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PAL Control of Theater Nuclear Weapons (U)

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PAL Control of Theater Nuclear Weapons (U)

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Abstract (U)

The requirements and objectives of the theater PAL systems are discussed. Current PAL systems, including both hardware and code management, in the European and Pacific Commands are reviewed, and some potential improvements are identified. Advanced development PAL technology also is reviewed. Issues which deserve additional study are presented.

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Contents (U)

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Acronyms (U)

AADCOM	Army Air Defense Command
AAFCE	Allied Air Forces Central Europe
ABNCP	Airborne Command Post
ACE	Allied Command Europe
AD	Air Defense
ADM	Atomic Demolition Munition
AEC	Atomic Energy Commission
AFAP	Artillery Fired Atomic Projectile
AFCENT	Allied Forces Central Region
AFNORTH	Allied Forces Northern Region
AFSOUTH	Allied Forces Southern Region
AK	Adaption Kit
ALCM	Air Launched Cruise Missile
AMAC	Aircraft Monitor and Control
APC	Automated PAL Controller
APS	Active Protection System
ASW	Antisubmarine Warfare
ATAF	Allied Tactical Air Force
BALTAP	Baltic Approaches
C3	Command, Control, and Communication
C3S	Command, Control, and Communication System
CAP	Code Activated Processor
CES	Code Enable Switch
CD	Command Disable
CDS	Command Disable System
CENTAG	Central Army Group
CINCLANT	Commander in Chief Atlantic
CINCPAC	Commander in Chief Pacific
CLS	Classified Logistics Shipping
COMUSK	Commander US Forces Korea
COMUSMFK	Commander US Marine Forces Korea
CSM	Cipher System Module
DCA	Defense Communications Agency

Acronyms (cont) (U)

DIVARTY	Division Artillery
DOD	Department of Defense
EA	Emergency Action
EAM	Emergency Action Message
ERDA	Energy Research and Development Administration
ESD	Environmental Sensing Device
EUCOM	European Command
FA	Field Artillery
FFSS	Forward Field Storage Site
FSS	Field Storage Site
GEP	Group Employment Plan
GLCM	Ground Launched Cruise Missile
GSU	GLCM Security Unit
HCP	Headquarters Code Processor
ICU	Integrated Control Unit
IOC	Initial Operational Capability
IPS	Integral Protection System
JCAE	Joint Committee on Atomic Energy
JCS	Joint Chiefs of Staff
LCC	Launch Control Center
MAF	Marine Amphibious Force
MC	Military Characteristics
MCCS	Multiple Code Coded Switch
MCCSS	Multiple Code Coded Security Switch
MCP	Missile Command Post
MOB	Main Operating Base
MUNSS	Munitions Support Squadron
MWWU	Marine Wing Weapons Unit
NASP	Nuclear Ammunition Supply Point
NCA	National Command Authority
NH	Nike Hercules
NMCC	National Military Command Center
NON	North Norway
NOP	Nuclear Ordnance Platoon
NORTHAG	Northern Army Group

Acronyms (cont) (U)

NSA	National Security Agency
NSAM	National Security Action Memorandum
NST	Nuclear Support Team
OB	Ordnance Brigade
PACOM	Pacific Command
PAL	Permissive Action Link
PDM	Portable Data Module
PIA	Pershing IA
PMCT	PAL Management Control Team
QRA	Quick Re ion Alert
ROC	Required Operational Capability
ROK	Republic of Korea
SACEUR	Supreme Allied Commander Europe
SACLANT	Supreme Allied Commander Atlantic
SAS	Sealed Authenticator System
SASP	Special Ammunition Supply Point
SCS	Security Container System
SDM	Source Data Module
SEP	Selective Employment Plan
SETAF	Southern European Task Force
SHAPE	Supreme Headquarters Allied Powers Europe
SHOC	SHAPE Operations Center
SIOP	Single Integrated Operational Plan
SIP	System Improvement Plan
SLCM	Sea Launched Cruise Missile
SLO	Stabilization Lockout
SNL	Sandia National Laboratories
SONOR	South Norway
SSBN	Submarine Strategic Ballistic Nuclear
SSP	Scheduled Strike Program
TFW	Tactical Fighter Wing
TNF	Theater Nuclear Force
TNW	Theater Nuclear Weapon
UDL	Use Denial Lock

Acronyms (cont) (U)

USAAG	US Army Artillery Group
USAFAD	US Army Field Artillery Detachment
USAFE	US Air Force Europe
USAFK	US Air Force Korea
USAREUR	US Army Europe
USCINCEUR	US Commander in Chief Europe
USCINCLANT	US Commander in Chief Atlantic
USG	Unique Signal Generator
USNAVEUR	US Navy Europe
WSD—K	Weapons Support Detachment—Korea

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PAL Control of Theater Nuclear Weapons

1. Introduction (U)

(U) The Defense Communications Agency (DCA), Planning and Systems Integration Division, has been requested by the Office of the Secretary of Defense (OSD) to undertake the task of planning improvements to the Command, Control, and Communications (C3) System which supports theater nuclear forces (TNFs) in the US European Command (EUCOM) and Pacific Command (PACOM). System Improvement Plans[1,2] (SIPs) for both theaters, based on Required Operational Capability (ROC) generated by theater personnel, have been drafted by DCA. These documents reflect the need, expressed in ROCs from both commands, to improve the present Permissive Action Link (PAL) code management system. The DCA has asked Sandia National Laboratories (SNL) to perform a preliminary review of the PAL systems in PACOM and EUCOM and generate a reference document for ROC validation and SIP review. It is also intended that this review attempt to identify and describe potential improvements to existing capabilities beyond those discussed in the existing ROCs.

(U) Section 1 of this report seeks to compile, through historical review, the requirements and objectives of the theater PAL systems as they exist today. Section 2 reviews and discusses the PAL systems in PACOM and EUCOM as they existed in the 1982-83 time frame. Both hardware elements and code management are discussed. In Section 3, areas of possible improvement are presented. Section 4 reviews advanced development currently under way, and Section 5 discusses system improvement and issues which deserve more detailed study than is possible in the context of this report.

1.1 PAL and Nuclear Weapons Command and Control (U)

(U) The President of the United States and the Secretary of Defense (or their designated successors) comprise the National Command Authority (NCA) in which is vested the sole authority to order the use of US nuclear forces. Nuclear weapons C3 systems are designed to provide assurance that the risk of unauthorized use of US nuclear weapons is acceptably small. At the same time, C3 systems must provide the capability for the President to exercise his authority should he deem it necessary. The dual nature of the C3S objective was aptly summarized by a joint ERDA/Army working group which described the objective as follows: "to provide effective control while retaining maximum operational flexibility and minimum restrictions on National Command Authority actions and alternatives."[3]

(S)Control of nuclear weapons has historically included two complementary elements: administrative measures and mechanistic systems. Administrative measures (e.g., guards, exclusion areas, no-lone zones, and sealed authenticator systems) are designed to limit access to the weapons themselves or to critical information.[4,5] The effectiveness of such measures depends on the reliability and dedication of the involved Department of Defense (DOD) personnel. Mechanistic systems have been based on disenabled weapon hardware.

DOE b(3)

The effectiveness of such systems depends on the difficulty in circumventing the disenabling hardware and is measured by the length of delay afforded by the protective mechanism.

(U) During the past 20 years several mechanistic systems have been developed, including the positive enable system for Minuteman, the bomber coded switch, the Titan coded switch, and the PAL system for theater nuclear weapons. The historical evolution of the PAL system is described in the next section.

1.2 History of PAL

(U) In the years immediately following World War II, the issues of nuclear weapon safety, security, and control were thought to be adequately addressed since the weapons were either deployed within the US or with sizable US units abroad and since the inherent design of the early weapons physically separated critical nuclear components from the rest of the weapon system. This precluded nuclear detonation prior to final weapon assembly. These components were maintained in the custody of the Atomic Energy Commission (AEC) (part of which is now the Department of

Energy (DOE)) until the President authorized transfer to military units for assembly and delivery. Increasing concerns with readiness/reaction times led first to the development of weapons with inflight insertion of the nuclear components and ultimately to sealed pit ("wooden bomb") designs. These weapons are complete rounds which require very little preparation for use.

(U) In February 1957, the Armed Forces Special Weapons Project (now the Defense Nuclear Agency) initiated a series of safety studies of the stockpiled sealed pit weapons. These studies led to the concept of a trajectory or environmental sensing device (ESD) which would interrupt critical warhead electrical systems until a characteristic delivery environment (spin acceleration, velocity, etc) was sensed. The W49 warhead (carried by the Thor, Atlas, and Jupiter missiles) was the first stockpiled weapon to receive ESDs. The W49 retrofit program was complete by the summer of 1959, and a family of ESDs was under development for incorporation in other weapons.

(U) ESDs cannot be devised for Atomic Demolition Munitions (ADM) whose delivery environments are not easily distinguishable from other elements of their stockpile-to-target (STS) sequences. In lieu of ESDs, ADMs were fitted with 3-digit combination locks (50^3 or 1.25×10^5 code population). The locks prevented physical access to critical arming components. Unlocking these devices provided an extra step in the prearming sequence which increased handling safety. In August 1959, in response to the DoD desire for a remote unlocking capability, Sandia began to develop the concept of a remotely-operated combination lock. By June 1960, a number of possible mechanical design approaches had been identified.

(U) In parallel with the increase in concern for nuclear safety, the issues of nuclear weapon security and control began to assume a higher profile in the late 1950s. In June 1957, the NATO Military Committee called for the use of non-US NATO delivery systems to be used in addition to US systems in case of a massive nuclear response. In December 1957, the NATO Military Commitee formally requested President Eisenhower to establish a NATO nuclear stockpile under US custodial control. Within a month, the President had requested an amendment to the Atomic Energy Act of 1954 to allow the transfer of limited restricted data and nonnuclear weapons system components to some NATO allies.

(U) In June 1958, Congress passed PL 85-479 which accomplished these goals and paved the way for the negotiation of bilateral programs of cooperation between the US and various NATO allies. Each of these agreements provides for the deployment of US weapons to the host country for use by NATO forces. The weapons remain under US custodial control until transfer is authorized by the President. The host country assumes primary responsibility for the security of the weapons. The deployment of weapons to support non-US NATO forces significantly increased the number of US weapons abroad. Since most of these weapons were not sealed pit types, custodial control of the critical nuclear components was deemed adequate.

(U) In 1960, the Supreme Allied Commander in Europe (SACEUR) decided to place some of his nuclear forces on Quick Reaction Alert (QRA). This required assembled warheads to be mated to NATO aircraft and missiles. The first QRA units became operational in July 1960. By late 1960, concern had arisen in several quarters over possible unauthorized use of NATO weapons.

(U) During the summer, Sandia had begun to discuss the use of remotely operated combination locks as command and control aids with the AEC Department of Military Application; by November, prototype coded switch hardware (a 10^4 code population electromechanical device) had been demonstrated. In October, the AEC had requested Los Alamos Scientific Laboratory and Lawrence Livermore Laboratory to study concepts for devices to enhance the safety and use control of NATO weapons. During November and December, members of the Joint Congressional Committee on Atomic Energy (JCAE) toured weapon storage sites in Europe to assess the adequacy of US custodial control. Their report, which was delivered to newly-elected President Kennedy in February 1961, suggested that with respect to custodial arrangements for US weapons in an alert posture, the DoD was not in compliance of Section 92 of the Atomic Energy Act which specified US possession of all US weapons.

(U) By April 1961, three DoD committees had been formed to study the use control issue: the Special Warhead Arming Control (SWAC) Committee under the Defense Atomic Support Agency (now DNA), the Safety Steering Group under Dr. Marvin Stern (the Stern Committee) in the Office of Deputy Secretary of Defense for Research and Engineering, and Project 106 (j), the Joint Command and Control Study Group under the Joint Chiefs of Staff (JCS). By August, all of these groups had focused on the concept of a permissive link to preclude weapon arming without the use of a controlled numerical code. At about the same time, the Director of Military Applications DOE had requested a Sandia study on the availability of code-controlled special warhead arming devices.

(U) As a result of these studies, in August the Secretary of Defense formally requested the AEC to develop permissive links for NATO weapons. In September, the Director of Military Applications requested Sandia to continue developing the Permissive Action Link (PAL), as they had come to be called, and to report a plan for retrofitting NATO weapons with these devices. This report was delivered in January 1962.

(U) In March, the JCAE convened to discuss the adequacy of existing weapon custodial arrangements. They reported an urgent requirement to develop the permissive link technology. In May, the President convened a study group under Science Advisor Jerome Wiesner to report a plan for incorporating permissive links in NATO weapons. After receiving Weisner's report, the President issued National Security Action Memorandum (NSAM) 160[6] on June 6, 1962. This Order directed that all US weapons deployed to NATO be equipped with permissive links. In February 1972, following a visit by members of the JCAE to the Pacific theater, the Secretary of Defense decided to extend PAL control to weapons deployed on foriegn soil in the Western Pacific area.

(U) NSAM 160 also directed the establishment of a research program aimed at developing more advanced PAL devices and thus initiated a program of research, development, and implementation of PAL hardware that continues today. In response to NSAM-160, the DoD integrated new command and control hardware with all existing NATO-based systems. The short-range theater systems were fitted with 5-digit mechanical combination locks. The W31 Nike Hercules and Honest John missiles, the W45 and W54 ADMs, the W54 Davy Crockett projectile, and the W33 and W48 artillery-fired atomic projectiles (AFAPs) were equipped with these locks.

(U) Meanwhile, a crash program was initiated to finish development of the electromechanical, 4-digit (10^4 code population) coded switch (MC1541) and its associated control equipment. This device, known as Category A (CAT A) PAL, was retrofitted to the existing long-range systems. These included the W49 Jupiter IRBM, the B7 and B28 gravity bombs, and the W28 Mace, W50 Pershing, and W52 Sergeant tactical missiles.

(U) In mid-1961, development of Category B (CAT B) PAL had already begun.[7] This device (MC1707) was also an electromechanical, 4-digit coded switch, but it could be controlled by fewer wires than were required for CAT A PAL. This made it practical to unlock PAL from an aircraft cockpit. CAT B PAL incorporated a number of other improvements, including the ability to recode and check the operational code without unlocking the PAL, decreased operation time, and a code-controlled lock operation. The B28, B43, and B57 gravity bombs were modified to accept CAT B PAL. CAT B was included in the baseline B61 design and fielded in the B61-0.

(S) By 1964, command and control hardware in the form of mechanical locks and CAT A and B PAL devices (and their associated control equipment) were available to provide code control for all weapons deployed to NATO.

[redacted]

(U) Development of the improved CAT B PAL began in 1965.[8] The objective of this effort was to provide a "limited try" feature that would preclude an exhaustive-search attack, in which all possible codes are tried until the switch unlocks. This improved switch (MC1707A), called CAT B' PAL, was fielded in only one weapon system, the W72 Walleye guided glide bomb.

[redacted]

(U) In 1971, the Military Characteristics (MC) for the W70 Lance warhead were amended to require a 6-digit, limited-try PAL for the initial WR production.[10] This requirement was met by extending the design of the CAT B' PAL to accommodate a 10^6 code population. The resulting component (MC2607) was called the CAT C PAL; it was fielded only in the W70-0.

(C) The first electronic PAL device, the MC2764 Multiple Code Coded Switch (MCCS), began development in late 1970.[11]

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(U) The foregoing historical sketch has emphasized the technical evolution of PAL equipment. Development of objectives and requirements for PAL is discussed in more detail in Section 1.3.

1.3 PAL Objectives and Requirements (U)

(U) For 20 years, the maintenance of a PAL system for theater nuclear forces has been a policy of the US Government. A clear understanding of the objectives behind the policy is necessary to evaluate the effectiveness of the existing PAL system and to identify potential improvements to that system. The following sections review historical and current documentation related to the PAL policy in an effort to establish the objectives against which today's PAL system can be measured.

DoE b(3)

1.3.1 Objectives and Requirements—Historical Perspective (U)

(U) The extraordinary care taken with nuclear weapons by the DOD reflects the underlying concern, as stated in Air Force Regulation 122-10[16], of the US Government that:

> "Because of their political and military importance, their destructive power, their cost, and the consequences of an unauthorized or accidental nuclear or high explosive detonation, nuclear weapons must be protected against the risks and threats inherent in their environment.
>
> a. The conservation of nuclear weapons as a national resource and the safety of the public, operating personnel, and property are of paramount importance. These weapons and weapon systems must be designed to incorporate maximum safety consistent with operational requirements.
>
> b. Nuclear safety requirements are to prevent nuclear accidents and to minimize both the number and consequence of nuclear incidents and deficiencies."

(U) The concern is codified in Section 92 of the Atomic Energy Act of 1954 (or the Atomic Energy Act of 1946, as amended) which states:

> (U) "It shall be unlawful for any person to transfer, receive in interstate commerce, manufacture, produce, transfer, acquire, possess, import or export any atomic weapons, except as may be authorized by the Commission pursuant to the provisions of Section 91."[17]

(U) In 1960, Congress, as discussed above, became concerned that US arrangements for employment of US nuclear weapons by NATO forces (in particular those policies and procedures governing weapons placed in an alert posture with non-US NATO delivery units) were not in compliance with this law, since possession of a U.S. atomic weapon by any person (including agents of a foreign government) is prohibited. A series of subsequent studies developed the concept of a PAL device that would preclude arming a weapon without receipt of a coded signal. Thus, possession of information necessary to arm a weapon was added to the sometimes minimal custodial presence.

(U) In March 1962, the JCAE met to examine the legality of existing arrangements for possession and control of US nuclear weapons in NATO. The committee recommended ". . .that an urgent requirement should be established to develop such controls and devices," i.e., the PALs.

1.3.1.1 NSAM-160 (U)

(U) In June 1962, President Kennedy issued National Security Action Memorandum No. 160 (NSAM-160) which ordered the installation of PALs on all US nuclear weapons in NATO. An attached memorandum by Presidential Science Advisor Jerome Wiesner describes the capabilities of existing PAL devices and presents deployment options. NSAM 160 and the attached memo are included in Appendix A. The memo listed four possible objectives for PAL. In order of increasing technical difficulty, these were:

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(C) Except for number 2, these objectives are stated in terms of the adversary against which PAL might ~~provide protection.~~

(U) ~~It was not~~ Wiesner's intent to suggest a particular objective for PAL:

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> (C) "For the purpose of this review, I have not attempted to meet a specific objective but rather have analyzed the operational value of the best available equipment."

(U) Rather, he wanted to present options for the implementation of PAL, but

> (C) ". . .the decision as to the extent to which permissive link equipment should, in fact, be

incorporated in dispersed weapons can be made solely in terms of broad policy considerations as to the desired objective."

[redacted]

DOE b(3)

1.3.1.2 PAL General Characteristics (U)

(U) In September 1962, the Secretary of Defense approved a set of DoD design guidelines for PAL systems. These guidelines, entitled "General Characteristics for Permissive Devices for Use With Nuclear Weapons," or revisions thereof have served since that time as standards in specifying PAL devices in the MC of new weapons systems. The original guidelines and the four revisions (1969, 1970, 1972, and 1980) are included in Appendix B.

(U) The statement of purpose in the first edition of the General Characteristics of PAL defines:

> (U) "an arming control device for use with designated nuclear weapons which is intended to provide some additional physical means for preventing unauthorized use of nuclear weapons."[18]

(U) A number of specific design requirements are included. Most of these relate to specific operational features of the PAL system or to issues of compatibility with the rest of the weapons system. For instance, the PAL system

- (U) must not degrade weapon safety or reliability
- (U) must be compatible with weapon operational concepts as stated in the STS
- (U) must not significantly lengthen the reaction time for the weapon system

(U) These requirements are restated in all subsequent versions of the General Characteristics. However, as suggested in the Weisner memo, the objective of this system and its reason for existence is based on its ability to protect the weapon against unauthorized use by a potential adversary. Of the twelve specific design requirements stated in the original document, only one relates to the performance of PAL against an adversary.

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[redacted]

(U) Thus, the objective in terms of an adversary is not specified. However, some bounds are placed on the adversary's capabilities. The *function* of PAL is stated in terms of delay following unauthorized access to a weapon.

