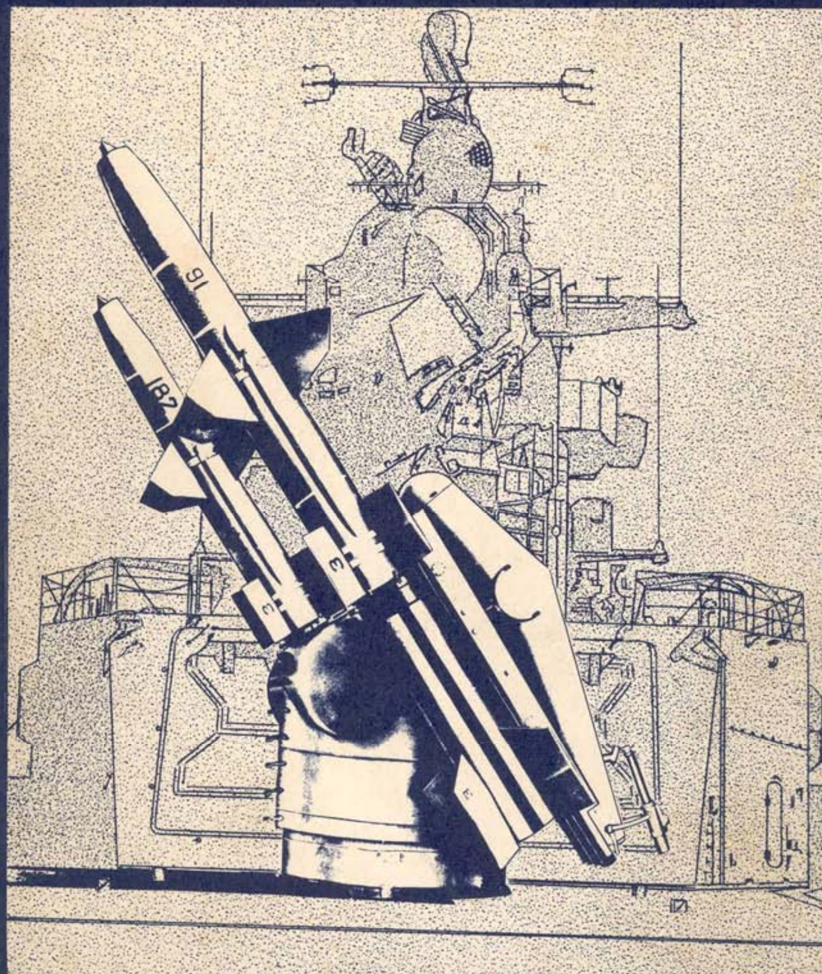

GUNNER'S MATE M 1 & C

NAVAL TRAINING COMMAND

RATE TRAINING MANUAL NAVTRA 10200-B

INSIDE FRONT COVER

PREFACE

This is one of a series of Rate Training Manuals designed to provide enlisted men with background information that will be useful in preparing for advancement in rating, and necessary in the proper performance of their duties. This course was written to serve as an aid for enlisted men of the U.S. Navy and the U.S. Naval Reserve who are preparing for advancement to Gunner's Mate Missiles 1 and C. Appropriate sections of the Manual of Qualifications for Advancement, NAVPERS 18068-C, were used as a guide in selecting the contents of this text.

This book was prepared by the Naval Training Publications Detachment, Washington, D.C. for the Chief of Naval Training. Special credit is given to the Naval Ordnance Systems Command, Washington, D.C.; the Naval Examining Center, and the Service School Command, U.S. Naval Training Center, Great Lakes, Illinois; for their assistance in technical review of this text.

Revised 1972

Stock Ordering No.
0502-051-0010

Published by
Naval Training Command

UNITED STATES
GOVERNMENT PRINTING OFFICE
WASHINGTON. D.C.: 1973

THE UNITED STATES NAVY

GUARDIAN OF OUR COUNTRY

The United States Navy is responsible for maintaining control of the sea and is a ready force on watch at home and overseas, capable of strong action to preserve the peace or of instant offensive action to win in war.

It is upon the maintenance of this control that our country's glorious future depends; the United States Navy exists to make it so.

WE SERVE WITH HONOR

Tradition, valor, and victory are the Navy's heritage from the past. To these may be added dedication, discipline, and vigilance as the watchwords of the present and the future.

At home or on distant stations we serve with pride, confident in the respect of our country, our shipmates, and our families.

Our responsibilities sober us; our adversities strengthen us.

Service to God and Country is our special privilege. We serve with honor.

THE FUTURE OF THE NAVY

The Navy will always employ new weapons, new techniques, and greater power to protect and defend the United States on the sea, under the sea, and in the air.

Now and in the future, control of the sea gives the United States her greatest advantage for the maintenance of peace and for victory in war.

Mobility, surprise, dispersal, and offensive power are the keynotes of the new Navy. The roots of the Navy lie in a strong belief in the future, in continued dedication to our tasks, and in reflection on our heritage from the past.

Never have our opportunities and our responsibilities been greater.

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Phillip Hays PhD LT USNR-R

March 2009

CHAPTER 1

AIMING HIGHER

This rate training manual is designed to help you meet the occupational qualifications for advancement to Gunner's Mate Missile First and Chief. Chapter 2 through 12 deal with the technical subject matter of the Gunner's Mate Missile rating. The present chapter provides introductory, information that will help you in working for advancement in rate. It is strongly recommended that you study this chapter carefully before beginning intensive study of the chapters that follow.

REWARDS AND RESPONSIBILITIES

Advancement in rate brings both increased rewards and increased responsibilities. The time to start looking ahead and considering the rewards and the responsibilities of advancement is right now, while you are preparing for advancement to GMM1 or GMMC.

By this time, you are probably well aware of many of the advantages of advancement in rate - higher pay, greater prestige, more interesting and challenging work, and the satisfaction of getting ahead in your chosen career. By this time, also, you have probably discovered that one of the most enduring rewards of advancement is the personal satisfaction you find in developing your skills and increasing your knowledge.

The Navy also benefits by your advancement. Highly trained personnel are essential to the functioning of the Navy. By each advancement in rate you increase your value to the Navy in two ways. First, you become more valuable as a technical specialist in your own rating. And second, you' become more valuable as a person who can supervise, lead, and train others and thus make far reaching and long lasting contributions to the Navy.

In large measure, the extent of your contribution to the Navy depends upon your willingness and ability to accept increasing responsibilities as you advance in rate. When you assumed the duties of a GMM3, you began to accept a certain amount of responsibility for the work of others. With each advancement in rate, you accept an increasing responsibility in military matters and in matters relating to the occupational requirements of the Gunner's Mate M rate.

You will find that your responsibilities for military leadership are about the same as those of petty officers in other ratings since every petty officer is a military person as well as a technical specialist. Your responsibilities for technical leadership are special to your rating and are directly related to the nature of your work. Operating and maintaining the ship's missile systems is a job of vital importance, and. it's a teamwork job; it requires a special kind of leadership ability that can be developed only by personnel who have a high degree of technical competence and a deep sense of personal responsibility.

Certain practical details that relate to your responsibilities for launching system administration, supervision, and training are discussed in chapter 11 of this training manual. At this point, let's consider some of the broader aspects of your increasing responsibilities for military and technical leadership.

YOUR RESPONSIBILITIES WILL EXTEND BOTH UPWARD AND DOWNWARD.-Both officers and enlisted personnel will expect you to translate the general orders given by officers into detailed, practical on-the-job language that can be understood and followed even by relatively inexperienced personnel. In dealing with your juniors, it is up to you to see that they perform their work properly. At the same time, you must be able to explain to officers any important needs or problems of the enlisted men.

YOU WILL HAVE REGULAR AND CONTINUING RESPONSIBILITIES FOR TRAINING.-Even if you are lucky enough to have a highly skilled and well trained missile launching force, you will still find that training is necessary. For example, you will always be responsible for training lower rated men for advancement in rate. Also, some of your best workers may be transferred and inexperienced or poorly trained personnel may be assigned to you. Or a particular job may call for skills that none of your personnel has. These and similar problems require you to be a training specialist who can conduct formal and informal training programs to qualify personnel for advancement and who can train individuals and groups in the effective execution of assigned tasks.

YOU WILL HAVE INCREASING RESPONSIBILITIES FOR WORKING WITH OTHERS.- As you advance to GMM1 and then GMMC, you will find that many of your plans and decisions affect a large number of people, some of whom are not in your division, and some of whom are not even in the weapons department. It becomes increasingly important, therefore, to understand the duties and responsibilities of personnel in other ratings. Every petty officer in the Navy is a technical specialist in his own field. Learn as much as you can about the work of their ratings, and plan your own work so that it will fit in with the overall mission of the organization.

AS YOUR RESPONSIBILITIES INCREASE, YOUR ABILITY TO COMMUNICATE CLEARLY AND EFFECTIVELY MUST ALSO INCREASE.- The basic requirement for effective communication is, a knowledge of your own language. Use correct language in speaking and in writing. Remember that. the basic purpose of communication is understanding. To lead, supervise and train others, you must be able to speak and write in such a way that others can understand exactly what you mean.

A second requirement for effective communication in the Navy is a sound knowledge of the Navy way of saying things. Some Navy terms have been standardized for the purpose of ensuring efficient communication. When a situation calls for the use of standard Navy terminology, use it.

Still another requirement of effective communication is precision in the use of technical, terms. A command of the technical language of the Gunner's Mate M rating will enable you to receive and convey information accurately and to exchange ideas with others. A person who does not understand the precise meaning of terms used in connection with the work of his own rating is at a disadvantage when he tries to read official publications relating to his work. He is also at a great disadvantage when he takes the written examinations for advancement in rate. Although it is always important for you to use technical terms correctly, it is particularly important when you are dealing with lower rated men; sloppiness in the use of technical terms is likely to be very confusing to an inexperienced man.

YOU WILL HAVE INCREASED RESPONSIBILITIES FOR KEEPING UP WITH NEW DEVELOPMENTS.-Practically everything in the Navy - policies, procedures, equipment, publications, systems - is subject to change and development. As a GMMl, and even more so as a GMMC, you must keep yourself informed about all changes and new developments that might affect your rating or your work. Some changes will be called directly to your attention, but others you will have to look for. Try to develop a special kind of alertness for new information. Keep up to date on all available sources of technical information. And, above all, keep an open mind on the subject of missile launchers and associated equipment. New types of missiles are constantly being designed and tested, and existing types of launching systems are subject to modification. If you look back over the history of missile launchers, you will find that a number of important changes have occurred, and other changes are being made constantly. New missiles have been introduced and launching systems had to be designed or modified for them. Greater sophistication in missile guidance and control has required greater cooperation between GMMs and FTs. The addition of nuclear warheads to many of the missiles has increased the security problem and aggravated the safety problem. These changes are by no means the only ones that have occurred; they are noted here merely to indicate the variety of changes that can be expected in the field of missile systems and associated equipment.

THE GUNNER'S MATE

The Gunner's Mate (GM) rate was first established in 1797. In May of 1864, General Order 37 established the pay grade of Chief Petty Officer. It was not until 1894, by General Order 409 that the pay grades of third class through first class petty officers were established. The GM at all rate levels became the "jack of all trades" in the ordnance field. As new gun systems were developed the need for special training and a system of shipboard billets became necessary. In July of 1903, General Order 137 established the rate's of Turret Captain first class and chief. From WWI to WWII the GM rate structure changed very little. During WWII two new rates were established; the Armourer and Powderman. The rate structure was changed again in 1947 to three new ratings: the GMM (mount), the GMA (armourer) and the GMT (turret). In 1948 all personnel in the Gunner's Mate rating were combined into one general GM rate. Each member of the GM rating was assigned a job code number which reflected a specific type of weapon or weapon system and was used as a guide for shipboard assignments. In 1958 the pay grades of E-8 and E-9 were established for all Naval ratings. It was not until 1961 that the present GM rate structure was developed.

The Gunner's Mate Missile Ratings

As aircraft performance (speed, maneuvering and altitude capabilities) increased the efficiency of gunfire against them decreased correspondingly. This situation led to the development of a surface to air missile system which became operational in the fleet in 1955. In 1944 the Navy assigned development of a surface to air missile project to John Hopkins University. This project, known as "Bumblebee", produced the Navy's 3Ts; Terrier, Talos, and Tartar missiles.

The Terrier medium range surface to air missile became the Navy's first operational missile system aboard the USS Boston (CA59) in 1955. The first guided missile ship, the USS Gyatt (DDG-l), was equipped with GMLS Mk 8 and was used as a test frame for evaluating Terrier missiles and never became an operational unit of the fleet.

The long range Talos surface to air missile became the Navy's second operational missile system aboard the USS Galveston late in 1958 and gave the fleet a missile nuclear weapon capability against aircraft.

The Tartar short range surface to air missile was the last of the 3Ts to become operational and was designed to be used aboard DDG and DEGs.

As weaponry changed in types and complexity so did the Gunner's Mate' Rating. When guided missile systems were added to the fire power of the fleet, selected personnel of the general rating of Gunner's Mate were given the responsibility of operating and maintaining the missile launching systems. As the missile system multiplied and became more sophisticated and the working knowledge of electricity and electronics became more extensive, the decision was made to separate the general service rating into three allied ratings. In 1961 the GM rating was split into three groups: the GMG (Guns), the GMT (Nuclear) and the GMM (Missile). Each group is now responsible for maintaining, operating, training and repairing the equipments of a specific type weapon system.

The Missile Gunner's Mate is required to operate and perform organizational and intermediate maintenance on guided missile launching groups, and missile handling equipment; make detailed casualty analyses; inspect and repair electric, electronic, hydraulic, and mechanical systems and servosystems in missile launching systems; and supervise personnel in handling and stowing missiles and supervise wing and fin assemblymen in their duties. To obtain all the skills and technical background necessary for the maintenance, operation, and repair of guided missile launchers, the GMM must have an extensive knowledge of hydraulics, be able to use a wide variety of tools and test equipment, and have a working knowledge of electricity and electronics as well as all explosives associated with a surface launched missile.

The separation of the ratings holds true up to and including E-7. At the E-8 and E-9 levels, the GMG and GMM requirements are combined. This means that the E-7 Gunner's Mate M, to be advance to E-8, must be prepared to maintain the conventional weapons. An E-7 GMM, taking an examination for E-8 (GM), will be examined on qualifications expected of a GMG in addition to his own.

The GMM rating can be further subdivided into classes, each class being assigned a code number. The purpose of these codes is to assist in identifying personnel in a rating when a broad definition (such as GMM) is not sufficient to identify his special skill. These are called Navy Enlisted Classification (NEC) Codes. The codes are changed to suit the needs of the Navy. At the present time, all trainees are given NEC code numbers. Some codes are canceled and personnel in them are recoded. For example, GM-0982 was canceled and replaced by GM-0986, Terrier, Mk 4/10. Men assigned that code are specially qualified in the Terrier missile system. A complete list of the codes is in the Manual of Navy Enlisted Classifications, NAVPERS 15105 (latest revision).

CLASSIFICATION CODES

The NEC Coding system is designed to facilitate management control over enlisted skills by accurately identifying billets and personnel and to ensure maximum skill utilization in distribution and detailing. There are three types of NEC's.

1. Entry Series. These NBC's identify aptitudes and qualifications not discernible from rates alone. They are used to code personnel who are not yet identified strikers or who are in training for change of rating or status. All USN or USNR paygrade E-2 and E-3 personnel, who are not designated strikers, are assigned a Rating Entry NEC of an appropriate rating within the normal path of advancement. Rating Conversion NEC's parallel Rating Entry NEC's but are assigned only to identify petty officers or identified strikers, who are assigned in-service training for change of rating or status under approved programs. The Entry Series NEC's for our rating are

Entry	Title	Conversion NEC
GMM-0950	Gunner's Mate (M) Basic	GM-0899

2. Rating Series. These NEC's are related to specific general and service source ratings. They are used to identify billet requirements which are not sufficiently identified by rates, and to identify the personnel who are qualified to be distributed and detailed to fill these requirements. The following is a list of the Rating Series NEC's for our rating, showing source ratings, applicable courses, and a brief description of the jobs involved.

Priority Number

4 *GM-0984 Terrier Missile and GMLS (MK 9) Maintenance Technician*
Applicable Course: None

NOTE: No new assignment of this NEC will be made.

4 *GM-0986 Terrier Missile and GMLS (MK 4/10) Maintenance Technician*
Applicable Course: Terrier Guided Missile Launching System MK 10, Class C (A-l 2 I-0046)

4 *GM-0987 Tartar Missile and GMLS (MK 11) Maintenance Technician*
Applicable Course: Tartar Guided, Missile 'Launching System MK 11, Class C (A-121-0043)

4 *GM-9988 Tartar Missile and GMLS (MK 13/22) Maintenance Technician*
Applicable Course: Tartar Guided Missile Launching System MK 13, (A-l 2 1-0044)

3 *GM-O993 Improved Point Defense Launching System (MK 29 Mod 0) Technician*
Applicable Course: Under development

3 *GM-O997 Talos Missile and GMLS (MK 7) Maintenance Technician*
Applicable Course: None
Component NEC: GM-O998
NOTE: This NEC is assigned to personnel after having satisfactorily demonstrated performance on GMLS MK7.

4 *GM-O998 Talos Missile and GMLS (MK 12) Maintenance Technician*
Applicable Course: Talos Guided Missile Launching System MK 12, Class C (A-121-0042)

2 *GM-O981 Ordnance Systems Technician*
Source Ratings: GMG, GMM
Applicable Course: Ordnance Systems Technician, Class "C" (Number to be Assigned)
Component NECs: Anyone of: GM-O873, GM-O876, GM-O877, GM-O986, GM-O987 , GM-O988, or GM-O988
NOTES: (1) This NEC is assigned only to personnel in paygrades E-8 and E-9.
(2) Satisfactory completion of applicable course is mandatory.
Administers the test, maintenance, and repair of Guided Missile-Launching System, 5"/54 rapid fire Gun Mounts, and AS ROC Launching System Mk 16 with primary concern for overall systems maintenance: Ensures that tests and interface with other component systems properly reflect readiness of sub-system, system and integrated weapons system; and supervises organization and administration of weapons department.

3. Special Series. These NEC's are not related to any particular rating. They are used to identify billet requirements which are not sufficiently identified by rates, and to identify the personnel who are qualified to be distributed and detailed to fill these requirements. Special Series NEC's may be assigned to personnel in any rating, provided they are otherwise eligible to receive the training involved. It is not practical to present all of the Special Series NEC's in this rate training manual.

Assignment Priorities

Each NEC has been assigned a priority number from 1 to 8, with priority 1 being the highest and 8 being the lowest. All Entry Series NEC's are priority 1, ensuring their assignment as primary NEC's. Because of personnel concerned (E-2 and E-3), they are always more significant than rates. All other NEC's are in consecutive priority sequence from 2 through 8.

When a man is qualified for two or more NEC's, the priority number determines which NEC is primary and which is secondary. The priorities for each GMM's NEC are shown in the preceding paragraph. If a Gunner's Mate is qualified for an Ordnance System Technician (GM - 0981 NEC) and a Tartar Missile And GMLS Mk 13/22 Maintenance Technician (GM - 0988 NEC), he would be coded GM 0981/GM 0988. His primary NEC is priority 2 and his secondary NEC is priority 4, The fact that one NEC is priority 2 and another is priority 4 does not imply that the priority 2 skill is a higher level skill than the priority 4 skill, Priority numbers are based on the need to retain NEC identification in any given instance and this need varies for each rating.

TYPES OF ASSIGNMENTS

All ships that have surface to air missiles as armament or ammunition supply ships that carry surface to air missiles and shore activities where missiles are repaired, assembled, tested, and/or stored will have a GMM assigned for duty. Your duties naturally will vary according to your NEC and the type ship in which a Guided Missile Launching System (GMLS) is part of a Surface Missile System (SMS). Some large ships may carry more than one GML system and require a large number of GMM's. Smaller require fewer personnel. Since the number of GMMs varies according to a type ship, so does the rate level of each ship. The senior GMM aboard a large ship (DLG) could be a E-8 or E-9 where on a small ship (DDG) the senior GMM could be a E-6 or E-7. As senior Gunner's Mate, our enlisted job code number is the primary factor in determining your assignability.

In training assignments ashore GMM's serve as instructors in the Gunner's Mate School Great Lakes, Ill; as item writer's (E-9 Gunner's Mate) at Naval Examining Center, Great Lakes, Ill.; and as a writer of Rate Training Manuals and/or Correspondence Courses at the Naval Training Publication Detachment, Washington D.C., where texts such as this one are prepared. In fulfilling duties in training billets, the knowledge gained afloat will be put to use in preparing training material. Personnel selected for training billets are carefully chosen and are expected to be experts in specific missile systems.

In addition to training billets the GMM can be assigned duty ashore at Naval Weapons Stations where missiles are assembled and tested prior to shipboard loading.

The billets mentioned above comprise a portion of the billets ashore for GMMs. In some instances your primary duties will be military rather than technical or occupational although such assignments are seldom made for personnel in critical ratings. .

- This training manual includes information that is related to both the KNOWLEDGE FACTORS and the PRACTICAL FACTORS of the qualifications for advancement to GMM1 and GMMC. However no training manual can take the place of actual on-the-job experience for developing skill in the practical factors. The training manual can help you understand some of the whys and wherefores, but you must combine knowledge with practical experience before you can develop the required skills. The Record of Practical Factors should be utilized in conjunction with this training manual whenever possible.
- This training manual deals almost entirely with the missile launching systems and associated equipment installed on conventional surface ships. It does NOT contain information that is primarily related to supply ships, repair ships or tenders, or to submarines.
- Chapters 2 through 12 of this training manual deal with the occupational subject matter of the Gunner's Mate M rating. Before studying these chapters, study the table of contents and note the arrangement of information. Information can be organized and presented in many different ways. You will find it helpful to get an overall view of the organization of this training manual before you start to study it.

SCOPE OF THIS TRAINING MANUAL

Before studying any book, it is a good idea to know the purpose and the scope of the book. Here are some things you should know about this training manual:

- It is designed to give you information on the occupational qualifications for advancement to GMMl and GMMC.
- It must be satisfactorily completed before you can advance to GMMI or GMMC, whether you are in the regular Navy or in the Naval Reserve.
- It is NOT designed to give you information on the military requirements for advancement to PO1 or CPO. Rate Training Manuals that are specially prepared to give information on the military requirements are discussed in the section of this chapter that deals with sources of information.
- It is NOT designed to give you information that is related primarily to the qualifications for advancement to GMM3 and GMM2. Such information is given in Gunner's Mate M (Missiles) 3 & 2 NAVTRA 10199.

The occupational Gunner's Mate M (Missiles) qualifications that were used as a guide in the preparation of this training manual are those promulgated in the Manual of Qualifications for Advancement, NAVPERS 18068-C, Charge 1. Therefore, changes in the Gunner's Mate M (Missiles) qualifications occurring after this change may not be reflected in the information given in this training manual. Since your major purpose in studying this training manual is to meet the qualifications for advancement to GMM1 or GMMC, it is important for you to obtain and study a set of the most recent Gunner's Mate M qualifications.

Studying For The Test

Trying to read and study every manual or publication related to Navy weapon systems is an unrealistic and inefficient goal. There are many OPs and OD's dealing with ordnance equipments which are used by the GMMs during maintenance and system upkeep. Each missile house of each ship of. different classes has a different set of manuals which contain information related only to a specific missile or missile system. If every ship ordered all the OPs and ODs for every surface missile system within the fleet, there would be no room for missiles. The GMM would be firing paper instead of missiles. Since we all have a saturation point which certainly would be exceeded if we tried to study everything, a pamphlet is produced yearly which indicates which reference material is used as sources for examination questions in writing an advancement examination for all rate levels from E-4 thru E-9. This pamphlet, NAVTRA 10052, is available at your I and E office.

BIBLIOGRAPHY FOR ADVANCEMENT STUDY, NAVTRA 10052 SERIES.-The "bibliography" is the most important single item when preparing for advancement. This pamphlet is based upon the Manual of Qualifications for Advancement NAVPERS 18068-C, and lists the training manuals and other publications prescribed for use by all personnel concerned with advancement in rate training and writing advancement examinations. Thus, the Bibliography provides-a working list of material for enlisted personnel to study in preparation for advancement examination, and this same list is used by the item writer at the Naval Examining Center. The first few pages of the pamphlet show the military requirements references which apply to' all ratings. This part of the Bibliography is of special importance at the E4/E5 'levels, because separate examinations on military subjects are given locally at those rate levels.

Asterisks which appear throughout the listings indicate the Rate Training Manuals whose mandatory completion is specified by the Advancement Manual or Correspondence Courses that are mandatory. A manatory training manual may be completed by (1) passing the appropriate enlisted correspondence course based on the mandatory manual, (2) passing locally prepared tests based on the information given in the mandatory manual, or (3) in some cases, successfully completing an appropriate Navy school. Note that, as is pointed out in the Manual of Qualifications for Advancement, NAVPERS 18068-C, all higher pay grades may be held responsible for the material contained in publications listed for lower rates in their paths of advancement.

RATE TRAINING MANUALS.- The rate training and military training manuals are written using the professional and military quals from the Manual of Qualifications for Advancement as a guide. With a few exceptions, sufficient information is presented in these manuals to cover most quals. Obviously some quals, such as those on security, cannot be realistically covered in a rate and military training manual. These type of quals and others covered in basic manuals, such as Blueprint Reading and Sketching, are listed in the Bibliography by chapter and/or article numbers so that personnel taking advancement exams know exactly where to look for information not covered in rate and military training manuals.

Also, keep in mind that some of the test questions may be based on information contained in the GMM 3/2 and Military Requirements 3/2 RTMs because you are also responsible for quals of the lower rates. You can bet that there are some E-5s and E-6s who wish they had given the 3/2 manuals a little more attention before the last advancement exam.

The Advancement Examination

All of the GMM's Advancement Examinations are written by an item writer at the Naval Examining Center, Great Lakes, Illinois. The item writer is responsible for constructing the 120 question professional section of the examinations, someone else usually writes the 30 military questions. The writer has a bank of many items that have been used on previous examinations and he will use many of the items from his bank when he constructs an examination. He will also write some new items.

The examination questions are grouped by subject matter into categories, or sections. There may be from 5 to 12 sections on a particular test. Each item is carefully checked and re-checked to make sure it is a valid item.

Unfortunately, there is an unavoidable delay built into. the examination system since the Bibliography is printed and distributed about one year in advance. For example, the Bibliography for the 1973 exams was printed in the spring of 1972. As soon as the Bibliography is made available to him, the Master Chief at the Naval Examining Center, begins writing the exams for the following year. During this period of time many changes may be made to the reference publications listed in the Bibliography. These changes may invalidate some of the exam questions. However, this will not affect your examination grade.

On the day that you take the advancement exam, the Master Chief at the Naval Examining Center also takes that same test. For your benefit, he thoroughly checks every item on the examination to make sure none are outdated. Any outdated questions that he finds will not be considered when the test is graded. This has the same affect as counting all four answers correct, because the answer you pick for an outdated question is correct, no matter which one you select. Thus, you do not have to worry about test items that contain superseded information.

Two important restrictions are placed upon the item writer: First, his examination must: cover all of the quals, as indicated by the Manual of Qualifications for Advancement, NAVPERS 18068-C, for the particular rate. He may also include questions that cover quals for lower rates within the GMM rating. In other words, when you take the GMMC exam you may have to answer questions that are based upon GMM 3 thru GMMC quals.

Second, his references are restricted to those listed in the Bibliography for Advancement Study, NAVTRA 10052, or the secondary references that are referred to by one of the references in the Bibliography. Lets say, for example, that somewhere in the GMM 3/2 Rate Training Manual, which is listed in the Bibliography, a reference is made to a publication which is not listed in the Bibliography, then that publication is also fair game.

GRADING THE EXAMINATION.-The Navywide Advancement Examination is graded by machine and the maximum score is 80 points. Figure 1-1 shows the bell shaped curve that is the basis for advancement examination grading.

After all of the answer sheets for a particular rate run through the machine, the average number of questions correct is assigned a score of 50 (in the middle of the curve). This means

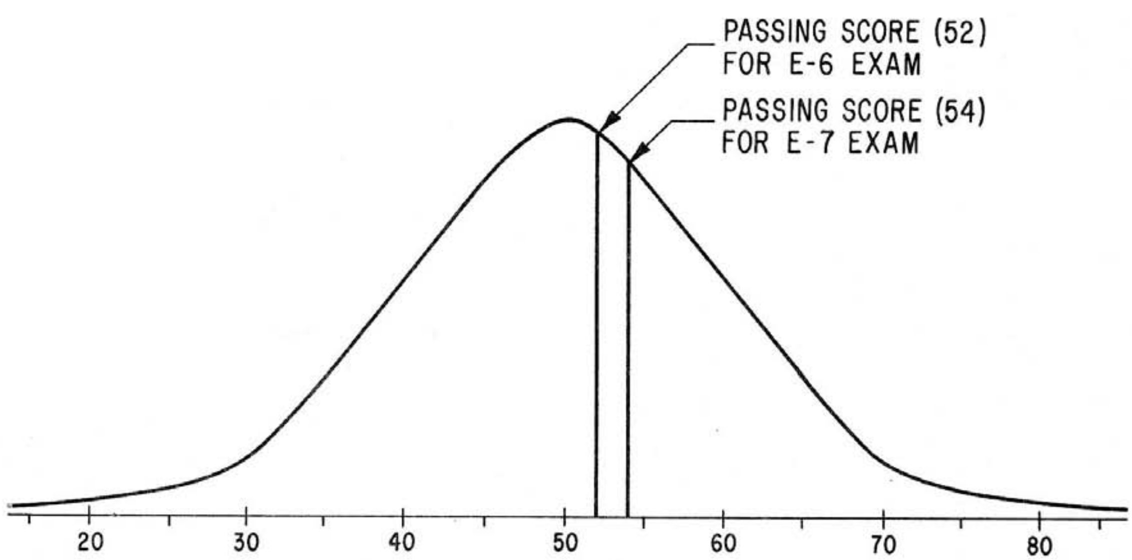

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Figure 1-1.—Advancement examination grading curve.

that the number of correct questions required to obtain a score of 50 will vary from test to test. Your test score then, is influenced by two factors; your own performance on the test and the performance of all of the other GMM's taking that same examination.

Once the test average (standard score 50) has been determined, the passing grade is established. Although special circumstances may require a different method of determining the passing grade, it is normally determined as follows:

- To pass the 3rd Class exam a striker must obtain a standard score of 48 (two points below the average). About 60% of all those taking the exam should pass. .
- Passing the 2nd Class exam requires the man to obtain a standard score of 50 (the examination average). About one half of all those taking the exam should pass.
- To pass the 1st Class exam, a standard score to 52 (two points above average) is required. About 42% of all those taking the exam should pass.
- To pass the Chiefs exam, a standard score of 54 (four points above the. average)-is required. About 34% of all those taking the exam should pass.

Lets say for example, that the average number of questions correct for a particular GMMC exam is 105. Then, 105 questions becomes the standard score of 50 points. For you to obtain a standard score of 54 (passing), you must answer correctly perhaps as many as 113 questions.

Notice that all along we have only talked about the total number of correct questions affecting your test score. Nothing has been said about having to pass each individual section of the exam. Many of us are led to believe that we must at least pass each .section of. the test. Not, so. No numerical grade is even assigned to each section. For profile sheet purposes, a letter is assigned to each section to point out weak areas. This enables you to better prepare for the next exam. Of course, if you miss most of the questions in one section of the exam, it may pull your overall grade down below the passing score, but it is your overall grade that determines whether you pass or fail, not. your performance on each individual section of the test. Thus, your test grade is determined by the total number of questions that you answer correctly and your relative standing among your peers - nothing else.

Multiple

The competitive advancement system, as outlined in the Advancement Manual, NAVPERS 15989, utilizes a combination of factors to accumulate a final multiple for each candidate. The factors, which recognize the candidates knowledge, performance, and seniority, contribute to the final multiple. All personnel in each applicable pay grade, for each rating in the Navy, who have passed the most recent Navy-wide advancement examination are arranged in order of their final multiple, from the highest to the lowest. Advancements are then authorized to fill vacancies on the basis of final multiple achieved.

The final multiple system was revised and became effective with the August 1972 Navy-wide Advancement Cycle. The factors and their associated maximum points comprising the competitive Navy-wide advancement final multiple are as follows:

FACTOR	MAXIMUM CREDIT
Examination Score	80
Performance (Evaluations)	50
Length of service (Years)	20
Service in Pay Grade (Years x 2)	20
Medals and Awards	15
PNA Points	15

Two substantive changes have been made to the awards factor.

1. Unit commendations will no longer be creditable. Holders of the following awards, who have previously received multiple credit for these awards, may not claim further multiple credit.

