On FADAC Maintenance

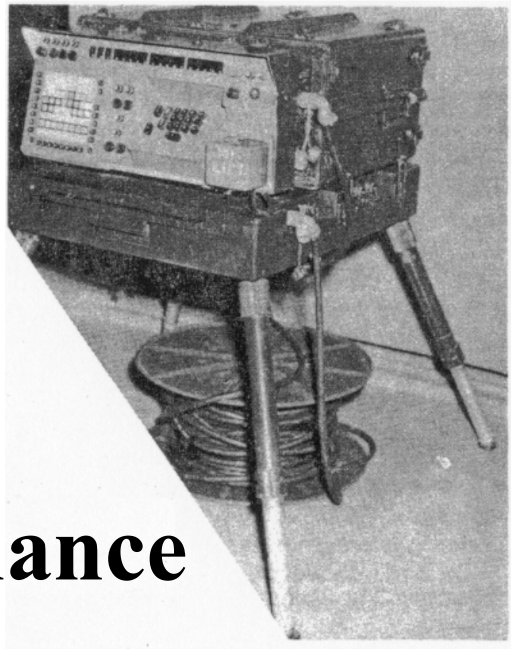

Figure 1. FADAC

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The ultimate objective of artillery is to place fire on a target with speed and accuracy. One method of obtaining timely, accurate fires is through the use of highly trained, well-drilled fire direction center (FDC) teams, coupled with simplified, approximate-method techniques for solving fire direction problems. However, the requirements for both speed and accuracy have increased proportionately with the changes in the character of modern warfare. To significantly improve accuracy, while retaining the speed provided by current FDC procedures, the field artillery digital automatic computer M18 (FADAC) has been developed. The FADAC, also known as the gun direction computer M18 (fig 1) is used in a variety of artillery applications but primarily is used in fire direction and survey.*

The FADAC is an all-transistorized, stored-program, general purpose digital computer designed primarily to compute firing data for a variety of artillery weapons. Weighing approximately 200 pounds, the computer is readily transportable in the field. The FADAC is issued with a field table, weighing approximately 40 pounds, which provides a level support for the computer. A standard 3-kilowatt Corps of Engineers generator

*Reference "FADAC Zeros In," Valerie Antoine, Army Information Digest, Jan 65.

supplies 120/208-volt, 3-phase, 4-wire, 400-cycle power to the computer and its associated equipment. The FADAC can operate between the temperatures of —40° F and + 125° F. Voltage fluctuations of 16 percent above and below the rated voltage (100 volts to 140 volts) cause no loss of accuracy in the problem solution.

To compute firing data, the FADAC selects a charge and trial elevation. Then, using this trial elevation and applying all nonstandard conditions, it solves the equation which describes the path of the projectile. It then determines the location of the burst with respect to the target. If the miss distance is greater than 10 meters, it recomputes the data, using another trial elevation. If the miss distance is less than 10 meters, the FADAC displays the firing data.

In performing the computations to produce this firing data, the FADAC components utilize approximately 1,600 transistors, 9,000 diodes, 6,000 resistors, 500 capacitors, and many other switches, transformers, and neon lamps. In addition, there are some 12,000 wires and 15,000 soldered connections. This should give some idea of the maintenance considerations involved with the FADAC system.

In the past, a problem with most digital computers was that maintenance personnel required extensive training. The FADAC system, however, is based on the concept of module or component replacement at organizational level. The simplicity of this maintenance concept results in the maximum utilization of the FADAC with minimum downtime.

