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![Diagram](image)

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CONTENTS
 Data Processing in the NY Common IFR Room (COVER STORY) Robert H. Anderson 6
 Executive Routine Jerome T. Murray 30
 Documentation in a Financial Environment F. Stuart Magie 32
 Checkmate 40
 New Products 41
 Adventures in Fortran for Fun and Profit . 42
 The Marketplace (Classifieds) 43
 S/A Confidential Inquiry Form 45
 Index to Advertisers 46

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The rapid growth of aviation activity has created a need for improved air traffic control capabilities. Recent improvements in air traffic control systems have been directed toward achieving increased efficiency in the utilization of airspace, and increased traffic-handling capability with no compromise to safety. A significant development is the introduction of automatic data processing techniques to provide direct assistance to the air traffic radar controller.

Through radar observation, pilot reports, and flight plans the controller follows those aircraft on instrument flight rules (IFR) in his area of jurisdiction. He keeps the aircraft safely separated by voice radio instructions to the pilots. As a flight progresses through various sectors of the airspace, control responsibility for the aircraft is transferred (handed off) from one controller to another.

The airspace surveillance required by an air traffic control ground facility is provided by radar and beacon sensor systems. The radar and beacon equipment both derive aircraft position (azimuth and slant range) information from the antenna orientation and the time delay between transmitted and received pulses of r-f energy. Whereas the radar receives reflected energy, the beacon equipment triggers and receives signals from a transponder aboard the aircraft. The transponder reply signals can be coded to convey aircraft identity and altitude. However, the sensor data must be presented to the controller in such a manner that he can readily assimilate it. The conventional radar plan position indicator (PPI) has several shortcomings:

1. The controller has to deter-
mine which video returns (blips) on the radar scope correspond to aircraft of interest to him.

2. He must then keep the identity of each aircraft properly associated even in congested traffic or clutter areas where many video returns appear in proximity.

3. With the radar PPI he has a two dimensional representation. Altitude, the vital third dimension of the air traffic situation, is missing.

To alleviate these shortcomings, the FAA has developed a computer-assisted display technique that provides a dynamic display of flight data, in alphanumeric (letters and numbers) form, directly on the radar scope. This technique provides the controller with aircraft identity and altitude information continuously associated with the proper video returns. A prototype system, the advanced radar traffic control system (ARTS), has been in operation for several years at the terminal facility in Atlanta, Georgia.

A second installation, the New York Center beacon alphanumeric (NYCBAN) systems, located at the FAA air route traffic control center (ARTCC) on Long Island, was put into operation early in 1967. A new control facility, serving the New York terminal area, is now opera-
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ional. It is the data processing capability of this facility, the Common IFR Room, that is the subject of this article.

**Common IFR Room.** The New York terminal area is one of the busiest air traffic control complexes in the world. It encompasses three major airports and numerous satellite airports each of which accommodates instrument flight traffic. The control of terminal operations has been divided among three separate control facilities with a portion of the available airspace assigned for the exclusive use of each. The operating quarters (IFR Rooms) have been located at Kennedy International, Newark, and LaGuardia Airports.

These installations are being combined to provide a common centralized terminal area control facility located at Kennedy International Airport. A common IFR room will permit more efficient utilization of airspace, and will minimize delays by providing flexibility in the routing and control of flights. From this central control room, arrival and departure operations at all of the airports can be controlled on a fully integrated basis. Since controllers for the different airports work side-by-side in the same room, it becomes much simpler to coordinate their actions. It is not necessary to waste valuable airspace to provide buffer zones between operations controlled by separate facilities. Furthermore, personnel controlling aircraft in the same general proximity actually share the same displays, including large-screen displays, which provide a common reference source for all control teams.

The individual controller radar scopes and two large-screen radar displays are all augmented with alphanumeric capability. Under computer control, pertinent flight data, including aircraft identity and altitude, is electronically superimposed as tag-like data blocks adjacent to the appropriate radar video returns (see Fig. 1). The alphanumeric tags automatically follow the video while the aircraft maneuver through the terminal area.

There are significant advantages in having identity and altitude continuously associated with the radar presentation. Even a skilled controller, adapt at interpreting the radar picture, presently expends considerable effort just to identify the video returns of aircraft under his control. He also relies on pilot reports for altitude information. The amount of attention and communication required increases rapidly with the number of radar targets involved. By assisting the controller in this task, the alphanumeric display system permits him to focus more of his attention on the problem of controlling aircraft. In addition, it reduces the amount of controller-pilot communication required.

A secondary benefit is the manner in which this display technique facilitates aircraft handoffs within the Common IFR Room. When responsibility for an aircraft is transferred from one man to another, the controller initiating the handoff...
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pushes a button to cause the tag for the aircraft to appear on another controller's display. The recipient then pushes a button to signify that he has accepted control of the aircraft. Permanent transfer of control is accomplished by the computer, with little or no verbal exchange of aircraft data.

**System Configuration.** The hardware for the Common IFR Room system includes data acquisition equipment, display equipment, and a computer complex (Fig. 2).

**Data acquisition equipment—Surveillance of the volume of airspace comprising the New York terminal area is provided by radar and beacon sensors (Fig. 3) located at two sites: Kennedy and Newark Airports. Each site is equipped with an airport surveillance radar (ASR-4) and a beacon interrogator (ATCBI-3). The radar and beacon systems provide a 60-mile radius of coverage from each site. Wideband transponder-equipped aircraft operating in the United States are limited to 64 codes, and the system is designed to handle up to 64 transponders simultaneously. Transponders are generally coded with a four-digit number, which is used to identify the aircraft and its location. Transponders are automatically monitored by the radar and beacon systems, which can transmit any one of 4096 discrete identity codes as selected by the pilot.

In Fig. 4, alphanumerical video and scan-converted radar and beacon video are mixed to provide a composite TV display. The Common IFR Room will be equipped initially with 8 RDDE-5s and two large-screen displays.

---

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February, 1969
Fig. 5—The tracking processor tracks aircraft by means of target reports from the data acquisition equipment. Alphanumeric flight data originating at the ARTCC (or introduced by the controllers) is supplied to display equipment by display processor. Switching equipment (not shown) permits reconfiguration for single-computer operation.

porting transmit data that is encoded directly from a pressure-sensing altitude transducer in the aircraft. The transmitted altitude data is measured in 100-ft increments with respect to a standard pressure of 29.92 inches mercury.

Analog radar video, although suitable for PPI displays, cannot be used directly by the digital computer complex. Therefore, a radar video digitizer (RVD) is employed for each radar to convert the analog data into digital form. The RVD quantizes the video signal, correlated with successive radar pulses, detects radar targets, and determines target range and azimuth. It provides the computer with target reports in digital form containing the range and azimuth of each detected target.