Presidential Unit Citation
Navy Unit Commendation
Navy Meritorious Unit Commendation

Distinguished Unit Citation (Army)
Meritorious Unit Emblem Citation (Army)
Distinguished Unit Citation (Air Force)
Outstanding Unit Award (Air Force)

2. A letter of commendation awarded to you will be creditable to the awards factor of final multiple. Generally, circumstances which would be the subject of a letter of commendation consist of noteworthy commendable accomplishments beyond the usual requirements of duty, or exceptional displays of energy, judgment, or initiative. You will be credited with one point for each letter of commendation in this category up to a maximum of two points provided:

a. The letter of commendation is signed by a flag officer or officer senior to, and in the chain of command of, your commanding officer/officer in charge.

b. The Gate of the letter is subsequent to 1 April 1971, and dated prior to the administration date of the Navy-wide examination for which credit is desired.

c. The letter of commendation was awarded to you while in present pay grade, and you have maintained continuous active service in present pay grade subsequent to the date the commendation was delivered: Therefore, if your service in rate is interrupted by reduction or discharge and ensuing broken, service, you will not receive credit for letters of commendation earned prior to the interruption. Also, you will only receive credit for letters of commendation earned while serving in the pay grade immediately below the grade for which you are being examined.

A new factor PNA (passed but not advanced) points, is now included in the final multiple of the competitive Navy-wide advancement system. In February 1972, the U.S. Naval Examining Center started assigning PNA points to all Navy-wide examination participants who passed the examination but were not authorized advancement due to quota limitations. These points are shown on ~!our profile card which is updated during each examination cycle.

PNA points are comprised of two subfactors, Navy-wide examination score and performance mark standing. Individually. both subfactors are weighted in relation to your standing among all those who participated in your specific examination rate for a given cycle. In the case of the performance mark standing subfactor, your performance mark averages are submitted to the Naval Examining Center and are used as the basis for determining your performance standing in relation to your contemporaries. PNA points are awarded in accordance with the schedule I established for each sub factor as follows:

EXAMINATION SCORE	POINTS
70 thru 80	1.5
60 thru 69	1.0
Passing thru 59	0.5

PERFORMANCE MARK AVERAGE	POINTS
Top 25 percent	1.5
Upper 25 to 50 percent	1.0
Lower 50 to 25 percent	0.5
Bottom 25 percent	0.0

PNA points awarded as a result of previous advancement examination cycles (subsequent to February 1972) will be automatically credited to each individual's final multiple, by the Naval Examining Center. These points will be creditable toward the individual's most recent five of the last six Navy-wide advancement cycle.. Accumulation of the PNA points for an individual candidate is limited to three (3) points (1.5 for exam score, 1.5 for performance) per advancement cycle to a maximum of 7.5 for exam score and 7.5 for performance mark for a total combined maximum of 15 points. In determining the cumulative total PNA points, "the most recent five" includes examinations failed or those where the results were assigned a. BUPERS or command requested invalidation or other special category which warrants processing similar to a "fail." The individual, of course, is not awarded PNA points when he fails the test. The "most recent five" does not, however, include examinations in which the individual did not participate (no show). Also excluded are those special categories where fairness to the.. individual dictates a processing similar to the ., "no show" category. The procedure used in' processing a "no show" accounts for reemployment of the "last six Navy-wide advancement cycles. This means. that subsequent to the February 1974 advancement cycle, an individual who does not participate in one of the last six Navy-wide advancement cycles may still accumulate the maximum credit of 15 PNA points based upon the five examinations in which he participated. However, should the member fail to participate in two or more of the last six examinations, he cannot possibly accumulate the maximum points authorized for the PNA actor.

The award of PNA points to an individual is contingent upon his participation in an examination resulting in a passed but not advanced status. The crediting of PNA points to the individual's final multiple requires that he participate in a subsequent examination for the examination rate for which the PNA points were awarded him. For example, lets say a GM2 took he GM 1 examination for the first time in August 1972. If he passed the test, then he would be awarded PNA points according to his relative standing in examination score and performance mark average. These points were not considered in his August 1972 final multiple, but they will be added to his multiple on the February 1973 examination. PNA credit is not authorized in cases where the individual's examination rate is other than the rate which constitutes the correct path of advancement for his present rate. Therefore, anyone undergoing rating conversion may not retain PNA points awarded for the rate from which he is converting.

Figures 1-2 through 1-6 show Examination Profile Information sheets as they might be returned to a man who takes several advancement examinations without being advanced.

In figure 1-2, Petty Officer Appleton's profile information reveals that he passed the examination (with a standard score between 60 and 69). Regrettably his overall final multiple was 2.11 below the minimum required for advancement to HT2 as a result of the Series 60 Navy-wide examination. The Series 60 examination was the regular February 1972 Navy-wide advancement cycle. Petty Officer Appleton has been awarded PNA points which. will be creditable toward his final multiple in a future examination. The information on the projected PNA points line indicates that from this Series 60 (S60) examination, Petty Officer Appleton received an award of 1.0 PNA points for his relative standing on the written examination. Also, he received 1.5 NPA points for performance standing which, in his case, was within the top 25 percent performance-wise of those members who participated in the Series 60 examination for HT2.

Figure 1-3 reveals that Petty Officer Appleton maintained the recommendation of his commanding officer as is evidenced by his participation in the August 1972 (Series 61) Navy-wide examination for HT2. Again he passed the examination and ended up short of the minimum final multiple required for advancement, even with 2.5 PNA points (from the February 1972 exam) which are included in his final multiple of 130.02. The projected PNA points line now reveals that Petty Officer Appleton has been awarded 0.5 for his relative exam score and 1.0 for performance mark average in the way of PNA points from the August 1972 Navy-wide examination.

In figure 1-4, even with 4 PNA points from the February and August 1972 examinations which are now included in his final multiple of 131.52, Petty Officer Appleton is still shy on minimum final multiple.

He has also received an additional award of 2.5 PNA points which will make him very competitive in the next Navy-wide examination.

As projected in figure 1-5 Petty Officer Appleton failed the Series 64, August, 1973 examination. Petty Officer Appleton isn't awarded any PNA points on the projected PNA points line for this examination. Remember! Performance PNA points also only go to those who pass the examination. Petty Officer Appleton still has the 6.5 PNA points awarded him for his participation in the Series 63, 61 and 60 examinations. Notice also that final and minimum multiples are not shown since these multiples are only displayed when the man passes the examination. .

In figure 1-6 Petty Officer Appleton is back on track. He passed the Series 66, February . 1974 HT2 exam. In addition to other multiple factors such as length of service and service in pay grade added to his final multiple score, Petty Officer Appleton has 6.5 PNA points included in his 132.32 final multiple for the S66 exam. If he had passed the S64 exam and picked

9ND-C-11989

I

DEPARTMENT OF THE NAVY
NAVAL EXAMINING CENTER
GREAT LAKES, ILLINOIS

1234-18333

FROM: COMMANDING OFFICER

		SERIES/DATE	APC	DCAPC
TO: APPLETON CRABBY	919-23-2473 HT3 HT2	60-FEB-72	1234-1236-11	

SUBJ: EXAMINATION PROFILE INFORMATION
PROJECTED PNA PTS. S60-1.0/1.5

THE INFORMATION PROVIDED BELOW IS A PROFILE OF YOUR RELATIVE STANDING WITH ALL OTHERS IN YOUR RATE IN EACH SUBJECT-MATTER SECTION. THE INFORMATION IS TO BE USED WITH THE SUBJECT-MATTER IDENTIFICATION SHEET FOR THE EXAMINATION SERIES INDICATED. STANDINGS ARE BASED ON OVER 90% RETURNS; NO SIGNIFICANT CHANGE WITH ALL RETURNS IN.

EXAMINATION STATUS	YOUR FINAL MULTIPLE	MINIMUM MULTIPLE REQUIRED	SECTION	1	2	3	4	5	6	7	8	9	10	11	12	PAGE
PASS	127.52	129.63	STANDING	H	E	S	E	A	-	-	-	-	-	-	-	001

COPY TO SERVICE RECORD

CODE INTERPRETATION
S (Superior) = upper 10%
E (Excellent) = upper 20%
H (High) 30%
HA (High Average) = upper 40%
A (Average) = middle
LA (Low Average) = lower 40%
L (Low) = lower 30%
P (Poor) = lower 20%
VP (Very Poor) = lower 10%

181.38-60

Figure 1-2.—Exam Series 60 Profile Sheet.

9ND-C-11989

II

DEPARTMENT OF THE NAVY
NAVAL EXAMINING CENTER
GREAT LAKES, ILLINOIS

1234-18333

FROM: COMMANDING OFFICER

		SERIES/DATE	APC	DCAPC
TO: APPLETON CRABBY	919-23-2473 HT3 HT2	61-AUG-72	1234-1236-11	

SUBJ: EXAMINATION PROFILE INFORMATION
PROJECTED PNA PTS. S61-0.5/1.0 S60-2.5

THE INFORMATION PROVIDED BELOW IS A PROFILE OF YOUR RELATIVE STANDING WITH ALL OTHERS IN YOUR RATE IN EACH SUBJECT-MATTER SECTION. THE INFORMATION IS TO BE USED WITH THE SUBJECT-MATTER IDENTIFICATION SHEET FOR THE EXAMINATION SERIES INDICATED. STANDINGS ARE BASED ON OVER 90% RETURNS; NO SIGNIFICANT CHANGE WITH ALL RETURNS IN.

EXAMINATION STATUS	YOUR FINAL MULTIPLE	MINIMUM MULTIPLE REQUIRED	SECTION	1	2	3	4	5	6	7	8	9	10	11	12	PAGE
PASS	130.02	135.68	STANDING	A	HA	A	A	HA	A	-	-	-	-	-	-	001

COPY TO SERVICE RECORD

CODE INTERPRETATION
S (Superior) = upper 10%
E (Excellent) = upper 20%
H (High) 30%
HA (High Average) = upper 40%
A (Average) = middle
LA (Low Average) = lower 40%
L (Low) = lower 30%
P (Poor) = lower 20%
VP (Very Poor) = lower 10%

181.38-61

Figure 1-3.—Exam Series 61 Profile Sheet.

9ND-C-11989

III

DEPARTMENT OF THE NAVY
NAVAL EXAMINING CENTER
GREAT LAKES, ILLINOIS

FROM: COMMANDING OFFICER

TO: APPLETON CRABBY 919-23-2473 HT3 HT2

SERIES/DATE 63-FEB-73 | APC DCAPC 1234-1236-11

SUBJ: EXAMINATION PROFILE INFORMATION

PROJECTED PNA PTS. S63-1.0/1.5 S61-1.5 S60-2.5

1234-15333

THE INFORMATION PROVIDED BELOW IS A PROFILE OF YOUR RELATIVE STANDING WITH ALL OTHERS IN YOUR RATE IN EACH SUBJECT-MATTER SECTION. THE INFORMATION IS TO BE USED WITH THE SUBJECT-MATTER IDENTIFICATION SHEET FOR THE EXAMINATION SERIES INDICATED. STANDINGS ARE BASED ON OVER 90% RETURNS; NO SIGNIFICANT CHANGE WITH ALL RETURNS IN.

EXAMINATION STATUS	YOUR FINAL MULTIPLE	MINIMUM MULTIPLE REQUIRED	SECTION	1	2	3	4	5	6	7	8	9	10	11	12	PAGE
PASS	131.52	135.70	STANDING	E	E	H	E	H	E	-	-	-	-	-	-	001

COPY TO SERVICE RECORD

CODE INTERPRETATION

S (Superior) = upper 10%
E (Excellent) = upper 20%
H (High) 30%
HA (High Average) = upper 40%
A (Average) = middle
LA (Low Average) = lower 40%
L (Low) = lower 30%
P (Poor) = lower 20%
VP (Very Poor) = lower 10%

181.38-63

Figure 1-4.—Exam Series 63 Profile Sheet.

9ND-C-11989

IV

DEPARTMENT OF THE NAVY
NAVAL EXAMINING CENTER
GREAT LAKES, ILLINOIS

FROM: COMMANDING OFFICER

TO: APPLETON CRABBY 919-23-2473 HT3 HT2

SERIES/DATE 64-AUG-73 | APC DCAPC 1234-1236-11

SUBJ: EXAMINATION PROFILE INFORMATION

PROJECTED PNA PTS. S64-FAIL S63-2.5 S61-1.5 S60-2.5

1234-15333

THE INFORMATION PROVIDED BELOW IS A PROFILE OF YOUR RELATIVE STANDING WITH ALL OTHERS IN YOUR RATE IN EACH SUBJECT-MATTER SECTION. THE INFORMATION IS TO BE USED WITH THE SUBJECT-MATTER IDENTIFICATION SHEET FOR THE EXAMINATION SERIES INDICATED. STANDINGS ARE BASED ON OVER 90% RETURNS; NO SIGNIFICANT CHANGE WITH ALL RETURNS IN.

EXAMINATION STATUS	YOUR FINAL MULTIPLE	MINIMUM MULTIPLE REQUIRED	SECTION	1	2	3	4	5	6	7	8	9	10	11	12	PAGE
FAIL			STANDING	VP	P	A	HA	VP	VP	-	-	-	-	-	-	001

COPY TO SERVICE RECORD

CODE INTERPRETATION

S (Superior) = upper 10%
E (Excellent) = upper 20%
H (High) 30%
HA (High Average) = upper 40%
A (Average) = middle
LA (Low Average) = lower 40%
L (Low) = lower 30%
P (Poor) = lower 20%
VP (Very Poor) = lower 10%

181.38-64

Figure 1-5.—Exam Series 64 Profile Sheet.

9ND-C-11989

V

DEPARTMENT OF THE NAVY
NAVAL EXAMINING CENTER
GREAT LAKES, ILLINOIS

FROM: COMMANDING OFFICER

SERIES/DATE 66-FEB-74 APC DCAPC 1234-1236-11

TO: APPLETON CRABBY 919-23-2473 HT3 HT2

SUBJ: EXAMINATION PROFILE INFORMATION

PROJECTED PNA PTS. S66-1.0/1.0 S64-FAIL S63-2.5 S61-1.5 S60-2.5

1234-18333

THE INFORMATION PROVIDED BELOW IS A PROFILE OF YOUR RELATIVE STANDING WITH ALL OTHERS IN YOUR RATE IN EACH SUBJECT-MATTER SECTION. THE INFORMATION IS TO BE USED WITH THE SUBJECT-MATTER IDENTIFICATION SHEET FOR THE EXAMINATION SERIES INDICATED. STANDINGS ARE BASED ON OVER 90% RETURNS. NO SIGNIFICANT CHANGE WITH ALL RETURNS IN.

EXAMINATION STATUS	YOUR FINAL MULTIPLE	MINIMUM MULTIPLE REQUIRED	SECTION	1	2	3	4	5	6	7	8	9	10	11	12	PAGE
PASS	132.32	134.20	STANDING	A	A	A	HA	E	-	-	-	-	-	-	-	001

COPY TO SERVICE RECORD

CODE INTERPRETATION

S (Superior): upper 10%
E (Excellent): upper 20%
H (High) 30%

HA (High Average): upper 40%
A (Average): middle
LA (Low Average): lower 40%

L (Low): lower 30%
P (Poor): lower 20%
VP (Very Poor): lower 10%

181.38-66

Figure 1-6.—Exam Series 66 Profile Sheet.

up 2.0 PNA points, he would have be authorized advancement from the S66 examination with a final multiple of 134.32.

ADVANCEMENT OPPORTUNITIES FOR PETTY OFFICERS

Making chief is not the end of the line as far as .advancement is concerned. Proficiency pay, advancement to E-8 and E-9, advancement to Warrant Officer, and advancement to commissioned officer status are among the opportunities that are available to qualified petty officers. These special paths of advancement are open to personnel who have demonstrated outstanding occupational ability, the highest order of leadership and military responsibility, and unquestionable moral integrity.

Proficiency Pay

The Career Compensation Act of 1949, as amended, provides for the award of proficiency pay to designated enlisted personnel who possess special proficiency in a military skill. Proficiency pay is given in addition to your regular pay and allowances and any special or incentive pay to which you are entitled. Enlisted personnel pay grades E-4 through E-9 are eligible for proficiency pay. Proficiency pay is allocated by ratings and NECs, with most awards being give in the ratings and NECs which are designated critical. The eligibility requirements for proficiency pay are subject to change. In general however, you must be recommended by your commanding officer, have a certain length of time on continuous active duty, and be career designated.

Advancement to E-8 and E-9

Chief petty officers may qualify for the advanced grades E-8 and E-9 which are now provided in the enlisted pay structure. These advanced grades provide for substantial increase in pay, together with increased responsibilities and additional prestige. The requirements for advancement to E-8 and E-9 are subject to change, but in general include a certain length of time in grade, a certain length of time in the naval service, a recommendation by the commanding officer, and a sufficiently high mark on the servicewide examination. The final selection for E-8 and E-9 is made by a regularly convened selection board.

Motivation

The Navy has taken great strides in improving its living standards. The food is better and even the pay has become reasonable. These factors fulfill a man's basic survival and security needs, but they are not motivating factors. We have to look elsewhere for factors that will motivate him. When we learn to recognize motivating ,factors and use them correctly, we will obtain better results and our subordinates will be happier in their jobs. We are all capable of performing "impossible" tasks if motivated properly.

No one has all of the answers to effective management. However, the highest degree of effectiveness is realized when management techniques are based upon the following list of assumptions:

1. People are not lazy, indifferent, uncooperative or uncreative. Work is as natural as play or rest.
2. Tight controls and threats of punishment are not the only means of getting men to work. Men will exercise self-direction and self-control toward objectives to which they are committed.
3. Every man must have a meaningful job. Without meaningful work he is bored and not of much use.
4. Man is a growing, learning animal who craves recognition.
5. Most men learn to accept and to seek responsibility.
6. The average man's intellectual potentials are only partially utilized. Most are capable of a high degree of imagination, ingenuity, and creativity.
7. Man by his nature is gregarious. One of his basic urges is his desire to be an integral part of some group. He must feel that he is an important, contributing member of the group.

Do we, as managers, really consider the needs and desires of our subordinates? Most of us have our own preconceived ideas of what a person's needs are. We try to compare a subordinate's reaction, to various management techniques, to what we think our own reactions would be under similar circumstances. Thus, we set up a model subordinate, usually based upon ourselves, and we decide to manage according to our model's desires, and treat everyone the same-be consistent. This is entirely the wrong approach. In the first place, no two individuals are alike. We all react differently to different situations. Therefore, a good manager must know and understand his men and be flexible enough to adjust his management techniques according to the individual(s}. Flexibility is a key to successful management.

Job assignments should be planned to challenge the ability of each individual. When a man masters one task, make his next one is just a little more difficult. Always keep in mind that, for motivating purposes, succeeding is better than success. For example, operating a control panel during a missile firing exercise is a great challenge for a GMM striker, but once he becomes a proficient operator, his job should be changed to increase his interest. If not, he may become bored and his efficiency as a system operator may decrease. If it's not possible to change his job, explain the reasons why. Encourage competition between strikers by using a different striker on a control panel during a firing exercise. If a GMM striker is stationed outside of a missile launcher system during firing exercise, make sure that he. also has an opportunity to try the job of a control panel operator. Each subordinate must be assigned some challenge no matter how large or small. Use any challenge you may think of to keep strikers interested. When a challenge is accepted by a striker, assignment of responsibility should follow. If a striker shows good leadership among other strikers encourage him by asking opinions about daily evolutions. in which they are involved and also encourage group opinions prior to and after training sessions or training exercises. Occasionally examine your management techniques and keep an open mind for new and useful methods. A good idea from a striker may make your job easier. Always listen to your "missile gang" and respect their opinions.

CHAPTER 2

MISSILE HANDLING AND STOWAGE

Early in your career as a GMM you learned to handle missiles from dockside to ship to stowage area, or from ship to ship. You became familiar with standard and special handling equipment, the operation of strikedown and strikeup machinery, and the equipment or tools needed for mating and checkout of the missile. General and special rules of safety as applied to missile handling were called to your attention many times, so you wouldn't forget them. You performed operational tests on the handling equipment; lubricated, disassembled, inspected, cleaned, and reassembled mechanical, electric, pneumatic, and hydraulic handling equipment.

As you advanced in rating, you not only had to know how to operate the handling equipment, but you trained others in the use of the equipment, as individuals or teams. If your missiles required wing and fin assembly, you were expected to train the teams to do the work with the speed and accuracy required for that weapon system.

If something went wrong with the electrical or electronic parts of the handling equipment, it was your responsibility as a GMM 2 to trace the trouble to its source with the use of test equipment and the aid of wiring diagrams.

What is left for the GMM 1 and C to learn regarding the handling and stowage of missiles and missile components? Planning of the work and supervision and teaching of lower rated men are important parts of your duties. To teach others, you have to have knowledge that is broader and deeper than that of those you teach. This knowledge is also necessary for intelligent planning of handling and stowage operations. From experience and study, you should know about different missiles and different ships. Your men may have had experience with, only one or two types of missiles.

The lower rated men perform the routine preventive maintenance, and the simpler repairs. Adjustment, overhaul, and the more difficult repairs are the province of the GMMI and C. In addition to the ability to troubleshoot and repair the equipment, you must be able to plan and carry out a maintenance and repair program for the equipment.

Rules for stowage of supplies are the proper concern of the supply department or the supply officer, but the GMM must know and apply the special rules that apply to the stowage of guided missiles and their components. Because guided missiles contain explosives, the GMM needs to know the properties of explosives and the rules for handling and stowing the explosives safely. The GMM 1 and C sees to it that the weapons and their components receive the proper stowage, insisting on observance of safety regulations all through the process of handling and stowing.

LOADING AND STOWAGE PLANS

In this chapter, the loading operation discussed is that of putting the missile on the ship, whether from dockside or from another ship. Chapter 4 discusses the loading of missiles into the launcher for firing.

KNOWLEDGE REQUIRED FOR PLANNING WORK

Before you can plan a loading operation, you need to know a great deal, not only about the missile itself, but also about the ship, its handling equipment, and its stowage areas. How much responsibility for planning will-be yours depends on the size of the ship, the personnel of the ship, and other factors. On a small ship you may be the leading petty officer in the GMM rating; prepare yourself to accept responsibility.

About Your Ship

If you have been on your ship for some time, it is assumed that you have learned the location of strikedown hatches, missile elevators, missile stowage areas, and strikedown equipment. If, however, you have not had the opportunity to become acquainted with these details, you need to make an. active effort to know your ship. When a loading operation is impending, you need to know whether the loading will be from dockside or from another ship. Missiles might be brought on deck by helicopter. This is information you must have in order to plan the handling of the missiles in getting them on the ship. Standard transfer at sea requires different handling equipment than transfer by helicopter.

Find out which of the stowage spaces are to be used for this particular load; then determine which elevator or strikedown equipment is best or most convenient to use.

STREAM - A method designed for transfer of missiles at sea is the missile/cargo STREAM transfer method, formerly known as FAST. Missile/cargo STREAM method maintains control in the movement of missile components from storage on the delivery ship through the intership transfer and through the strikedown operation on the combatant ship. Proper use of STREAM will ensure delivery of "go" missiles; will reduce alongside time, deck handling, and hazard to crew; and will increase heavy weather replenishment capability.

STREAM receivers installed in combatant ships are of two basic designs; the Tartar/Terrier receiver, and the Talos receiver. STREAM systems are installed on both the supply ship and the receiving ship. The system consists of three basic subdivisions: the strikeup/strikedown equipment on the delivery ship, the intership transfer equipment, and the strikeup/strikedown equipment on the combatant. Figure 2-1 illustrates the transfer of a missile by means of the : STREAM method.

The basic principle of STREAM is to suspend a bare missile rigidly from a transfer-at-sea trolley and strongback, haul the loaded trolley between two ships on a tensioned highline, and capture the trolley at the combatant ship. The pickup arm of the elevator captures the trolley and missile, and after releasing the trolley, lowers the missile directly to the ship's strikedown elevator.

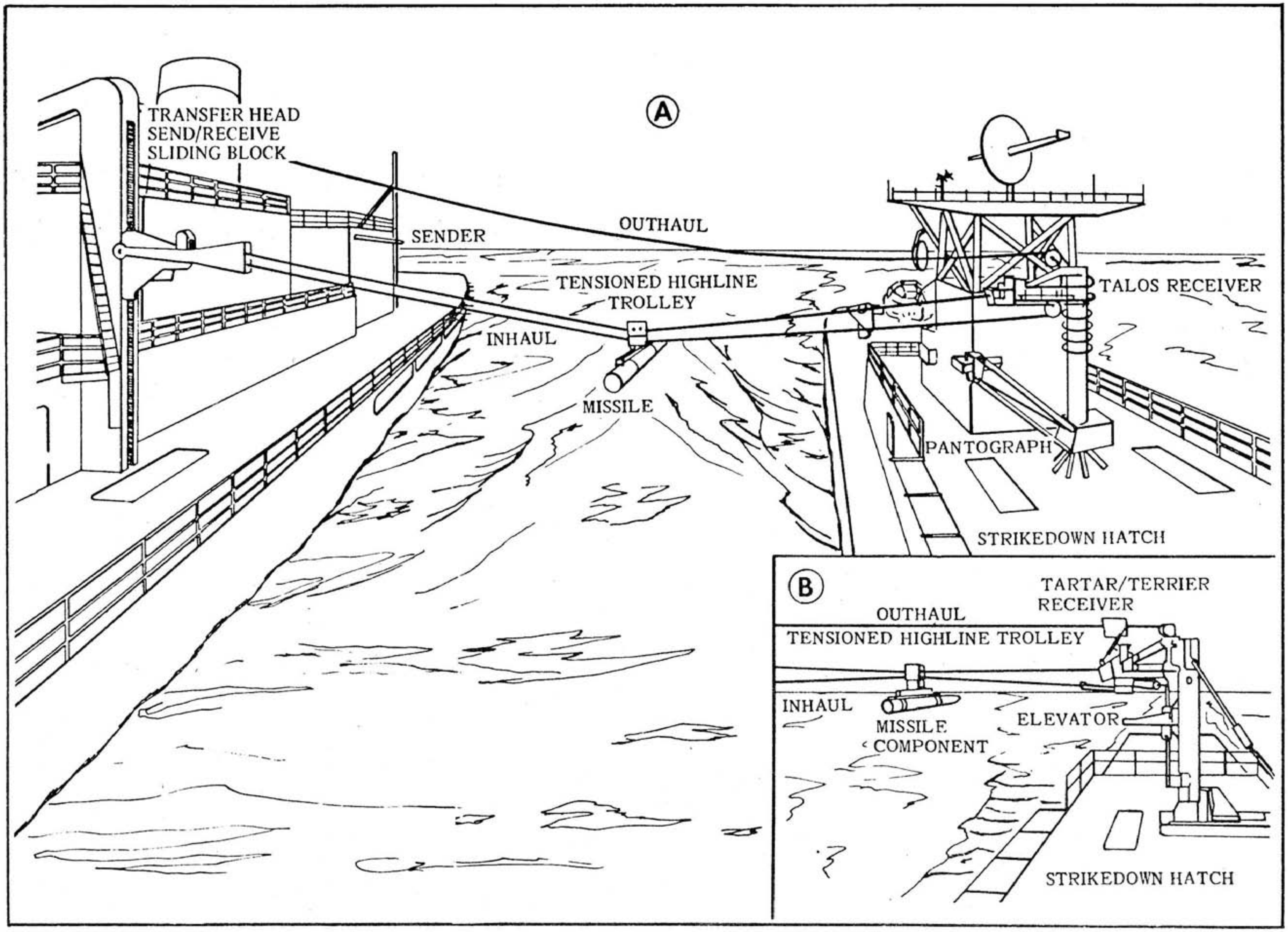
The three major components of the receiving unit are the receiving head, the elevator, and a kingpost. The receiving head catches and positions the transfer trolley and missile as it arrives on the highline from the sending ship. The elevator removes the missile from the trolley, then lowers it, and positions it oil the strikedown elevator. The kingpost supports the receiving head, elevator, and rigging. On some ships the kingpost is installed in a fixed upright position; on others it is stowed when not in use.

The receiving units of the STREAM system are the responsibility of the GMMs. You need to know enough about it so that you know where to position your men to receive the missiles, and how to release the missile and position it on the ship's elevator or on the launcher (Tartar).

About the Weapon

The planner needs to know the number of weapons of each type to be taken aboard. If only one type of weapon is being received, the matter is greatly simplified. Handling requirements may vary widely for different weapons. You need to know the configuration of the weapon (stage of assembly in which it is received), the number of containers per weapon, the size and weight of each container (shape may be important, too), the places on the containers where attachments are to be made, and the special handling equipment to be used with each. How many men will you need for each type of weapon, and what will be their specific posts and duties? These are the things that you must find out before the loading operation begins.

Safety rules for handling of explosives are applicable to guided missiles, but there are some additional rules for handling of particular missiles. What are the rules for grounding of the missile components during handling and stowage? What are the temperature and moisture



63.65

Figure 2-1.—Transfer of missiles between auxiliary and combatant.

limits of the explosive components? Do they have to be kept in the shade while waiting to be struck down?

Missiles with nuclear warheads may be delivered to the ship with the warhead installed in the missile, or the warhead and/or nuclear components may be in separate containers. Nuclear weapons in "birdcages" or other containers are the responsibility of the GMTs, but when the nuclear warhead is received installed in the missile, it is handled and stowed by GMMs. In that case, you need to know any special handling and stowage rules that apply. Consult the technical manual or OP for the missile.

Knowledge of Operation

Your experience in using handling equipment (during your years as a striker, a GMM 3, and then a GMM 2) is invaluable, ,and may be sufficient to enable you to manage the present situation with a high degree of efficiency. Again, it may not. A good planner does not just "hope" everything will work out all right; he checks beforehand. If there is equipment which you have not used before, find out how to operate it so you can show your men. Know the safety precautions that apply. Find out where each missile is to be stowed; this is especially necessary if you are fairly new on the ship. Considerable confusion can result, for example, if you discover after a missile has been brought down to the magazine that it belongs in a magazine at the other end of the ship. This can be particularly bad if the missiles are of the type in which the components are sent down in a specific sequence so that they will be in the correct order for assembly. If you are in charge of the handling operations, the blame for the confusion is yours. Careful pre planning prevents such mixups.

SCHEDULING OF WORK

On any ship, cooperation among divisions is necessary for a loading. or offloading operation, even though the load consists entirely of missiles. The Boatswain's Mates rig the lines and other cargo gear; the engineering department keeps the ship's elevators in operating condition; etc. When other material besides missiles is being loaded, the time for using certain of the ship's gear has to be allotted. If missile loading is scheduled, let us say, for 1000, be ready with your men to swing into action, and do your work on schedule. Loading of explosives should be done in daylight hours if at all possible, and the ship's plan for the loading will conform to this rule. Unexpected foul-ups can throw the plan off schedule. Plan your part of the work so there will not be such delays. Remember, however, that missile handling must not become a speed contest.

Usually you will have information several days in advance of the actual loading date. Have your men check the operation of the special handling equipment to be used with the missiles. If any of the equipment does not operate as it should, locate the cause of the trouble with the use of test equipment, wiring diagrams, hydraulic schematic, and trouble-shooting techniques, beginning with the simplest method. Then make the necessary repairs and adjustments. The checking of the ship's cargo handling gear is the responsibility of the Boatswain's Mates; but before you entrust any of your missile cargo to the gear, be sure it has been checked out for handling the weights required. It is the responsibility of you and your men to cycle the equipment for striking down the weapons, or the special gear for moving them to on-deck launchers. If the equipment does not operate properly, you must. repair and adjust. it so it will be ready to use on the day required. As' a GMM 2 you have had some experience in locating the trouble spots in such equipment; now you must learn to make more difficult repairs on the equipment and adjust it to working condition.

SECURITY

In addition to the safety provisions that must be observed during handling of any explosives to prevent fire or explosions, provision must also be made for the security of the weapons against theft, damage, destruction, or access to enemies. Knowledge of the transfer of the weapons, of the type and number of weapons, of the design of the weapons, etc., is information that must be concealed from enemies. Access to nuclear warheads must be especially guarded against. The commanding officer sets the security watch on the pier and on the ship. You learned about sentry and watch duties and security of classified documents in *Seaman*, NAVTRA 10120-F, in *Basic Military Requirements*, NAVTRA 10054-C, and in *Military Requirements for Petty Officer 3&2*, NAVTRA 10056-C. You can instruct your men in their duties when they are assigned to watch duty for security, fire watch, or other watch assignment, and ensure control of classified material.

Although the stenciled information on containers conceals any classified nature of the contents, the men handling the containers usually need to be aware of what they are handling so they will use adequate precautions. If the men who handle fuzes, for example, know that is what they are handling, they will be much more careful than if they don't know.