(U) In the 1969 edition, the stated purpose is

> (U) "To provide general characteristics for permissive action links incorporated in weapons systems to prevent unauthorized nuclear detonation."[19]

DOE b(3)

[redacted]

(U) In 1972, a new edition was prepared to include all existing PAL technology. While the statement of purpose remained essentially the same as in the 1969 edition, PALs are defined as

> (U) "devices and subsystems designed to reduce the possibility of obtaining a nuclear detonation from a nuclear warhead without the use (insertion) of a controlled numerical code, thus reducing the probability of an unauthorized nuclear detonation."[20]

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(U) The 1962-1980 evolution of PAL characteristics is marked by several features.

- (U) Compatibility with other weapon systems requirements, such as safety, reliability, reaction time, and deliverability, is specified.
- (U) All versions emphasized the prevention of unauthorized nuclear detonations as the general objective of PAL.
- (U) All versions recognized the function of PAL as delay of unauthorized detonation once unauthorized access to weapons has been achieved.
- (U) Numerical standards of performance were stated in terms of minimum delay times associated with different types of PAL systems. However, these standards were not explicitly related to the function of the overall command and control system.

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(U) In April 1980, the current version of the General Characteristics of PAL was published. This document is discussed below.

1.3.2 Current Objectives and Requirements (U)

(U) In this section, current documentation relevant to PAL policy is reviewed to determine the objective against which the performance of today's PAL system may be measured.

1.3.2.1 The Executive Requirement (U)

(S) The executive requirement for PAL originated with NSAM-160, which was rescinded in December 1976.

1.3.2.3 Military Requirements (U)

(U) The executive requirement for PAL is promulgated through the Joint Chiefs of Staff (JCS).

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(U) Today, the commanders of the unified and specified commands to which nuclear weapons are allocated are responsible to the President and the Secretary of Defense to:

(U) "establish and supervise the policies, practices and responsibilities for the storage, safety, security, custodial control, deployment, and utilization of nuclear weapons."[23]

(U) Explicit reference to PAL in relation to the theater commander's custodial mission and in particular to his weapon security responsibilities does not appear in either Ref 23 or 24.

DOE b(3)

1.3.2.4 Related Documents (U)

(C) A letter from James P. Wade, Jr., Chairman of the Military Liaison Committee, to Duane Sewell, Assistant Secretary for Defense Programs, dated 18 April 1980, accompanied the current version of the PAL General Characteristics. This letter (Appendix C) comments on the role and function of PAL. The function of PAL as delay is emphasized. However, a broader role is presented for PAL than that envisioned in today's theater implementation.

DOE b(3)

(U) A third relevant document[28] from the office of the Assistant to the Secretary of Defense for Atomic Energy summarizes measures currently being implemented to upgrade the safety and security of nuclear weapons. Among the issues discussed in this document are

- Improvements in physical security to minimize the likelihood of loss of control of a nuclear weapon
- Stockpile improvement programs that address, among other things, modernization of the PAL protection in some of the older systems expected to remain in stockpile
- Modernization of DoD policy directives to clarify standards and criteria for positive control measures for nuclear weapon systems.

1.3.3 Summary of Objectives and Requirements (U)

(U) A review of historical and current documents and examination of today's theater PAL systems lead to the following conclusions:

- (S) The requirement for PAL originated at the Presidential level and is promulgated through the JCS. This requirement states that all TNWs deployed to foreign soil will be PAL-equipped. Responsibility for implementing and operating the PAL code-management system is delegated to the theater CINC.

DOE b(3)

- (U) PAL must be compatible with all other weapon system requirements.
- (C) The function of PAL devices was historically recognized as delaying for a period of time, after unauthorized access to a weapon has been gained, the unauthorized detonation of that weapon. This is also the recognized function of PAL today.
- (C) The operational context in which today's theater PAL systems function suggests that PAL is one measure which protects against unauthorized use by US or Allied forces. Additionally, some benefit (delay) would be provided if outsiders (terrorists or host nation forces) were to gain access to a weapon. However, no explicit and agreed-upon definition of the threat against which PAL is intended to provide protection currently exists. Such definition would be useful in assessing the performance of todays PAL system.

2. PAL Systems Today (U)

2.1 Hardware Elements (U)

DOE b(3)

(U) PAL devices are utilized to delay use of a nuclear weapon by someone without knowledge of a controlled numerical combination. Today, PAL devices are either combination locks or coded switches. Combination locks mechanically prevent, by a variety of means, use of the associated weapon until removed. Coded switches maintain a weapon in an electrically disenabled state until the combination is inserted (Figure 1). All PAL devices undergo unlock, recode, and verification operations. For combination locks, these are manual operations requiring no specialized equipment. Coded switches require external control equipment to perform these operations. In this section, the presently fielded PAL devices and control equipment (both ground and aircraft controllers) associated with the coded switches are described.

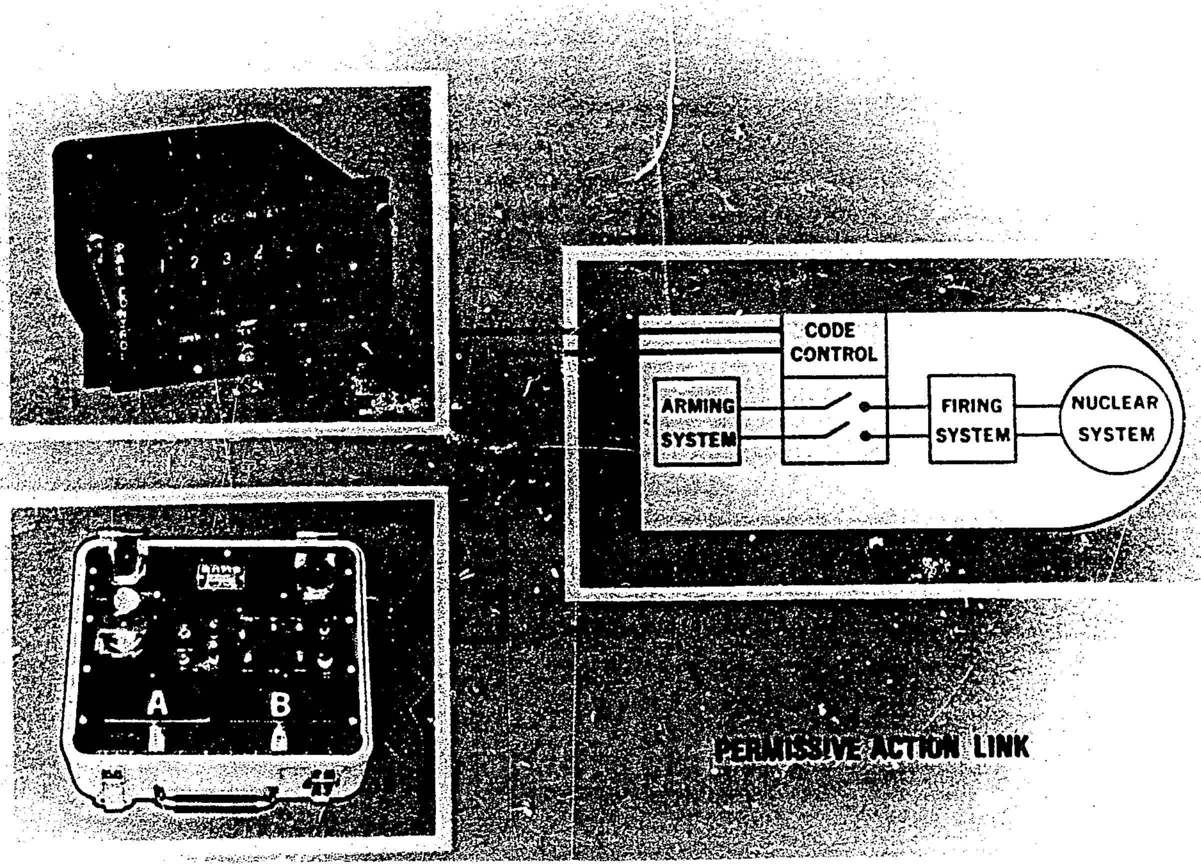

Figure 1. Hardware Elements (U)

2.1.1 PAL Devices (U)

(U) Table 1 shows current and planned weapons by PAL device type. These devices are discussed below.

Table 1. Current PAL-Equipped Weapons (U)

Combination Locks	CAT A	CAT B	CAT D	CAT F
W31	W50	B28-RE	B28-0,-1	B61-3,-4
W33		B43-2	B61-2,-5	W84
W45-3		B57-2	(B61-6,-7,-8)	W85
W48		B61-0	W70-1,-2,-3	
W54			W79	
			(W80-0)	
			W80-1	
			(W81)	
			(W82)	
			B83	

Note: ( ) indicates weapon in development

2.1.1.1 Combination Locks (U)

(U) Most weapons—bombs delivered by aircraft, missiles, and shells—experience a unique environment during deployment, e.g., spin, acceleration, pressure change. To provide the desired preflight handling safety, a family of ESDs evolved which close critical electrical arming lines only after the weapon experiences the desired environmental signature. In the case of ADMs, manually set in place and fired by either command or timer, there was no launch, drop, or fire environment which could be sensed by an ESD. Installation of 3-digit combination locks provided an additional safety step in the prefiring sequence (Figure 2). The 3-digit locks were redesigned by the AEC to provide 5 digits to be compatible with a 4-digit split-knowledge code management system. The Army also developed combination locks for use on several weapon systems. About half of the European stockpile is still equipped with combination locks. They are used on the W31 Nike Hercules, W45 MADM, W54 SADM, M422 (W33/8-in. AFAP) and M454 (W48/155-mm AFAP).

(U) The M422 uses an Army lock. The M83 atomic weapon locking device screws into the projectile's base; one part (the locking tube and desiccant assembly) occupies the volume into which the breech-lock-fuze assembly must be installed before firing. The M454 uses an Army lock. The M76 atomic weapon locking device screws onto the projectile's nose,
replacing the projectile's fuze (Figure 3). The W31 warhead for the Nike Hercules missile uses an Army lock. The M77 atomic weapon locking device fits onto the safing plug of the Adaption Kit (AK) (Figures 4 and 5). The W31 warhead for the Honest John missile uses an Army lock. The M81 atomic weapon locking device fits onto the safing plug of the AK (Figures 6 and 7).

(U) The W45-3 warhead for the MADM uses an AEC lock. The MC1885 padlock is installed on the warhead's J1 connector and prevents input of electrical signals to warhead circuits (Figure 8). The B54 warhead for the SADM also uses an AEC lock. The MC1948 lock-secured cover includes an MC1827 padlock (Figure 9). The cover denies unauthorized access to the arming and fuzing components.

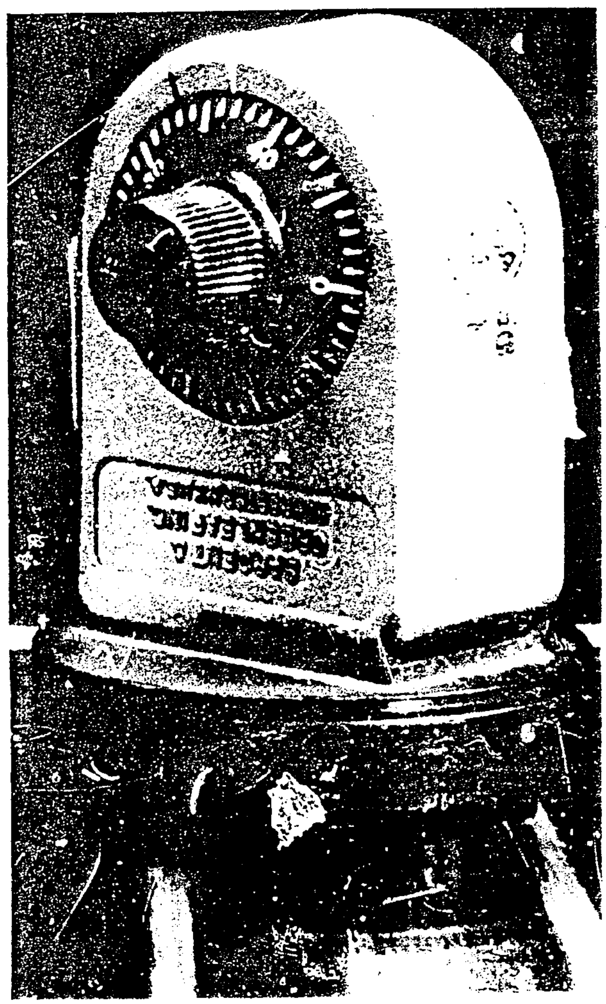

Figure 2. Combination Lock (U)

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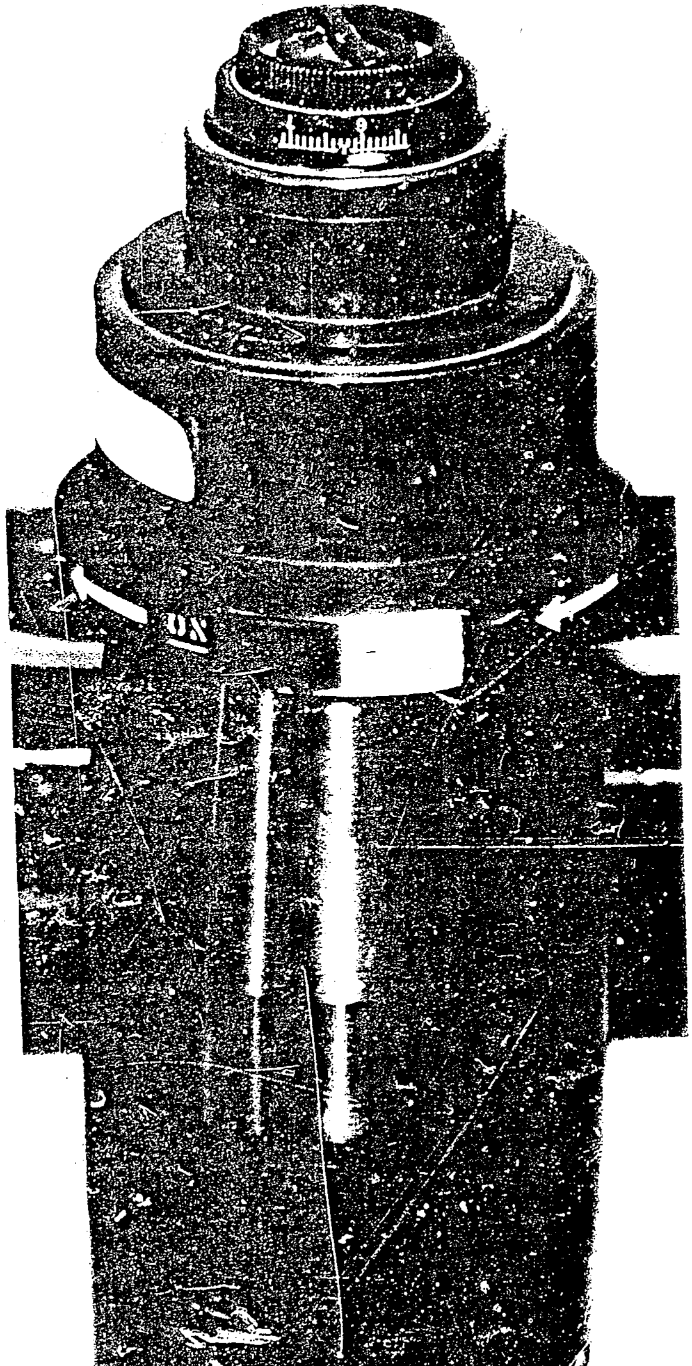

Figure 3. M[illegible] Atomic Weapon Locking Device [illegible]

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[redacted] UNCLASSIFIED

Figure 4. M77 Atomic Weapon Locking Device (U)

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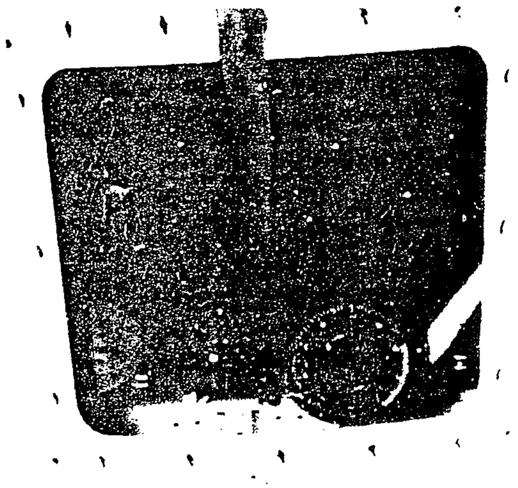

Figure 5. M77 Atomic Weapon Locking Device (U)

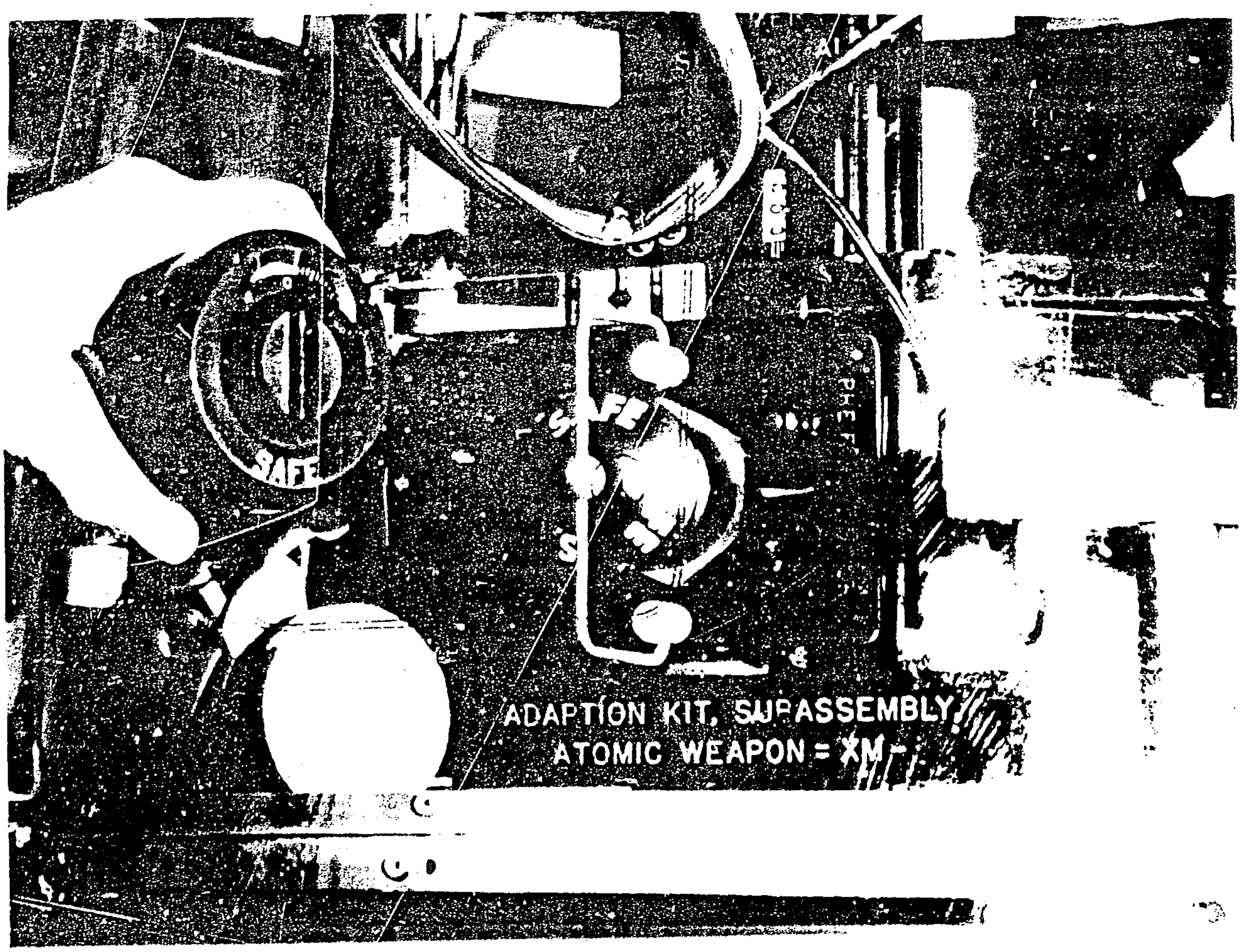

Figure 6. M81 Atomic Weapon Locking Device (U)

