"First Round Hits" With FADAC

The capability of guaranteed first-round hits without registration for any weapon-weather-ammunition condition would be "music to the ears" to all artillerymen. The development of longer range cannon-type weapons and missiles has added impetus to the search to improve the present gunnery solution. The search has produced improved firing tables, graphical devices, and fire direction techniques second to none, and enabled the artillery to render outstanding fire support in World War II and the Korean conflict.

About 1950 it became apparent that some type of computer solution would be necessary to achieve the goal of rapid first-round accuracy on short notice without registration. The proper solution of the artillery gunnery problem appeared to be simulation of the flight of the projectile through a known nonstandard atmosphere from the tube or launcher to impact. This is referred to as solving the differential equations of motion of the projectile. Until about 1954, the necessary equations could only be solved on large scale electronic digital computers.

The first of the M15 and M15C analog computers, the heart of the M35 Field Artillery Fire Control System, were delivered to troop units on a limited procurement contract during January and February of 1960 (fig 3). The M15 and M15C computers produce a geometric and a

ORGANIZATION	**1**	**2**	**3**	**4**
USAAMS	3	1	2	3
4th Infantry Division	5	5	5	15
101st Airborne Division	6	0	1	9
2nd Armored Division	3	0	1	4
2nd Howitzer Battalion, 2nd Artillery	3	0	1	4
2nd Howitzer Battalion, 17th Artillery	3	0	1	4
TOTALS	23	6	11	39

Key: **1** Computer gun data M15 (105-mm How) conversion unit, power M27. **2** Computer gun data M15C (155-mm How) conversion unit, power M27. **3** Gunnery officer's console. **4** Generators.

Figure 3. Issue of the M35 Fire Control System.

firing tables solution for the 105-mm and 155-mm howitzers, respectively, with a measurable increase in accuracy and speed over manual techniques. However, the analog system has several disadvantages: First, it is accurate in the solution for the shorter range weapons but, as range increases, accuracy decreases; second, the solution is built into the hardware of the machine, which means that the machine can solve a problem for just one type of weapon. A more flexible system of computing, one that would expand the computer application to all artillery weapons, was needed.

Rapid strides forward in electronic digital computers—made possible by the development of improved memories, transistors, and printed circuitry—have made it possible for Ordnance to develop the Field Artillery Data Computer (FADAC). The FADAC (fig 4) is small and is capable of meeting the accuracy, flexibility, reliability, ruggedness, operator training, and maintenance requirements imposed by the mission and the environmental conditions under which the artillery must operate. Prototype models of the FADAC reached the US Army Artillery Board, Fort Sill, Oklahoma, in March 1960, for user test.

CHARACTERISTICS OF FADAC

The FADAC is a solid-state (no vacuum tubes), general purpose electronic digital computer that uses a 4,096 word rotating disk memory. Physical and environmental characteristics of the FADAC are summarized in figure 5.

In the fire control role the computer, under present concepts, will provide firing data for one battery of cannons or rockets. However, one computer is capable of storing data for three batteries and can provide firing data for any of the three batteries by simple operator selection of the battery solution desired. Without reprograming, computations can be made for three batteries of any two calibers of the cannon artillery family. For example, the computer can have the ballistic solution for 105-mm and 155-mm howitzers stored in its memory at one time. By using the memory loading unit and changing the small input face plate (see page 13), field personnel can make program changes to permit solution of other cannon, rocket, or missile problems; or other artillery problems such as survey, counterbattery, fire planning, flash and sound ranging, reduction of meteorological (met) data, and master control and programing for automatic checkout of missiles.

A problem in the use of digital computers in civilian industry today is the extensive operator training necessary to effectively use the machines. The FADAC will not require intense operator training. The method by which operation has been made simple is explained by reference to the FADAC control panel, which encompasses the entire front shown in figure 4.

