls in a tub, and all are black except one which is white, the Probability of drawing a black ball is $1.00000$, yet we still might draw a non-black ball.

3. The Probability of an impossible result is zero, but a Probability of zero does not necessarily describe an impossible result; both of these statements follow from reasoning similar to that above. It is fair to state, with respect to Probabilities of zero and one, that they represent results which are "for all practical purposes" impossible or certain, respectively.

4. The Probability of a result other than $\alpha_i$, i.e., the Probability that $\alpha_i$ will not occur (defined as $P(\alpha_i)$ is

$$P(\alpha_i) = 1 - P(\alpha_i),$$

(Since all results of the $k$ trials which are not $\alpha_i$ must be $\bar{\alpha}_i$, then

$$f(\bar{\alpha}_i) = k - f(\alpha_i),$$

and

$$P(\alpha_i) = \lim_{n \to \infty} \frac{f(\bar{\alpha}_i)}{k} = \lim_{n \to \infty} \left[ \frac{k-f(\alpha_i)}{k} \right] = 1 - P(\alpha_i).$$

5. It follows from 4 above, that the sum of the Probabilities of the results of an operation must be unity. That is, if $\alpha_1$, $\alpha_2$, $\alpha_3$, and $\alpha_i$ are the only possible results of a given operation, then

$$P(\alpha_1) + P(\alpha_2) + P(\alpha_3) + P(\alpha_i) = 1$$

This property is known as exhaustiveness. Note that it holds only if the results $\alpha_1$, $\alpha_2$, $\alpha_3$, and $\alpha_i$ are disjoint, that is, no two of them may occur simultaneously.

### EQUIPROBABLE RESULTS

An important class of operations (significantly including most gambling problems) can be described by the following characteristics:

1. There are $n$ possible results: $\alpha_1$, $\alpha_2$, $\alpha_3$, $\ldots$, $\alpha_n$, and one of them must occur.

2. The results are mutually exclusive (disjoint), i.e., only one of them may occur for any trial.

3. The results are equiprobable of occurrence, i.e.,

$$P(\alpha_1) = P(\alpha_2) = P(\alpha_3) = \ldots = P(\alpha_n).$$

Under these conditions, the Probability of a particular condition is the simple ratio of the number of possible results which satisfy the condition (known by "successes") to the total number of possible results, $n$. For example, in the standard 52-card deck of playing cards, there are 52 possible and equiprobable results of the operation of drawing one card. If a "success" is defined as drawing a heart, there are 13 results which can cause a "success," and 52 possible results, so that:

$$P(\text{heart}) = \frac{13}{52} = \frac{1}{4}.$$  

In the roll of a pair of dice, there are 36 possible results:

<table>
<thead>
<tr>
<th>Result</th>
<th>Probability</th>
</tr>
</thead>
<tbody>
<tr>
<td>1+1=2</td>
<td>1/36</td>
</tr>
<tr>
<td>1+2=3</td>
<td>1/36</td>
</tr>
<tr>
<td>1+3=4</td>
<td>1/36</td>
</tr>
<tr>
<td>1+4=5</td>
<td>1/36</td>
</tr>
<tr>
<td>1+5=6</td>
<td>1/36</td>
</tr>
<tr>
<td>1+6=7</td>
<td>1/36</td>
</tr>
<tr>
<td>2+1=3</td>
<td>1/36</td>
</tr>
<tr>
<td>2+2=4</td>
<td>1/36</td>
</tr>
<tr>
<td>2+3=5</td>
<td>1/36</td>
</tr>
<tr>
<td>2+4=6</td>
<td>1/36</td>
</tr>
<tr>
<td>2+5=7</td>
<td>1/36</td>
</tr>
<tr>
<td>2+6=8</td>
<td>1/36</td>
</tr>
<tr>
<td>3+1=4</td>
<td>1/36</td>
</tr>
<tr>
<td>3+2=5</td>
<td>1/36</td>
</tr>
<tr>
<td>3+3=6</td>
<td>1/36</td>
</tr>
<tr>
<td>3+4=7</td>
<td>1/36</td>
</tr>
<tr>
<td>3+5=8</td>
<td>1/36</td>
</tr>
<tr>
<td>3+6=9</td>
<td>1/36</td>
</tr>
<tr>
<td>4+1=5</td>
<td>1/36</td>
</tr>
<tr>
<td>4+2=6</td>
<td>1/36</td>
</tr>
<tr>
<td>4+3=7</td>
<td>1/36</td>
</tr>
<tr>
<td>4+4=8</td>
<td>1/36</td>
</tr>
<tr>
<td>4+5=9</td>
<td>1/36</td>
</tr>
<tr>
<td>4+6=10</td>
<td>1/36</td>
</tr>
<tr>
<td>5+1=6</td>
<td>1/36</td>
</tr>
<tr>
<td>5+2=7</td>
<td>1/36</td>
</tr>
<tr>
<td>5+3=8</td>
<td>1/36</td>
</tr>
<tr>
<td>5+4=9</td>
<td>1/36</td>
</tr>
<tr>
<td>5+5=10</td>
<td>1/36</td>
</tr>
<tr>
<td>5+6=11</td>
<td>1/36</td>
</tr>
<tr>
<td>6+1=7</td>
<td>1/36</td>
</tr>
<tr>
<td>6+2=8</td>
<td>1/36</td>
</tr>
<tr>
<td>6+3=9</td>
<td>1/36</td>
</tr>
<tr>
<td>6+4=10</td>
<td>1/36</td>
</tr>
<tr>
<td>6+5=11</td>
<td>1/36</td>
</tr>
<tr>
<td>6+6=12</td>
<td>1/36</td>
</tr>
</tbody>
</table>

From the rule described above, we can easily calculate the Probability of each total throw value:

$$P(1) = \frac{0}{36} = 0.000$$
$$P(7) = \frac{6}{36} = 0.167$$
$$P(2) = \frac{1}{36} = 0.028$$
$$P(8) = \frac{5}{36} = 0.139$$
$$P(3) = \frac{2}{36} = 0.056$$
$$P(9) = \frac{4}{36} = 0.111$$
$$P(4) = \frac{3}{36} = 0.083$$
$$P(10) = \frac{3}{36} = 0.083$$
$$P(5) = \frac{4}{36} = 0.111$$
$$P(11) = \frac{2}{36} = 0.056$$
$$P(6) = \frac{5}{36} = 0.139$$
$$P(12) = \frac{1}{36} = 0.028$$

Using only the definition of Probability for equiprobable results, we can calculate the Probabilities of a number of interesting operations. In the examples used in the beginning of this article, it is easily seen that:

- for the balanced die,
  $$P(1) = P(2) = P(3) = P(4) = P(5) = P(6) = \frac{1}{6}.$$  
- for the balanced coin,
  $$P(\text{heads}) = P(\text{tails}) = \frac{1}{2}$$

for the 99-black-and-one-white ball,
look ma...no hands!

Teletype page printers can be equipped to be turned on, transmitted to, and turned off by remote stations—without an operator present. This, in part, is accomplished by an automatic answer-back mechanism installed in the set’s receiver.

STORES UP TO 20 CHARACTERS
Capable of storing up to 20 characters, the answer-back mechanism of an unattended set can be triggered by a distant Teletype machine to automatically return its identification call letters. This notifies the transmitting station that it is connected and ready to receive data.

A station’s call letters are easily coded on a rotating drum within the answer-back mechanism. You can change your identification call letters at any time by merely replacing the existing drum with a newly coded one.

THREE DIFFERENT METHODS
The answer-back mechanism can be triggered in three different ways. (1) A converter within the called Teletype set automatically turns on the set’s motor and energizes a magnet, which in turn actuates the answer-back mechanism. (2) A “WHO ARE YOU” character can be transmitted by the sending station. This triggers the answer-back drum in the remote receiver to return its identification call letters to the sending station. (3) Local identification is initiated by depressing the “HERE IS” key. The answer-back drum will then print the receiving station’s call letters at both terminals.

DISCRETE CODE
Telespeed sending sets can be equipped for automatic unattended transmission to a receiving unit. However, in order to assure that only your own receivers are capable of turning on your sending unit, both sets have a discretely coded signal. This special 14-bit code prevents any other receiver from accidentally calling in your sending set.

Here’s how it works with Telespeed 750 equipment. A previously punched paper tape is placed in the tape reader of the sending unit, and the AUTO key pressed to make the set ready for unattended operation.

Incoming calls to the sending set will be answered with a tone signal. On hearing the tone, the receiving set operator presses an AUTO RDR START key which transmits the discrete code. The sending unit recognizes the correct code, turns on its tape reader, and transmits the information prepared in tape form.

The versatility of this Teletype equipment is another reason why it’s made for the Bell System and others who require reliable communications at the lowest possible cost. For additional information on the discrete code, write for our new “TELESPEED 750” brochure. Teletype Corporation, Dept. 71D, 5555 Touhy Avenue, Skokie, Illinois 60076.
For the 5000-ticket-stub problems, the calculations are less obvious. Intuitively, since there are 5000 stubs and 5 to be drawn, we expect the probability of success to be 1/1000. The total number of possible results of drawing five stubs out of 5000 is the number of combinations of 5000 things, taken 5 at a time (see Rule 4 in Table 1), which is:

\[
\binom{5000}{5} = \frac{5000!}{5!(5000-5)!} = 25,997,949,781,251,000.
\]

A success in this operation consists of a draw of the one "winning" stub, plus any other four of the 4999 non-winning stubs. This, by Rule 4, can happen in \(\binom{4999}{4}\) ways. The Probability of success, therefore, is the ratio of the number of ways a success can occur to the number of possible results,

\[
\frac{\binom{4999}{4}}{\binom{5000}{5}} = \frac{1}{1000}
\]

Similarly, we can calculate the Probabilities of desired results in card games. The probability of a perfect hand (all of one suit) in bridge, is the ratio of the number of such perfect hands possible (4) to the total number of hands possible, \(\binom{52}{13}\), which is 635,013,559,600; therefore, we can expect to have one of the four perfect hands — in the long run — for each 157 billion hands of bridge that we play.

More within the realm of possibility is the Probability of a good poker hand, for example, p aces in a deal of five-card stud. There are \(\binom{52}{5}\) possible poker hands. A success is defined as having p aces and 5 - p other cards. The aces can occur in \(\binom{4}{p}\) ways, and the other cards can occur in \(\binom{48}{5-p}\) ways, since there are 4 aces and 48 other cards to choose from. By Rule 1 in Table 1, there are, therefore, \(\binom{4}{p}\frac{48}{5-p}\) successful combinations, and the desired probability is

\[
\frac{\binom{4}{p}\binom{48}{5-p}}{\binom{52}{5}}
\]

It is left as an exercise for the serious gambler to complete the problem for the desired number of aces. (Note — before betting — that this expression gives only the probability of getting exactly p aces. In the next article we shall see how one determines such things as the probability of getting at least p aces.)

Once certain Probabilities have been calculated, it is useful to operate with them to obtain the Probabilities of more complex events. In this way, we avoid having to return to the basic (and frequently, as seen above, quite messy) combinatorial representations for further calculations. Also, of course, there are many problems which cannot be solved with this basic approach. The next article in this series will develop and illustrate the manipulation rules for Probabilities.

END
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We’ve been able to reach these speeds by using a simple but ingenious magnetic organization. We call it 2½ D. It combines the speed potential of linear select with the economy of coincident current techniques. We’ve also reduced stack connections by 80% and widened operating margins to increase reliability.

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CIRCLE NO. 18 ON INQUIRY CARD
Programming Languages

E. E. GRIFFITH

One of the most common questions asked by the hardware-oriented professional trying to learn more about programming is: What's the difference between FORTRAN and COBOL? Many times the programmer accepts this question at face value and barges head-on into a discussion which attempts to define "the differences." Words such as verb, jargon, syntax, dialect, idiom, punctuation, etc., are used until the listener has the confused feeling he is getting a course in linguistics instead of programming. If he had been forewarned, perhaps he wouldn't be so confused.

Whenever discussing programming languages, it is usually interesting and sometimes informative to draw a parallel with the social languages.

If we say that the difference between FORTRAN and COBOL is really one of jargon it would not be too misleading. COBOL is simply designed for a different purpose than FORTRAN. The former is used by accountants, payroll personnel, etc., in which transactions, entries, opening and closing of files are terms in daily use and are, therefore, part of the jargon of those particular areas. On the other hand, terms such as functions, arrays, equivalence, relational operators, etc., are found in use by the mathematician/scientist. FORTRAN has been designed for use by these disciplines.

It is interesting to note that there are dialect problems in programming languages just as there are in the social languages. The word ACCEPT in one dialect of FORTRAN may have to be replaced with READ in another dialect to accomplish the same thing. The traveler is certainly aware of this type of problem by expecting to get the same thing in Boston when he orders the "milk shake" that he ordered in Los Angeles.

Sometimes, these differences are more severe, and therefore, cause rather serious communication problems. ALGOL, for example, is similar in some ways to FORTRAN, but is sufficiently different in grammar so that a programmer who understands FORTRAN will not necessarily be able to understand ALGOL. Perhaps the magnitude of this type of problem can be recognized by the analogy of the differences in Italian and Spanish. They are similar in many respects, but are quite different.

A practical suggestion might be for everyone to get together and decide on a standard programming language. The mathematicians could choose from FORTRAN, ALGOL, ALTAC, AUTOCODE, etc.; the business community could select from COBOL, GECOM, TABSOL, FACT, etc.; the control area could decide from APT, AUTOPROMPT, PROCOM, PIGEON, etc. This is still being attempted with some, but disappointingly little, success. Unfortunately, emotion is not the least of the problems. Who can really explain why ALGOL is more popular in Europe and FORTRAN is the de facto standard in the U.S.?

No one will deny the need for standards, but the selection of a standard is something else. But is this really too different from the problems confronting the various disciplines when communicating in social languages? It would appear worthwhile for the medical profession to standardize on a language for their journals. It is not inconceivable that there would be factions in favor of German as being more precise than English or a proposition that Latin is more universally understood.

We have heard criticisms of the programming profession that suggest the reasons for so many different languages are due to a lack of discipline; that if there were some semblance of strong leadership there wouldn't be so many languages. However, if we apply our analogy, we can see that these criticisms might be unfair. Human nature seems to have more of an impact than might be expected, even in the stark technical world.

There is considerable pressure within the programming profession to develop a universal programming language; a language that is all things to all people. The interest in NPL (i.e., PL/I) is the result of such pressure. This new language seems quite good and appears to place the goal of
Does your present custom power supply give you...

70% to 90% efficiency?  
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OMNIMOD is a dc to dc converter using transistors in a CONSTANT PULSE WIDTH, variable repetition rate switching mode to regulate output voltage or current. Two small plug-in units make-up the OMNIMOD concept—a power control module and a control amplifier.

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All the power used by every element in a typical data processing system could be supplied by custom power supplies constructed with interchangeable OMNIMOD modules.

Isn't this enough to consider OMNIMOD for your custom requirement? We will design an OMNIMOD custom power supply to your specs, or will help you design your own system using our plug-in OMNIMOD modules.

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This rugged, high-speed printer will transcribe information from ANY computer at rates up to 1,000 lines per minute.

NCR's low-priced EM-C2 Printer - packaged the way you want it - can be merged into your own line of computer peripherals in a surprisingly short time. Its 64-character and 160-column print line encourages flexibility without sacrificing compactness. And you can back it with a double warranty for dependability! Over confident? Not at all! The EM-C2 has a history of over 5 million hours in successful tests and on-the-job production. The blood and sweat that go with development are in the past. The cost is written off.

"Dress it any way you wish to match your own EDP components." Or NCR can provide you with a completely designed package. Either way, it'll amaze you when you learn how so much quality and dependability can be merged into your own computer system at such a low, low price. Write to NCR's Industrial Products Division (OEM) for the complete story about the EM-C2 High-Speed Printer.

Other quality peripherals are available from NCR's IP Div., like Paper Tape Readers, Paper Tape Punches, Punched Card Readers, Mag Tape Transports, Mag Tape Units, and CRAM (Card Random Access Memory).
standardization within reach (this is controversial, but certainly we are closer than we were a few years ago). The programming profession, you see, has not ignored the problem, but does in fact have a direction and even a plausible solution in mind. The challenge is now out to the social scientist. A universal social language would certainly solve many problems that confront societies. Is all hope lost for Esperanto? It certainly doesn't appear realistic in the foreseeable future, but it would be nice if societies had a standard language in which to communicate. If Esperanto were chosen as the universal social language and NPL were selected as the universal programming language, the final step would be to tie the two together and define NPL in Esperanto!

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CIRCLE NO. 21 ON INQUIRY CARD
RECENT ANNOUNCEMENTS FROM COMPUTER MANUFACTURERS:

FROM SDS — Boeing orders an SDS 9300; Jet Propulsion Labs orders 13 SDS 920 computers; Tymshare Associates orders an SDS 940; and SDS 92 working in tandem with an SDS 930 will control a nation-wide network of 60 communications terminals for Sandia Corp.

FROM CDC — Curtis Publishing Co. orders two CDC 8090 computer systems and a CDC 915 page reader; CDC's 6600 passes acceptance test at Berkeley's Lawrence Radiation Lab facility; Navy's Underwater Ordnance Station now using a CDC 3200 for testing of underwater weapons; San Francisco bank installs CDC 915 optical page reader system; Duncan Electric of Lafayette, Ind. installs a CDC 160 for calibrating watt-hour meters; a CDC 3100 will be used by Itek Corp. in their digital mapping system and another CDC 3100 was installed at the U.S. Navy's Pacific Missile Range; the Interstate Power Company at Dubuque, Iowa has placed an order for a CDC 636 industrial computer system to be used for monitoring and data logging of power plant operation.

FROM HONEYWELL — U.S. Navy will lease one Series 200 computer for their Public Works Center at San Diego to be followed by similar installation at 8 other Public Works Centers around the world; a Series 400 computer system was recently installed at a London insurance brokerage firm; a British textile firm orders a Honeywell 120 smallest of the Series 200 line.

FROM DEC — The Australian Atomic Energy Commission orders a PDP Multianalyzer; a geodetic survey ship called the Whiting will use a PDP 8 to plot data; the Argonne National Lab in Chicago is using a PDP 7 for film-scanning development program for low-energy physics studies.

FROM IBM — Three IBM 360/30 computers are reported in successful operation at C-E-I-R, Inc's service bureau; Computer Sciences Corp. will expand its remote services with an IBM 360/65 and a 360/75; an IBM 360/50 is now undergoing testing at Rensselaer Polytechnic Institute.

FROM UNIVAC — Sperry Rand announced the receipt of a multi-million dollar contract from Bell Telephone Labs for continuation of the design, development, and delivery of data processors and thin-film memory modules for use in the Nike-X system; a Univac 418 computer became the operating hub of a real-time stock market computer answering network in London.

FROM 3C — Computer Control is furnishing two DDP 116 systems to Tridea Corp. to be used for on-line machine tool programming in conjunction with a Tridea-developed automatic line tracer.

