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IDEEA NETWORK IMPLEMENTATION FISCAL YEAR 1965

by

S. E. TORREY

AMCMS Code 5900.21.24660.00.01

DA Project 2PO23201A720

January 1966

UNITED STATES ARMY
FRANKFORD ARSENAL
PHILADELPHIA, PA.

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January 1966

Fire Control Engineering Directorate
FRANKFORD ARSENAL
Philadelphia, Pa. 19137

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ABSTRACT

The IDEEA Network is a five-station experimental system for the storage, retrieval, and dissemination of chemical structures and data. The Network is being implemented with available hardware and will be used to collect data on the rates and modes of use. The Network concept and the hardware to be used in the Network are described. The effort that was applied to the Network implementation during Fiscal Year 1965 is also described.

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INTRODUCTION

During Fiscal Year 1965 work was started on the development of the Information Data Experimental Exchange Activities (IDEEA) Network. This report describes the IDEEA Network concept and the implementation effort that was applied during Fiscal Year 1965. The program is being conducted at Frankford Arsenal under the CIDS (Chemical Information Data Systems) Phase V portion of the U. S. Army STINFO (Scientific and Technical Information) Project.

The IDEEA Network is an experimental system for the storage, retrieval and dissemination of chemical structures and data. The purpose of implementing the network is to provide an operational information exchange system which can be used to obtain use data and experience for the design of future information systems. The network is being implemented with available equipment to minimize hardware development and to provide a functional system as quickly as possible. Once the network has been established it will be used to collect data on the rates and modes of use. In addition, the structure of the network will be varied to experiment with new concepts and to evaluate hardware and software. The IDEEA Network effort will culminate in the specification of the required characteristics for efficient, reasonably priced, practical information exchange systems.

DISCUSSION

1. IDEEA Network Concept

The concept of the presently planned five station IDEEA Network is illustrated in figure 1. Since the network is being designed to handle chemical information, each station is at a U. S. Army installation which has a specific chemistry interest. Each station will have its own bulk storage device to store data, the means for inputting and retrieving data from storage, and a small digital computer to provide control and computational capability. All five stations are connected to the AUTOVON (Automatic Voice Network) so that data may be interchanged between stations. Thus one station may request and receive via the AUTOVON telephone lines data which is being stored at another station.

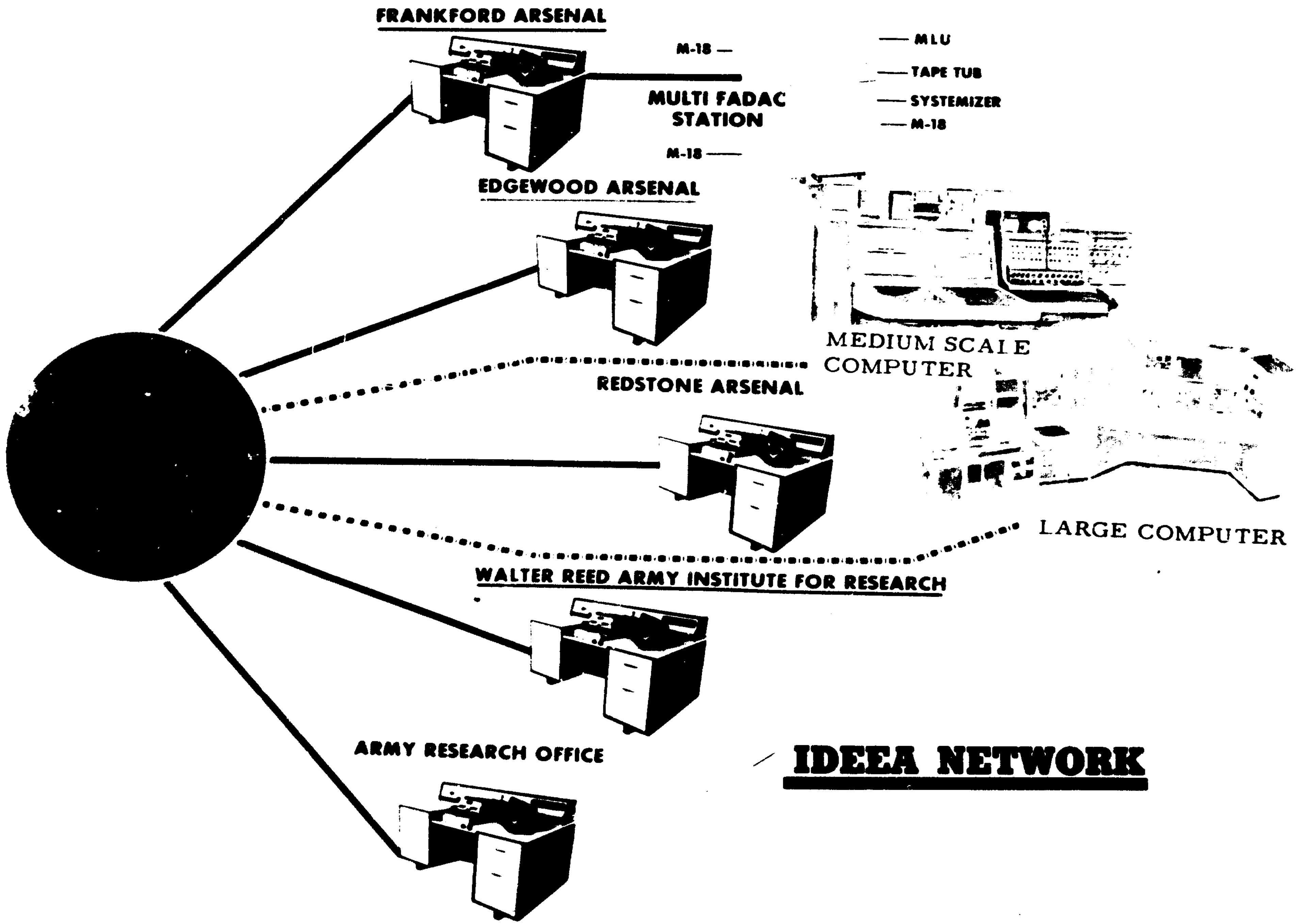

Figure 1. IDEEA Network Concept

As depicted in figure 1, the IDEEA Network will interconnect a number of different equipments with a wide variation in capabilities. However, each station will have the independent capability for inputting, storing, and retrieving data as well as the means to interchange data with any of the other Network stations via the AUTOVON system. Identical stations will be located at the Army Research Office, Walter Reed Army Institute for Research, Redstone Arsenal, and Edgewood Arsenal. In addition, a large commercial computer (IBM 7094) located at Redstone Arsenal will be interconnected with the Network. Similarly, a medium scale commercial computer (H200/400) at Edgewood Arsenal will be tied in with the Network. The Frankford Arsenal station will use a number of M18 (FADAC) military computers combined into a system so that they can share complex computational tasks.