By pressing the POWER ON pushbutton, power is applied to the computer, memory, and control section. The magnetic disk begins to

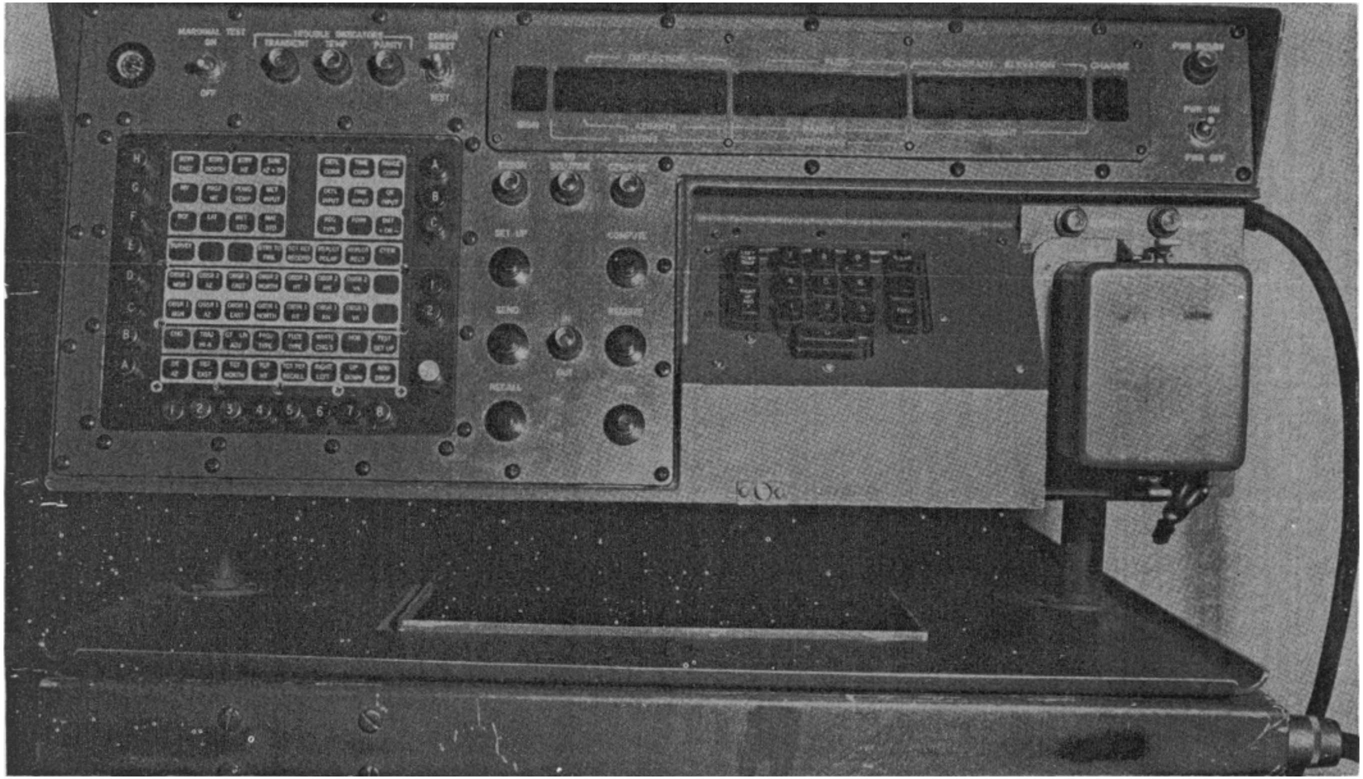


Figure 4.The Field Artillery Data Computer.