Beacon replies are in the form of coded pulse trains. Like radar video, these signals are unsuitable for direct processing by a computer. For each beacon system, a beacon video digitizer (BVD) isolates the replies, correlates replies from successive interrogations, detects beacon targets, and determines target range and azimuth. For each detected target, the BVD provides a digital target report to the computer. In addition to range and azimuth, the target report includes transponded identity code and altitude when this information is received in ungarbled form.

Display equipment—The Common IFR Room is equipped with radar bright display equipment (RBDE-5) modified to include alphanumeric capability (Fig. 4). In addition, the standard 22-inch and 16-inch display consoles are supplemented with large screen projection displays. Eight individual consoles and two 9-by-12-ft display screens provide a composite picture of radar and beacon video and computer-processed alphanumeric flight data.

The radar display utilizes a storage tube scan-conversion principle whereby the sensor video is converted from its original polar (range and azimuth) form into a television-type rectilinear scan before it is displayed. The resulting bright high-resolution (945 lines) presentation does not require a low ambient light environment usually necessary with radar displays. Since each display unit is essentially a TV monitor, alphanumeric data originating in the computer complex must be changed into TV form before it can be displayed. This task is performed by an alphanumeric generator, which accepts coded digital data from the computer complex and converts it into TV form signals. Alphanumeric TV signals from the generator are then mixed with radar and beacon TV signals from a scan converter, and the resulting composite is dis-
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played. The alphanumeric generator has twelve independent alphanu-
meric video channels individually addressable by the computer com-
plex. Each display console or large screen projector receives and dis-
plays flight data blocks from one or more alphanumeric channels. In ad-
dition, common data, in the form of single symbols at the position of
each controlled aircraft in the system, is distributed to all display
channels.

The displays are updated by the computer complex every two-and-
one-half seconds to provide a dy-
namic picture of air traffic. Between
times, the current alphanumeric
video for each display channel is
recorded on a magnetic drum within
the alphanumeric generator. This
video is then played back cyclically
in synchronism with the TV raster
to maintain a flicker-free display.

The manual controls that are present at each operating position enable
the controller to introduce commands, alphanumeric data, and
aircraft position coordinates into the computer complex. These controls
include command pushbuttons, an
alphanumeric keyboard and a cursor
control. Nine broad command cate-
gories are defined for use by con-
trollers in the Common IFR Room,
and each can be further qualified
by up to ten specific modifiers,
called functions. Supplemental data, such as aircraft identity or assigned
altitude, is entered through the al-
phanumeric keyboard when required. The cursor control is used to
position a small movable cursor
symbol on the display. The position
coordinates of this cursor symbol
can be entered into the computer
for the controller to specify the loca-
tion of an aircraft or a data block.

Computer complex—The computer complex (Fig. 5) tracks the
tensor inputs, associates flight plan data with tracked aircraft, and sup-
plies alphanumeric information to the
controller displays. Two Uni-
vacs® 1219 general-purpose digital
computers provide the system with
a capability for arithmetic compu-
tation, logical decision-making, data
storage, and over-all system coor-
dination.

The computer complex includes other equipment items commonly
found in a data processing applica-
tion. Magnetic tape units provide
permanent storage for the computer
programs, and are used to load the
programs into computer memory.
In addition, selected data obtained
during system operation is recorded
on magnetic tape for future proc-
essing and analysis. The input–out-
put console, containing a low-speed
printer, typewriter keyboard, and
paper tape facilities is provided to
permit the watch supervisor to com-
municate with the computers. This
console, designated the supervisory
console, is used to enter variable
parameters (such as time or altim-
eter setting) required by the sys-
tem. High-speed printing and
punched card capability for the
1219 computers is provided by an
on-line 1004 card processor.

The computer complex is con-
ected to a teletype circuit, which
originates in the air route traffic
control center located at Long
Island–McArthur Airport. A com-
puter at the center transmits flight
plan data for future flights to the
Common IFR Room. The serial
teletype signal is converted into
parallel digital format by an adapter
and fed into one of the 1219 com-
puters. Automatic insertion of flight
plan data is a significant advance
over previous prototype alphanu-
meric systems, because it relieves
the controller of the task of manually
entering this data via a keyboard.

Data is transferred between the
1219 computers and the other de-
vices by means of high-speed digital
input or output channels. Each com-
puter has 16 bidirectional channels
to accommodate concurrent com-
munication with all of the hardware
in the computer complex as well as
with the data acquisition and dis-
play equipment. The system con-
figuration has been made flexible
by a manual cable-switching ar-
angement that allows each exter-
nal device to be connected to either
computer. Normally both computers
share the data processing load. One,
the tracking processor, performs an
aircraft tracking function, while the
second, the display processor, pro-
vides alphanumeric data to the
display equipment. However, if one
1219 should be unavailable, the sys-
tem can be reconfigured to operate
with reduced capability in a single-
computer mode.

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it keeps pace with events in the air traffic environment. The tracking processor and the display processor, although they exchange data, are completely independent asynchronous computers. They execute their programs simultaneously, thereby providing a parallel processing capability. Within each computer, however, the internal processing tasks are performed on a time-shared basis. To accomplish this, the sequence of instructions associated with each major processing task is organized into a module called a subprogram. In addition, each computer employs an executive control subprogram that performs no processing of its own, but serves to control the execution of the task subprograms. The subprograms are not executed in a fixed sequence. Rather, selection of a task depends upon an assigned priority scheme that adapts to changes in the system’s processing load and permits the processor to respond to asynchronous external demands. Some tasks are executed on the basis of a fixed time interval, while others depend upon the completion of prerequisite processing or external events.

**Data Inputs.** The principal inputs to the computer complex are target reports, flight plans, and controller entries.

Target report messages enter the tracking processor through independent input channels from each of the four video digitizers. To facilitate efficient target report processing and tracking, each digitizer also transmits sector mark messages at 11.25-deg intervals of antenna azimuth rotation. Thus the 360-deg azimuth scan is divided into 32 segments of convenient size for segmented, real-time processing. Approximately once per sector (125 msec), all newly received target reports are examined for format and completeness. They are ordered by sector and stored in the computer’s core memory for subsequent use by

---

Fig. 6—Tracking. For correlation, the track is associated with the new sensor target report by beacon identity match or by position. Positioned correlation (a) finds target report R within bin, centered about predicted track position P. For correction, (b) present position C is calculated along with velocity vector V, using damping factors dynamically related to track-data reliability. For prediction (c) track is extrapolated along velocity vector to P', a scan period in the future. P' becomes new position of bin when track is processed on next scan.
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the tracking function. Depending upon the density and distribution of air traffic, and the presence of noise and clutter, numerous target reports may be received in some sectors and few in other sectors. However, sufficient storage is provided in the tracking processor to accommodate 48 target reports per sector from each radar digitizer plus 24 target reports per sector from each beacon digitizer. Because of the tracking technique, the reports received in the most recent sixteen sectors must always be available.