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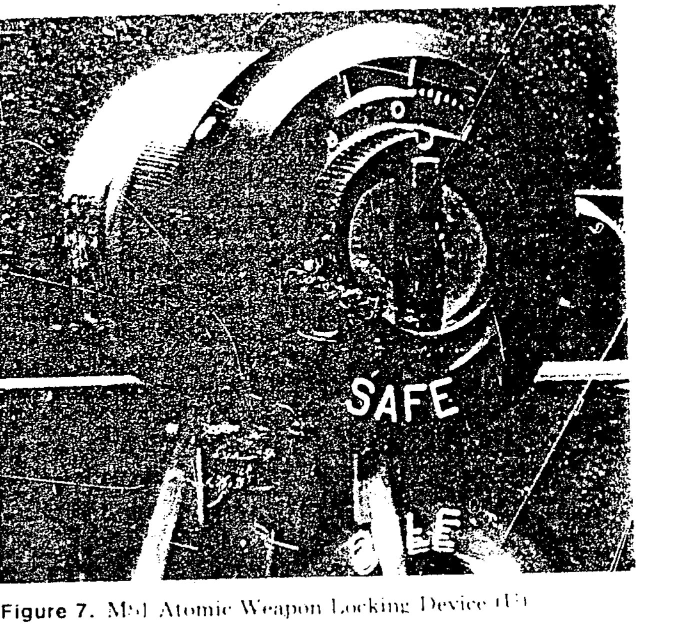
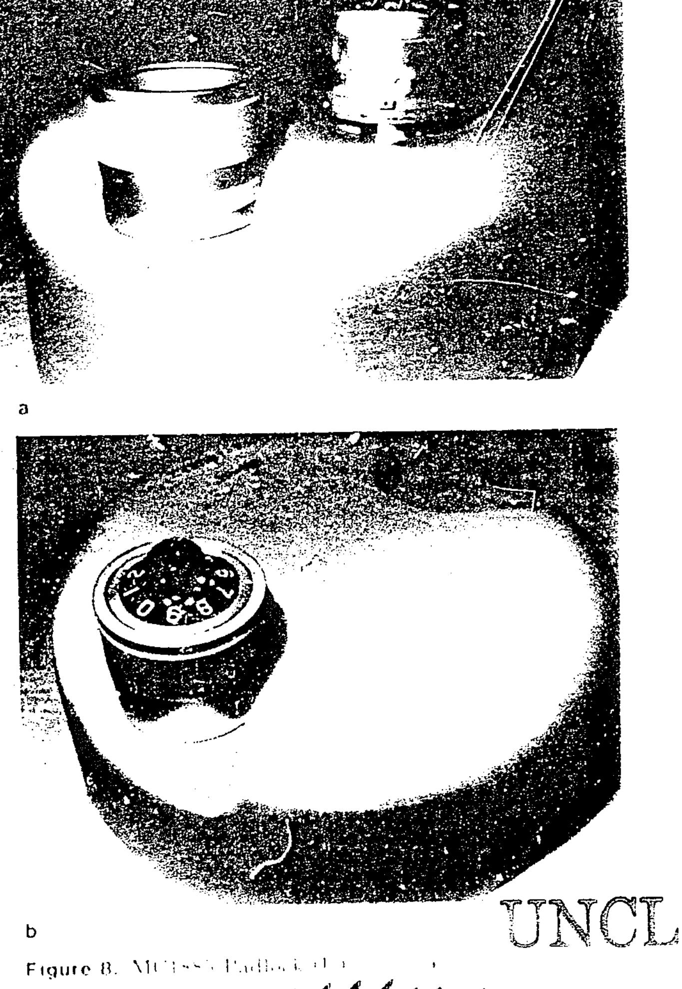


Figure 7. M51 Atomic Weapon Locking Device (U)



a

b

Figure 8. MC1885 Padlock (U)

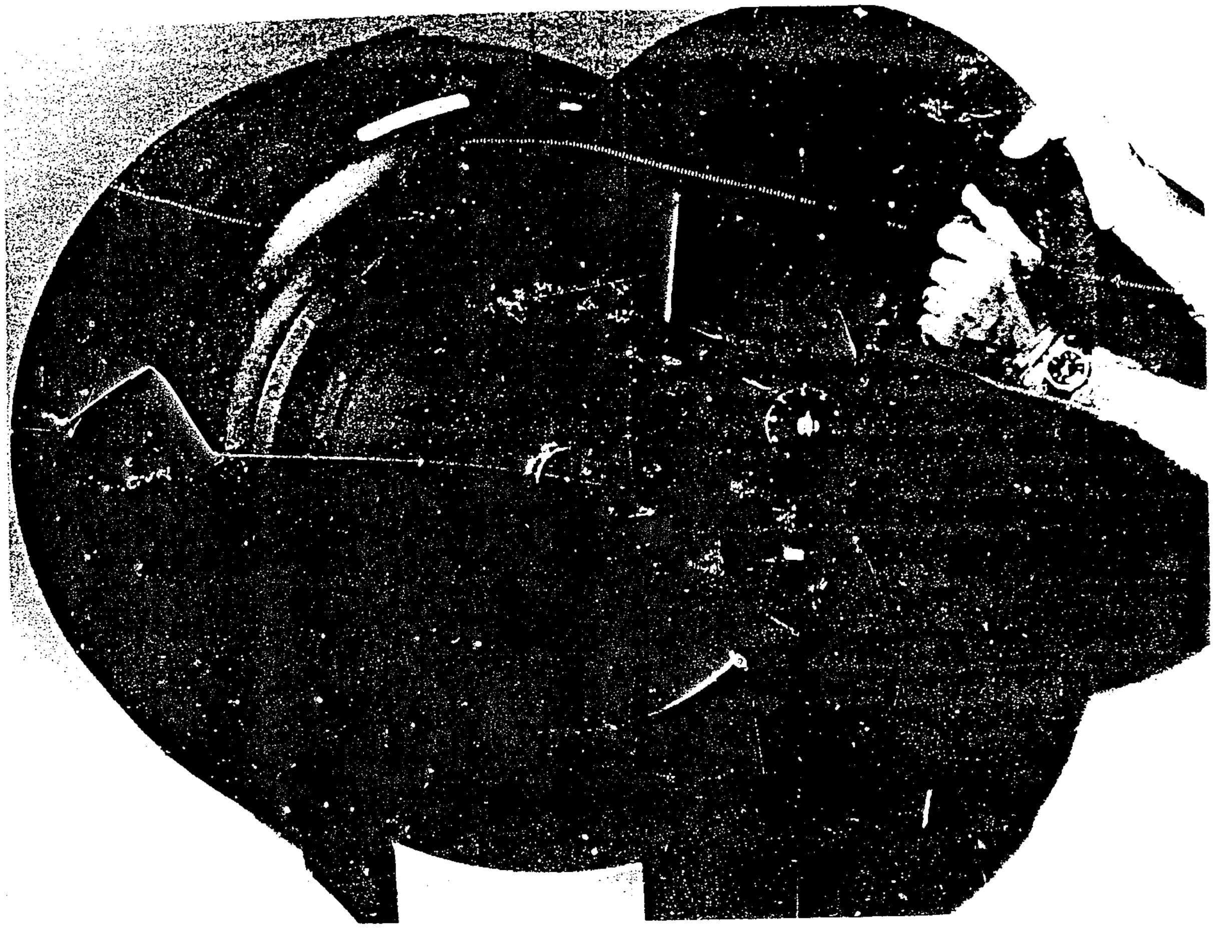


Figure 9. MC1948 Lock-Secured Cover (U)

2.1.1.2 Category A PAL (U)

(U) To provide remote control capability for weapons requiring a combination lock in lieu of an environmental sensing device, development had begun on a remotely controlled combination device prior to NSAM-160. As a result of NSAM-160, a crash effort was undertaken to complete development of this electromechanical coded switch and appropriate controllers and to install the switch to interrupt critical electrical circuits in European land-based US weapons. The switch carried the AEC nomenclature MC1541 and was first installed on the W49 Jupiter. The Jupiter, B7, B28, W28 Mace, and W52 Sergeant with the MC1541 have been retired, but it is still operational in the W50 Pershing. The MC1541 systems, which provide a 10^4 code population, are called CAT A PAL.

(U) The CAT A PAL system (Figure 10) includes an electromechanical coded switch (MC1541), two controllers (T1500 Decoder and T1501 Recoder), a controller tester (T1502), and a power source (T436 Battery Power Supply).

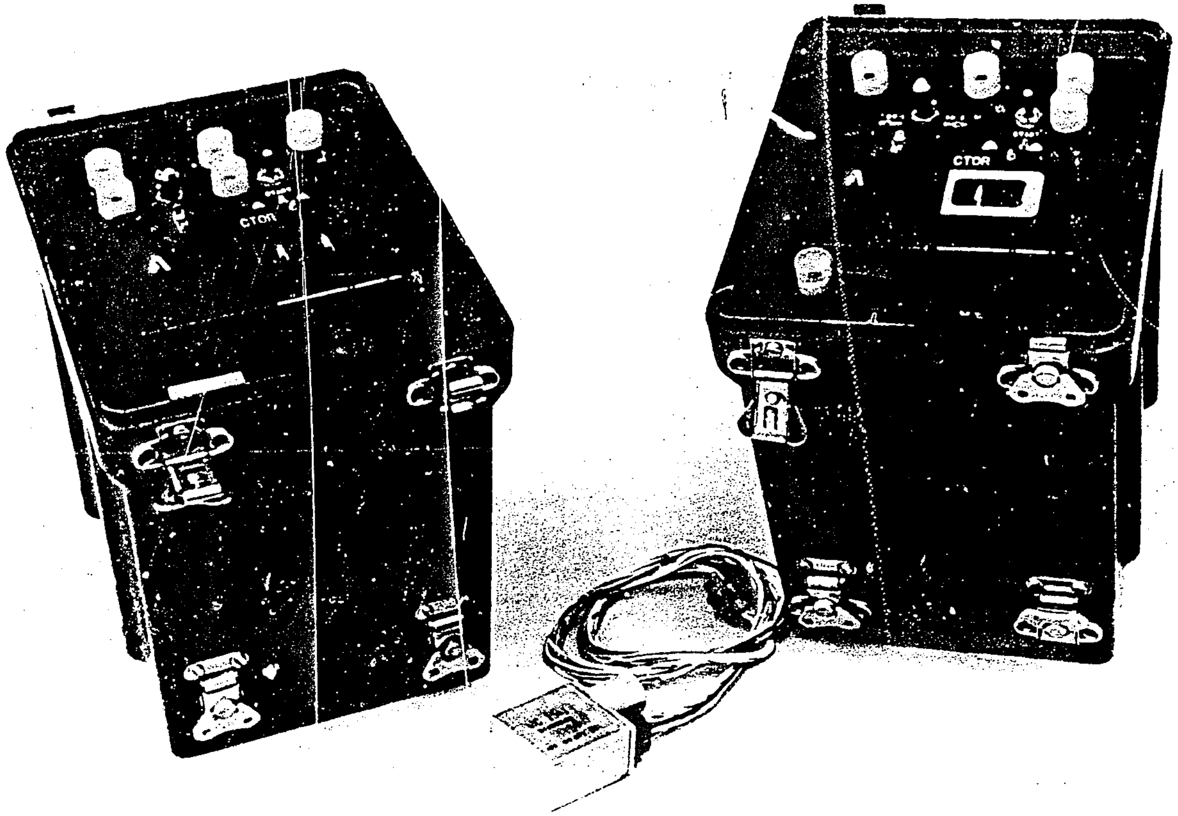


Figure 10. CAT A PAL System (U)

(U) The MC1541 weighs ~1.2 lbs, occupies a volume of ~10 cu in., and takes between 30 s and 2-1/2 min to operate. A motor-driven family of gears, cams, and cam followers operate together to provide 10^4 discrete, relative gear and cam positions. If a controller operates the motor so a proper position of the gears (code wheels) is established, the unit allows the output switches to be closed (unlock). Operating the motor to any other position of the code wheels opens the output switches (lock); thus, the MC1541 cannot be secured in the unlock mode. Two MC1541 switches were used in each weapon for reliability, although stockpile data have indicated that a single switch would have sufficed. Because of the lock system and variations in motor speed, each MC1541 must be controlled separately. Each MC1541 requires 7 control and monitor lines to the controller (14 per weapon).

(U) To change the MC1541 code information, it must first be unlocked and then a code change solenoid in the unit activated. When activated, this solenoid allows the code wheels to be driven to a new position corresponding to the new code. With the new code inserted, the solenoid is released; this sets the new code in the unit, i.e., stores the new code. Following recode, an incorrect code must be entered to relock the MC1541.

2.1.1.3 Category B PAL (U)

(U) Because of the large number of circuits required for MC1541 operation, control from an aircraft cockpit was not practical. Therefore, the MC1707 coded switch allowing lock/unlock control and monitor with four wires was developed for the Air Force. This became CAT B PAL. The MC1707, which also provided a 10^4 code population, was installed in some B28, B43, B57, and B61 bombs. Weapons with the MC1707 can be unlocked in parallel, thus providing multiple carriage capability. In all installations, the MC1707 is used to interrupt critical warhead electrical circuits until the proper code is inserted either by aircraft or ground control equipment.

(U) As originally fielded, the CAT B PAL system (Figure 11) included two electromechanical coded switches (MC1707s) in each weapon, two ground controllers (T1508 Decoder and T1509 Recoder), two controller testers (T1520 and T1521 for the Decoder and Recoder, respectively), three aircraft controllers (DCU117/A and DCU121/A, combined AMAC and PAL, and the DCU116/A PAL only), and a power source (T436 Battery). CAT B was installed only in bombs which have Air Force and Navy applications (primarily Air Force).

(U) The subsequent fielding of CAT D and F PAL has resulted in requirements for back-compatibility of CAT B with newer control equipment developed for CAT D and F. Today, CAT B PAL can be operated by the T1535 Ground Decoder; the T1536, T1555, and T1563 Recoders; the T1539 Verifier; and the DCU192, 196, 201, 218, 238, and 239, as well as those controllers listed earlier.

(U) The MC1707 (Figure 12) occupies a retangular volume of ~18 cu in., weighs ~ 2.2 lbs, and takes ~30 s to operate. It is used today in the B28-RE, B43-2, B57-2, and B61-0 bombs. Several improvements were made in the MC1707 design to overcome problems with the CAT A PAL system. The CAT B system requires 5 wires to recode, control, and monitor a weapon instead of the 14 required by CAT A. In addition, to minimize the impact on aircraft wiring, only three wires are required to control any number of switches operating in parallel, plus one wire per weapon to monitor the weapon's lock/unlock status.

(U) The CAT B system provides recode and code check capability for the stored codes without transferring the output contacts from the locked to the unlocked condition, or vice versa. Also, CAT B requires use of the stored code for a lock operation. This avoids possible accidental relock upon insertion of a wrong code after unlock. Finally, the recoders provide automated sequences of old code insertion, new code insertion, and code check operations.

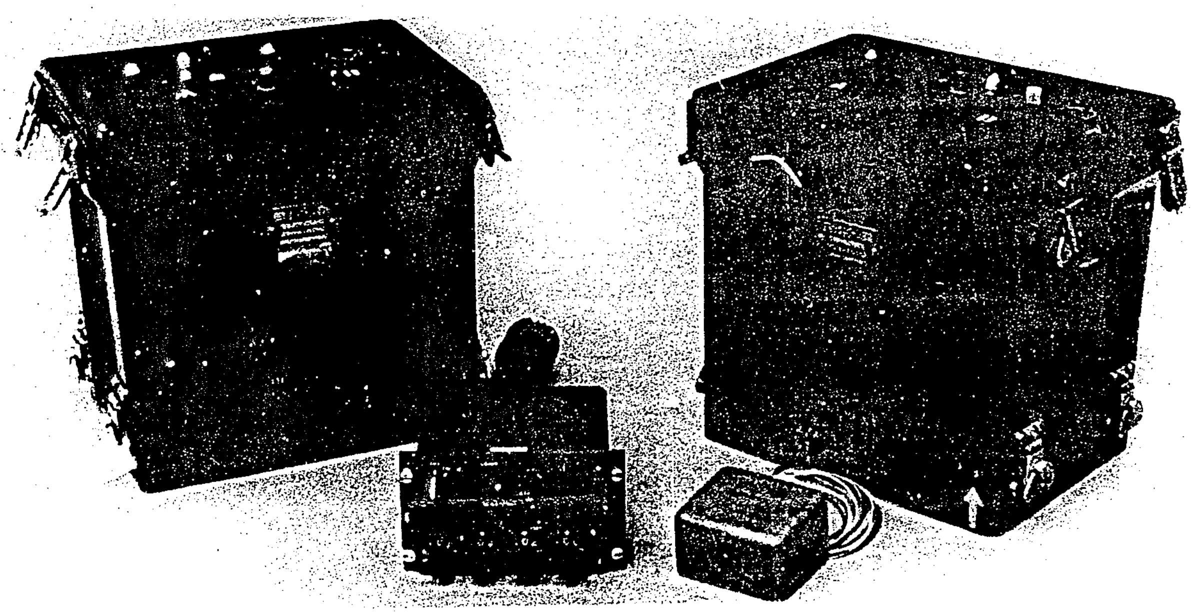


Figure 11. CAT B PAL System (U)

Figure 12. MC1707 (U)

2.1.1.4 Multiple-Code Coded Switch (U)

(C) A desire for selective unlocking through the use of multiple codes led to the concept of a multiple-code coded switch (MCCS). In May 1971, a requirement to incorporate an MCCS into the W74 was approved as Amendment 3 to the 155 mm Howitzer Projectile Military Characteristics. Miniaturization was essential because of the small volumes of the newer systems (W74 155-mm and W75 8-in. projectiles).

The MCCS design combined some new PAL-associated features with existing and still-required characteristics. They were:

- No power required for memory storage
- Compatible with aircraft cockpit control
- Knowledge of old code required for recode

DOE b(3)

(C) The MCCS was developed as two separate items, the MC2764, ~17 cu in. (Figure 13), and the MC2907, ~1.5 cu in. (Figure 14). Both devices provide similar capabilities and are compatible with the same control equipment. MC2764 was developed on an accelerated basis to be available on an early timescale and is used in the W70-1 Lance and B61-2 CAT D applications. MC2907, with more difficult packaging concepts but employing basically the same hybrid microcircuit technology, was developed on longer timescales and is presently used or planned in the B28-0, and -1, B61-5, -6, -7, and -8, W79, W80, W81, and B83 CAT D applications.

DOE b(3)

2.1.1.5 Multiple Code Coded Security Switch (U)

(C) The MC3641 MCCSS, sometimes called GLCM Security Unit (GSU), is ~4.36 cu in. in volume and will be used with the GLCM to provide a 12-digit

DOE b(3)

code capability (Figure 15). It will permit numerical assurance against bypass in accordance with DOD Directive 5200.16 in several scenarios associated with unauthorized launch.

[redacted]

DOE b(3) ID or serial number can be obtained upon query. Because the MCCSS is microprocessor-controlled and because of the different code length, a byte-oriented data format between the controllers and the MCCSS was chosen. The MCCSS will require new control equipment for recode and control. The T1563 Automated PAL Controller is being fielded on a timescale compatible with the GLCM for recode and APS maintenance control.