PLANNING SEQUENCE OF OPERATION

As soon as you know your working party assignment in the loading or unloading operation, think through the work sequence as you and I your men are going to accomplish it. Roughly sketching in your plan of action on paper may be very helpful in filling in the details of the, plan. Where are you going to spot your men? How are you going to manage the handling of the missile components so they will be placed in the correct order without delay or confusion? What checkouts are necessary before the missile components are struck below? How much assembly, if any, is to be performed before stowing the components? Have your men been trained for this work or will you have to schedule a practice session before the day of loading arrives? If such a session is necessary, check to be sure the men aren't already scheduled to be doing something else during the time you want them. Consult with the training officer of the division on this.

STOWAGE AREAS

Before the loading day arrives, check the stowage areas that will be needed. All of them should be clean, with no material that shouldn't be there. The sprinkler systems must be in operating condition. Repair and adjust any parts that need it. Check all other firefighting systems or equipment in and adjacent to the magazines. Be sure the alarm systems are working. In addition to fire warning systems, continuous operation of a radiation detection device with an automatic alarm is required at shore stations and on submarines in spaces where nuclear missiles or weapons (or warheads) are stowed. In air conditioned spaces, check to be sure the system is maintaining the space at the required temperature and humidity.

Some extra checkups are needed after a magazine has been painted. The areas for attaching ground wires should be clear of paint. Make sure that the holes in the sprinkler head valves and sprinkler pipes are not clogged with paint. Hooks, latches, pins, straps, and similar gear may be made inoperable by painting. Free all such fittings so they can be used. Check openings such as ventilation ducts and outlets to be sure they can be opened. Inspect tiedown, blocking and bracing gear, chocks, and other means for stowing and holding missiles and their components. Examine the movable parts of trolley conveyors, such as switches, portable tracks, and trolleys, and make sure they operate freely.

Much of the work of checking the magazines can be delegated to your men, but you must be sure the spaces are in the best condition possible. The simpler repairs may be done by lower rated men, but you need to approve the results. Make a checklist to be sure nothing is overlooked, and that the stowage areas and stowing equipment are ready to receive the cargo of missiles and components.

Radiation Monitoring and Protection

Formerly, all areas in which nuclear weapons or nuclear warheads were stowed or were worked on had to have permanently installed radiation detection equipment, and monitoring was continuous. At present, continuous monitoring for radioactivity is required only on submarines and at shore stations. Surface ships are allotted portable monitoring equipment for use in weapon spaces. Monitoring is required before entering a space containing one or more nuclear components if the space has been unoccupied for over 24 hours. Monitoring of the spaces is not required when no personnel are in the space.

Neither is it required during replenishment at sea and during strikedown operations, or when weapons are transported on elevators or through passageways during an alert operation.

If there is an accident with a nuclear weapon or nuclear warhead, monitoring must be done immediately. The space in which the accident occurred must be closed off to prevent spread of contamination to other parts of the ship. Every effort should be made to move the weapon to a naturally ventilated place. All unnecessary personnel should be evacuated. If the space has access to the atmosphere, all such should be opened. The emergency ventilation EXHAUST should be opened, and after that, open the . emergency ventilation AIR SUPPLY. Get out of the space as quickly as possible (the actions above should take very little time), and secure the space, then notify the appropriate personnel. The trained decontamination group, of which you may be a member. dressed in protective clothing, and each wearing an oxygen breathing mask (OBA), reenter the room and remove the source of contamination. The path to be followed must be cleared and the elevator ready. Afterward, the elevator used and the path followed must be decontaminated.

The order in which the above actions are accomplished will differ with the location of the contamination, the severity of the radiation, and whether the radiation is detected immediately or upon preparing to enter a closed space. If the accident occurs on an open deck, the radiation will be carried away into the atmosphere; personnel need to be evacuated from the immediate

The T-290 portable air sampler is used to monitor the weapon space and the weapon. Instructions for operating it ace given in Navy SWOP T290-2. As soon as they can be procured, the IC/T2-PA (fig. 2-2) or the battery operated IC/T2-PB will replace the T -290. Technical *Manual for Tritium Air Monitor, Portable, Type IC/T2-PA* NAVSHIPS 0969-000-6000, describes the new model, tells how to use it, and how to maintain it. The instrument is designed to detect tritium contamination in the air, but it is also sensitive to gamma radiation and to gaseous or particulate activity in the air. To use it, remove it and carry it by the carrying strap over the.

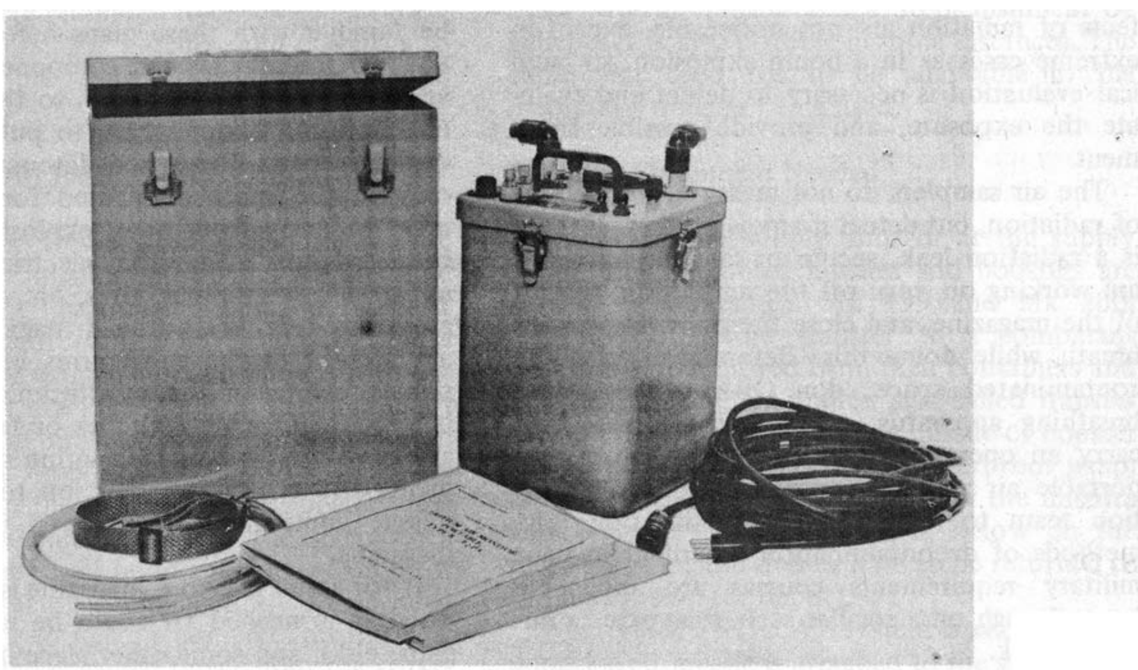


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Figure 2-2.—IC/T2-PA portable radiation monitoring instrument with accessories.

shoulder, or set it on a bench or similar place. The power cord supplied with it is 35 feet long, which allows monitoring of quite a wide area. Plug it into any 115-volt a-c 60-hertz single phase source, 3/4 ampere or greater. As air is drawn through the ion chamber of the monitor, the level of radioactivity is measured. The reading shows on the meter, and when the amount exceeds the normal setting, the alarm sounds. If you need to monitor a space without entering it, perhaps because of suspected high contamination, attach the "sniffing hose" to the instrument and insert it into the space.

The monitor is a delicate electronic instrument and should be handled with care, not dropped or abused in any way. If it becomes contaminated with radioactive particles it must be decontaminated. Careful wiping of the outside with a cloth dampened with water and detergent will remove light contamination. Be careful not to get any water on the inside.

Permanently installed continuous monitoring units formerly used in nuclear weapons spaces have been ordered removed from surface ships according to NAVSHIPS Instr 9650.5. Men who have been exposed to radiation must be sent to the medical department for evaluation. The effects of radiation are not noticeable, except in extreme cases as in a bomb explosion, so medical evaluation is necessary to detect and evaluate the exposure, and provide possible treatment.

The air samplers do not measure the amount of radiation, but detect if any is present. If there is a radiation leak, secure or safe the item you are working on, turn off the ventilation, get out of the magazine, and close the door. Hold your breath while doing this. Before reentering the contaminated space, don OBA or equivalent breathing apparatus, wear rubber gloves, and carry an operating T-290 or IC-T2-PB or -PA, portable air monitor, or call the decontamination team to take care of the situation. The methods of decontamination described in your military requirements courses are applicable here, though on a smaller scale than after a nuclear attack.

The need for extreme care to avoid inhalation or ingestion of nuclear particles should be impressed on your men. Any detectable amount of tritium is potentially dangerous. Although the chances of a leak occurring in a nuclear weapon are small, the danger is ever present and you must teach your men how to act in case it happens. The reason for turning off the ventilation on shipboard is to prevent the spread of, radioactive particles through the ventilation system. Where ventilation to the open air is possible (as at shore stations), activate ventilation systems and open windows.

The danger of unauthorized personnel gaining access to a nuclear weapon during an alarm incident makes it essential to secure the area quickly. Two technically trained men must enter the area as soon as possible to secure it.

Rules of Where to Stow

Most of our missiles are stowed completely assembled (except for wings, fins, etc,) in the magazine or ready service ring that is part of the missile launching system. The supplies of additional parts, such as extra electronic sections, warheads, or repair parts, have to be stowed in separate magazines and stowage compartments.

The ship's plans show the designated stowage for all the ammunition, missile, and missile components that are allotted to the ship. You should be familiar with these plans before attempting to stow the missiles and components. The magazine doors are also marked, so there should be no confusion about where to put the different explosive parts. Fuzes and detonators are stored only in the space designated for them, which must be away from other explosives, and specified distances away from electric or electronic apparatus, steam pipes, fires, etc. (Terrier fuzes are stowed in the warhead magazine.) Primers are stowed in the small arms magazine; flash signals belong in the pyrotechnic locker. The magazines for each launcher or launcher group are as nearby as possible (within safety requirements). It is part of your job to see that the missile components are stowed in the proper magazine.

If for some reason a magazine is not available when it is needed (it could be undergoing repairs, etc.), and some other place must be found to use instead, consult the "Chart of Permissible Stowages of Ammunition and Explosives," in OP 4, Volume 2, *Ammunition Afloat*, to determine the next best place for stowage. Study the explanation of how to use the chart. You will not find missiles listed on this chart, but components such as boosters, JATO units, and primers are listed.

SUPPLY PRINCIPLES AND STOWAGE.- Some components have an expiration date marked on them, beyond which they are not to be used. When stowing such components, place the oldest ones nearest the front, so they will be used first. The oldest items should always be used first, even if they are not tagged with an expiration date. When a replenishment arrives, move old missile components so they will be most accessible and will be used first. Standard supply items that you might need for repairs or replacement are stored by the supply department.

TERRIER MISSILE HANDLING AND STOWAGE

Terrier missile systems are operational on DLGs, CVAs, CAGs, CLGs, and CGNs. The number and the location of the launchers, the location of the magazines, assembly areas, and checkout areas are different for each ship. That is why you were reminded to check the location of the magazines, the hatches, and elevators to be used when preparing to load Terrier missiles on the ship.

SPECIAL PROBLEMS WITH TERRIER

Although the Terrier is not the largest nor the heaviest of our missiles, its size and weight make special handling equipment necessary (fig. 2-1). The extra length of the BT-3 booster makes special handling care essential in moving it to the mating area. A crack or strain in the propellant grain can cause missile failure through uneven burning when fired. In striking down boosters and missiles to the mating area, a booster must precede every missile through the strikedown hatches, so they will be in the correct order of assembly. A set of complementary items must follow in order to make a complete missile. The order must be maintained throughout the strikedown operation.

It might seem more efficient to transfer all items that require the same handling equipment before breaking out other equipment. However, the reason for requiring transfer of all parts of a missile is obvious when you give it some thought. Suppose you transferred all the missiles and boosters first because they required the same handling equipment. Should anything occur to break off the loading operation, such as a severe storm, or the appearance of an enemy, your ship might have all the missiles and boosters and the other ship all the complementary items, all equally useless when not put together. The rule, therefore, is that for every booster a missile must be transferred, followed by all the complementary parts needed to complete the missile.

Safety rules for handling high explosives and propellants must be observed during handling and strike down. Flash units are treated as pyrotechnic items; they must not be dropped and must not be brought into areas where they will be exposed to RF energy from radars or communication transmitters, or beams from operating missile radars.

INITIAL RECEIPT

Missile components may be received from' dockside, from barges or lighters, or from another ship in transfer at sea. Replenishment by helicopter is also possible in some instances. The equipment used has to be adaptable to the method of transfer being used.

Handling Equipment Needed

On board the supply ship or at the supply depot, the assembled missiles and boosters are stowed in Containers Mk 199 and Mk 200, respectively. Before transfer to a combatant ship, they are removed from their containers and attached to handling dollies, also called transfer dollies (fig. 2-3). Sometimes a missile or booster and its dolly are sealed into a waterproof wrap, especially for transfer at sea. After the missiles and boosters have been struck below on the receiving ship, the dollies have to be returned to the supply ship (or depot).

Wherever the STREAM system is available, the unpackaged missile is attached to. the strongback on the trolley, which carries the missile to the receiving ship. The missile and the booster are sent separately, to be mated on the receiving

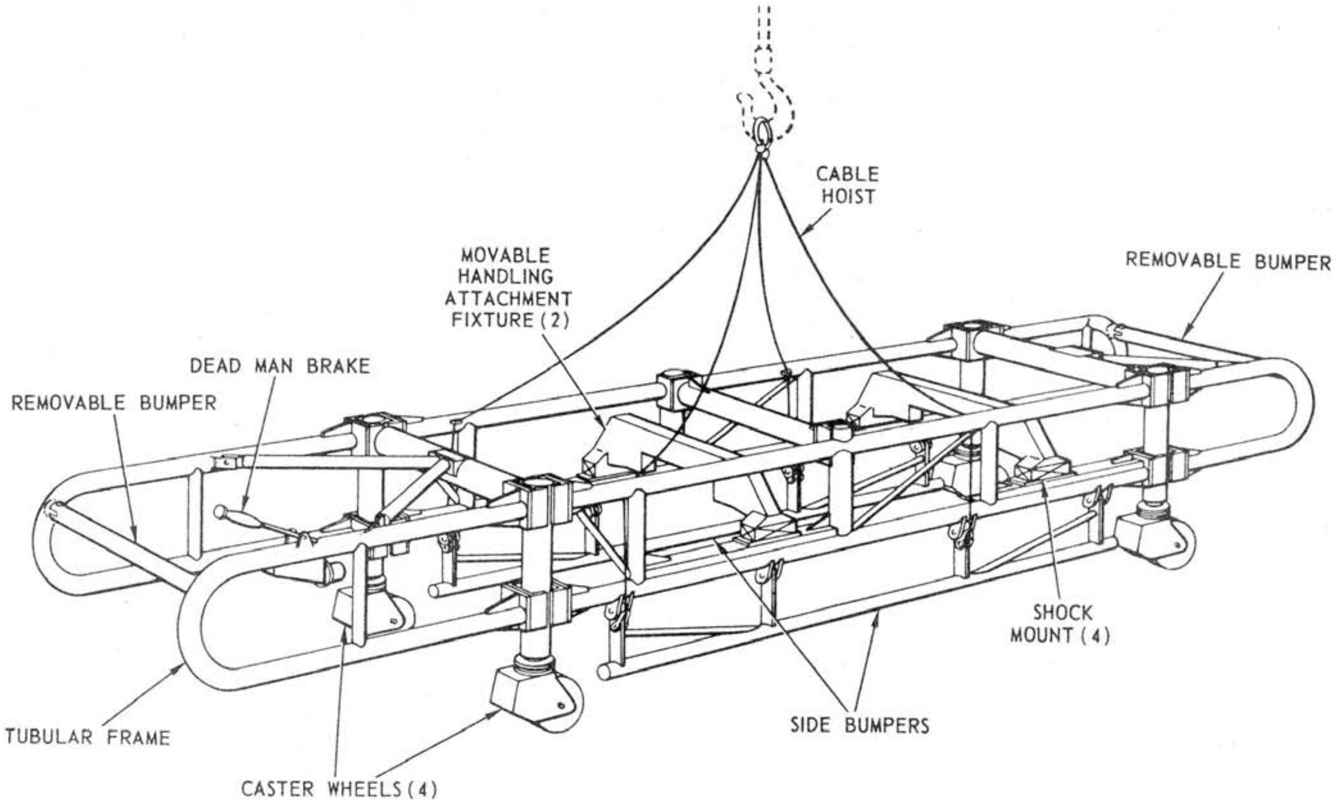

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Figure 2-3.—Transfer dolly for Terrier missile.

ship. So many ships now have the STREAM system that. you may never need to use the handling dolly.

Wings and fins are packed in reusable metal containers, which have to be returned. Other complementary items, such as warheads, exercise heads, fuzes, warhead boosters, and code plugs, are transferred and stowed in their containers. They may be handled with skip boxes, or special handling cradles, but are never rolled or slid.

TRANSFER AT SEA-For underway transfer from an ammunition ship (AE), both Modified housefall (fig. 2-4) or the burtoning method, and constant-tension highline rigging (fig. 2-5) are required if the STREAM system is not installed on both ships. The modified housefall rig may be used to land the boosters and missiles on the topside replenishment area, though a tensioned highline or burtoning are preferable. The highline is used to land the complementary items in their skip boxes on the aft deck. Boosters and missiles are received at specified landing areas for subsequent strikedown through the port and starboard strikedown hatches near the after end of the 02 level (on cruisers). The lines are tended by cable winches on the ammunition ship deck. As each missile or booster on its dolly is landed on deck, it is snaked over to the strikedown elevator and is struck down. The empty dollies are returned to the ammunition ship by reversing the handling process. The only dolly with its load must be kept under control at all times. This precaution is especially necessary in rough seas.

Constant tension on the highlines wires is maintained by a winch on the ammunition ship or by a counterweight or ram tensioner. Loads are placed in a skip box hooked to a trolley block (fig. 2-5) on the wire highline. When the skip box is lowered to the ship's deck, the contents are removed, and the empty skip box is returned to the AE by the highline.

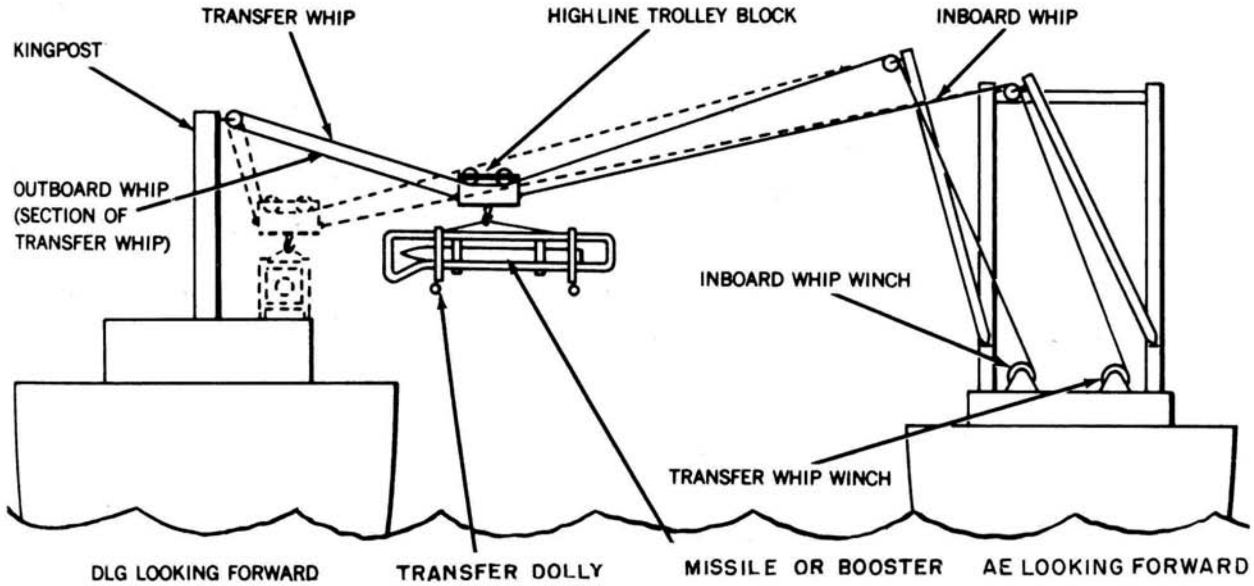

Figure 2-4.—Modified housefall transfer method.

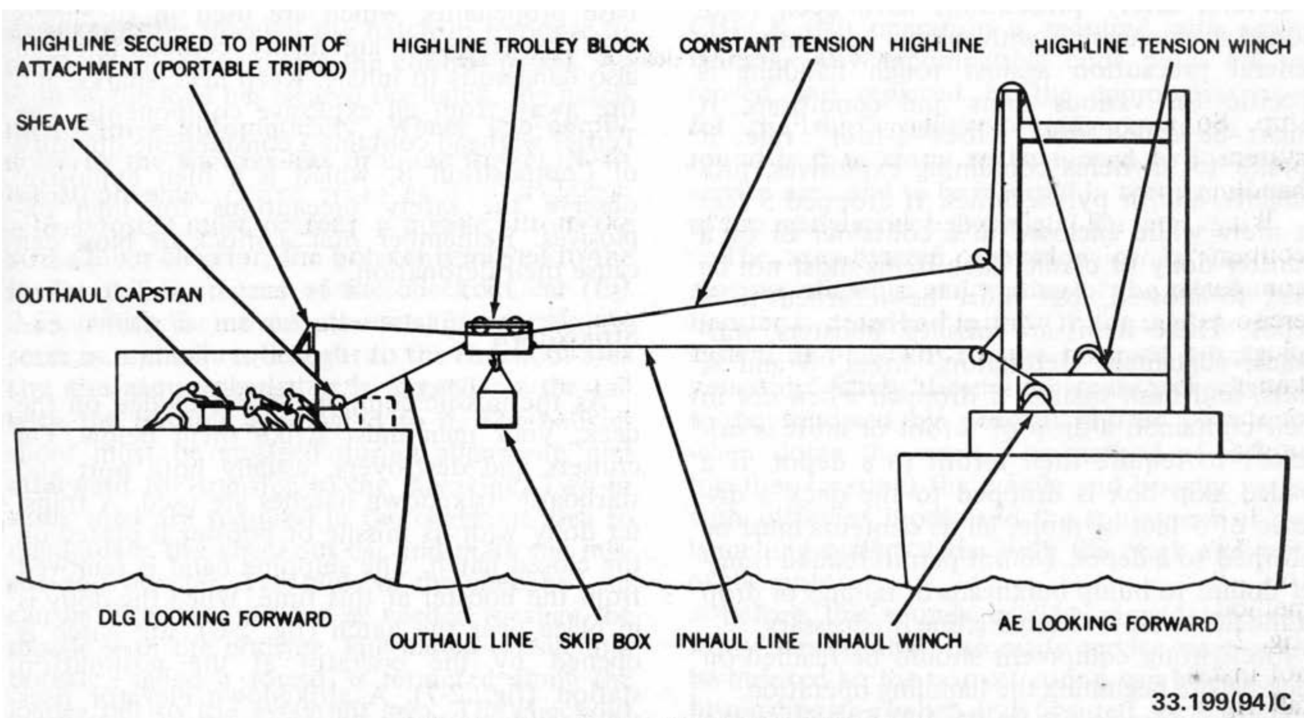

Figure 2-5.—Constant tension highline transfer method.

The work of handling the lines and winch may all be done by the boatswain's crew, but a trained and experienced GMM needs to be at hand to ensure that the explosive components will be handled with proper care. Skip boxes and dollies must be lowered gently to the deck. No smoking is permitted while any ammunition is being handled. The PO in charge should have all his men leave their smoking materials, including lights and matches, at a specific check point before coming to the loading area. Lead the way by putting yours there first.

TRANSFER FROM DOCKSIDE LIGHTER, OR BARGE.-A dockside or floating crane is used to transfer boosters and missiles on their transfer dollies. The complementary items may be carried aboard manually or landed aboard by crane. Subsequent handling is the same as in transfer at sea. While handling explosives on a pier or in a building, ship's personnel are under the authority of the commanding officer of the ordnance facility.

Safety Precautions in Handling

Several safety precautions have been mentioned in connection with missile handling. The general precaution against rough handling is specific for various units and conditions. It might be called the "5-foot-l-foot" rule; it applies to all items containing explosives, propellants, and/or' pyrotechnics. If dropped 5 feet or more while enclosed in a container or on a transfer dolly or cradle, such items must not be used to stowed, but must be returned to a depot. These items are missiles, boosters, warheads, sustainers, detonators, fuzes, S and A units, and flash signals. .If dropped when not in their container, a drop of 1 foot or more is sufficient to require their return to a depot. If a loaded skip box is dropped to the deck a distance of 5 feet or more, all its contents must be returned to a depot. Do not permit loaded transfer dollies to bump bulkheads or railings or drop to the deck; use a steadying line if necessary.

Firefighting equipment should be readied on deck before beginning the handling operation.

Since the tragic fire on the USS Oriskany, the rules for handling of explosive items, especially pyrotechnics, have been reexamined. New, stricter and more comprehensive rules have ~ I promulgated to help prevent such catastrophes in the future. Adding new rules, however, will not prevent accidents. Only strict adherence to the rules will achieve that. You not only need to observe that your men obey the rules, but you need to strive constantly to get your men to believe in the need for the rules.

When planning movement of missiles and components on deck, plot the movements to avoid RF radiation. The beams from radars and other electronic transmitting equipment can cause detonation of some components, and they are also harmful to people. The commanding officer will order inactivation of all possible radar and electronic equipment during ammunition handling, but usually some units have to be kept operating at all times. Flash units are very susceptible to detonation by RF radiation.

The RAD HAZ and HERO programs on the effects of radiation from electronic equipment are discussed in chapter 8.

In the magazines and stowage spaces or ready service rings, if you detect any odor of ether or nitroglycerine, report it immediately to the officer in charge. These fumes exude from double-base propellants, which are used in sustainers and boosters, and are highly combustible and also dangerous to inhale. Keep heat, sparks, and, fire away from all explosive components. The Terrier warhead contains a considerable quantity of Composition B, which is a high explosive; observe the safety precautions for high explosives. Remember that a shock or blow can cause their detonation.

Strikedown

As the missile components are landed on the deck, your men must strike them below. On cruisers and destroyers, usually both port and starboard strikedown hatches are used. A transfer dolly with its missile or booster is placed on the closed hatch. The shipping band is removed from the booster at this time. When the dolly is in place over the hatch (fig. 2-6), the hatch is opened by the operator at the pushbutton station (fig. 2-7). A strikedown elevator rises beneath the dolly and latches onto the handling attachments on the missile or booster. The handling attachments are then manually released

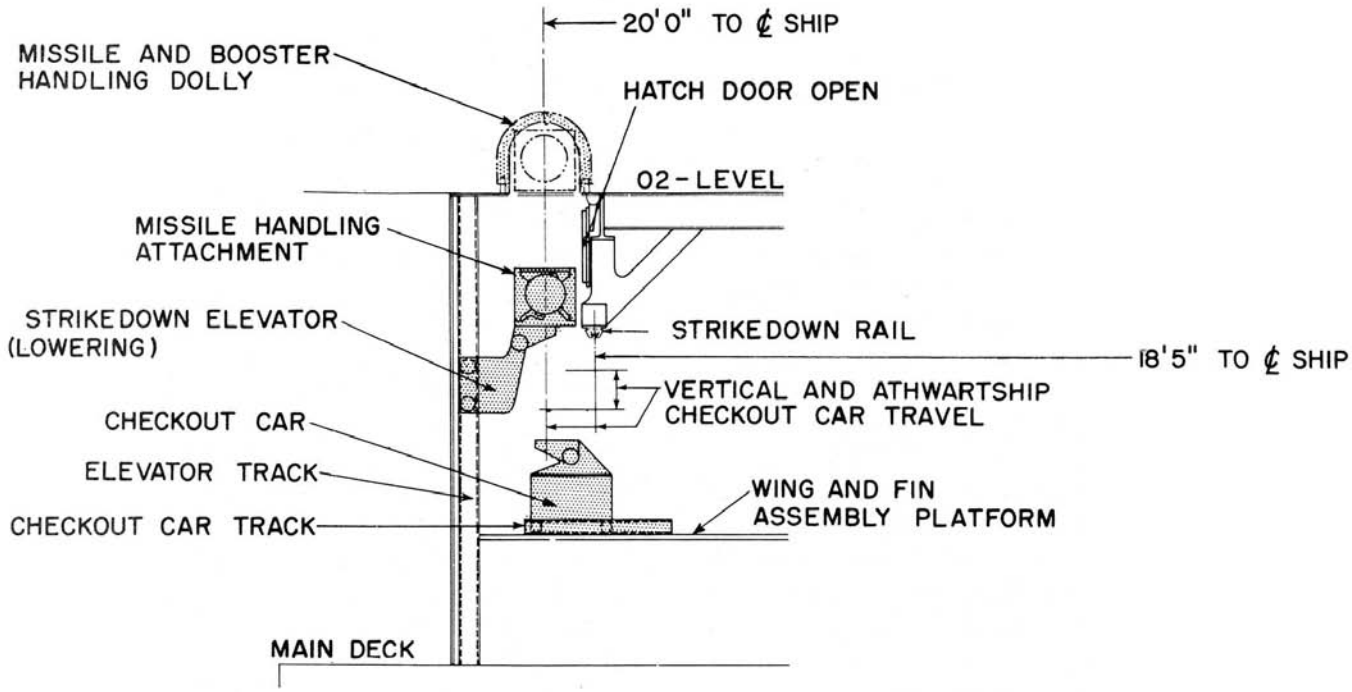

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Figure 2-6.—CLG (Terrier). Strikedown and checkout missile handling equipment. (Elevation).

from the dolly and the elevator lowers the missile or booster through the hatch in response to pushbutton operation at the control panels. As soon as the load has cleared the hatch, the hatch door closes automatically. Wheel the empty dolly to the transfer line or crane for return to ,the supply ship.

A booster must precede a missile. From the strikedown elevator, the booster is 'moved to the loader rail by means of the checkout car (fig. 2-6), which is moved athwartship on rails. As soon as a missile is brought to the checkout area (by the same means), it is aligned on the rail with the booster and mated to it. The booster shoes must be engaged during alignment, and afterward for transfer to the magazine. Two or three men are required in the checkout area to manipulate the checkout car and mate the missile and booster. The table of the checkout car can be tilted and rotated as needed to align the missile with the booster. The mated missile and booster, called a round, is retracted along the loader rail to the assembly area. The checkout car is returned to carry the next unit. In the assembly area, the code plug is inserted and the sustainer on the BW-1 is mechanically armed; the sustainer arming switch of the BT-3 is set on CHECK. No operation is required with newer igniters. Any incompatible code plugs are removed and replaced by the appropriate ones for the ship's assigned guidance codes. The round is then ready to be moved. to the ready service area and to be inserted in the proper tray of the ready service ring (fig. 2-8).

The step-by-step operation to be used in moving, aligning, and mating of the missile and booster is described in the OP for the launching system and the OP for the mk/mod missile on your ship. Study these and prepare a checksheet to be followed by yourself and/or your men when doing the work. The method of locking together (mating) the missile and booster varies with different mods, and the equipment of the launching system varies with the mark and mod of the system.