1966 FJCC CALL FOR PAPERS

The Technical Program Committee for the 1966 Fall Joint Computer Conference, November 8-10 at San Francisco Civic Center, has issued a call for papers dealing with significant trends, achievements, concepts and techniques covering the entire information processing field. Survey and tutorial papers are welcome. Sessions are planned on on-line hardware, software and applications in commerce, business, and industry. Session topics at present include: Analog and Hybrid Computers, Communication Devices and Systems, Components and Circuits, Impact of Computers on Education, Impact of Computers on Management, Machine Organization, Management of Data Processing Centers, New Areas of Application, Numerical Analysis, On-Line Systems, Peripheral Equipment, Programming Languages, and Storage Devices. An AFIPS $500 award has been established for the best paper presented at the conference. Submissions are due by May 2. Only new papers not exceeding 10,000 words will be considered. Five copies of drafts, including 100/500-word abstracts, should be sent to: Dr. William H. Davidow, Technical Program Committee Chairman, 1966 FJCC, P.O. Box 2208, Menlo Park, Cal. 94025.
Like to see our new T Series modules perform?
Warm up your scope, we’ll be right over.

Our new T Series integrated circuit logic modules are so fast and flexible that we can hardly blame you if you doubt the amazing specs: Fan out of 14. Noise rejection up to 1.8v. 18 nanosecond gates. 40 nanosecond flip-flops.

So we’ve given our men demonstration kits and you can see for yourself.

Each kit contains an assortment of module cards and has its own power supply and timing source. You furnish the problems and the oscilloscope. Our man may even leave the kit a few days for you to play with. Fun.

Scientific Data Systems
1649 Seventeenth Street, Santa Monica, California
taking a low-cost look at memory cores is no longer a problem

For 8 years most progress in high speed handling of ferrite memory cores has been due to the innovations of Ramsey Engineering. In 1966 over 4,000,000,000 cores will pass through hundreds of Ramsey handlers operating in every major computer facility throughout the world. The CH 100 is Ramsey’s most advanced handler. It is made of cams, linkages, drives, probes, contacts, and 8 years of know how. It processes 60,000 ferrites per hour and has just reduced the overall cost of core testing.
ASSIGNMENT: BUILD A 16,384-BIT MEMORY STACK FIT FOR OUTER SPACE, TO WITHSTAND:

50 G SHOCK
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\(\Delta T\) OF -55°C TO +105°C

Result: This RCA ferrite memory stack, designed to withstand the rigors of space flight, meets the toughest kind of environmental specs:

Vibration—10 g (0 to peak) 5 to 2000 to 5 cps at 1 minute/octave logarithmic sweeps, once along each of 3 mutually perpendicular axes.

Mechanical Shock—50 g, 11 ± 1 msec, half-sine wave, 2 shocks in both directions in each of 3 mutually perpendicular axes, a total of 12 shocks.

\(\Delta T\)—5 cycles per MIL-STD-202, Method 102A, within limits of -55°C to +105°C. Unit to operate at specs at 0°C, 25°C and 70°C (without use of heaters or other means of internal temperature control).

How did RCA meet these demanding requirements?

- By double-testing each RCA wide-temperature-range ferrite memory core for 100% quality assurance.
- Precision stringing an array of 16 planes, each 32 x 32 cores, with continuous wiring through all 16,384 cores; no splices or internal solder joints are permitted. Then 100% testing the entire array.
- Folding the 16 planes over to form a continuously wired memory stack—and 100% testing it again.
- Encapsulating the stack in silicone rubber and securing it to its support case—and 100% testing it again.
- Shaking, shocking and temperature cycling the stack and 100% testing it at three different temperature levels.

Here’s one more example of what RCA can do to build memory-system components to meet your requirements, regardless of how difficult they may be. Whatever you need in ferrite memory components, call your local RCA Field Office or write, wire or phone: RCA Electronic Components & Devices, Memory Products Operation, Section FZB4, 64 “A” Street, Needham Heights, 94, Mass. Phone: (617) 472-0000.
This is our 3 step. Give us a call and see all the steps in our routine.

If you really want to swing you can also step 4, 8, 12, 24, 48, and 200 increments without gears.

Or to indicate, Measure and Control using flag and remote angle indicators, synchros, resolvers, steppers, or solenoids.

They are in stock at IMC Magnetics Corp., Western Division. For quick service contact the Applications Section at Western Division, 6058 Walker Ave., Maywood, Calif. 90270. Phone 213 583 4785 or TWX 910 321 3089.

If you need data sheets for references or consideration for future projects, write IMC's Marketing Division at 570 Main Street, Westbury, New York 11591.

CIRCLE NO. 26 ON INQUIRY CARD

4 ways to beat a hot system
1. Centrifugal Blowers
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Learn about them from a 12 page booklet called the "Airmover Selector." It has a technical information section to aid you in your choice of airmovers. On the remaining pages we have plugs for our products which help pay the cost of free booklets. Or a better bargain is our 136 page catalog given free when you meet with our technical sales reps. For very quick service contact: IMC Magnetics Corp., Eastern Division, 570 Main Street, Westbury, N.Y. 11591. Phone 516 334 7070 or TWX 516 333 3319. For the "Airmover Selector" write: Marketing Division at the same address, or circle the Bingo number below.

CIRCLE NO. 27 ON INQUIRY CARD

INDUSTRY NEWS

HONEYWELL'S EDP DIVISION WILL MARKET THE BUNKER-RAMO CORP'S NEW SERIES 200 AND 400 INFORMATION DISPLAY AND INQUIRY DEVICES IN COMMERCIAL AND GOVERNMENT DATA PROCESSING MARKETS here and abroad. Bunker-Ramo will continue to manufacture and market these input/output display devices. The worldwide service to organizations of both firms will coordinate field servicing of the devices. The arrangement also provides Honeywell with rights for future manufacture of display units in the United Kingdom, Germany, and Canada as well as in other selected countries. The agreement excludes Japan, where Bunker-Ramo display devices are marketed by the Nippon Electric Company. Nippon Electric also manufactures and markets Series 200 computer systems under a Honeywell license.

THE THIRD CONSECUTIVE YEAR OF RECORD SALES AND EARNINGS WAS REPORTED BY SCIENTIFIC DATA SYSTEMS for the year ended December 31, 1965. Total revenues more than doubled 1964 results, increasing to $43,999,924 from $20,486,789 for the previous year. Substantial growth was also shown in net income which rose to $3,371,628 for 1965 as compared to $2,179,399 in 1964. According to SDS President Max Palevsky, "New orders during the fourth quarter and in the first eight weeks of 1966 continue to be received at a satisfactory rate." More than 200 SDS computers were shipped last year bringing the total of installations at year end to over 400 computers in 20 countries. The number of employees at SDS also rose substantially to 2,373 at the end of 1965 from 1,557 in 1964.

COMPUTER DESIGN/APRIL 1966
No one has a larger line of disc memories.

See the largest line of disc memories available at the Spring Joint Computer Conference, Booth 913-916

Whether your information storage requirements are small or require data stored in millions of bits, Librascope Group of General Precision, Inc., has a disc memory system for every application. These systems have a proven history of reliable performance in computing systems designed for military, business, engineering, and educational applications.

LIBRAFILE mass memories: Large-capacity, high-speed, random-access information storage systems. Two disc sizes available. 48” discs capable of storing up to 400 million bits. 38” discs with a capacity of 200 million bits. LIBRAFILE mass memory information retrieval is either fixed-address search or search-by-record content. Access time less than 20 ms. Data transfer rates in the megacycles.

Militarized disc-memory systems: High-speed, random-access, information-storage systems. Consists of disc memory for data storage and an electronic subsystem that provides complete interface, control, and read/write electronics. These systems can be used as a data base for shelter, van, or shipboard applications. Storage capacity of 25 million bits on 24” discs. Customized capacity up to 80 million bits.

L-400 magnetic-disc memory systems: Provide data storage and transfer in computer systems, peripheral equipment, and other systems where rapid-access memory is a requirement. 24” disc storage capacity up to 36 million bits.

Airborne disc file: Small, compact file designed for airborne (MIL-E-5400 class 2) applications, as well as for shipboard and mobile field operations. 6¼” disc with capacity of 1 million bits. Customized airborne memories available with capacity up to 50 million bits.

L-300 disc memory: For use in computer systems and peripheral equipment as main storage, buffer storage, or as a supplemental memory. 10” disc with a capacity of 275,000 bits. For complete details, write for our technical bulletins.

Engineers: For career openings, call or send resume in confidence to B. Larson, General Precision, Inc., Librascope Group, 808 Western Avenue, Glendale, California 91201. An equal opportunity employer.

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More than half of the top computer makers use Lockheed memories

Maybe you ought to know these reasons why:

Unique Performance. For example, Lockheed Electronics makes the largest high-speed commercial memory in operation today. It has 32,768 words, 74 bits, and operates at 1 microsecond complete cycle time. We've built the concepts behind it into an integrated circuit memory for military aerospace... and other systems and stacks equally outstanding.

Economical custom design. With Lockheed's exclusive "plug in" memory stacks, and other unique modules, we can assemble special memories to fit your need quickly and at low cost.

Unmatched reliability. Lockheed has carried "worst case design" further than anyone else in the field. This is a long story. We'd like to tell it to you point by technical point. Just contact us.

Tell us your memory application, so we can give you the most useful information. Address: 6201 E. Randolph St., Los Angeles, California 90022.

Interested in sub-microsecond and integrated circuit memories? See us at Booth 106-108 at SJCC.

CIRCLE NO. 29 ON INQUIRY CARD
< 3 microseconds write to read recovery time -

Where else can you find this remarkably low recovery time, less than 1 bit in $10^{12}$ bits transient error rate and single bit alteration phase modulation recording — all at one megacycle data rate? At Magne-Head, these are standard features — not extra-cost "options!"

Comparison is the key to your best buy. For Magnetic Drum Memory Systems — designed... engineered... and manufactured to your exact requirements, contact Magne-Head today.

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If you want... a computer specifically designed to meet your system requirements — with such useful system features as MicroExec for sub $\mu$sec processing rates — independent CP memories for simultaneous operation — two memory access channels, 555 KC and 200 KC — 16 or 18 bit words — 1.8 $\mu$sec core memories, and 0 to 12 v. logic levels.

If you want... Input/Output flexibility, DATA/620 has six types of I/O facilities and up to sixty-four devices for simultaneous I/O rates of more than 500,000 words per DMA.

If you want... complete software, DATA/620 is equipped for FORTRAN in 4 K, Assembler, Aid, Maintain — all open ended — and more than 100 machine commands.

If you want... a computer built for your system, the DATA/620 rack mounts in only 26½ inches of space with front access, and offers highly reliable operation with 7,500 hours MTBF. And, DATA/620's low initial cost of $27,900 will not break your system budget.

If you want... 90 day delivery you can still have it — although 37 DATA/620s have been sold and 10 delivered.

There is a lot more we would like to tell you about the DATA/620 in a fact filled 36 page brochure. If you would like one, write to:

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Division of DECISION Control, Inc.

See the DATA/620 at booth 1113 at the Spring Joint Computer Conference.
CIRCLE NO. 31 ON INQUIRY CARD
Increased emphasis abroad on EDP equipment for accounting, inventory control, and production planning is expected to contribute to a strong growth in exports of computer machines in 1966, according to the Commerce Department's Bureau of International Trade. This increase will continue the long-standing upward trend in these sales, as foreign governments and industries follow the U.S. lead in EDP routines.

The EDP system of the Internal Revenue Service produced over $35 million in additional revenue during 1965, and offset $33.6 million in potential refunds of 178,000 business and individual taxpayers against unpaid tax balance of the same taxpayers. A total of $70 million in additional revenues is credited to the EDP system since it became operational in 1962. Business returns were processed on a nationwide basis for the first time in 1965, and processing of individual returns under EDP was introduced into a second IRS region. In addition, the IRS Data Center in Detroit handled centrally such Revenue Service programs and activities as payroll preparation, taxpayer compliance measurement, statistics of income, tax forms distribution, and management information programs.

We can expect requirements for qualified well-trained scientists and engineers to be as great as, or greater than, the numbers we will train, according to Dr. Bowen C. Dees, associate director for planning at the National Science Foundation. He further predicted, in congressional testimony, that this country will face large requirements for scientists and engineers. The anticipated supply of university graduates in science and engineering becoming available, he believes, over the decade will not meet all our requirements. It is likely, he added, that scientific manpower deficits will be clearly observable in large numbers of unfilled jobs late in the decade.

The Joint Committee on the Organization of the Congress is exploring the possibilities of using EDP equipment as an aid to Congress. Members of the Joint Committee are intensely interested in the possible use of EDP equipment and information storage and retrieval systems as a means of assisting the Congress, its committees, and its Members in more rapid and complete access to information as a basis for legislative decisions.

President Johnson in his budget message to Congress called attention to the great benefits the Federal Government has obtained from the use of electronic computers. With the direct annual cost of accruing and operating this equipment now in the range of $2 billion, the President said he intended to make sure that this huge investment is managed efficiently — through such means as research, equipment sharing, careful purchasing, and coordinated government-wide utilization policies.

Efforts will be made to achieve greater standardization in the field of EDP by approving additional funds in the budget for the new Center for Computer Sciences and Technology at the Bureau of Standards.

Recent Defense Department Contracts

THE GARRETT CORP., Los Angeles, Cal., an order in the amount of $1,365,438 for spare parts to support the central air data computer on F-4 series aircraft. Work will be done in Los Angeles. The Middletown Air Materiel Area, Olmstead AFB, Pa., is the contracting agency.

GENERAL PRECISION, INC., Little Falls, N.J., a $5,200,000 initial increment to a fixed-price contract for components for navigational computer sets and aerospace ground equipment for C-141 aircraft. Estimated final amount of this contract is $13,000,000. Work will be done in San Marcos, Cal.

BENDIX CORP., Teterboro, N.J., for the Aeronautical Systems Division a $1,500,000 initial increment to a $5,760,625 fixed-price contract for production of aircraft navigational computer equipment.

...It made all sorts of useful things like d/c battery chargers... air cooled engine-generators... emergency standby electric power supply units... electric plants on wheels... and other fascinating equipment. In fact, this company still does. Many of you know the company we’re talking about—UNITED STATES MOTORS CORPORATION. Giants of industry and those responsible for our defense posture did business with it you know when—AND NOW! It continues to build quality products—more sophisticated of course—but then what isn’t today! It has highly sensitive “No-Break” MICRO POWER Electrical Plants... Standby Emergency Power Equipment on wheels... without wheels... and in capacities ranging from only 500 watts to 750 KW. Its plant is modern inside and outside. Its equipment is used in communications systems... computer systems... in hospitals and schools, and by industrials to protect special processes from losses due to power outages. Applications are virtually unlimited. Let’s get together. Our sales and service centers are—

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a new era for current-mode switching... with Motorola's
1800 MHz 2N3960 NPN Silicon Annular* Transistor

A new magnitude of switching speed for non-saturated, digital systems applications is here — ready for your immediate prototype designs... with typical $f_t$ performance of 1800 MHz!

Previously, frequency response has been limited to a range of about 1200 MHz before encountering a self-limiting trade-off with breakdown voltage. Now, Motorola's newly developed "narrow-base profile" process technique makes possible a micro-thin base thickness (on the order of 0.1 micron) and a new high level of frequency response ($f_t$).

And, because the 2N3960 uses Motorola's patented annular device structure, this frequency response is offered to you at no sacrifice in breakdown voltages. You've come to expect this with all annular built devices.

As a result, both 2N3960 and its sister device, 2N3959, are able to satisfy, as never before, the three key requirements for highest speed in current-mode designs — high $f_t$, low capacitances, and low base-spreading resistance.

Guaranteed minimum $f_t$ values are 1300 MHz for 2N3959 and 1600 MHz for 2N3960 at 10 mA. Both are also specified at 5 and 30 mA collector currents.

Other high-performance characteristics...

- **Output Capacitance ($C_{o(b)}$)**
  - $V_{cc} = 4$ Vdc, $I_C = 0$, $f = 100$ Kc: 2.5 pf max.
  - $V_{cc} = 0.5$ Vdc, $I_C = 0$, $f = 100$ Kc: 2.5 pf max.

- **Collector-Base Time Constant ($\tau_{cb}$)**
  - $I_C = 10$ mA, $V_{cc} = 10$ V: 2N3959 25 psec max., 2N3960 40 psec max.

- **Collector-Base Breakdown Voltage ($B(V_{cb})$)**: 20 Vdc min.
  - $I_C = 10$ mA, $V_{cc} = 10$ V: 2N3959 12 Vdc min., 2N3960 11 Vdc min.

*Annular semiconductors patented by Motorola Inc.

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**LIMIT CURVES AVAILABLE IN DESIGNERS’ DATA SHEET**

You'll find a full complement of limit curves on each device in a special Motorola Designers Data Sheet. Thus, you can readily explore their use in your circuits using "worst case" design techniques. Both devices are in stock in TO-18 packages. TO GET STARTED, send for your copy of the Data Sheet. Simply write Technical Information Center, Motorola Semiconductor Products Inc., Box 955, Phoenix, Arizona 85001.
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15. Cambridge Charterhouse

TRANSPORTATION:
16. Logan Airport
17. South Station
18. North Station
19. Callahan & Sumner Tunnels
20. Back Bay Station
21. Bus Terminal

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22. Bunker Hill Monument
23. Navy Yard
24. "Old Ironsides"
25. Museum of Science
26. Mass. Institute of Technology
27. New Government Center
28. State Capitol
29. Old North Church
30. Custom House
31. Faneuil Hall
32. Boston Common
33. Public Gardens
34. John Hancock Tower
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36. Boston Public Library
37. Prudential Tower

STREETS:
38. Boylston St.
40. Beacon St.
41. Storrow Drive
42. Memorial Drive
44. Huntington Ave.
45. Mass. Turnpike
46. Southeast Expressway
47. Mystic River Bridge

MISCELLANEOUS:
48. Boston Harbor
49. Charles River
50. Mystic River

1966 SPRING JOINT COMPUTER CONFERENCE

WAR MEMORIAL AUDITORIUM, BOSTON, MASS.
APRIL 26, 27, 28, 1966
The 1966 SJCC is being held in Boston's new Prudential Center, a multi-million dollar complex consisting of offices, shops, restaurants, the Sheraton-Boston Hotel, and the War Memorial Auditorium. This new center is located along Boylston Street near Copley Square.

All of the SJCC activities will be carried on in the Sheraton-Boston Hotel and the War Memorial Auditorium which are adjoining buildings with direct interior connection. Registration booths, exhibits, the Science Theater, and most technical sessions will take place in the Auditorium. Some technical sessions and all other SJCC activities will take place in the hotel.
TECHNICAL PROGRAM SUMMARY

TUESDAY, APRIL 26
SESSION 1 .......... 1:00 P.M. GRAND BALLROOM
DISPLAY APPLICATIONS RESEARCH

SESSION 2 .......... 1:00 P.M. BABBAGE ROOM
COHERENT OPTICAL INFORMATION PROCESSING

SESSION 3 .......... 3:30 P.M. AUDITORIUM
TIME-SHARING

WEDNESDAY, APRIL 27
SESSION 4 .......... 9:00 A.M. AUDITORIUM
PANEL DISCUSSION: THE MEANING OF COMPUTER TIME-SHARING

SESSION 5 .......... 9:00 A.M. BABBAGE ROOM
SIMULATION AND MODEL-BUILDING

SESSION 6 .......... 1:30 P.M. AUDITORIUM
PROCESSING LARGE FILES
TECHNIQUES FOR REPLACING CHARACTERS THAT ARE GARBLED ON INPUT, G. Carlson; ADAM — A GENERALIZED DATA MANAGEMENT SYSTEM, T. L. Connors; THE ENGINEER-SCIENTIST AND AN INFORMATION RETRIEVAL SYSTEM, C. A. Merritt and P. J. Nelson.