2. Available Materiel for IDEEA Network

As previously stated, the IDEEA Network is being developed by integrating available hardware into a functional system. The advantage of this approach is that the network can be implemented with a minimum of equipment development thus conserving time and funds. A possible disadvantage is that none of the available equipment was specifically designed for an information exchange network; however, at present it is not possible to specify the precise requirements for the hardware in such a network. In fact, a basic objective of the IDEEA Network implementation is to provide a functional network as quickly as possible so that actual experience and use data can be obtained to guide the specification of hardware for future data exchange systems. The major available elements of hardware which will be used in the IDEEA Network are described briefly in the following paragraphs.

a. The FADAC (Gun Direction Computer M18) will be the heart of each of the IDEEA Network stations. It will provide automatic control and computational capability so that each station can be operated by personnel with minimum training. The stations are being so designed that the operators will not have to have a knowledge of chemistry, electronics or computer programming.

Figure 2 shows a FADAC setup on its field table ready for use. For the IDEEA Network stations, the field table will not be used since the computer will be integrated into the station console. The FADAC is a solid state, general purpose digital computer which within the limits of its memory can perform any computational task for which a program has been written.

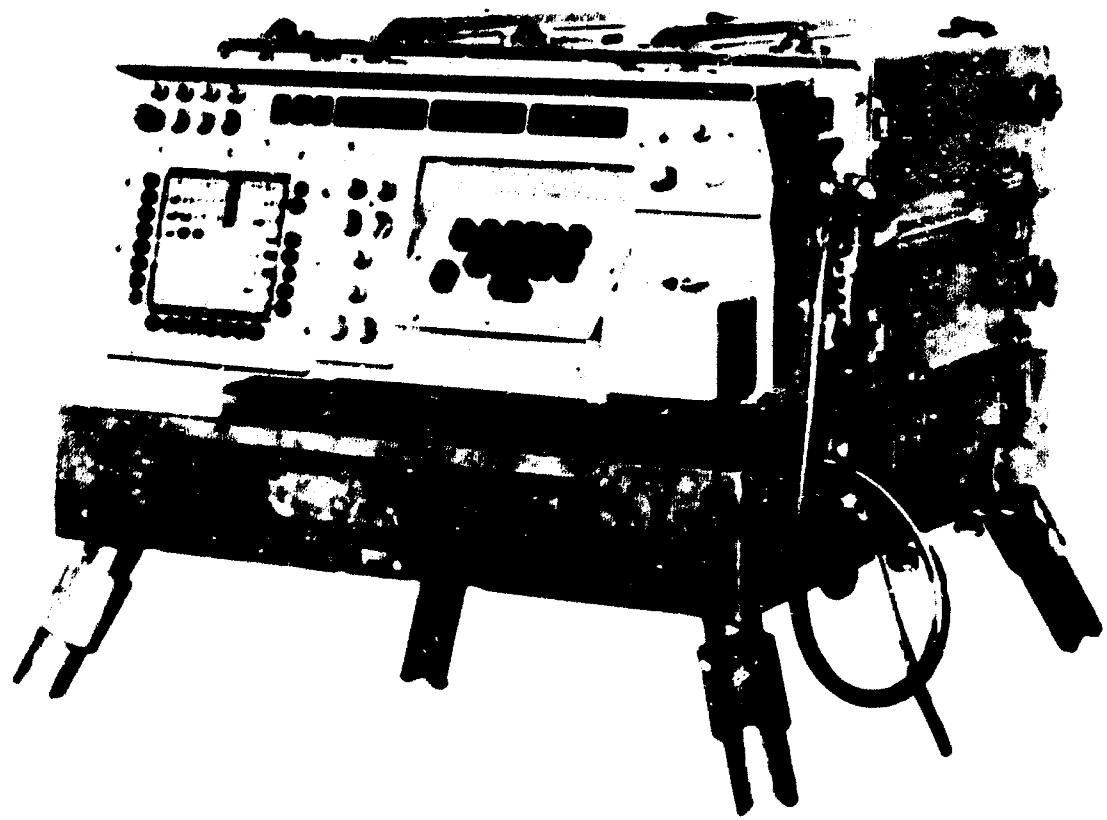

Figure 2. FADAC (Gun Direction Computer M18)

The internal memory of the computer is a magnetic disk with a capacity of 8192 FADAC words of 32 bits per word. The FADAC has been in production for several years and is currently being issued to troops in the field. Since the computer is in the military supply system, peripheral equipment, spare parts, operational manuals, etc. as well as trained maintenance and programming personnel are available. Finally, since the development costs have been paid under previous projects the FADAC is available at its current production price which is less than $30,000 per unit.

Available peripheral equipment for the FADAC includes the Signal Data Reproducer AN/GSQ-64 and the Logic Unit Test Set AN/GSQ-64. The Signal Data Reproducer is a photoelectric paper tape reader which is used to enter data from punched paper tape into the FADAC memory. The Logic Unit Test Set is used in conjunction with the Signal Data Reproducer to locate automatically malfunctioning subsystems within a FADAC. The M18 Computers, Signal Data Reproducers and Logic Unit Test Sets required for the IDEEA Network were ordered during Fiscal Year 1965. In addition, spare parts were ordered for the computers and their peripheral equipment. Since the equipments are ordered on current production contracts, delivery is expected during Fiscal Year 1966.

b. An input-output device which can handle chemical structure diagrams is required and several available units are being considered for the IDEEA Network. The network was originally planned with the ACT (Army Chemical Typewriter) for the input-output device. This unit was developed by the Walter Reed Institute for Research and has evolved through several generations of development. The present ACT uses a commercial encoding typewriter which has been modified to provide a third case for chemical structure symbols. In addition, encoding devices have been installed to generate X and Y coordinates. Figure 3 is a photograph of the ACT which was loaned to Frankford Arsenal for the latter half of Fiscal Year 1965. The typewriter is equipped with a paper tape reader and a paper tape punch is located in the upper right hand drawer. The two drawers on the left side of the ACT cabinet house power supplies, controls, and the logic circuitry for producing X and Y coordinates.