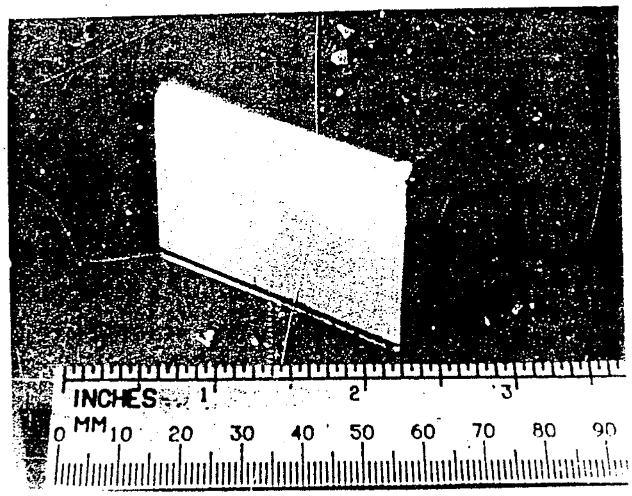


Figure 15. MC3641 (U)

2.1.1.6 Active Protection Systems (U)

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Figure 13. MC2764 (U)

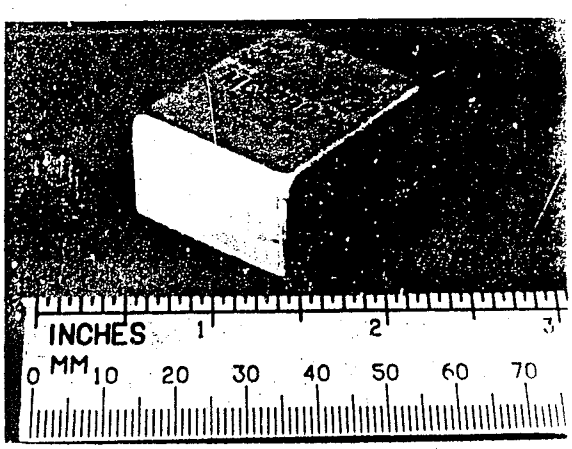

Figure 14. MC2907 (U)

2.1.2 Control Equipment (U)

(U) PAL control equipment has become very diverse and, in some cases, quite specialized. In most cases, control equipment was designed and developed by the DOE with DOE funds in response to DOD needs. Production has usually been managed by DOE and funded by DOD. There have been a few recent examples of specialized application (PII and GLCM) for which DOE specifications were provided, and design, development, and production were funded and managed by DOD. The categories of PAL control equipment are:

Recoders (Recode and Code Check)
Verifiers (Code Check)
Ground Decoders (Unlock and Lock Control)
Cockpit Decoders
Controller Testers

(U) The listing of Table 2 is believed to be complete. Newer controllers are back-compatible with earlier categories of PAL, except for CAT A. In most cases, older controllers have remained operational, particularly the decoders, because they are usually available and meet original operational requirements. Individual ground control items are discussed below.

Table 2. DOE-Supplied PAL Ground Controllers (U)

Item	Function	Quantity	FPU Date	PAL Category	Military Service
T1500A	Decoder	578	3/63	A	Army
T1501A	Recoder	57	3/63	A	Army
T1502	T1500/01 Tester	274	7/63	A	Army
T1508	Decoder	340	3/64	B,B′	AF/Navy
T1509	Recoder	39	3/64	B,B′	AF/Navy
T1520	T1508 Tester	442	4/64	B,B′	AF/Navy
T1521	T1509 Tester	39	4/64	B,B′	AF/Navy
T1526**	Recoder	17	8/73	C	Army
T1527**	Decoder	33	6/73	C	Army
T1533	Decoder	192	11/73	C,D,E,F	Army
T1534	Recoder	37	12/73	C,D,E,F	Army
T1535	Decoder	182	1/75	B,D,E,F	AF/Navy
T1536	Recoder	23	2/75	B,D,E,F	AF/Navy
T1539	Verifier	12	5/75	B,C,D,E,F	AF/Navy
T1547	CAT F Adapter	118		E,F	
T1549A	Controller Tester	147	6/75	B,D,E,F	AF/Navy
T1554	Decoder	308	1/81	D,E,F	Army/Navy
T1555	Recoder/ Verifier	40	4/79	B,D,E,F	All
T1563	Recoder/Controller	130*	10/83	B,D,E,F	All
T1565	T1563 HQ EQ	2*	7/84		All

* Estimates
** No Longer Used

2.1.2.1 T1500 Category A Decoder (U)

(U) The T1500 controller is used to unlock and lock the MC1541 coded switches (Figure 16). It drives the MC1541 motor to a position consistent with the code selected and set in the T1500, provides energy to open or close the output switches, and monitors the status of the MC1541. The T1500 weighs ~40 lbs with the T436 Power Supply attached. It controls two MC1541s simultaneously from the two independent channels and indicates when at least one of the MC1541 output switch sets closes.

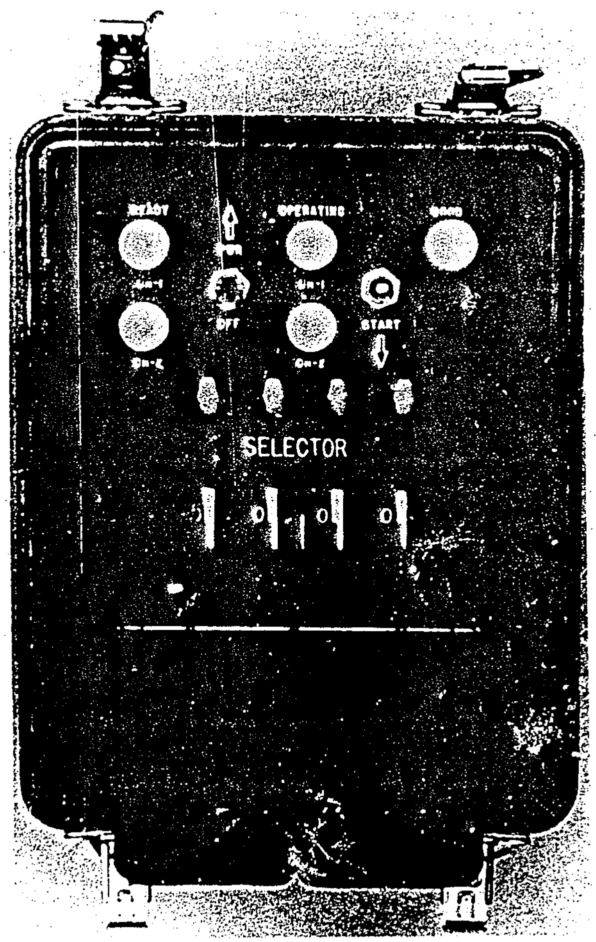

Figure 16. T1500 CAT A PAL Controller (U)

2.1.2.2 T1501 Category A Recorder (U)

(U) The T1501 is similar to the T1500 decoder but has a code change capability (Figure 17). It selectively operates only one MC1541 coded switch at a time, first setting in the correct old code, then unlocking and preparing the switch for insertion of a new code. The new code is then set into the T1501 and the operation repeated, inserting the desired new code. An incorrect code must then be entered to relock the coded switch. This does not occur in an automated sequence but is done as separate operations for each of two coded switches in the weapon.

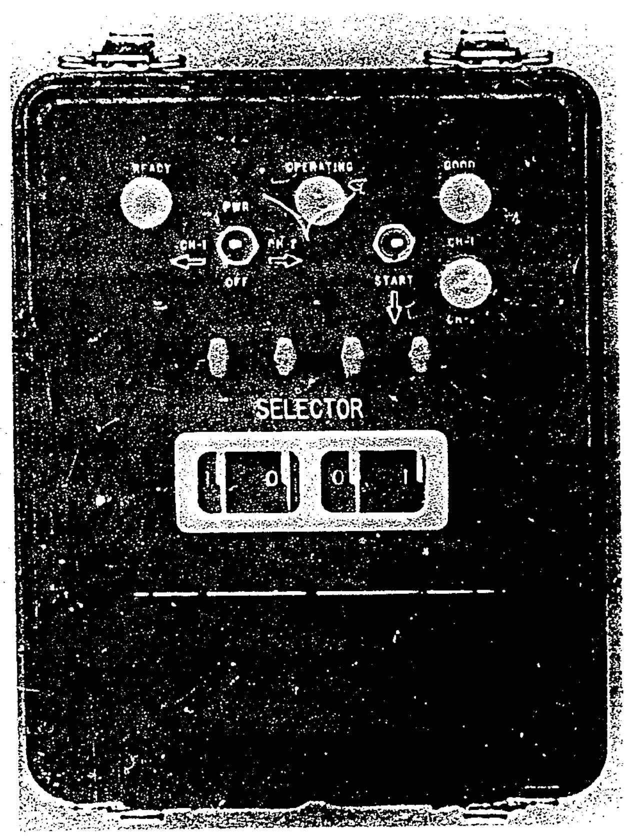

Figure 17. T1501 CAT A PAL Recoder (U)

2.1.2.3 T1502 Programmer (U)

(U) The T1502 (Figure 18) functionally tests the T1500A and T1501A. It simulates an MC1541 so that either the T1500A or T1501A may be evaluated for proper operation.

2.1.2.4 T1508 Category B, B′ Decoder (U)

(U) The T1508 Controller (Figure 19) is designed to enable, code-check, or disenable a weapon; if desired, it can be used to check the enable/disenable condition of the weapon. The T1508 is not capable of recoding. It provides visual indications of the specific codes being utilized and of proper operations of the MC1707. Power is supplied by the T436 Power Supply which is installed in the bottom compartment prior to use.

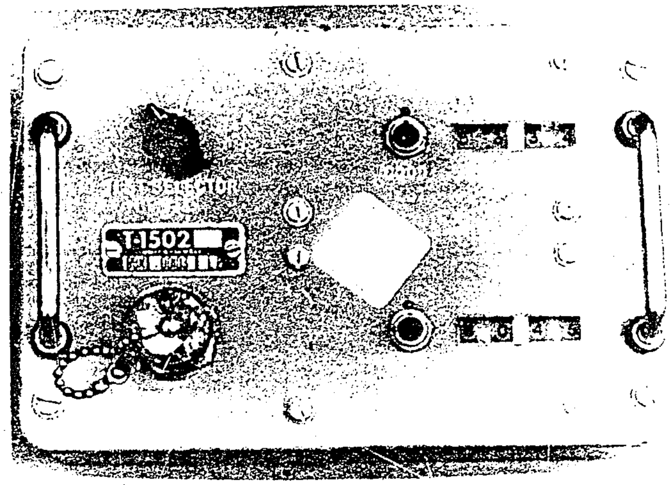

Figure 18. T1502 Programmer (U)

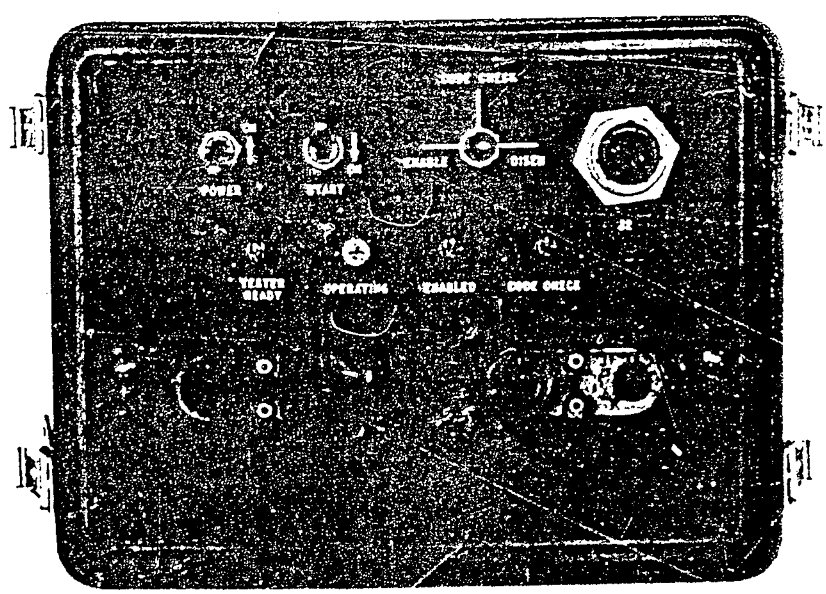

Figure 19. T1508 CAT B, B′ PAL Decoder (U)

2.1.2.5 T1509 Category B, B′ Recoder (U)

(U) The T1509 (Figure 20) is a controller which code-checks and recodes the coded switches of a weapon; it is not capable of an enabling operation. The T1509 provides visual indications of the specific codes being utilized and of the proper operation of the coded switches. Power is supplied by the T436 Power Supply which is installed in the bottom compartment of the unit prior to use.

2.1.2.6 T1520 and T1521 Controller Testers (U)

(U) The T1520 (Figure 21) and T1521 (Figure 22) allow field certification of the operability of the T1508 Decoder and T1509 Recoder, respectively, by electronic simulation of the MC1707. The T1520 is also used to certify aircraft decoders. If the output of the T1508 is proper for that code, the T1520 will so indicate at the end of the operation. The T1509 and T1521 operate in a similar manner except that both an old and new code are set in the units. Power for both is supplied by the T436 Power Supply which is installed in the bottom compartment prior to use.

2.1.2.7 T1533 Army Decoder for PAL Categories C, D, and F (U)

(U) The T1533 (Figure 23) is a controller used by the Army to lock or unlock the coded switch in a weapon, or it may be used to check the locked/unlocked status of the weapon; it is not capable of a recoding operation. The T1533 was originally purchased to support the Lance system.

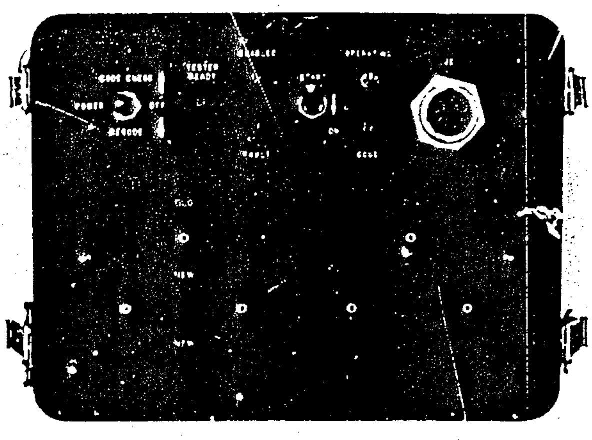

Figure 20. T1509 CAT B, B′ PAL Recoder (U)

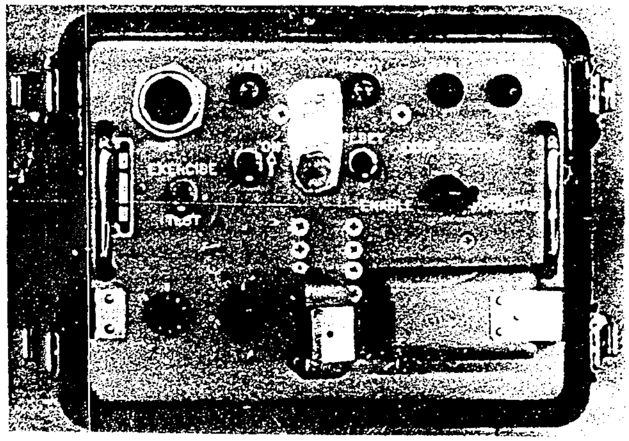

Figure 21. T1520 Controller Tester (U)

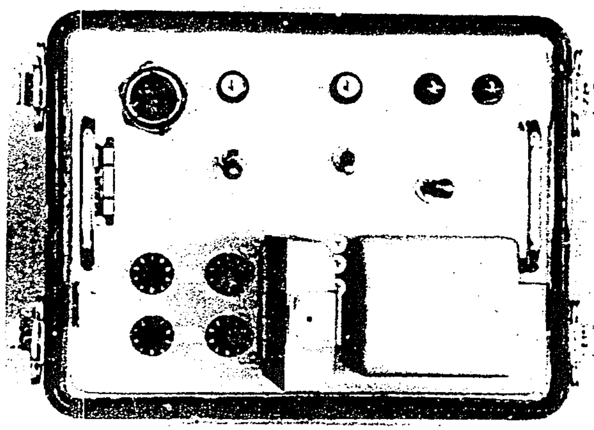

Figure 22. T1521 Controller Tester (U)

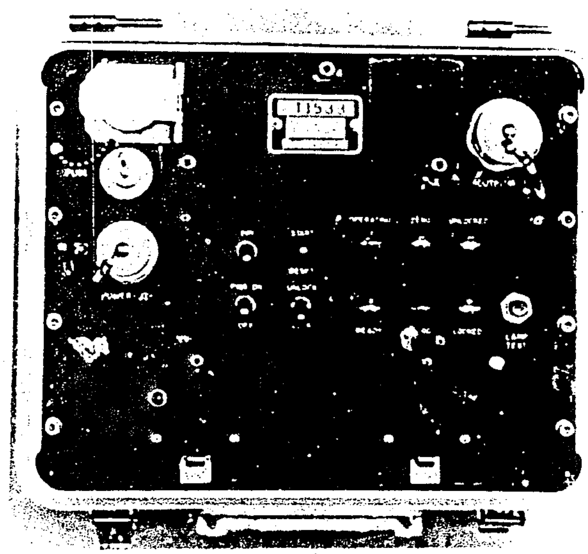

Figure 23. T1533 Army Decoder for CAT C, D, and F PALs (U)

(U) Power is supplied to the T1533 through the CT1478 cable from a T436B Power Supply or from a tactical vehicle's battery. If tactical vehicle power is used, the T1533 will operate with the vehicle either off or operating. The T1533 automatically recognizes a coded switch system as either single code (CAT C) or multiple code (CAT D/F) and furnishes the appropriate output to the coded switch in the weapon.

2.1.2.8 T1534 Army Recoder for PAL Categories C, D, and F (U)

(U) The T1534 (Figure 24) is a controller used by the Army to recode and code-check the coded switch in a weapon; it can also be used to check the lock/unlock status of the weapon.

(U) A single-code or all-codes recode operation will always leave the weapon coded switch in the locked state. A code-check operation will not change the locked/unlocked status of the coded switch. The T1534 automatically recognizes a coded switch system as either single code or multiple code and furnishes the appropriate address to the coded switch in a weapon. Power is supplied to the T1534 through a CT1478 cable from the T436B Power Supply or from a tactical vehicle's battery. If tactical vehicle battery power is used, the engine and stabilization lockout (SLO) must not be operating. All of the necessary codes (one old and six new PAL codes) plus one new maintenance code are manually set into the T1534. After the codes are set, recoding or code-check is a single-cycle, semiautomatic operation.

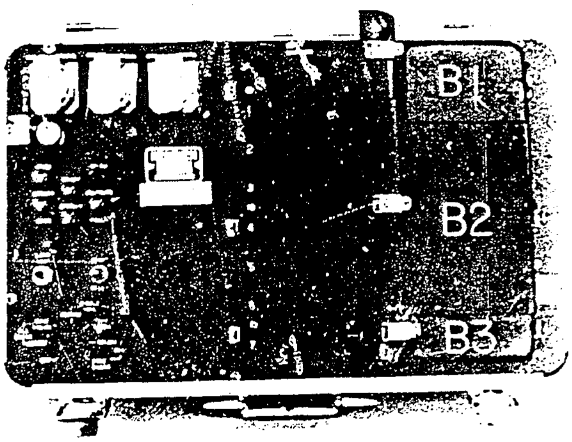

Figure 24. T1534 Army Recoder for CAT C, D, and F PALs (U)

2.1.2.9 T1535 Air Force/Navy Decoder for PAL Categories B, D, and F (U)

(U) The T1535 (Figure 25) is a controller designed to lock or unlock the coded switch in a weapon; it can also be used to check the locked/unlocked status of the weapon. The T1535 is not capable of a recoding operation. Power is supplied to the T1535 through a CT1478 cable from a T436B Power Supply. The T1535 will furnish the proper input for a weapon having either a single-code (CAT B) or a multiple-code (CAT D/F).