Before the rounds can be moved into the ready service rings, the ready service rings must be indexed so the correct round can be selected by pushbutton when it is wanted for firing or exercise. This is done by the panel operator setting the pushbuttons according to the plan. The actual arrangement of the weapons in the

Gene Slover's US Navy Pages
Phil Hays' Talos Missile Page
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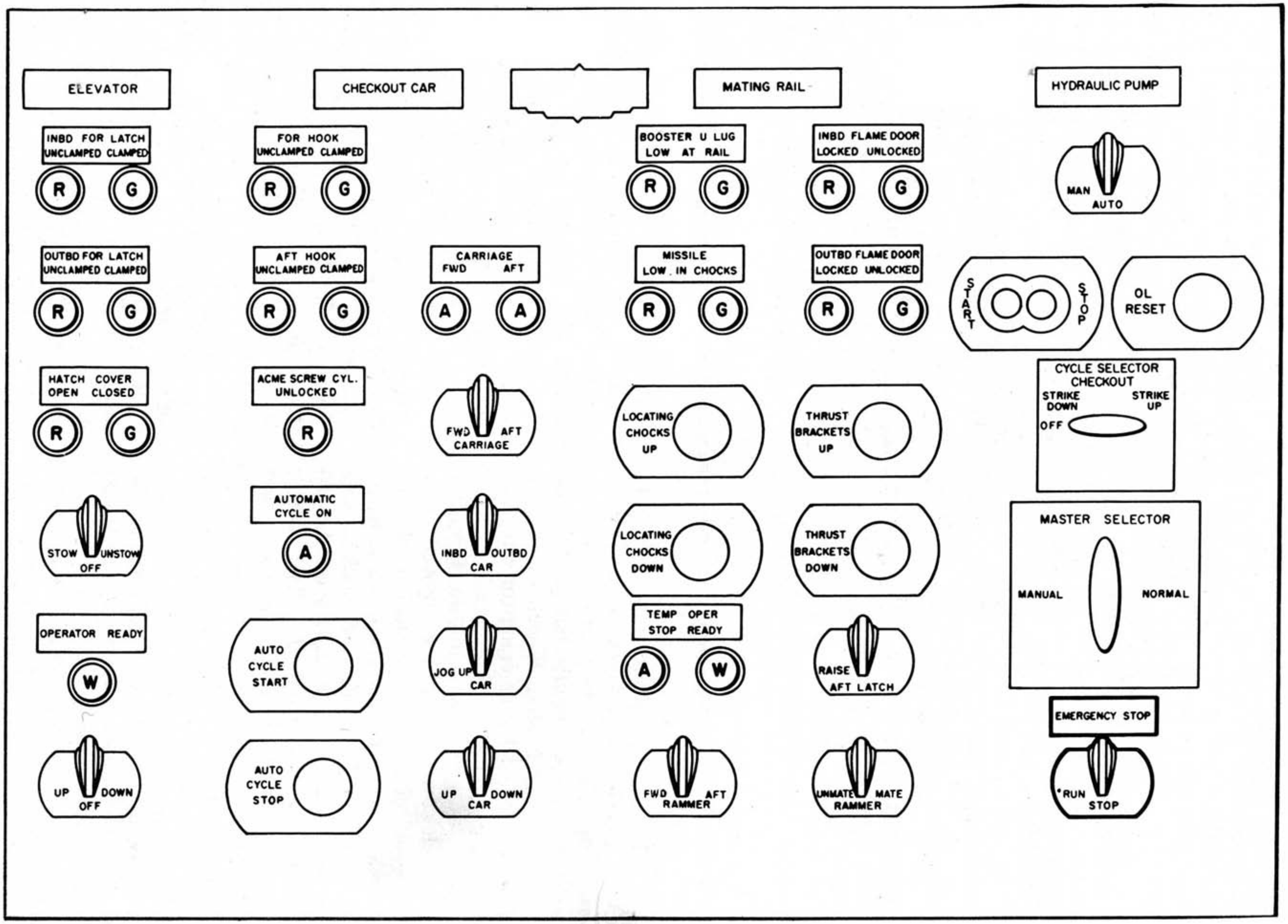

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Figure 2-7.—Strikedown panel, GMLS Mk 9.

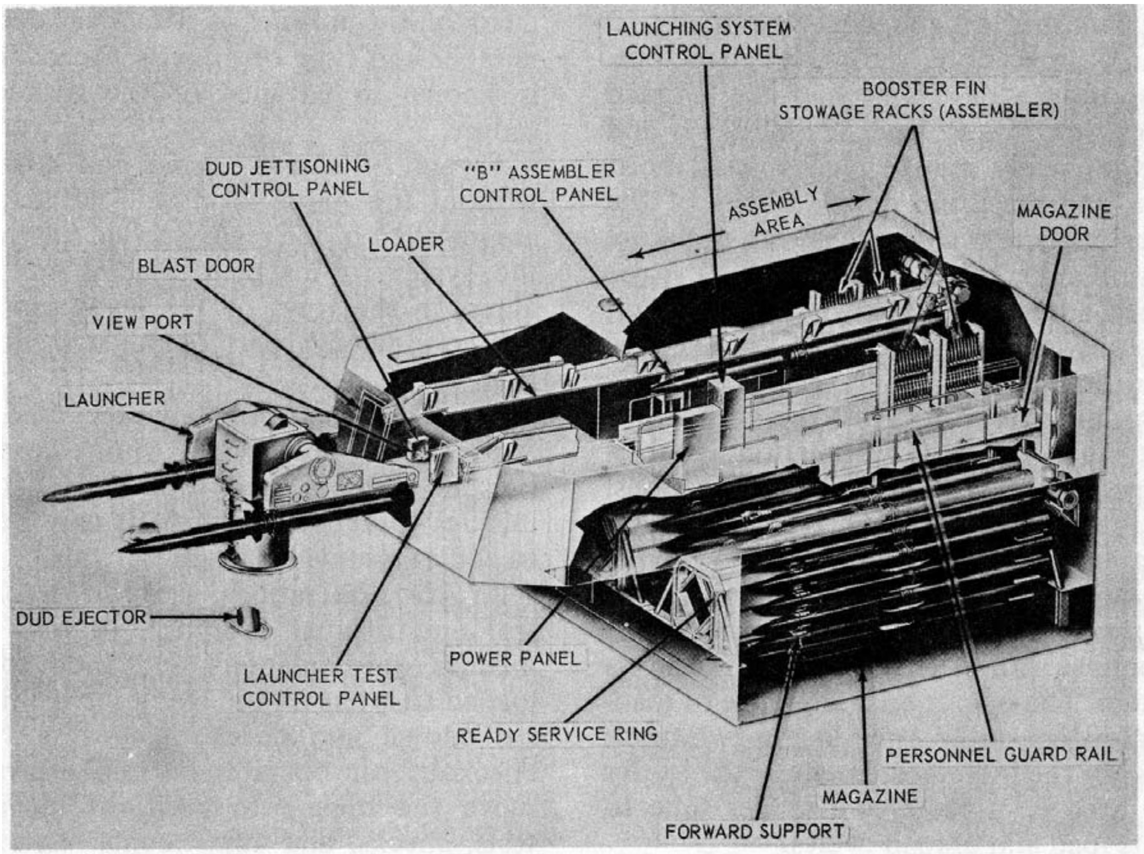

Figure 2-8.—Guided missile launching system Mk 10 Mod 0.

service ring is a tactical decision. A Terrier missile ship may carry one or two or even three types of Terrier missiles. The BW-1 type has a smaller booster, and therefore the service ring trays that are to hold BW-1 type missiles must have inserts added to them. This is considered a maintenance operation, which must be done before missiles are stowed. Make a sketch of the service ring and indicate the positions of the various weapons as planned. Then add the inserts to the trays indicated for BW-1 missiles. (There are very few BW-1 missiles left, and those are used for practice runs.)

The Assembler Panel (fig. 2-8) has a light for each tray, with colors and lettering to indicate what is loaded into the tray. The operator of the panel can select the weapon required by pushing the correct button for the tray wanted. When the round is ready to put into the ready service ring, it can be done automatically or step-controlled. Step control requires operation of pushbuttons for each step. Automatic operation is initiated by pushbuttons on the EP-2 panel. The tray with the code designation of the round in the assembly area moves to the hoist position, the magazine doors open, and the hoist raises to the loader rail. The loader chain pawl moves the round from the loader rail' onto the hoist. The hoist lowers the round into the ready service ring tray; the tray shifts the round free of the hoist; the booster shoes engage in the ready service ring structure and the magazine doors close. As each round in unloaded to the ready service ring, the lamp (on the control panel) associated with the tray goes out. The magazine for Terrier rounds is in the deckhouse (fig. 2-8) or below deck, depending on the ship installation. Each weapon must be identified by a serial number and recorded in a missile log for each missile on board. The number of the tray in which it is stored is not sufficient identification as it may be put into another similar tray when it is returned after having been taken out for checkout, maintenance, or exercise.

STRIKEDOWN OF ASROC MISSILES.- The Terrier Guided Missile Launching System Mk 10 Mods 7 and 8 stows both Terrier and Asroc missiles. It has three stowage mechanisms: Guided Missile Magazine Mk 5 Mod 12, Mod 13, and Mod 14, with ready service mechanisms, hoist mechanism, and magazine doors. Either of the two upper ready service mechanisms can store 20 Terrier missiles, or 10 Terrier and 10 Asroc missiles with adapters. The lower, or auxiliary, mechanism stows only Terrier missiles. The missile strikedown. equipment is located in the strike down and checkout area. The strikedown equipment is a NAVSHIPS installation; its operation is described. in NAVSHIPS publications. *Gunner's Mate M (Missiles) 3&2*, NAVTRA 10199-B contains an illustration of the Mod 7 launching system, showing Terriers and Asrocs placed in the ready service rings. The Mod 8 is almost identical, but it has no tilting rail in its feeder system. The operational sequence of loading and unloading is the same in the two mods but because of the increased length of the loader rail in the Mod 8, it requires a longer time to complete its load and unload cycles.

Asroc rounds cannot be located next to each other in the ready service ring. Consequently, the table of assignments of missiles to the tray must be followed carefully. The actual arrangement of the missiles is a tactical decision. The number and type of missiles for loading usually is known in advance of the strikedown procedure.

Figure 2-9 shows Terrier and Asroc missiles, without the Asroc adapter. The adapters often are installed in the ready service rings at the time the system is installed. Placing the Asroc adapters in the trays of the ready service rings is not considered a part of the strikedown operation.

In addition to the adapter used with the Asroc missile because it is shorter than the Terrier, an insert is used with X or Z type Asroc missiles (practice missiles). It may be necessary to add or remove an insert.

In Asroc operations, strikedown is a step control and manual operation to load assembled missiles onto adapters and then to stow the loaded adapters on the ready service rings. In the strikedown and checkout area, a NAVSHIPS checkout car operates on rails athwartships to move the missile to positions for performing tests, checks, and adjustments. The Asroc missiles arrive on board assembled, so there is no mating process as with Terriers and Talos. An Asroc attached to an adapter rail is shown in the

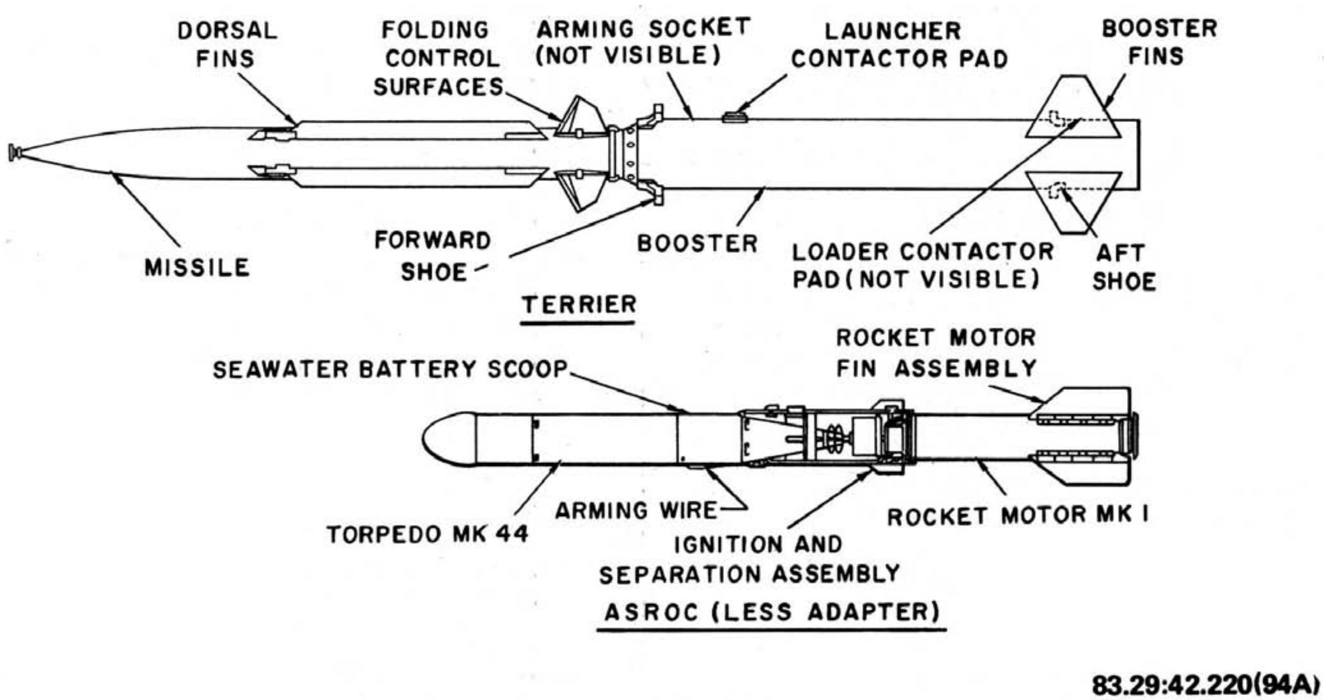

Figure 2-9.—Terrier and Asroc weapon types.

text, *Gunner's Mate M (Missiles) 3&2*, NAVTRA 10l99-B. A special Asroc adapter loader assembly is in the strikedown area for attaching the adapter to the missile before putting it on the loader. The Asroc missile is brought to the strikedown and checkout area on the strikedown car. It is aligned with the adapter by means of the adapter loading fixture, and latched into the adapter. The snubbers on the adapter are air operated, and need to be unlocked with care to avoid casualties. Everyone must be clear of the snubbers before unlocking. After the missile is attached to the adapter, the strikedown-checkout car is stowed and the missile with adapter taken to the magazine via the loader.

STRIKEDOWN OF COMPLEMENTARY ITEMS. - The complementary items include wings, fins, after control surfaces, warheads, warhead boosters, fuzes, exercise heads, and miscellaneous missile spare parts.

The WINGS and FINS or BOOSTER FINS are hand carried away from the main deck landing area and stacked in their reusable containers in a convenient place until they can be unpacked. After unpacking, the containers are returned to the supply ship (or depot) and the wings and fins are stacked in the racks in the assembly area. If the number of personnel available is sufficient, all this should be done at the time of strike down to avoid pile-up of material.

The WARHEADS or EXERCISE HEADS that are not assembled to Terrier missiles while they are stowed, are sent to the warhead magazine below decks. The strikedown elevators are used. but these must have special handling cradles temporarily installed. One at a time, each warhead (or exercise head) in its container is lowered to the checkout car. The car moves within range of an overhead bridge crane, which mounts a birail trolley hoist with an attached J-bar. The J-bar adapter is attached to the upper end of the container, and the container is lifted clear of the cradle and checkout car and placed on a dolly on the component parts hoist and lowered to the warhead magazine, where it is stowed. The checkout car with the cradle on it moves back up to its position under the strikedown elevator. ready for the next load.

The FUZES and WARHEAD BOOSTERS in their containers are stacked out of the way until completion of missile-booster strikedown. Then they are struck down to the warhead magazine by means of the missile component parts hoist. The fuzes are placed in fuze stowage racks in the warhead magazines; the warhead boosters and S and A devices have bins in the warhead magazine.

NONEXPLOSIVE complementary items, other than wings and fins, are stacked aside in their containers, and then struck down to the second platform and stowed in the missile component storeroom. Miscellaneons tools and parts are placed in this magazine. Normally, insert components are not stowed in the same compartment with explosive or flame-producing components. If lack of space makes mixed stowage necessary, specific approval must be obtained from the operational commander. Flammable material may not be stowed in any magazine.

DEPOT HANDLING AND STOWAGE

At depots, missile parts are received in sealed containers from the manufacturers. They are placed in receipt stowage, according to the type of component. Sustainers, boosters, and auxiliary power supply gas generators and igniters are placed in the smokeless power and projectile magazines. The warhead, destructor charge (if any), fuze booster, and the safety and arming (S & A) device are placed in a high explosive magazine. Flash signals are stored in the pyrotechnic magazine. Inert missile components are stored in the guided missile service unit checkout building.

On shipboard, the work of GMMs is focused on care and operation of the launching systems. Note, however, that one of your quals requires the E-7 to have a knowledge of methods of handling and stowing of missiles ashore. Few assignments of GMMs are made to amunition depots, but Naval Weapons of GMMs are made to ammunition depots, but Naval Weapons Stations require many GMMs.

The volumes of OP 5 are pertinent references: Volume 1, Ammunition and Explosives Ashore, Safety and Security for Handling, Storting, Production and Shipping, Volume 2, *Ammunition Ashore*, Stowage Data and Volume 3, *Ammunition Ashore, Advanced Bases*. Volume 1 contains much information on the properties of different explosives, and how they must be stored and handled because of these properties. Numerous sketches illustrate the quantity-distance requirements for different types of ammunition. On shipboard, the quantity-distance requirements cannot be followed be cause there simply isn't room enough to stow ammunitions at the separate distances specified. At shore bases the requirements must be observed. The purpose of the requirement is to keep the quantity of ammunition per building small enough so that a fire or explosion in one building will not spread to adjacent buildings.

Guided missiles are considered a mass detonation hazard, but assembled missiles present several types of hazards. Therefore, regulations and instructions for storing, shipping, handling, and marking of guided missiles and their major components are not covered in OP 5. The OP for the particular missile must be consulted for the specific instructions. The hazard classification and storage requirements of some components are mentioned in OP 5. Solid propellant sustainers and boosters, without warheads, are classed as group 6 materials if so designated by NAVORDSYSCOM, and must be stored a minimum of 1800 feet from any inhabited dwelling, passenger railway, or public highway. Guided missile warheads are group 7, 9 or 10, unless classed otherwise by NAVORDSYSCOM. The distance requirement varies with the number stowed in the building, and the type of magazine. Other components are in other storage classifications. Fuzes, for instance, are called group 8 materials, which must be stored in special magazines, earth-covered or with equivalent protection.

The rate training manual, *Gunner's Mate M (Missiles) 3&2*, NAVTRA 10199-B mentioned in several places that a defective component, or a missile, was to be returned to a depot for repair or destruction. OP 5, volume 1, contains a chapter of instructions on how to dispose of damage or dangerous explosives of different kinds. Some are burned; some are dumped in deep water. Maintenance and surveillance instructions are given for various small components such. as fuzes, but missiles and boosters (except rocket boosters) are not covered. A missile is not destroyed except as a last resort if the missile cannot be made safe. A publication available from NAVORDSYSCOM is *Safety Regulations for Guided Missile Propellants*. Request specific instructions for each missile, in the event that destruction seems to be necessary.

Rules for shipping explosive components by truck and by railroad are not given for missile components or assembled missiles, but have to be interpreted for missile shipments. Many of the rules are applicable to transportation of any . type of explosive. For example, passengers are not permitted on trucks carrying explosives. In addition to giving such general rules, OP 5 lists references you will need if you have to pack and/or ship missiles and missile components. With on-land shipments, you not only have to follow Navy regulations, but also state and inter-state rules.

Security regulations, firefighting, lighting protection, static grounding, and industrial safety,. health, and hygiene procedures given in OP 5 are applicable to missiles and missile components. Revisions to OP 5 added rules for quantity-distance storage of missile propellants according' to their hazard classification. The application of the rules to Navy missiles containing liquid propellant (Talos, Bullpup) is described in the OPs for the missile.

The four routine missile operations at an ammunition depot are initial receipt, retest, loadout, and missile return processing. Many variations are possible in each of those operations. While initial receipt is defined as receipt of the missile components from the manufacturers, the components may be delivered by different methods of transportation (railroad car, truck, etc.). The containers are designed for particular missiles and their components; some handling equipment is designed for particular missiles and their components.

All components must pass inspection when unloaded, but the extent of testing varies. On shipboard, a booster is never tested. At a depot, the booster is unpacked, transported to the igniter test cell, where it is given an igniter squib check, then is repackaged. If it is to be shipped with a missile, it is placed in ready issue stowage until the missile is assembled and ready for shipment. If it is to be stored for some future time, it must be repackaged and sealed with desiccant.

Let us assume that you are going to assemble: a missile to be sent to a ship for tactical use, or ready issue. Assume that each package has been given on-receipt inspection, tests when applicable, and has been repackaged, awaiting assembly. The booster remains in ready issue storage until the last, when it is to accompany the assembled missile, but not assembled to it. The sustainer is brought to the igniter test cell and is given a continuity test, then is repacked and taken to the assembly area. As each of the other components is inspected and checked out, it is brought to the assembly area to be assembled into the missile. Present type depots perform only pneumatic missile system tests (MST), which require a missile assembled without the warhead section, S&A device, and fuze booster. After the missile has successfully passed the initial MST and has been transported back to the assembly area, the nose section, the target detection device (TDD), and the tactical missile test spacer are removed to prepare the missile for tripak storage or for tactical assembly.

The tripak configuration for Terrier missiles consists of the electronic section, sustainer, and aft section assembled with dorsal fins and placed in a Mk 199 Mod 0 container (fig. 2-10). By the use of different blocking and bracing and cushioning materials, this container can be used for bipak storage (electronic section, aft section, nose section, and dorsal fins), or for a ready issue missile, or for sustainers, or for spare parts. Two handlift trucks Mk 40 Mod 0 are used to handle it on deck. A forklift truck may also be used. The tripak must be grounded and the sustainer arming device must be in SAFE position during all handling operations. The loaded container is closed with 20 latches on the container lid. Fresh desiccant is placed in the desiccant basket; the air release valve on the container is closed, the missile log and records are placed in the records receptacle on the end of the container, and security seals are placed on it and on

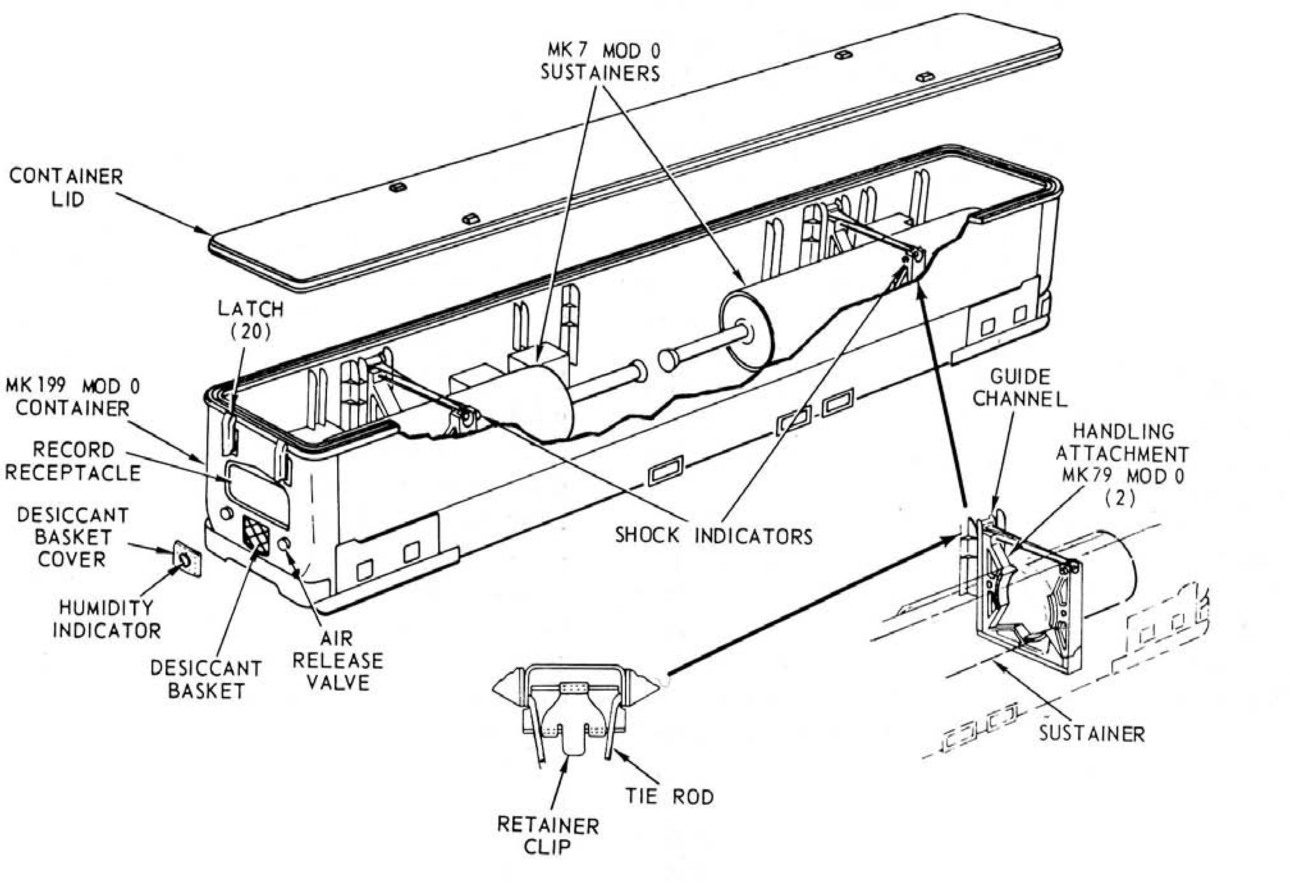

Figure 2-10.—Container Mk 199 Mod 0, with two sustainers, and showing placement of handling attachment for lifting sustainer.

two of the latches. The container then is ready to be transported to storage.

When the missile is to be assembled for ready issue or tactical assembly, the warhead section, target detection device (TDD), and nose section are added to the already assembled tripak configuration. If a Mk 5 and 7 warhead is used, a fuze booster and an S&A device are required to complete the fuze section. All these contain high explosives and must be handled as such.

The assembled missile is shipped from the depot in a Mk 199 Mod 0 container; its booster is in container Mk 200 Mod 0, and the booster fins are in container Mk 205 Mod 0. They are moved from ready issue storage and loaded on trucks or railroad cars by means of handlift trucks or forklift trucks. The trucks or railway cars are moved to the loading dock, where the missiles are moved for ship loadout.

For loadout to an ammunition ship, the missiles are kept in their containers. If a combatant ship is loaded directly from the dock, the missiles and components are removed from their containers on the dock and transferred to the ship on a weapon component transfer dolly. On the ship, the missiles are struck down to the .magazine and the dollies are returned to the dock.

Tests and Inspection

Few tests of missile components are made aboard ship by GMMs. Boosters, S&A units, fuzes and flash signals are never tested aboard ship.

Before Stowage

As the components are brought aboard, inspect them for visual damage. Check for external dents, cracks, or other obvious physical damage to the unit. Notice the expiration date if there is one on the unit. Set aside any units that are too old to be used. Boosters must not be armed. If you find one that is armed, notify the loading officer at once. Also call the officer if there is any odor of ether or nitroglycerine. Do not strike below any items on which you have found damage or defects. When the case of any explosive, propellant, or pyrotechnic item appears dented, cracked, or bent, or if it has been dropped 5 feet or more when in its container (1 foot if out of the container), return the unit to a depot.

If an S&A unit is found in an armed condition, store the unit, without the warhead or fuze booster, in an explosive locker; request disposition instructions from NAVORDSYSCOM Headquarters. DO NOT test or disassemble any S&A unit aboard ship, or make any attempt to repair one. This rule also applies to fuzes and flash signal units.

Rough handling may damage the coupling flanges on the fore and aft ends of the warhead; inspect for such damage. Check the central tube in the warhead for rust and for damage caused by the warhead lifting tool mandrel. There should be no exudate on the warhead. At replenishment the warhead is stowed in its container; this inspection is made when the warhead is unpacked.

Check to make sure that the booster arming socket is positioned at SAFE at all times until armed on the launcher.

On the sustainer the SAFE position is not for use on board ship. Make certain that the manual tool-controlled mechanical arming device on the BW-l Mk 5 sustainer is in the ARMED position. The BT-3 Mk 7 arming device should be in the CHECK position at all times aboard ship except when the round is ready to load on the launcher. Do not disassemble, check, or tamper with any part of the sustainer units.

Checkout

As soon as possible after strikedown and stowage, the missiles must be given an initial checkout and servicing. At present, BT-3 missiles are checked upon receipt, after a 3-month interval, and at 6-month intervals thereafter. (This rule may be changed by NAVORDSYSCOM directive.) As a GMM 3 you learn to use the strikdown equipment for strikeup of the missile components to the checkout areas, and to unmate the missile and booster for the checkout tests. You learned to use the checkout handling equipment. To advance to GMM1 and C, you must be able to supervise and direct this work and to operate the control panels.

The checkout equipment consists of the guided missile test set (GMTS), the hydraulic fluid pumping unit, the air diffuser panel, and the gas pressure actuator assembly. Other ratings may have the responsibility for the checkout tests. If you need to perform the checkout tests, study the technical publications that give the full details of how to perform the checkout on Terrier missiles. OP 2329, Vol. 2, *Terrier Guided Missile Mk 7 Mod 0 and Mk 8 Mod 0*, describes field checkout procedures for BW-1 missiles, and OP 2512, Vol. 2, *Guided Missile Complete Round Mk 1 Mod 0 and Mk 2 Mod 0 (Terrier BT-3)*, describes depot and checkout procedures for BT-3 missiles. OP 2898 covers BT-3A missile checkout, and OP 3051 is for the BT-3B missile, while OP 3043 is for HT-3 and HT-3A's. Check OP 0, *Index of Ordnance Publications*, to be sure you have the latest revision of these instructions. Also, keep abreast of instructions and directives as they are issued.

The checkout equipment is in the checkout areas which are in the main deckhouse. The checkout areas are separated from the magazine by flametight magazine doors. Compressed air is supplied by the ship's compressed air system at 4500 psi which can be reduced to 3250 psi with the aid of a reducer. A stream of such high pressure air can be fatal if directed at a person. A 500-psi nitrogen source is provided for the hydraulic fluid pumping unit. Figure 2-11 shows the checkout area portside, and depicts the checkout equipment and checkout station. The starboard checkout area is identical, but the test sets are used by both areas. The missile to be checked out is brought from the magazine by the reverse of the strikedown process, but in step-control only, not automatic. It is attached to the checkout car by means of a set of handling attachments. The blowout pipe and blowout pipe adapter are for the purpose of conducting away any dangerous gases in case of an accidental ignition. Connect the adapter to the missile (fig. 2-11). The booster is returned to the magazine while the missile is being given the checkout tests. The warhead, warhead booster, and fuze are placed in temporary storage lockers during maintenance on the missile. After successful completion of the tests, the booster is again mated to the missile and the complete round is stowed in the ready service ring. If the tests indicate NO GO, the round may be stored in the magazine to await repairs to the missile.

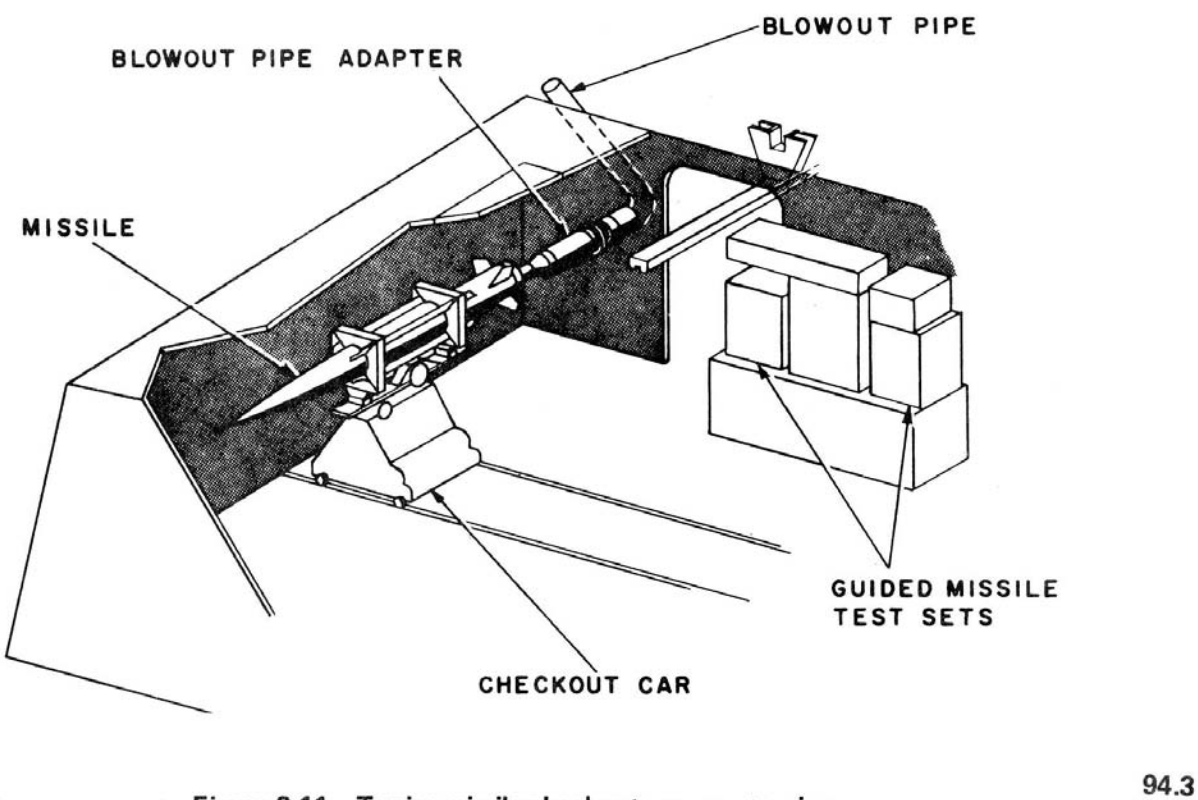

Figure 2-11.—Terrier missile checkout area on a cruiser.