Two of the three cases on the ACT provide standard upper case and lower case alphanumeric and punctuation characters. The third case provides special characters for making chemical structure diagrams. Data can be input through the ACT either by punched paper tape or by operating the keyboard. When inputting a chemical structure through the keyboard, the operator types the required characters and manipulates the platen to

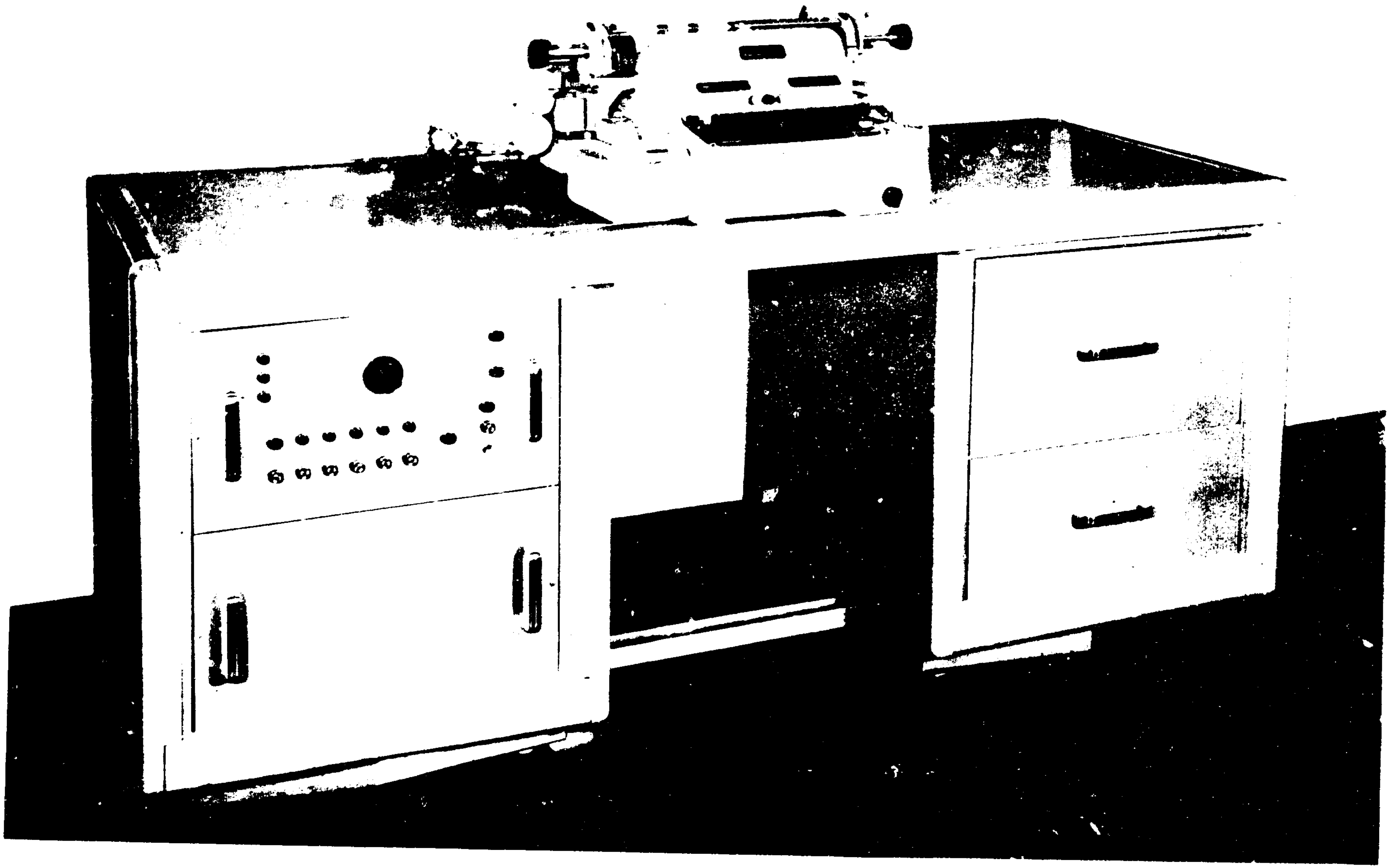

Figure 3. ACT (Army Chemical Typewriter)

produce a hard copy of the desired structure with the correct configuration. This causes a paper tape to be punched with codes for all of the structure characters plus X and Y coordinate data to locate all of the characters properly with respect to each other. Coordinates are not produced for every character typed; instead, coordinates for the last character typed are generated whenever the tab, line advance, carriage return, or back space keys are operated or whenever the operator manually positions the typewriter platen. This permits the operator to type a structure diagram in any order that is convenient and also permits returning to any desired portion of the structure for error correction of both the hard copy and the punched paper tape. When outputting a hard copy from the punched paper tape the data must be supplied line-by-line since the ACT is not equipped with a reverse line feed feature. This means that the tape produced while inputting cannot be used directly for outputting. Instead, the data on a "coordinate-tape" must be rearrranged into a line-by-line order on a "line-tape." This rearrangement process can be carried out by a properly programmed digital computer.

Part of the Fiscal Year 1965 effort on the IDEEA Network was devoted to developing an ACT/FADAC interface which is described later in this report. This interface permits the encoded characters generated by the ACT to be fed directly into a FADAC. In addition, a FADAC input routine was developed so that the encoded characters from the ACT would be stored in matrix form in FADAC memory. An output routine was also written in such a manner that the structure stored in the matrix in the FADAC memory could be read out line-by-line. Thus the ACT and FADAC can be used together to produce either "line-tapes" directly or structures encoded in digital form ready for filing in a digital storage device.

Consideration is being given to the use of an input-output device other than the ACT for the IDEEA Network. During the last quarter of Fiscal Year 1965 a survey was made to determine the availability of other devices capable of handling chemical structure and data. The detailed results of the survey are described in a Frankford Arsenal report.[1] It was found that there were several electric typewriters available which were capable of typing chemical structure diagrams. All of the available units are two case machines so that they have only about two-thirds the number of characters that the ACT has. However, since they are standard commercial machines (with

[1]Memorandum Report M66-15-1, "Information Data Exchange Experimental Activities (IDEEA) Network Input-Output Device Study" by John J. Carr.

a few special characters added to their type fonts) they are cheaper, and more readily available and probably more reliable than the ACT. None of the available commercial units generate coordinate data but they can be equipped with a reverse line feed function.