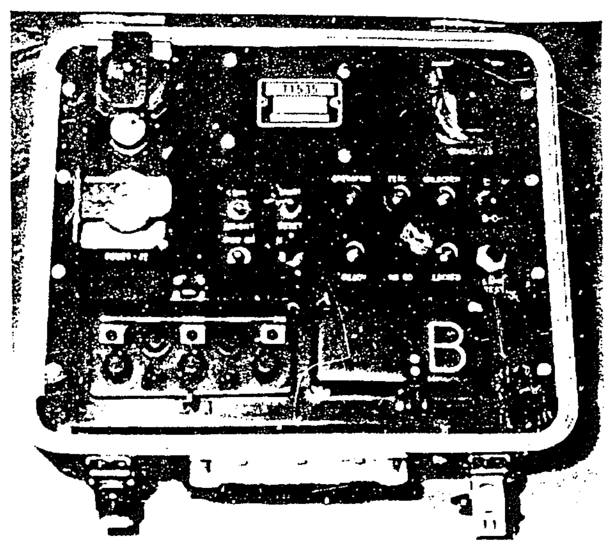

Figure 25. T1535 Air Force Decoder for CAT B, D, and F PALs (U)

2.1.2.10 T1536 Air Force/Navy Recoder for PAL Categories B, D, and F (U)

(U) The T1536 (Figure 26) is a controller used by the Air Force and Navy to recode and code-check the coded switch in a weapon; it can also be used to check the lock/unlock status of the weapon.

(U) A single-code or all-codes recode operation will always leave the weapon coded switch in the locked state. A code-check operation will not change the locked/unlocked status of the coded switch. The T1536 automatically recognizes a coded switch system as either single code (CAT B) or multiple code (CAT D/F) and furnishes the appropriate signals to the coded switch in a weapon. Power is supplied to the T1536 through a CT1478 cable from the T436B Power Supply. All of the necessary codes (one old and six new PAL codes) plus one new maintenance code are manually set into the T1536. After the codes are set, recoding or code-check is a single-cycle, semiautomatic operation.

2.1.2.11 T1539 Army/Air Force/Navy/ Code Verifier for PAL Categories B, C, D, and F (U)

(U) The T1539 is a controller used in the field by the Army, Air Force, and Navy to check code values in the coded switch in CAT B, B', C, D, and F PAL weapons; it may also be used to check the locked/unlocked status of the weapon. The T1539 recognizes a coded switch system as either single code (CAT B/B'/C) or multiple code (CAT D/F) and furnishes the appropriate address to the coded switch in the weapon. Power is supplied to the T1539 through a CT1478 cable from a T436B Power Supply.

Figure 26. T1536 Air Force Recoder for CAT B, D, and F PALs (U)

2.1.2.12 T1547 Army/Air Force/Navy Adapter for Category F PAL (U)

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2.1.2.13 T1549A Air Force/Navy Programmer for PAL Categories B, D, and F (U)

(U) The T1549A performs two functions when connected to the new controllers. It performs a duration and amplitude check on the aircraft and ground controller output data and power circuits for CAT D

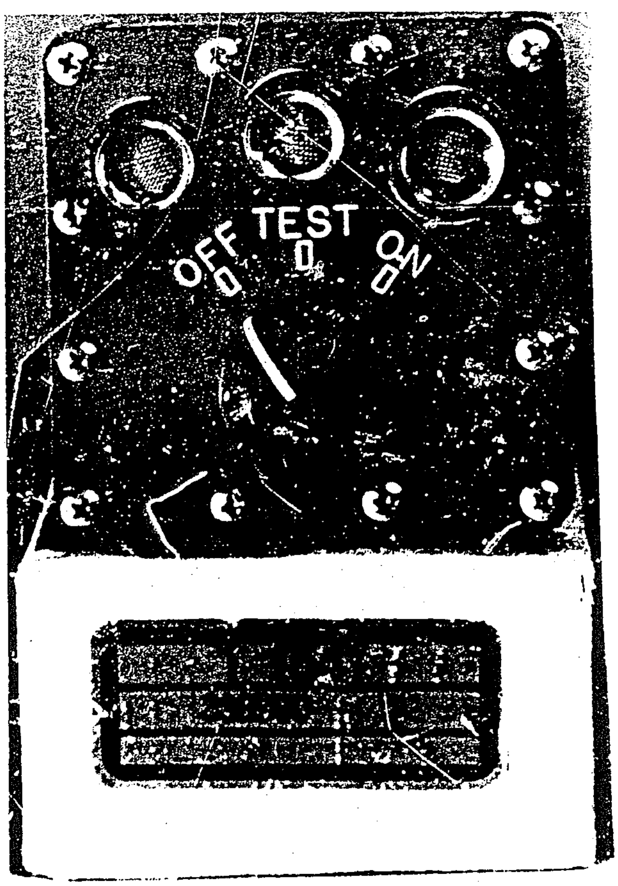

Figure 27. T1547 CAT F PAL Adapter (U)

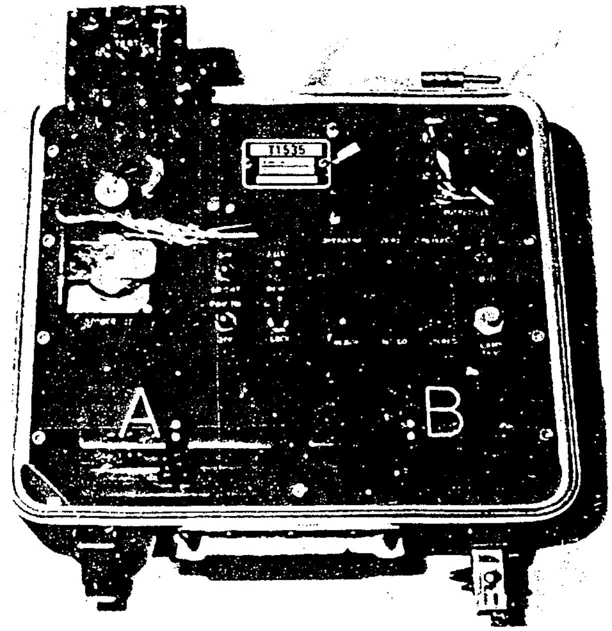

Figure 28. T1535 Decoder with T1547 Attached (U)

and F PAL systems; it also functions as a coded switch simulator for CAT B, D, and F PAL systems for training in decoding operations with the T1549A, the aircraft, and T1535 Ground Decoder.

(U) The T1549A furnishes feedback to the decoder which allows the operator to determine that an acceptable or unacceptable response has occurred. For training operations, storage of seven different codes is provided; any of these codes furnishes "off" and/or lock and unlock indications, as appropriate. The T1549A contains no control switches or monitor lamps. These responses are furnished by the controller to which the T1549A is interfaced.

Three cables are required for use with the T1549A. The CT1504 connects the T1535 Ground Decoder to the T1549A Programmer. This cable is currently used with all Air Force/Navy ground controllers. In addition, the CT1507 cable connects the T1549A to the pylon of the F4C, D, or E, and the CT1510 connects the T1549A to the F-111E aircraft pylon. No external or auxiliary power cable is required because the T1549A is powered by the ground decoder or aircraft safe power.

2.1.2.14 T1554 Army/Navy Decoder for PAL Categories D and F (U)

(U) The T1554 (Figure 29) is a controller used by the Army to lock or unlock the coded switch or to check the locked/unlocked status of the weapon. It is very similar to the T1533 except that it cannot be used to operate the single code CAT C System.

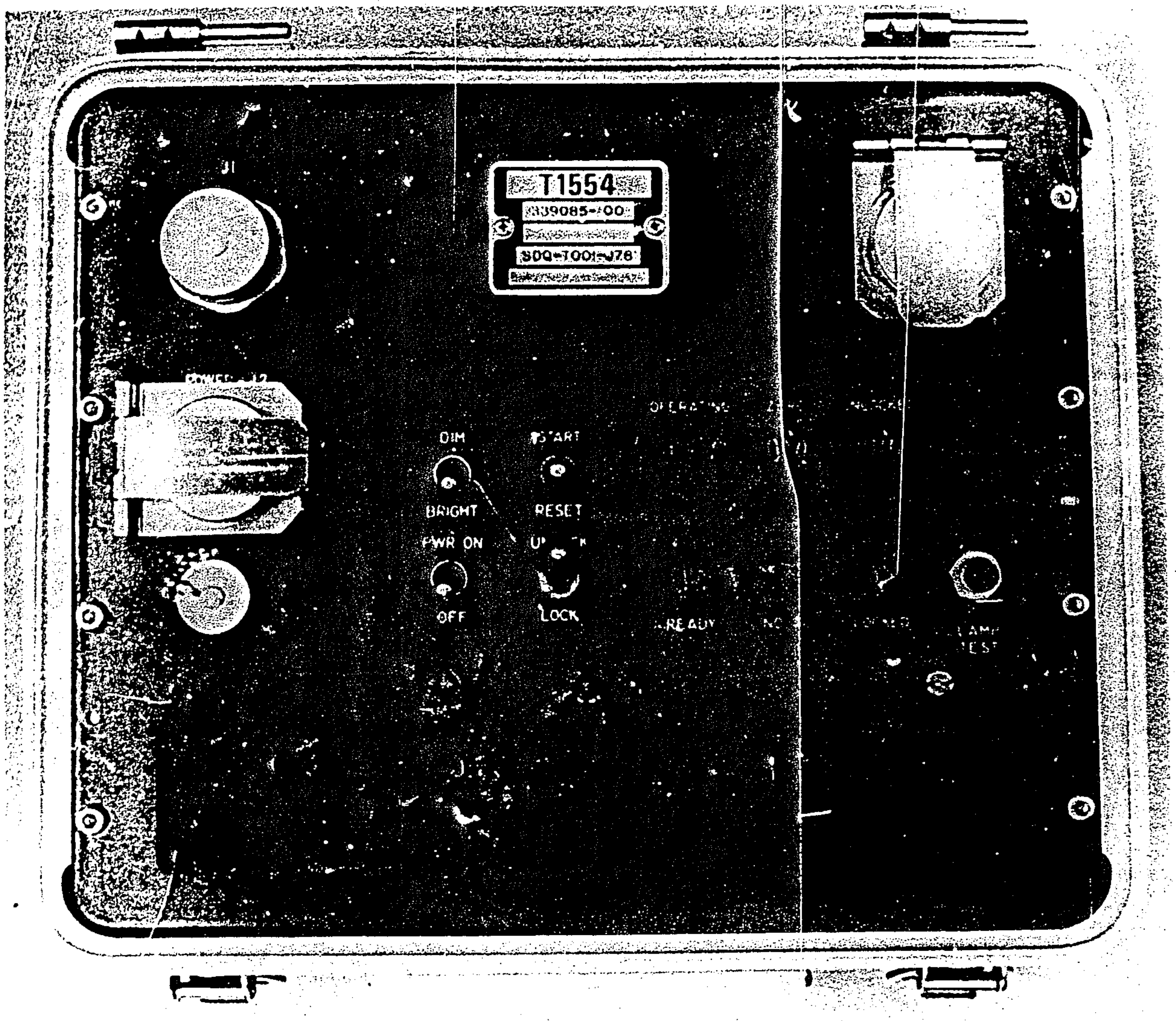

Figure 29. T1554 Army Decoder for CAT D and F PALs (U)

(U) The T1554 is not capable of a recoding operation. Power is supplied through the CT1478 cable from a T436B Power Supply or from a tactical vehicle's battery. If tactical vehicle power is used, the T1554 will operate with the vehicle either off or operating. The decoder was originally purchased to support the W79 system.

2.1.2.15 T1555 Army/Air Force/Navy Recoder/Verifier for PAL Categories B, C, D, and F (U)

(U) The T1555 (Figure 30) is a controller that can be used by all services as either a recoder or a code verifier. The T1555 by itself is a controller used in the field to verify the code values in the coded switch in CAT B, C, D, and F weapons and may also be used to check the locked/unlocked status of the weapon. With the T1558 plug adapter installed, the T1555 is a recoder used in the field to recode and code-check the coded switch in a weapon; it may also be used to check the lock/unlock status of the weapon. A single-code or all-codes recode operation will always leave the weapon coded switch in the locked state. A code-check operation will not change the locked/unlocked status of the coded switch. The T1555 automatically recognizes a coded switch system as either single code or multiple code and furnishes the appropriate signals to the coded switch in a weapon. Power is supplied to the T1555 through a CT1478 cable from the T436B Power Supply. All of the necessary codes (one old and six new PAL codes) plus one new maintenance code are manually set into the T1555. After the codes are set, recoding or code-check is a single-cycle, semiautomatic operation.

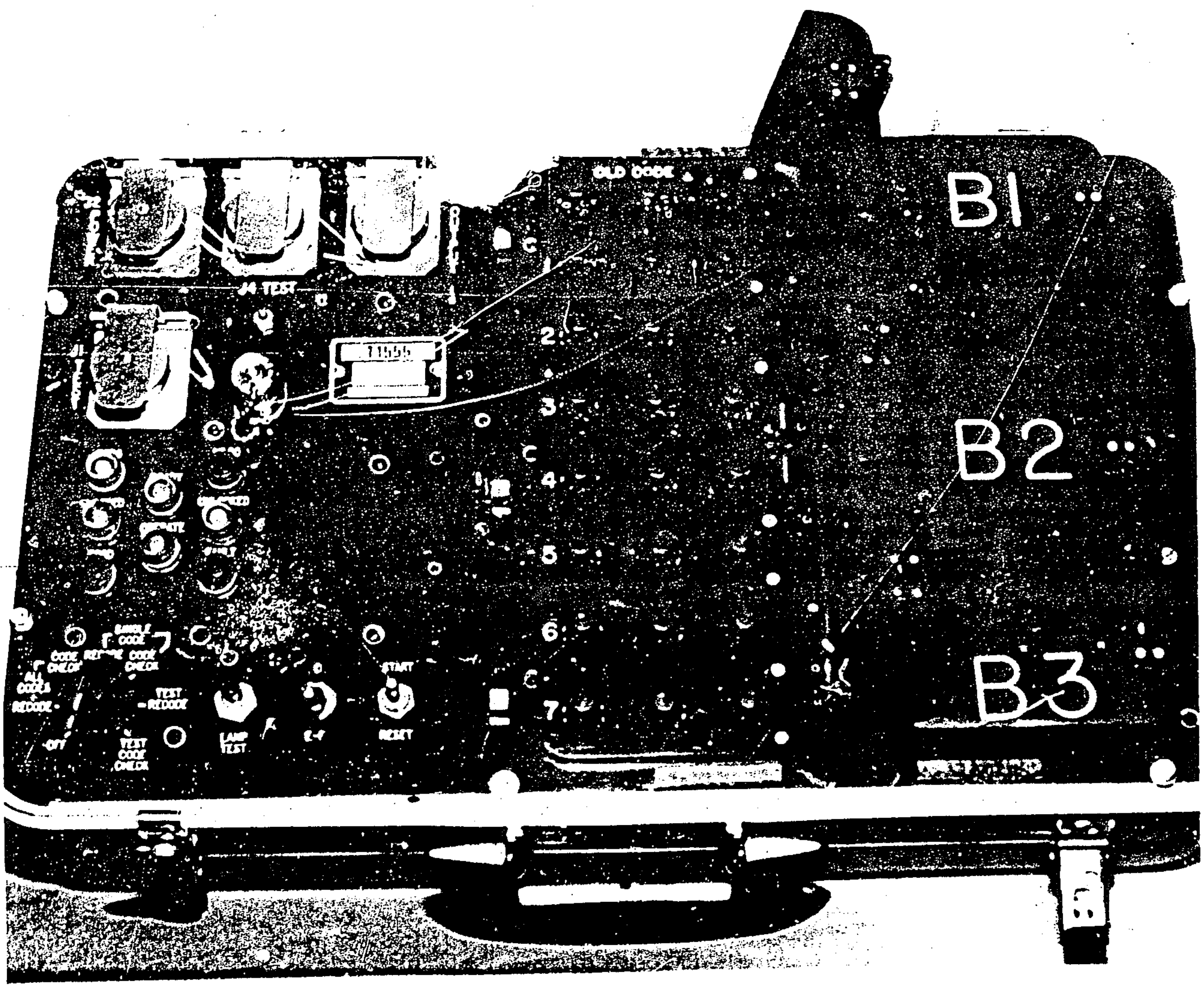

Figure 30. T1555 Recoder/Verifier for CAT B, C, D, and F PALs for Army/Navy/Airforce (U)

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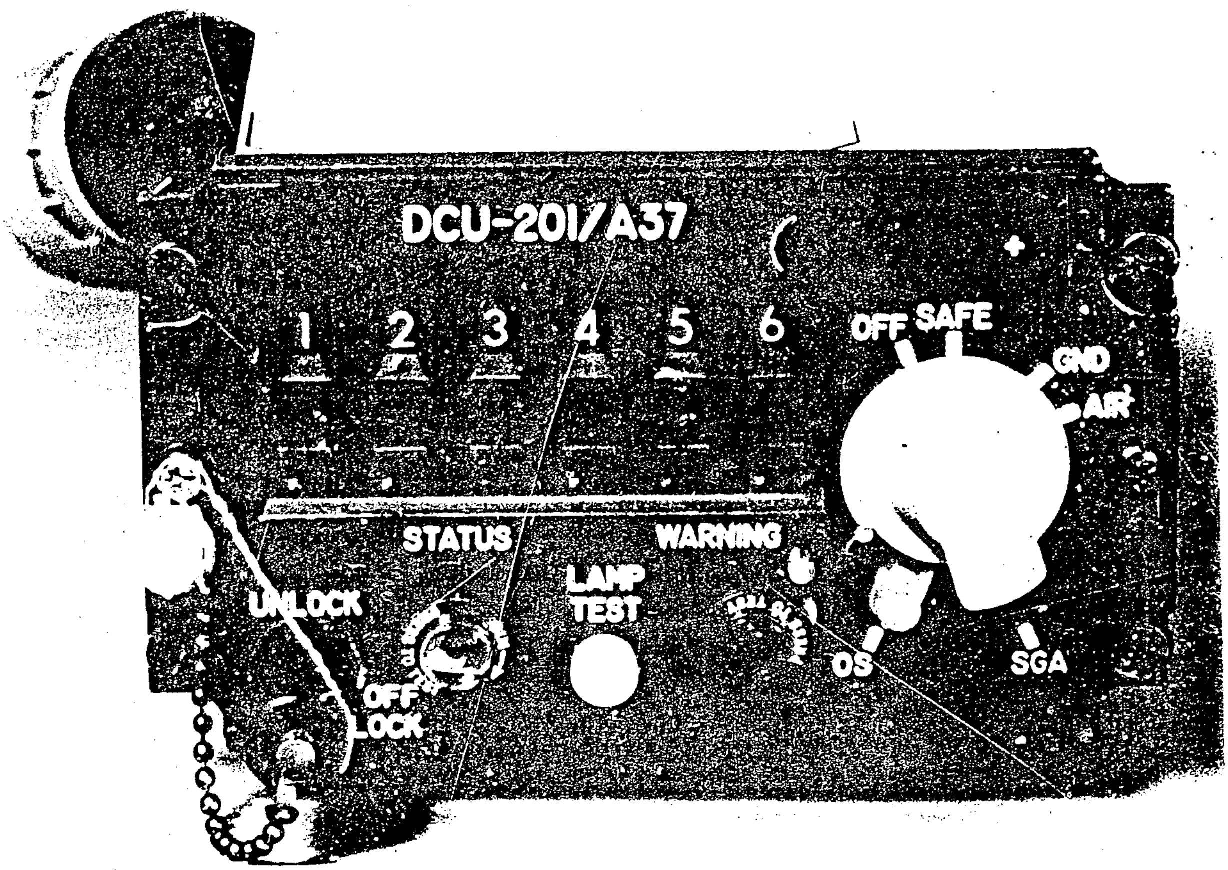

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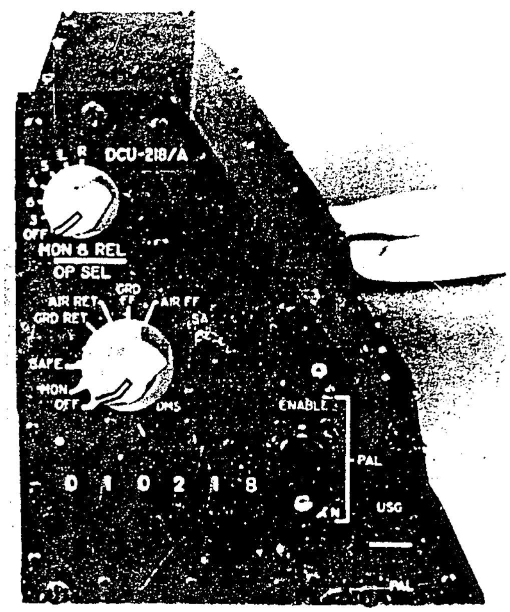

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Figure 32. Cockpit PAL Controllers (U)

Table 3. Cockpit PAL Controllers (U)

Item	Function/Aircraft	Quantity	FPU Date	PAL Category	Military Service
DCU116/A (T1522)	PAL Only F4C,D,E/F111E	524	4/64	B	AF/NATO
DCU117/A (T1517)	PAL/AMAC F104/F100	1137	2/64	B	AF/NATO
DCU192/A	PAL Only F4C,D,E	314	6/68	B	AF/NATO
DCU121/A (T1524)	PAL/AMAC F100/F104	487	4/65	B	AF/NATO
DCU196/A37	PAL Only F4C,D,E	256	7/72	B,D,F	AF/NATO
DCU201/A	PAL/AMAC/USG F104	340	11/76	B,D,F	AF/NATO
DCU218/A	PAL/AMAC/USG F111F	111	1/78	B,D,F	AF/NATO
SWC-2	PAL/AMAC/USG MRCA Tornado	N/A	N/A	B,D,F	NATO
DCU-238	PAL/AMAC/USG/CD B52	292	7/83	B,D	USAF(SAC)
DCU-239	PAL/AMAC/USG/CD FB111A	77	4/83	B,D	USAF(SAC)

2.1.2.16 T1563 Army/Air Force/ Navy Recoder/Controller for PAL Categories B, D, F, and Bomber Coded Switches (U)

(U) The T1563 Automated PAL Controller (APC) (Figure 31) is currently in development and is scheduled to be available to support the GLCM in October 1983. It is necessary for GLCM because the GLCM coded switch is a 12-digit device for which there is no other control equipment. The APC is also being developed in response to EUCOM and PACOM ROCs (Required Operational Capability) to provide secure data transport and storage and automated code retrieval in support of increasingly complex coding plans. Its prime function will be to recode PAL weapons and the SAC Code Enable Switch (CES). It will recode PAL weapons and CES without the operators knowing the code values (no knowledge recode) involved by using recently developed cryptographic techniques. The cryptographic system is activated electronically upon insertion of two proper individual memory phrases. The heart of the APC is a programmable microprocessor which allows it to perform functions as required [redacted] Because of the microprocessor control, APC capability can be updated with properly authenticated reprogramming commands after the controller is fielded.