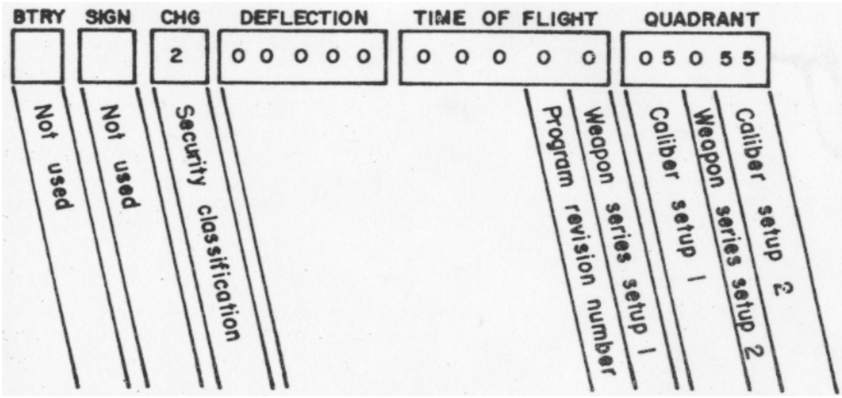
Artillery personnel are capable of performing such maintenance. The concept of module replacement by maintenance personnel at organizational level is a practical way of achieving maximum operating time from the FADAC and represents an impressive saving of training time and economy of personnel. In contrast to maintenance personnel trained from "scratch" in the traditional manner, the FADAC maintenance technician is a field radio mechanic who receives additional training as a computer mechanic. This radio and FADAC mechanic is identified by MOS 31B30.

The purpose of operator maintenance of the FADAC is primarily to prevent equipment breakdowns and the need for higher echelon repair services. The preventive maintenance consists of daily and weekly services as outlined in table I. The operator's training course for FADAC is a 1-week course conducted at the United States Army Artillery and Missile School (USAAMS), Fort Sill, Oklahoma. Publications required are three field manuals and one technical manual. No special tools or test equipment are required. Corrective maintenance by the removal and replacement of parts at the operator level is limited to the indicator lamps and air filters.

Determination of a computer malfunction is also an operator responsibility and is facilitated by utilization of proper computer checkout procedures and application of malfunction recognition principles. Several built-in maintenance aids are at the disposal of the operator to help him determine whether he has an operational computer.

Table I. Operator Daily and Weekly Preventive Maintenance Procedures.

Item	Procedure	Remarks
1.	Inspect exterior surfaces (before and after operation). Keep clean and dry.	Wipe exterior surfaces as necessary.
2.	Inspect for mechanical damage to the computer and table (weekly).	External visual examinations.
3.	Tighten loose hardware (weekly).	Use common hand tools.
4.	Inspect air filters (daily). Clean or replace if necessary.	Wash in warm, soapy water, rinse with clear water, and air dry.
5.	Clean windows of readout display and input display matrix.	Wipe with a soft, lint-free cloth.
6.	Insure that ventilation blowers operate when power is applied.	Listen for whine of blower motors.
7.	Check front panel controls for ease of operation, (no binding of pushbuttons, etc.).	Manually actuate push-button controls.
8.	Check illumination of indicator lamps. Replace if necessary.	To replace a lamp, remove the lens by unscrewing it in a counterclockwise direction. Install new indicator lamp and replace the lens.
9.	Perform program tests or sample problem computations in marginal test positions.	If a steady-state malfunction is generated by a marginal test, corrective maintenance by organizational personnel should be scheduled as soon as possible.
10.	Inspect all cable assemblies for wear, abrasions, kinks, or connector damage.	Replace if necessary.



Security classifications

0—unclassified
1—for official use only
2—confidential
3—secret
4—top secret
9—for training, otherwise unclassified

Program revisions

0—original program
1—first revision
2—second revision

Weapon series code

105-mm howitzer
0—M101A1 (M2A2)
—M101 (M2A1)
—M52 (M49)
1—M108 (XM103)

155-mm howitzer
0—M114A1 (M1)
—M44A1 (M45)
1—T255E2

Caliber codes
05—105-mm how
55—155-mm how
08—8-in how
75—175-mm gun

Figure 2. Program test 1 display for 105-mm, (towed) 155-mm (towed) weapons.

The first of these aids is the program tests. There are two such tests—the permanent storage program test and the temporary storage program test. The permanent storage program test, referred to as program test 1, is a check to determine whether the program is properly loaded in the permanent storage portion of the memory. In this test, all the numbers in the program are added together. The resultant sum is subtracted from a given prestored number in the memory, and the remainder is then displayed on the indicator display panel (fig 2). The temporary storage program test, or program test 2, is a check to insure that the proper information is stored in the temporary storage portion of the memory.