c. It is planned to use the Magnetic Tape Memory System, hereafter referred to as the tape tub, for the bulk storage device in each IDEEA Network station. The tape tub was developed to provide a bulk storage device for FADAC; in use it is connected directly to FADAC and operates under FADAC control. The tape tub consists of a transport unit, housing control circuitry and the drive motor, and up to four tape cartridges which are stacked on the transport. Figure 4 shows a tape tub with two cartridges mounted on the transport. Each cartridge has an endless loop of magnetic tape, read and write heads, relays to connect the selected head, and tape drive sprockets. When mounted on the transport the sprockets in each cartridge are driven in tandem by the motor in the transport unit. Each tape has 10 tracks for recording data plus one track of timing information to identify the memory block locations on the recording tracks. Each cartridge can store 40, 000 FADAC words so a tape tub with four cartridges can store 160, 000 FADAC words or about twenty times the internal memory capacity of FADAC. The tape tub is directly controlled by FADAC and the drive motor is only operated during search, read or write operations. Thus, the motor and tape do not run when the tape tub is not being used. This conserves power and reduces tape wear. Since the tape in each cartridge is 90 feet long and since the tape is driven at 120 inches per second, the average access time for data stored in the tape tub is 4.5 seconds.

d. The AUTOVON (Automatic Voice Network) telephone system will be used to interconnect the five stations planned for the IDEEA Network. The AUTOVON system is a Department of Defense direct dialing telephone system which uses a number of dispersed switching centers and automatic switching. It was evolved by combining the Army's Switched Circuit Automatic Network (SCAN) and the NORAD/ADC Automatic Dial Switching Network. Eventually the AUTOVON System will make use of electronic switching equipment and it will be the world-wide communications system for handling end-to-end switched communications for the Department of Defense and certain non-Department of Defense customers. During Fiscal Year 1965 approval was requested for two AUTOVON lines at Frankford Arsenal for use in developing and testing the IDEEA Network stations. Laboratory model equipment for interfacing a FADAC computer to the AUTOVON system has been developed and demonstrated.

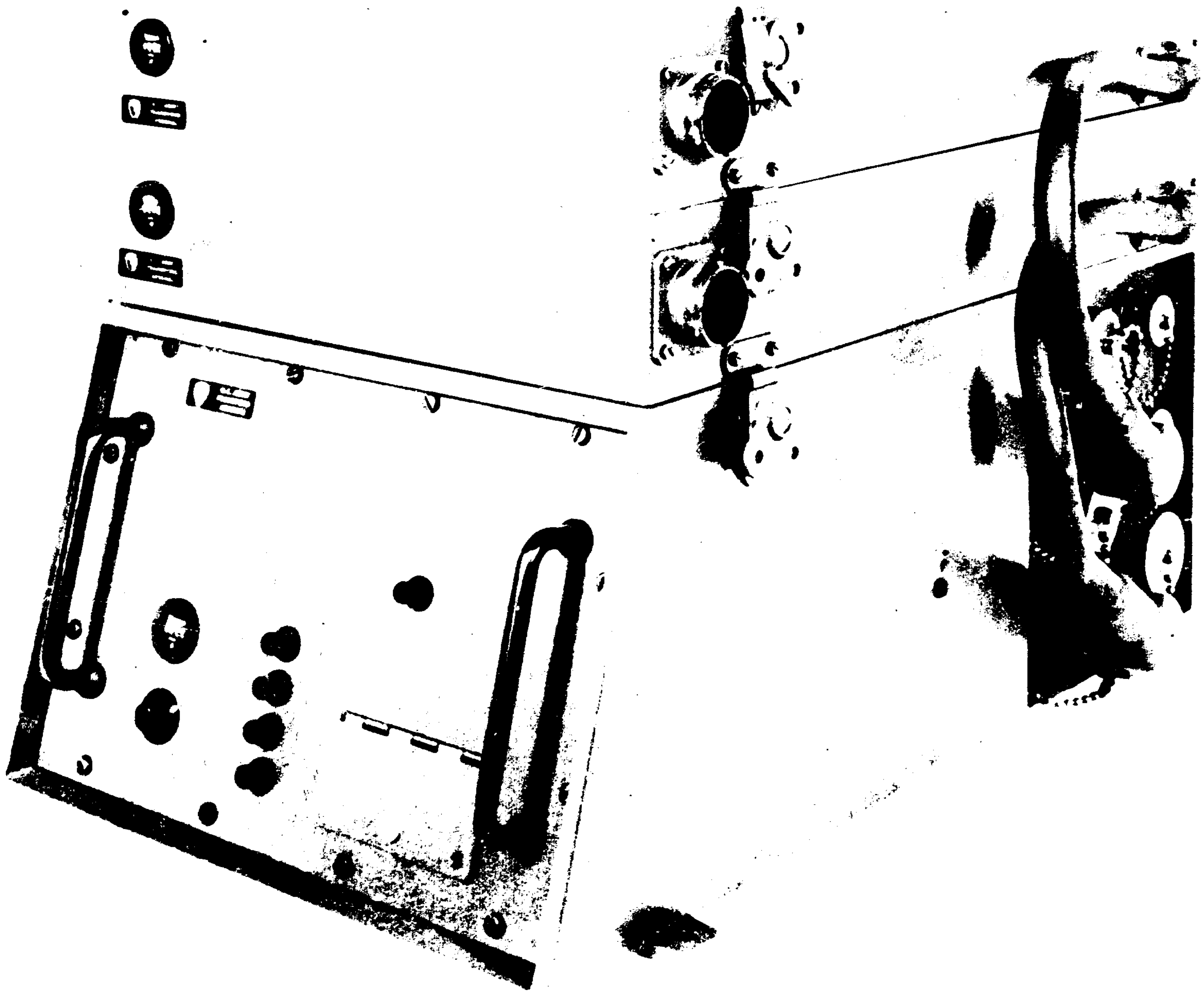

Figure 4. Tape Tub (Magnetic Tape Memory System) with Two Cartridges

3. IDEEA Network Design Effort

The IDEEA Network is planned so that the required design and fabrication effort is a bare minimum. All of the major items in the system will be used in their available form with virtually no modifications required. A modest amount of design work is required to integrate the selected available hardware into a functional system and this design effort was initiated during Fiscal Year 1965. The following sections describe the development efforts that have been accomplished to date. Since the major hardware items are presently being procured most of the development work was done with borrowed equipment. Despite this restriction significant progress was made during Fiscal Year 1965.

a. An ACT/FADAC interface was designed and a laboratory model of the circuitry was developed and tested. Figure 5 is a photograph of the laboratory model ACT/FADAC interface that was built. This unit is used to permit the direct transfer of encoded data between FADAC and ACT. Connectors are also provided on the interface for connecting the magnetic tape bulk storage system (tape tub) to FADAC. The circuitry within the interface is designed to provide the proper signal levels and timing during the transfer of data between the ACT and the FADAC. The ACT/FADAC interface was designed so that no modifications were required for either device; when disconnected from the interface both the ACT and the FADAC operate normally.