SESSION 7 .......... 1:30 P.M. BABBAGE ROOM
WAVEFORM PROCESSING
EFFECTS OF QUANTIZATION NOISE IN DIGITAL FILTERS, B. Gold and C. Rader; A REAL-TIME COMPUTING SYSTEM FOR LASA, H. W. Briscoe and P. L. Fleck; HIGH-SPEED CONVOLUTION AND CORRELATION, T. G. Stockham, Jr.
THURSDAY, APRIL 28

SESSION 10 .......... 9:00 A.M. AUDITORIUM
THE EVOLVING LIBRARY
LIBRARIES AND MACHINES — A REVIEW, B. W. Adkinson; CO-
ORDINATED INFORMATION PROCESSING IN THREE MEDICAL LI-
BRARIES, F. G. Kilgour; PLANS FOR INFORMATION TRANSFER
EXPERIMENTS AT M.I.T., C. F. J. Overhage; ON-LINE INFORMATION
NETWORKS, J. C. R. Licklider.

SESSION 11 .......... 9:00 A.M. BABBAGE ROOM
CURRENT DEVELOPMENTS IN
PERIPHERAL HARDWARE
A NEW LOOK IN PERIPHERAL EQUIPMENT DESIGN APPROACH,
E. Masterson; A SERIAL READER PUNCH WITH NOVEL CONCEPTS,
D. W. Bernard, R. F. Borelli, F. A. Digilio and F. V. Thiemann; THE IBM
2560 MULTI-FUNCTION CARD MACHINE, C. E. Spurrer; A NEW
DEVELOPMENT IN THE TRANSMISSION, STORAGE AND CONVERSION

SESSION 12 .......... 9:00 A.M. GRAND BALLROOM
ANALOG/HYBRID TECHNIQUES
HYBRID SIMULATION OF A HELICOPTER, W. J. Kenneally, E. E. L.
Mitchell, I. Hay and G. Bolton; A TIME-SHARED HYBRID SIMULATION
FACILITY, R. Belluardo, R. Gocht, and G. Paquette; HYBRID SIMU-
LATION OF A FREE PISTON ENGINE, R. E. Gagne and E. J. Wright;
HYBRID ANALOG/DIGITAL TECHNIQUES FOR SIGNAL PROCESSING
APPLICATIONS, T. G. Hagan and R. Treiber; HYBRID SIMULATION
OF A REACTING DISTILLATION COLUMN, R. Ruszyk and E. E. L.
Mitchell; TRANSIENT NEUTRON FLUX DISTRIBUTION STUDIES BY
COMPRESSED AND REAL-TIME COMPUTER COMPLEXES, J. E. Godts
and A. S. Weinstein.

SESSION 13 .......... 1:00 P.M. AUDITORIUM
PANEL DISCUSSION: RESOURCE ALLOCATION
PANELISTS: C. R. Blair, E. L. Glaser, T. Kallner, V. A. Vyssotsky, S.
MacD. Warshall.

SESSION 14 .......... 1:00 P.M. BABBAGE ROOM
COMPUTER TECHNIQUES
IN PATTERN RECOGNITION
PATTERN RECOGNITION STUDIES IN THE BIOMEDICAL SCIENCES,
R. S. Ledley, J. Jacobsen, M. Belson, J. Wilson, L. Rovolo, and T. Golab;
A CHESS MATING COMBINATIONS PROGRAM, G. W. Baylor and
H. A. Simon; MULTIDIMENSIONAL CORRELATION LATTICES AS AN
AID TO THREE-DIMENSIONAL PATTERN RECONSTRUCTION, S. J. Penny
and J. H. Burkhard; A PATTERN RECOGNITION TECHNIQUE, AND ITS
APPLICATION TO HIGH RESOLUTION IMAGERY, R. D. Joseph and
S. S. Viglione; THE DEVIL’S ADVOCATE, M. L. Minsky.

SESSION 15 .......... 3:30 P.M. AUDITORIUM
PANEL DISCUSSION: DEVELOPMENT OF
A “CHECKLESS-NO MONEY” ECONOMY
PANELISTS: Neal Dean, John Mc Cleary, Richard Bez, Robert Whitby.

SESSION 16 .......... 3:30 P.M. BABBAGE ROOM
PANEL DISCUSSION: HYBRID COMPUTATION
PANELISTS: R. Belluardo, D. C. Augustin, G. Paquette, R. Gocht, M. F.
1966 SPRING JOINT COMPUTER CONFERENCE
(continued)

SJCC EXHIBITS

Approximately 85 exhibitors will occupy 150,000 sq. ft. of space on two floors in the War Memorial Auditorium. Exhibit hours are Tuesday, 11 A.M. to 5 P.M.; Wednesday, 10 A.M. to 8 P.M.; and Thursday, 10 A.M. to 5 P.M.

Below are brief descriptions of some of the equipment that will be on display.

ADAGE, INC., BOSTON, MASS.

Will demonstrate a hybrid computer, called Ambilog 200, which performs signal processing on either of two “fresh” inputs — the human voice or the human heartbeat sound. Operator will demonstrate full control of all computer operations by light pen and CRT communications. These processing operations will include power-spectrum-density analysis, auto-correlation, and cross-correlation. Also on display will be a computer linkage system and an A/D converter with 800 nanosecond conversion time.

AMPEX CORP., REDWOOD CITY, CAL.

Memory products and magnetic tape equipment.

ANELEX CORP., BOSTON, MASS.

Will demonstrate their new 4000 printer that produces up to 150 columns at 300 lines per minute. Also on display will be a disk file storage that has a total capacity of 60 million bits with a positioning time of 100 microseconds. The exhibit will also show a high-speed print station and Franklin Electronics’ digital printers.

APPLIED DYNAMICS, INC., ANN ARBOR, MICH.

Analog and hybrid computing equipment.

AUTO-TROL CORP., ARVADA, COLO.

Will demonstrate a “machine tool director” designed specifically for use with existing machine tools and positioning tables of various types. Input data can be from punch cards, paper tape, or magnetic tape; or the unit can be operated manually from switches on the front panel. This all-digital device will be on display attached to a coordinate graph for automatic drawing and scribbling.

BELL SYSTEM, NEW YORK, N.Y.

Touch-tone telephone (12-button card dialer) and a tele-typewriter which operates at 150 words per minute with expanded ASCII code.

BECKMAN INSTRUMENTS, INC., FULLERTON, CAL.

General-purpose digital and hybrid computers.

BENSON-LEHNER CORP., VAN NUYS, CAL.

Will demonstrate their off-line CRT microfilm printer/ploter and magnetic tape plotting systems.

CALIFORNIA COMPUTER PRODUCTS, ANAHEIM, CAL.

Will display a new CRT microfilm plotting system in which input commands from a computer are used to produce discrete incremental steps relative to the X and Y axes. A number of other types of plotting equipment will also be on display.

COMPUTER ACCESSORIES CORP., SANTA BARBARA, CAL.

A magnetic card memory that provides an on-line random access storage capacity of 100 million bits will be demonstrated. The unit uses flexible magnetic cards contained in interchangeable cartridges as the storage medium.

COMPUTER CONTROL CO., FRAMINGHAM, MASS.

Exhibit will demonstrate wide product line including three general-purpose computers (DDP-124, DDP-116, and the DDP-224), new integrated circuit core memory, complete line of IC digital modules, new memory exerciser, and other digital products.

COMPUTRON, INC., WALTHAM, MASS.

Magnetic tape certification equipment and tape cleaning systems.

CONTROL DATA CORP., MINNEAPOLIS, MINN.

Exhibit will feature a computerized information system employing a visual display system with six entry/display stations. Four remote calculators will be linked to a computer in Los Angeles and one remote station will be linked to a computer in Minneapolis.

DARTEX, INC., SANTA ANA, CAL.

Will demonstrate digital magnetic tape data systems that serve as buffered links between high-speed computers and data source devices. Exhibit will also feature data logging incremental recorders, remote data collectors, and other magnetic tape equipment.

DATA PRODUCTS CORP., CULVER CITY, CAL.

High-speed page printers and disc file storage systems.

DATA MACHINES, INC., NEWPORT BEACH, CAL.

Will demonstrate their new Data/620 system computer designed for integrated information, processing, and control systems.

DECISION CONTROL, INC., NEWPORT BEACH, CAL.

Will introduce a complete new line of integrated circuit logic modules. Includes twenty types that operate to 5 mc with noise rejections of over 1 volt.

DI/AN CONTROLS, BOSTON, MASS.

Will introduce a new computer keyboard that is a self-contained system especially designed for automatic typesetting operations. Other equipment on display includes a high-speed printer, a field-programmable magnetic timer, core-transistor logic modules, and a two-microsecond memory.

DIGITAL EQUIPMENT CORP., MAYNARD, MASS.

New DEC system that will be introduced at the exhibit will either be a CRT display system built around a PDP-8 computer or a LINC-8 laboratory computer system. Standard products such as “Flip-chip” digital modules will also be displayed. Handbooks on this module line will be given out.

DIGITRONICS CORP., ALBERTSON, N.Y.

Complete line of perforated tape reading and handling equipment.

ELCO CORP., WILLOW GROVE, PA.

Line of electrical connectors including microcircuit connecting components and systems.

ELECTRONIC ASSOCIATES, WEST LONG BRANCH, N.J.

Scientific digital computers and hybrid computing systems.
ELECTRONIC MEMORIES, INC., HAWTHORNE, CAL.

Large scale memory system operating at a cycle time of only 650 nanoseconds will be demonstrated. It has a capacity of 16,384 words of up to 84 bits and an access time of 300 nanoseconds.

FABRI-TEK, INC., AMERY, WISC.

Magnetic core memory systems.

FAIRCHILD SEMICONDUCTOR, MOUNTAIN VIEW, CAL.

Ferrite core stacks which use printed circuit planes and soldered connections of both the single and four-mat configurations. Also on display will be a mechanical model of a microcircuit memory. And — perhaps — a portion, or the whole, of a new 2^{1/2}D memory system.

FERROXCUBE CORP. OF AMERICA, SAUGERTIES, N.Y.

Exhibit will feature magnetic recording head assemblies, memory cores, planes and stacks, and memory systems. A new glass-bonded ferrite recording head will be on display. Also a new line of low-cost 10-microsecond memory systems will be introduced.

GENERAL ELECTRIC COMPUTER DEPT., PHOENIX, ARIZ.

General-purpose computing systems.

GENERAL PRECISION/LIBRASCOPE, GLENDALE, CAL.

Memory drums and disc file storage systems.

HEWLETT-PACKARD, DATAMEC DIV., MOUNTAIN VIEW, CAL.

Magnetic tape transports and tape handling equipment.

HONEYWELL EDP DIV., WELLESLEY HILLS, MASS.

Will demonstrate on-line information processing from multiple display terminals to Honeywell 200 computers located at the company's plants in the greater Boston area. File updating, data readout, and a graphic "clue game" puzzle will be included in the demonstrations.

INDIANA GENERAL CORP., VALPARAISO, IND.

Memory cores, planes, and stacks.

IBM CORP., WHITE PLAINS, N.Y.

General-purpose computing systems.

ITT INDUSTRIAL PRODUCTS DIV., SAN FERNANDO, CAL.

Color display computer oscilloscopes and a character generator unit will be displayed.

KENNEDY CO., PASADENA, CAL.

Magnetic tape incremental recording equipment.

LOCKHEED ELECTRONICS CO., LOS ANGELES, CAL.

Will introduce two new magnetic core memory systems — a 2^{1/2}D system and an integrated circuit system. The 2^{1/2}D memory has a read-write cycle of 750 nanoseconds and an access time of 300 nanoseconds. The IC memory weighs less than 6 pounds; requires only 20 watts of power.

MAGNE-HEAD DIV. OF GENERAL INST., HAWTHORNE, CAL.

Will display memory drums, memory discs, and digital magnetic tape heads. A feature of the exhibit will be a complete line of economical commercial-grade disc storage units with prices ranging from $2500 for a 1 million-bit capacity to $9000 for 8 million-bit capacity.

MIDWESTERN INSTRUMENTS, TULSA, OKLA.

Will exhibit digital magnetic tape transports that provide a full range of compatibility with third generation computers.

MONROE DATALOG DIV., LITTON INDUSTRIES, SAN FRANCISCO, CAL.

Various models of digital printers.

NATIONAL CASH REGISTER, DAYTON, OHIO

Complete line of input/output and peripheral equipment.

NORTH ATLANTIC INDUSTRIES, PLAINVIEW, L.I., N.Y.

Thumbwheel switch assemblies and A/D conversion interfaces for computer systems.

OHTRONICS, INC., NEW YORK, N.Y.

Will exhibit tape readers, tape punches, encoding keyboards, tape duplication systems, edge-punched card readers, punched ticket readers, and ticket print punch machines.

POTTER INSTRUMENT CO., PLAINVIEW, L.I., N.Y.

Exhibit will feature their new chain printer, an offline print station, and a dual-cartridge random access magnetic tape memory system.

RAYTHEON COMPUTER, SANTA ANA, CAL.

General-purpose computers, logic modules and A/D converters/multiplexers.

RCA — EC & D DIV., HARRISON, N.J.

Ferrite memory cores, planes, and stacks.

REEVES INSTRUMENT CO., GARDEN CITY, N.Y.

Complete line of input/output and peripheral devices and equipment.

TALLY CORP., SEATTLE, WASH.

Complete line of paper tape readers, punches, and handling equipment. Also will display new data communications systems.

TELETYPE CORP., SKOKIE, ILL.

Will feature page printer linked to a computer to demonstrate on-line real-time data processing. Also a high-speed tape-to-tape system designed for use with other Teletype equipment or for communications with various computer and business machines.

TEXAS INSTRUMENTS, IND. PROD. GROUP., HOUSTON, TEX.

Will display data acquisition instruments, pulse generators, digital tape transports, and a high-speed digital computer which was optimized for seismic data processing.

TRANSISTOR ELECTRONICS CORP., MINNEAPOLIS, MINN.

Information display panels, indicators, readouts, and switches.

VERMONT RESEARCH CORP., N. SPRINGFIELD, VT.

Drum memory system that is capable of storing 256,000 24-bit words with an average access time of 8.6 milliseconds and a bit transfer rate of 1.5 megacycles.
How can Potter offer a chain printer priced so low?

This new Potter printer provides the combined benefits of high reliability and lowest cost of any line printer now available. Potter made it all possible by taking a completely fresh approach to printer design and construction... producing a 600-line-per-minute unit with only a fraction of the parts used in a conventional drum printer.

Take a look at these features:
- Speed to 600 lines-per-minute; up to 192 characters in 80 to 132 columns
- Precise vertical registration
- Sharp character definition—up to six copies
- Integrated circuit electronics
- Minimum maintenance—fewer parts to replace or service
The answer's a radical new design starting with the chain.

The chain? It's completely different from any you've ever seen. A continuous rotating belt with individually attached, easily removable type slugs.

This newest of line printers is available to you at an unbelievably low price. So send this coupon today. Or better yet, phone or wire us for complete specs and price. You'll be glad you did.

See it at SJCC—Boston, April 26, 27, 28.
Unique driving and sensing circuits combined with a simplified core stack result in a large-scale memory system that offers 4-wire versatility with 2-wire cost.

The new Series MT Mass Memory system developed by Fabri-Tek uses a two-wire large-plane stack design and a novel sensing circuit to reduce “per bit” cost of a large system to a practical level. The typical four-wire core stack, which is the major cost factor for large 3D coincident-current core memories, has been replaced in this new system with a 2-wire, 2½-D stack. Normally, the lower-cost two-wire stack usually means slower, word-organized 2D selection and increased cost for additional address selection circuits. However, the 2½-D selection retains the speed and most of the circuit economy of coincident-current systems.

Cost-Conscious Design

Core Costs

Core costs were kept down by using high-production low-cost 30-mil cores and relaxing core requirements as follows:

- Improving current margins by eliminating the inhibit function
- Relaxing delta noise requirements with new sensing system
- Allowing wider limits for peaking and switching times.

Plane Costs

Core plane costs were kept down by using larger planes which reduce stringing, terminating, testing, and rework cost on a per-bit basis as follows:

- Stringing only two wires through each core reduces cost over 50 percent from four-wire stacks of same size, since the first wires are the easiest to string
- Larger planes reduce the number of terminations; fewer terminations mean reduced cost and increased reliability
- Larger planes take only slightly more testing time, resulting in lower test cost per bit
- Larger planes would tend to indicate more rework, but the simpler stringing and relaxed core requirements actually reduced rework cost per-bit.

Circuit Costs

Sensing circuit uses Y drive lines as sense lines and permits each sense amplifier to serve 262,144 bits. Complete system requires only 80 sense amplifiers.

Organization and Operation

A system containing 262,144 words of 80 bits represents the maximum module size. Actual arrangement consists of 64 separate planes in four substacks of 16 planes each. Each plane contains 327,680 cores arranged 256 x 1280. Substacks measure approximately 3 by 10 by 47 inches. There are 4096 X lines and 5120 Y lines, with Y lines arranged in 80 groups of 64 lines each. The complete stack operates as a single massive two-dimensional array totaling 20,971,520 bits. A block diagram of a complete MT system is shown in Fig. 1.

A read-restore cycle consists of the following:

- One Y line in each of the 80 groups is selected by the address register under control of the six low-order address bits
- A half-current enabling pulse is
Memory

generated on the selected lines
- Noise on the Y lines is allowed to decay, since these lines are also used for sensing
- One of the 4096 X lines is selected by the 12 uppermost bits of the address
- The selected X line is pulsed with a half current to read out 80 cores, one in each of the 80 Y line groups
- The outputs are amplified, strobed, and transferred in parallel to the data register.

Restoration is accomplished by applying reverse half-current pulses on the selected X lines and on those Y lines where a “one” is to be written.

Figs. 2, 3, and 4 describe, respectively, the Y driving and sensing method, the X drive selection, and the Y selection matrix.

Sense Amplifiers

Fig. 5 is a schematic of a complete sense amplifier. Only 80 such amplifiers are required for all 5120 Y lines. Each of the 80 main sense amplifiers has available to it the output of any of eight preamplifiers, selected by the address register. Each of the preamplifiers is connected to eight Y lines by four transformers with series-connected secondaries.