Flight plan messages received via teletype line from the New York ARTCC are automatically fed into the display processor. A flight plan includes aircraft identity, route, estimated time of arrival (ETA) or departure (ETD), aircraft type, approach fix, departure or destination airport, and assigned beacon code. The display processor verifies the format and content of the flight plans and stores them in core memory for future use. Since this data may be received considerably in advance of the flight arrival or departure time, the display processor provides storage space for 250 flight plans.

The ETA or ETD of each stored flight plan is periodically checked by the display processor. Ten minutes before the aircraft is due to arrive or depart, the flight plan data is examined and the computer determines which controller will be initially responsible for the aircraft. Although active tracking does not begin at this time, the computer assigns a track number, and causes the aircraft identity to be displayed in a tabular STORE list on the appropriate controller’s radar display. This informs the controller of the pending arrival or departure and allows him to plan for it.

Controller entries transmitted as digital messages originating at the controller data entry devices (keyboard, cursor, etc.), are channeled into the display processor. These messages contain category and function elements that describe the action desired by the controller as well as amplifying data in the form of alphanumeric and cursor coordinates. After the parity and format of a message is validated, the message is interpreted and executed by the display processor program. A controller entry affecting the
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tracking function is relayed by the display processor to the tracking processor.

Tracking. Each aircraft of interest to the Common IFR Room is automatically tracked by the tracking processor so that the alphanumeric data tags will follow the sensor video on the controllers' displays. Through scan-to-scan correlation of radar and beacon target reports, the tracking function computes dynamic position and velocity for each aircraft and associates flight data with the proper aircraft. As many as 250 aircraft can be tracked simultaneously. Tracking of each aircraft (target) is accomplished with the target reports from a single radar-beacon site. Aircraft under the jurisdiction of Kennedy and LaGuardia controllers are tracked utilizing only the Kennedy radar and beacon reports. Those under the jurisdiction of Newark controllers are tracked via Newark radar and beacon reports. This approach avoids inter-radar correlation difficulties resulting from antenna misalignment, propagation anomalies, and slant-range corrections.

Tracking (Fig. 6) is accomplished by associating new radar and beacon target reports with previous track information, determining the present position and velocity of the aircraft, and predicting where the radar should see it next. Three basic processes (correlation, correction, and prediction) are performed for every track once each radar scan.

The correlation process (Fig. 6a) determines which new target report is associated with a tracked aircraft. Correlation is accomplished primarily on the basis of positional proximity. A two-dimensional (range, azimuth) bin, or gate, is formed around the predicted position of the track. The new target reports are searched to find if any of them fall within the bin. In the ideal case, one, and only one, report is found, and unique correlation is achieved. Due to sensor and digitizer noise, aircraft maneuvers, and tracking compromises this does not always occur. Ambiguous situations are logically resolved by the tracking subprogram by comparison of the assigned and reported beacon codes, when necessary. During correlation, beacon reports are normally used in
preference to radar reports. Radar reports are used, however, when no valid beacon report is received or when the controller specifies that a particular aircraft is to be tracked by radar only.

The bin-size parameters depend upon the history of the track. An initial track, less than three scans old, requires a large bin to ensure correlation because its position and velocity are still unreliable. For a normal track, with a history of successful correlation, the bin becomes progressively smaller as the ability to predict future positions increases. However, if an aircraft with a normal track should perform a sudden maneuver, the next target report may fall outside the primary correlation bin. To enable the tracker to detect the maneuver and follow the aircraft, a secondary correlation procedure, utilizing a much larger bin, is attempted. Successful secondary correlation results in a trial track, which branches away from the original track. If the trial track then correlates on the succeeding scans, it becomes the main track, and the original is discontinued. Otherwise, the trial track is eliminated. The primary and secondary correlation bin sizes are optimized for aircraft having speeds less than 600 knots and turning accelerations up to 1 g.

As a result of correlation, either a track is associated with a unique target report or else unsuccessful correlation is indicated. In the former case, the target report is used to update the track data through a process called correction (Fig. 6b). The corrected position \((X_c, Y_c)\) in Cartesian coordinates is calculated by combining the predicted position \((Y_p, Y_p)\), which was obtained during the previous scan, and the reported position \((X_R, Y_R)\) from the correlated target report, as follows:

\[
X_c = X_p + \alpha (X_R - X_p) \\
Y_c = Y_p + \alpha (Y_R - Y_p)
\]

The factor \(\alpha\) is a smoothing parameter whose value \((0 < \alpha \leq 1)\) is a function of the previous history of a track. It determines how much the track position will be influenced by a new target report. Initially, a unity value of \(\alpha\) is used to make a track responsive to the reported data. However, as a track accumulates a history of successful correla-
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flight data is removed from the STORE area and displayed at the reported position. Active tracking will then be automatically initiated. Automatic acquisition of arriving aircraft occurs at a range of 45 to 60 miles. Departing aircraft are acquired several miles after takeoff.

Tracks are automatically terminated by the computer when they are no longer required. After prediction, the position of each track is checked to see if it satisfies the geographic criteria for automatic termination.

**Display Data.** The display processor transmits updated alphanumeric data to the display equipment every two-and-one-half seconds to provide the controller with a dynamic current picture of the air traffic situation. Flight data is presented to the controller in one of several formats depending on whether the aircraft is being actively tracked or is displayed in a tabular list. Each tag, tabular item, or single symbol to be displayed requires a digital message from the computer specifying the location, format, and content of the display data.

The location information in a digital display message can be specified in either of two x, y coordinate systems: display coordinates or system coordinates. Tabular data, positioned in display coordinates, appears at an absolute location on the display screen. The fixed 512 by 512 display coordinate grid is independent of the radar range-scale and off-center controls on the display. The radar-related alphanumeric tags and symbols, however, are keyed to a system coordinate grid. This grid, 2048 miles square, is entered at the Kennedy radar site. System coordinates, specified to the nearest 1/8 n.m., are referred to the southwest corner of the grid. Alphanumeric data in system coordinates, like the sensor video display, is sensitive to radar range-scale and off-center controls. Therefore, it remains in registration with the radar picture.

The alphanumeric tag, which accompanies an active track (Fig. 7a), is positioned according to coordinates predicted by the tracking processor. A leader connects the tag to a single symbol, which represents the tracked position of the aircraft. This symbol is an alpha character that uniquely denotes the cognizant controller. A velocity vector with length proportional to the calculated track speed may also be displayed by controller selection. The tag can contain as many as 21 alphanumeric characters arranged in three rows, each holding a maximum of 7 characters.