When transferring data from the ACT to FADAC, information is typed by an operator or entered through the punched paper tape reader and is transferred through the interface to FADAC. Each encoded character consists of 8 bits (7 information bits and one parity bit) which are transferred in parallel. The encoded character signals are obtained from the magnetic coils of the paper tape punch. These signals (true +50, false 0 volts) are modified by the interface to provide acceptable FADAC input signals (true -6, false 0 volts). Special circuits were developed to prevent loading down of the punch magnet coils during data transfer. The interface supplies the data signals to the DIA (Discrete Input to Accumulator) lines of FADAC. A timing signal is obtained from the coil of the clutch on the ACT paper punch; this signal initiates a delayed (approximately 10 milliseconds) input which notifies the FADAC that data is present on its input DIA lines.

When transferring data from FADAC to the ACT the alpha-4 output mode of FADAC is used. Again each character is made up of 8 bits which are transferred in parallel. The interface accepts the output signals (true

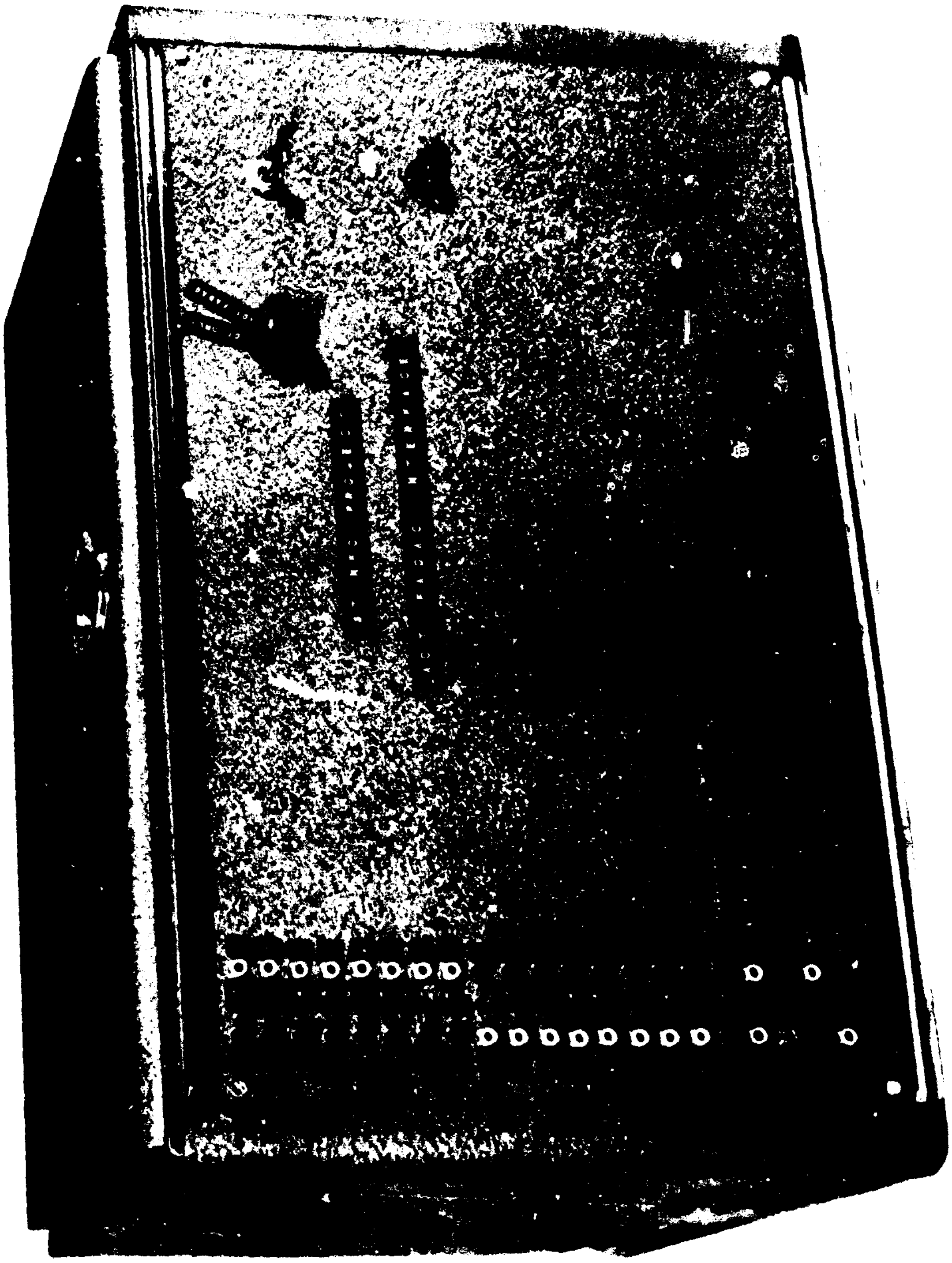

Figure 5. Laboratory Model of ACT/FADAC Interface

-6, false 0 volts) from FADAC and processes them to provide +90 volt signals to the appropriate ACT translator code magnet coil. This causes the transmitted character to be printed out on a hard copy and/or punched on paper tape. The interface also generates timing signals to permit the FADAC to output at close to the maximum operating speed of the ACT.

The completed interface was tested with an ACT which was borrowed from Walter Reed Institute for Research. All required interface connection points within the ACT were located and brought out to spare sockets on one of the ACT connectors. A special adaptor mates with this connector to connect the ACT to the interface. No modifications were made to the ACT which would effect its internal functions; when it is not used with the interface the adaptor cable can be removed and the ACT will operate normally.

During debugging of the program to input structures from the ACT tape reader into FADAC memory, it was found to be necessary to permit FADAC to start and stop the reader. This is due to the fact that the coordinates which show the locations of structure characters are generated after the characters are transmitted. Also coordinate characters are generated only after special movements of the platen (line feed, tab, back space, etc.). This means that FADAC does not know where the structure characters belong until the coordinate characters are transmitted and FADAC may receive a number of structure characters before receiving the coordinate characters. Thus FADAC must put the structure characters into temporary storage until the coordinates are received; then the structure characters must be removed from temporary storage and placed in their proper location in the matrix. Circuitry is provided in the interface to stop the reader while FADAC is transferring structure characters from temporary storage to the matrix portion of its memory. When this processing has been completed FADAC starts the reader again. The control signals for the tape reader are brought out on a separate cable from the interface to the ACT. If the ACT is used without the interface a shorting plug is used to restore normal operation of the ACT paper tape reader.

b. A FADAC/AUTOVON interface has also been developed; this permits serial data to be processed through FADAC to and from the AUTOVON telephone system. Figure 6 is a photograph of a laboratory model FADAC/AUTOVON interface. This unit matches a FADAC to a 103A dataphone set which terminates an AUTOVON line. The interface and dataset have been operated together to input and output data from FADAC via the AUTOVON system.