Because only one preamplifier is selected at a time, each main amplifier “sees” no more than eight sense lines at a time. One of the eight sense lines carries the output from the selected core. The other seven each have half-current noise from only one core. Thus, the main sense amplifier receives the output from the selected core and the noise from only seven other cores. In contrast,
Fig. 3 The X drive line selection consists of the following. The X lines are selected by a 64 x 64 transformer-diode matrix. At the start of the cycle, a selector switch controlled by the upper six bits of the address grounds the center taps of 64 transformers. The next six bits of the address and a suitable timing pulse turn on a read current driver and selector switch, and a positive pulse is generated in the selected X line. After the read pulse is completed, the same six bits of the address turn on the write current driver, generating a negative current pulse in the selected X line. The first stage of the current driver performs the NAND function. Its output is transformer coupled to Q2, which amplifies the current. The backswing of transformer T1 is adjusted so the base of Q2 is driven with sufficient reverse current to obtain a fast turn-off at the termination of the input pulse. The selector switch is functionally a high-gain logic NAND circuit. The collector of Q4 must be able to handle the current generated by a current driver as well as the current in the pull-up resistor and current from shunt capacitance.

Fig. 4 The Y drive line selection is similar to that for the X lines except that the Y current drivers and the selector switches must handle twice the current, since they provide current for two lines. The Y selection matrix requires four diodes for each pair of lines because current must be driven in both directions. For the purpose of illustration, a 2 x 2 matrix is shown, but the same scheme is used for the 8 x 4 matrix of the actual system.

Fig. 5 Sense amplifier used in new memory system.

a typical four-wire coincident-current memory system of 4096 words has 126 cores which contribute half-current noise at read time.

The amplified signal from the preamplifier is transformer coupled to the main sense amplifier. Noise resulting from Y current generation or an unbalance in the preamplifier collector currents can cause a voltage level shift in the main sense amplifier. Such a level shift changes the threshold of the main amplifier, and it is desirable that the amplifier return to the quiescent level before the core signal is applied. This is accomplished by the delay line across the input to the main amplifier. A step voltage, such as might be caused by unequal currents in the two driven Y lines, appears at the input only during the down-and-back time of the delay line. No further voltage due to the unbalance appears across the delay line until the step voltage is removed. Thus, a signal superimposed on a dc level appears at the input as being referenced to ground and the threshold of the amplifier is not changed during strobe time.

The down-and-back time of the delay line is made long enough so the major portion of the signal is passed through the amplifier. The signal is rectified, amplified, inverted, and ultimately ANDeed with the strobe pulse. The resulting output is used to set the data register flip-flop.
Clark Equipment Company gets data
from 127 sales offices, 4 manufacturing plants,
and a major warehouse as soon as it's recorded

Bell System communications is the vital link

Bell System data communications services link
Clark's distant locations to a centralized computer
center at Buchanan, Michigan. The result is better
management control of all activities—sales, inventory,
purchasing, production, payroll and accounting.

With current and accurate information, Clark man­
gement can quickly adjust to changing marketing
conditions. Important orders get priority scheduling
for production and shipment. And yet, purchasing,
production and inventories stay at optimum levels.

An integrated information system of this size uses
computer switching with store and forward capabilities.
The fully automatic Clark system polls satellite stations,
receives and transmits messages, assigns priorities,
and converts different speed and code formats to
one standard code. Other features of the switching
unit provide the necessary supervisory control of the
network.

Consider the economies a real-time, integrated
information system can bring to your business with
automatic data processing linked with fast, reliable
communications.

Today's dynamic competition requires many com­
panies to consider organizing for data processing in
some phase of their operations. It's important to start
organizing communications at the same time.

So when you think of data communications, think
of the Bell System. Our Communications Consultant
is ready and able to help you plan an integrated
information system.

See the latest in data communications.
Visit the Bell System exhibit at the Spring Joint Computer Conference.

Bell System
American Telephone & Telegraph
and Associated Companies

CIRCLE NO. 35 ON INQUIRY CARD
STABLE N-CHANNEL INSULATED GATE FIELD-EFFECT TRANSISTORS

New Development Seen as the Most Important Microelectronic Advance in the Last Five Years.

Development of the first n-channel metal nitride semiconductor insulated-gate field-effect transistors (MNS/IGFET) fabricated via a new silicon planar technology was reported at the IEEE's International Solid State Circuits Conference by scientists from the Sperry Rand Research Center, Sudbury, Mass. The development, which promises to cure the electrical instability of present n-channel IGFETs, was based on the substitution of silicon nitride for silicon oxide as a more effective insulating material in the devices.

P-channel, enhancement mode MNS/IGFETs built and tested at the Sperry Rand Research Center have demonstrated marked improvements in electrical stability, lower threshold voltage and greater voltage-handling capability over the newest metal oxide semiconductor (MOS) devices. Now under early tests, experimental n-channel enhancement mode devices using silicon nitride are expected to perform as well. Sperry is using the silicon nitride in these devices as a mask against diffusion, as a passivation layer over p-n and n-p junctions, and as an insulating dielectric.

Until the Research Center's recent development of a deposition process that made practical the switch from oxide to nitride, the microelectronics industry was largely stymied in its pursuit of electrically-stable IGFETs and microcircuits of the new and promising MOS-type. Use of this type of device in such applications as computer logic and memory array circuits is expected to effect a sharp cut in equipment size and cost. Engineers at the Sperry Semiconductor Division, Norwalk, Conn., said that up to ten times the number of MOS-type components can be packed on the same chip with no increase in the size of the circuit package or the number of electrical connections.

Sperry Rand researchers, led by Drs. Nigel C. Tombs, H. A. Richard Wegener, and Roger Newman, manager of solid state sciences, last month reported solution of the stability problem in the p-channel enhancement mode. Company officials said that the development could be the most important advance in the industry in the last five years. Sperry Semiconductor Division expects to have silicon nitride devices in its product line this year.
Complementary Pairs

The achievement of stable n-channel devices will open the way to production of complementary pairs of both p- and n-channel units on the same chip substrate, Dr. Wegener said. The enhancement mode of operation is especially attractive, he added, because the device is normally off until turned on by the application of a voltage to the gate. Its opposite number, a depletion mode device, is easier to construct, but is normally on, and draining full power until shut off by a bias voltage from a separate power supply. While p-channel IGFETs had been difficult to fabricate, the physicist explained, n-channel devices were a virtual impossibility. This was due to the inability of the oxide insulation to keep contaminants from moving toward the silicon. Nitride, on the other hand, has proved an effective barrier.

In their first tests, Sperry's n-channel MNS/IGFETs have shown source-to-drain leakage currents to be orders of magnitude less than the same currents in n-channel MOS devices. Dr. Wegener has observed leakage currents of less than one-tenth nanoampere across MNS/IGFETs in the "OFF" mode, an exceptionally low level which provides a well-defined threshold voltage.

Sperry has just begun temperature-bias stability tests on its n-channel enhancement mode MNS/IGFETs, and definitive results are not yet available. Dr. Wegener said, however, that they expect the n-channel devices to perform as well as p-channel MNS units under test. In this test both MOS and MNS devices intentionally contaminated with sodium ions were stored at 150 degrees C with +30 volts applied to their gates. Results showed that the operating point of the gates of the MOS devices had shifted by about 20 volts; the MNS characteristics by less than one volt.

The company will extend the use of silicon nitride to integrated circuits, diodes, and double-diffused transistors. The latter are expected to double their present voltage-handling capability. The new technology also may be applied to such materials as germanium, gallium arsenide, and indium arsenide, in addition to silicon.

END
The ferrite core industry is an old and mature one and automatic core testing is very sophisticated; for example, cores can be production-tested currently at the rate of up to 1000 per minute. However, up to the present, automatic core testing is range testing. This means that certain limits are pre-established for the core output values and cores are tested to fall within these limits. Very little, if any, of the automatic testing is done to give actual core outputs. Testing to give actual core outputs seems to be laborious and time consuming for more than a few cores. Therefore, a core test setup that automatically measures the actual core output has been designed at Fairchild Semiconductor's memory products department. This core test setup is described in this article.

The basic parts of the test setup are:
- A programmed manual core tester
- A programmed sampling core
- A digital printer
- An X-Y recorder
- Calibration and reference standards equipment.

Typical core outputs that will be measured are:
- \( uV_1 \) — undisturbed ONE output
- \( dV_1 \) — read disturbed ONE output
- \( dV_z \) — write disturbed ZERO output
- \( t_s \) — switching time of ONE output
- \( t_p \) — peaking time of ONE output.

The purpose of this core test setup is three-fold. The actual core outputs are used for AQL testing, the generation of tag samples for correlation with customers, and statistical trend analysis. All of these test procedures, described in detail in Table 1, require that the individual core outputs be measured and recorded. In some cases, the actual cores are associated with their data outputs. Since the test results are printed out...
In contrast to conventional range testing, this new core test setup automatically measures the actual core outputs for a more thorough analysis of core quality.

on paper tape, they are immediately available to an operator for interpretation. Also, this data is used to plot core output distributions or it is sent to customers in the case of tag samples. Cores are serialized such that they can be tagged with their individual results. The accuracy of the automatic test setup is within 1% of that obtained using standard calibrators for the same core measurements. A photograph and a block diagram of the core test setup are shown in Figs. 1 and 2 respectively.

**Operation of the New Tester**

The measuring technique with the new tester is as follows. If the cores are to be serialized, a prepunched adhesive tape is first placed on a manual core jig sticky side up. A core is then placed above the tape, the jig is closed and the measurements are automatically made. If the cores are not to be serialized, a manual core jig or an AQL handler is used. The core is pulsed using a program generated by the programmed pulse generator. A typical pulse program is shown in Fig. 3.

The numbers below the pulses in Fig. 3 indicate the program step at which the pulse occurs. If for example, a dV1 core output is to be measured, the scope is synchronized on program step 7. The sampling scope now measures the average of ten sweeps of the core output before a print-out is made. After a print-out the programmer sequences to the next program card, that could be, for example, a switching time measurement. If this is the switching time of a uV1 core output, the scope sync is changed to program step 2. Fig. 4 shows the relationship operator control. It contains both accept and reject bottles for the tested cores. Since the individual core outputs are available, the rejected cores can be removed from the reject bottle and tagged with their data. This AQL test technique is faster because the amount of manual core handling is greatly reduced.

**TABLE 1**

<table>
<thead>
<tr>
<th>Lot Size</th>
<th>Sample Size</th>
<th>No. of Rejects</th>
</tr>
</thead>
<tbody>
<tr>
<td>10,000-35,000</td>
<td>315</td>
<td>0</td>
</tr>
<tr>
<td>35,000-150,000</td>
<td>500</td>
<td>0</td>
</tr>
<tr>
<td>150,000-500,000</td>
<td>800</td>
<td>0</td>
</tr>
<tr>
<td>over 500,000</td>
<td>1200</td>
<td>1</td>
</tr>
</tbody>
</table>

A 250,000 core lot indicates a sample size of 800 cores with no rejects allowed to pass the 0.015 AQL level. Typical core measurements are uV1, dV1, dV2, t1, and t2. In a typical AQL test procedure N samples are randomly selected from a shipment lot. The number N is obtained from the above table; for instance, for a 250,000 core lot, N would be 800 cores. Eight-hundred cores are then tested with an AQL test setup. AQL test data is generated in one of two ways:

1. The cores are loaded one at a time on a manual core jig, the actual core outputs printed out and each core serialized. This can be very time consuming and costly, because of the labor involved in handling the cores.

2. Alternately, an AQL core handler is used to select the cores. An AQL handler is a modified high-speed automatic core handler that selects cores singly under operator control. It contains both accept and reject bottles for the tested cores. Since the individual core outputs are available, the rejected cores can be removed from the reject bottle and tagged with their data. This AQL test technique is faster because the amount of manual core handling is greatly reduced.

**TAG SAMPLES**

The purpose of tag samples is to establish and maintain tester correlation with customers. It is vitally important that agreement be maintained on the level of quality of cores being received by customers. Tag samples are routinely furnished with each core shipment. A typical tag sample contains 10 cores with their associated data. Although tag samples may seem unnecessary once correlation has been established, tag samples are very useful in maintaining correlation and also in giving another check on the shipment of cores that is actually going to a customer.

**STATISTICAL TREND ANALYSIS**

A continuing problem of statistical analysis is obtaining enough samples to be representative of an entire lot. Not only are numbers of cores important, but accurate measurements have to be made; range testing is not sufficient. With the test setup described here, data on large numbers of cores is conveniently obtained for distribution plots. The data is printed out on paper tape and sent to a computer facility for reduction and distribution plotting. The data obtained during AQL'ing is used to generate the distribution plots. These plots are used both as feedback to core production and to marketing for price adjustments when special orders require only a part of the normal distribution. These distributions measured over a long period, for a particular core type, are a good measure of both the long and short term uniformity of the cores.
Fig. 2 Block diagram of automatic core tester. The basic parts are a Computer Test Corp. (CTC) Model 1700 programmed pulse generator, a Tektronix 567 oscilloscope with a Type 262 Programmer, a digital printer, and calibration and reference standard equipment that typically consists of a Computer Test Corp. Model 1085 Calibrator, a time mark generator, and a signal generator.

Fig. 3 Core test pulse pattern.

Fig. 4 Read current and core output.

Fig. 5 Outputs of the automatic core test setup. They include a tag sample that is serialized, a print-out from the digital printer of the core outputs, and drive current waveforms as obtained from the X-Y recorder with typical measurements illustrated.

Other measurements that are made with the same test setup (more accurately than can be measured visually from the face of an oscilloscope) are the pulse program's rise time, fall time, and duration. This facilitates adjusting the core tester from one test program to another. This setup can also be used for the selection of matched calibrated cores of the core output to the read current pulse. As many as eight different preprogrammed measurements are available with the type of programmer used in this tester. The test time for seven core measurements including print-out is approximately one minute.

Basic to any core analysis is an accurate description of the test current pulses, especially the read current pulse. The linearity, overshoot and corner deviation must be accurately measured in addition to the amplitude. The Tektronix 567 operated in the manual scan mode is used to generate signals for an X-Y recorder to make 11” x 16” plots of the read current. From these plots, measurements of the overshoot, linearity, and corner deviation with a 2% to 3% accuracy can be made. This is impossible to do visually from the face of an oscilloscope. Fig. 5 shows the outputs of the automatic core test setup. They include a tag sample that is serialized, a print-out from the digital printer of the core outputs, and drive current waveforms as obtained from the X-Y recorder with typical measurements illustrated.
that are required in production automatic core testing. This is especially true when multiplexed core handlers are operating with an automatic core tester.

**Summary**

An automatic core test setup has been described that accurately measures and records the actual core output. The core data obtained is extremely valuable for AQL testing, tag samples, and parameter distributions. Since all of the core outputs are measured with a programmed sampling scope, the element of unpredictable human error is eliminated.

**ACKNOWLEDGMENTS**

Many people have contributed in one way or another to this project and all cannot possibly be named. However, special thanks are due to Harley Perkins and Mel Phelps of Fairchild Memory Products for their ideas and encouragement. I am also indebted to Kerm Fleck of Tektronix, Inc. for help with equipment problems.

**REFERENCES**

THE QUINE-McCLUSKEY MINIMIZATION METHOD

Based on an example that is real, relevant, and sufficiently simple, here is a clear, straightforward explanation of an important logic minimization technique.

The minimization of Boolean functions of six or more variables is a unique and interesting problem because map methods, which are fast and reliable for problems involving functions of fewer variables, become cumbersome as the number of variables increases. Different and more systematic techniques must be considered for these problems.

The Quine-McCluskey method is an important technique for three reasons: (1) it is completely systematic, that is, all minimal representations of the functions can be found; (2) it is a practical hand method for solving problems involving six or more variables; and (3) it is the basis for many of the computer programs now available for logic minimization.

This article explains Quine's original method and then gives McCluskey's important improvements. Three notations are given (algebraic, binary, decimal) so that the reader can clearly see the similarities between and advantages of the various notations.

Quine's Method

The method developed by Quine is a two step process. First, all prime implicants are found by an exhaustive comparison of algebraic minterms of the function to be simplified. This comparison looks for pairs of minterms that differ in only one variable such as:

\[ A \bar{B} \bar{C} \bar{D}, A B C D \]

This pair can be immediately combined to form the term AC \( \bar{D} \) because AC \( \bar{D} (B + \bar{B}) = AC \bar{D} \).

After each minterm has been compared with every other minterm, the process is continued with the new group of terms just formed. Any term combined into a new term is checked off the list indicating that it is not a prime implicant.

When the comparison process is completed, all prime implicants have been formed, and the next step is to select a group of these to form the simplified expression. This selection is accomplished with a prime implicant table as shown below:

<table>
<thead>
<tr>
<th>PRIME IMPLICANTS</th>
<th>A B C D</th>
<th>A B C D</th>
</tr>
</thead>
<tbody>
<tr>
<td>*A B C</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>A B D</td>
<td></td>
<td>X</td>
</tr>
</tbody>
</table>

An X in the chart indicates that the corresponding minterm is included in the corresponding prime implicant.

After the chart is filled out, all columns are scanned to find those having only a single X. Such a condition means that the minterm is only included in one prime implicant, thus that prime implicant is essential and is so marked with an asterisk. It must be included in the final expression.

Next, all minterms that are included in the essential prime implicants should be indicated by circling all X's in their columns.

Any minterm not included in the essential prime implicants must be included in the simplified function by
including one or more non-essential prime implicants along with the essential ones.

To illustrate Quine’s method consider the following problem:

Design a switching network whose inputs are BCD digits in the excess-three code and whose single output is logical 1 if the input is a legitimate excess-three digit.

The standard-sum expression for this function is as follows:

\[ F = \overline{A}BCD + \overline{A}BCD + \overline{A}BCD + A\overline{B}CD + A\overline{B}CD + A\overline{B}CD + A\overline{B}CD + A\overline{B}CD + A\overline{B}CD + A\overline{B}CD \]

Note that the terms are given high-order-first, that is, \( A \) is the 2\(^{3}\) bit. The first step is to list the above terms in a column and systematically compare and check off combined terms:

Now continue with the new list as shown in the right-hand column of figure above. When the process can be carried no further, the unchecked terms are prime implicants: \( ACD, BCD, BCD, ACD, AB, AB \).

Now the prime implicant chart can be drawn:

Note that \( \overline{AB} \) and \( AB \) are essential, thus we circle all minterm entries included by these two prime implicants.

The only entries not circled by this process are those of the minterms \( A\overline{B}CD \) and \( A\overline{B}CD \). These can be included in the simplified expression by including \( ACD \) or \( BCD \) and \( BCD \) or \( ACD \).

Thus, four minimal solutions exist, each consisting of the essential prime implicants plus one of the four combinations of the needed non-essential prime implicants. These expressions are:

\[
\begin{align*}
F &= \overline{A}B + AB + \overline{A}CD + B\overline{C}D \\
F &= \overline{A}B + AB + ACD + AC \overline{D} \\
F &= \overline{A}B + AB + B\overline{C}D + \overline{A}CD \\
F &= \overline{A}B + AB + B\overline{C}D + A\overline{C}D
\end{align*}
\]

Except for the possibility of factoring, these four expressions are equally simple.

While this simple problem could easily be solved using map methods, the important point is that Quine’s method is completely systematic and, by using it, all
equivalent sum-of-products expressions containing no redundant terms can be found. Also, the method is equally applicable regardless of the complexity of the problem.

**McCluskey's Method**

McCluskey noted that many of the comparisons made in Quine's method are unnecessary since for some of these comparisons, terms cannot possibly be combined. An example of such a case would be:

\[ A B C D, A B C D \]

Since two variables differ, these two minterms cannot combine to eliminate a variable.