The top row displays assigned altitude and reported beacon altitude expressed in hundreds of feet. Also displayed in the top row, when necessary, is a controller-entered arrow which indicates that the aircraft has been cleared to climb or descend. When an arrow is not present, the display processor automatically monitors the beacon altitude reported by the aircraft. If it differs from the assigned altitude by 200 ft or more, a blinking square symbol is displayed to alert the controller to the altitude discrepancy. The altitude reported by the beacon transponder must be corrected by the display processor before it is displayed. For aircraft flying below 18,000 ft it is necessary to compensate for the difference between local barometric pressure and the reference pressure (29.92 inches Hg) used by the aircraft altitude sensor.


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The middle row of characters contains the aircraft identification. For a commercial airliner, this normally consists of the airline initials and flight number. The bottom row of alphanumerics is used to display information that is somewhat less significant to the controller. This row is time-shared to permit accommodation of four data items. Tracker-derived aircraft speed and controller-entered scratch pad data are displayed alternately for short periods of time (8–16 sec). The display of reported beacon code and computer-assigned track number is similarly alternated.

Directly above the alphanumeric tag there is space for the display of two horizontal bars. A solid upper bar is used to mark a track that requires special attention or handling. It is automatically displayed as an alert when the associated aircraft is transmitting an emergency beacon code. A dashed lower bar indicates that the track is involved in a hand-off action between controllers. A solid lower bar indicates that the track is being coasted on the basis of historical velocity information. The alphanumeric tag and leader can be offset in different directions from the track position symbol. To minimize the overlap of tags in congested areas of the display, the computer periodically checks the relative positions of all tags and adjusts the offset to reduce superposition of alphanumerics.

Each item displayed in the tabular STORE list (Fig. 7b) of pending flights consists solely of the aircraft identification. The list is automatically ordered according to the ETA or ETD of the flights. A second tabular display list is available when it becomes necessary for the controller to discontinue active tracking of flights assigned to a holding pattern. Each item in this HOLD list has a format consisting of two rows of alphanumerics (Fig. 7c). The data content is identical to the first two rows of the active track tag, except that an additional letter is included to denote the holding fix. HOLD items are listed according to their chronological order of entry. At the option of the controller, the STORE and HOLD lists can be located at any convenient place on the display screen.

Conclusion. The Common IFR Room and previous installations (ARTS, NYCABN) demonstrate the applicability of electronic data processing techniques to air traffic control alphanumeric display systems. The digital computer data handling and processing capabilities are sufficient to meet the real-time requirements of the most complex air traffic environment, as exemplified by the New York terminal area. Furthermore, a general-purpose computer with a stored program provides significant benefits in the form of system flexibility, which cannot be matched by special-purpose, fixed-logic hardware. The system can be improved by altering program instructions rather than redesigning equipment.
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Duties & Accomplishments

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<table>
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<tr>
<th>Previous Position</th>
<th>Employer</th>
<th>City/State</th>
<th>From</th>
<th>To</th>
</tr>
</thead>
</table>

Duties & Accomplishments

General Information

(Summarize your overall qualifications and experience in your field. List any pertinent information not included above.)

Current Annual Base Salary: [ ]

Total Years Of Experience: [ ]

Date Available: [ ]

Employed [ ]

Unemployed [ ]

Self-Employed [ ]

Level of Security Clearance:

| U.S. Citizen [ ] | Non U.S. Citizen [ ] | My Identity May Be Released To: | Any Employer [ ] | All But My Present Employer [ ] | No Employer [ ] |

National Manpower Register. 635 Madison Avenue, New York, N.Y. 10022

February, 1969

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EXECUTIVE ROUTINE
software age
2211 Fordem Avenue
Madison, Wisconsin 53701

— Your installation is large and unusual. Each of six departments has a computer dedicated to its needs. There are six computers in all and they share a common I/O device pool which is facilitated by switching units. The Operations Research department has just sent you a deck of punched cards with the request that they be put on magnetic tape using a special program which they have sent with the input cards. The OR department claims the run will take 2 hrs. 30 min., it is now 1:30 p.m. and the DP department closes for the day at 5:15. There is no overtime. You know the following:

1. Five computers are now processing.
2. A payroll is processing in the computer dedicated to the manufacturing department.
3. The program in the manufacturing department's computer is using the CRT for output.
4. The program that runs for 4 hrs. 30 min. receives OCR input.
5. The credit department's computer is immediately to the right of sales department's.
6. The program in the personnel department's computer will run for 1 hr.
7. A classification program is running in the computer next to the budget department's.
8. The program that runs for 4 hrs. outputs punched cards.
9. The sort program runs 30 min.
10. The computation program outputs on the printer.
11. The file update program receives input from a remote terminal.
12. A 3-hr. program is running in the computer next to the one whose program receives paper tape input.
13. The classification program is running in the first computer.
14. A 1-hr. program is in the computer next to the one whose program receives MICR input.
15. The program running in the credit department's computer outputs on disk.

You must determine which computer is using magnetic tape and which is using the card reader so that you can determine whether or not it is possible to run the program on the OR department's computer today. They want to know and they are asking YOU!

By starting with statement 13 and working systematically we can construct the table above. Computer 5 will free the card reader in 30 min. and the magnetic tape output will be free in 1 hr. The OR department's run can be accommodated comfortably this afternoon.

Let's take a closer look at the

<table>
<thead>
<tr>
<th>Computers</th>
<th>1</th>
<th>2</th>
<th>3</th>
</tr>
</thead>
<tbody>
<tr>
<td>Departments</td>
<td>Personnel</td>
<td>Budget</td>
<td>Manufacturing payroll</td>
</tr>
<tr>
<td>Programs</td>
<td>classification</td>
<td>computation</td>
<td>CRT</td>
</tr>
<tr>
<td>Output</td>
<td>magnetic tape</td>
<td>printer</td>
<td>four hours thirty minutes</td>
</tr>
<tr>
<td>Timings</td>
<td>one hour</td>
<td>MICR</td>
<td>OCR</td>
</tr>
<tr>
<td>Input</td>
<td>paper tape</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

SOLUTION

<table>
<thead>
<tr>
<th>Computers</th>
<th>4</th>
</tr>
</thead>
<tbody>
<tr>
<td>Departments</td>
<td>Sales</td>
</tr>
<tr>
<td>Programs</td>
<td>file update</td>
</tr>
<tr>
<td>Output</td>
<td>punched card</td>
</tr>
<tr>
<td>Timings</td>
<td>four hours</td>
</tr>
<tr>
<td>Input</td>
<td>remote terminal</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>5</th>
</tr>
</thead>
<tbody>
<tr>
<td>Credit</td>
</tr>
<tr>
<td>sort</td>
</tr>
<tr>
<td>disk</td>
</tr>
<tr>
<td>thirty minutes</td>
</tr>
<tr>
<td>card</td>
</tr>
</tbody>
</table>

Software Age
logic of the table: (Computers are #1 ... #5)

Clue Argument
1. Statement 13 fixes the program on #1.
2. Statements 13 and 7 fix the department on #2.
3. Statement 3 fixes the output for #3.
4. Statements 3, 5 and 7 fix the department for #1.
5. Statement 6 and Clue 4 fix the timing for #1.
6. Statement 14 and Clue 5 fix the input for #2.
7. Statements 2, 3, 5, 10, 15 and Clue 2 fix the program and the printer as output for either #2 or #4—assume the output and program are fixed for #4.
8. Statement 8 may only apply to fix a condition for #2.