1.	**Overall size**	14 inches high, 24 inches wide, 34 inches deep
2.	**Weight**	Approximately 165 pounds
3.	**Power**	Three-phase, four-wire, 400 cycles per second system; 120/208 volt (60 cycles per second will also be evaluated)
4.	**Operating temperatures**	External temperature at sea level; —25 to 125 degrees Fahrenheit; —40 degrees Fahrenheit with kit
5.	**Environmental control**	Inner chamber sealed during operation by combination case and heat exchanger. Internal air is recirculated through heat exchanger inner section for cooling
6.	**Field operation**	a. Operable in dusty or humid environments b. Operation at elevations up to 10,000 feet above sea level and at any orientation up to 20 degrees from normal operating orientation c. Continuous operation for one year, alternating 16 hours on and 4 hours off, with normal maintenance

Figure 5. Physical and environmental characteristics of the Field Artillery Data Computer.

rotate and as soon as it reaches operating speed (6,000 revolutions per minute) the POWER READY lamp lights.

COMPUTER CHECKED FOR CORRECT OPERATION

Next, the computer is checked for correct operation by pressing the TEST button. This causes the computer to perform test functions to determine if it is in working order. The results are checked against answers stored in the computer circuitry. If there is an incorrect comparison, the ERROR light flashes and the operator knows he must go through simplified maintenance procedures using the FADAC Automatic Logic Tester (FALT) (fig 6). The procedure is entirely automatic and standardized due to a prepared test tape. Checkout operations can be performed by relatively nonskilled personnel. If there is no error, the COMPUTE lamp lights when the TEST button is pressed and remains lighted until test routines have been solved. When this light goes off, the operator can proceed to the next step.

Selection of input data is made by using an input function, for example, Battery Easting or Muzzle Velocity, on the input selection panel (fig 7). The eight buttons at the left side and the eight buttons at the bottom of the input selection panel are pushbuttons. The larger rectangular