In order to eliminate the need for making these needless comparisons, McCluskey introduced a binary notation for minterms as follows:

Form a binary number designator for each minterm replacing complemented literals with a 0 and non-complemented literals with a 1. Every minterm has a unique binary designation.

**EXAMPLES:**

- \( \overline{A} B C D \) converts to 0111
- \( A \overline{B} C D \) converts to 1001

McCluskey further noted that for a minterm with \( X \) numbers of binary l's in its designator, that minterm need only be compared with minterms having \( X + 1 \) binary l's in their designators since all other minterms must differ by more than one variable.

Therefore, the first step in McCluskey's method is to convert all minterms into their binary designators and list these in a column in groups according to the number of binary l's in their designators. The logic behind this step is that when the terms are so ordered, the terms of one group need only be compared with the terms in the groups on either side.

As an example, consider the previous problem. The equivalent expression using binary designators is:

\[
F = 0011 + 0100 + 0101 + 0110 + 0111 + 1000 + 1001 + 1010 + 1011 + 1100
\]

Ordering these terms in accordance with McCluskey's rule yields:

\[
\begin{align*}
0100 \\
1000 \\
0011 \\
0101 \\
0110 \\
1001 \\
1010 \\
1100 \\
0111 \\
1011
\end{align*}
\]

The comparison process is quite easy with the binary designators, as we merely look for pairs of numbers differing by only one bit. When such a pair is found, the numbers involved are checked off as before and the combined term is written with a blank in the differing bit position to indicate that the variable has been eliminated by the combination process.

The comparison process starts by comparing the numbers in the first group with those in the second. When this step is completed a line is drawn under the newly formed combined terms, and the numbers in the second group are compared to those in the third, etc.

The same comparison process is applied to the newly formed groups. It is important to note that in order for two numbers having blanks to be combined, the blanks must be in the same bit positions and the numbers must differ in one bit position. For example: 01-1 and -111 cannot be combined while 01-1 and 00-1 can be combined to form the term 0 - .

When the comparison process cannot be carried further, all prime implicants have been formed, and the next step is to build a prime implicant chart. The use of the chart is identical in Quine's and McCluskey's methods.

After the simplified expression has been found, it can be reconverted to algebraic notation.

The same example is fully worked out below using McCluskey's methods:

\[
\begin{align*}
0100 & \rightarrow 01- \\
1000 & \rightarrow 10- \\
0011 & \rightarrow -00 \\
0101 & \rightarrow 00- \\
0110 & \rightarrow -01 \\
1001 & \rightarrow -10 \\
1010 & \rightarrow 10- \\
1100 & \rightarrow 10- \\
0111 & \rightarrow 01- \\
1011 & \rightarrow 01-
\end{align*}
\]

The prime implicants are then -100, 1-00, 0-11, -011, 01 --, and 10 --. The prime implicant table can now be formed:

<table>
<thead>
<tr>
<th>( -100 )</th>
<th>( 0-11 )</th>
<th>( 01-- )</th>
<th>( 10-- )</th>
</tr>
</thead>
<tbody>
<tr>
<td>( x )</td>
<td>( x )</td>
<td>( x )</td>
<td>( x )</td>
</tr>
</tbody>
</table>

Now the essential prime implicants are identified and all \( X \)'s of minterms included in essential prime implicants are circled.

The simplified expressions are:

\[
\begin{align*}
F &= 01-- + 10-- + 0-11 + -100 \\
F &= 01-- + 10-- + -011 + -100 \\
F &= 01-- + 10-- + -011 + 1-00 \\
F &= 01-- + 10-- + -011 + 1-00
\end{align*}
\]

which are equivalent to the solutions obtained before.

**McCluskey's Method with Decimal Notation**

Even further improvement in the methods previously described can be achieved by adopting a decimal notation. In this notation, the decimal number equiva-
lents of the binary designators will be used. Thus the symbol A B C D, 0101 and 5 are all equivalent representations for the minterm A B C D. The function of the example problem could be written: \( F = 3 + 4 + 5 + 6 + 7 + 8 + 9 + 10 + 11 + 12 \) or, more compactly, \( F = \Sigma (3, 4, 5, 6, 7, 8, 9, 10, 11, 12) \).

The ordering of minterms takes place as before, thus the example problem would be ordered:

\[
4 \quad 8 \quad 3 \quad 5 \quad 6 \quad 9 \quad 10 \quad 12 \quad 7 \quad 11
\]

As an aid in solving problems in decimal notation, the following chart gives all possible 6 variable minterms grouped according to the number of binary 1's in their equivalent binary designators. An extension of this chart (up to 7 variables) is contained in Appendix 2 of Reference 1.

Chart for ordering 6 variable problems.

<table>
<thead>
<tr>
<th>Number of 1's</th>
<th>Minterms</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>1</td>
<td>1, 2, 4, 8, 16, 32</td>
</tr>
<tr>
<td>2</td>
<td>3, 5, 6, 9, 10, 12, 17, 18, 20, 24, 33, 34, 36, 40, 48</td>
</tr>
<tr>
<td>3</td>
<td>7, 11, 13, 14, 19, 21, 22, 25, 26, 28, 35, 37, 38, 41, 42, 44, 49, 50, 52, 56</td>
</tr>
<tr>
<td>4</td>
<td>15, 23, 27, 29, 30, 39, 43, 45, 46, 51, 53, 54, 57, 58, 60</td>
</tr>
<tr>
<td>5</td>
<td>31, 47, 55, 59, 61, 62</td>
</tr>
<tr>
<td>6</td>
<td>63</td>
</tr>
</tbody>
</table>

The comparison process initially looks for pairs of minterms that differ by an integral power of 2 such as 1, 2, 4, 8, 16, 32, etc. Note that this is exactly equivalent to looking for pairs of binary numbers which differ in only one bit position.

When such a pair of decimal numbers is found they are grouped together, the individual numbers are checked off, and the difference is placed in parentheses after the pair to indicate which variable had been eliminated. Thus the following combining operations are exactly equivalent:

\[
\begin{align*}
&\text{ABCD} \rightarrow BCD \\
&\text{0101} \rightarrow 101 \\
&\frac{5}{13} \rightarrow 5, 13 \ (8)
\end{align*}
\]

While making comparisons in the minterm column, some additional needless comparisons can be eliminated.

If a number, \( X \), in one group is being compared to all numbers in the next group, there is no need to compare \( X \) with any numbers smaller than \( X \). The reason why no such valid comparison can take place can be seen from the following argument:

Let \( X \) be a number in the group having 2 binary ones. All numbers in the next group have 3 binary ones. In comparing \( X \) with any number, \( Y \), having 3 binary ones, the additional one in \( Y \) constitutes a differing variable. Consequently, in order for a comparison to take place, all other bits in \( X \) and \( Y \) would have to be identical. If this is the case, then it is clear that \( Y \) must be larger than \( X \).

After all possible combinations of minterms have been formed, the process continues by comparing pairs of minterms. Only pairs having the same number(s) in parentheses can be combined, and for two pairs to combine to form a group of 4 minterms, the first numbers of each pair must differ by a power of two.

A further improvement which the decimal notation allows is the elimination of duplicated terms. This can be accomplished by only combining groups which result in an increasing series of numbers. For example, the term 4, 5, 6, 7, (1, 2) would be accepted while the redundant term 4, 6, 5, 7 (2, 1) would be thrown out by the above rule.

When the combining process is completed, all unchecked entries correspond to prime implicants. The next step is to draw the prime implicant chart, identify the essential prime implicants, and finally write down the simplified expression.

The prime implicants are 4, 12 (8); 8, 12 (4); 3, 7 (4); 3, 11 (8); 4, 5, 6, 7 (1, 2) and 8, 9, 10, 11, (1, 2). Again the prime implicant chart is formed:

\[
\begin{align*}
&\text{QUINE'S METHOD} \\
&\text{McCLUSKEY'S BINARY} \\
&\text{McCLUSKEY'S DECIMAL}
\end{align*}
\]

The prime implicants are 4, 12 (8); 8, 12 (4); 3, 7 (4); 3, 11 (8); 4, 5, 6, 7 (1, 2) and 8, 9, 10, 11, (1, 2). Again the prime implicant chart is formed:
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DC forward current ($I_\text{F}$) ........................................... <330mA
Recurrent forward peak ($I_{\text{RFP}}$) .................................... <800mA
Reverse current ($I_{\text{R}}$) .................................................. <100mA ($V_T=-40V$)
Reverse current ($I_{\text{R}}$) ($T_\text{A}=150^\circ C$) ...................... <100µA ($V_T=-40V$)
Capacitance ($C$) .............................................................. <8.0pf
Reverse recovery time ($T_{\text{rr}}$) ..................................... <25nsec. ($I_{\text{R}}=10$ to 200mA)
Reverse recovery time ($T_{\text{rr}}$) ..................................... <90nsec. ($I_{\text{R}}=300mA$ $I_{\text{F}}=60mA$)
Operating Temperature ($T$) .............................................. -65 °C to 175 °C

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Converting the prime implicants will result in the same four equations as before.

The Prime Implicant Chart

The selecting of the best group of non-essential prime implicants to complete a function is not always easy merely by inspection of the prime implicant chart. However, a systematic method is available for writing down all possible solutions from which the best one can be selected.

Consider the prime implicant chart shown below where the prime implicants have been given letter designations for identification purposes.

<table>
<thead>
<tr>
<th>3</th>
<th>5</th>
<th>8</th>
<th>9</th>
<th>10</th>
<th>12</th>
<th>13</th>
<th>14</th>
<th>19</th>
<th>23</th>
<th>25</th>
<th>26</th>
<th>27</th>
<th>28</th>
<th>31</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>X</td>
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</tr>
</tbody>
</table>

The essential prime implicants include all minterms except 9, 25, and 26. Minterm 9 can be included with prime implicant C or H, 25 with prime implicant C or F, and 26 with D or G. Or, stated another way, the function must consist of: A and B and E and I and J, and C or H, and C or F, and D or G. This statement can be directly translated into a Boolean function:

$$A B E I J (C+H) (C+F) (D+G).$$

When fully expanded with redundant terms removed by application of the theorem $X+XY=X$, this expression represents all possible non-redundant, minimum, sum-of-products solutions to the problem:

$$\begin{align*}
ABEIJ (C+H) (C+F) (D+G) &= \\
ABEIJ (C+CH+CH+FH) (D+G) &= ABEIJ (C+FH) (D+G) = ABEIJCG + ABEIJFHD + ABEIJFHG
\end{align*}$$

Thus, we have 4 solutions to the problem. Of these, 2 require 7 prime implicants, and 2 require 8 prime
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<table>
<thead>
<tr>
<th>TABLE 1</th>
</tr>
</thead>
<tbody>
<tr>
<td>DEFINITIONS OF SOME SWITCHING THEORY TERMS</td>
</tr>
</tbody>
</table>
| Prime Implicant — A product term formed by combining two or more minterms so that one or more variables drops out of the expression. Essentially the same as a subcube on the Karnaugh map.
| Prime Implicant — Simply an implicant which cannot be contained in another implicant. The map analogy would be a subcube which cannot be contained in a larger subcube.
| Prime Implicant — A prime implicant which must be used in the simplified expression by virtue of the fact that it is the only prime implicant that contains a particular minterm of the original function.
| Prime Implicant — A table of prime implicants versus minterms whose entries indicate which minterms are included by each prime implicant.

implicants. Thus, the simplest expression for the function would be:

\[ A + B + C + D + E + I + J \]  
\[ A + B + C + E + G + I + J \]

where A through J are letters which identify the prime implicants on the prime implicant chart. These prime implicants would have to be converted back to algebraic form to get a Boolean expression for the simplified function.

Optional Terms

Any of the methods described can handle "don't care" or optional terms with no difficulty. In this case, all optional terms are included in the list of minterms when the prime implicants are being formed. When the prime implicant chart is made, however, only the essential minterms are included. This process assures that the optional terms will be used to best advantage.

REFERENCES
**Simple Circuit Produces High-Speed, Fixed Duration Pulses**

**THE PROBLEM**

To generate an output pulse of fixed duration from a variable duration input pulse ranging from 50 to several hundred nanoseconds. Prior art differentiated the input pulse to obtain a trigger pulse to be applied to a monostable or blocking oscillator. This method requires complex circuitry that consumes a relatively large amount of power.

**THE SOLUTION**

A circuit consisting of a tunnel diode in parallel with an inductance driven by a constant-current generator. Input pulses of variable width in the nanosecond range yield output pulses of fixed width.

**HOW IT'S DONE**

The variable duration pulse applied to the input of a constant-current generator, as shown in the accompanying diagram, allows a current to flow through a parallel network. When this current is first applied to the network, the initial high impedance of the inductor causes the entire current to flow through a tunnel diode. This current is adjusted to be greater than the peak current of the tunnel diode, causing the tunnel diode to switch to its high-voltage state. Current through an inductor, initially zero, increases with time and the tunnel diode current and voltage decrease until the valley point of the tunnel diode is reached, causing it to switch to its low-voltage state. Because the inductor now has a relatively low impedance, the output voltage will be approximately zero for the duration of the input pulse.

**NOTES**

1. Close control of output pulse width is easily accomplished by varying the value of the inductor.
2. This circuit should be of interest to designers of computer and pulsed communications equipment.
3. Inquiries concerning this invention may be directed to: Technology Utilization Officer, Goddard Space Flight Center, Greenbelt, Maryland 20771, Reference: B65-10228.

**PATENT STATUS**

NASA encourages the immediate commercial use of this invention. Inquiries about obtaining rights for its commercial use may be made to NASA, Code AGP, Washington, D.C. 20546.
NEW PRODUCTS

INCREMENTAL RECORDER

New incremental digital recorder accepts randomly occurring digital data at rates from zero to 200 steps per second for the automatic preparation of 200-bit per inch magnetic tapes of computer compatible format. Price of the new model, the PI-1167 is $3,650. According to the company, previous digital recorders with this performance cost approximately $6,000 or more. With solid-state electronics, the compact recorder also can record digital characters received synchronously at 500 steps per second. The PI-1167 uses 10 1/2-inch reels of standard one-half inch computer tape to produce a seven-channel NRZ format digital tape. Internal electronics automatically generate inter-record gaps, parity check characters, end-of-file gap and tape mark. Precision Instrument Co., Palo Alto, Cal.

Circle No. 120 on Inquiry Card

SHAFT ENCODING SYSTEMS

Precision shaft angle-to-digital and digital-to-shaft angle conversion systems utilize a solid-state resolver/syncho. The new resolver/syncho is said to be extremely versatile because it can use CX, CT, CDX, or any resolver or syncho configuration and requires no modification of existing equipment. The resolver/syncho generates sine and cosine trigonometric conductances as a function of a linear digital angle, and has a response time within 5 usec. (or less) of the digital change. Typical performance characteristics include an accuracy to 20 bits with resolution greater than 20 bits. The analog input can be any voltage and any frequency up to 10 kc. The digital input/output can take any digital format. Reeves Instrument Co., Garden City, N. Y.

Circle No. 122 on Inquiry Card

DIGITAL PRINTER

Low-cost digital printer operates on a counting principle thus avoiding the problem of precise synchronization circuitry. Upon applying a binary code, the printer quickly counts to the decimal equivalent indicated by the code and prints out with one operation of a platen. All columns are printed simultaneously. Print speed is 1 line per second. Number of columns is from 1 to 20. The unit measures 7” H x 19” W x 15” D and may be rack or table mounted. Typical cost of an eight-column printer is less than $900. PH Electronics, Clifton Heights, Pa.

Circle No. 184 on Inquiry Card

VARIABLE-TC CAPACITOR

Adjustable temperature co-efficient is the unique feature of a new 2.3 pF capacitor known as the Thermitrimmer. Although the component looks like a differential air-spaced trimmer with a ceramic base, adjustment of the rotor alters not the capacitance but the temperature co-efficient, to any desired value from +1700 ppm through zero to -1700 ppm. Capacitance changes linearly with temperature. The variation at maximum + co-efficient is from 2.3 pF at 20°C to 2.6 pF at 100°C. A similar negative co-efficient is produced simply by turning the rotor through 180°. Thermal compensation of an oscillator which incorporates a Thermitrimmer is quickly achieved, the manufacturer claims. The frequency is noted upon switching on. After warm-up, the oscillator is retuned to its original “cold” frequency by adjustment of the Thermitrimmer. This one adjustment provides a high degree of compensation and eliminates the need for tedious capacitor substitution. The Thermitrimmer measures 0.6” x 0.4” x 0.4”. BREL Corp., Washington, D. C.

Circle No. 133 on Inquiry Card

CALCULATOR/COMPUTER

A new auxiliary program memory storage unit greatly expands the computational capabilities of an electronic calculator/computer. Called the APS (for Auxiliary Program Storage), the new unit in conjunction with the company's standard desk top calculator/computer provides 48 to 88 individually addressable storage registers plus 490 steps of program memory. Data, formulas, and programs are entered directly through a simple calculator-type keyboard using ordinary algebraic language including parentheses. Up to 18 prewired programs, of 48 steps each, may be incorporated into the unit and entered automatically by the program or with a touch of a button. Decimal points are located automatically and all answers are printed out to 8 or 9 significant digit accuracy with a 2 digit power of 10 exponent. In addition to the storage registers and program memory, 5 separate registers are used for arithmetic manipulations. Number capacity is 100 columns. Optional accessory units include a paper tape punch and reader with page printer, remote location keyboard, and direct entry punched paper tape reader. Mathatronics, Inc., Waltham, Mass.

Circle No. 146 on Inquiry Card

Circle No. 133 on Inquiry Card

COMPUTER DESIGN/APRIL 1966
Direct photoelectric encoding is one of the major reasons for the extreme reliability of Invac's new Universal Photoelectric Keyboard. There are no switches and no complicated diode matrix. The problems associated with contact bounce and RFI are eliminated. Keyboard touch (operator feel) compares favorably with that of the best typewriters. A unique mechanical interlock prevents depression of more than one key at a time, for all banks.

**New Universal Photoelectric Keyboard joins the Invac family of highly reliable Peripheral Equipment**

![Keyboard Image]

The basic Invac Keyboard is a self-contained unit with 10 to 75 keys which generates directly any binary code up to 8 bits including ASCII. In addition to the 8 data channels, a strobe and a spare channel are also provided. Output data is parallel by bit, and serial by character. Burst speeds of greater than 20 characters per second are possible. When desired, the keyboard can be integrated into a console.

A. Tapes Punches
   100,000,000 operations
B. Photoelectric Tape Readers
   no motors . . . no clutches
C. Input/Output Typewriters
   transmit and receive data
   in coded form
D. Tape Systems
   for Off-Line and On-Line
   Applications
   Write for Data Sheets

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FULL · 64-CHARACTER · TAPE · PRINTER
Thoroughly proved in commercial, telephone and military applications, Model 118A offers advanced capabilities for air-borne and ground communications, and as a "read-out" device for computers. Weight: under 4 lbs. 5" wide by 10" long by 2" high. Speed infinitely variable up to $12\frac{3}{4}$ characters per second. Self-contained 3 inch roll of $\frac{5}{16}$" impact-sensitive paper tape. Any 64-character alphabet can be furnished. For details on low cost, write—

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EVERYTHING YOU WANT,
IN ONE DIGITAL READOUT

HIGH READABILITY — Figures are bright, unobstructed and easily read from all angles.