NOTE: If Clues 7 and 8 hold their assumptions, no program may be found that is consistent with #2's other known features, hence:
9. Clue 7 should identify #2, not #4.

Proceeding in this manner the whole table may be completed and the relations sought identified.

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DOCUMENTATION

IN A FINANCIAL ENVIRONMENT

F. Stuart Magie
Assistant Vice President
Union Bank
Los Angeles, California

Unfortunately, it has been the general experience in data processing installations from coast to coast that documentation has been overlooked. Some data processing installations have little or no documentation concerning individual programs or even whole systems. Other installations have documentation such as card or magnetic tape layouts and even, in some instances, system flow diagrams. But usually this documentation is not accurate because it has not been kept updated by the individual Programmer or Analyst when modifications have been made to programs. Lack of documentation becomes a very expensive problem when one considers the length of time required for a new Programmer to understand an existing operational program and attempt modifying its logic. This problem is magnified by our current data processing growth. Turnover of technical personnel is also a large problem. Therefore, good documentation of programs and systems must be made a firm and necessary rule for all installations to follow. Naturally, data processing people usually plan and estimate completion dates based on time required for definition, logic, coding, testing, and implementation and, therefore, leave little or no time for correctly documenting the results of their efforts.

HISTORY OF DOCUMENTATION

During the 1940's and 50's, some documentation was kept in various Tab Operators' desks. This documentation was in the form of tabulating steps and diagrams of wired panels. When a Tab Operator was required to run a specific job, it often became necessary for a panel board to be wired for controlling the tab machine. In performing the specific function required for the system, usually a wiring diagram could be found and more times than not all types of special notes and lines would be written on the diagram. Sometimes Operators would write memos for their reference when running various jobs. In some installations a run flow was required to be created and these documents were placed in the tab run book. Very often updating to these procedures would be lacking if Operators were to leave the installation and the people assigned to various tasks were not aware of certain undocumented procedures. In some cases it took two or three runs to straighten out the procedures, and so it went until the advent of the 1st generation computers in the late 50's. At this time, technicians changed from wired panels and found that they had to construct their processing problems using stored programs. In this case, wired-panel diagrams were no longer necessary and coding sheets were substituted as documentation for the various runs with a few people creating run flows, much as in the Tab days. Documentation went along this way until the early 1960's and the release of second generation equipment. At this time more concentration was applied to documentation. Coding sheets, as well as assembly listings, were usually kept in various Programmers' desks as documentation. Also it became very evident that computer run instructions were now required. This documentation was usually made as each person saw fit. With the advent of third-generation equipment, it becomes even more necessary that good documentation be created because it is now many times more complex for a Programmer to debug someone else's program, or for an Analyst to understand existing systems without proper documentation. Third-generation computers have allowed technicians to do more and more work within a computer, thereby demanding that documentation be created to assist other technicians in following logic and/or system flows. One of the most expensive situations an installation can find itself involved in is that of requiring modification to be made and in having little or no documentation for the current Programmer to refer to. Sometimes this problem can force a complete re-write of the program. Proper documentation and the enforcing of documentation rules will greatly reduce this problem which reduces costs and creates a more professional environment for the technician.

DATA PROCESSING DOCUMENTATION FORMATS

Most data processing people agree to the fact that documentation is a necessary requirement, but what type of documentation should a data processing installation have?

1. System Flow Diagram
   Each processing system should have a complete diagram of the
ANALYSTS
Start at the TOP
and GO even HIGHER

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February, 1969
Program Logic Narrative

Program: XYZ-01

Name: Jones-Smith-Jones Recon Accounts

Main Routine:
This routine reads the master file, transaction file, and compares account numbers. At the same time, a computation is made multiplying rate X units. If the transaction account number is less than the master, a branch is made to routine called CREATEMSTR. If the account numbers are equal, a branch is made to UPDATEMSTR. If the transaction account number is greater than the master, a branch is made to WRITEMSTR.

CREATEMSTR:
This routine will add one (1) to a counter then move the hours field to a hold hours work area. A move is made of the units from the transaction record to a hold units work area. A check is made for the record codes A through D. If the record is an "A", a branch is made to AROUT. If the record is a "B", a branch is made to BROUT. If the record is a "C", a branch is made to CROUT. If the record is a "D", a branch is made to DROUT.

UPDATEMSTR:
A one (1) is added to the master counter. A one (1) is added to the transaction counter. The master record hours are moved to the hours work area. The transaction hours are added to the master work area. The master units field is moved to a units work area. The transaction record units are added to the units work area. A calculation is made by multiplying the rate from the master record X the hours in the hours work area. The result is added to the grand total dollars counter. A branch is made to WRITEMSTR.

WRITEMSTR:
A one (1) is added to the master counter. The hours are added to hours counter. The units are added to the units counter, and record is moved to the output WRITEMSTR record area. A branch is made back to MAIN.

Flow of the system from Data Control Clerk thru each computer operation and back to the Data Control Clerk. This flow chart, in order to be meaningful to the particular installation, should be created in a standard manner that is adopted by that particular installation. One easy-to-follow format is illustrated in Figure 1. (XYZ is the system number. The next two digits are the number given to the program, followed by a two-digit number, channel and drive or "SYS" device.)

2. General Narrative of the Total System
A general narrative of the complete data processing system should be created and should include a "picture" of the total system from the User thru the Data Control Clerk and Computer Operations back to the User. It should include such things as input/output schedules, number of computer operations, methods for balancing and clerical procedures, etc. A typical systems narrative is shown in Figure 2.