When the booster is received above ship, the torque screw will be fully loosened and the adjustment nut will be fully tightened. This should again be the condition when missile and booster are separate for the checkout. When the missile is mated to the booster, the suitcase latch is closed, and the torque screw is tightened with 480 in-lb of torque. The clamp links should make contact with the ends of the pivot pin to ensure that the latch will not accidentally spring open under torque conditions, and possibly cause injury to personnel. Do not release the latch without first removing all torque from the torque screw. Keep the missile supported on the checkout car during the entire time. Do not use the locking ring to pull the sections together.

The missile-booster release mechanism is illustrated in *Gunner's Mate M (Missiles) 3&2*. NAVTRA 10199-B, where the suitcase latch is shown fully closed and fully opened.

Only the men necessary to perform the tests are permitted in the checkout area during the tests. During the charging of the missile air flask, only one man is permitted in the area, and he must remain behind a protective shield (if there is one) during the charging and for 5 minutes afterward.

REVISED RULES FOR CHECKOUT.- The trend is toward reduction in the number and complexity of tests for missiles and their components, especially after they have been tested at a depot and assembled. The interval between inspections and test has been greatly increased. Some missiles such as Tartar and Terrier are under a No-test program. This program requires no shipboard testing of a number of designated missiles. There are missile service records for each missile aboard ship. There service records indicate either a test or No-test program for each missile. A great deal of dependence is placed on careful inspections, careful handling, and controlled stowage temperatures and humidity requirements for No-test missiles.

ASSEMBLY AND DISASSEMBLY

The mating of the missile to the booster before stowing of the round, and the unmating for the checkout tests, are assembly and disassembly processes already mentioned. Wings and fins are assembled to the round prior to loading onto the launcher. Any additional assembly or disassembly or the missile is usually done at a repair activity. Assembly or disassembly of the handling and launching equipment is done as part of the maintenance and overhaul program, and will be discussed in another chapter.

Maintenance procedures are discussed in later chapters, especially in chapter 10.

If the Mk 22 Mod 0 warhead section of the Terrier BT-3A missile is received in a warhead container, it must be unpacked, given receipt inspection, and given a monitor test before it is assembled into the missile, and the missile is mated to the booster before stowing in the magazine. Spare' warheads are repackaged with desiccant and stored in the special warhead magazine.

Present practice is not to install the battery . power supply until ordered by the commander. This practice may be changed in the future. In anticipation of such a change, OP 2898 gives the instructions for installing the battery power supply and giving it a monitor test before the complete missile round is stowed in the magazine on shipboard.

TALOS MISSILE HANDLING AND STOWAGE (GMLS MK 12)

The handling procedures for Talos missiles include:

1. Transfer to ship, at sea transfer, or dock-side transfer, and depot or weapons station handling.
2. Strikedown of missiles, boosters, and complementary items
3. Checkout of missiles stowed in magazine and ready service areas
4. Ready service replenishment
5. Athwartship transfer

The methods of transfer are very similar to those for Terrier missiles. Areas of difference will be pointed out. An important difference between the Mk 7 and Mod 0 and Mk 12 Mod 0 Talos launching systems is the location of the magazines.

SHIPBOARD EQUIPMENT

Although some handling equipment is especially designed for the Talos missile, the method of use is very similar to that for Terrier handling equipment. The following shipboard equipment is used during transfer, strikedown, and prefiring operations.

1. Burtoning or automatic tension highline and highline gear
2. Strikedown elevators
3. Ready service cranes
4. Missile and booster carts (instead of checkout car)
5. Component handling hoist and associated gear
6. Warhead hoists
7. Component elevator and birail trolley hoists
8. Warhead magazine bridge crane
9. Receiving stand
10. Ready service magazine hoists
11. Ready service magazine trays
12. Magazine tray transfer mechanism.

Handling Equipment-Similarities and Differences

Missiles and boosters are received aboard ship, .. each in assembled condition, attached to the handling dollies by which they are transferred. Boosters and missiles are transferred by the constant-tension highline or burtoning, and the components are transferred by the housefall method. A floating crane is used for dock-side transfer. New construction ships may have a missile/Cargo Stream system installed for transfer at sea

As with the Terrier, Talos missiles and boosters must be transferred and struck down in sequence so they will arrive at the mating area in correct order. The sequence differs on CLGs and GGs. (Talos missiles and boosters may be stowed unmated.) On CLG 4 and 5, the order of transfer and strikedown for other components is not specified. Transfer dollies, innerbody, and wing and fin containers must be returned to the supply ship or depot if you do not have storage space. Other components are stowed in their containers, which are disposable.

A CLG has two missile strikedown elevators, one each, port and starboard of the deckhouse, which are used simultaneously during replenishment. The strikedown operation is the same on A and B sides of the deckhouse. Strike down on a CLG is described. Figure 2-12 shows the relative location of the areas used in strikedown and stowage.

Instead of a checkout car below the elevator, a missile cart or a booster cart is located on the elevator, and the missile or booster is attached to the cart. When the elevator has lowered, the cart can be rolled off onto tracks on the deck and moved to the station where it is needed for mating, stowage, or checkout. The carts differ principally in the method of securing and supporting the load.

Two warhead hoists travel on overhead birail tracks from the checkout areas in the deckhouse to the warhead strikedown hatch on the main deck. With adapters, the hoists are used to handle warheads, exercise heads, and innerbodies, which are stowed in the warhead magazine. These are the spares, which are not assembled in the round.

For the missiles and boosters that are to be mated into rounds, the after lenses, packaged and stored within the missile after section, must be removed prior to mating. The ready service crane is positioned over the mating station. The missile and the booster carts are brought on tracks to the mating area and are positioned. The missile cart is attached to the ram cylinder which produces the movements necessary for the mating, and the booster cart is secured to the handling track. After the missile and booster are mated, the ready service crane is used to raise the weapon, and the carts are returned. The operator at the pushbutton-station opens a magazine door, positions the crane over the magazine, and raises the hoist containing an empty magazine tray. He then lowers the round into the tray, and orders the hoist to a level in the magazine for stowing the tray and missile. When this is done, the magazine door is closed. As a GMM2 you were required to be able to man all stations; as a GMM1 and C, you need to be able to train individuals and teams in the operation of the system. The operator at the pushbutton station must be constantly alert so the missile' components will move smoothly to their destination in the proper magazine.

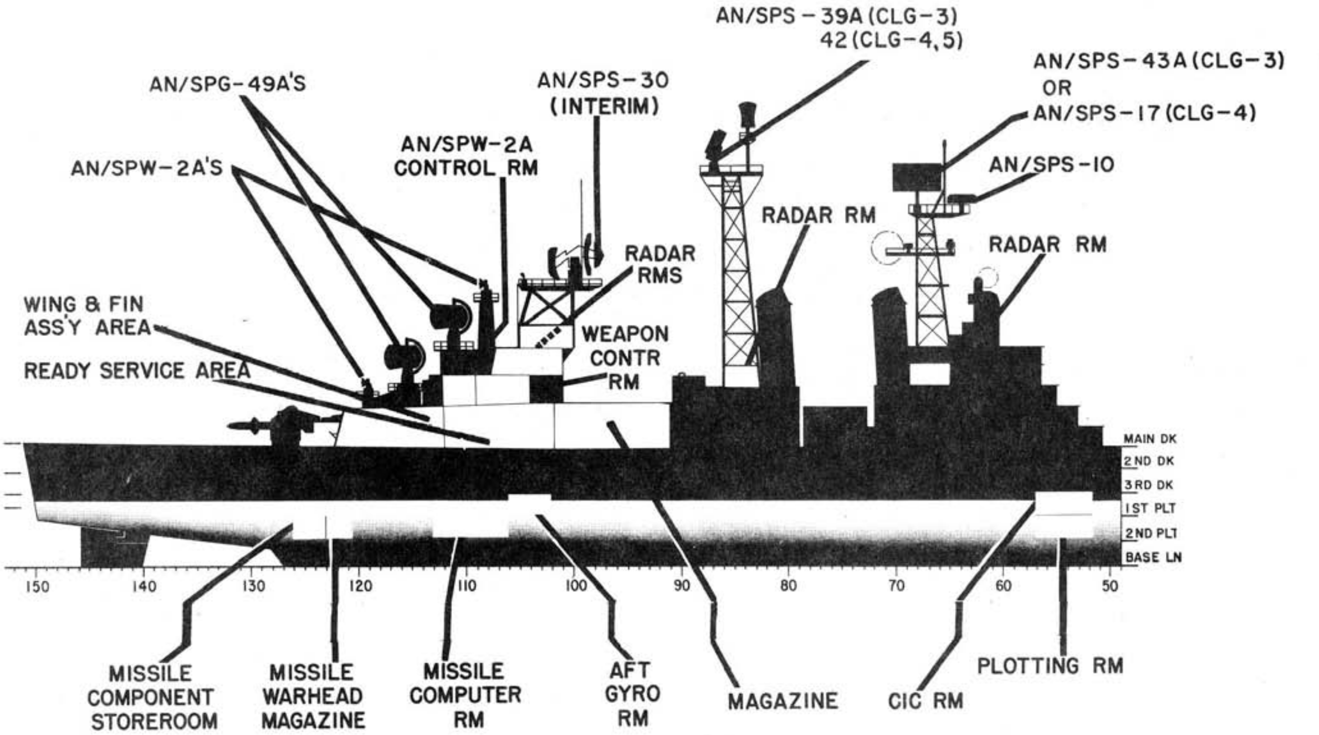

Figure 2-12.—Profile view showing location of missile handling and stowage areas.

The location of many of the equipments used in transfer and strikedown of Talos missiles on a CLG may be seen in figure 2-13. Locate the missile strikedown elevator, ready service crane, power cart, check out fixture, warhead hoist, and overhead crane.

The spare innerbody, which contains the warhead when assembled for tactical use, or a dummy warhead for exercises, is brought aboard in a container. It is struck below from the 02 level by means of the warhead strikedown hatch. Then the bottom part of the container is removed and the innerbody, supported in the upper part. of the container, is lowered in a vertical position to the second level by the component handling hoist. There it is placed on the receiving stand and secured to it. The container is returned to the 02 level. The receiving stand (there are two of them) is pneumatic-powered and has a built-in tilting mechanism so the innerbody can be rotated from vertical to horizontal position. The receiving stand moves inboard until it is adjacent to the elevator and-from there the innerbody is moved by the birail trolley hoist to the component elevator, which lowers it to the warhead magazine. Within the warhead magazine, a bridge crane is used to move the innerbody into position over the stowage chock, where it is positioned and fastened down. The receiving stand must be in position before the innerbody is lowered.

Different methods of stowing and securing warheads and innerbodies are used on different classes of ships.

Stowage Spaces

The spaces for stowing Talos missile components are very similar to those of the Terrier. If the ship has two sets of launchers, separate stowage facilities are provided for each. Replenishment is carried on simultaneously at both places. Whoever is in charge must make sure that the correct items are landed on the deck near the fore and aft strikedown elevators. The essential difference in handling and strike down between the Mk 12 launching system and the Mk 7 system (fig. 2-13) is that of location of the equipment and the stowage spaces.

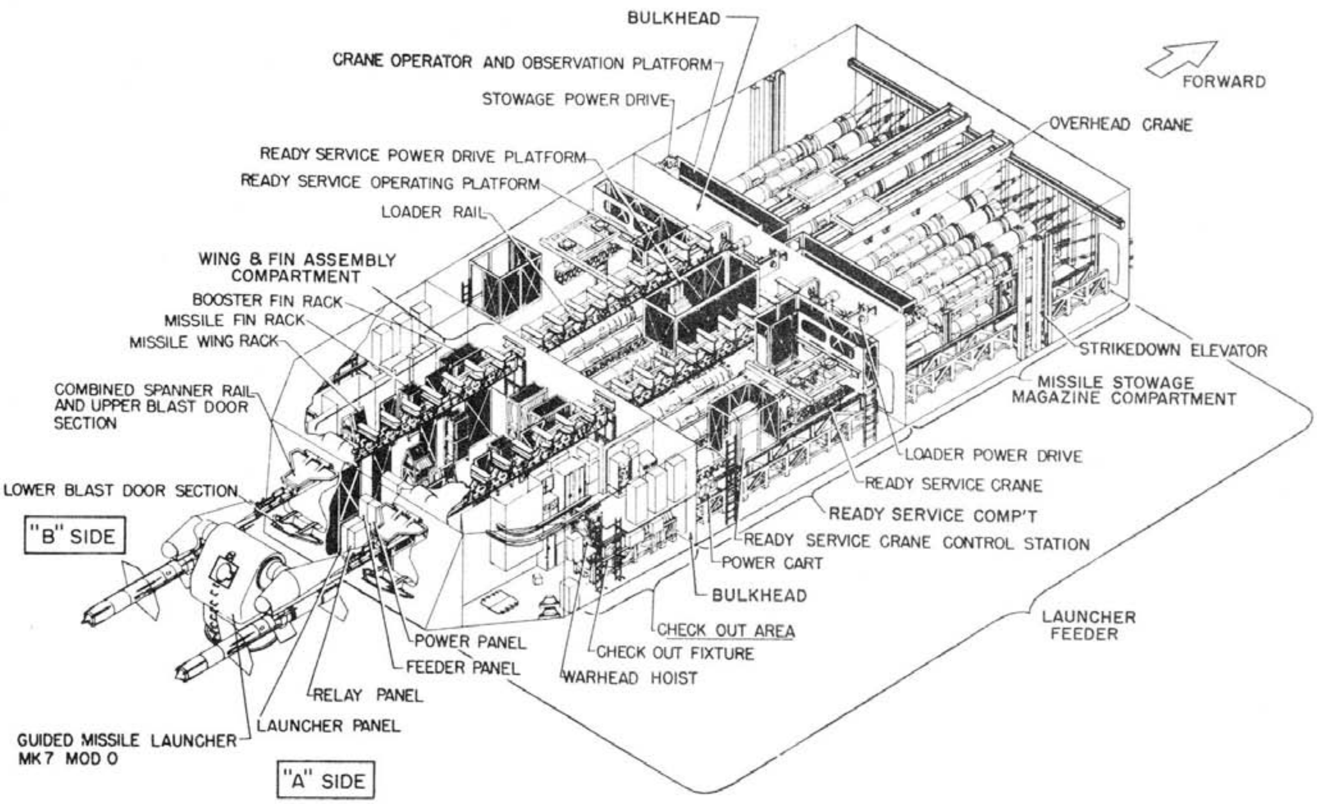

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Figure 2-13.—Cutaway view of deckhouse on a CLG, showing location of components of Talos launching system, Mk 7 Mod 0.

On a ship with forward and aft (Mk 12 Mod 0 and/or Mk 12 Mod 1) launching system installations, there are four strike down elevators, two for each installation. *Gunner's Mate M (Missiles) 3&2*, NAVTRA 10199-B has illustrations of the Mk 12 launching system, as does chapter 3 of this text. The deckhouse of the Mk 12 launching system is divided into area 1 and area 2. Area 1 is the assembler area, where the missile wings and missile and booster fins are stowed at strikedown and assembled preparatory to firing. It also contains some of the panels of the Missile Launching System Control-the power panels, the launcher control panel, assembly panels, and relay panel. Area 2 is directly over the belowdecks magazines. The remainder of the control panels are located here, and the mating area for mating missiles and boosters is here. The missile-booster combination is lowered to the magazine on the magazine hoist through the magazine door. Figure 2-14 shows the general location of the areas with respect to each other.

The A and B sides of the launcher are served from the A and B sides of the magazine, called the Mk 7 Mod 0 and Mk 7 Mod 1 magazines. Each magazine has a loader trunk, which passes through both area 1 and area 2 of the deckhouse, moving the missile-booster combination to the launcher when loading.

Complete descriptions of strikedown operations on particular ships are given in NAVSHIPS publications. For example: NAVSHIPS 378-0351, *Talos Handling and Stowage (Aboard USS Albany (CG-10), USS Chicago (CG-11), and USS Columbus (CG-12))*. Figure 2-12 shows the location of the various parts and areas of the Mk 7 launching system.

The Talos Mk 12 launching system does not have a ready service ring, nor does it have a second magazine to stow unmated missiles as does the Mk 7 system. The mated rounds are

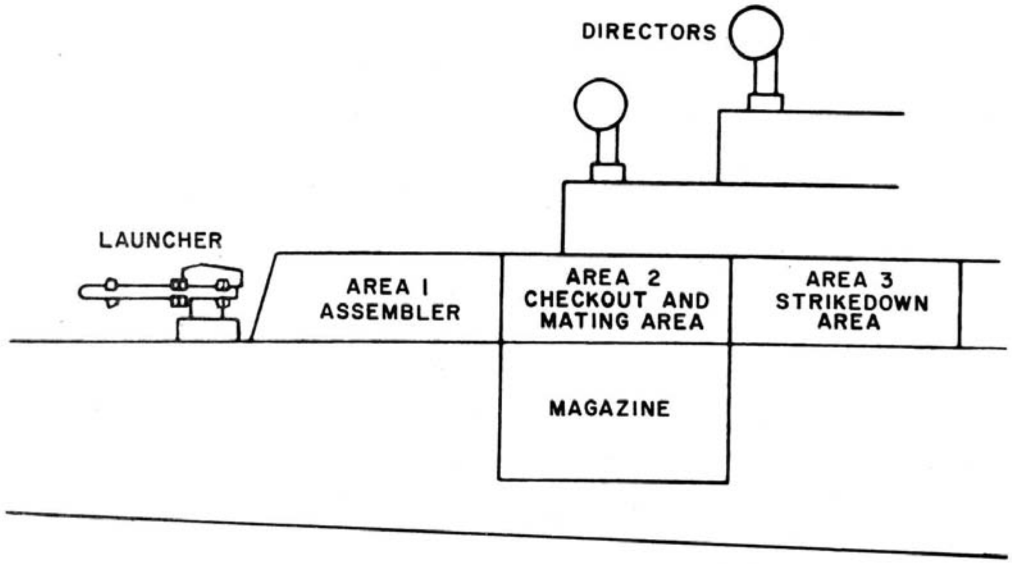

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Figure 2-14.—Location of areas occupied by GMLS Mk 12, with relation to each other.

stowed in trays in the magazine. Any unmated spares must be placed in magazine spaces designed for them.

MAGAZINES.-In the Mk 7 Mod 0 launching system the missile and booster and booster magazines are in the deckhouse, but the warhead" magazine and the components magazine are below decks, below the waterline of the ship. Each mating and checkout area (in the deckhouse) will hold one completely assembled weapon.

As you saw in figures 2-12, 2-13, and 2-14, the magazines may be located differently on different ships and for different missiles, and launching systems.

Blowout Patch or Vent.-Near the forward end of each magazine is a blowout plug or vent. Its purpose is to allow escape of gases in case of accidental ignition of the round, and thus prevent the terrific buildup of pressures that would otherwise result.

Wings, Fins, and Arming Plugs.- The wings and fins are removed from their containers and are stowed in racks in the wing and fin assembly area. Spare missile modules are stowed in the same area, as are the arming plugs (in locked boxes).

Batteries.- The missile batteries are of the nickel-cadmium type. The spare batteries are stored and charged or discharged in the missile battery shop, not in the ship's battery room. Some types of batteries are placed in locked storage and the key placed in the custody of the officer.

Antenna Lenses.-Missiles in ready service! stowage have the antenna lenses assembled into them. They are removed during missile checkout and are stowed in a locker provided for them. This locker is also used to stow spare guidance, homing, and beacon antenna lenses.

Ready Service.-Missile-booster combinations that have been checked out are moved into the ready service spaces. They do not have the wings, fins, or arming plugs installed.

HANDLING AND STOWAGE AT DEPOTS

At a depot, the weapon components may be received directly from the manufacturers, packaged in separate containers. Fork-lift trucks and other trucks can be used for much of the handling and moving of components. Missile components are assembled to form missiles, and: booster components are assembled into boosters The missiles and boosters are then packaged for stowage at the depot or for shipment. The components not assembled to form missiles and boosters (warheads, innerbodies, wings and fins, safing and arming plugs) are packaged separately. If not shipped to using activities, they are stored in different buildings. The buildings must meet the requirements set fourth in OP 5, Volume 1, *Ammunition and Explosives Ashore* for the stowage of ammunition of various kinds. You will need to check the condition of the buildings for compliance with the requirements. Nuclear warheads, for example, should be placed in air-conditioned buildings, with radiation and security alarms installed. They must be in buildings that can be adequately guarded. . If you have duty at a shore base, study OP 5 for the regulations that apply to the different explosive components of the weapons. OP 2540, *Containers and Association Handling Equipment for Talos Missile Mk 11, Mod 3, 4, and 5; Description, Operation, and Maintenance* (U), has the newest information on Talos containers and handling equipment.

As with Terrier missiles, most Talos missiles and components are handled at Naval Weapons Stations, of which there are six, rather than at depots.

TARTAR MISSILE HANDLING AND STOWAGE

Strikedown operation of Tartar missiles is the process of either onloading or offloading a missile. Onloading transfers a missile into the launching system; offloading transfers a missile out of the launching system. These operations involve not only launching system personnel and other crewmembers but also dockside crews, crewmembers of a second ship, or a helicopter crew.

The Tartar missile is brought aboard ship as a complete weapon. When transferred from dockside or from a barge, the missile is mounted in a transfer dolly. Instead of being struck below on an elevator as with Talos and Terrier, the missile is transferred from the transfer dolly to the launcher guide arm rail, figure 2-15. It is then struckdown (stowed) in a vertical position in the missile magazine beneath the launcher. When

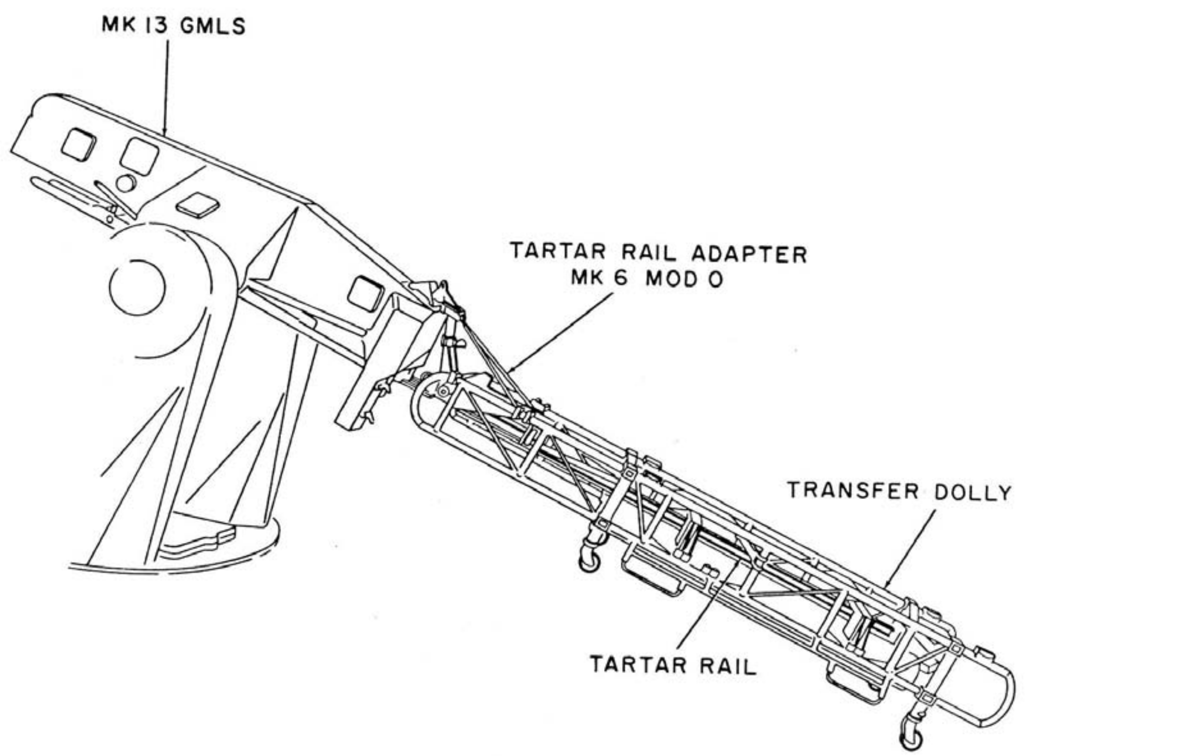

Figure 2-15.—Transfer dolly alined with Mk 13 GMLS.

handling Tartar missiles, particular care must be taken to avoid damage to the missile radome, to the target detection devices (TDD), and to the missile control surfaces.

When transferring Tartar missiles at sea by the Missile/Stream system, special deck handling equipment designed to contain and control the missile from sending ship to receiving ship has been installed on most Tartar missile ships. Deck handling is accomplished by either a Tartar Transfer Fixture, figure 2-16, or by Dolly/Loadbeam equipment Figure 2-17.

DECK HANDLING EQUIPMENT

The Tartar transfer fixture used on DEG's is a hydraulically powered portable unit bolted to the weather deck and is capable of onloading or offloading a Tartar missile from the receiver unit to the launcher, Fig. 2-16.

The combination dolly/loadbeam fixture used on DDG's is a track-guided, manually-powered handling system capable of onloading or offloading a missile from the receiver unit to the dolly, from the dolly to the loadbeam, and from the load beam to the launcher rail, fig. 2-17.

Strikedown Operation

For the launching system, strikedown operation begins with the crewmembers attaching the strike down equipment consisting of a chain drive fixture, a deck control box, and a manual air control valve and air supply lines. The chain drive fixture is attached to the front of the launcher guide arm, figure 2-17, whenever a transfer dolly or combination dolly/loadbeam deck handling equipment is used. The purpose of the chain drive fixture is to move a missile from the deck handling equipment onto or off the launcher guide arm. The chain drive fixture is a pneumatically operated unit controlled by a manually operated control valve. A crewmember operates the pneumatic control valve which determines the direction of chain drive movement for either on load or off load operations.

A portable electrical control box (figure 2-18), called the deck control box, is plugged into the launcher control system and is operated by personnel on deck (missile handling area) to control the movements of the launcher when mating the launcher with the deck handling equipment during strikedown operations. The deck control box is a manually operated switching unit contained in a metal box which has two handles, indicating lamps, and toggle switches, a cable attached to one end of the control box is plugged into a receptacle on the launcher stand or bulkhead. For training and elevating the launcher to a strikedown position, an operator uses the toggle switches on the deck control box which connect fixed position synchros in the launcher control system to position the launcher to a fixed load position for either port or starboard strikedown operations. For transferring the missile between the launcher rail and missile magazine, and operator at the EP-2 panel (Launcher System Control Panel) operates switches in either the step load or step unload mode of operation on orders from the launcher captain. The launcher captain operates the deck control box and orders missile movement for onload or offload operations whenever the launcher is in a position to transfer a missile between the launcher rail and missile magazine. The launcher captain is in charge of all strikedown operations.

The chain drive fixture is not used with launchers that employ the Tartar transfer fixture shown in figure 2-16. A built-in rammer chain unit which is a component of the transfer fixture is used to move the missile from the deck handling equipment to the launcher guide arm and serves the same purpose as the chain drive fixture. The location of the strikedown equipment in relation to the launcher is illustrated in Chapter 7 of this text. Chapter 7 illustrates and describes how the pneumatic chain drive fixture is used to transfer the missile during strikedown operations.

Tartar Missile-No-test Program

A technical evaluation project for the Improved Tartar missiles indicated that those Tartar missiles not tested by ships were in better condition and had a higher success rate than those that were tested aboard ship. In view of the foregoing all activities concerned have suspended shipboard testing of Improved Tartar missiles and all Tartar missile spare parts and test equipment is being deleted from. shipboard

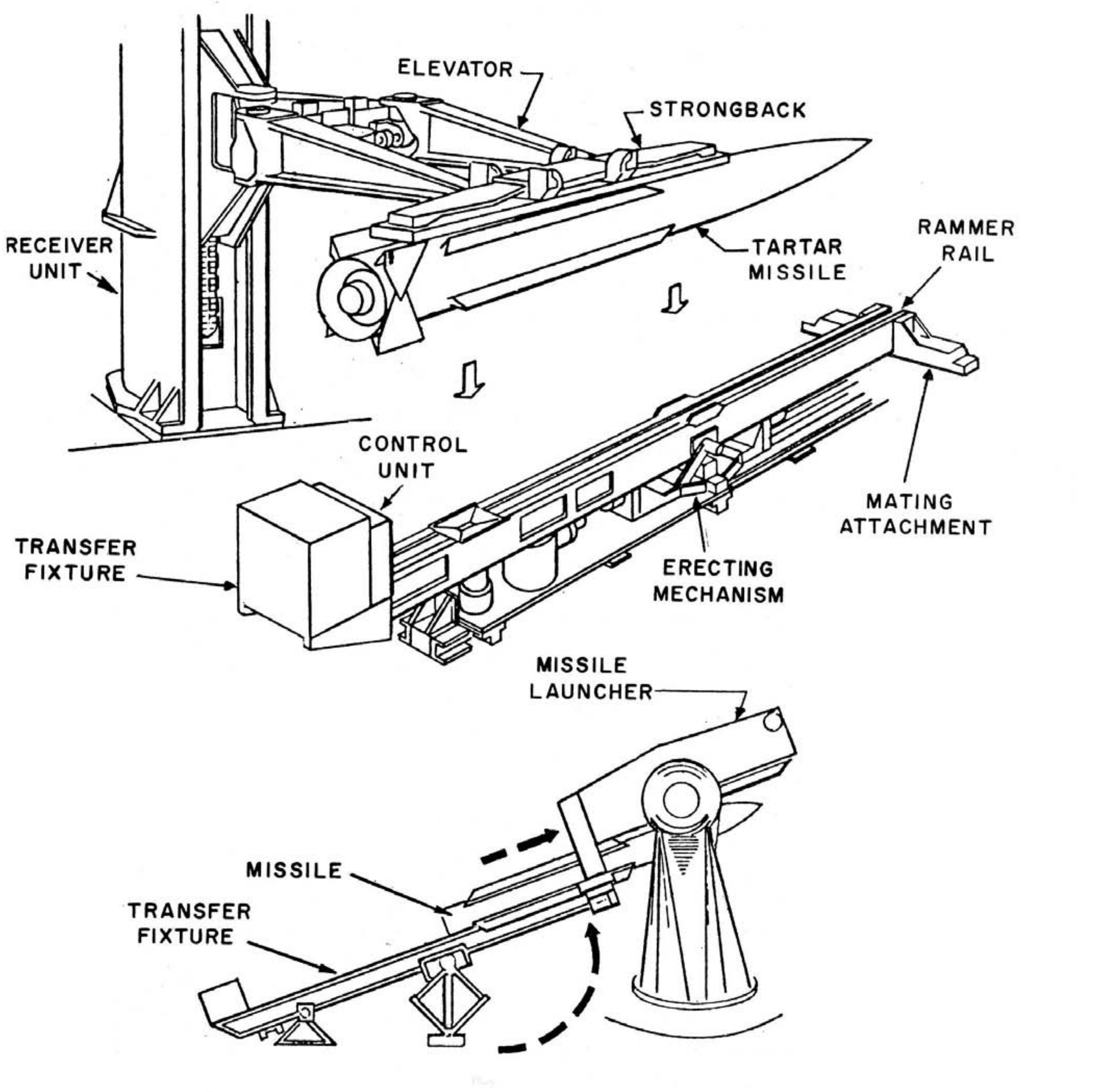

Figure 2-16.—Tartar transfer fixture.

allowance lists. Current NAVORD instructions limit shipboard testing of Tartar missiles to periodic external missile inspection. All missiles received aboard ship are now certified as reliable and require no test after being issued by a Naval Weapons Station.

It must be emphasized that the No-test concept places certified missiles in the magazine. They are to be fired, returned to a supply source, or jettisoned; the missiles are not to be taken apart, or repaired aboard a combatant ship.