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DECODER-DRIVERS FOR ALL APPLICATIONS — Operate without buffers from standard or integrated logic, positive or negative logic levels and 8 or 4 line data in various BCD codes.

ONE SIMPLE POWER SUPPLY — Unfiltered, unregulated, full-wave rectified line voltage operates both display and decoder-drivers.

LOW COST — Display and BCD decoder-driver as low as $39 per digit.

Send for series NQ and NSD data sheets.

NEW PRODUCTS

HIGH-SPEED CORE DRIVERS

New family of 8 ultra-fast diode arrays were designed especially for high-speed core driver applications. The new units, all of silicon Planar epitaxial construction, are hermetically-sealed to permit operation to 400 milliwatts. The family includes a sixteen diode core driver array in a basic 10-lead TO-5 package and also in a ceramic package, eight diode core driver arrays in 10-lead, TO-5 packages, and ceramic packages, and eight diode common anode and common cathode arrays. Typical specs include maximum forward voltages of 1.50 volts at forward currents of 500 milliamps, peak forward voltages of 5.0 volts, breakdown voltages of 60 volts minimum, and maximum reverse recovery times of 25 nanoseconds. Fairchild Semiconductor, Mt. View, Cal.

Circle No. 156 on Inquiry Card

DATA GENERATOR

A 25 MHz general-purpose digital data generator is said to be the first unit of its kind to supply independent delay for each of the two output channels operating in NRZ as well as in a variable width pulse output mode. The generator utilizes integrated circuits and is designed to be housed within a 5\frac{1}{4}"-inch high package. Capabilities of the new instrument are applicable to a wide range of requirements for data simulation, particularly those required for development of integrated circuit computers, delay line memories, and high-speed telemetry systems. It may be used as a digital data parallel-to-serial converter. Multiple units may be interconnected to provide subcommutation or additional channels. Delay and width of each channel are independently controlled to 5 milliseconds. Polarity is selectable as positive or negative, with amplitude variable to 5 volts into 50 ohms. Rise time is less than 3 nanoseconds. Datapulse, Inc., Inglewood, Cal.

Circle No. 168 on Inquiry Card
How good are Datamec Tape Units?

Ask any of the people who build or use these computer systems.*

Perhaps you, too, have a program that would profit from low cost/high reliability in computer tape handling. Check with the company that stresses service to its customers. Write Tom Tracy at Datamec, 345 Middlefield Road, Mountain View, California 94041. Better yet, phone Tom at (415) 968-7291.

1. Astrodata Inc.  
   Automatic Data Acquisition System
2. Benson-Lehner Corp.  
   B-L 120 off-line Microlfilm Printer/Plotter
3. Cubic Corporation  
   Computer Tape Synchronizer for European Air Defense System
4. Digital Equipment Corp.  
   Programmed Data Processor 7
5. Digitronics Corporation  
   Model 522 Dial-o-verter  
   Magnetic Tape Terminal
6. Raytheon Computer Operation  
   Raytheon 520 System

* Sorry there's space for so few pictures. If you'd like a lot more names, contact Tom.

CIRCLE NO. 48 ON INQUIRY CARD
Microsonics has proven capabilities and facilities to design and build reliable ultrasonic storage systems at high information rates (up to 100 me) which gives long term service in difficult environments of shock, vibration, and temperature. These systems have the capability of handling digital signals for computer storage or analog information as in radar signal processing.

Microsonics will design and manufacture any portion of a storage requirement. Single delay lines, multiple delay lines or complete overall storage systems. Shown above is a complete system of 36 parallel channels with each channel storing 4500 bits at a 5 mc rate.

Write for Bulletin 5350

**MAGNETIC CARD MEMORY**

Magnetic card memory provides an on-line random access storage capacity of 100 million bits with a maximum access time of 50 milliseconds. The unit uses long-wearing flexible magnetic cards contained in interchangeable cartridges as the storage medium. Each cartridge holds 64 cards and can be loaded or unloaded in less than 5 seconds, according to the company. A single 32-track dual-gap magnetic head provides read-after-write capability and the maximum data rate is 10.4 megabits/second when 32 tracks are processed in parallel. There are 128 recorded tracks on each magnetic card divided into four groups of 32 tracks each. Moving the magnetic head from one group to another takes less than 20 milliseconds. The unit includes a transport mechanism, two electronics chassis, and one power supply chassis all housed in a self-supporting metal cabinet 6.5' high by 25" wide by 30" deep. All cooling is incorporated so that in normal computer applications no special temperature control is required. Prices start at $18,000. Computer Accessories Corp., Santa Barbara, Cal.

Circle No. 179 on Inquiry Card

**MONOLITHIC MULTI-CHANNEL COMMUTATOR**

Built as a monolithic integrated circuit structure, a multi-channel commutator was designed for use in multiplexing and telemetry systems where low on-resistance and low channel leakage are required. The circuit offers an on-resistance of less than 200 ohms and a channel leakage of less than one nanoamp per channel. Using MOS field-effect transistors as active resistors, the device has all channel blanking capability for four channel operation. Five channel operation is also available. Each gate is diode-protected. Input analog signal voltage is ±10 volts, and output capacitance is 40 picofarads. Channel turn-on time is 500 nanoseconds, and turn-off time is 2 microseconds. Fairchild Semiconductor, Mountain View, Cal.

Circle No. 144 on Inquiry Card

**D/A CONVERTER NETWORKS**

With a new stable digital/analog converter ladder network, straight binary conversion is available to 14 bits with ±½ least significant bit accuracy — giving a capability of recognition to 1 part in more than 30,000. Precision wire-wound resistors are used in the new ladder network to produce a highly-stable voltage output of ±10 ppm, one year operating, referenced to input voltage. The unit’s height is held to 0.250 inch to make them compatible for use with standard 0.250 inch components used in high-density circuitry packages. Ultronix, Inc., Grand Junction, Colo.

Circle No. 131 on Inquiry Card

**AUTOMATIC CABLE TESTER**

New testers check cables, chassis wiring, printed circuit boards, connectors, etc., which contain up to 50 circuits. It tests each circuit for continuity to 1 ohm (adjustable) and checks each circuit to all other circuits for shorts to 200 megohms (adjustable). All tests are performed automatically at 4 tests per second. Unit stops and positively identifies all faults. It can automatically test branched-circuits. V. J. Electronics, Ontario, Cal.

Circle No. 175 on Inquiry Card
MAG TAPE HEADS

Magnetic tape playback heads, incorporating micro-miniaturized pre-amplifiers as part of the unit, are designed for low signal applications ranging from 100 cycles to 2.5 megacycles. In addition to eliminating the need for extra equipment and space requirements, the new heads are said to improve the reliability and accuracy of system operation; there is less likelihood of transmission error and high signal-to-noise ratio. Units are supplied with up to 20 channels per inch of tape width. Either differential or single ended output may be selected. Typical specs include output impedance, 50 ohms maximum; voltage gain, 10 nominal; frequency response, 100 cps to 2.5 mcps minimum; temperature range, -55°C to +85°C. Western Magnetics, Glendale, Cal.

Circle No. 148 on Inquiry Card

MODULAR POWER SUPPLIES

Two new models added to a line of modular supplies are dual output modules supplying ±12 volts and ±15 volts at 300 ma, respectively, and feature automatic self tracking to maintain the relative accuracy of both outputs. In addition, these compact modules, designed for system integration, feature 0.1% regulation, 0.5 mv ripple, remote sensing, and operate in environments up to +71°C without derating. Units measure 5 inches high x 4⅞ inches deep x 3¾ inches wide. Trygon Electronics, Roosevelt, L.I., N.Y.

Circle No. 147 on Inquiry Card

Can you take advantage of this cost breakthrough in time code generators?

If you're paying for exotic levels of precision you don't really need and can't use, this remarkable new electromechanical unit may cut your costs in half!

Here's a precision electromechanical time code generator specifically designed to fill many applications at about half the cost of comparable electronic units!

If you've had to buy costly code generators with fancy specifications because nothing else fits your application, this new development can save you real money. It's designed around standard A. W. Haydon Company components and on a modular basis that allows us to customize it to your exact requirements. The time base is established by a synchronous motor-driven repeat cycle timer which rapidly steps a preset code pattern of output switches. Standard output codes available are straight decimal or binary coded decimal.

Typical applications include computers, data handling system, illuminated time displays, direct printout devices, checkout equipment, telemetry systems, and tape punching devices. These units should be carefully considered for any commercial/industrial equipment requiring a time code. This versatile instrument can be arranged to supply readings in days, hours, minutes, and seconds. It can be used as a master clock to drive slave units. It can be custom adapted to handle special codes. Code output is displayed on the front panel, and setting is by convenient knurled wheels. Standard models are available with time outputs from 59 minutes, 59 seconds, to 369 days, 23 hours, 59 minutes, 59 seconds. Panel fits standard 19" racks. Electrical requirement is 105-125 VAC, 58-62 CPS. Send for further information.

Timing & Stepper Motors • Electromechanical & Electronic Timing Devices & Systems

CIRCLE NO. 50 ON INQUIRY CARD

AWH HAYDON COMPANY

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4060 INCE BLVD., CULVER CITY, CALIF. 90231
Tel: 213-Upton 0-5461 TX: 213-836-0444
NEW PRODUCTS

DATA LOGGING SYSTEM

Accepting high-level analog data from up to 16 sources, a new data logging system time-division multiplexes these channels, converts each sample of each channel into a 12-bit binary number, organizes the information into computer-compatible format, and writes it onto digital magnetic tape. The system uses rectangular plug-in digital logic modules for flexibility and low maintenance costs. Asynchronous sampling rate is 100 samples per second; synchronous, 500 samples per second. It can be converted to a high-speed system (50,000 sps) with the addition of a higher speed recorder.

Control and Communication Div., Radiation Inc., Melbourne, Fla.

Circle No. 162 on Inquiry Card

ILLUMINATED DISPLAYS

Improved series of compact illuminated in-line visual display readouts has increased character or numeral recognition up to 30° at viewing angles of 45° on the smaller units. Surface and interface reflections have been reduced with Polaroid filtering. Single or multiple visual display decades are available with characters as small as 1/4" in height. Miniature decade assemblies require 1½" x 2½" x 2" space — including connector plate clearance.

Transformer Engineers, San Gabriel, Cal.

Circle No. 182 on Inquiry Card

PHOTON-COUPL ED ISOLATOR

Solid-state photon-coupled isolator incorporates an improved gallium arsenide diode injection luminescent photon source and an improved silicon diode photodetector. The isolator is packaged in a 4 lead, JEDEC TO-18 size, hermetically-sealed case permitting its use on PC boards as a conventional semiconductor component. The anode of the input diode is connected to the case. The working voltage rating between input/output is 200v peak maximum, and the photon-coupled current transfer ratio is of the order of 0.001 from dc to the cutoff frequency of 10 MHz. The unit is intended for use in circuits where economical input/output common mode isolation of moderate levels is required. One important application is the interruption of common ground currents in various digital and analog circuits.

hp associates, Palo Alto, Cal.

Circle No. 136 on Inquiry Card

Stare at these digits for a few seconds.
PELLET RESISTORS

New experimental kit contains an assortment of microminiature solid cermet pellet resistors that have an extremely high power-to-size ratio, i.e., a minimum of 15 watts per cubic centimeter, with tolerances as low as ±1%. According to the manufacturer, they will not short out under any operating conditions, are extremely stable under extreme environments, and are not affected by radiation. Resistance range is 15 ohms to 200K ohms. The resistors operate at 175°C hot spot without leads and are available with leads or terminating surfaces for soldering or welding. Kit contains resistors with and without leads in random resistances and in the following sizes: 0.050" dia. x 0.030"; 0.050" dia. x 0.062"; 0.100" dia. x 0.030" and 0.100" dia. x 0.062". Kit price is $10.00. CTS Research, Inc., W. Lafayette, Ind.

Circle No. 139 on Inquiry Card

DC POWER SUPPLIES

Specifically designed for systems use, new power supplies offer outputs from 0 vdc to 51 vdc in fourteen models. Each model has a range of about 5 volts. Modules are available with currents from 5 A to 14 A. Prices, in the $300 bracket, are said to be about $100 less than comparative wide voltage range laboratory supplies often used in systems. All the modules are unconditionally guaranteed for five years and have a MTBF of 35,000 hours, calculated according to Mil Handbook 217. Units are packaged in standard half-rack widths thus permitting systems engineers to achieve high amounts of power in a single rack. They have a regulation (line and load combined) of ±0.05% or ±2mv, whichever is greater. Silicon transistors permit operation to 75°C and a response time of 25 microseconds. Consolidated Avionics, Westbury, N. Y.

Circle No. 129 on Inquiry Card

PRINTED CIRCUIT CONNECTOR

A new series of edge connectors for printed circuit cards were specifically designed for dip soldering. They contain gold-plated Duometal contacts; half beryllium copper for high tensile strength, and half brass for maximum soldering reliability and conductivity. The series is furnished with a single row of 6, 10, 15, 18, or 22 contacts. These connectors will accept printed circuit boards ranging from 0.054 to 0.071 inch in thickness and include corrosion-resistant, passivated, stainless steel inserts with 4-40 NC threads for mounting. In addition to meeting all applicable provisions of MIL-C-21097B, MIL-C-21097/1, and MIL-C-21097/6, they have also passed successfully the rigid industrial specifications set by a computer manufacturer and have been used in tape handling and other peripheral equipment. U. S. Components, Inc., Bronx, N. Y.

Circle No. 124 on Inquiry Card

Now try it with a Polaroid circular polarizer.

It's the best way to cut glare, kill reflections, increase contrast (as much as 600% better than a comparable neutral density filter). In digital readouts, radar screens, oscilloscopes and television equipment. Ask us why and how. We're the Polarizer Division, Department CD-4, Polaroid Corporation, Cambridge, Mass. 02139.

"POLAROID®"
World’s Fastest, Low-Cost Digital Printer

Apply several drops of oil to the drive-motor shaft-ends each year (or every fifty-million lines). Brush out any accumulated dust or lint. Clean the air filter periodically.

That’s the extent of maintenance for a Franklin Model 1000... the only digital printer that offers a printing rate of 40 lines per second (or less) at low, low, OEM prices.

REQUEST BULLETIN 2301

NEW PRODUCTS

READOUT CONVERTER/DRIVER

A 4-line BCD converter that converts low level logic signals into numeric display driver currents is a correlated package of a transistor/resistor decoder circuit module, to drive company’s series of numeric readouts. The unit’s design permits the use of only a single power supply to drive both the converter and the readout. Its low current requirements and wide voltage range of required logic inputs are said to enable it to be used directly with many integrated circuit designs and thus eliminate the need for additional buffers. Specs include power supply of +5.5 vdc at 0.65 amp max., including readout lamp supply, logic levels of +2.0 to +15.0 and 0 to +0.5, a required logic drive of 0.3 ma at +2.0 vdc, and an operating temperature range of 0 to 70C. Microphysics, Incorporated, Westbury, N.Y.

Circle No. 149 on Inquiry Card

IC TEST BOARD

A new test board was developed for the testing and prototype operation of integrated circuits in equipment utilizing standard printed circuit card connectors. The board can incorporate flat-pack integrated circuits of up to 14 leads mounted in carriers. The board is designed for plug-in operation to a standard 15 position edge connector with contacts spaced on 0.156” centers. An associated connector can be purchased separately for use in permanent test installations, prototype design, and production packaging. Metals & Controls, Inc., Div. of Texas Instrument, Attleboro, Mass.

Circle No. 140 on Inquiry Card

RESISTOR POTENTIOMETER

New component combines the features of a precision resistor with the adjustability of a trimmer potentiometer. It has been named a varizistor. Several dozen models of varizistors can replace over a hundred thousand individual fixed value resistors, according to the manufacturer. They can be adjusted to provide extremely accurate resistance values in various circuit applications in computers and other commercial and industrial equipment. The varizistor consists of a deposited metal, thin-film resistance element bonded to the inside surface of a ceramic housing. A multi-contact wiper is attached between an insulator and a lead, which runs through the body of the unit, making contact with the resistance element. The entire body slides, within fixed limits, moving the wiper across the resistance element, providing an approximate 20% variation in resistance value, above and below the nominal value. Since there is a continuous film element, rather than the conventional wire-wound type, resolution is high. One of the major advantages of the varizistor is that units can be installed in assembly line fashion and then adjusted to “tune the circuit” at final inspection. It is said to be ideally-suited to computer servicing where minute resistance adjustments are required. Resistance values from 0.5 ohms to 1 megohm are available in 42 units with ratings from ¼ watt to 1 watt. Vacco Electronics Div., Vacco Valve Company, El Monte, Cal.

Circle No. 138 on Inquiry Card

READOUT CONVERTER/DRIVER

A 4-line BCD converter that converts low level logic signals into numeric display driver currents is a correlated package of a transistor/resistor decoder circuit module, to drive company’s series of numeric readouts. The unit’s design permits the use of only a single power supply to drive both the converter and the readout. Its low current requirements and wide voltage range of required logic inputs are said to enable it to be used directly with many integrated circuit designs and thus eliminate the need for additional buffers. Specs include power supply of +5.5 vdc at 0.65 amp max., including readout lamp supply, logic levels of +2.0 to +15.0 and 0 to +0.5, a required logic drive of 0.3 ma at +2.0 vdc, and an operating temperature range of 0 to 70C. Microphysics, Incorporated, Westbury, N.Y.

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Circle No. 138 on Inquiry Card
IC TEST SET

New test set determines operating temperature characteristics of integrated circuit chips and discrete components in a broad range of temperatures. Designated Model 898, the unit includes a three stage thermo-electric cooling module with an enclosure and "O" ring seal for high vacuum use. The heat sink supplied can be of forced convection type or water cooled. The power supply-controller allows the operator to adjust and monitor cold surface temperature through the unit's operating range. Circuits to be tested are easily mounted on the cold plate and terminals are provided for external connection to the circuit tester. In a vacuum of $10^{-5}$ torr, no-load cold junction temperatures will be between $-72$ to $-78$°C with a heat sink temperature of $+27$°C. The cooler operates at an optimum power of 12 amps at 1 volt and varying current below 12 amperes yields temperatures between minimum and ambient. The system will maintain cold surface temperature within 1°C with variations in load and ambient temperature. Borg-Warner Thermoelectric Dept., Borg-Warner Co., Des Plaines, Ill.

Circle No. 137 on Inquiry Card

PAPER TAPE SYSTEM

A complete tape preparation, duplication, and verification system consists of a paper tape punch, two paper tape readers, an encoding keyboard, and an indicating master control panel. The system is housed in a free standing cabinet, operates from 115 volts, 60 cycles, and can punch and read paper, Mylar, or metalized Mylar tapes. At all times, the indicator control panel visually indicates in which mode the unit is operating, as well as showing at any instant which bits are being read. Should the system stop due to an error, the cause can be instantly detected and corrected by use of the keyboards. The system can skip "zero" and "delete" codes (all 8 holes punched). Ohr-Tronics, Inc., New York, N. Y.

Circle No. 130 on Inquiry Card

Quik/Sert

SOCKETS from BARNES...