A second aid for the operator is the running of a precomputed sample problem the solution to which is known. Appropriate sample problems are given in the pertinent operation manual of the FM 6-3-1 series. In general, the steps in running a sample problem involve setting up the FADAC; associating the FADAC with a specific weapon system;

removing from the computer all previous battery corrections and target information; entry of all meteorological, battery, and target information; initial computations and solutions; entry of observer corrections; and computation of subsequent solutions and final solutions, as represented by fire-for-effect data. Once the operator has run a precomputed sample problem and has obtained the correct answer, he is assured that the computer is operational.

In addition to the built-in program tests and sample problems, the operator has available to him a marginal test circuit which permits him to perform a limited check of computer operation when intermittent malfunctioning is suspected or known.

The intermittent malfunction is perhaps the most difficult to locate and correct, since clear-cut indications of a malfunction are never present long enough to permit logical troubleshooting. The marginal test procedure is provided to allow variation of certain computer DC power supply voltages to marginal conditions. If a circuit function in the computer has degraded to the point where failure is imminent, the marginal test may be used to encourage the failure of the circuit, thus allowing replacement or servicing of the computer prior to sudden and unexpected breakdown. The use of a marginal test is preventive maintenance in the fullest sense of the word. The MARGINAL TEST control is located on the left side of the FADAC control panel assembly (fig 3). It consists of a six-position rotary switch. The six positions are one OFF position and five positions numbered 1 through 5.

The procedure used by the operator in performing a marginal test is as follows: First select a numbered position and attempt to run the program tests. If no malfunction is detected, then select another numbered position and repeat the tests. Continue testing until a malfunction is or is not indicated by successfully completing both tests and problems in all of the five numbered positions. The organizational maintenance technician must be called if a malfunction is found.

Table II. Authorized Parts for Replacement at the Organizational Level.

a. Input display matrix (④, figure 4)
b. Manual Keyboard (⑤, figure 4)
c. Nixie indicator tubes (⑥, figure 4)
d. Mechanical tape reader (⑦, figure 4)
e. Circuit Board assemblies (figure 5, figure 6)
f. Power control relays (figure 5)
g. Matrix lamps and diodes (contained in ④, figure 4)
h. Power terminal strip on the field table.

Organizational maintenance of the FADAC is corrective in nature and includes replacement of selected assemblies and parts and isolation of malfunctions by diagnostic troubleshooting. The assemblies and parts authorized for removal and replacement at organizational level are listed in table II and illustrated in figures 4, 5, and 6. Among those items authorized for organizational replacement is the keyboard assembly (fig 7). To replace the keyboard assembly, the organizational mechanic removes

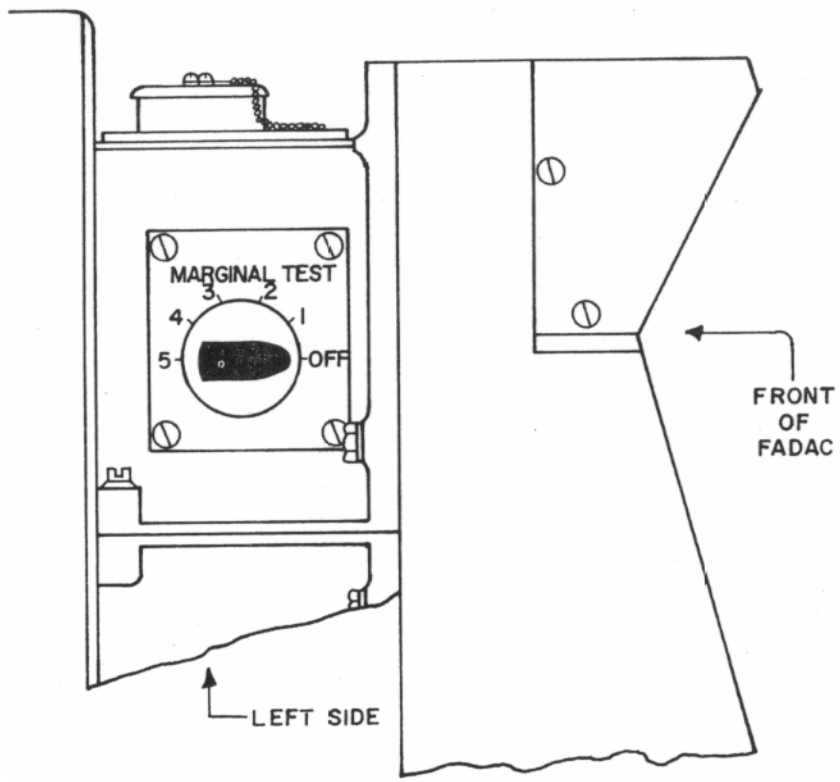


Figure 3. Location of the MARGINAL TEST control on the FADAC.