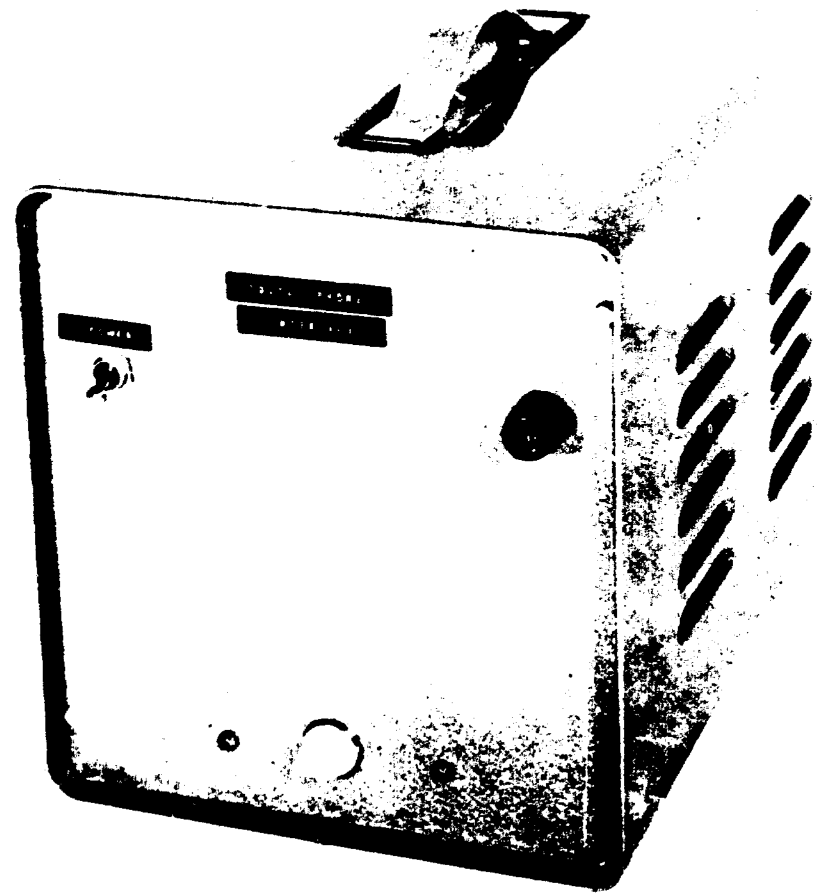

Figure 6. Laboratory Model of FADAC/AUTOVON Interface

The FADAC/AUTOVON interface contains FADAC input drivers which convert 103A dataset logic levels to FADAC logic levels for the following functions:

(1) Incoming serial data.

(2) A signal to inform FADAC that a remote connection has been made so that FADAC can start transmitting serial data.

(3) A ringing signal to inform FADAC it is being called from a remote location.

A FADAC output driver in the interface converts FADAC logic levels to 103A dataset levels when data is being transmitted from FADAC. The interface also has a toggle flip-flop circuit which is used to provide a ready signal to the 103A dataset so that the set will remain in the data mode and incoming calls can be answered automatically.

The FADAC/AUTOVON interface has been demonstrated using a temporary AUTOVON line installation and a teletype machine for the remote location. For the demonstration, the FADAC and the teletype machine were located in the same room but they communicated with each other over several hundred miles of AUTOVON lines. When the teletype operator manually dials the FADAC through the 103A dataset, if FADAC is available, a tone signal is sent to the operator and he knows that the computer is ready. Then via the teletype machine the operator can request or update data which is stored in FADAC memory. The FADAC echoes the received instruction back to the teletype machine and the operator can see that the computer has received the proper message. If the received instruction is a request for data, the computer extracts the information from its memory and outputs it in serial form through the interface, the dataset and it is transmitted over the AUTOVON lines to the teletype machine. If the received instruction is a command to update a particular block of data, the FADAC inserts the new data into the proper location in its memory. The computer can be programmed to accept calls on a priority basis, restrict the duration of calls, and require proper identification of the requester before supplying or updating data. Although the present FADAC/AUTOVON demonstration uses manual dialing it is understood that commercial telephone equipment is now available which enables a computer to perform a dialing action. This would permit a computer to originate as well as receive calls automatically and it might be an attractive feature for data exhange systems.

c. Programming material was prepared for the FADAC to be used with the ACT and the ACT/FADAC interface. With these programs the FADAC will accept data from the ACT and store it in proper form in order to be read out on a line-by-line basis. Because it was necessary to return the ACT to Walter Reed Institute for Research it was not possible to test the developed programs thoroughly. The input, storage and output routines were debugged and it is believed that no major problems would be encountered in their use. However, a more thorough test of the developed routines should be conducted, if the ACT is to be used as the input-output device for the IDEEA Network.

For the ACT/FADAC programs a number of computer memory locations are reserved as a matrix which is equivalent to physical positions of the platen on the ACT. During inputting each data character is stored in a memory location which corresponds to the position of the ACT platen when the character key was struck. Coordinate characters produced by the ACT are used by the computer to determine the proper storage locations for the data characters. When all of the data characters for a structure have been received and stored, the memory locations of the matrix are read in the proper sequence to provide a line-by-line readout of the structure.

The programs that were developed provide a matrix in FADAC memory of 96 spaces in the X direction and 228 spaces in the Y direction. This area is more than adequate for any structures encountered to date and is probably more than would be required in actual use. The shape of the matrix could be altered by increasing the spaces along one axis and corresponding decreasing the spaces along the other axis. With the 96 x 228 matrix 89 percent of the FADAC meory is required for the matrix. This means that the present matrix plus input, storage and output routines utilize most of the FADAC memory locations. A reduction in size of the matrix would free more of the computer's memory for other purposes. Punched tapes, a card deck, and machine printouts have been prepared to document the developed ACT/FADAC program.

d. A preliminary design was prepared for the console to be used in each IDEEA Network station. This design was based upon using the ACT as the input-output device. It is planned to use the same console for all stations and volumetric studies were conducted to design a console capable of housing all of the major items in a station. The console was designed to encompass the ACT, its electronics and tape punch, the FADAC, the tape tub, the ACT/FADAC/AUTOVON interface and a 103A dataset. A wooden mock-up of the console was built and is shown in figure 7. Figure 8 illustrates the planned locations for the various equipments in the console.