THE MOST ADVANCED LINE
OF SOCKETS FOR SEMICONDUCTOR
AND OTHER MINIATURE DEVICES

- for production, test, aging, and breadboarding applications
- for flat pack and multi-lead TO-5 packaged I.C.'s, transistors, relays and other miniature components
- for mounting on P.C. boards, chassis, breadboards, or use with mating base connectors
- for hard wiring, dip soldering, wire wrap, welding, tab or pin base mounting, compression fitting, or saddle mounting
- for flat pack carriers and contactors, flip-top sockets for flat packs, module test connectors, and breadboard test connectors

Choose from over 3,000 standard sizes, configurations and materials. And Barnes can quickly produce custom sockets to meet any requirement. Call or write for complete technical data.

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Circle No. 53 on Inquiry Card
VERTICAL LAMINAR FLOW HOODS

The vertical laminar flow hood having a top mounted HEPA filter and a perforated work surface through which the clean air flows is one of the most versatile of any of the existing types of clean hoods.

Air flow can be regulated and varied in an infinite number of ways to achieve any desired condition.

The use of a properly installed HEPA filter enables this unit to more than fulfill all requirements as set forth in Federal Standard #209 for a Class 100 clean bench.

Vertical flow units may be used with a single blower for a complete recirculation of air or may be used with a controlled secondary blower whenever an exhaust condition is required.

This unit when used with an exhaust blower solves the problem of handling any toxic or noxious fumes generated by the work operation.

Units can be provided with stainless steel, P.V.C., or polypropylene liners for use when harsh chemicals or acids are a part of the operation.

Sinks, drains, tanks, valves and taps can be installed for any desired application making this unit a must when setting up a photo-resist line.

Let Baker engineers, with over 20 years experience in contamination control, evaluate your problems for an efficient, economical solution.

THE BAKER COMPANY, INC.
106 Granite St.
Biddeford, Maine 04005

CIRCLE NO. 54 ON INQUIRY CARD

NEW PRODUCTS

TOUCH-OPERATED SWITCH

Based on a semiconductor surface effect which is sensitive to touch, a new switching device features fast action, high repeat rate, and freedom from switching transients. In use, the operator or simile thereof, is isolated from the power circuit. The "touch" sensitive area may be any size from as small as a finger button to as large as a wall in a room. Thus, the switch may be used for a wide variety of applications from the simplest appliance switch to the most complex computer control. For voltage ranges up to 24 volts rms, models will handle 100 ma, 1 amp, and 5 amps. For 24 to 120 volts rms, and for ranges from 120 to 230 volts rms, models will handle 500 ma, 1 amp, and 5 amps. Hall-Barkan Opticon, Tuckahoe, N.Y.

CIRCLE NO. 178 ON INQUIRY CARD

FLEXIBLE PRINTED CIRCUITS

A versatile new family of flexible copper-clad materials for printed circuits includes copper-clad glass-reinforced polyester, copper-clad glass-reinforced epoxy, a low-cost paper-reinforced copper-clad material, and copper-clad Mylar. The insulating materials, in thicknesses from 2 to 12 mils are furnished with 1-oz., 2-oz., or 3-oz. copper bonded to one or both sides. Treated or untreated copper, as rolled or electrodeposited foil, can be bonded to the insulation. The insulating material, without copper, is also supplied, bondable on one or both sides, for use as binder and cover sheets in construction of multilayer circuitry. Electrical characteristics of glass-reinforced epoxy and polyester systems are comparable. Surface resistivity for both glass-epoxy and glass-polyester copper-clad materials is $1 \times 10^6$ megohms per square under test conditions of 96 hr. at 35°C and 90 per cent relative humidity. Dissipation factor at 1 megacycle is less than 0.05 for both. Similarly, dielectric strength, short-time, Condition A, is 1,500 volts per mil for glass-epoxy and glass-polyester. However, the dielectric constant for glass-polyester approaches 3, while for glass-epoxy it is less than 4. Flexibility of the copper-clad materials is said to afford economies in the fabrication of printed circuits by the use of continuous machinery. They can be soldered for example, by standard production methods on dip or wave soldering machines. In addition, flexible printed circuits eliminate much wiring during manufacture. Westinghouse Electric, Insulating Materials Div., Trafford, Pa.

All the facts are included in Bulletin TC-143B. Write for your FREE copy today. Sanders Associates, Inc., Microwave Division, Nashua, New Hampshire 03060.

SANDERS ASSOCIATES, INC.
Creating New Directions in Electronics

CIRCLE NO. 55 ON INQUIRY CARD
**COMPUTER LAMPS**

The integrally-molded base is said to be the first major development in subminiature lamps in over a decade. Designed for the specific requirements of the computer industry, this integrally-molded base lamp differs from the conventional lamp in that it employs a plastic (nylon or other thermoplastic materials) base molded to a standard bulb. It replaces not only the separately attached metal base but also the mated socket which it requires. The new lamps are said to provide significant advantages in reliability, economy, and design freedom over the conventional types. The most important advantage of the new lamps will probably be the ability to make entire lamp assemblies as a single piece of equipment for direct installation into a system. Present production units which, according to the company, have been successfully proven out in pilot installations over the past year are printed circuit board indicators, long lead photocell actuators, and many complex shaped packages.

Tung-Sol Industries, Incorporated, Newark, N.J.

Circle No. 176 on Inquiry Card

**EPITAXIAL DIODES**

A new line of silicon planar epitaxial diodes for high speed switching and computer applications are miniature glass units packaged in a standard DO-7 case. Application of advanced epitaxial technology is said to provide greater reliability, increased yield, and reduced cost. It offers extremely low forward voltage drop at higher forward current. Operating over a temperature range of \(-65^\circ C\) to \(+175^\circ C\), these diodes have a peak reverse voltage of \(-100\) v for Types 1N914 through 1N916A, and \(-75\) v for Type 1N3064. Nucleonic Products Co., Inc., Los Angeles, Cal.

Circle No. 128 on Inquiry Card

**OPTISYN®**

DRC offers the OPTISYN optical, incremental encoder:
- Accuracies to better than ± one count per turn
- Resolutions from 100 to 131,072 counts per turn
- Wide-aperture optics produce high signals
- Sizes from 1" to 3½"
- Standard or special design models

Write for descriptive brochure to:

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CD HANDBOOKS AND REPRINTS

"CAUSES AND CURES OF NOISE IN DIGITAL SYSTEMS"

A 56-page, pocket-size, design reference handbook gives basic guideline rules and design tips for eliminating or minimizing noise in digital systems. The discussion is divided into 3 sections: Part 1 — Systems Design Considerations; Part 2 — Noise Elimination in Digital Modules; Part 3 — Control of External Noise.

Price: $1.75 per copy

"TELETYPETRAPER FUNDAMENTALS HANDBOOK"

A 32-page, pocket-size, handbook explains the basic principles of teletypewriter equipments — how they operate and how they are used. A glossary of teletypewriter terminology and descriptions of typical machines are included.

Price: $1.50 per copy

"PERFORATED TAPE READERS"

The industry-wide survey of perforated tape reading equipment that appeared as a Product Reference File feature in COMPUTER DESIGN is available as a 20-page reprint. It serves as an excellent reference for evaluating and selecting a tape reader for a particular application.

Price: $0.50 per copy

"PAPER TAPE PUNCHES"

This 12-page reprint of another CD Product Reference File feature describes the performance characteristics of commercially-available paper tape punch units. Typical punch mechanisms are also described in this survey.

Price: $0.50 per copy

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___copy(ies) of "Paper Tape Punches" at $0.50 each

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NEW PRODUCTS

TIME SHARING COMPUTER

Designed specifically for time sharing, the SDS 940 computer features multi-programming, real-time processing, on-line remote data processing, and simultaneous access to the central processor. The SDS 940 time sharing system will provide up to 32 users with simultaneous access. A response time of two to three seconds facilitates rapid communication between the user and the 940. For up to six simultaneous conversational users, the response time is less than one second. Memory protection is provided to prevent one user from accidentally destroying or gaining access to the programs or data of another user. Another important feature of the computer is its ability to load programs continuously in any available portion of core memory so that users do not have to wait for a specific memory location. Programming languages included with the system are Fortran II; CAL, a conversational algebraic language; SNOBOL, for string manipulation; QED, a conversational text editor; a macroassembler that permits programs to be written in machine language, LISP, a list processing language, and a machine-language debugging system. Memory cycle time is 1.75 microseconds with memory expandable to 65,536 words. The computer features a 24 bit word size and 48 bit capability for floating point arithmetic. Other features include built-in "multiply" and "divide" logic circuitry, automatic checking of memory transfers and input/output operation, multiple-level indirect addressing with indexing at any level, and up to 1,024 levels of priority interrupt, each with a unique priority and address in memory. A typical 940 system includes a minimum of 24,576 words of core memory; two random access discs, each providing 2,000,000 characters of auxiliary storage; two magnetic tape transports; teletype multiplexer; card reader, and eight on-line user stations. The 940 configuration is $430,050. Scientific Data Systems, Santa Monica, Cal.

Circle No. 166 on Inquiry Card
PC HEAT SINK

New printed circuit board heat sinks are said to exhibit good performance characteristics with TO5 transistor cases: a case rise of 36°C at 1 watt with bright aluminum natural finish or 30°C rise with black anodize finish. The area required for mounting is only 0.375 sq. in. Two #4 x 1/4" long sheet metal screws are used to clamp the TO5 case in the Type 150 heat sink. Three eyelets extruded from the mounting base provide keying to the circuit board. A sheet metal screw in the center eyelet anchors the heat sink to the pc board and the two outer eyelets are set for permanent positioning. Cost is less than 9¢ each in volume quantities without black anodizing. Wakefield Engineering, Inc., Wakefield, Mass.

Circle No. 142 on Inquiry Card

ELECTRONIC TRIGGERS

For low frequency applications (from 40 cpm to 1000 cps), with high power (up to 100 watts), new solid-state electronic triggers provide a square wave output from a dc input which is said to be ideal for flip-flop action. Applications for the custom triggers, include special lights which require alternate on-off action, time-lapse photography, heart pumps, and a variety of other low frequency pulsing operations. Space/Defense Corp., Birmingham, Mich.

Circle No. 171 on Inquiry Card

"Special" Pulse Generators are made to order at TI. Modular construction allows assembly of the right building blocks to meet your requirements. Now, "specials" cost you no more, frequently cost less than conventional pulse generators.

For example, the 6613 is an economical general-purpose unit with PRF from 15 cps to 15 mc, priced at only $950. Another model, the 6325, is a ten-channel, word-bit programmable unit operating up to 25 mc. The single unit does the job of ten discrete generators, at half the cost, and fits in a cabinet 23 in. wide, 38 in. high, 18 in. deep.

TI Pulse Generators give you outstanding performance: PRF's to 100 mc, fast rise and fall times, variable pulse width and delay, variable rise and fall times, plus and minus outputs, pulse mixing, programmed and random word generation. You have your choice of portable or rack-mounting cases.

When you need special pulse generator performance, choose one of the thousands of standard pulse generator combinations from Texas Instruments. For more information, contact your nearest TI Authorized Representative or write to the Industrial Products Group in Houston.
... of smaller drum memory systems. Just one advantage of the 1264B—our large economy size. Stores more than 2,000,000 36-bit words. Costs less than 5¢ per word.

Then, too, the 1264B adapts to any computer with direct memory access... offers phase modulation recording with internal parity generation and checking... is word addressable with 17.3msec average access (sequential words at 36µsec).

Your application demands even higher transfer rates? Then we'll build into your 1264B bit, byte or word parallel data format. All of this... plus electronic switching... and you still pay less than 5¢ per word.

NEW PRODUCTS

MAGNETIC TIMER

A field-programmable magnetic timer was designed to perform a wide variety of timing and sequencing operations in the most demanding aerospace environments. Weighing only 5 pounds, the unit provides discrete timing and interval stepping for 12 sequential events and features complete field-programming capability of all 12 intervals. It can be kept in stock and programmed as needed to meet specific requirements, thereby reducing lead time. A resistor matrix employs interchangeable plugs readily accessible behind a removable panel. By the appropriate placement of these hand-insertable plugs at each of 168 intersections, the entire program can be set up very quickly for all 12 events. A combination of core transistor logic elements and magnetic commutator elements are used to perform all logic and control functions. A low-frequency magnetic core oscillator serves as the master time base and 14-stage presettable magnetic core binary counter determines the time duration of each event. A plugboard programming matrix controls the countdown duration of the binary counter for each of the 12 desired time intervals between successive relay contact transfers. A 13-stage magnetic shift register/relay driver combination is used to trigger the latching doublethrow relays at the conclusion of each time interval and is also used to preset the binary counter for the next event time. Di/An Controls, Incorporated, Boston, Mass.

DIGITAL STRIP PRINTER

A digital strip printer, priced at less than $300, prints a single line along a ½"-wide paper tape featuring a full complement of 64 alphanumeric characters. The Model 120A strip printer measures only 3" W x 6½" H x 8¾" D and weighs less than 5 lbs. Franklin Electronics, Inc., Bridgeport, Pa.
PHOTOSENSORS

Two miniature photosensors have been developed for use in tape and card readers, optically-coupled circuits, encoder-decoders, character recognition devices, and process control applications. Both units are silicon and feature planar passivation for long term device stability. The FPM-100 phototransistor has a special response extending from 0.4 to 1.1 microns and features a maximum power dissipation of 75 mw at 25 degrees C. Collector current rises from a maximum dark value of 0.1 microamp to typical values in the range 1.5 to 2.5 milliamps upon illumination. Typical rise time is 3 microseconds. Packaged in a hermetically sealed cylinder with a diameter of 0.08 inches and length of 0.18 inches, the FPM-100 "reads" at the top end of the cylinder through a flat polished window.

By using a flat window, a divergence angle of 70 degrees has been obtained. The avoidance of any optical magnification eliminates the possibility of a hot spot developing to introduce random errors, and since the flat window is flush with the cylinder body, an array of units may be placed in physical contact with a moving tape without abrading the tape. Cross-talk is also said to have been eliminated by this feature. The companion photodiode, FPM-200, is packaged in the same cylindrical welded case. The dark current maximum is 25 nanoamps and the light current minimum is 13 microamps when illuminated with a source of radiation equivalent to 15 mw/cm² at a color temperature of 2670 degrees K. Rise time for the FPM-200 is typically 3 microseconds. Fairchild Semiconductor, Mountain View, Cal.

Circle No. 121 on Inquiry Card

TIME CODE GENERATOR

With 13 simultaneous serial code outputs, a new time code generator was designed to provide precision standards for time-correlating data from magnetic tape recorders, visual recorders, cameras, digital printers, and computers. The generator accumulates time from a high stability crystal oscillator and provides the capability of close synchronization to external time standards such as radio station WWV or a high-stability external frequency standard. The basic unit generates seven serial time codes, and the associated circuits, mounted on a standard module chassis. Vermont Research Corp., No. Springfield, Vt.

Circle No. 151 on Inquiry Card

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ELIMINATE PAPER TAPE PROBLEMS WITH DIGI-STORE® DS-2 MAGNETIC TAPE UNITS

BIDIRECTIONAL . . . ASYNCHRONOUS
• Speeds up to 333 characters per second.
• Operates in either write or read mode—can replace both tape punch and reader.
• Lower initial cost than high-speed punches.
• Handles any code up to 8 levels.
• 8 times more packing density than paper tape—less tape bulk—no chad problems.
• Less tape handling cost—DS-2 tape can be reused thousands of times without erasing.
• Compatible with conventional paper tape digital data handling systems.

- Plug-in interface logic available to suit individual requirements.
- High reliability — all-solid-state circuitry — only one main moving part — less downtime — reduced maintenance cost.

WRITE TODAY FOR DS-2 TECHNICAL DATA AND SPECIFICATIONS

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CIRCLE NO. 60 ON INQUIRY CARD

NEW PRODUCTS

DIGITAL CONTROL MODULES

Factory-stocked to aid designers of direct-digital controls, data printers, XY plotters, counters, incremental tape and other digital systems, a line of step-servo control modules plug in between a serial pulse train and a stepper motor bidirectionally. Three different models have 0.7, 1.5, and 5.0 amp current-carrying capabilities.

IMC Magnetics Co., Westbury, N.Y.

CIRCLE NO. 177 ON INQUIRY CARD

NO-DRIFT SCOPE

Push-button controlled oscilloscope is said to be entirely free of dc drift. Every major function is programmable by external circuit closures. Settings for any desired series of wave-form observations may be pre-selected, displays presented in rapid order, and repeated exactly. With drift eliminated and correct settings assured, testing is fast and errors are reduced. The Model 155A oscilloscope is a 5 mv/cm, MHz instrument with illuminated push-button controls. A companion to the oscilloscope, the Model 1550A programmer has 18 buttons, each of which will, at one touch, select an entire set-up on the scope. The preset combination will include not only sensitivity, sweep, and offset (i.e., vertical position), but also input coupling (ac or dc), trigger source, and trigger slope. Programs are determined by the position of plug-in diodes in the programmer’s circuit boards. Programmers may be cascaded, extending the number of available programs without limit.

Hewlett-Packard, Palo Alto, Cal.

CIRCLE NO. 173 ON INQUIRY CARD
NEW NIXIE TUBE

A Nixie tube of new design and construction, which will sell for $4.95 in quantities of 1000, is a side-viewing tube with a 0.750" maximum bulb width for 0.8" center-to-center spacing and a 0.6" character height in a bulb only 1.8" maximum height. The stem of the new tube has been designed to afford maximum printed-circuit line width and spacing of the associated circuitry, permitting high printed-circuit board packaging density. New sockets which permit flush mounting of the tube for up-front viewing are available for wiring applications and printed circuit applications. Internal, independently-operable decimal points which are positioned on both sides of the numeral are an optional feature of the tube. Another version of the tube providing “plus” and “minus” indication is also available. The new Nixie is expected to replace many other kinds of numerical readouts, such as projection and electro-luminescent types, in numerous applications because of its simple operation, brightness, long life, and lower cost. Burroughs Corp., Electronic Components Div., Plainfield, N.J.

Circle No. 185 on Inquiry Card

DIGITAL TRANSMISSION LINES

Supplied as complete cable assemblies with connectors, new high-frequency transmission lines were designed especially for such applications as transmission of digital data in computers. Offering consistent impedance characteristics, these 93-ohm dual lines have 20 pairs of conductors, terminated in a double row of 0.050" center distance connectors. Cable assemblies are constructed of 33 gauge round silver-plated copper wire and are insulated with homogeneous TFE Teflon. The dual line assemblies are 0.028" thick by 1 inch wide. Digital Sensors Inc., Los Angeles, Cal.

Circle No. 143 on Inquiry Card

DECIMAL PROGRAMMER

New, 60-position, decimal plugboards with 16 decimal digits for each square inch of panel face can be used as 60/1-digit switches, 30/2-digit switches, or 20/3-digit switches. Bussing between common input and output signal lines is accomplished in a simplified manner. Space is provided behind each module for mounting isolation diodes eliminating holding pins or remote diode mounting. Applications include decimal memory, decimal-oriented program control, decimal format control, temperature limits, voltage limits, counter presetting digital control, time code generation, analog comparison, and pulse pattern detection and generation. Spring loaded pins of varying lengths provide the switching capabilities. Molded finger tip pins are permanently numbered 0 through 9 for value identification. The panel mounts in a cutout 1.81" wide by 2.72" high. The frame face is 2.30" wide by 4.21" high. Verselector Co., Burbank, Cal.