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(U) In use, encrypted combinations will be supplied by the National Security Agency (NSA) electronically stored in a Source Data Module (SDM) (an NSA-provided Programable Read Only Memory (PROM)). At a headquarters location, data from the SDM can be read into either a T1563 or a T1565 Headquarters Code Processor (see Section 4.4), where it is processed and sorted. The required data can then be transferred to Portable Data Modules (PDMs) by either the T1563 or the T1565 for transport to the recode detachments. The recode detachment personnel then load the recode data into their T1563s. The PDM is also used as a transport medium for return of the field operation monitor data when used with the T1565. The combination data are always encrypted when transported in the SDM or the PDM.

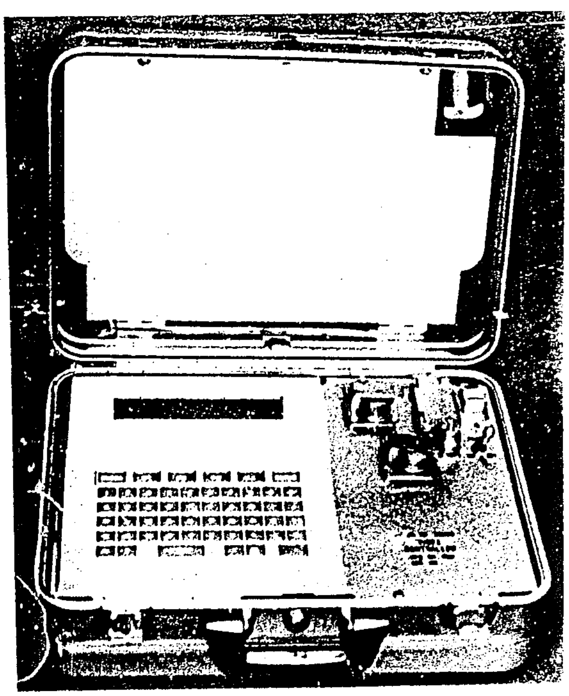

Figure 31. T1563 Recoder/Controller for CAT B, D, F, and G PALs (U)

2.1.3 Cockpit Controllers (U)

(U) Table 3 lists the cockpit PAL controllers that have been fielded to date or are currently in development. Figure 32 shows representative units. To save space, the cockpit controllers are designed to very stringent panel space restrictions. PAL and Aircraft Monitor and Control (AMAC) functions are frequently combined. Because of special space and control requirements, a different controller is usually required for each aircraft (F-4, F-104, F-16, etc.). Originally, the AMAC function was simply safe/arm (ground/air) selection. Increasing concern for safety resulted in unique signal weapon switches designed not to operate on normally available (fault) voltage formats. To control these switches, Unique Signal Generator (USG) devices have been added to the cockpit controllers. In addition to PAL, AMAC and USG, some new controllers are requiring Command Disable (CD) control. Cockpit controllers are funded in a manner similar to ground controllers, with the DOE covering development costs and the DOD funding production costs for the required quantities.

2.2 PAL Code Managment (U)

(S) PAL code management includes all personnel and procedures necessary to administer the PAL system. [redacted] In peacetime, code management is centered around weapon recoding. Recoding occurs for logistics purposes and to maintain code security. Recode operations are described in Section 2.2.2.

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2.2.1.5 The Structure of the Selective Unlock Cipher System (C)

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2.2.1.6.2 PAL Release Procedures in the European Theater (U)

(U) Weapon Deployment in the European Theater—In general terms, the mission of all US and Allied forces and weapons in Europe is to

> (U) "deter war by their presence and the credibility of their probable use and effectiveness in any conflict situation between Warsaw Pact and NATO forces"[30]

(U) To this end, US nuclear weapons have been deployed to locations in EUCOM for possible use by US and NATO forces. This deployment is made possible through bilateral programs of cooperation negotiated between the host NATO countries and the US.

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(U) Weapon Employment in the European Theater—(U) In keeping with the NATO nuclear strategy of flexible response, planning for nuclear weapon employment in a European conflict encompasses options which range from massive response to very selective employment of a few weapons.

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2.2.2 Recode Operations (U)

2.2.2.1 Concept of Recode (U)

(U) In order to maintain security, ability to change the combination required to unlock a PAL device is necessary. All PAL devices are designed to allow changing the combination after inserting the old combination. Combination locks require manual insertion of the old and new values. All electromechanical and electronic PAL devices require specialized recode equipment. (See Hardware, Section 2.1.2, for discussion of T1501, T1509, T1534, T1536, T1555, and T1563 recoders.)

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(U) The requirements for PAL, stated at the Executive, JCS, and theater CINC levels, are thus apparently satisfied by existing PAL systems. However, as with any system, there are areas for possible improvement. In the remainder of this section, some of these areas are identified.

3.1 Definition of PAL Goals and Purpose (U)

(U) While today's PAL systems seem to satisfy the stated requirements, the role of the PAL system in accomplishing the national policy objectives that drive the requirements for PAL and the extent to which the PAL system fulfills that role are not clear. This is because the statements of policy have not been related to the operational function of PAL. The stated function of PAL is to delay unauthorized detonation once unauthorized access to a weapon has been gained. Two representative statements of PAL system objectives are:[21]

- "to prevent unauthorized nuclear detonations"
- "to reduce the possibility of obtaining a nuclear detonation from a nuclear warhead without the use of a controlled numerical code"

(U) Strictly speaking, PAL, as a device for delaying unauthorized actions, cannot by itself achieve either of these goals, but it can make a contribution. Two issues are important to an understanding and evaluation of the role PAL plays in deterring and preventing unauthorized nuclear detonations: threat definition and the characterization of the larger system of which PAL is a part.

(U) Threat definition involves complete specification of the threat against which protection is desired. Elements of the threat include the identity, objectives, and capabilities of the potential adversary. Threat definition is important because the amount of delay afforded by a PAL device depends on the capabilities of the adversary and on other aspects of the threat scenario, such as the number of weapons subject to unauthorized use. Detailed threat definition is essential to the performance characterization of PAL systems.

(U) Overall system characterization identifies all elements of the protective system and develops the functional relationships between them. The interaction among system elements can then be analyzed to determine performance standards for each element. These standards, in turn, can be compared to the actual performance characteristics in order to evaluate the performance both of system elements and the protective system as a whole.

(U) System characterization and threat definition are not independent. In many cases, the elements of the overall system depend on the identity and objectives of the threat. For example, measures taken to protect against unauthorized detonation by an insider would include the personnel reliability program and the two-man rule. Neither of these measures provides protection against detonation following a host nation takeover. PAL however, could play a part against either threat.

(U) A clear statement of the purpose of PAL in terms of defining the threat(s) against which it is intended to provide protection, and the role of PAL in terms of characterizing the overall protective system(s), is needed to evaluate objectively the performance of the existing PAL system and the utility of new technology.

3.2 Deployment of Early-Technology PAL (U)

(U) Today's PAL system includes a variety of PAL devices, including mechanical locks, CAT A and B PAL, the MCCS, the APS, and soon the MCCSS for GLCM. These devices reflect the results of a 20-year engineering development effort. Based on the capabilities of the devices, it is useful to divide them into two groups which we call, for convenience, Old PAL and Modern PAL.

(U) Weapons equipped with Modern PAL devices feature a code-controlled, warhead-enable feature provided by an MCCS or an MCCSS. These weapons may, in addition, be equipped with an APS. Modern PAL, developed since the early- to mid-1970s, is characterized by:

- limited try capability
- multiple code capability
- unlock combination population $> 10^6$
- code inhibit

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(U) As weapon and control hardware evolve, improvements and changes are expected to occur. Because a mix of old and new systems is likely to remain, it may not be possible to utilize some capabilities fully. Study of goals and requirements is warranted to give direction to acquisition of future systems.

4. PAL Advanced Development (U)

(U) Today's PAL hardware elements and code management system were described in Section 2. New concepts in both hardware and code management are now in various stages of development. These concepts are summarized in this section.

4.1 New PAL Weapon Systems (U)

(U) The W84 warhead for the GLCM, which is scheduled for deployment in late 1983, is the most recent PAL weapon system described in Section 2. Several other new systems are in various stages of development or production.

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(U) The W79 8-in. AFAP preceded the W84, entering Phase 6 production in September 1981. Ultimately the W79 will replace the W33 8-in. projectile in stockpile. However, a date for overseas deployment is uncertain at this time. The W79 is equipped with the MC2907 MCCS that provides CAT D PAL protection.

(C) The W85 PII warhead begins Phase 6 production in May 1983. Eventually, the improved PII system will replace many PIs presently deployed to NATO. The W85 is basically a B61-4, CAT F warhead adapted to the warhead section of the PII missile. As such, it is equipped with an MC2907A MCCS.

(C) The W82 155-mm AFAP that will replace the W48 projectile is presently scheduled to enter Phase 6 production in June 1986. No deployment date has been announced. The W82 will be equipped with the MC3764 CAP (Section 4.2). The CAP will provide the same multiple code population and limited-try features as the MCCS, but the W82 will not be maintained in a disenabled state by interrupting warhead circuitry. Instead, the CAP will be located outside the weapon in a Use Denial Lock (UDL). The UDL (Figure 44) is a device which fastens to the nose of the projectile, preventing installation of the fuze. Unlocking the CAP allows removal of the UDL. An Integrated Control Unit (ICU) in the shipping container of each round will provide unlock and relock control of the UDL (Figure 45).

(U) A factory-rebuild program is currently under way to upgrade early versions of the B61. The B61-6 will result from retrofitting the B61-0 with enhanced safety features and the MC2907 CAT D PAL. First Phase 6 production is scheduled for October 1985. The B61-8 represents a safety upgrade of the B61-2 and B61-5. The B61-8 will have an MC2907 CAT D PAL and is scheduled for initial Phase 6 production in January 1988.

(U) Four strategic systems with PAL are planned for the stockpile. Two of these are modifications of existing systems. The B28 (Mods 0 and 1) will be field retrofitted (beginning April 1983); B61-1 will be factory rebuilt (Phase 6 begins September 1985) into the B61-7. Present plans call for an MC2907 CAT D PAL in both systems. Two new strategic systems, the W80-1 warhead for the Air-Launched Cruise Missile (ALCM) (Phase 6 production began February 1982) and the B83 modern strategic bomb (Phase 6 production is scheduled to begin September 1983), also will be equipped with the MC2907 CAT D PAL.

(U) Two new PAL-equipped Navy systems are currently planned. Both the W80-0 warhead for the Tomahawk Sea-Launched Cruise Missile (SLCM) (Phase 6 production is to begin April 1984) and the W81 warhead for the SM-2 fleet air defense missile (Phase 6 production to begin November 1986) will have CAT D PAL (MC2907 or MC3764).

(U) A stockpile projection[31] (Figure 46) shows the planned distribution of PAL-equipped weapons (weapons with no PAL are not shown) through FY 1992. This projection reflects the planned production of weapons equipped with modern CAT D and F PAL devices.

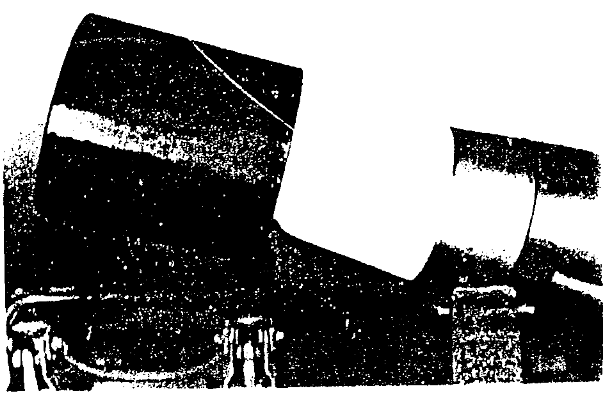

Figure 44. Use Denial Lock (U)

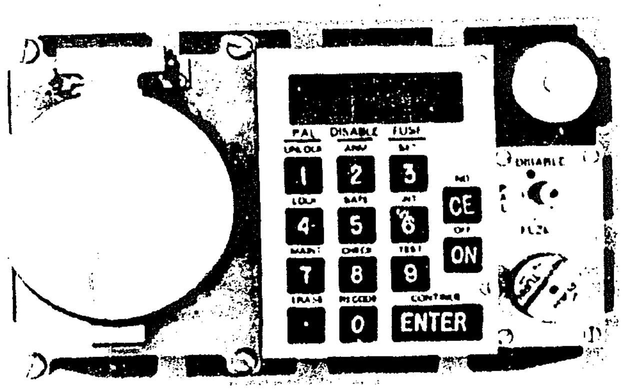

Figure 45. Integrated Control Unit (U)

4.2 The Code Activated Processor (U)

(U) The Code Activated Processor (CAP) is the next generation PAL device. It is being developed as a replacement for the MCCS, which will become increasingly difficult to manufacture because of decreasing component availability and obsolete technology.

(U) The microprocessor-based CAP is being designed as a drop-in replacement for the MC2907; it will have the same size and weight and will emulate the MCCS input and output signals. It will be compatible with all existing CAT D and F control equipment and will have limited-try and code population features identical to those of the MCCS.

(U) The CAP will also have a number of capabilities beyond those provided by the MCCS. First, several additional operations will be possible. Some of those operations will be under code control. These include:

- Maintenance lock—a UDL requirement
- Recovery of recode status information
- Storage and recovery of weapon state-of-health data
- Encrypted recode—the ability to recode using encrypted data, thus lessening concerns about bugging and emanation
- Encrypted code check

(U) New operations that are not under code control include:

- Recovery of weapon ID
- Self test

(U) Current control equipment does not allow the operator to take full advantage of these additional features. Software modifications could make the APC compatible with the additional recode capabilities of the CAP.

(U) In addition to new functions, the CAP will have a higher tolerance for voltage fluctuations in the input signals than does the MCCS and will withstand harsher shock and radiation environments. Finally, the CAP will have a more flexible output structure that can be tailored to the needs of the weapon designer.

4.3 Asymmetric Crypto PAL (U)

(U) The Asymmetric Crypto PAL (ACP) is an advanced PAL that has been under exploratory development.[32] It consists of an electronic coded-switch system whose inputs are processed by an asymmetric cryptographic system.

(U) Like the CAP, the ACP could provide recode and verification operations which are encrypted communications with the PAL controller. This reduces the vulnerability of the system to bugging and emanation. The asymmetric nature of the ACP crypto system also provides protection against code extraction, e.g., the determination of a code/combination by dissection or probing of a PAL to read its memory.

(U) The ACP has reached a stage of development marked by the completion of demonstration hardware. Although the system is feasible, development timescales for operational hardware depend on the availability of special large-scale integrated circuits that are needed for implementation of the cryptographic system.

4.4 Headquarters Equipment for Peacetime Code Management (U)

(U) The T1565 Headquarters Code Processor (HCP) is being developed in parallel with the T1563 APC as a peacetime code management aid. While the APC can (and will, initially) function by itself, the HCP will provide a number of additional capabilities.

(U) The HCP (Figure 47) is built around an HP 1000 computer. The system includes a printer, CRT display screen, keyboard, tape and disc storage units, and a cryptographic system. HCP operation is depicted in Figure 48. It has a number of functions. First, it provides access, under two-man control, to encrypted code information from the source data module generated by NSA. In addition, it contains a weapon data base that may be periodically updated.

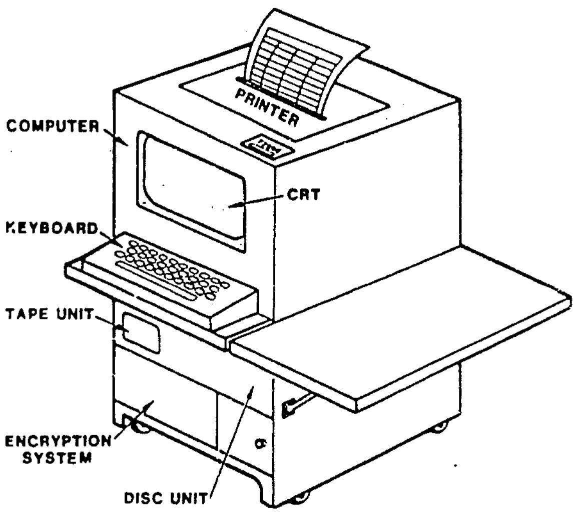

Figure 47. T1565 HQ Code Processor (U)

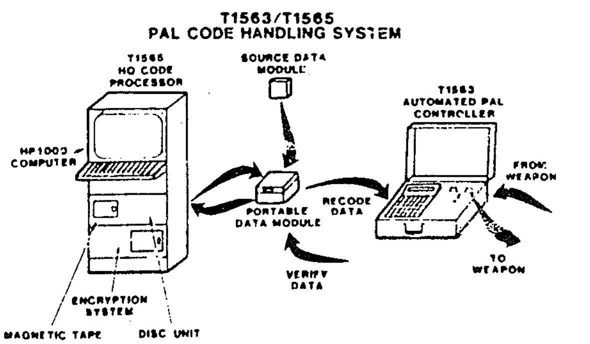

Figure 48. T1563/T1565 PAL Code Handling System (U)

This data base would include, for example, the theater weapon inventory information: mark and mod, serial number, and location of weapons in theater. Utility programs will be available for correlating the data base information with the weapon code information to aid in the construction of theater code plans. Given a theater code plan, the HCP will be able to generate the appropriate portable data modules for use by APCs during recode operations. The HCP will also be capable of reading monitor modules generated by the APC during recode. This may eliminate the need for on-site recode verification by the PMCT in cases where recode can be done with the APC.