the screws which hold the keyboard in place, lifts the assembly out of the control panel assembly, disconnects a plug in the rear, inserts the replacement keyboard, and replaces and tightens the screws. Other components authorized for replacement at organizational level are replaced in a similar manner. No soldering is involved or authorized at this level. Training for the organizational maintenance technician consists of a 2-week course conducted at USAAMS, Fort Sill, Oklahoma. Five technical manuals are the required publications at this echelon, and a screwdriver, a wrench, and a board extractor are the only required tools.

Additional equipment used by the organizational maintenance technician in troubleshooting the FADAC are the diagnostic test tape kit (fig 8), the signal data reproducer AN/GSQ-64 (SDR) (fig 9), and the FADAC automatic logic tester AN/GSM-70 (FALT) (fig 10). The diagnostic test tape kit consists of a protective case, appropriate technical manuals, and a set of five prepunched, fan-folded paper tapes, lettered A through E, each of which is used in a malfunction troubleshooting role. Tape A is used

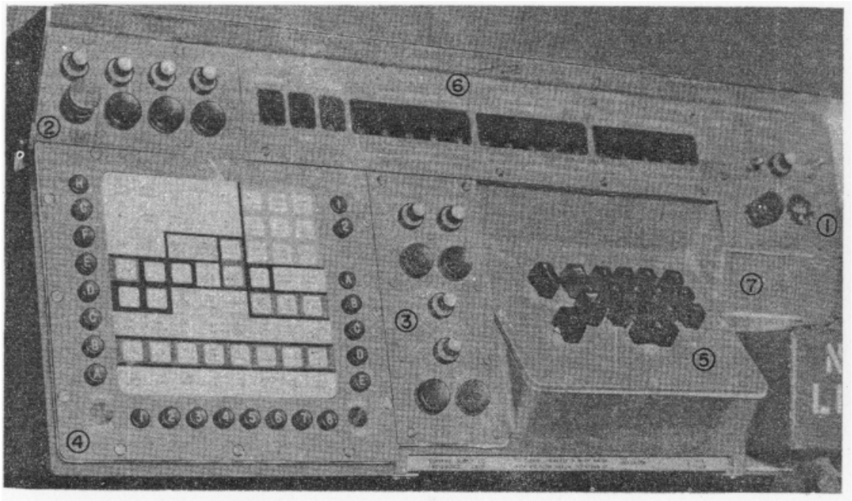


Figure 4. Control Panel Assembly

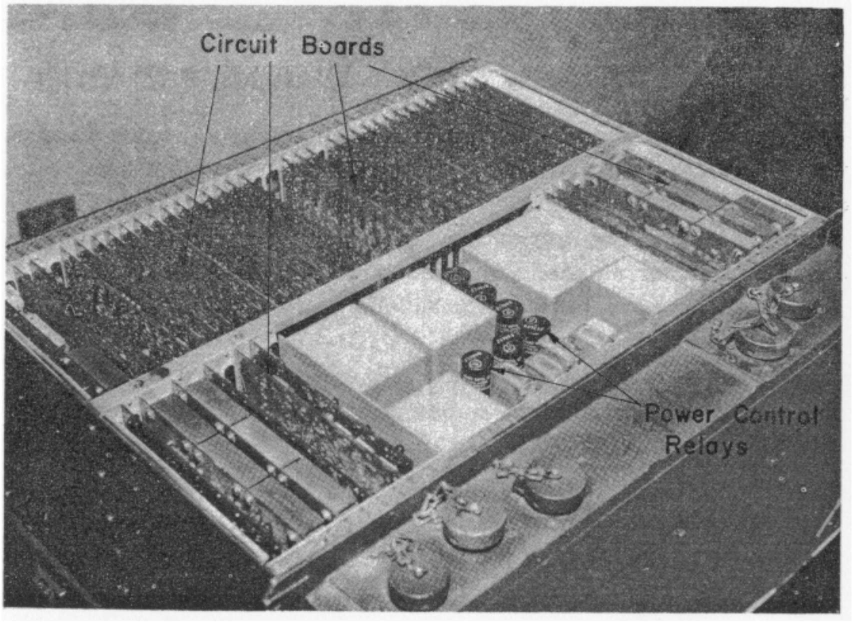


Figure 5. Computer Chassis Assembly

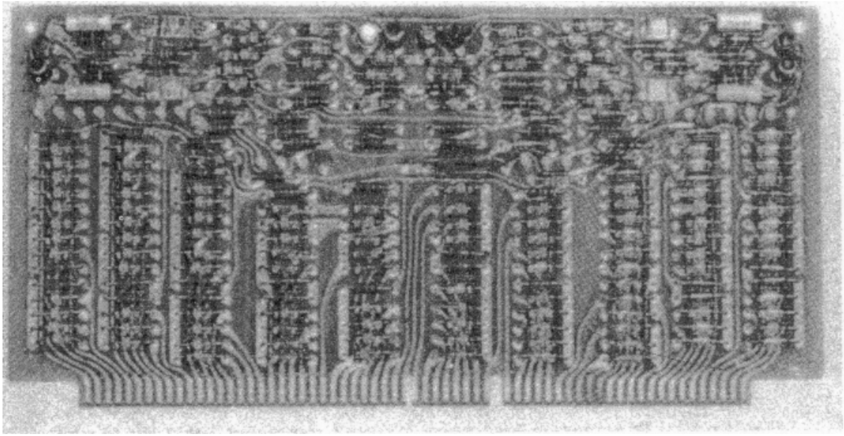


Figure 6. Modular circuit board

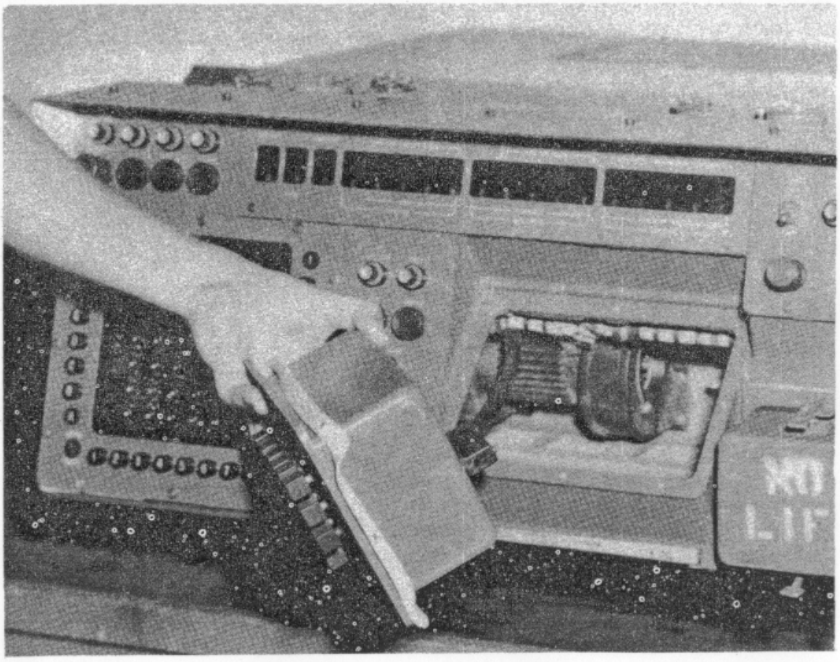


Figure 7. Replacement of manual keyboard

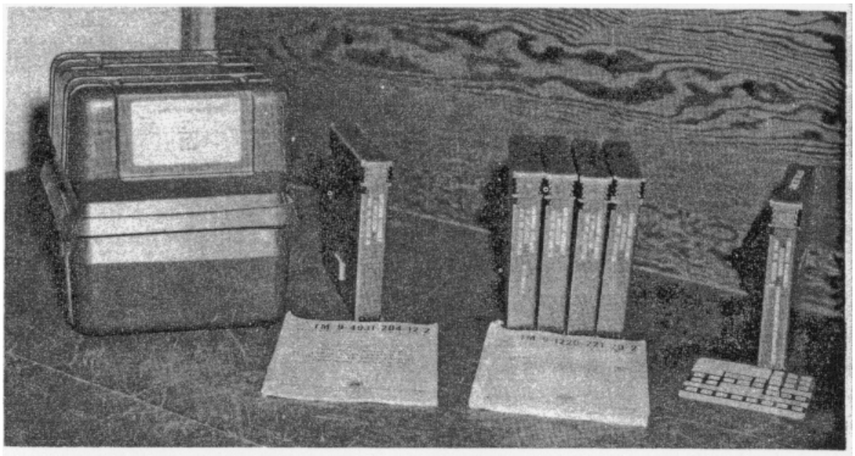


Figure 8. Diagnostic test tape kit and program tape kit (right)