3. Detail Program Abstract
Detailed documentation should be found in the form of a narrative or program abstract written for each computer operation. The abstract should describe in detail that particular operation. A standard method for writing abstracts should be established for the installation in order to simplify the effort for Analysts and Programmers to read abstracts and thereby know what is to be found within the program. It has been my experience that the abstract should start by defining the name and number of the system, followed by the name and number of the particular program within the system. Next should be a short description of the objective (or the problem solved by) this particular program step. After the objective there is a description of all input files, possibly with a note to "See attached record layout" or simply a listing of the individual fields that must be contained in the files and the length of each field specifying whether they are alpha or numeric. When all input files are defined, the next section of the abstract will contain a description of all output files in the same manner as described above. This section also refers to any output reports produced by this particular computer step. This can be done by
GENERAL NARRATIVE OF TOTAL SYSTEM

The Jones-Smith-Jones Recon Accounts is a contract collection system designed primarily toward Recon Accounts Contracts. The system produces payment coupons, which, on receipt of payment, are used to update the Master History File. The system produces the required accounting reports needed for delinquent collection and general accounting.

The overall system is divided into six programs:
1. Edit and Capture
2. Correction
3. Transaction Sort
4. Update
5. Report Sort
6. Report

The Edit and Capture Program will read the incoming new accounts, changes, and monetary transactions, producing a capture tape and a Proof List. The Proof List is used for balancing purposes and the capture tape is used as input to the Correction Program.

After the Proof List has been balanced and the corrections have been keypunched, the capture tape and correction cards are used as input to the Correction Program, which creates an activity tape and final balancing totals. When all input has been balanced, the activity tape is sorted, producing a sorted transaction file.

The sorted transaction and the master are the input files to the Update Program which produces the new master and the report file. The report file is a formatted file with additional information in each record allowing proper sorting and print spacing.

The system presently provides the following reports at the indicated times:

<table>
<thead>
<tr>
<th>Daily</th>
<th>Weekly</th>
<th>Monthly</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cash Proof List</td>
<td>Trial Balance</td>
<td>Name and Address List</td>
</tr>
<tr>
<td>Final Balance List</td>
<td>Billing Summary</td>
<td>Mortgage Receivable</td>
</tr>
<tr>
<td>File Maintenance List</td>
<td>Tract Status</td>
<td></td>
</tr>
<tr>
<td>Un-Processed Items</td>
<td>Delinquent Notices</td>
<td></td>
</tr>
<tr>
<td>Detail Activity</td>
<td>Delinquency Aged List</td>
<td></td>
</tr>
</tbody>
</table>

Input due in daily at 6:00 p.m.

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PROGRAMMER 11,000
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DATA PROCESSING FLOW CHART

The diagram below is a typical example of standard production flow techniques that is to be employed by Systems Analysts and Programmers when finalizing production flow documentation.

*The three numerical blocks given in the processing flow are respectively: System Number, Program Number, and Estimated Average Run Time.

From 2111
Accounts Payable Summary

From 2000
New York City and Labor Adj.

XYZ 01 0.5
Edit and Balance 1401

Labor Distribution

Material Distribution

XYZ-01-06
XYZ-01-02
XYZ-01-03

Update W/O B/F T/M Tape

Updated W/O B/F T/M Tape

XYZ-05-22

XYZ-05-23

From XYZ-05

XYZ-02-XX

Sort

Cost Tape

Current Week Suspense Tape

XYZ-03-15

XYZ-03-15

XYZ-03-23

All Trans Tape

Wip Input Tape

Updated W/O B/F T/M Tape

XYZ-03-22

To XYZ-30
XYZ-50
XYZ-04
XYZ-55

To XYZ-01
XYZ-02

To XYZ-05
XYZ-03
XYZ-05

Scratch

XYZ 12

XYZ 12-XX

Sorted Suspense Tape

Print Weekly

Current Week Suspense

4. Detailed Program Logic Narrative
During the last six to ten years attempts have been made at documenting the logic of a computer program. One of the most popular documentation methods is for the Programmer to save and file his "logic diagram"; that is, if he has created a logic diagram. Not all Programmers create logic diagrams when constructing a program. Some write rough logic summaries, others draw very crude boxes, and still others are able to create small programs as they are coding. These diagrams, etc., are usually never updated after the program is completed. I have found a successful method for obtaining a definition of the program and logic is to require all Programmers, after completing a program (that is to say, when the program is implemented into production), to write a narrative describing their program. In order to enforce this rule, a program is not accepted without the "Logic Narrative". See Figure 4 for an example of a logic narrative.

5. Current Program Listing
A listing of the present production program must be retained as documentation for the program. This listing will be produced by the final assembly and filed with the other documentation. See Figure 5.
6. Test Data

In order for the Programmer to positively assure that the program functions as per specifications, test data must be created. Usually “static” test data is created by the Programmer and “systems” test data supplied by the User or by the Analyst. The test data that must thoroughly “checks” the program should be maintained on file, not only card decks, but a listing of the test data and the results. Whenever a change is made to the program the test data can be rerun and thereby prove if the new version of the program is correct.

7. Record Layouts and Sample of Input and Output Reports

The record layout of all files must be included either with the abstract or filed by themselves with each program within a system. Also samples of the printed output should be filed as well as samples of the input documents. In this section of the file, one other piece of documentation must be kept and that is Keypunch Operator punch instructions. See Figures 6 and 7 for samples of this type of documentation.

8. Computer Operator Instructions

Clear instruction must be created for the Computer Operator to follow when running each program. Two copies are usually made: One is filed in the documentation book and the other is forwarded to the Computer Operations Department with the program. See Figure 8.

9. Miscellaneous Documentation

Any other documentation should be kept as miscellaneous documentation and filed. This documentation may be memos and letters from and to the User or...
Customer of this particular system,

10. Data Control Instructions

If the system requires any manual handling prior to keypunching, and also requires clerical handling after computer operations, special clerical instructions must be written. Clerical balancing and handling is usually done by a section sometimes called Data Control. Instructions for balancing input and/or output must be included in this section of the documentation.

If the above documentation is created at the proper time and kept on file, it makes the job of modifying a system or program 50 to 75 percent easier.

As can be seen, control over documentation of this type could become very cumbersome. Some installations have created a documentation library. In this library binders and books are maintained containing all the documentation as described above. Also, files for source and object decks can be contained in the library. In a larger installation it becomes necessary to assign one or two people to act as Source Documentation Librarians, their job being that of maintaining all the documentation and keeping track of who has withdrawn the documentation. This position is also a fine starting point for Programming trainees.

STANDARD DOCUMENTATION LIBRARIAN

In most cases, it is necessary to require the Programmer or Analyst to update documentation when a program is being modified or changed. If the installation can afford a Librarian, he or she should be given the responsibility of seeing that all documentation is updated and changed when modifications are implemented. Some of the duties that can be controlled by a Data Processing Librarian are:

1. Communications: Any memo requesting changes to programs or requesting new programs or systems to be updated can be controlled by the Librarian. In these instances, the Librarian can bring such requests to the attention of the Systems Manager or Data Processing Manager. If these requests are substantial, the Librarian can keep track of who has been assigned to the modification or new program creation. As the programs are created and implemented, the Librarian will account for the fact that all documentation has been received and is on file.