The several components of the ACT would be removed from the cabinet in which they were delivered and installed in the console as shown in figure 8. The ACT electronic circuits would be installed in the upper left hand drawer with the punch in the drawer below. The typewriter itself would be installed on the center shelf with the keyboard at the proper height for operator comfort and efficiency. The error indicator lights for the ACT would be mounted on the left end of the console control panel along with the main power controls and indicators. The front panel assembly will be removed from FADAC and the essential controls will be installed in an auxiliary panel on the right hand side of the console. The FADAC nixie display will be mounted on the right end of console control panel. The FADAC controls and displays are primarily for use by programmers or maintenance personnel; the station operator will not be required to perform any elaborate manipulations on the FADAC controls. With its control panel and case removed, the computer will be unfolded and mounted vertically in the rear wall of the console. The tape tub will be mounted on rollers in the right rear corner of the console. The rollers will permit the unit to be easily pulled out to remove and add tape cartridges as required. The interface will be installed in the right front corner of the console; this unit will have the circuits to match the FADAC to both the AUTOVON and the ACT. A shelf for the 103A dataset will be provided above the interface.

e. A design was also prepared for the Systemizer which will be used to interconnect the various components of the multi-FADAC station. This design is based on one evolved previously under another program. The earlier design has been breadboarded and tested successfully. However, the Systemizer for the IDEEA Network incorporates several design improvements and will have considerably more capability than the earlier unit. The new Systemizer will be able to accommodate the following equipments:

(1) Up to seven M18 computers (FADAC'S)

(2) Up to two tape tubs

(3) Up to three serial input/output devices (including the 103A dataset from the AUTOVON system)

(4) Up to two parallel input/output devices (including the ACT)

(5) One Memory Loading Unit (MLU).