as a confidence self-test of the test equipment. This self-test assures the maintenance technician that his test equipment is operating properly. Tapes B, C, D, and E, when run in association with the test equipment, provide a test of circuits within the FADAC. A sixth tape, shown in figure 8, is a program tape which, with its associated overlay, is used by the organizational maintenance technician to program the computer.

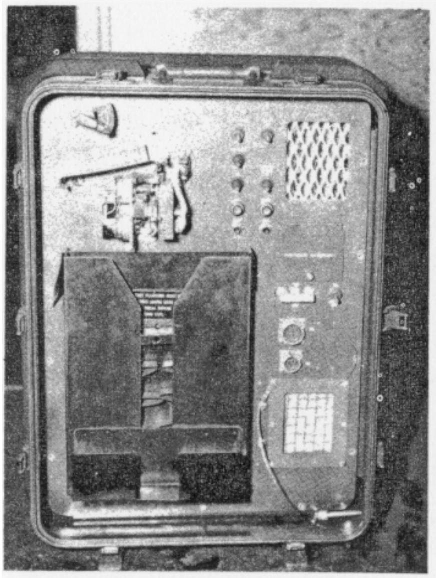


Figure 9. Signal data reproducer AN/GSQ-64 (SDR)

At one time the Signal Data Reproducer (SDR) was called the memory Loading Unit. The SDR is a portable, high-speed, photoelectric, punched-tape reader which translates input information from the punched holes in a moving tape into electrical pulse outputs at a speed of approximately 700 characters per second. The SDR weighs approximately 89 pounds. When the SDR is running, the punched paper tape feeds between a light source and a bank of light-sensing photodiodes. Light passing through the punched holes causes the photodiodes to conduct so that current pulses are formed. These pulses are then amplified in the SDR and sent to the unit to which the SDR is cabled. The SDR has two uses in the FADAC system—to load prepunched programs into the FADAC memory and, in conjunction with the FALT, to effect corrective maintenance for the FADAC.

The FADAC automatic logic tester, contained in a watertight case, is field transportable, semiautomatic, and weighs approximately 185 pounds. The FALT receives the electrical pulses from the SDR. These pulses are interpreted as instructions which cause certain conditions to be established at the inputs of the logic circuits in the FADAC.

Isolation of the majority of FADAC malfunctions at the organizational level is semiautomatic through the use of the diagnostic test tapes. The FALT, driven by test tapes read by the SDR, is used in the isolation of FADAC malfunctions. Isolation techniques (diagnostic troubleshooting) identify malfunctions in both the plug-in type of etched circuit boards (fig 5) and the subassemblies of the control panel assembly (fig 4). Parts replacement to correct such malfunctions is limited to the replacement of those assemblies and parts listed in table II.

The FALT is also used to monitor FADAC power supply output voltages. Elements of the FADAC which are not checked by the diagnostic tapes are the power supplies and power circuits, the air blowers, and the cable assemblies.

The cabling arrangement for the FALT, SDR, field table, and FADAC, in preparation for diagnostic troubleshooting procedures, is shown in figure 11. In a field situation, a cable connection data can be verified by referring to the decal mounted on the top surface of the light hood above the control panel of the FALT. As another aid in cabling, the connectors are keyed so that they will fit in only one socket on the FADAC or FALT. Setup of the separate units for troubleshooting should include a check to insure that no power is applied to any unit until the controls of all the units have been audited for correct position. After the maintenance technician makes sure that all of the controls are in their proper positions, the equipment may be turned on. The FADAC is **always** the last unit to be turned on and the first to be turned off.
This is to prevent sending any stray pulses to the memory of the FADAC. Power for the FADAC, FALT, and SDR is obtained from the power terminal strip of the FADAC field table and is supplied by a 3-kilowatt generator.