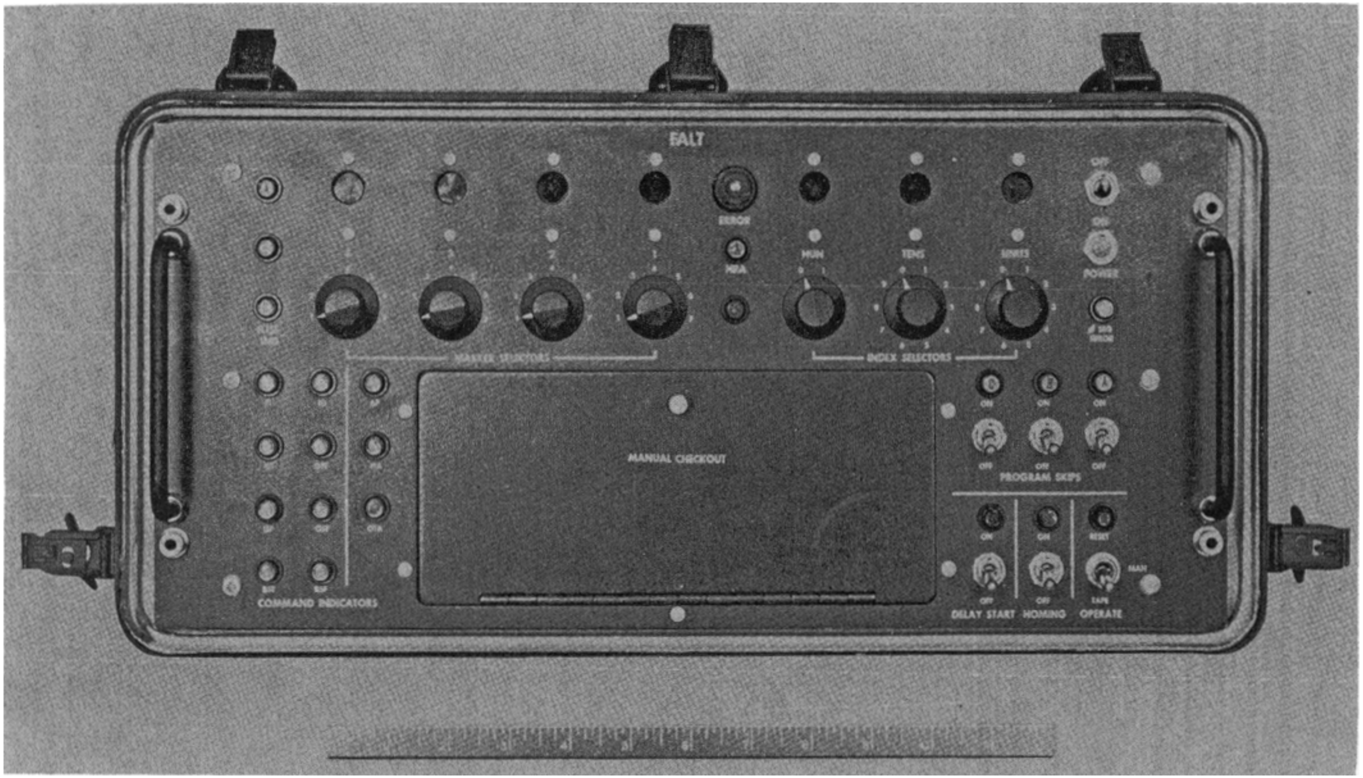


Figure 6.The Field Artillery Data Computer Automatic Logic Tester.

openings are rear lighted windows with the input data functions engraved on their faces, and are arranged for selection convenience. This provides 64 possible button combinations for entering specific problem input data. The 64 rear lighted windows permit the display of information in terminology familiar to fire direction center and battery personnel, thus reducing special operator training. Operators familiar with current graphical means of solution can be trained to operate FADAC in a short time. To enter input data, the operator locates the function name on one of the windows and presses a button directly below and another at the left of that window. The following events then occur:

(1) The selected input window lights up and enables a visual check on the proper input function selection.

(2) The computer program (a set of stored instructions) samples the position of these buttons so that the input data, when entered from the keyboard (fig 8), is stored in a predetermined memory location. Activation of these buttons will not affect the memory during computation.

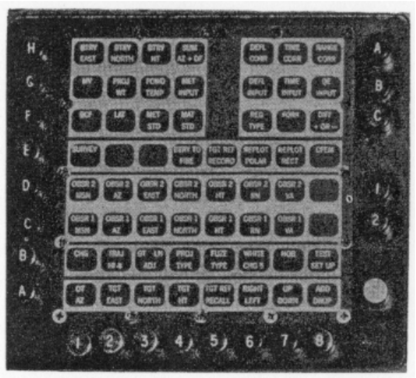


Figure 7. The input selection panel.

(3) The keyboard lamp flashes to indicate that a keyboard entry is necessary and power reaches the keyboard so that input can be entered.

The proper keys enter the sign and numerical data for an input function. As input data are entered from the keyboard, they are displayed in neon decimal indicators (Nixie tubes) for verification before entry into the computer memory. Actuating the CLEAR button clears the Nixie display and erases an erroneous entry before it goes into the working memory. After each entry, a new input function is selected, and the process continues until all entries have been made.

Once an entry has been made the data will stay in effect until replaced by a new entry into the proper memory location. This means that after the setup data, such as battery coordinates and powder temperature have been fed to the computer, succeeding fire missions will require only a new target location.

BUTTONS A, B, AND C

On the right side of the input selection panel there are three buttons labeled A, B, and C (fig 7). These buttons provide input and solutions for three batteries. For example, the upper left selection window is labeled BTRY EAST; by depressing the A, B, and C buttons in turn, it is possible for the operator to input the battery easting coordinate of the three batteries. By using the A, B, or C buttons in conjunction with the COMPUTE button, a solution can be obtained for any of three batteries.

There are also two buttons labeled 1 and 2 (fig 7) on the right side of the input selection panel. These buttons provide the operator a solution for two types of cannon, depending on which program is in the machine. For example, if button 1 was depressed, this could mean a 105-mm howitzer solution; if button 2 was depressed, this could mean a 155-mm howitzer solution.