Circle No. 127 on Inquiry Card

Rotron brings a new DIMENSION for LOW PROFILE cooling applications

A fan that’s just 3¼” square — fits standard 3½” rack panel. Delivers big 35 CFM of air at free delivery. Pressure characteristics better than larger conventional fan designs. Optimum performance. .05 to .075 inch water at 25-30 CFM. Double flange construction for universal flush mounting. Low maintenance. Costs as low as $5.85 in quantity.

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RAYTHEON

NEW PRODUCTS

PLUG-IN IMPULSE DISPLAY

Impulse-actuated and magnetically-detented display was especially designed for miniaturized readout applications in computer and data annotation systems. Called the Logicator II, it is described as a fast-acting readout module available in integral packages of from three to eight units, each of which is independently operated through a three-wire system by computer or converter codes. Each modular wheel has 12 positions: 10 for 0-9 numerals, and 2 for letters or symbols. Inherent memory magnetically holds all readout positions without any power input until change pulses are received. Plug-in nature of the individual wheel modules, which are immediately accessible behind the assembly faceplate, facilitates almost instant replacement of damaged modules or substitution of other desired readout configurations. Total response time is half a second, maximum, for adjacent numerals; and one second, maximum for numerals requiring 180° of wheel rotation. Each wheel requires 1.5 watts of 24 vdc pulsed power. A five-wheel assembly case measures 1.937" across the reading face, 0.9" in height, and 2" in length. Bowmar — Fort Wayne Div., Fort Wayne, Indiana.

Circle No. 155 on Inquiry Card

DATA PRINTERS

New printers are parallel-entry recorders capable of printing a line of 20 characters at the rate of two lines per second. Standard inputs are low-level 8421 BCD codes. Standard characters are the ten decimal digits, a minus sign, and a blank space. Units are designed for continuous operation in industrial and scientific systems. Standard, solid-state plug-in modules are used to increase serviceability; the modules are also available for implementing custom logic designs. Control Equipment Corp., Needham Heights, Mass.

Circle No. 135 on Inquiry Card
IC CARDS

Both TO-5 and flat pack types of integrated circuits can be breadboarded on new integrated circuit cards. These cards are of gold-plated glass epoxy with flat pack mounting tabs on one side and TO-5 pads on the other. Six integrated circuits can be intermixed on the boards in any combination. Price of the new integrated circuit cards is $4.95 each in lots of 50-99. Triad Distributor Div., Litton Industries, Huntington, Ind.

Circle No. 167 on Inquiry Card

SCIENTIFIC CALCULATOR

A solid-state, desk-top instrument was designed for high-speed engineering and scientific calculations. The new unit is said to provide the engineer and researcher with an extremely flexible, relatively low-cost tool for performing a broad range of normally tedious and time-consuming calculations. It can execute all normal arithmetic operations (+, −, ×, ÷) within a fraction of a second. In addition, it has the capability of providing, with a single keystroke, the square, square root, natural logarithm, and exponential of any number previously entered or calculated. All data entered are automatically converted to natural logarithms, are operated on in this form, and then are reconverted to decimal form for readout. This process greatly simplifies and speeds the internal arithmetic of the instrument, and extends its capabilities substantially beyond those of any other device within its price range, according to the company. The Model 320 consists of a small keyboard-and-display console scarcely larger than a telephone, together with a compact electronics package (less than 1/2 cubic foot in size) which can be placed in any convenient location up to 200 feet from the console. Entries and results are displayed instantaneously on the console. The Model 320 with one keyboard and electronics package is priced at $2095, and additional keyboard units list for $495 each. Wang Labs, Tewksbury, Mass.

Circle No. 134 on Inquiry Card

INFORMATION SYSTEMS SCIENTISTS AND ENGINEERS

Bendix Research Laboratories has excellent career opportunities for B.S., M.S., and Ph.D. graduates with 2 to 15 years experience in one or more of the following key areas:

- **ARTIFICIAL INTELLIGENCE**, pattern recognition, trainable systems, adaptive logic.
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- **DIGITAL COMPUTER DESIGN**, systems analysis, logic and circuit design, real-time computer control.
- **ANALOG COMPUTERS AND SYSTEMS**, information theory, control theory, circuit and servo analysis, correlation techniques.
- **REAL-TIME COMPUTER PROGRAMMING**, mathematical analysis, scientific computing.

Assignments involve research and development in automatic extraction of information from photographic records, image processing and analysis, adaptive and trainable control systems, digital and hybrid computing techniques, and advanced real-time computer control applications.

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— Express individual initiative and action.
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— Attain a sense of accomplishment by undertaking projects from design to operating hardware.

If this challenge interests you and you qualify, we want to talk to you!

Sr. Systems Engineer
To develop advanced systems concepts for NASA meteorological satellite program. Must have MS or PhD in EE or Physics with 5 or more years experience in systems analysis, logic design, hardware development of missile and/or satellite guidance and control systems employing computer and telemetry networks.

Systems Engineers
To perform systems design of interface equipment to adapt CalComp plotting equipment to the new generation of computers. Must have experience in digital logic and circuit design of computer systems and I/O equipment.

Circuit Design Engineers
To perform design of digital circuits. Must be experienced in integrated circuit specifications, application and test requirements.

Sr. Mechanical Engineer
BS or MS in ME with 5 or more years experience in mechanisms design and dynamic design analysis of peripheral computer equipment; i.e., magnetic tape transports, printers, plotters, etc.

Contact or send resume to T. E. HARDY (714) 774-9141

CALCOMP

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CIRCLE NO. 901 ON INQUIRY CARD

NEW PRODUCTS

MATRIX PROGRAM BOARDS
New 3-D program boards with rigid 0.106 dia. 2-D and 3-D pins, shorting and coaxial type, are said to widen the function of matrix switching. Crosspoints are on 3/16" centers. Full line interface contact of pin to closed entry contact strips provides reliable electrical characteristics. Standard matrices from 100 to 625 crosspoints are offered; custom units to 11,000 crosspoints are also available. These program boards have been used as variable diode matrices, systems interfaces, computer memories, circuit selectors, and variable process programmers. CO-ORD Switch Div. LVC Industries Inc., Corona, N. Y. Circle No. 181 on Inquiry Card

PHOTOELECTRIC KEYBOARD
A completely solid-state photoelectric keyboard can be adapted to almost any encoding and power requirement. The keyboard utilizes long-life lamps which excite an arrangement of photo-sensitive devices. When a key is depressed, a given arrangement of shutters, unique to that key, blocks the light path to a series of phototastic sensors, and initiates a delayed clock pulse. Data cannot be released for external use until this delayed clock pulse has been accomplished, thus eliminating ambiguous codes. Keys are in modular rows and each row can generate eight bits plus a clock pulse. Keys are spaced on multiple centers of 0.750 inch, both horizontally and vertically, to any customer arrangement. Quantity of keys per row and number of rows per keyboard are controlled by the customer's configuration. This button spacing feature and the modular row approach means that a wide range of "special" keyboards can be implemented quickly and economically. This solid-state keyboard is said to offer other advantages over its electro-mechanical counterparts including extremely high reliability since only one mechanical part per key travels, and switching is accomplished by the presence or absence of light on highly reliable solid-state sensors. MTBF of the lamps is above 20,000 hours. An added feature of the keyboard over its electro-mechanical counterpart is the nine output connections to be wired, against possibly hundreds of connections on an electro-mechanical keyboard. Telemetries Div., TMC, Santa Ana, Cal. Circle No. 153 on Inquiry Card

COMPUTER POWER SUPPLIES

Rack-mounted dc power supplies have been developed primarily for use with data processing, computer, and automation equipment. Available in single and multiple output configurations, they offer such options as overvoltage protection, voltage margining, energy storage, and instantaneous turn off during a short circuit to prevent burn-up of logic wiring. Standard specs include input range of 100-130 vac, 47-63 cps, regulation of 0.1% for fluctuations of line and load, ripple 1 mv rms maximum, and transient response of 40 microseconds. Output voltages up to 100 vdc, and currents up to 50 amps, are available. Powertec, Inc., Van Nuys, Cal. Circle No. 180 on Inquiry Card

LOGIC CARDS

A new logic card with two adjustable fast recovery one-shots is capable of operating in a temperature range from -20° to +70° C. Pulse width stability in this range is ± 0.06%/° C. Both circuits can be adjusted by potentiometers mounted on the 1/16 inch thick, flame resistant, glass impregnated epoxy board. With a nominal pulse width of 25 usec. ± 10 percent, the one-shot's maximum pulse with an external capacitor is 10 seconds. AC set input loading is 2.5C per input, amplitude is 10 ± 2 volts, and rise time is 0.5 usec. maximum. DC set and reset input loading is 1.5N per input, with an amplitude of -10 ± 2 volts and a duration of 5 usecs. maximum. Wyle Laboratories, El Segundo, Cal. Circle No. 145 on Inquiry Card
SJCC INTERVIEWS

... at Honeywell EDP’s nearby facilities, or at the Convention hotel in Boston, may be arranged by calling Mr. Edwin Barr at 266-7128 during SJCC or 891-8400 prior to your arrival.

Take full advantage of this dual opportunity, meet and talk with our senior technical staff about the present and future career positions at Honeywell EDP, and accept their invitation to visit Honeywell’s suburban Boston facilities.

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SYSTEMS ANALYSIS
TERMINAL EQUIPMENT
DESIGN
MASS STORAGE
DEVELOPMENT
DESIGN AUTOMATION
PROGRAMMING
DIAGNOSTIC
PROGRAMMING

If an interview during the SJCC is not convenient, forward your resume to Mr. Edwin Barr, Employment Supervisor for prompt consideration.

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ARE YOU AWARE OF OPPORTUNITIES . . . IN INDUSTRIAL COMPUTER TECHNOLOGY

The field of industrial computers has mushroomed on a national and international scale. In fact, it is one of the fastest growing of the whole computer industry and presents a highly sophisticated real-time hardware and software challenge. The Foxboro Company, over 50 years a leader in industrial controls, is at the forefront of industrial computer technology. Designing systems to meet the growing demands of non-defense industries, such as chemicals, petroleum, power and paper, presents new challenges which in many cases have never before been tackled. We invite you to learn more about us and determine how your experience can add strength and leadership to our capabilities.

DEVELOPMENT ENGINEER — CIRCUIT DESIGN

BS or MSEE with 3-5 years’ experience in digital circuit design. Emphasis on integrated circuits is desirable. Some knowledge of logic design, programming, and computer organization is required. Will participate in the design and application of solid state digital and analog circuits as applied to computer control systems and related products. Also, the design of advanced I/O equipments which interface digital computers.

DIGITAL PROJECT ENGINEERS

BSEE with training in computer technology. At least two years’ experience in computer applications, with knowledge of logic design, programming, and proven ability in project engineering. Responsible for equipment specification and design on customer projects.

SYSTEMS ENGINEERS

BS or MS in engineering. Minimum 3 years’ experience including project engineering, programming, instrumentation, application of digital computer equipment, system start-up, and customer negotiation. Ability to define system specification, design, checkout, etc. Technical decisions on application requirements, manpower capabilities, time and cost. Principal technical responsibility for customer projects.

PROGRAMMERS & SENIOR PROGRAMMERS

Engineering or Scientific degree desired with systems programming ability. At least 2 years’ solid programming. Mathematical analysis and process control experience plus knowledge of assemblers and compilers is desirable to handle industrial process control problems.

SENIOR DEVELOPMENT ENGINEER — DIGITAL CIRCUIT DESIGN

BSEE with 4-6 years’ experience in circuit design of high speed digital circuitry above 2 megacycles. Emphasis on integrated circuit design application. Should have background in noise, signal propagation and all logical element design problems. Proven ability to handle project efforts in circuit engineering. Contributes to system logic organization for analyzing optimum logic and circuit configurations.

SENIOR SYSTEMS ANALYSTS

Computer process control. Advanced ME or ChE degree preferred. Must have 5-10 years’ experience in chemical, refinery or power plant computer automation. Simulation and process modeling experience desirable.

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TYPE 4002/3
Bi-directional, high speed reader-spooler combination. Desk Top Reader also available.

TYPE 260 MILITARIZED
Lightweight reader reads tape from an endless loop magazine at speeds up to 100 characters per second.

TYPE 422 MILITARIZED
Solid state design. Bi-directional operation at speeds of 300 and 600 characters per second.

TYPE 228A MILITARIZED
Processes punched tape at an average speed of 620 characters per second.

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The field of industrial computers has mushroomed on a national and international scale. In fact, it is one of the fastest growing of the whole computer industry and presents a highly sophisticated real-time hardware and software challenge. The Foxboro Company, over 50 years a leader in industrial controls, is at the forefront of industrial computer technology. Designing systems to meet the growing demands of non-defense industries, such as chemicals, petroleum, power and paper, presents new challenges which in many cases have never before been tackled. We invite you to learn more about us and determine how your experience can add strength and leadership to our capabilities.

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Engineering or Scientific degree desired with systems programming ability. At least 2 years’ solid programming. Mathematical analysis and process control experience plus knowledge of assemblers and compilers is desirable to handle industrial process control problems.

SENIOR DEVELOPMENT ENGINEER — DIGITAL CIRCUIT DESIGN

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LITERATURE

Digital Instruments


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Digital Plotting Systems

16-page bulletin summarizes the characteristics of a plotting system. The literature also presents pertinent points of consideration in the evolution of plotting systems and provides comparative specifications on various models. California Computer Products, Inc., Anaheim, Cal.

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Indicator Lights

A 16-page catalog presents a wide array of miniature and large indicator lights (many of which meet or exceed the requirements of MIL-L-3661) for use with neon or incandescent light sources and tamper-proof open-type assemblies and lens caps for panel mounting. Covered are indicator lights for mounting in 9/32", 7/16", 11/16", and 1" clearance holes — each fully documented with data, materials and finishes, and catalog number charts to simplify selection and procurement. Hot-stamped or engraved legends are available with many series for readout applications. Lamp charts listing appropriate lamps for use with any given indicator light are included. Dialight Corp., Brooklyn, N.Y.

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Pulse Generator

Variable linear rise time to 4.0 ns, variable baseline level, rep rates to 40 mc, and other features of a new pulse generator are illustrated with waveform photos in a technical bulletin. Datapulse Inc., Inglewood, Cal.

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Stepping Switches

A 34-page stepper catalog contains a concentrated “short course” for designers of multiple circuitry. Included are photographs, working drawings, specs, and operating data. Special sections include application guides, stepper terminology, a guide to stepper selection, and ordering information. Guardian Electric Mfg. Co., Chicago, Ill.

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Dual Output Supply

Data sheet describes a dual output power supply designed to meet the requirements of MIL-E-16400 and intended for use in instrumentation and systems in ground support applications. The power supply operates from a 115 volt 60 cps source and delivers dual outputs of +26 to +30 volts and -26 to -30 volts at up to 6 amps, both highly regulated to within 0.1% for a ±5% line or load swing. Chatham Electronics, Div. of Tung-Sol Electric Inc., Livingston, N. J.

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Four-page bulletin describes a new line of automatic voltage regulators which provide closely regulated ac output voltages from varying input voltages. The units utilize solid-state control to maintain a pre-selected output voltage level within an accuracy of ±1 percent. They can be cabinet or relay rack mounted. General Electric Co., Schenectady, New York.

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**IC Guide**

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**PC Reed Switches**

An 8-page specification and application data booklet describes and illustrates a complete line of printed circuit dry reed switches called Correeds. Dimensional diagrams are used to illustrate ten basic forms. Corresponding tables list coil resistance and turns, the operate-release-maximum voltage for nominal dc voltages, and indicate those modules available directly from stock. Technical information includes timing curves and explanations of the use of magnetic biasing. Automatic Electric Co., Northlake, Ill.

Circle No. 202 on Inquiry Card

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ADVERTISERS' INDEX

AMERICAN TELEPHONE & TELEGRAPH
AMP, INC. ........................................ 12, 13
Baird-Atomic, Inc.
Electronic Products Div. .................. 8
The Baker Co., Inc. ......................... 78
Barnes Development Corp. ................. 77
Bendix Corp.
Research Laboratories Div. .............. 87
Boston Technical Publishers, Inc. ..... 93
Bryant Computer Products ............... 14
Burroughs Corp. .......................... 13, 94
California Computer Products ......... 1, 88
Chicago Miniature Lamp Works ....... 66
Computer Control Co. ................. Cover 2
Computer Test Corp. .................. 32
Connecticut Technical Corp. ......... 66
Consolidated Ohmic Devices, Inc. .... 65
Contemporary Electronics .............. 27
Data Machines, Inc. .................. 38
DataMec .................................. 71
Decision Control, Inc. ................. 4
Di/An Controls, Inc. ................ 59
Digi-Data Corp. .......................... 54
Digitronics Corp. ......................... 10
Dynamics Research Corp. ............. 79
Electronic Engineering Co. of California
Electronic Memories, Inc. .............. 29
Fabri-Tek, Inc. ........................... 9
Fairchild Semiconductor ............... 64
Ferranti-Packard Electric, Ltd. ....... 90
Foxboro Co. ................................. 90
Franklin Electronics, Inc. .......... 76
General Dynamics
Electronics Div. ........................ 91
General Instrument Corp. .............. 11
General Precision, Inc.
Librascope Group ........................ 35
A. W. Haydon Co. .................. 73
Honeywell EDP .......................... 89
IBM ........................................ 5
IMC Magnetics Corp. ................... 34
Industrial Electronic Engineers, Inc.
Invac Corp. ................................. 69
Litton Industries, Inc.
Encoder Div. ............................. 17
Manpee Data Link Div. ................ 36
Lockheed Electronics ..................... 36
MB Associates ............................ 70
Magne-Head
Div. of General Instruments .......... 37
MEPCO, Inc. ............................... 55
Microsonics, Inc. ....................... 72
Midwestern Instruments ............... 16
Mite Corp. ................................. 70
Mosaic Fabrications, Inc. ............. 86
Motorola Semiconductor ................. 41
NCR Co.
Industrial Products Div. .............. 28
Polaroid Corp. ........................... 74, 75
Potter Instrument Co. ................. 48, 49
RCA ........................................ 33
Raytheon Co.
Components Div. ..................... 6, 7
Raytheon Computer ....................... 86
Rotron Mfg. Co. ......................... 83, 85
Royal Typewriter Co. ................. 2
Raytron .................................. 2
Sanders Associates, Inc. ............. 78
Scientific Data Systems, Inc. ....... 31
Sealed Corp. ............................... 67
Tally Corp. ................................. 92
Teletype Corp. .......................... 19, 21, 22
Texas Instruments Inc. ............... 81
Trak Electronics Co., Inc. ............ 84
United States Motors Corp. ........... 40
Vermont Research Corp. ............... 82
Walden Electronics Corp. ............. 87
Wakefield Engineering Inc. .......... 29
Western Union ............................. 94
Xerox Corp. ............................... 95
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