Table III. Extracted Portion of Operator's Instructions for Test Tape E.

2 2 3
CH
1. RELEASE THE *RECALL* BUTTON.
2. PUSH AND HOLD THE *RESET* BUTTON UNTIL THE NEXT CH STOP.
3. START THE TAPE READER.

2 2 4
CH

1. RELEASE THE *RESET* BUTTON.
2. THIS TEST CHECKS THE OFF POSITION OF THE SETUP AND RESET BUTTONS.
3. START THE TAPE READER.

2 2 5

CH

PLACE THE *MARGINAL TEST* SWITCH IN ANY ONE OF THE ON POSITIONS.

THE *POWER READY* LAMP SHALL BE BLINKING.

PLACE THE *MARGINAL TEST* SWITCH IN THE OFF POSITION.

THE *POWER READY* LAMP SHALL BE LIGHTED AND SHALL NOT BE BLINKING.

START THE TAPE READER.

2 2 6

CH

THE *IN OUT* LAMP SHALL BE LIGHTED.

THE *COMPUTE* AND *KEYBOARD* LAMPS SHALL NOT BE LIGHTED.

THE *PARITY*, *ERROR*, and *NO SOLUTION* LAMPS SHALL BE LIGHTED AND NOT BLINKING.

START THE TAPE READER.

NOTE: **a.** Digits, such as 2 2 3, etc., refer to the marker portion of marker-index numbers. The display which accompanies 22 3 is 223-000.

b. The designation CH means COMMAND HALT and indicates that the halt originates on the test tape.

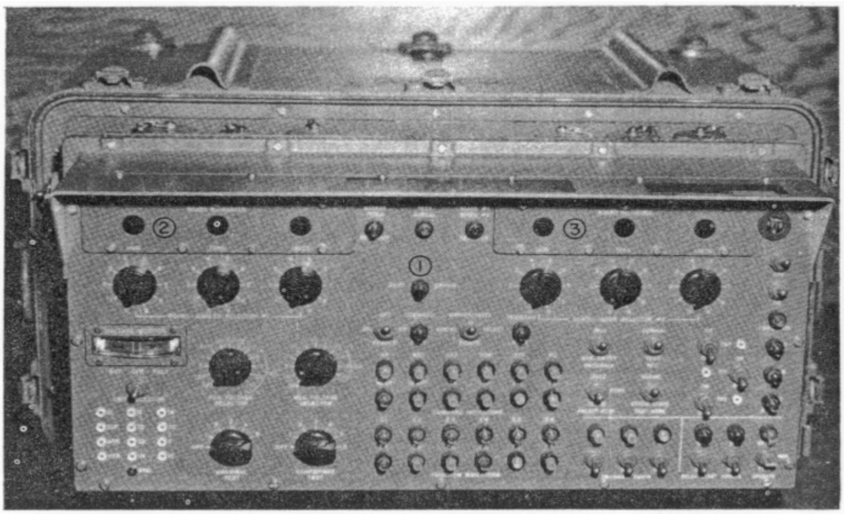


Figure 10. FADAC Automatic Logic Tesrter AN/GSM-70 (FALT)

With the B test tape loaded in the SDR, the maintenance technician starts testing the FADAC. The tape containing the coded test commands is fed through the readhead assembly of the SDR. The photodiodes sense the presence of holes in the tape and generate a current pulse. This pulse is then amplified and sent to the FALT. The FALT interprets the test command and sets up the logic circuits within the FADAC for the test. If the output of the logic circuit being tested is correct, the testing of the FADAC continues. If the output of the logic circuit is incorrect, the FALT sends a pulse to the SDR which stops the tape. The FALT indicates that an error has been found by flashing the TEST ERROR indicator lamp (①, fig 10) along with a display of the appropriate marker-index number (② and ③, fig 10). If the tape stops at a program halt, with a marker-index number displayed, the maintenance technician refers to the corresponding marker-index number in the test tape listing for instructions. An example of such instructions (as extracted from TM 9-1220-221-20/2, Organizational Maintenance Manual: Computer, Gun Direction, M18 (Composite Test Tape Program Print out)) is shown in table III. If the tape stops at a test error halt, as indicated by the flashing of the TEST ERROR lamp, the maintenance technician again refers to the corresponding marker-index number in the test tape listing for the circuit board(s) or other component(s) that should be replaced. Thus, it may be seen in table IV that an error halt at marker 312 - index 092 (or at any index