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These differences include:

- A PAL inventory made up almost entirely of Modern PAL devices featuring limited-try, multiple code capability, and code populations $\geq 10^6$
- A significant fraction of the deployed stockpile equipped with APSs
- An APC that will permit "no knowledge" recode operations and remote verification

(U) In the long term, these efforts address the preponderance in today's stockpile of Old PAL devices and the resource limitation of the theater code management organizations.

(U) Identification of needed system improvements presupposes the ability to compare the function of the existing system with a set of performance criteria to determine system deficiencies. Today, performance criteria for PAL, based on an analysis of the overall command and control systems of which PAL is but one element, do not exist. In addition, it is not possible to estimate or measure the performance of PAL without a useful threat definition. No such definition is presently available. Thus it has not been possible, within the context of this report, to determine what improvements are needed in today's PAL system. Definitions of the purpose of PAL, in terms of a useful definition of threat(s) and of the role of PAL within the command and control structure, are needed to evaluate the performance of today's systems and the utility of new technology. Given a useful specification of the purpose and role of PAL for TNWs, a number of other issues could be explored.

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References (U)

[1]*European Theater Nuclear Weapons Command, Control, and Communications (TNWC³) System Improvement Plan (SIP)* (U), Draft Report (Washington, DC: Defense Communications Agency, 15 December 1980). SFRD.

[2]*Pacific Theater Nuclear Forces Command, Control, and Communications (PACOM TNFC³) System Improvement Plan (SIP)* (U), Draft Report (Washington, DC: Defense Communications Agency, 22 January 1982). SFRD.

[3]*Joint Army/ERDA Evaluation of Command, Control, and Security of Army Nuclear Weapon Systems*, 01794-77-00 (Washington, DC: Army/Energy Research and Development Administration, 16 May 1977). Secret.

[4]*Nuclear Weapon Security Manual* (U), DOD5210.41-M, Change (Washington, DC: Department of Defense, 1 September 1978). Confidential.

[5]*Policy and Procedures Governing the Permissive Action Link/Coded Switch/Positive Enable Cipher System* (U), JCS Pub 13, Vol II (Washington, DC: JCS, 1 January 1981, Rev 9 June 1981). SFRD. Hereafter cited as JCS Pub 13.

[6]"Permissive Links for Nuclear Weapons in NATO," memo from President J. F. Kennedy to Secy of State, Secy of Defense, Chairman of AEC, Dir Bur of Budget, NSAM-160, RS3446/53567, 6 June 1962. Secret.

[7]R. S. Pinkham, W. L. Clement, and A. M. Jackson, *Characteristics and Development Report for the MC1707 Coded Switch* (U), SC-DR-65-62, November 1965. Confidential.

[8]D. P. Roberts and J. H. Barnette, *Characteristics and Development Report for the MC1707A Coded Switch* (U), SC-DR-67-833, December 1967. Confidential.

[9]S. V. Asselin, *Countersink Program Final Report*, RS1514/643, September 1969. Secret.

[10]*Final Development Report on the W70 Warhead* (U), SLL73-0035, February 1974. Secret.

[11]R. E. Bair et al, *MC2764 Multiple Code Coded Switch Development Report* (U), SAND74-0228 (Albuquerque, NM: Sandia Laboratories, December 1974). Confidential

[12]M. M. Newsome and P. H. Stokes, *The Multiple Code Coded Switch*, SC-DR-66-422, August 1966.

[13]*Preliminary Development Report for the MC2707 Security Container System Used With the XM517 AFAP*, RS3410/2027, SC-WD-70-508, January 1971. CFRD.

[14]*Preliminary Development Report for the W75/XM673 Category E PAL* (U), RS3150/2410, SLA-73-0061, October 1974.

[15]"Phase 3 Authorization for B57 and B61 With Integral Protective System (IPS)," letter from Maj Gen E. B. Giller, OMA, to J. A. Hornbeck, 18 April 1972.

[16]*Nuclear Weapon System Safety Design and Evaluation Criteria*, AF Regulation 122-10, 7 November 1975.

[17]Atomic Energy Act of 1954, PL 703, Section 92.

[18]*General Characteristics for Permissive Devices for Use With Nuclear Weapons*, RS4323/1036, 13 September 1962. SFRD.

[19]*General Characteristics for Permissive Action Link Systems for Use With Nuclear Weapons*, RS4324/1035, 27 October 1969. SFRD.

[20]*General Characteristics for Permissive Action Link Systems for Use With Nuclear Weapons*, RS3148-1/95912, 26 July 1972. SFRD.

[21]*General Characteristics for Permissive Action Link System for Use With Nuclear Weapons*, RS2612/80/0302, 18 April 1980. SFRD.

[22]JCS Pub 13, op cit.

[23]*USCINCEUR Operational Concept for Theater Nuclear Forces Comand, Control, and Communications System (TNFC3S)*. (U) (Washington, DC: Defense Communications Agency, 16 April 1980), p II-6. SFRD. Hereafter cited as USCINCEUR.

[24]*CINCPAC Operational Concept and Required Operational Capabilities for Theater Nuclear Forces Command, Control, and Communications System (TNFC3S)* (U), Vol I (Washington, DC: Defense Communications Agency, 27 July 1981). SFRD. Hereafter cited as CINCPAC.

[25]*Nuclear Weapon Security Manual*, op cit.

[26]Policy and Procedures Governing the Permissive Action Link/Coded Switch/Positive Enable Cipher System, 1 January 1980, JCS Pub 13, Vol II.

[27]Letter from J. P. Wade, Chairman, Military Liaison Committee, to D. C. Sewell, Assistant to Secretary of Defense for Planning, 18 April 1983.

[28]*Measures for Upgrading Nuclear Weapons Safety and Security*, (U), OATSDAE, USDRE 83-0275, February 1983.

[29]CINCPAC, op cit.

[30]USCINCEUR, op cit.

[31]*Nuclear Weapons Production and Planning Directive (P&PD) 80-0* (U), Military Application (Washington, DC: Department of Energy, 31 March 1980). SRD.

[32]T. S. Edrington, *Asymmetric Crypto PAL* (U), SAND82-1665 (Albuquerque, NM: Sandia National Laboratories, December 1982). SFRD.

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THE WHITE HOUSE
WASHINGTON

June 6, 1962

NATIONAL SECURITY ACTION MEMORANDUM NO. 160

TO: The Secretary of State
The Secretary of Defense
The Chairman, Atomic Energy Commission
The Director, Bureau of the Budget

SUBJECT: Permissive Links for Nuclear Weapons in NATO

1. After an examination of the problem of installing permissive links in nuclear weapons dispersed in NATO commands, I have decided we should now make the commitment to procure appropriate devices for all nuclear weapons, now dispersed and to be dispersed to NATO commands, for both non-U.S. and U.S. forces. (See attached memorandum to me from Dr. Wiesner dated May 29. This decision corresponds to Alternative 5 of that memorandum.)

2. This will require a supplementary appropriation for the Atomic Energy Commission budget. The Secretary of Defense, the Chairman, Atomic Energy Commission, and the Director, Bureau of the Budget will work out the details of the budget presentation.

3. At the earliest feasible time, the Secretary of Defense will submit for my approval a schedule for installation of these devices in NATO weapons. In making this schedule, the Secretary should consult with the Secretary of State on the political problems arising from the existence of weapons assigned to U.S. forces and weapons assigned to our Allies.

4. The Chairman, Atomic Energy Commission, in consultation with the Secretary of Defense, will carry out a research program on an urgent basis directed toward an examination of the feasibility and desirability of more advanced permissive link devices with a wider range of capabilities.

/s/ John F. Kennedy

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APPENDIX A

NSAM-160 and Wiesner Memorandum
Original Document Secret

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MEMORANDUM FOR

THE PRESIDENT

At your request, I have reviewed, in consultation with the AEC and the DOD, the technical and cost aspects of equipping nuclear weapons dispersed overseas with permissive link hardware. The object of this review was to establish the program options that were technically available to implement such a program as rapidly as possible, and to determine the amount of supplemental funds that would have to be requested in the AEC FY '63 Budget to accomplish these options.

A decision on this problem involves the following basic policy issues which, while not technical in themselves, are affected by the availability of equipment and the program timing and cost:

(1) Should a permissive link be incorporated at this time in all dispersed nuclear weapons or just in those critical weapon systems with quick reaction, high yield and long range (e.g., Jupiter missiles and quick reaction aircraft)?

(2) Should a permissive link be incorporated at this time in all weapons dispersed to NATO (U.S. as well as non-U.S.) or just to non-U.S. weapons?

(3) Should a permissive link be incorporated at this time in weapons committed to NATO but based in the U.K. as well as weapons based on the European Continent?

These policy issues raised the more basic question as to what objective one is attempting to accomplish by incorporating a permissive link. A permissive link can attempt to meet any of the following objectives, each of which imposes increasingly difficult technical problems:

purpose of this review, I have not attempted to meet a specific objective but rather have analyzed the operational value of the best available equipment and attempted to determine how rapidly it could be incorporated in dispersed nuclear weapons.

While the permissive link equipment presently recommended by the AEC leaves something to be desired and can clearly be much improved with time, I believe that this equipment can be used as the basis for a crash program since development quality hardware exists and initial production and installation could begin in the immediate future.

Specifically the AEC recommends that, if a permissive link program is undertaken on a crash basis, bombs for aircraft and warheads for longer range missiles be equipped with an electro-mechanical lock which would have to receive a prearm numerical code in order to make the weapon operable. In the case of certain bombs which cannot be easily retrofitted with this equipment, as an interim measure pending the development of improved compatible permissive link hardware, mechanical combination locks would be installed to cover a socket into which an arming plug must be inserted. In the case of those bombs as well as short range missiles, such as Honest John and Mike Hercules, and the 8-inch shell, the arming plugs would be stored in self-destruct safes. The proposed program does not include specific hardware for the Davy Crockett missile which presents a particularly difficult problem because of its small size and possible forward deployment.

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The numbers which would operate both the electro-mechanical and the combination lock could be held at any echelon or command. If circumstances required, the combination could be held by the U.S. custodial officer himself. This procedure could therefore give the weapons the same state of readiness that they now possess.

In evaluating the utility of this equipment, it must be recognized that it is simply intended to buy time. A specialist with proper equipment might be able to crack the electro-mechanical lock in a few hours time. If he were able to circumvent the self-destruct feature of a safe, a skilled locksmith could open a combination lock relatively quickly. In any event, it would also be possible for skilled technicians familiar with weapons to make these weapons operate in a period of from several hours to weeks, depending on the extent of thier knowledge, by opening the weapons and bypassing the electric circuits. Despite the limitations of this equipment, I believe it would give further (and probably decisive) protection against individual psychotics and would certainly cover unauthorized use by military forces holding the weapons during periods of high tension or military combat. While it would not assure that the weapons could not be used if they were forceably seized by an organized group or a foreign power with technically capable individuals, it would provide in the case of the more important weapon systems equipped with electro-mechanical lock a period of time, varying from hours to days, in which decisions could be made as to what our proper response to the seizure should be. The question of the legal and political requirements of control were beyond the scope of my review.

The question has been raised whether the installation of this development quality hardware on a crash basis might reduce the reliability of the nuclear weapons. However, in view of the simple nature of this equipment and the method of installation, I believe that it is now generally agreed that it would not reduce the inherent reliability of the weapons. The weapons would, of course, not be operable if the combination number were not received from a higher headquarters. This is a communication and management problem, which can be very simple or a very complex, depending on the level of command at which the combination number is held and the degree of control maintained through coding procedures or the use of different combination numbers for different weapons. In its simplest form, it should be possible to handle this procedure wherever a "go code" can be transmitted which is presently a requirement if any control is to exist. In any event, I wish to emphasize that, if circumstances demand, a decision can be made to release the combination number to the U.S. custodian with the field unit and thereby revert to the state of readiness and control that exists today.

At my request, the AEC has estimated the cost and time for completion of the following five alternative programs, which I believe represent the full range of possible application of the permissive link on a crash basis to nuclear weapons dispersed to the European Theater:

The estimated completion date, total cost, and FY '63 for each of these programs is as follows:

Alternative	Estimated Date Completed Installation	Total Cost ($ Millions)	FY '63 Cost ($ Millions)
I	June 1963	3.2	3.2
II	Oct. 1963	11.3	10.6
III	Dec. 1963	13.6	11.7
IV	Mar. 1964	18.6	13.8
V	Aug. 1964	26.9	14.0

A supplemental to the AEC FY '63 Budget would call for obligation of the total cost of the program but expenditure of only the FY '63 cost of the program.

On the basis of this review, I have concluded that it is technically possible to equip on a crash basis all nuclear-weapons dispersed to the European Theater with reasonably effective permissive link equipment at relatively small cost. Therefore, the decision as to the extent to which permissive link equipment should in fact be incorporated in dispersed weapons can be made solely in terms of broad policy considerations as to the desired objective.

Whatever decision is made on the crash program to install permissive link equipment on dispersed nuclear weapons equipment, I would recommend that a vigorous program be undertaken to develop an improved electronic lock which would be incorporated directly in the electronic package associated with all future weapons so that the option of a permissive link would always exist. This program should also include work to develop improved devices to retrofit the bombs and medium range missiles which were equipped with combination locks only as an interim measure in the above crash program. I would also recommend that there be an agressive research program to develop more advanced concepts of the permissive link including mechanics to assure the self-destruction of a weapon if efforts were made to by-pass the permissive link. It is my understanding that the AEC has funds available to cover the R&D necessary for these advanced programs.

Jerome B. Wiesner

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APPENDIX B

General Characteristics for PAL Devices
Original Document Secret

Item I

GENERAL CHARACTERISTICS FOR PREMISSIVE DEVICES FOR USE WITH NUCLEAR WEAPONS (U)

General Characteristics
Approved by the OSD:
13 September 1962

1. Purpose. These General Characteristics define an arming control device for use with designated nuclear weapons which is intended to provide some additional physical means for preventing unauthorized use of nuclear weapons.

2. General Characteristics. The device shall conform to the general characteristics and provide the capabilities listed below:

a. The device shall be capable of repeated enabling, disenabling, and recoding. Further, the device shall be capable of being maintained in either the enabled or disenabled mode.

b. When the device is enabled, a positive indication of enabled condition shall be provided. It is highly desirable that this indication provide no usable information to an unauthorized operator.

c. The time required for authorized enabling of the device shall not add to the weapon system reaction time under any readiness condition. Capability for inflight operation of this device is required for certain aircraft applications.

DOE b(3)

e. The device and associated equipment shall be designed so that inspection or disassembly of the weapon will not disclose the combination or code.

f. The combination or code shall be transmitable by all standard communications means, and shall be capable of being changed rapidly and accurately by persons having the appropriate equipment and the old combination or code.

g. The device shall be so located and shall function in such a manner that it will permit performance of the required weapon maintenance, retrofit, and test operation throughout the stockpile-to-target sequence, without enabling the device.

h. The device and associated equipment shall be of such quality as not to decrease significantly the weapon reliability.

i. The device and its associated equipment shall be designed so as to permit installation and use of the device in bombs or warheads without degrading weapon safety.

j. The device installed in the weapon itself should not degrade the delivery capability or alter the ballistics of the weapon system.

k. Meters, dials, and switches on device components which are used in the open without blackout protection shall be illuminated in such a manner that blackout will not be violated.

l. The device and its related equipment shall withstand, without functional impairment or reduction of operational reliability, the environmental criteria specified in the applicable stockpile-to-target sequence of authorized weapon applications and in assoicated environmental specifications.

Item 2

GENERAL CHARACTERISTICS FOR PERMISSIVE ACTION LINK SYSTEMS USED WITH NUCLEAR WEAPONS (U)

(Attachment to DDR&F Letter to Chun, AEC, Same Subject, 27 October 1969)
(Original Document Secret)

1. Purpose. To provide general characteristics for permissive action link systems incorporated in weapon systems to prevent unauthorized nuclear detonation. This document is not intended to in any way inhibit development of improvements beyond the characteristics set forth.

2. General.

[redacted]

DOE b(3)

b. The system shall provide for two modes, enable (unlock) and disenable (lock), of the warhead by insertion of one 4-digit decimal code.

[redacted]

DOE b(3)

d. The system shall not significantly degrade weapon reliability, nor shall it degrade safety, or delivery capability. The time required for enabling (unlocking) of the device shall not unduly add to the weapon system reaction time under any readiness condition.

3. System Operation.

a. The control equipment must provide visual indications of the satus of the system. As a minimum, the equipment must indicate when (a) the number of unsuccessful enabling (unlocking) attempts is zero, (b) the number of unsuccessful enabling (unlocking) attempts is greater than zero but less than that required for lockout, and (c) the device is locked out.

b. The system shall be capable of recoding, enabling (unlocking) or disenabling (locking) at any point in the STS:

(1) in the case of aircraft weapon systems, up to the time of taxi and/or aircraft launch; and enabling (unlocking) or disenabling (locking) after aircraft launch.

(2) in the case of projectiles, at any time up to the time of loading into the weapon breech.

(3) in the case of missile systems, up to the time of final; prefire operations.

c. The code shall be capable of being changed rapidly and accurately by persons using the appropriate equipment. Changing of the code will be dependent upon possession of the old (existing) code.

d. At anytime prior to permanent lockout the feature which counts the number of incorrect tries shall reset to zero whenever the proper code is inserted.

e. The system shall be capable of a code check operation which will allow verification of the ser code without changing the mode of the device.

4. System Compatibility and Reliability.

a. The system shall be compatible with the weapon operational concepts to include the readiness requirements stated in the STS.

b. The system will be compatible with normal logistical movement in either selected mode.

c. The system shall be electrically compatible with other weapons system circuitry. In the case of aircraft systems it will be compatible with circuitry during all phases of circuit operation, both ground and air.

d. The design of control equipment shall preclude permanent disenabling (locking) if a permissive action link operation is interrupted by power failure.

e. The system shall incorporate a means of determining electrically, by a T-304 or similar service continuity test equipment, whether the permissive action link device is in the enabled (unlocked) condition.

5. Inspection & Maintenance.

a. The system shall be designed so that inspection or disassembly of any component external to the warhead will not disclose the codes.

b. The permissive action link shall be so located and the system shall function in such a manner that it will permit perormance of the required warhead maintenance, retrofit (including internal and external components exclusive of the permissive action link system), and test operations throughout the STS without changing the mode of the device.

c. The system shall be capable of having maintenance performed on it in either the enabled (unlocked) or dis-enabled (locked) mode.

d. The operational storage life of that portion of the system installed in the warhead shall be no less than that of other warhead components.

6. Control Equipment.

a. Control equipment with the exception of decoders installed in aircraft shall be designed to permit disenabling (locking) and enabling (unlocking) using the "two-man" concept, and recoding using the "two-team" concept.

b. Control equipment shall provide a positive indication of the mode of the permissive action link device. This indication should provide no information regarding the set code.

c. Decoders shall be capable of enabling (unlocking), disenabling (locking), and code checking.

d. Recoders shall be capable of recoding and code checking the system without enabling (unlocking) the device.

e. Design alternatives which combine decoders and recoders are acceptable.

7. Environmental Considerations.

a. Meters, dials, and switches on componenets which are used in the open without blackout protection shall be illuminated in such a manner that blackout will not be violated.

b. The system and its related equipment shall withstand, without functional impairment or reduction of operational reliability, the evironmental criteria specified in the applicable stockpile-to-target sequence of authorized weapon applications and in associated environmental specifications.

Item 3

GENERAL CHARACTERISTICS FOR PERMISSIVE ACTION LINK SYSTEMS USED WITH NUCLEAR WEAPONS (U)

(Attachment to DDR&E Letter to Chmn, AEC, same subject, 31 Dec 1970.)
(Original Document Secret)

1. Purpose. To provide general characteristics for permissive action links incorporated in weapon systems to prevent an unauthorized nuclear detonation. This document is not intended to inhibit in any way development of improvements beyond the characteristics set forth.

2. General.

DoE b(3)

b. The system shall provide for two modes, unlock and lock of the warhead by insertion of one 6-digit decimal code.

DoE b(3)

d. The system shall not significantly degrade weapon reliability, nor shall it degrade safety, or delivery capability. The time required for unlocking the device shall not unduly add to the weapon system reaction time under any readiness condition.