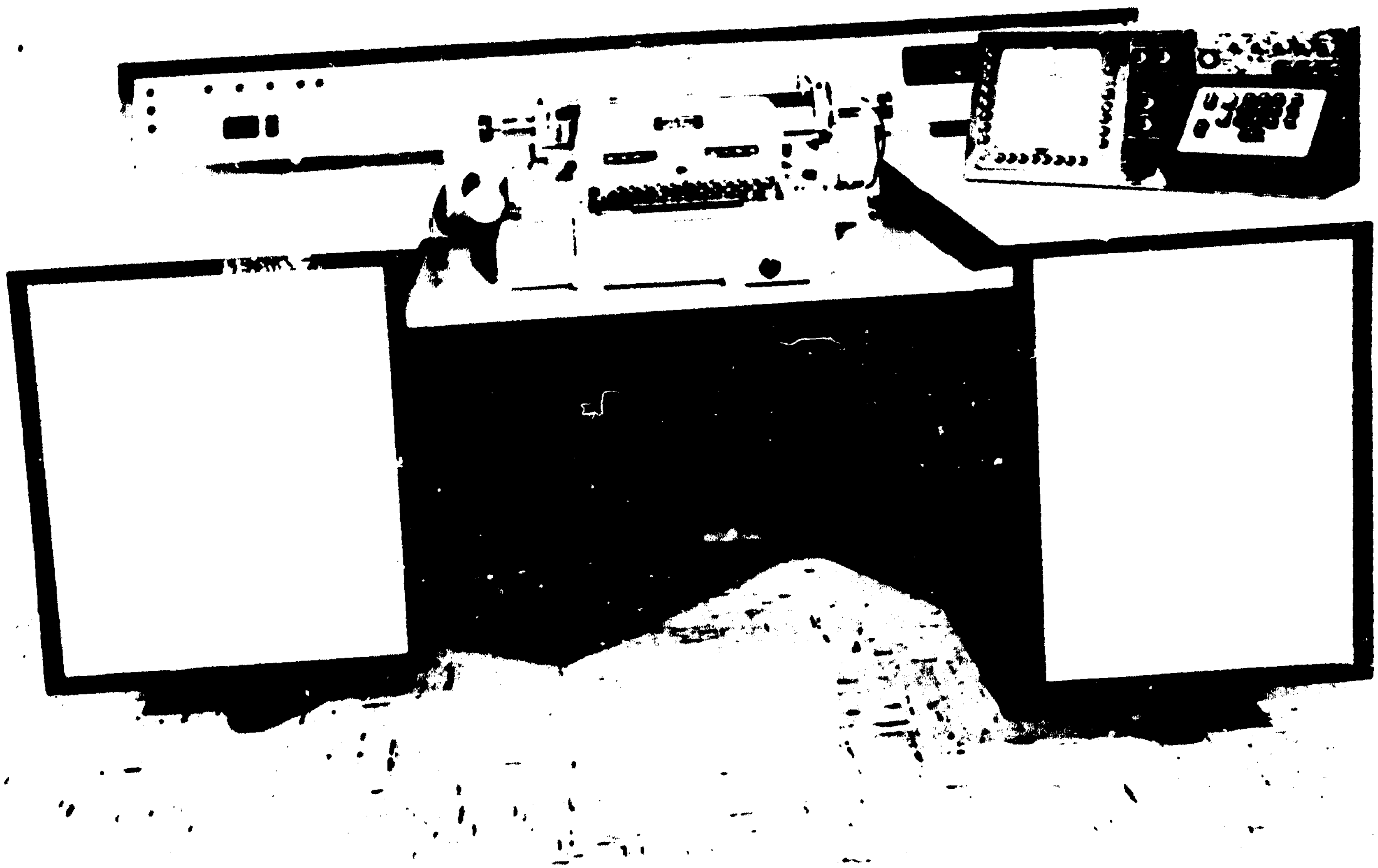

Figure 7. IDEEA Network Console Mockup with ACT

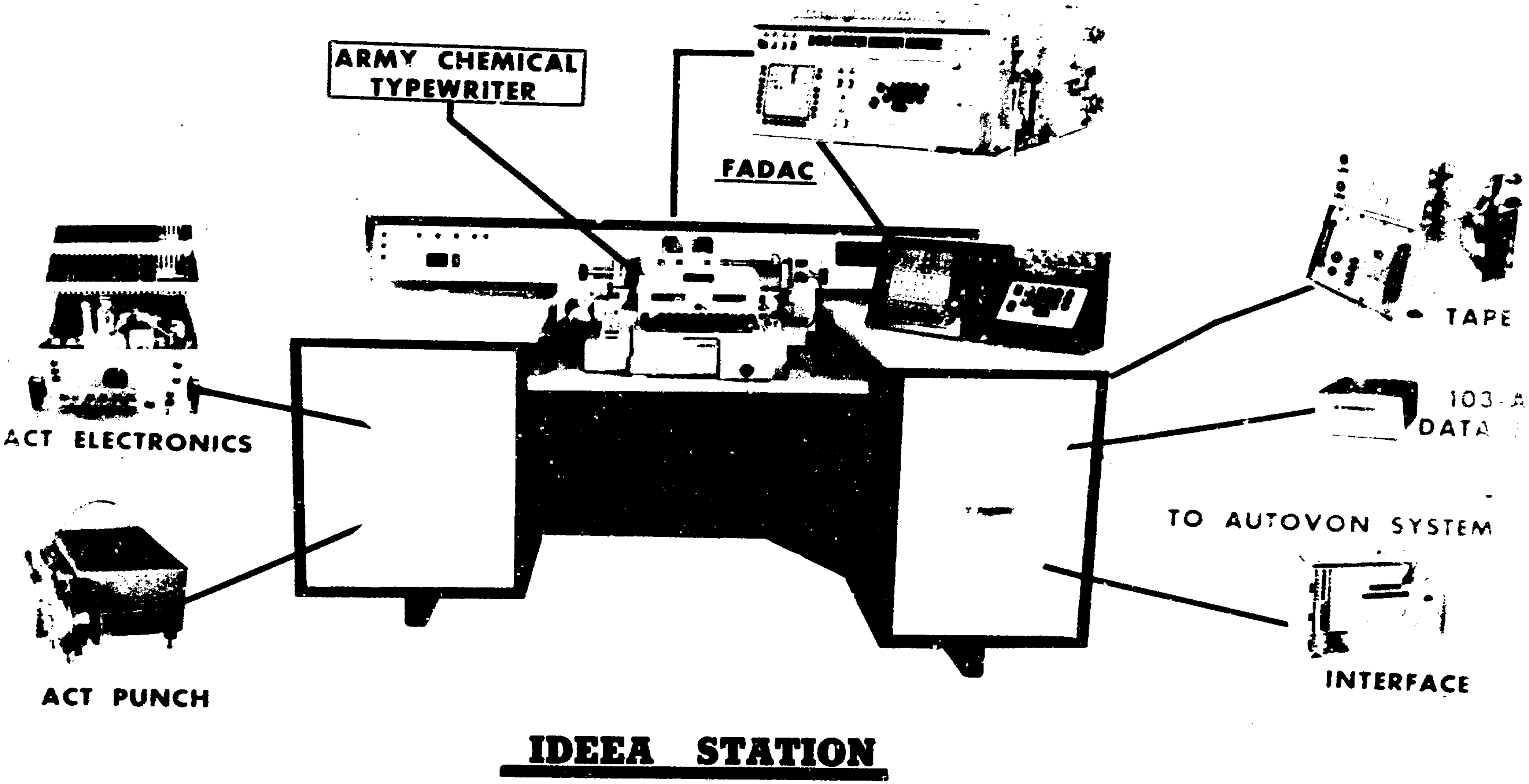

Figure 8. IDEEA Network Station Showing Planned Equipment Locations

The prime function of the Systemizer is to make and break connections between one computer and another, or between a computer and one of the peripheral equipments. These connections permit data to be transferred between computers or between a computer and a piece of peripheral equipment. Each computer can only be involved in one connection at a time, but several independent computer hookups can occur simultaneously. For example, with the seven computer systemizer it is possible for each of the seven computers to be involved in a hookup at the same time. If each computer was connected to a piece of peripheral equipment, seven independent connections could occur simultaneously. When the Systemizer is used in the manual mode, the desired connection is effected by depressing a switch on the front panel. When the automatic mode, the connections are made by the computers themselves under program control. In the automatic mode one computer is designated as the "executive" computer and the other six operate as "satellites". The "executive" computer controls and supervises the "satellites" by making task assignments and monitoring their activities. The "executive" computer can also interrupt any of the "satellites" at any time and reassign work on a priority basis.

The IDEEA Network Systemizer will consist of two units with one housing the power supplies and the other having the logic circuitry, relays, and controls. Both the relays and logic circuits will be mounted on double-sided etched wire boards. Most of the logic circuitry is made up of commercial integrated circuits. The control panel will have a matrix made up of lighted push-button switches. The display will indicate the status of the various equipments in the system and show which connections have been made, and in the manual mode the switches can be used to select desired interconnections. The power and mode selection switches and their associated indicators will also be located on the control panel.

4. IDEEA Network Support Program

When the IDEEA Network was planned it was proposed to utilize available equipment to provide a functional network as soon as possible. However, it was also recognized that the performance and usefulness of the network could be substantially increased by developing new equipments designed specifically for information exchange systems. Therefore, in conjunction with the effort to implement the IDEEA Network with available hardware, it was planned to conduct a support program to develop improved materiel for the network. The items to be produced under the support program are: a multi-program compiler, an improved input-output device and an improved bulk memory.

The multi-program compiler is required for the efficient utilization of the multi-FADAC Station. The compiler will be used to prepare computer programs and because of the large amount of programming and data handling required, the compiler is considered essential to the efficient operation of the system. The improved input-output device will utilize solid-state electronic systems to replace the relatively slow, inefficient and less reliable electromechanical devices used for the initial network installation. Electronic symbol generators and a cathode-ray tube display system are being considered for inputting and displaying data with a hard copy output to be obtained by means of high speed optical reproduction techniques. The improved bulk memory may be similar to the present tape tub, however, the new device will have a capacity of at least one million FADAC words and will have a shorter access time.

The support program developments will require Determination and Finding approval before the contractual efforts can be initiated. However, insufficient program authority during Fiscal Year 1965 precluded the initiation of the planned support program endeavors.

CONCLUSIONS

1. The proposed IDEEA Network concept is feasible and should be implemented as quickly as possible with currently available hardware. The support program should be initiated to develop materiel to expand the capability and increase the utility of the IDEEA Network.

2. Substantial progress has been made in preparing preliminary designs for integrating the available hardware into the IDEEA Network. Plans should be prepared for conducting systematic and meaningful tests on the IDEEA Network to obtain useful data and design information for use in future information exchange systems.

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13. ABSTRACT

The IDEEA Network is a five-station experimental system for the storage, retrieval, and dissemination of chemical structures and data. The Network is being implemented with available hardware and will be used to collect data on the rates and modes of use. The Network concept and the hardware to be used in the Network are described. The effort that was applied to the Network implementation during Fiscal Year 1965 is also described.

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Digital computer systems						
Multi-computer systems						

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