Tartar Missile Safety Precautions

The Dual Thrust Rocket Motor (DTRM) is considered a class B explosive and should be handled accordingly. The DTRM produces an extremely hot exhaust blast and noxious gases. It is relatively safe when handled properly, but a

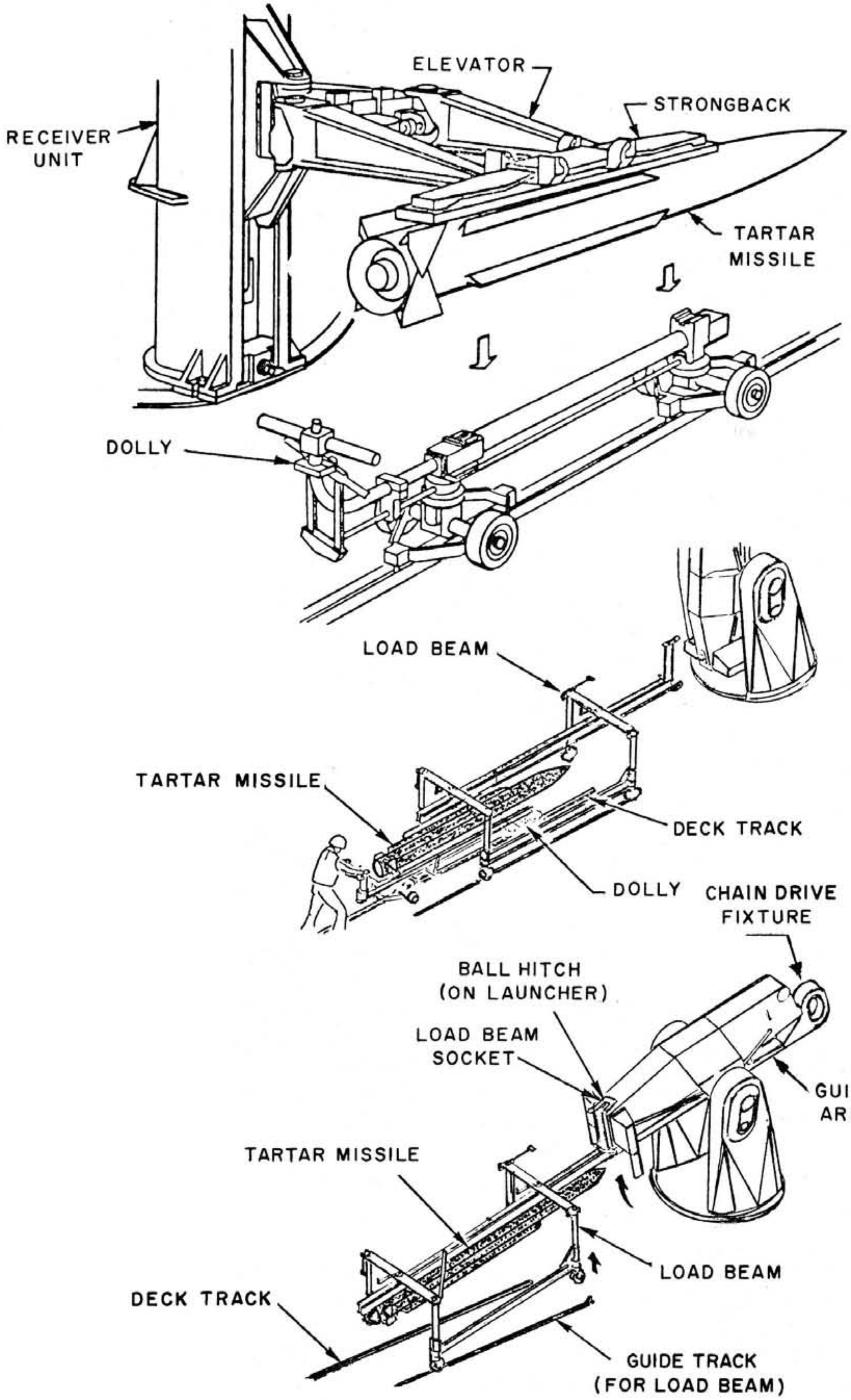

Figure 2-17.—Load beam and dolly.

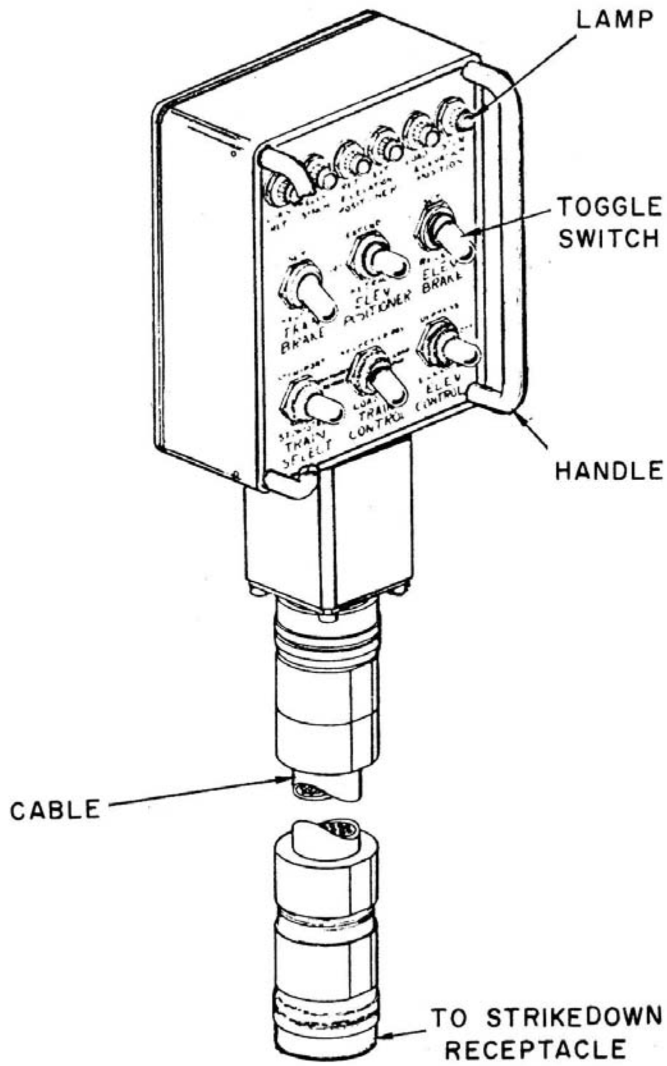

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Figure 2-18.—Deck control box and cable.

sharp blow could crack the propellant grain resulting in an explosion when the missile is fired. If the DTRM is found to be armed, manually move the arming lever to the SAFE position and request disposition and instructions from NAVORDSYSCOM.

Personnel shall keep clear of the area aft of the missile (DTRM area) at all times.

Because the missile contains electro-explosive devices (EEDS), observation of currently prescribed Hazards of Electro-magnetic Radiation to Ordnance (HERO) safety precautions during handling is mandatory.

Take all possible steps to protect all missiles from extremes of temperature, humidity, vibrations, electrical or magnetic fields, and radiological exposure. Exposure to any of these conditions, when excessive, may require disposal of the missile.

Upon receipt of the missile, a visual inspection shall be made to ensure that no physical damage has occurred during handling. This inspection is to determine if all sections are free of rust and corrosion, that all covers, plugs, tape, and decals are in place and secure, and that safety devices are in the SAFE position. When any abnormal conditions are indicated, the defective missile shall not be struck down, but shall be returned to the replenishing source.

Interlocks and warning bells are built into the handling system as safety features and are not to be bypassed or disregarded at any time except under emergency conditions. In the event that such devices are disabled or bypassed, adequate warning signs shall be posted to indicate that such a condition exists. Also, all applicable safety precautions shall be posted at each operating station of the handling system. Regular handling drills employing dummy or training missiles shall be held to ensure safe operations and improved individual proficiency. During drills, the officer-in-charge and leading chief shall carefully observe all operations which might create hazardous conditions and shall take the necessary corrective steps to alleviate them.

NUCLEAR WEAPONS HANDLING AND STOWAGE

Nuclear weapons used by the Navy may be bombs, torpedoes, missiles, depth charges, and projectiles. Rules for peacetime operation of nuclear weapon systems issued by the Chief of Naval Operations, along with official Naval Ordnance System Command special weapons checklists, are mandatory directives which must be followed.

The operation of each type of nuclear weapon is described in the applicable Special Weapons Ordnance Publications (Navy SWOPS). Nuclear weapons will be handled and stored in accordance with Navy SWOP 50-1 and SWOP's of the 20 series. No ammunition assemblies or components shall be disassembled or modified unless authorized by applicable technical instructions. Detailed safety precautions and considerations are prescribed in Navy SWOP 50-1.

Missiles that have nuclear warheads are . stowed in a ready service condition in the same missile magazine as those with conventional warheads and require no special handling or testing. The GMM that deals with any weapon must ensure that a proper storage condition is maintained. This ensures the reliability of the weapon and also guarantees personnel safety. As a leading GMM, it is essential that you have a thorough knowledge of the hazards concerned and the restrictions imposed on nuclear weapons. For this reason your main concern when dealing with a nuclear weapon is their security and protection.

Safeguarding Nuclear Weapons

Nuclear weapons require special protection because of their political and military importance, their destructiveness, and the attendant consequences of an unauthorized nuclear detonation. Procedures and responsibilities for the establishment of effective security measures are set forth in DOD directives and implemented by the using agencies. The Navy's security program is outlined in OPNAV Instruction 05510.83B, Criteria and Standards for Safeguarding Nuclear Weapons. This instruction is the basis for determining the minimum necessary requirements for all nuclear weapons in Navy custody. It may be augmented by additional security measures as deemed necessary by local commanders.

This section outlines the basic requirements for safeguarding nuclear weapons in the Navy, and is not intended to include all of the local area commander's requirements. .It is your responsibility as a senior petty officer to keep informed of the security requirements of your activity.

Definitions

The definitions that follow are used throughout the Navy in conjunction with nuclear weapons. Navy SWOP 4-1 is the approved source for definitions other than those in OPNAVINST 05510.83B.

Access: As applied to nuclear weapons, access means physical proximity in such a manner as to allow the opportunity to cause a nuclear detonation. (Whenever the word access appears in the nuclear weapons program, only this meaning will apply.) Access should not be confused with entrance.

Technical Knowledge: That knowledge, however obtained, required to cause a nuclear detonation.

Critical Position: One in which the incumbent has (1) technical knowledge of nuclear weapons, and (2) access to nuclear weapons.

Limited Position: One in which the incumbent could acquire both knowledge and access.

Controlled Position: One in which the incumbent is performing duties physically associated with nuclear weapons, but does not require technical knowledge of, nor access to, nuclear weapons.

Exclusion area: The designated area containing one or more nuclear weapons.

Limited Area: The designated area surrounding one or more exclusion areas.

Two-Man Rule

No other single area identifies more with the spirit and intent of the nuclear safety and security program than the two-man rule. All personnel working with nuclear weapons should read and understand this rule, which is explained in GMM 3&2, NAVTRA 10199.

Entry and Access Control

Entry control to limited and/or exclusion areas is formalized and maintained to ensure positive identification of personnel prior to admission. An exchange badge system, entry control rosters, visitor escorts, and a duress system are employed.

Unauthorized actions by persons with approved access to nuclear weapons is one of the threats to nuclear weapons. Therefore, entrance to exclusion areas containing nuclear weapons is restricted to properly cleared personnel who have a positive need for access, or to personnel who have to enter a space containing nuclear weapons during the course of their duties. Only persons authorized by the commanding officer can be admitted to exclusion areas. Limited area access may be authorized by the commanding officer's designated representative.

When projects in a limited and/or exclusion area require the presence of personnel not cleared for normal entry, such persons are kept under constant escort by the security force or supplementary personnel. Their movements are limited to only those necessary for the performance of assigned tasks. A log of persons entering and leaving exclusion areas is kept and maintained locally for a period of at least 2 years.

In those spaces in which nuclear weapons are stored and manned by only two men, all openings and entrances to those spaces (other than those in use) must be locked and alarmed. The unlocked entrance(s) are guarded by an armed guard who also controls entrance to the spaces.

When transporting nuclear weapons from one area aboard ship to another, an appropriately armed guard accompanies the personnel loading, handling, or transporting the weapon.

Once working hours commence and the exclusion area is entered by two authorized persons, the responsibility for maintaining the two rule rests with the senior man present. No one individual is allowed to remain in the exclusion area alone.

SAFETY STANDARDS

Safety rules are issued for every nuclear weapon system. These rules are to be followed in peacetime and wartime, when possible. All safety rules are applied against the four safety standards.

All hands must take positive measures to prevent weapons involved in accidents or incidents, or jettisoned weapons, from producing a nuclear. yield.

Also take positive measures to prevent deliberate arming, launching, firing, or releasing except upon lawful orders.

Positive measures must be taken to prevent inadvertent arming, launching, firing, or releasing, and provide adequate security.

Handling Precautions

The best handling equipment designed is only as good and as safe as the personnel who operate it. With nuclear weapons, it is imperative that you know the type material you are handling and its hazards; further, you must know the capabilities and limitations of the equipment you are using when handling the weapons.

When using hoisting equipment in handling nuclear weapons, it should never be loaded in excess of its rated capacity. No piece of handling equipment should be used for other than its intended purposes. When elevated loads are moved horizontally on a monorail, sudden stops or starts must be avoided. Remove any obstructions from the path of the load.. Never raise weapons higher or let them remain suspended longer than is absolutely necessary to complete the required handling operation.

PERSONNEL

All personnel assigned to work with nuclear weapons must receive special training in the handling, storage, and, a accounting methods of nuclear weapons. Prior to such training they must possess at least a secret clearance based on a background investigation. Only properly cleared personnel who have need for access to spaces containing nuclear weapons will be allowed entry to these spaces. Only personnel of demonstrated reliability and stability as outlined in BUPERINST 5510.11 A, Criteria and Standards for Personnel Assigned to Duties Involving Nuclear Weapons, will be assigned to this type duty.

Human Reliability Program

The human reliability program is aimed at all personnel who control, handle, have access to, or control access to nuclear weapons or nuclear weapons systems. The program covers selection, screening, and continuous evaluation of the personnel assigned to various nuclear duties. The program seeks to ensure that personnel coming under its purview are mentally and emotionally stable and reliable.

Alarm and Warning Systems

Numerous alarm and warning signals are installed on ships with nuclear weapon spaces. Some are audible alarms, such as bells and buzzers; others are warning lights. Some are connected to all parts of the ship, and others only to certain spaces. The nuclear weapons stowage spaces have warning signals for high temperature and security.

The operation of security alarms and warning signals can be mechanically operated switches or pushbuttons activated by the opening of access doors and/or hatches to nuclear weapons spaces. Alarm panels used for security alarm systems are located in ship's areas that normally are manned at sea and inport such as quarter deck areas and damage control central. When the alarm panels include entry into a nuclear weapons space, special security forces are alerted to safe-guard nuclear weapons and components.

Ventilation In Nuclear Weapons Spaces

On most ships with nuclear weapons spaces, the ventilation system for those spaces is not connected to the system that services other parts of the ship. The reason for this arrangement is that, in the event of a nuclear accident, radioactive particles will not be carried from nuclear weapons spaces through the ventilation system into other living or working spaces.

Circulation of air in nuclear weapon spaces is provided by distribution ducts and fans. Stale air is taken out through exhaust ducts. It is necessary to keep exhaust systems running at all times, even though areas are not occupied. The ventilation weather openings should be kept open as long as possible, even in rough weather, to permit ventilation with outside air.

HANDLING AND STOWAGE OF OTHER MISSILES

Missile magazines in aircraft carriers generally are located below the water line and within the ship's armor belt. For ease in handling of missile components, these magazines contain power operated handling equipment such as electrical, hydraulic, or pneumatic hoists, trolleys, etc. To provide adequate and continuous surveillance in magazines containing certain missiles, and to provide assurance that a specific hazard is not actively present, these magazines are equipped with special detection equipment.

Aboard most aircraft carriers the handling, stowage, and assembly of aircraft launched missiles is the responsibility of personnel in the Aviation Ordnancemen rate. Some carriers split this responsibility and utilize personnel in GMG and GMM rates for the maintenance of storage magazines and some missile handling equipment.

The movements of aircraft ammunition and explosives between the magazine areas and aircraft involve specific handling and assembling functions that are controlled by areas designed for a specific purpose. Two of these areas, the magazine or stowage area and the delivery assembly area, are of interest to personnel of the GMM rating assigned to the ship's armory aboard a carrier.

Handling Areas

The magazine, or stowage area, is the location with fixed installations designed for stowage of all the various types of aircraft ammunition.

The delivery assembly area is the location aboard carriers where the various components of ammunition are delivered for assembly into complete weapons for use on aircraft.

Since the assembly, testing, and arming of aircraft launched missiles are the duties of the Aviation Ordnanceman, the GMM assigned to the ship's armory has the primary duties of ensuring that all components of aircraft launched missiles are properly stowed and maintained in a state of readiness at all times. He may also be called upon to supply the various components of aircraft launched missiles to personnel in the delivery assembly area where the missiles are assembled for use or transfer to ready service areas. If you are charged with the responsibility of stowage magazines and the transfer of rocket and missile components, you should thoroughly familiarize yourself with the practical methods or safe handling and stowage of such items. Listed below are some safety precautions to be observed when handling rockets and guided missiles.

Firing temperature limits specified for each missile must be observed for safe operation. If a missile is exposed outside of temperature limits stenciled on the unit, it should be set aside and handled in accordance with current instructions.

Continued exposure to abnormal stowage temperatures which may cause the propellant to deteriorate, with attendant hazards of possible explosion when the rocket is fired.

Rough handling or blows which may break the propellant grain thus exposing too much surface to burning and leading to possible excessive pressure in the motor. Excessive pressures may cause the motor to explode when fired.

STANDARD MISSILE

Standard Missiles, RIM-66A, RIM-66B, and RIM-67A, are surface launched, supersonic guided missiles which may be used against surface or airborne targets. RIM-66A and RIM-66B are medium range (MR) missiles employed aboard guided missile ships having Tartar Fire Control Systems. RIM-67A is an extended range (ER) missile employed aboard guided missile ships having Terrier Fire Control Systems.

The MR missile is propelled by a solid fuel dual-thrust rocket motor (DTRM) which provides short duration high thrust for the initial or boost flight period, and long duration low thrust for the remainder of the propelled flight.

The ER missile is propelled from a launcher by a solid fuel booster rocket which provides short duration high thrust for a boost flight period. Separation of the booster results in ignition of a solid-fuel sustainer rocket which supplies long duration long thrust energy for the remainder of the flight.

Standard Missile Handling

The Standard MR missile and its components are shipped and stowed in the same type containers as the Tartar missile. The handling equipment and procedures for loadout, offload, underway replenishment, and stowage are identical for the Standard MR and Tartar missiles.

The Standard ER missile and its components are shipped and stowed in the same type containers as the Terrier missile. The handling equipment and procedures for loadout, offload, underway replenishment, and stowage are identical for the Standard ER and Terrier missile.

Special Handling Procedures for Standard

Power for the Standard Missile is supplied by a squibactivated primary battery. This battery will generate gas, when activated, requiring the following special handling procedure whenever the battery is activated or a misfire occurs:

Allow approximately four hours for battery temperature to return to normal.

Inspect the battery vent port (forward of the dorsal fin) to determine if temperature has cooled sufficiently to work safely.

Clean up any vented electrolyte (potassium hydroxide, a caustic alkali). Do not allow the electrolyte to contact body or clothing. If it does, immediately flush the contaminated area with large quantities of vinegar and water or fresh water.

After cooling and cleanup, replace the missile battery vent port plug and return the missile to the magazine for future offloading.

If, during missile handling or firing exercises, black smoke appears from the battery vent port, the missile should be jettisoned immediately. Black smoke indicates a missile battery fire. The appearance of white steam from the missile vent port is due to the battery venting and should not be mistaken for a battery fire within the missile.

Make sure that the DTRM igniter arming level (Standard MR) and the sustainer arming indicator (Standard ER) are in the SAFE position prior to and during handling operations.

CHAPTER 3

MISSILE LAUNCHING SYSTEMS

The last chapter dealt with the parts of the ship's missile system that were used in handling and storing the weapons. You already know a good deal about launching systems from study and experience. What additional information or skills must you gain to qualify as a GMM 1 and C? Look at the quals that apply to the missile launcher system.

Notice that most of the knowledge factors are placed at the GMM 3 level. In the practical factors, note that the GMM 3 must be able to make operational tests. To advance to GMM 2, you had to be able to man any station in the launching system on your ship, use special test equipment, interpret the test results, and record and report the results. You learned to inspect and disassemble, clean, lubricate, and reassemble many of the launching system components, and the missile handling and dud-jettisoning equipment.

Now you must be able to train individuals and teams in the operation of the launching systems on your ship. If there is more than one type of system on your ship, you have to train on ALL of them. You must learn to perform ALL tests of the equipment and to locate trouble in any part. Overhaul, repair, and adjustment of all mechanical, electrical, electronic, and hydraulic equipment in the missile launching systems are part of the job of the GMM 1I and C. As you are aware, that includes a large array of complicated equipment,

Not only must you be able to do all these different kinds of work, but you must be able to teach others, to plan programs for getting the work done, and to conduct classes to carry out the programs. Planning of work and supervision of men doing the work will be important parts of your job.

PREPARATION OF LAUNCHER FOR FIRING

Practice sessions in preparing a launcher for firing are necessary to develop coordination, speed, and skill in carrying out the steps in order. Rotate the men to different positions so each man can be come proficient in the different operations. This is cross-training, described in chapter 1. Shifting the men to different positions undoubtedly will slow down the team for the time being, but it is much more valuable training than training each man to become an expert at only one position. Each man should be able to take over any other position in an emergency.

The types of missile launchers and their major components were described in *Gunner's Mate M (Missiles) 3&2*, NAVTRA 10199 and additional information is given in this course. The care and 'repair of launching systems are discussed in chapter 10, on maintenance. It is assumed that all checks and tests required after repair or maintenance have been performed and the launching system is ready for firing a missile. Tests and checkoffs to be performed in the process of preparing for a firing or firing exercise are given some attention in this chapter but are described more specifically in chapter 10. Alignment of missile batteries is covered in chapter 9.

Although different missile systems differ in the details of preparation of the launcher for firing, the general steps in the operation of the system are very similar. For the missile system these steps are:

1. Search radar detection
2. Fire control radar tracking
3. Missile launching
4. Guidance and target intercept

Your special concern is with the third step, but you need to have some knowledge of how the whole system operates, so the work will be coordinated. This knowledge will also help you in operating control stations. Figure 3-1 shows the main components at different stations of a Terrier weapons system on a DLG, and the flow of information and instructions among the components.

When a target is detected by the ship's search radars (or sonar), radar information concerning the target's range, azimuth, and height is supplied to the ship's Combat Information Center (CIC). The data is evaluated in CIC and the target (or targets) assigned to the Weapons Control Station (WCS). Further target evaluation is made by WCS and a director radar is assigned to track the target. If the target is considered to be an enemy, General Quarters is sounded and all men take their stations. Power is turned on to activate the system. The Launching System Captain activates the EP-I power panel and takes his station at the EP-2 (Launcher Captain's) panel. Decisions as to the type of weapon to use and, if and/or, when to fire are made by the Antiaircraft Warfare Commander on the basis of information from CIC and WCS, and the decisions are relayed to the various control stations of the weapons system. The operators of the control panels push the buttons to set in operation the mechanisms to carry out the decisions.

NTDS/WDS

A newer and more advanced Terrier guided missile weapon system installed on the DLG's consists of Naval Tactical Data System/Weapon

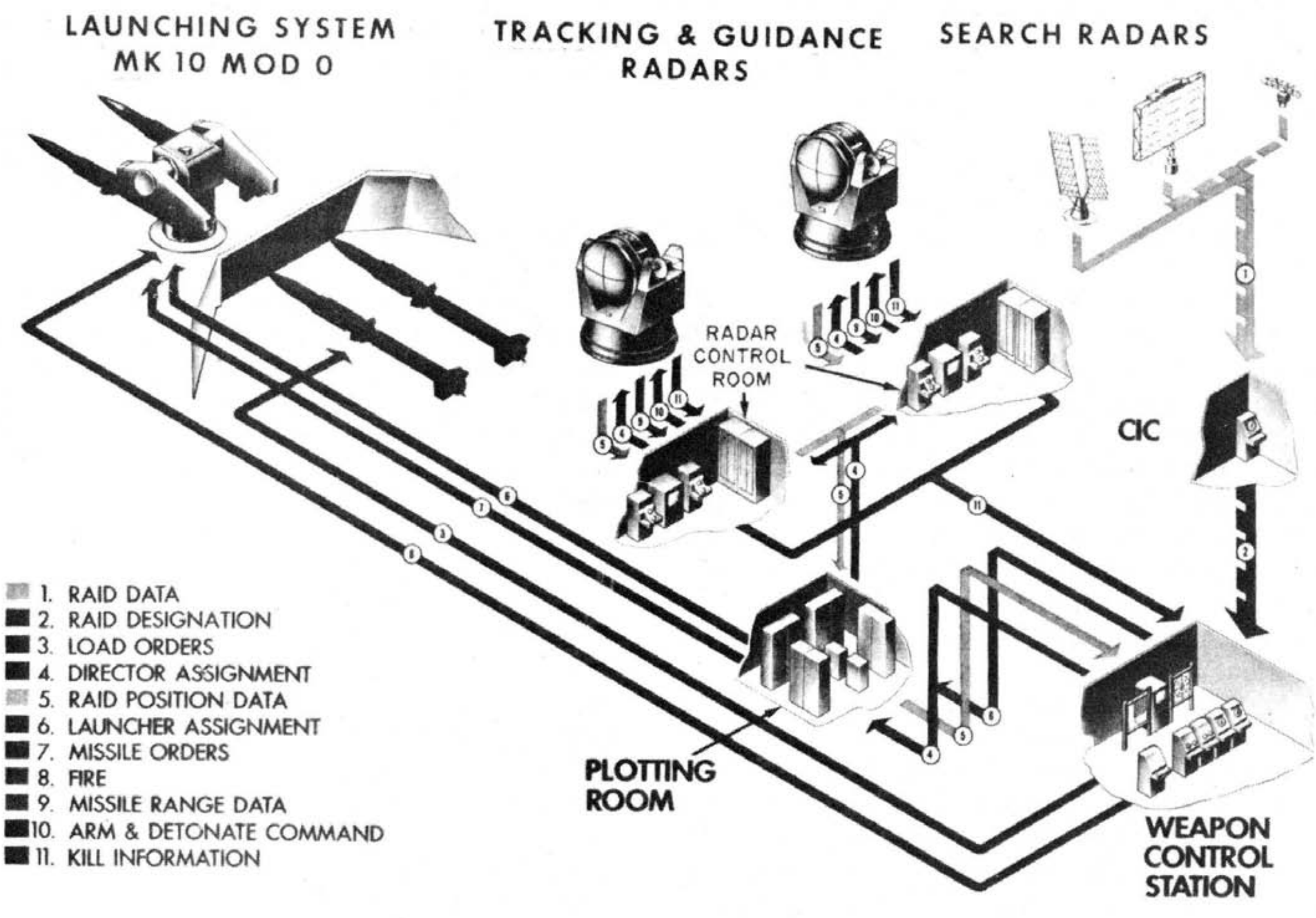

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Figure 3-1.—Terrier weapon system on a DLG; flow of information and directions.

Direction System (NTDS/WDS). The NTDS/WDS is a high speed digital data processing, display and communication system that provides for a more effective fleetwide defense against all types of enemy targets encountered at sea. Target information can be received from and transmitted to remotely located units of the fleet. NTDS/WDS is the primary source of target assignment and target tracking is accomplished using the NTDS/WDS displays. If a particular target is to be engaged, the WDS is assigned. The NTDS/WDS comprises data processing equipment, data display equipment, and data transmission and communication equipment which are located within the CIC area.

MANNING THE CONTROL PANELS

As a GMM 2 you had to be able to take over the operation of any of the launcher control panels; to advance to GMM 1 and C you should be able to supervise the panel operators and teach others the panel operation techniques. The number and types of panels vary with the system and the names may differ, but all systems have at least three types (table 3-1):

1. Power panels
2. System control or launcher captain's panel
3. Test panels

Older systems have many small control panels for control of components of the system. In newer mods, the tendency is to enclose several panels in two or three large panels (table 3-1). This requites fewer operators but the operators must. be alert to many things. The small individual panels are used mostly for unloading and maintenance.

The dud-jettisoning panel is associated with the launching system controls. It is discussed in the next chapter.

Power Panels

All launching systems have one or more power panels by which the system is connected to ship's power. Some, such as the Mk 12 launching system, have separate power panels for the launcher and feeder components. All the electrical power is supplied from the ship's electrical system, but the voltage has to be stepped down for many applications. The power panel contains circuit breakers, contactors, and overload relays for the launcher power drives, missile warmup, train and elevation motors, blower motors, and loaders and/or feeders.

In automatic operation, the power panels usually are activated from the launcher captain's station. In step Qperation, which is used for strike down for stowage, strikeup for checkout, unloading the launcher, or loading the launcher, some of the power panels are activated from other control stations.

Launcher Captain's Panel

Figure 3-2 shows one type of launcher control panel. The launcher control panel will vary with the mark and mod of the launching system, the type of shipboard installation, and other factors, so it is not possible to tell you just which buttons to push. After you have turned on the power, set the EP-2 panel (EP-3 on the Mk 11 launching system) on STANDBY and watch and listen for signals that will indicate what to do next. An ALERT signal from the weapons control station will cause a flashing signal on all the launcher system panels and also will give an audible signal. When all the panel operators have set their panels on READY, the signal goes to the launcher captain's panel; he then sets his panel on READY, and this signals WCS that all parts of his launcher system are ready.