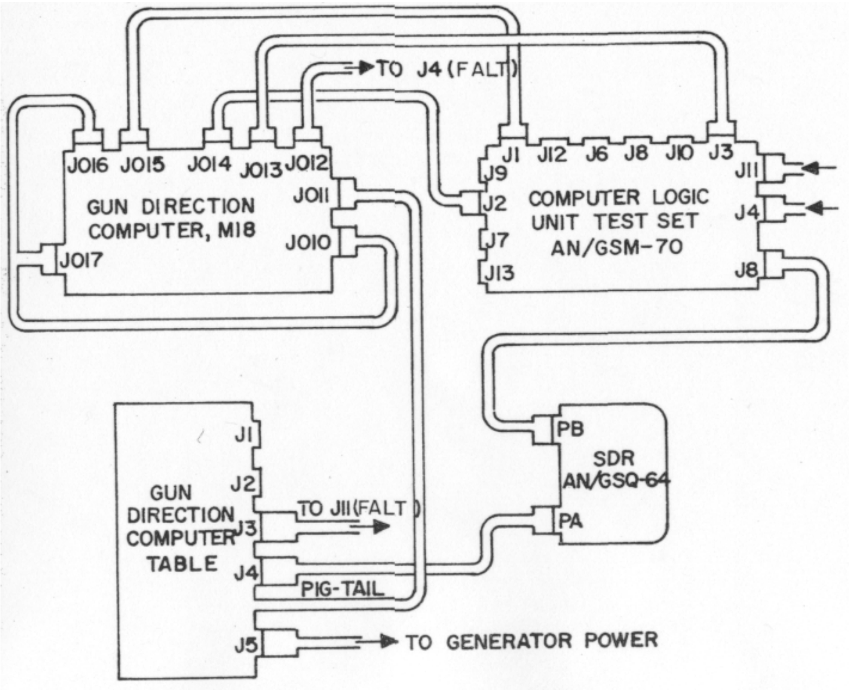


Figure 11. Cable connection diagram for FADAC troubleshooting.

number from 092 to 110) indicates that board 314 contains a malfunction. The board number refers to a location in the computer as designated by the position numbers on the frame of the computer. Once the mechanic has located the malfunctioning component, he shuts down the equipment and replaces the circuit board in location 314. He then backs up the test tape and reruns the error-producing portion of the tape. In the normal FADAC troubleshooting, all four test tapes (B, C, D, and E) are run, in sequence, beginning with the B tape. When all tapes have been run successfully, with no test error halts, the troubleshooting is complete. A defective board(s) or component(s) is forwarded through supply channels to depot maintenance facilities where the defect is repaired and the component returned to supply. New parts are obtained from supply to replace defective parts that have been sent in for repair. If a malfunction is determined to be in a component that is not authorized for replacement at the organizational level, correction of the malfunction must be accomplished by support or depot maintenance personnel.

FADAC has been designed for ruggedness and ease of maintenance. With only a moderate amount of training, personnel organic to artillery units may perform troubleshooting on the computer in order to locate and replace defective components. With this capability, artillerymen can be confident that fires will be on target when called for.

Table IV. Extracted Portion of Marker, Index, Board, and Associated Equipment Listing for Test Tape E.

Marker	Index	Board/s		
312	048-092	313	407	402
312	092-110	314		
313	001-008	303	304	402
313	009-037	304	305	
314	040-067	311	312	
315	001-006	303	304	408
316	100-160	314		
317	001-012	401	402	314
318	ALL	402		
319	001-021	408	409	

M109's PURCHASED

In January 1968, Swiss Government representatives signed an order with the United States Department of Defense for a purchase of selected U. S. Army equipment. Under this order, Switzerland will purchase a quantity of M109(155-mm) Howitzers (self-propelled), M113A1 Armored Personnel Carriers and fitter (maintenance) vehicles. The total value of the order approximates $37 million. This purchase is subject to final approval of the Swiss Parliament.