When all input data have been entered the COMPUTE button is actuated and the computer starts solving the gunnery problem for the battery and caliber designated. When a solution has been obtained, the gun data are displayed in the Nixie readout tubes under deflection, fuze, quadrant elevation, and charge. Solution time will be from 10 to 30 seconds with computational accuracy unheard of in present day artillery.

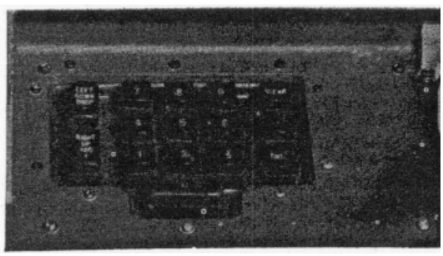


Figure 8. The Field Artillery Data Computer keyboard.

Upon successful completion of the fire mission, replot data may be obtained and displayed in the appropriate readout windows by selection of these functions on the input selection panel.

METEOROLOGICAL DATA MUST BE UNWEIGHTED

The mathematical solution used in FADAC requires the use of unweighted meteorological data. The FADAC senses the weather conditions at each of many levels through which the projectile passes and corrects for this weather at each level, thereby producing a true trajectory solution. This procedure was impossible by hand solution because of the cumbersomeness of a multiline met computation. A met message form has been approved with the heading "Computer Met Message" which transmits in 5-level teletype code the 26-line representation of the meteorological conditions prevalent at the time. To permit rapid and reliable entry of this large met data group, a simple mechanical tape reader is included on the right side of the control panel. If the punched paper tape met message is not available, or if some malfunction of the tape reader occurs, the met data can be entered by use of the keyboard.

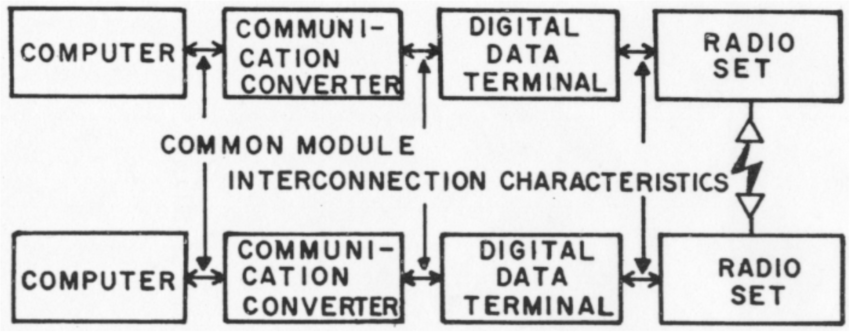
By removing the small set screws around the perimeter of the input selection windows the complete face plate can be removed and a new plate with different window labels can be substituted to perform functions other than fire control. A new program, for example, fire planning, or possibly survey, can be loaded into the memory of the machine. Operator simplicity is maintained while giving the computer extreme flexibility in range of computational applications possible.

To be acceptable for artillery application, a digital computer must be accurate, fast, rugged, small, and easy to operate and maintain. With FADAC now on the scene, the artillery is near its goal of computational accuracy for cannons, rockets, and missiles.

"REAL-TIME" COMMUNICATION CAPABILITY FOR ADP

The importance of a "real-time" communication capability in applying general-purpose digital computers to varied military tasks cannot be overemphasized. Among the features or characteristics that must be provided as a basis for the development and application of the family of equipment are—

(1) A communication buffer or converter with each computer.
(2) Digital data transmission equipment.
(3) A common language or code for information interchange.
(4) A common set of electrical and functional interconnection standards or characteristics for the various pieces of equipment.



The basic elements of a "real-time" communication system between two computers are shown in the above diagram.

Many tactical applications require the computer to receive data from several sources and to transmit data to several data storage or display locations. It is, therefore, usually desirable that the Communication Converter be designed for multiple input and output channels. It is probable that more than one type of Communication Converter will be required for varied tactical applications.