Four types of orders are transmitted from the weapons control station to the launching system, and these go through the launcher captain's panel:

1. Missile order-determines the type of round(s) to be loaded
2. Load select order-distinguishes between simultaneous operation of "A" and "B" sides or separate operation of either side
3. Loading order-distinguishes between hold, single, or continuous loading of the type missile ordered .
4. Unloading order-distinguishes between "unload launcher" or "unload assembly area"

Gene Slover's US Navy Pages
Phil Hays' Talos Missile Page
Table of Contents

Table 3-1.—Launching Systems

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PARTS OF LAUNCHING SYSTEM	TALOS MARK 7 MOD 0	TALOS MARK 12 MOD 0	TALOS MARK 12 MOD 1	TERRIER MK 9 Mod 0	TERRIER MARK 10 Mod 0	TERRIER MARK 10 Mods 1 & 2	TERRIER MARK 10 Mods 3 & 4	TERRIER MARK 10 Mods 5 & 6	TERRIER MARK 10 Mods 7 & 8	TARTAR MARK 11 Mod 0	TARTAR MARK 11 Mod 1	TARTAR MARK 11 Mod 2	TARTAR MARK 13 MOD 0	TARTAR MARK 13 Mods 1, 2, 3	TARTAR MARK 22 Mod 0
	Mk-Mod	Mk-Mod	Mk-Mod	Mk-Mod	Mk-Mod	Mk-Mods	Mk-Mod	Mk-Mod	Mk-Mod	Mk-Mod	Mk-Mod	Mk-Mod	Mk-Mod	Mk Mod	Mk-Mod
1. LAUNCHER	7 0	7 0	7 1	5 2	5 3	5 4,5	5 6	5 7	5 8,9	8 0	8 1	8 2	116 0	126 1	123 0
a. Stand	5 0	5 0	5 0	3 0	3 1	3 1,2	3 1	3 2	3 2	6 0	6 1	6 2			
b. Carriage	5 0	5 0	5 1	3 1	3 2	3 2	3 2	3 3	3 3	6 0	6 1	6 2	8 0		9 0
c. Guide	5 0	5 1	5 1	3 2	3 3	3 4,5	3 4	3 4,5	3 6,7	6 0			8 0	113 0	8 0
d. Power drive, train	50 1	50 2	50 2	46 0	46 1	46 1	46 1	46 1	46 1	55 0			65 0	65 1	67 0
e. Power drive, elevation	50 1	50 2	50 2	46 0	46 1	46 1	46 1	46 1	46 1	56 0			66 0	66 1	68 0
f. Slipring assembly	6 0	6 1		4 0	4 2	4 2	4 2	4 2	4 2	8 0					
g. Emergency igniters		1 0													
2. LAUNCHER FEEDER	6 0	11 0	11 0	9 0	10 2	10 1,2	10 3,4	10 5,6	10 7,8						9 0
a. Magazine "A" side	2 0	7 0	7 0	4 0	5 0	5 2	5 6,8	5 10,12	5 12	6 0	6 1	6 2	8 0	108 mods 1,2,3	9 0
"B" side	2 1	7 1	7 1	4 1	5 1	5 3	5 7,9	5 11,13	5 13 C 14						
b. Loader					8 0										
"A" side	5 0	5 2	5 2	7 0	8 0,1	8 2,3	8 6,8	8 10,12,14	8 14,16						
"B" side	5 1	5 3	5 3	7 1		8 4,5	8 7,9	8 11,13,15	8 15,17						
c. Assembler	5 0	9 0	9 0	4 1	8 0	8 1,2	8 3,4	8 5,6	8 6						
d. Feeder	6 0	11 0		9 1	10 0	10, 1,2	10 3,4	10 5,6	10 7,8						
3. SYSTEMS CONTROL	5 0	10 0	10 1	7 0	8 0	8 1,2	8 3,4	8 5,6,7	8 7,8	9 0	9 1	9 1	13 0	13 1	21 0
a. Power panel	163 0 164 0	163 1 164 1	163 1 164 1 EP-1A&B	180 1	193 0	193 0,2 EP-1	193 3 (2 of these)		193 1 EP-1	208 0 EP-1	208 0	208 1 EP-1	253 0 EP-1	EP-1	EP-1
b. Launcher panel	165 0	EP-2 201 0	201 0 EP-2	EP-2 179 0	190 0	EP-2 190 1,2	190 3,4		190 8 EP-2	204 1 EP-3	204 1	204 1 EP-3	254 0 EP-2	EP-2	
c. Amplifier panel				181 0											
d. Feeder panel	166 0 EP-3		203 0 EP-3	EP-3 182 0					191 0 EP-3						
e. Feeder power panel				183 0											
f. Loader panel		239 0 239 1	239 0,1 EP-9 & 10 Local Cont.	185 0,1						206 1 EP-2	206 1	206 1 EP-2			
g. Loader power panel				186 0,1											
h. Assembler panel	167 0,1 EP-4 & 5	167 2,3 A&B side	167 2,3 EP-4 & 5	184 0,1	192 0,1	192 2,4 EP-4 192 3,5 EP-5	192 6.8 192 7,9		192 0 EP-4 192 1 EP-5						
i. Ready service panel	168 0,1 EP-6 & 7														
j. Power relay panel	169 0 EP-8	169 1 EP-8													
k. Relay control panel			169 1 EP-8							205 1, 2 RC 1, 2, 3	205	205 0,2,3 RC 1,2,3			
l. Test panel	187 0 EP-9	203 0 EP-3	203 0 EP-3	EP-12	191 0	EP-3 191 0	191 0 (2 of these)	191 0	191 0				255 0 EP-3 Incl. Local Cont.	EP-3	EP-3
m. Magazine control panel			173 0,1 EP-6 & 7												
n. Magazine loading indicator										209 0 IP-1	209 0	209 0 IP-1			
o. Missile latch indicator										210 0 IP-2	210 0	210 0 IP-2			
p. Local control panel										211 0 EP-5	211 0	211 0			
q. Hoist local control		240 0,1 EP-11 & 12	240 0,1 EP-11 & 12												
4. DUD JETTISON UNIT				107 0,1 EP-12	108 0	Not part of control system			108 0	109 0	109 0	109 0		nitrogen booster pump added	Part of guide

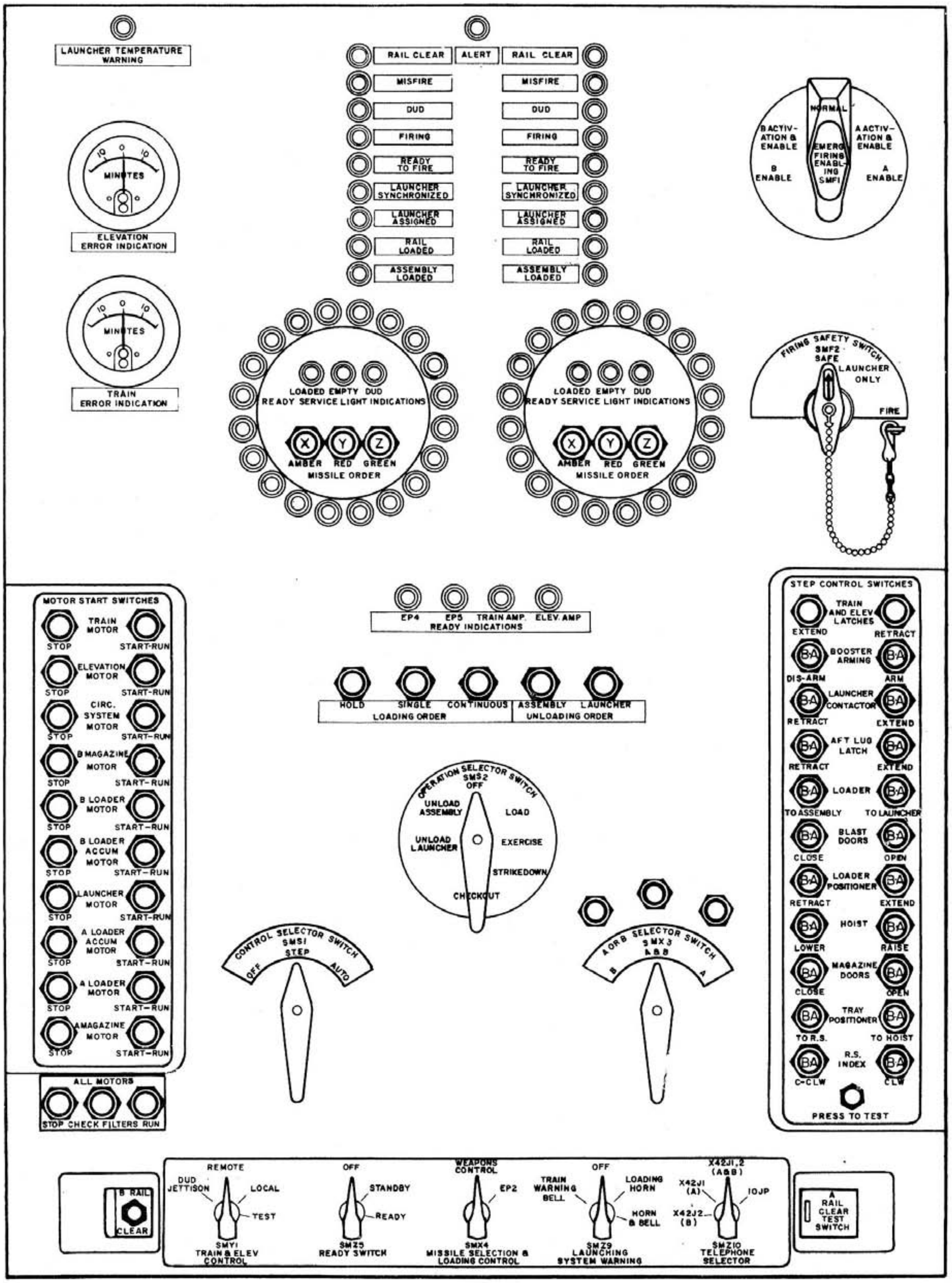

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Figure 3-2.—Launcher control panel, EP-2, for Terrier weapon system Mk 10.

Pushing the correct buttons on the panels causes the launching system to load automatically the type of round ordered. A few manual operations are required, and these differ with the type of round. For example, the Terrier BT -3A(N) requires actuation of the warhead manual disabling safety switch. All Terrier rounds require installation of aerodynamic surfaces (wings and fins), followed by operation of the safety foot (or hand) switch by each assembler at his station.

MISSILE ORDER.-The type of round(s) to be loaded will be ordered by the WCS when the system is activated. Although verbal orders may be given in some systems, the order is usually indicated by signal lights on the EP-2 Panel (EP-3 in Mk 11 systems). The operator of the EP-2 panel pushes the button that will cause the selected type round to be indexed to the loading position. if the order comes to HOLD, the round is held at the hoist position until the next order is received.

LOAD SELECTOR ORDER.-At the weapons control station the load select switch is set to either SINGLE or CONTINUOUS, the corresponding light signal on the EP-2 panel lights up, and the loading operation is started.

LOADING ORDER.-If the loading order is CONTINUOUS, the system will continue to select the same type of round, and hoist it to the loader rail each time the empty loader pawl returns to the load position. On SINGLE, one missile will be hoisted and loaded on the launcher. On HOLD, the launching system is held in READY condition, but no round is loaded.

UNLOADING ORDER.-When rounds are to be returned to the magazine, WCS will indicate UNLOAD LAUNCHER, or UNLOAD ASSEMBLY, which will cause a corresponding light on the EP-2 panel to be illuminated. The launcher captain will then initiate automatic unloading operations. (Not all systems can be unloaded automatically.)

The order for cessation of operation of the launching system is transmitted from the weapons control station to the launching system captain via telephone.

Look again at figure 3-2 and note the designations of the push buttons and lights. Some panels have a great many more buttons and lights than the model shown. The operator of the launcher captain's panel has to be alert to everything that is taking place in the launching system. He needs to know the system so he can picture in his mind's eye what is taking place on the launcher as each signal lights up or when he pushes a button in response to orders from the weapons control station. In automatic operation, the launcher slews to position in response to train and elevation orders from the computer in missile plot. In local operation, train and elevation orders have to be set in at the launcher captain's panel after receiving the computation from WCS. The firing key is on the Weapons Assignment Console (WAC) in the weapons control station. The WAC operator does not close the firing key until the launcher captain signals that all safety firing interlocks are closed. If a salvo is ordered, the second missile will be launched very soon after the first, following a similar program of orders.

Test Panels

One test panel is used for both port and starboard components of some systems, while other systems have separate test panels for port and starboard. The test panels are used only during launcher test operations and are unmanned during automatic loading operations. The test panel contains switches, synchros, and connections required to perform complete tests on the train and elevation systems. Auxiliary equipment connected to the EP-3 panel for testing include directors, signal generators, and oscillographs. This is not the test equipment used to test the weapon components; that equipment is in the missile checkout area.

The EP-3 panel of the Mk 13 launching system is used during local control of the launcher. At each panel, checklists should be posted for each type of procedure. Figure 3-3 shows part of a checklist posted at the EP-2 panel of a Mk 13 Mod 0 launching system. Use the checklist as a verification that all steps are performed in the correct sequence each time the launching system is operated.

Other Control Panels

Instead of one power panel for all of the launching system, several mk/mods have separate power panels for parts of the launching system, such as feeder power panels (one lor each side), loader power panels, assembler power panels, and power relay panels. Usually, each of these is activated from a control panel for that part of the launcher. Each control panel is manned by a captain, as feeder captain, assembler captain, or loader captain. Figure 34 shows an example of a feeder control panel. The one shown controls both the "A" and "B" sides. It contains switches for controlling the missile loading operations as directed by the weapons control station, and indicator lights for displaying the status of the loading operation. The operator of each feeder control panel activates the feeder power panel on his side of the launching system.

ASSEMBLER CONTROL PANELS.Launching systems such as the Mk 9 have two assembler panels, one each for the "A" and "B" sides of the launcher. Each assembler control panel contains switches for operation of blast doors, magazine doors, stage 1 and 2 rammers, and indicator lights for displaying the status of the loading operation. They are operated by assembler captains. (On the Mk 12 launching system, blast doors cannot be operated from the assembler control panel but are controlled from the EP2 panel).

LOADER CONTROL PANELS.-Loader captains man these panels, and activate the loader power panels from them. The loader control panels contain switches for controlling the operation of the transfer car, for stowing or extracting missiles from cell racks (Mk 9 system), and for loading or unloading the rammer rail and strike down rail. Light displays indicate the status of loading operations. Each cell rack is represented by a light which indicates whether the cell is loaded or empty, or is storing a dud, and also indicates the missile type.

MAGAZINE PANELS.-Several types of panels are associated with missile magazines on shipboard. The Mk 11 system has a magazine loading indicator and a magazine latch indicator panel. The Mk 12 has two magazine panels. The Mk 7 has two ready service panels. They all serve to control the operation of the missile magazine, bringing the missiles up to the launcher, or returning them to the magazine.

A system that has many control panels, each controlling a comparatively small part of the launching system, requires more men to operate .the panels than a system that consolidates several panels into a large one, Each man has fewer pushbuttons that he is responsible for but coordination of effort is required between a greater number of men, and. one man may be responsible for more than one panel.

MANNING OF OTHER STATIONS

Because much of the operation of a launching system is automatic, the number of men required is small. The number varies with the mark and mod of the system, the type of ship, the type of round, the type of warhead, and the type of operation (automatic, step control, or manual). The mark and mod of the launching system is related to the ship or class of ship on which it is used. The Mk 9 Terrier launching system is installed on CLG ships. The Mk 10 Mod 0 is placed on DLGs; Mods 1 and 2 are on CGNs, and Mods 3 and 4 are on CV As. The Mk 10 Mods 7 and 8 are placed on DLG-26 and later ships. Future changes, revisions, and modifications will assign new marks and mods.

Checkout Area

Weapons that require mating of the missile and booster before stowage (Terrier, Talos) and unmating for checkout, require a minimum of two men in the checkout area during replenishment and checkout operations. The Tartar and Asroc arrive aboard completely assembled and are not disassembled for checkout. Asroc missiles that are to be stowed in the Terrier magazine must be attached to an adapter. This is done in the checkout area. In preparation for firing, the checkout area is not manned. The Tartar system does not have a checkout area.

Wing and Fin Assembly Areas

Weapons that require the assembly of wings and fins before loading on the launcher require the most men to prepare them for firing. A Talos launching system, either Mk 7 or Mk 12, requires 24 wing and fin assemblymen at their stations in the wing and fin assembly areas. An assembly c3;ptain is in charge of each assembly area. When a nuclear missile is being readied, he removes the green SAFE plug and inserts the red (or magenta) ARM plug.

Terrier missiles also require wing and fin assemblymen, but the number differs with the type of missile. The Terrier missile requires 12 to 14 wing and fin assemblymen for the Terrier BT-3. On the Terrier BT-3 and the HT-3, the tail control surfaces are folded (not removed) during s towage, and need only to be erected at assembly. The booster fins are installed during assembly.

On Tartar weapons, the fins also are folded. They are erected automatically when the missile is on the launcher in automatic operation, and by pushing the FIN OPENER pushbuttons on the launcher control panel in step operation. When the Tartar missile is to be returned to the magazine, the fills have to be folded manually while the missile is on the launcher.

WARNING: Before folding missile fins, turn the -firing safety switch on the launcher control panel to SAFE. Then remove the switch handle and give it to the crew member going out to the launcher to fold the fins.

When the firing safety switch is set on SAFE, the launching system cannot be activated; removing the switch handle from the panel and placing it in the custody of the person working on the launcher prevents accidental activation.

DIFFERENCES IN LAUNCHING SYSTEMS

In the preceding pages, differences were brought out regarding the number and type of control panels, personnel needed, amount and type of assembly before loading, and some differences in the panels themselves. The steps in the operation of each station differ with the mark and mod of the equipment, the ship's installation, and other factors, so each station must have its own checkoff lists for the operator to follow. Table 3-1 brings together mark-mod information on the important components of launching systems in current use. Where two mods are listed for a component, it usually means that one mod is used on the starboard (right) side and the other on the port (left) side of the system.

Magazines

Most missile systems in present use have the mated or assembled rounds stowed in magazines, in close proximity to the launchers, so the rounds can be transferred automatically from the magazine to the launcher. The magazines are unmanned in automatic and step operation. In case of power failure, manual operation is necessary. Manual operation is also used for maintenance, checking, and installation purposes. Handcranks are used instead of pushbuttons. When using handcranks, remember that the electric and hydraulic interlocks are ineffective. If the unit seems to bind or is difficult to move, stop cranking and investigate.

The magazines below decks, where spare parts and components are stowed, are serviced by hoists. Manpower is necessary to transfer these components to the hoist, and the components have to be assembled into a round in the checkout area before the round can be used, or placed in the launcher magazine. Spare nuclear warheads are stowed in security areas the same as for mated rounds. If a nuclear warhead must be assembled into a missile, or disassembled from it, GMMs do that work.

The only time personnel are permitted in a Tartar magazine is when it is inactivated, as during maintenance. No assembly is required on the missile, the checkout is done on the launcher arm, and the control panels are outside the missile magazine, adjacent to it.

SAFETY CHECKS TO BE MADE

Safety checks have to be made frequently in all systems, methods, types, or modes of operation, and areas of operation. Many safety devices are built into each system to safeguard the men working with it, and to prevent damage to the missiles, machinery, or ship. They were placed in

At EP1 panel:

1. 440 Volts Power-On lights . . . . On
2. All circuit breakers . . . . ON
3. All switches . . . . ON
4. All Power-Available lights . . . . On
5. All Fuze-Blown lights . . . . Off

At EP2 panel:

1. Man station; plug headset into receptacle at right-hand side of panel.
2. SMZ4 (Telephone Selector switch) 10JP
3. SMWI (Missile Warmup Selector switch) . . . . Required position
4. Warmup Status indication light . . . . On
5. Toggle switch in circular light pattern . . . . NORMAL
6. Report from Safety Observer . . . . "All Clear"
7. SMS1 (Control Selector switch) . . . . STEP
8. SMS2 (Operation Selector switch) . . . . OFF
9. SMF2 (Firing Safety switch) . . . . FIRE ENABLE
10. SMY1 (Train And Elevation Control switch) . . . . REMOTE
11. SMX4 (Loading Control switch) . . . . WEAPONS CONTROL
12. Ready Indications (3 lights) . . . . On
13. SMY2 (Launching System Warning switch) . . . . BELL
14. Open left-hand switch cover
15. Start motors by depressing START-RUN pushbuttons.
    (START-RUN pushbutton lights) . . . . On
16. All Motors CHECK FILTERS light . . . . Off
17. All Motors Run light . . . . On
18. Open right-hand switch cover
19. Check Step Control Switches. If necessary, use Step pushbuttons
    to obtain following light indications:
    a. Dud Jettison RETRACT light . . . . On
    b. Launcher Rail EXTEND light . . . . On
    c. Train Positioner EXTEND light . . . . On
    d. Elevation Positioner EXTEND light . . . . On
    e. Arming DISARM light . . . . On
    f. Fin Opener Cranks RETRACT light . . . . On
    g. Contactor And Fin Opener Cranks DISENGAGE light. . . . . On
    h. Aft Motion Latch RETRACT light. . . . . On
    i. Hoist TO MAGAZINE light . . . . On
       (Hoist TO INTERMEDIATE and TO LAUNCHER lights off)
    j. Blast Door CLOSE light . . . . On
    k. Ready Service Index CCW and CW lights . . . . On
20. Close rightand left-hand switch covers.
21. SMS1 (Control Selector switch) . . . . AUTO
22. SMS2 (Operation Selector switch) . . . . LOAD
23. SMS3 (Ready switch) . . . . READY
24. SMS1 (Control Selector switch) . . . . OFF
25. SMS3 (Read switch) . . . . STANDBY

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Figure 3-3.Checkoff list, activation procedures, Mk 13 Mod 0 launching system.

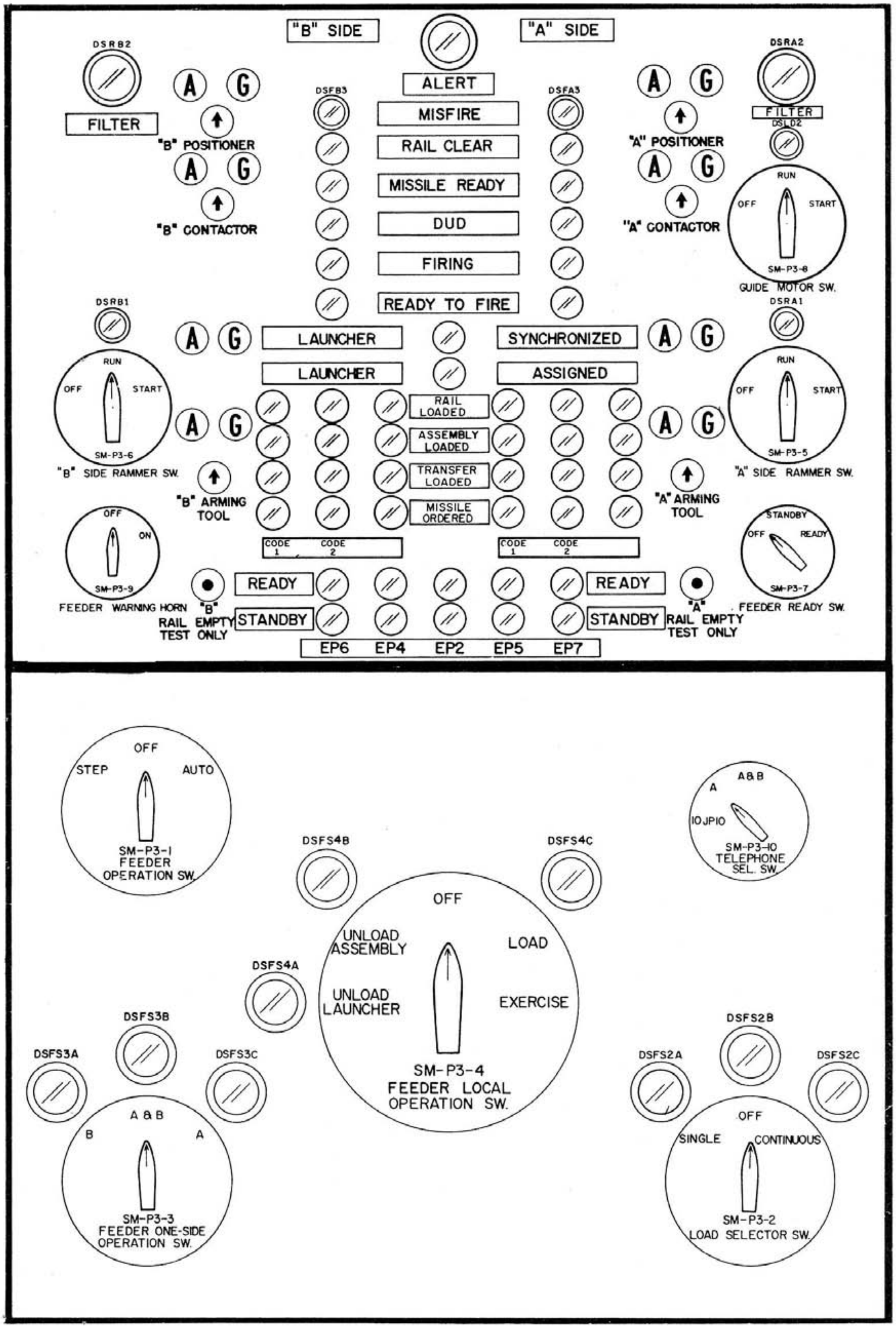

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Figure 3-4.—Feeder control panel for Terrier Launching System Mk 9.

the system because they were found to be necessary; do not inactivate or bypass a safety device for any reason, and do not permit your men to do it. During preparation for firing, a safety observer must be stationed in a position where he can observe the work, including the men and machines or equipment involved. The safety' observer must be an officer or a GMM I or C.

The checkoff lists posted at each station have the applicable safety precautions listed next to the operational steps to which they apply. The same safety precaution may be given several times on one list, each time it applies to a step in the operation to be performed. When you prepare a checkoff list, as you will be required to do, insert safety precautions in the same manner, next to each step to which they apply. Some of the technical manuals place the safety warnings throughout the text, wherever applicable, and also include a summary listing of all the safety precautions given in the book. Review this safety summary frequently.

Commanding officers may issue additional safety precautions. Observance of the safety precautions is mandatory. If you fail to enforce safety rules, you can be held responsible.

Types of Danger

Dangers may be classified according to the type of material or the object causing the danger, such as machinery, explosives, gases, liquids, irritants, pressure, fire, or electricity. A material that is dangerous in itself may be used only under prescribed conditions or circumstances. The caustic electrolyte in missile batteries, for example, will always burn the skin, so the problem is simple-don't let any get on the skin. Safe use of other materials may require compliance with special conditions. Particular conditions necessary for each type of explosive used in missiles are described in *Gunner's Mate M (Missiles) 3&2,* NAVTRA 10199. You Should know what types of explosives are used in the different parts of your missiles and the specific precautions for handling of each type. As all the explosives used in the missiles are enclosed by some form of container, there is little danger of skin contact with explosives that can cause dermatitis. The bulk and weight of the units present more, of a problem in safe handling.

MACHINERY.-Before any machinery is set in operation, the area must be checked to be sure no one is in a place where he could be injured by moving machinery. The launcher captain must sound the warning bell before he pushes a button to activate any machinery, and the safety observer must warn away anyone he sees in the area. Grisly experience has shown the need for this caution before operating any powered machinery such as a missile launching system.

If the safety observer sees any violation of safety rules or any dangerous situation, it is his duty to correct the situation immediately. If you are operating the launcher captain's panel, it is up to you to turn off the power if so ordered or if you see a situation that requires quick stoppage of any part of the launcher system.

Checking the launching system equipment and machinery for safe operating condition is part of routine maintenance performed by you and the men you supervise. The equipment is cycled without a load; any fault in the operation is corrected before the equipment is used with a load.

EXPLOSIVES.The "safe-distance" lines are the equivalent of the safety training circle lines painted on the deck around each gun mount. Their purpose is to remind all personnel that the area is covered by movement of the launcher with loaded guide arms. Personnel inside these safety lines are in a danger area where they could be struck by the moving guide arms and/or missiles. Also present is the possibility of accidental ignition during assembly, mating, handling, strikedown, or strikeup operations. Remind your men, if necessary, never to place themselves where they would be in the path of the blast if the missile or booster were ignited.

The smoking lamp must be out at all times in missile handling, test, checkout, and stowage areas.

Whenever an exercise head is assembled into a missile, flash signal units (smokepot type) are installed. Flash signal units are not tested or checked aboard ship; a safety lanyard indicates that the flash unit is in the unarmed condition. The lanyard is removed just before firing; do not remove it $ead of time. Flash signals must not be dropped and they may not be exposed to RF energy from radars or communication transmitters. Do not stand in front of a flash signal while working on an exercise head. A flash signal and the detonator in the S&A device can be set off by a radar beam, static electricity, or a spark. The S&A device is not tested, disassembled, or repaired aboard ship.

NUCLEAR DANGERS.-With nuclear warheads assembled into missiles, there is always the POSSIBILITY of nuclear radiation. Probably the chief cause of nuclear incidents and accidents is careless handling-dropping a weapon with a nuclear warhead, or dropping the warhead itself. Prevention therefore means making sure that the weapon or component is securely fastened to the hoist, crane, trolley, or other lifting machinery .

"SAFE" POSITIONS OR DEVICES TO CHECK

Each launching system has numerous safety devices, some of them entirely automatic in operation. The position of some components or devices is checked on the control panels by means of lights or other signals. Because control panels may be widely separated and on different decks, telephone communications must be established between the panel operators, the safety observer, and the men at work in the different areas. A loudspeaker announcement and/or a warning bell Should .warn people away from the topside loading area before operation begins. Only the persons actually needed for the work are permitted to remain there. No persons are required within the launching system to operate it, and signs should be posted to keep personnel out of the assembly and checkout areas. If anything goes wrong with the launcher or other part of the system and someone has to work on any part to correct the fault, disable the component so no one can start it accidentally. On the power panel, turn off the switch that activates the component, remove the handle of the switch and give it to the man who is going to do the repairs. Only when he is finished does he return the handle to the switch. The unit can then be activated again "and its operation tried out. No one may enter a magazine while a loading or unloading operation is in process. If you are in charge at a control panel, check carefully before you push a button that starts the machinery moving. The operator at each control panel signals the launcher captain when his part of the system is ready.

The SAFE-FIRE switches must remain at Launcher Only (fig. 3-2) position throughout all the daily operational checkout. (On the control panel of the Mk 12 launching system, the switch is labeled SAFE, RUN, FIRE.) There are safety switches for the magazine, the loader, and the loader accumulator. Each of these switches has two positions, SAFE and RUN. When in the SAFE position, the handle can be removed, to be retained by the person doing the maintenance on the equipment until he has finished his work.

Before activating a launching system, after receiving the order to do so, the operator of the EP2 panel must receive the "All Clear report from the safety observer, who is stationed where he can overlook the whole launcher area.

Lights on the operating panels indicate various conditions that need to be checked and corrected before proceeding. A light on the EPI panel, labeled with a warning sign, indicates that there is a blown fuse that inactivates the magnetic door lock. This must be corrected at once. A monitor on the 115-volt power supply triggers an alarm if there is a grounded circuit.

The safe positions or devices on the missile rounds will be discussed later.

ELEVATION AND TRAINING CHECK

The firing cutout cams are designed for each! installation of a launcher so the launcher cannot be trained where it could fire into any part of the ship. The installation is tested and checked at the shipyard and rechecked and tested after, any change or modification of the launcher. The: positioning of the launcher in response to train' and elevation orders is checked each time the: launcher is used during training, preparation for firing, or during and after maintenance work. The angle. of train and elevation necessary for target intercept is calculated by the computers in the weapons control station from the data obtained by radar or sonar tracking of the target and the computations made in CIC. In automatic operation, the train and elevation synchro signals cause the launcher to slew to the position ordered. In local control the launcher is moved to the computed train and elevation position at the launcher.

Train systems and elevation systems contain similar electric, hydraulic, and mechanical equipment. Each system receives and responds to order signals independently of the other. In normal operation, remote orders are supplied by the launcher computer. These signals determine the flight path of the missile during the "boost phase" of its flight.

The systems of different launchers are very similar in operation. The principles of operation are the same in all of them. Names and locations of units or components, details of wiring, pushbuttons to operate, etc., can vary considerably, depending on the complexity and size of the system, the location of the launchers on the ship and in relation to the control components, and other factors.

The voltages used by train and elevation systems are dangerous, and may be fatal if contacted. If electrical trouble develops, consider all circuits dangerous until the trouble is located and corrected.

LAUNCHER PREPARATION STEPS IN DIFFERENT SYSTEMS

The steps in preparation of a launcher for firing of a particular launching system vary with the mode (surface-to-surface, surface-to-air, surface-to-underwater), the type ship on which it is installed, the type of missile (conventional warhead, nuclear warhead), the purpose of firing (intercept, destruction, etc.), and other factors. Preparation for an exercise firing may require a number of steps different than in preparation for a live shot. Considering all the possibilities of difference, a complete and exact list of steps in preparation for firing cannot be made to cover all situations. The checkoff list you prepare must be made to fit your launching system and must be complete in detail.

TERRIER LAUNCHING SYSTEM

As you can see from table 3-1, the Mk 9 Terrier launching system has more control and power panels than the Mk 10 system. The Mk 9 system has Power Panels EP-I A, EP-I B, EP-I C, and EP-ID, besides Amplifier Panels EP-8, EP-9, and EP2A. The Mk 10 launching system has only the EP-I power panel. A similar consolidation is effected for the control and test panels. Improvement in the other components of the Terrier launching system has resulted in mod changes and some mark changes. All Terrier systems use a Mk 5 launcher, with mods ranging from 0 to 8. The latest change modifies the launching system so it can be used for Terrier and Asroc missiles.

In the Mk 9 launching system, a transfer area located between the forward and aft magazine service areas contains two transfer cars. These are used to transfer rounds athwartship from storage cell racks to the first stage rammer rail. In the Mk 10 launching system, the ready service ring is rotated to bring the selected round in position to be raised by the hoist, instead of the hoist being brought to the round as in the Mk 9 system.

Mk 9 Launching System

The operating cycle of a launching system is meant to cover only that part of the overall launching system that is concerned with removing a missile from stowage and ultimately placing it on the launcher for firing. If the system is unmanned and deenergized, the first step is to man all stations and energize all power motors. Upon receiving the load order, the cycle begins. The following steps in the cycle take place. See figure 3-5.

1. Movement of the transfer car to a preselected rack and cell. The transfer car is a part of the loader. It runs athwartship on tracks.
2. An extractor beam can be raised or lowered on the car, to extract a round from a magazine cell or insert it into the magazine.
3. The transfer car and extractor beam deposit the round on the overhead rammer rail.
4. Lifting and securing the round to the rammer rail. The first stage rammer rail, which receives the round from the transfer car extractor beam, is a component of the first stage rammer. Continuous grooves the length of the

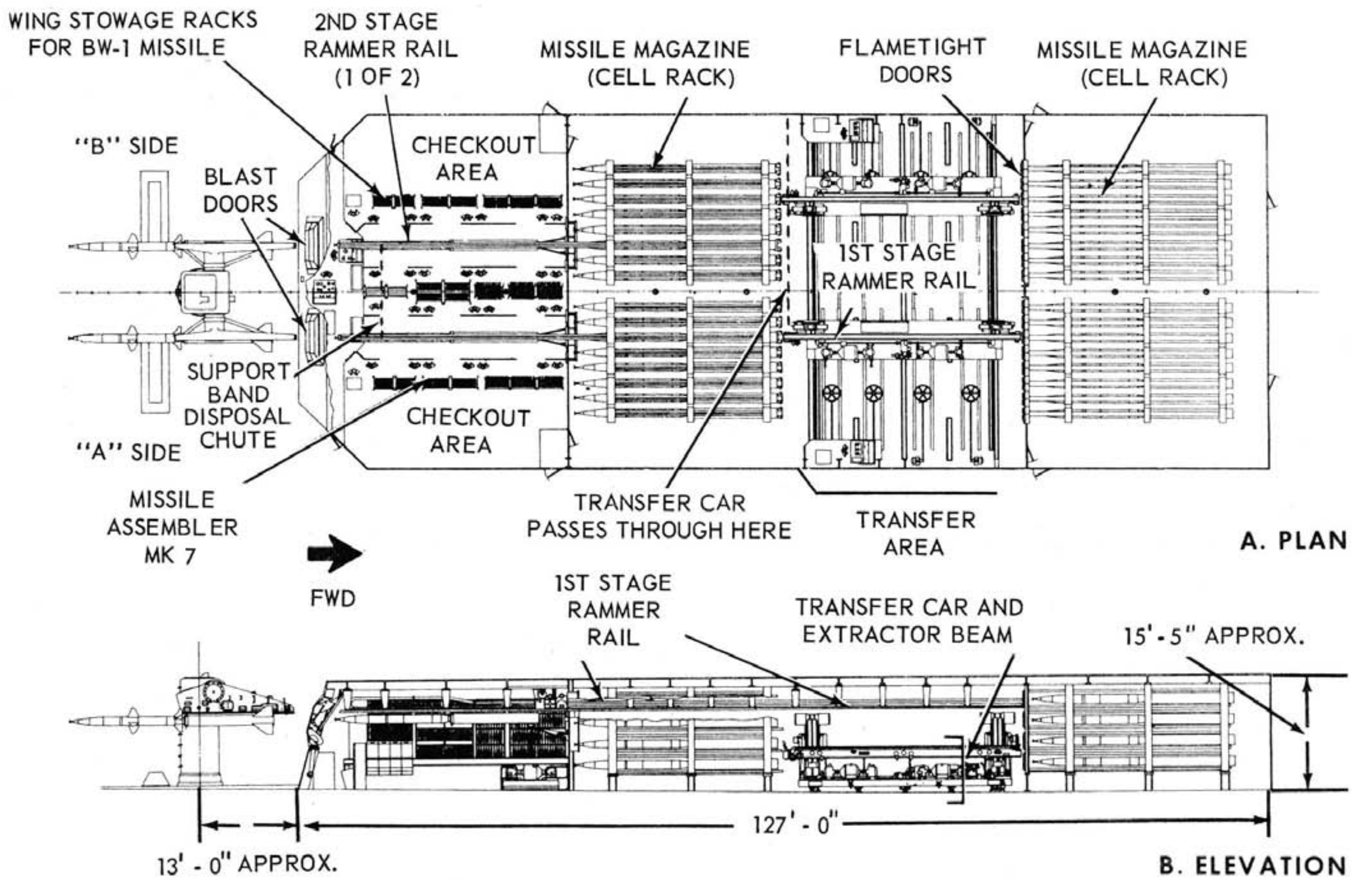

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Figure 3-5.—Guided Missile Launching System Mk 9: A. Plan; B. Elevation.

rammer rail serve as tracks in which the booster slides. In the rail interior is a continuous lengthwise slot in which a continuous sprocket-driven rammer rail chain rides. This chain engages the after booster shoe by a rammer head pawl and transports the round to the assembly area through the magazine door assembly.