3. System Operation.

a. The control equipment must provide visual indications of the status of the system. As a minimum, the equipment must indicate when (a) the number of unsuccessful unlocking attempts is zero, (b) the number of unsuccessful unlocking attempts is greater than zero but less than that required for lockout, and (c) the device is locked out.

b. The system shall be capable of recoding, unlocking or locking at any point in the STS:

(1) in the case of aircraft weapon systems, up to the time of taxi and/or aircraft launch; and enabling (unlocking) or disenabling (locking) after aircraft launch.

(2) in the case of projectiles, at any time up to the time of loading into the weapon breech.

(3) in the case of missile systems, up to the time of final prefire operations.

c. The code shall be capable of being changed rapidly and accurately by persons using the appropriate equipment. Changing of the code will be dependent upon possession of the old (existing) code.

d. At anytime prior to permanent lockout the feature which counts the number of incorrect tries shall reset to zero whenever the proper code is inserted.

e. The system shall be capable of a code check operation which will allow verification of the set code without changing the mode of the device.

4. System Compatibility and Reliability.

a. The system shall be compatible with the weapon operational concepts to include the readiness requirements stated in the STS.

b. The system will be compatible with normal logistical movement in either selected mode.

c. The system shall be electrically compatible with other weapons system circuitry. In the case of aircraft systems it will be compatible with aircraft circuitry during all phases of circuit operation, both ground and air.

d. The design of control equipment shall preclude permanent locking if a permissive action link operation is interrupted by power failure.

e. The system shall incorporate a means of determining electrically, by a T-304 or similar service continuity test equipment, whether the permissive action link device in the unlocked condition.

5. Inspection & Maintenance.

a. The system shall be designed so that inspection or disassembly of any component external to the warhead will not disclose the codes.

b. The permissive action link shall be so located and the system shall function in such a manner that it will permit performance of the required warhead maintenance, retrofit (including internal and external components exclusive of the permissive action link system), and test operations throughout the STS without changing the mode of the device.

c. The system shall be capable of having maintenance performed on it in either the unlocked or locked mode.

d. The operational storage life of that portion of the system installed in the warhead shall be no less than that of other warhead components.

6. Control Equipment.

a. Control equipment with the exception of decoders installed in aircraft shall be designed to permit disenabling (locking) and enabling (unlocking) using the "two-man" concept, and recoding using the "two-team" concept.

b. Control equipment shall provide a positive indication of the mode of the permissive action link device. This indication should provide no information regarding the set code.

c. Decoders shall be capable of unlocking, locking, and code checking.

d. Recoders shall be capable of recoding and code checking the system without unlocking the device.

e. Design alternatives which combine decoders and recoders are acceptable.

7. Environmental Considerations.

a. Meters, dials, and switches on componenets which are used in the open without blackout protection shall be illuminated in such a manner that blackout will not be violated.

b. The system and its related equipment shall withstand, without functional impairment or reduction of operational reliability, the evironmental criteria specified in the applicable stockpile-to-target sequence of authorized weapon applications and in associated environmental specifications.

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Item 4

GENERAL CHARACTERISTICS FOR PERMISSIVE ACTION LINK SYSTEMS USED WITH NUCLEAR WEAPONS

(Attachment to DDR&F Letter to Chun, AEC, Same Subject, 26 July 1972)
(Original Document Secret)

1. Purpose To provide general characteristics for AEC-produced electromechanical/electronic permissive action link (PAL) systems used with nuclear weapons to prevent an unauthorized nuclear detonation. This document is not intended to inhibit in any way development of improvements beyond the characteristics set forth.

2. Nomemclature

DOE
b(3)

3. Definitions

Permissive Action Link (PAL) – A family of devices and subsystems designed to reduce the possibility of obtaining a nuclear detonation from a nuclear warhead without the use (insertion) of a controlled numerical code, thus reducing the probability of an unauthorized nuclear detonation.

Passive Protection – Precludes operation of weapon arming circuits.

Active Protection – Senses attempts to gain unauthorized access to weapon arming circuits, with option to respond by initiating weapon disablement.

Mode – Refers to the protected condition (LOCK) or the unprotected condition (UNLOCK) of the PAL.

State – Refers to the condition of the active protection feature (OFF/TEST/ON).

Unlock Code – A preset code used to unlock the PAL.

Off Code – A preset code used to change state of OFF.

Code Check – Confirms stored code(s) in PAL without affecting weapon PAL mode.

Recode – Allows changing of stored code(s) in PAL.

Code Inhibit – Precludes a second unlock of a PAL with a given code until recode.

Limited-Try – Counts consecutive incorrect code trials and resets to zero on a correct code trial.

Temporary NO-GO – Precludes additional code trial operations without special field equipment after a number of incorrect code trials.

Permanent NO-GO – Precludes additional code trial operations with field equipment after additional incorrect code trials.

4. General Characteristics

A. Category A and Category B

DOE
b(3)

2. These systems shall provide for two modes, UNLOCK and LOCK of the PAL by insertion of one 4-digit decimal code.

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B. Category B'

DOE b(3)

3. The system shall provide for two modes, UNLOCK and LOCK of the PAL by the insertion of one 4-digit decimal code.

C. Category C – The characteristics stated above (Category B') apply with the following modifications:

1. The system shall provide for two modes, UNLOCK and LOCK of the PAL by insertion of one 6-digit decimal code.

D. Category D

DOE b(3)

DoE b(3)

5. System Operation

A. All Categories

1. The system shall not significantly degrade weapon reliability, safety, or delivery capability. The time required for unlocking the device shall not unduly add to the weapon system reaction time under any readiness condition.

2. The design shall preclude permanent locking if a PAL operation in interrupted by power failure.

B. Category A

1. The control equipment must provide visual indications of the mode of the system.

2. The system shall be capable of recoding, unlocking or locking at any point in the STS up to the time of final prefire operations.

3. The system shall be capable of being recoded rapidly and accurately by persons using the appropriate equipment. Recoding will be dependent upon possession of the old (existing) code.

C. Category B

1. The control equipment must provide visual indications of the mode of the system.

2. The system shall be capable of recoding, code checking, unlocking, or locking at any point in the STS up to the time of aircraft taxi and/or launch; and unlocking or locking after aircraft launch.

3. The system shall be capable of being recoded rapidly and accurately by persons using the appropriate equipment. Recoding will be dependent upon possession of the old (existing) code.

D. Category B' and C

1. The control equipment must provide visual indications of the mode of the system. The control equipment must also indicate when (a) the number of unsuccessful code trial attempts is zero, (b) the number of unsuccessful code trial attempts is greater than zero but less than that required for NO-GO, and (c) the device is NO-GO.

2. The system shall be capable of recoding, code checking, unlocking or locking at any point in the STS.

a. In the case of aircraft weapon systems, up to the time of taxi and/or aircraft launch; and unlocking or locking after aircraft launch.

b. In the case of missile systems, up to the time of final pre-fire operations.

3. At any time prior to permanent NO-GO the feature which counts the number of incorrect tries shall reset to zero whenever the correct code is inserted.

4. The system shall be capable of being recoded rapidly and accurately by persons using the appropriate equipment.

E. Category D

The characteristics stated for Category B' and C above apply with the following addition:

1. The system shall contain a Master Recode feature to allow recoding of all six stored codes using any one of the old not inhibited (existing) codes.

2. At any time prior to permanent NO-GO, the feature which counts the number of incorrect tries shall reset to zero whenever a correct, not inhibited code is inserted.

F. Category E and F

The characteristics stated for Category D shall apply with the following additions:

DOE b(3)

6. System Compatibility

A. Category A

1. The system shall be compatible with the weapon operational concepts to include the readiness requirements stated in the STS.

2. The system shall be compatible with normal logistical movement in either selected mode.

3. The system shall be electrically compatible with other weapon system circuitry.

B. Category B, B', C, D, E, and F

1. The system shall be compatible with the weapon operational concepts to include the readiness requirements stated in the STS.

2. The system shall be compatible with normal logistical movement in any selected mode.

3. The system shall be electrically compatible with other weapon system circuitry. In the case of aircraft systems, it will be compatible with aircraft circuitry during all phases of aircraft operation, both ground and air.

4. The system shall incorporate a means of determining electrically, by a T-304 or similar service continuity test equipment, whether the PAL is in the unlocked mode.

7. Control Equipment

A. Category A

1. Control equipment shall be designed to permit locking and unlocking using the "two-man" concept, and recoding using the "two-team" concept.

2. Control equipment shall provide a positive indication of the mode of the permissive action link. This indication should provide no information regarding the set code.

3. Decoders shall be capable of unlocking and locking.

B. Category B, B', and C

1. Control equipment shall be designed to permit locking and unlocking using the "two-man" concept, and recoding using the "two-team" concept.

2. Control equipment shall provide a positive indication of the mode of the PAL. This indication should provide no information regarding the set code.

3. Recoders shall be capable of recoding and code checking the system without unlocking the device.

4. Decoders shall be capable of unlocking, locking, and code checking.

5. Aircraft decoders shall be capable of unlocking.

6. Decoders installed in aircraft shall be designed for single man operation.

C. Category D, E, and F

1. The system shall be electrically compatible with other weapon system circuitry. In the case of aircraft systems, it will be compatible with aircraft circuitry during all phases of aircraft operation, both ground and air.

2. The system shall incorporate a means of determining electrically, by a T-304 or similar service continuity test equipment, whether the PAL is in the unlocked condition.

3. Recoders shall be capable of recoding and code checking the system without unlocking the PAL.

4. Decoders shall be capable of unlocking and locking.

5. Aircraft decoders shall be capable of unlocking and locking

6. Decoders installed in aircraft shall be designed for single man operation.

7. Recoders shall be capable of recoding all six unlock codes and the off code using any one of the old not inhibited stored unlock codes, or recoding any one new code using one of the old not inhibited stored codes.

8. Recoders shall be capable of code checking all seven stored codes in one operation or code checking any one of the stored codes.

9. Air Force recoders shall also be capable of recoding and code checking Category B and B' systems.

10. Army recoders shall also be capable of recoding and code checking Category C PAL systems.

11. Air Force aircraft decoders shall also be capable of unlocking Category B and B' systems.

12. Air Force ground decoders shall also be capable of unlocking, locking, and code checking Category B and B' systems.

13. Army decoders shall also be capable of unlocking, locking, and code checking Category C PAL systems.

8. Inspection and Maintenance

A. All Categories

1. The system shall be designed so that inspection or disassembly of any component external to the warhead will not disclose the codes.

DOE b(3)

[redacted]

B. Category E

1. The system shall be capable of extended storage in the environments specified in the weapon STS in any functional state for a period of eight years.

9. Environmental Considerations

A. All Categories

1. Meters, dials, and switches on components which are used in the open without blackout protection shall be illuminated in such a manner that blackout will not be violated.

2. The system and its related equipment shall withstand, without functional impairment or reduction of operational reliability, the environmental criteria specified in the applicable stockpile-to-target sequence of authorized weapon applications and in associated environmental specifications.

Item 5

GENERAL CHARACTERISTICS FOR PERMISSIVE ACTION LINK SYSTEMS USED WITH NUCLEAR WEAPONS
(Attachment to Director, DMA Letter, Same Subject, 18 April 1980)

1. (U) INTRODUCTION. These general characteristics describe permissive action link (PAL) systems used with nuclear weapons to prevent unauthorized nuclear detonations. Early PAL categories currently in stockpile weapons, but no longer being acquired, are not addressed in these characteristics. This document is not intended to inhibit in any way research and development of improvements beyond the characteristics set forth. These general characteristics will be maintained as a continuously current document and therefore will require amending, at appropriate future dates, to reflect changes of employment policy or improvements in PAL technology.

2. (U) DEFINITIONS.

(U) Permissive Action Link (PAL) – A family of devices and subsystems designed to reduce the possibility of obtaining a nuclear detonation from a nuclear warhead without the use (insertion) of a controlled numerical code.

(U) Passive Protection – Precludes normal operation of weapon arming and/or firing circuits.

(U) Active Protection – Senses attempts to gain unauthorized access to critical weapon components, and responds by initiating weapon disablement.

(U) Mode – Refers to the protected condition (LOCK) or the unprotected condition (UNLOCK) of the PAL.

(U) State – Refers to the condition of the active protection feature (OFF/TEST/ON).

(U) Unlock Code – A preset code used to unlock the PAL.

(U) Off Code – A preset code used to change state to OFF.

(U) Code Check – Confirms stored code(s) in PAL without affecting weapon PAL mode or state.

(U) Recode – Procedure for changing stored code(s) in PAL.

(U) Code Inhibit – Precludes use of a given code, for any PAL operation other than code check, once that code has been used (lock or unlock).

(U) Limited Try – Counts consecutive incorrect code trials, resets to zero on a correct code trial, and is capable of invoking temporary or permanent NO-GO options.

(U) Temporary NO-GO – Precludes PAL operations without special field equipment after a given number of incorrect code trials.

(U) Permanent NO-GO – Precludes PAL operations.

3. (U) GENERAL PAL CHARACTERISTICS

A. (U) Category D. DOE b(3)

(U) 2. This system shall have two modes, UNLOCK and LOCK of the PAL. PAL UNLOCK or LOCK shall occur upon insertion of any one of multiple preset unlock codes.

(U) 3. The system shall contain a "Code Inhibit" feature to allow a subset of the preset unlock codes to be inhibited. Once a code is inhibited, access for recoding that code and removing the inhibit may only occur using a different preset unlock code which itself has not been inhibited.

(U) 4. The system shall contain a "limited-try" feature to deter successful unlocking by trial and error.

B. (U) Category E and F. The characteristics stated in Category D apply with the following modifications.

DOE b(3)

DOE
b(3)

C. (U) <u>All Categories</u>

(U) 1. The system shall be compatible with the weapon operational concepts to include the readiness requirements stated in the STS.

(U) 2. The system shall be compatible with normal logistical movement in any selected mode.

(U) 3. The system shall not significantly degrade weapon reliability, safety or delivery capability. The time required for unlocking the device shall not unduly add to the weapon system reaction time under any readiness condition.

(U) 4. The system shall be capable of being recoded, code checked, unlocked or locked at any point in the STS up to:

a. (U) In the case of missile systems, up to the time of final pre-fire operations.

b. (U) In the case of aircraft weapon systems, up to the time of taxi and/or aircraft launch, with unlocking or locking after aircraft launch. However, recode is not required after weapon loading on aircraft.

(U) 5. The system shall contain a Master Recode feature to allow recoding of all stored codes using any one of the old codes which has not been inhibited.

(U) 6. The system shall be capable of being recoded rapidly and accurately by persons using the appropriate equipment.

4. (U) <u>CONTROL EQUIPMENT</u>

A. (U) <u>All Categories</u>

(U) 1. The system shall be electrically and mechanically compatible with the weapon system. In the case of aircraft systems, any equipment installed in the aircraft or associated with the weapon will be compatible with aircraft circuitry during all phases of aircraft operation, both ground and air.

(U) 2. The system shall incorporate a means of determining electrically, by service continuity test equipment, whether the PAL is in the unlocked condition.

(U) 3. The control equipment must indicate when (a) the number of unsuccessful trial attempts is zero; (b) the number unsuccessful code trial attempts is greater than zero but less than that required for NO-GO; and (c) the device is NO-GO.

(U) 4. Control equipment shall be provided that will:

a. (U) Allow recoding and code checking without unlocking the PAL.

b. (U) Allow recoding any one or all unlock and off codes using one not inhibited stored code.

c. (U) Allow code checking all stored codes in one operation or code checking any one of the stored codes.

d. (U) Allow unlocking and locking the PAL.

e. (U) Allow PAL unlocking and locking operations in an aircraft to be performed by a single individual.

(U) 5. New control equipment shall minimize potential TEMPEST, tampering, and bugging vulnerabilities. DoE b(3)

5. (U) INSPECTION AND MAINTENANCE

A. (U) All Categories

(U) 1. The system shall be designed so that inspection or disassembly of any component external to the warhead will not disclose the codes.

(U) 2. The PAL system shall function in such a manner that with the active protection OFF, warhead maintenance and test operations can be performed without changing the mode of the passive protection.

6. (U) ENVIRONMENTAL CONSIDERATIONS

A. (U) All Categories

(U) 1. The system and its related equipment shall withstand, without functional impairment or reduction of operational reliability, the environmental criteria specified in the applicable weapon stockpile-to-target sequence.

(U) 2. Meters, dials, and switches on components which are used in the open without blackout protection shall be illuminated in such a manner that blackout will not be violated.

APPENDIX C

Letter from J. P. Wade, Jr., to D. C. Sewell

[redacted] UNCLASSIFIED

DEPARTMENT OF DEFENSE
MILITARY LIAISON COMMITTEE
TO THE
DEPARTMENT OF ENERGY
WASHINGTON, D.C. 20301

April 18, 1980

Honorable Duane C. Sewell
Assistant Secretary for
Defense Programs
Department of Energy
Washington, D.C. 20585

Dear Mr. Sewell:

(U) Over the past several months a great deal of concern and discussion has surfaced involving the policy for non-violent disablement and what role it should play in nuclear weapon security matters. Specific controversy has centered on questions of: which weapons should have a disable capability?; what level of sophistication should be credited to the threat?; and how long should disablement render the weapon useless against this threat? Department of Defense guidance to the Department of Energy in this area has been presented in systems Military Characteristics and POG meetings, as well as in the Nuclear Weapon Development Guidance. Unfortunately, in many cases it has been less than specific or subject to interpretation in application.

(U) I would like to clarify the existing situation and toward that goal, two transmittals are enclosed. The first is a DoD statement of policy addressing the goals and current assessment needs associated with nuclear weapon disablement systems. The second is a revision of the July 1972 "General Characteristics for Permissive Action Link Systems Used with Nuclear Weapons."

DoE
b(3)

[redacted] UNCLASSIFIED

(U) The paper "General Characteristics for Permissive Action Link Systems Used with Nuclear Weapons" should be viewed as the basic DoD definitions for PAL systems in acquisition of weapon systems incorporating DoE produced PALs. This paper, that supersedes the original 1972 document and amendments, will be forwarded to DNA for handling in a manner similar to weapon military characteristics, that is DNA will be responsible for publication and maintenance of an up-to-date file including amendments that may occur in the future. Consistent with our intention to work toward standardization of PAL devices and associated control equipment, only three PAL systems, Category D, E, and F are addressed in this update of the paper. Earlier PAL devices continue to remain in the stockpile: however, their acquisition cycle has been completed and therefore they have not been included in this update of the characteristics document.

Sincerely,

/s/ James P. Wade, Jr.
Chairman

Attachments
a/s (SFRD)

DOE
b(3)

APPENDIX D

DoD Directive S-5200.16
September 22, 1970

(Original Document Secret)

Deputy Secretary of Defense

APPENDIX E

JCS Pub 13, Volume II
(Excerpt From Chapter 7)

Report and Evaluation of Possible Compromises (U)

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APPENDIX F

Excerpt From Amendment 3 to the Military Characteristics for a Nuclear Warhead for the 155 mm Howitzer Projectile (Approved by the MLC 27 April, 1971)

3. Control Devices

3.1 Security Container System (SCS)

An SCS, compatible with projectile and warhead designs, will be used with the M517 on an optional basis. The SCS will be developed under a program separate from the XM517 development program. The SCS shall be designed and function as specified in the SCS Characteristics attached as an Appendix.[2]

3.2. Permissive Action Link (PAL)

The PAL shall conform to the general characteristics outlined in the letter from the Director of Defense Research and Engineering to the Chairman of the Atomic Energy Commission, "General Characteristics for Permissive Action Link Systems Used with Nuclear Weapons," dated 31 December 1970.

3.2.1. The PAL control equipment shall also operate and be capable of recoding the SCS six-digit, limited-try coded switch.

3.2.2. It is desired that the control equipment be compatible with Category B, six-digit single code PAL devices.

3.2.3. The system shall provide for two modes, unlock and lock for the warhead by insertion of one six-digit decimal code. Unlock shall occur upon the insertion of any one correct code of six preset unlock codes. These unlock codes may be preset so that each is unique, or so that redundancies occur among them.

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