We have found it successful in our installation to establish a rule that no one can implement a new or revised program in the

Figure 7

UNION BANK #XYZ-01

STANDARD DOCUMENTATION LIBRARY KEYPUNCH INSTRUCTIONS

JONES-SMITH-JONES Recon Accounts

CARD TITLE: Phase I of Four Phases

CARD NUMBER: 5081

COLOR: Blue

SUBJECT: Jones-Smith-Jones Recon Accounts

INSTRUCTIONS:

If no account number, skip and continue punching remaining cards.

<table>
<thead>
<tr>
<th>COLUMNS</th>
<th>CARD FIELD</th>
<th>REMARKS</th>
</tr>
</thead>
<tbody>
<tr>
<td>X</td>
<td>X</td>
<td>1 - 7 Account Number</td>
</tr>
<tr>
<td>X</td>
<td></td>
<td>8 - 15 Issue Number</td>
</tr>
<tr>
<td>X</td>
<td>16</td>
<td>Phase Code A if 1, B if 2, C if 3, D if 4,</td>
</tr>
<tr>
<td>X</td>
<td>17</td>
<td>Card Number</td>
</tr>
<tr>
<td>X</td>
<td>X</td>
<td>18 - 57 Account Number Fill in with zeros,</td>
</tr>
<tr>
<td>58 - 80</td>
<td>Blank</td>
<td>Blank.</td>
</tr>
</tbody>
</table>

Figure 7
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Solutions:
Problem 1: Key Q-Q6
If 1 . . . BxQ 2 R-R7ch and mates the next move. If 1 . . . K-N1 2 K-B7ch K-R2 3 R-R8 mate; similar mate if King moves to K1.
Problem 2: Key Q-Q6

THE MINIGAME
This was the nineteenth game of the 1952 World Championship Tournament between Botvinnik and Smyslov.

<table>
<thead>
<tr>
<th>Smylov (White)</th>
<th>Botvinnik (Black)</th>
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<tbody>
<tr>
<td>P-K4</td>
<td>P-K3</td>
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<tr>
<td>P-Q4</td>
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<td>N-Q2</td>
<td>P-QB4</td>
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<tr>
<td>KPxP</td>
<td>KPxP</td>
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<tr>
<td>B-N5ch</td>
<td>N-B3</td>
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<td>Q-K2ch</td>
<td>Q-K2</td>
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<td>NxBQ</td>
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<td>N-QN3</td>
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<td>B-Q2</td>
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<td>B-B3</td>
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<td>O-O</td>
<td>KN-K2</td>
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<td>N(K21)-Q4</td>
<td>R-Q8B</td>
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<tr>
<td>NxN</td>
<td>BxN</td>
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<tr>
<td>Bx8ch</td>
<td>Drawn</td>
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</tbody>
</table>

MASS TOURNAMENTS
Since Botvinnik won the world championship in 1948, only Russians have qualified as challengers. Grand masters from other lands have succeeded to enter the final eliminating event, the Challenger's Tournament, but this has always been won by a Russian. The U.S.S.R. has more than twice as many grand masters as there are in the U.S.A. and approximately one-third of all the grand masters in the world today. The popularity of chess in the Soviet Union is undoubtedly the best explanation one can give for their enormous success; and the best yardstick for measuring this popularity is found in the numbers of players that enter chess tournaments.

The first mass tournament was held in Leningrad in 1926 with 1500 participants. In 1936, the third championship of the All-Union Central Council of Trade Unions attracted 700,000 participants. New Year mass tournaments have become a regular event and attract close to one million participants each year.

By comparison, the biggest U.S.A. tournaments each year attract 100–200 participants.

WORLD CHAMPIONS
The title has been in use since 1870, when Steinitz claimed it on the basis of his many successes. The unofficial champions before Steinitz were: Staunton (1844–1851), Anderssen (1851–1858 and 1859–1866), and Morphy (1858–1859).

Howard Staunton (1810–1874)—An actor and a Shakespearean scholar, he learned chess at the age of thirty and three years later, in 1843, he became the best player in the world by defeating the Frenchman St. Ament. He wrote a number of books and also published a magazine called "The British Miscellany and Chess Player's Chronicle."

In 1851 Staunton organized the first international chess tournament which was held in London with Anderssen winning the top prize. Staunton's chess career virtually stopped after his defeat in London. An extremely aggressive person, Staunton loved a good argument in print. He attained the heights in both chess and literary criticism and a place in the Encyclopedia Britannica as a Shakespearean scholar who "showed the qualities of acuteness and caution which made him excel in chess."

THE PSYCHOLOGY OF A CHESS PLAYER
In his book, "The Psychology of a Chess Player," Reuben Fine quotes Dr. Milton Gurnitz, a prison psychologist, saying that:

"In his experience those prisoners who learned chess during their incarceration were least likely to be recidivists. They evolve better ways of handling their aggression. The ego strength needed to play chess must also play a role here.

"In a situation where two men are voluntarily together for hours at a time with no women present, the homosexuality implications must necessarily be considered. Observation indicates that overt homosexuality is almost unknown among chess players. Among the chess masters of the present century I have heard of only one case. This is all the more striking in that artists, with whom chess masters like to compare themselves, are so frequently homosexual."
new products

Webster Computer Corporation, Danbury Connecticut has developed a computer software package for IBM System/360 users currently operating under DOS (Disk Operating System).

The software package, DOS MACHINE UTILIZATION REPORTING SYSTEM is a generalized record keeping system for IBM 360 users which provides complete time and cost analysis of all jobs, programs, projects and programmers operating on each computer system.

The efficiency of an IBM System/360 computer installation in terms of time and dollar cost is displayed by job, program, project and programmer with respect to production time, compilations, testing, run time, preventative maintenance and idle time.

Detail records provided through the use of DOS MACHINE UTILIZATION REPORTING SYSTEM may be retained, selected, sorted and summarized in many ways two computer analysts require as required by an IBM System/360 installation.

For more information, circle No. 50 on the Reader Service Card

The Model 502 Telephone Data Coupler provides a low cost portable coupling means to interface digital data terminals such as the Teletype Models 33 and 35 with computer systems via telephone lines. Half or full duplex operation at up to 300 Baud for serial binary data is provided.

The Model 502 was designed by Specialized Communications Inc., and manufactured and distributed by ITI Electronics, Inc.

For more information, circle No. 51 on the Reader Service Card

DataMate Computer Systems, Big Spring, Texas, has announced their new DataMate 16 digital computer.

The 16-bit arithmetic fully parallel processor, the DataMate has a 4096 word 1.0 microsecond memory modularly expandable to 32,724 words. Built in features include hardware multiply and divide; 8 I/O channels with priority interrupts; hardware index register and arithmetic instructions. A 16 line I/O bus accommodates up to 64 peripheral devices. Standard peripherals include a teletype; paper tape reader and punch; incremental magnetic tape; dual density IBM compatible magnetic tape system; CRT display; digital plotter; line printer and magnetic core memory storage. A simple plug-in card is used to interface DataMate 16 with these peripherals.

The DataMate 16 uses the latest digital design techniques—IC's and MSI devices throughout. The computer has byte, word, and double word processing capability with multi-level indirect addressing. Over 80 powerful commands are built into DataMate.

For more information, circle No. 52 on the Reader Service Card

Linnell Electronics, Inc.—a member of the Comstock-Keystone Computer Group—has entered the peripheral field with the introduction of a magnetic disc drive which uses a removable storage medium such as the IBM 1316 disk pack.

The new unit, the Linnell Model 1100 Disc Drive System, has been designed to meet all their requirements-program, interface, styling, maintenance and reliability. In achieving this, Linnell has paralelled the design of the IBM Model 2311 considerably beyond usual plug-for-plug compatibility conventionally claimed for other drives. In appearance the two units are almost identical, having the same contours, colors and dimensions. Mechanically, they are part-for-part interchangeable in essential components. Electrically, they employ the same logic. And they both use the same procedure-for-procedure maintenance.

The chief feature of the Model 1100 is the extremely reliable hydraulic head actuator. This component, which is directly interchangeable with the 2311 hydraulic actuator, eliminates the thermal, magnetic and drift problems inherent in electronic actuators. It also minimizes periodic adjustment and maintenance requirements.

For more information, circle No. 53 on the Reader Service Card

Called the COMMUNITYTYPE 850 Magnetic Tape Transmission System, the equipment is capable of sending and receiving computer data in high-speed (tape-to-tape) transmissions over ordinary telephone company direct-dial circuits, such as between computer centers.

The 850 unit was designed primarily for use with Community's 100SR Data Communication System, an input/output source data terminal featuring a standard-keyboard IBM Selectric® typewriter.

A single 850 unit placed at the corporate computer center can serve scores of widely-dispersed 100SR installations, regardless of leased or private lines are not necessary, and the traditional electronic data processing steps of punch card preparation and verification are eliminated.

As the 850 system receives the data from the 100SR units, it transforms the data instantly and automatically to computer code recorded on magnetic tape compatible with IBM-360 type computers using series 2400 9-track tape drives. The data is recorded at 800 bpi (bits per inch) density.

The 850 system can also transmit computer-prepared data to remotely-located 100SR units by reading the data block-by-block into a 160-character (or larger) MOSFET buffer memory unit.

For more information, circle No. 55 on the Reader Service Card

A proprietary program called ANALYZE has been developed for general use by programmers, DP Managers, and computer facilities to interface between the users program and the IBM-360 DOS/TOS supervisor.

The ANALYZE Program is designed to stop premature cancellation of computer programs because of defects in data, or programming errors. The ANALYZE Routine automatically intercepts program checks or operator interrupts and transfers control to the operator, who may select any of several actions to correct the error and resume processing if desired.

It is advantageous as a method of machine console debugging during program testing and production shakedown runs when the data may be unpredictable and/or the program itself may be of a complex nature. It also allows the operator to interrupt program processing at will in order to perform data or instruction set modification, obtain core-memory displays, etc.

For more information, circle No. 56 on the Reader Service Card

The development of a data input system to utilize a direct keyboard-to-magnetic disc storage file has been announced by Logic Corporation, Haddonfield, N. J. The LC-720-Disc Data Entry System consists of standard keyboard input terminals, a central processor, which will accept data from as many as 120 keyboards simultaneously, and an IBM 2311 disc pack drive.

The LC-720-Disc System offers simultaneous entry and verification of data by two different operators. Record size is from 1 to 240 characters long. A large library of up to 30 programs may be stored in the system and each is available simultaneously to all operators.

The keyboard is a standard 64 character IBM 029 keyboard layout. An alphanumeric display panel shows the operator in English the program number, the last character entered and column number, job number, record number, data availability, verification status, and the terminal operating mode.

For more information, circle No. 57 on the Reader Service Card

FEBRUARY, 1969
Here is a problem that has not violated any of the USA Standard FORTRAN rules, however, not all third generation computers will give the same answer.

C SUBMITTED BY F.M. OLIVA
A = 2
CALL XTRAN(A,A)
WRITE(6,100) A
100 FORMAT(F10.2)
STOP
END

SUBROUTINE XTRAN(A,B)
A = A + B**3
IF(A.LT.SQRT(B)) B = 3.14
RETURN
END

The problem is to determine which of the following systems will print a different answer for A and why?

CDC-6600, UNIVAC 1108, IBM 7094, GE-635, IBM System/360, SDS Sigma 7, Spectra 70, B5500.

The purpose of this problem was to emphasize the importance of thinking before coding. Programmers who do not like to be called coders should always be on guard and never write a single line of code without thinking about the constraints of the problem or the physical limitations of the equipment that is used to solve the problem.

You may recall that our young engineers John and Tom had coded the following program to compute a table of factorials:

DO 10 J = 1,100
X = J
10 CONTINUE
WRITE(1,100) J, F
F = F*X
END

It is obvious that John and Tom had not violated any FORTRAN rules. Then, why did XTRAN insist that something was wrong? The answer of course is found in the word factorial. Anyone who has used factorials before knows that a 100! is a very very large number, and outside the range of floating point numbers most computers would allow. Indeed 100! equals 9.33 x 10^{487} and only the CDC computers would accept such a large number. Most first and second generation computers use -38 to +38 as the range of exponents for real numbers. The magnitude of the largest real number allowed by IBM System/360 is 16^{30} (7.2 x 10^{75} approx.). SDS computers use -77 to +77 as the range of exponents.

Perhaps the simplest method of computing large numbers and still keeping track of the exponents is to pick a large constant such as 10^{30} and use it to divide the number that is being computed each time it exceeds this constant, then set a counter to count multiples of 10^{30}.

Many readers have sent me new material recently and, since it is rather difficult to answer each one individually, I would like to take this opportunity to express my gratitude to all of you and assure you that your problems will be carefully considered.

TROUBLE-TRAN WINNERS

SEPTEMBER
1st—R. Reichert, Murray Hill, N. J.

OCTOBER
1st—S. W. Herrold, St. Laurent, Canada
2nd—V. F. Jennemann, Tulsa, Okla.

NOVEMBER
1st—V. F. Latvis, West Haven, Conn.
2nd—R. Bressler, Brookline, Mass.
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<table>
<thead>
<tr>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>37</td>
</tr>
</tbody>
</table>

EMPLOYMENT AND SEARCH AGENCIES

<table>
<thead>
<tr>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>13</td>
</tr>
</tbody>
</table>

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