5. When a round is rammed into the assembly area, the first stage rammer head, which is part of a sprocket-driven chain, withdraws from the booster shoe and the second stage rammer head attaches.

6. Wings and fins are installed by the assemblymen in the assembly area. Missile support bands are removed, and are disposed of through chutes that convey them to the checkout area.

7. Second stage ramming. The second stage rammer, which also has a sprocket-driven chain, is generally similar to the first stage. Linkages and camming surfaces at the point where the first and second stage rammers interchange prevent interference in the ramming operations. On the second stage, a contractor on the rammer head mates with the warmup connector on the booster to provide warmup power during the second stage ramming to the launcher. Warmup power is applied continuously by the rammer until the round is received at the launcher.

The two stages have separate and independent hydraulic drives located in the overhead above the loader rails. Each drive is equipped with a power-off brake to hold moving parts stationary when the drive is not in operation. The electrohydraulic units (not shown in figure 3-5) also supply power for the blast and magazine door mechanisms.

In figure 3-5 you can see the tiers of cells in the magazine. Figure 3-6 illustrates the numbering system of the cells. A light (on the loader

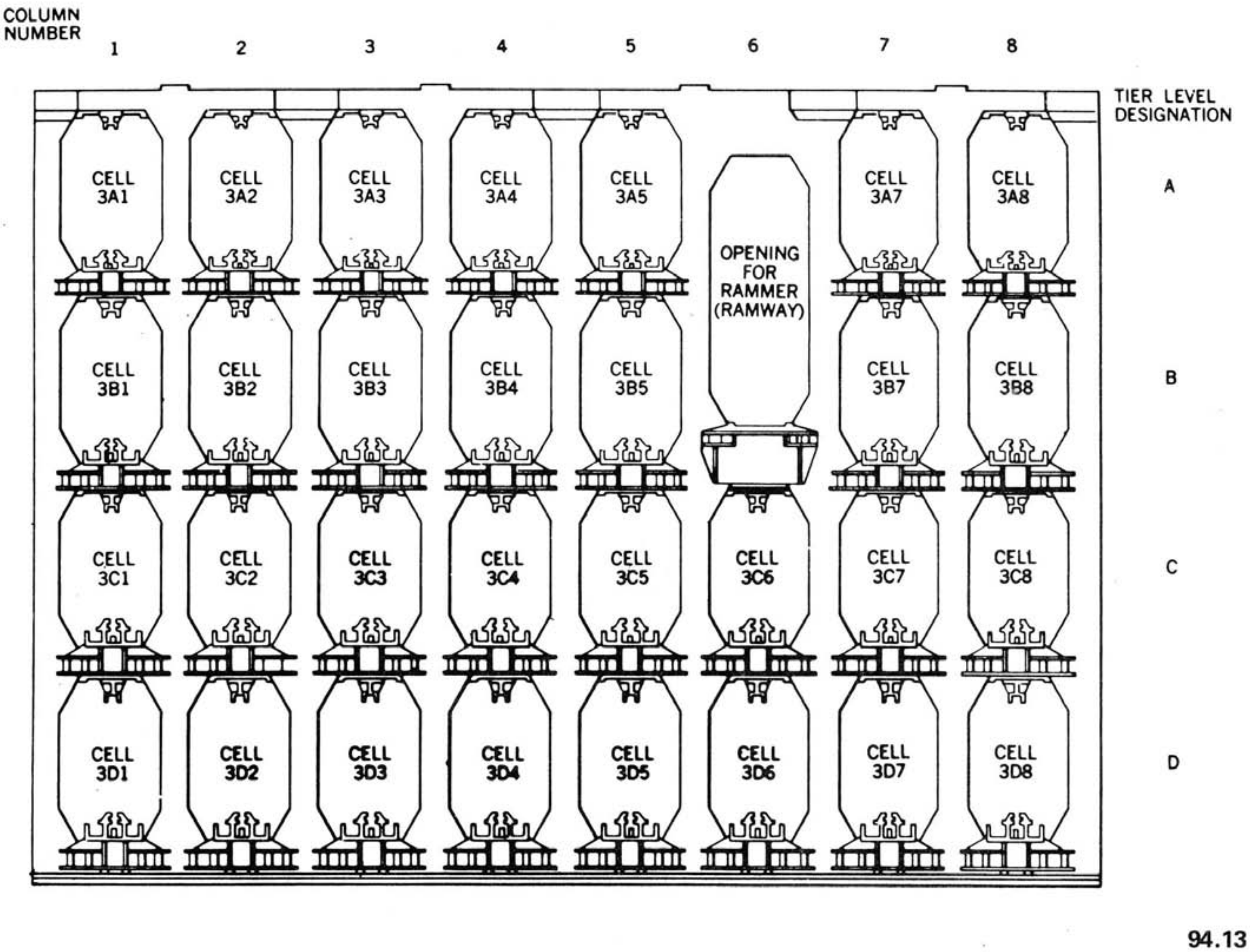

Figure 3-6.—Cell numbering system, Guided Missile Launching System Mk 9 Mod 0.

captain's control panel) for each cell indicates the type of missile that is loaded in each cell, enabling the loader captain to select by pushbutton the type of missile ordered for the operation.

The two forward magazine racks have a continuous bank of flametight doors in their after ends, one for each cell, in effect forming a bulkhead. In the bulkhead, aft of the after magazine racks, are two magazine doors. These doors are automatically and hydraulically operated, and interlock so that under normal conditions they cannot be opened while the deckhouse blast doors are open. The blast doors each have two halves that open vertically. "A" and "B" blast doors may be operated independently or concurrently. Heating facilities prevent trouble with icing. Interlocking with other system functions ensures that the doors will effectively isolate the system's interior while rounds are on the launcher, yet open during ramming of rounds to the launcher.

8. Placing and securing missile on launcher. As each assemblyman completes his work in assembling wings and fins to the missile, he moves out of the path of the -missile and closes his safety switch. Only when all the men have closed their safety switches is the missile moved to the launcher. The spanner rail, a component of the second stage rammer, bridges the gap between the launcher guide rails and the fixed second stage rammer rail. The spanning rail rotates into position as the blast doors open, and latches to the launcher rails. Interlocks ensure

proper coordination. The launcher rails or "arms" contain the missile positioner, locating stop, safety latch, arming tool, warmup contactor, firing contacts, and associated electric-hydraulic systems. The arms hold the missile in position during warmup and launcher synchronization to the train and elevation orders. They also maintain the position of the missile after firing until sufficient thrust has been built up for proper takeoff.

The complete launching cycle has been divided into various cycle events and the unit cycles timed in seconds and fractions of seconds. This timing information is useful when checking to locate the cause of a slowdown in the launching operation. Figure 3-7 lists the launching steps in detail but without the time information. An electronic timer properly connected into the circuitry through test panels provided can be used to measure operating speed of the individual units. A stopwatch can also be used for timing a launching cycle, but is not as accurate as an electronic timer.

Mk 4 Launching System

The general arrangement of the magazine, ready service ring, and the wing and fin assembly area in relation to the launcher were shown in *Gunner's Mate M (Missiles) 3&2*, NAVTRA 10199. It is capable of handling BW and BW-l Terrier missiles, which are now used as training and target missiles. With the missiles stowed in the vertical position, . the method of moving them to the launcher is different than with other launching systems in which the missiles are stowed in a horizontal position. There are only two ships with the Mk 4 system and both are now assigned to the inactive fleet.

Mk 10 Launching System

Mods of the Mk 10 launching system in current use are Mods 0 through 8. The dual mods 1 through 6 differ only in the adaptations necessary for use on opposite sides of the ship, or fore and aft location on the ship (fig. 3-8). Mod 0 is used on DLGs; Mods 1 and 2 on CLGs or CGNs; Mods 3 and 4 on CV As or CVNs; mods 5 and 6 on DLGs class 16; and Mods 7 and 8 on DLGs class 26 and later.

A difference between the Mk 9 and Mk 10 launching systems that is immediately evident from the illustrations is the difference in the stowage arrangement of the missiles. In the Mk 10, instead of each missile being in a separate cell, each magazine contains a ready service ring that holds numerous missiles. The ready service ring is rotated (by pus-button at the launcher captain's panel) to bring the selected weapon to the loading or No. I position, from which it is raised to the assembly area by the hoist. The loader-positioner rams the missile into engagement with the loader rail, the empty hoist lowers, and the magazine doors close. While the wings and fins are being assembled by the assemblymen, and warmup is applied to the missile, the ready service ring indexes another missile to the No. 1 position.

When the wings and fins are assembled, the twelve operators move to a safe area and depress foot switches, indicating that assembly is completed. This illuminates a light on the assembly captain's panel; he, in turn, operates a switch which indicates to the launcher captain that assembly is completed. If the missile is the correct one, it is brought to the launcher by the loader, which positions it on the guide arms. (If the missile is not the one ordered, a flashing indication appears on the EP4 (or EPS) panel; this situation must be corrected immediately.) , Then the launcher aft-shoe latches extend, thereby transferring the missile from the loader pawls to the aft-shoe latches. The launcher connectors extend and continue warmup of the missile after the loader pawls retract. When the booster contactors are fully extended, the arming tools extend. After the loader pawls have retracted clear of the spanning rails, the spanning rails retract and the blast doors close. When both blast doors are closed, the train and elevation latches retract, and. the launcher synchronizes with the remote order from the assigned director. The loader pawls and loader positioners move back to position, ready to receive the next weapon from the hoist. Before the launcher slews to the ordered train and elevation position, the panel operator must receive an all clear from the safety observer to be sure that no one is in the path of the launcher.

The firing safety switch is on the launcher captain's panel, and he operates it as ordered

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WEAPONS CONTROL SELECTS MISSILE TYPE.	STEPPING SWITCH SELECTS CELL WITH MISSILE TYPE.	TRAVERSE AND LIFT SIGNAL CIRCUITS ENERGIZED.	TRANSFER CAR MOVES TO SELECTED COLUMN.	LIFT RAISES EXTRACTOR BEAM TO ALIGN TO CELL.	HEAD POSITIONING FORK RETRACTS.	ALIGNING CYLINDERS EXTEND (VERTICAL AND HORIZONTAL).	CELL DOORS OPEN.	SPANNER RAIL LOWERS.
EXTRACTOR EXTENDS SECURES TO MISSILE.	EXTRACTOR HEAD STOP EXTENDS.	EXTRACTOR RETRACTS WITHDRAWS MISSILE.	POSITIONING FORK EXTENDS.	EXTRACTOR HEAD STOP RETRACTS.	SPANNER RAIL RAISES.	CELL DOORS CLOSE.	STEPPING SWITCH STEPS TO NEXT SELECT.	ALIGNING CYLINDERS RETRACT (VERTICAL AND HORIZONTAL).
LIFT MOVES TO TRANSFER LEVEL.	TRANSFER CAR MOVES TO COLUMN 6.	STAGE 1 RAMMER FLOATING RAILS RELEASE.	LIFT RAISES MISSILE TO STAGE 1 RAMMER RAIL.	EXTRACTOR BEAM ALIGNS TO RAMMER RAIL.	ALIGNING CYLINDERS EXTEND (HORIZONTAL).	LIFT LATCHES EXTEND.	HEAD POSITIONING FORK RETRACTS.	EXTRACTOR HEAD MOVES AFT 5 INCHES.
	MISSILE LATCHED BETWEEN LATCHES 1 AND 2.	FLOATING RAIL CENTERS.	STAGE 1 RAMMER MOVES AFT TO LATCH TO T-LUG.	MAGAZINE DOORS OPEN.	HEAD POSITIONING FORK EXTENDS.	ALIGNING CYLINDER RETRACTS (HORIZONTAL)	LIFT LATCHES RETRACT.	LUG RETAINING LATCHES OPEN.
LIFT LOWERS TO TIER D.	LUG RETAINING LATCHES CLOSE.	TRANSFER CAR MOVES FROM COLUMN 6 FOR NEXT SELECTION.	LATCHES 1 AND 2 RELEASE T-LUG.	STAGE 1 RAMMER EXTENDS.	MISSILE LATCHES IN FINNING AREA LATCHES 3 AND 4.	STAGE 1 RAMMER RETRACTS.	MAGAZINE DOORS CLOSE (AFTER RAMMER RETRACTS 6 FEET).	
STAGE 2 RAMMER LATCHES TO T-LUG.	WARMUP CONTACT PAD ENGAGES WARMUP START.	ASSEMBLE WINGS AND FINS TO MISSILE.	CLOSE PERSONNEL SAFETY SWITCHES.	LAUNCHER TRAIN TO LOAD POSITION.	GUIDE ARM DEPRESS TO LOAD POSITION.	TRAIN AND ELEVATION LATCHES EXTEND.	BLAST DOOR LOCKS RETRACT.	BLAST DOORS OPEN.
SPANNING RAIL LATCHES.	FINNING AREA LATCHES 3 AND 4 RETRACT.	STAGE 2 RAMMER EXTENDS.	POSITIONER SPADE EXTENDS TO HOLD MISSILE.	BOOSTER CONTACTOR EXTENDS.	ARMING TOOL EXTENDS.	STAGE 2 RAMMER RETRACTS.	BLAST DOORS CLOSED LOCK (WHEN STAGE 2 RAMMER RETRACTS 10 FEET).	
TRAIN AND ELEVATION LATCHES RETRACT.	LAUNCHER TRAINS AND ELEVATES TO FIRING POSITION.	FIRING CIRCUIT CLOSES.	MISSILE POWER BUILDUP.	BOOSTER ARMING TOOL WINDS AND RETRACTS.	"A" SIDE BOOSTER CONTACTOR RETRACTS.	BOOSTER FIRES.	"A" SIDE MISSILE CLEARS LAUNCHER.	
BOOSTER ARMING TOOL UNWINDS.	POSITIONER SPADE RETRACTS.	"B" MISSILE FIRING TIME DELAY.	"B" MISSILE POWER BUILDUP.	"B" BOOSTER ARMING TOOL WINDS AND RETRACTS.	"B" BOOSTER CONTACTOR RETRACTS.	"B" BOOSTER FIRES.	"B" ARMING TOOL UNWINDS.	"B" POSITIONER SPADE RETRACTS.
LAUNCHER RETURNS TO LOAD ORDER.	LAUNCHER TRAIN AND ELEVATION LATCHES EXTEND.							

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Figure 3-7.—Operational flow diagram for Guided Missile Launching System Mk 9 Mod 0.

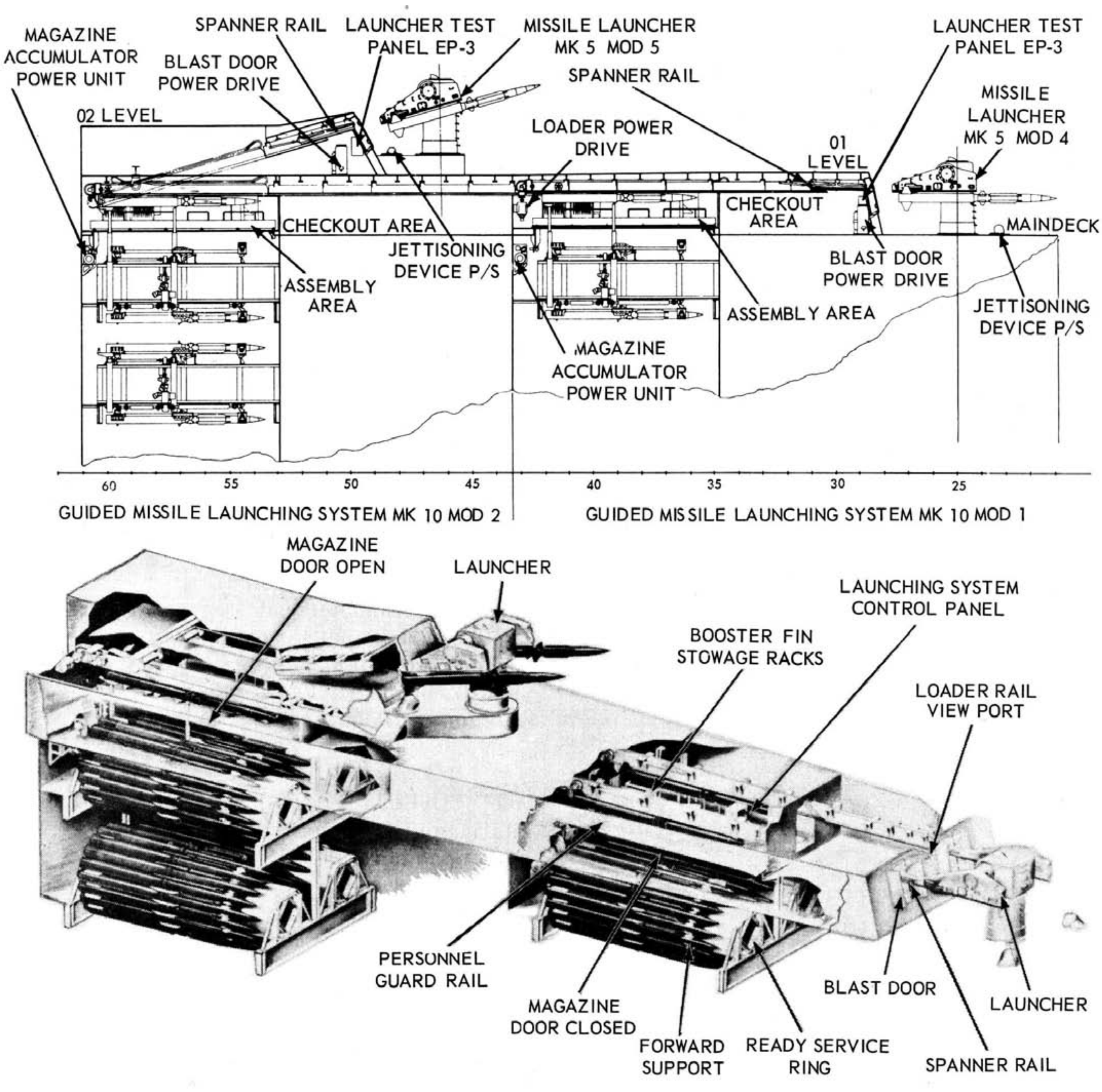

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Figure 3-8.—Guided Missile Launching System Mk 10 Mods 1 and 2, for Terrier missiles.

from the weapons control station. If the weapons control operator has his load-selector switch on. CONTINUOUS, the weapons are hoisted each time the loader returns to the assembly area, and the loading and firing sequence is repeated. If the load switch is on SINGLE, only one weapon will be loaded until further orders from the weapons control station.

MK 10 MODS 7 AND 8 LAUNCHING SYSTEMS.- The outstanding innovation in the Mods 7 and 8 is provision for stowing Asroc missiles alternately with Terrier missiles in the Terrier ready service magazine. *Gunner's Mate M (Missiles) 3&2*, NAVTRA 10199, has several pictures of this arrangement and describes it. OP 3114 PMS/SMS is the OP for the Mod 7, and Mod 8.

Guided Missile Launching System Mk 10 Mod 8 is an aft installation aboard a DLG(N)35-class ship. The loading and firing operations are identical with the Mod 7 system. However, the Mod 8 has no tilting rail in its feeder system. The increased length of its loader rail causes the load and unload cycles to be somewhat longer than on a Mod 7 system. The absence of the tilting rail also affects step operation. There are no pushbutton switches for Tilting Rail RAISE and LOWER on the EP2 panel. But there is an 8-second delay before the blast doors open, which gives time for attaching the fins to the weapons in the assembly area. The ready service mechanisms are identical to those of the Mod 7, having two upper ones, each designed to hold twenty missiles, alternating Terrier and Asroc missiles, and one lower ring that holds Terrier missiles only.

TARTAR LAUNCHING SYSTEM

Launching systems used with Tartar missiles are the Mk 11 Mods 0, 1, and 2, Mk 13 Mods 0, 1, 2, and 3, and Mk 22 Mod 0. In all these systems, the magazine is a compact metal structure and the launcher is placed on top of it. As the missiles are stowed completely assembled, there is no need for an assembly room nor a transfer room. The Tartar missile launching system serves as the primary armament of the DDG. The Mk 13 Mod 3 is placed on CV As, and the Mod 2 is designed for placement on converted DLs. Mods 1, 2, and 3 have flanges so they can be installed either entirely above deck or with the magazine partially below the deck.

The Mk 13 launching system has a single-arm launcher, in which the dud-jettison unit is integral with the launcher arm, a missile magazine, and missile launching system control equipment. The Mk 11 is a twin-rail launcher designed to handle two missiles simultaneously.

In automatic control, the launching system control initiates and controls the loading cycle, but the launcher is positioned and the missile is fired by the ship's fire control system.

Mk 11 Launching System

The Mod 0 is in use on DDG-2 class ships, and Mods 1 and 2 are installed on CGs. Two panel designations on the Mk 11 system are different than in other systems and this may lead to confusion if you have become accustomed to other systems. On the Mk 11 the EP-2 panel is the loader control panel and the EP-3 is the launcher control panel. The Mod 0 has several relay control panels in special cabinets, "RCl, RC2, RC3. Mods 1 and 2 place the relay controls in one panel, the Mk 205 relay control panel.

If the launcher is to be trained or elevated by local control, the operator of the launcher control panel uses the Mk 211 local control panel (EP-5) to train and elevate the launcher manually. The EP-5 panel also displays an error indication to assist the launcher captain in making the necessary corrections in training and elevation.

The Mk 11 system has other special indicating panels, the IP-l, IP-2 and the IP-5.

Magazine Loading Indicator Panel Mk 209 Mod 0 (IP-l), located above the loader control panel (EP-2), is an illuminated replica of the launcher, magazine, and magazine cover. It indicates the launcher position, the magazine cover and blast door positions in relation to the launcher, and indicates if cells are loaded or unloaded (fig. 3-9). The blast doors are represented by four colored discs in a clear plastic disc. The numbered discs in the illustration are . the indicating lights for the individual missile cells. The four corner lights indicate the cell location of the magazine cover doors, whether the cell is in the inner or the outer circle of the magazine, if the warmup power is on, and if the missiles are latched or unlatched.

The Missile Latch Indicator Panel (1P-2) is located in the center of the missile magazine. It is used chiefly during missile replenishment and readying for sea. As the missile latches cannot be checked visually to be certain the missiles are secured in the magazine, the unlatched missiles are indicated on the panel. This is an unsafe condition and must be corrected, as the missiles could slide (vertically) in the magazine. Of course the launching system must be inactivated while anyone is down inside the magazine.

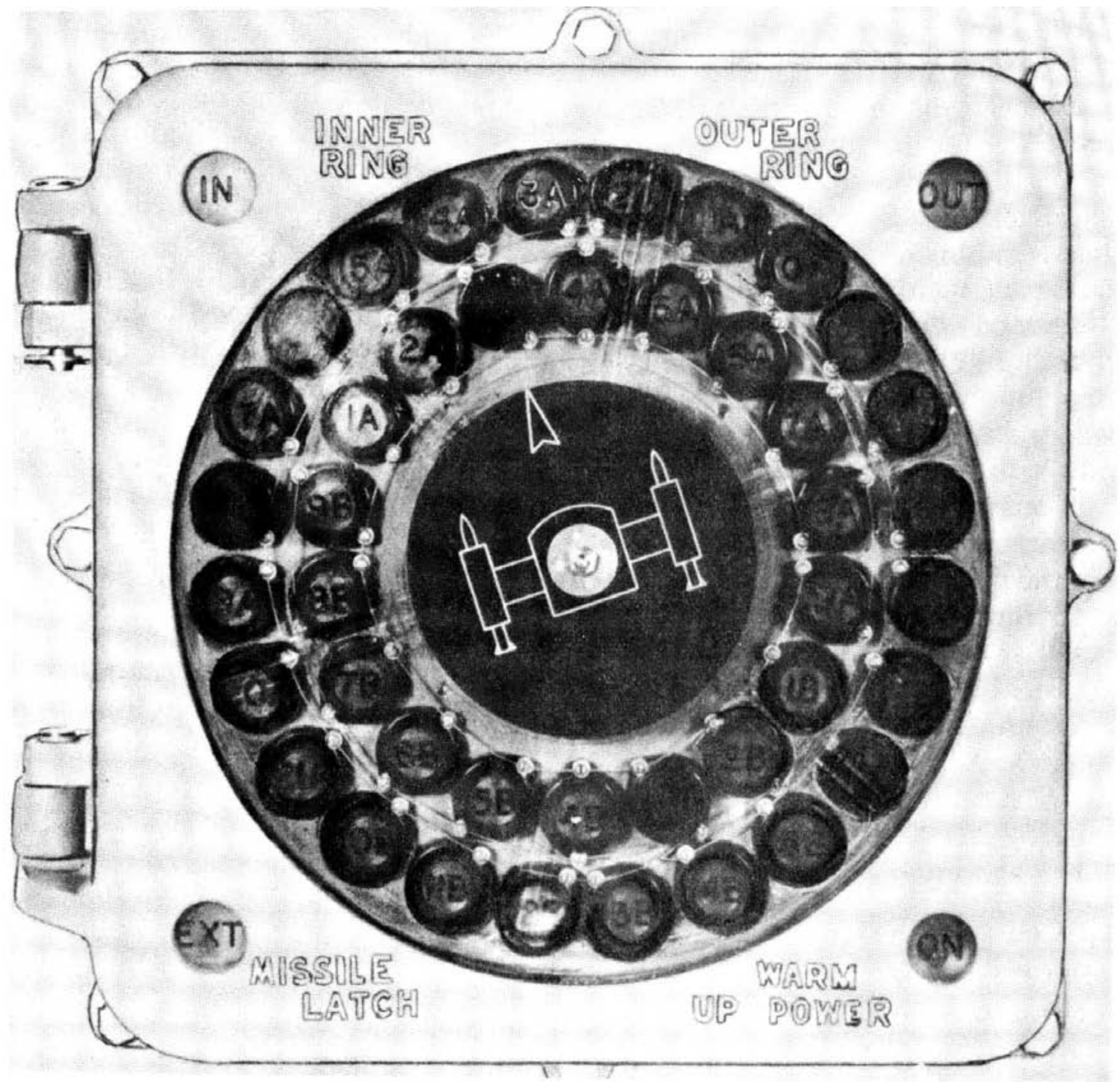

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Figure 3-9.—Magazine loading indicator panel IP-1, Mk 11 launching system.

The Missile Mode Order and Compliance Panel (IP-5) displays the launcher mode order (flashing), compliance (steady), and type of missile (X, Y, or Z) in position under the A and B blast doors.

Mk 13 Mod 0 Launching System

The Mk 13 launching system follows the trend in combining several control panels into one. This system has three control panels: EP-l, power control; EP-2, launcher control; and EP-3, test panel. The local control panel is made a part of the EP-3 panel. In automatic operation, the launcher captain operates EP-2 panel; EP-l and EP-3 are unmanned. The safety observer watches the launcher area and keeps the launcher captain informed on all phases of launcher operation.

The compact unit construction of this launching system makes it usable on a variety of ships. It may be mounted entirely above decks, or the magazine may be placed below deck level. The most noticeable difference between the Mk 11 and Mk 13 systems is the difference in the launchers Mk 11 has two launcher arms and the Mk 13 has only one, figure 3-10. This, of course, eliminates all operational steps that involve loading or unloading, or jettisoning for a second side. The Mk 13 is an extremely high speed system. The steps in operation are very similar for the Mk 11 and Mk 13 systems. In automatic control there are four large steps:

1. Warmup
2. Loading
3. Assignment
4. Firing

Steps 3 and 4 are performed by remote control from the weapons control station.

WARNING: Do not energize the launching system until communications have been established between the safety observer and the launcher captain, and the safety observer has reported that the launcher area is all clear.

As soon as the launching system is activated after receiving the order from the weapons control station, warmup power is applied to four missiles in the magazine of the Mk 11 system, and in the Mk 13 system, to three missiles in sequence, not simultaneously (fig. 3-10). Missile Warmup Selector Switch SMWI can be positioned to AUTO 1, AUTO 2 or AUTO 3. The position of SMWI determines how many missiles are put on warmup in the magazine. For normal automatic operation, AUTO 3 is selected. As missiles are loaded, warmup is applied to succeeding missiles in the magazine. If for any reason, the rust missile is not loaded within 14 minutes after start of warmup, this missile is automatically removed from warmup and another is placed on warmup. The warmup status light on the launcher control panel will turn red after 15 minutes. The circuit for the application of warmup power is established during strikedown; a warmup contactor enters a socket in each missile as it is placed in a cell in the ready service ring.

The operators at the control panels push the buttons in sequence according to the chart posted at each station and in response to orders from the weapons control station. In the Mk 13 system, the EP2 panel operator takes care of all the push buttons, but on the Mk 11 system, the work must be coordinated between the EP-2 and EP-3 operators, who must also operate the EP-5, IP-l, and relay panels. The safety observer keeps in contact with the panel operators, so any part of the system can be stopped quickly if necessary.

If the load order (from the weapons control station) is for continuous loading, the launching system will continue to load missiles until the magazine js empty (of the type ordered), beginning with the outer ring of missiles (if the outer ring was initially selected) and, when those cells are empty, loading missiles from the inner ring. If the inner ring was initially selected, then when the inner ring is depleted, loading will automatically be shifted to the outer ring. Warmup is applied to the missiles automatically at the successive stations in the" outer ring (fig. 3-10), and then in the inner ring (or in the opposite order if the inner ring WilS selected first). This assumes that every cell is loaded and there are no dud missiles among them. If the load order is for one missile, the launching system will stop after one missile has been loaded. With the Mk 11 system, a 2-missile salvo may be ordered.

As soon as the panel operator receives the load order, he indexes the magazine cover to the missile selected, and synchronizes the launcher to the loading position, for inner ring or outer ring position (Mk 11 only). If the missile selected' is not at the hoist position, the ready service ring rotates clockwise to bring the missile to that position. After the minimum warmup time has been applied to the missile, hydraulic power is transferred to the hoist and the hoist rises to the intermediate position. As the missile is moved from station at the hoist position, the warmup contactor at the base of the missile breaks contact.

At the intermediate level, the hoist pawl engages the missile aft shoe, and the magazine retractable rail extends to complete the missile track to the spanning rail, which is attached to the blast door. Then the blast door opens, extending the spanning rail, the elevation positioner extends into the open blast door, and the hoist with the missile raises to the launcher. When the loader hoist completes its raise cycle, the launcher aft motion latch secures the missile to the guide arm and the hoist returns to the magazine. The launcher warmup contactor engages the missile and warmup is again applied. The fin openers engage the fins on the missile for opening. The train and elevation positioners retract and the blast door closes, retracting the spanning rail.

When the missile is in position on the launcher, the missile aft shoe contacts the forward motion latch and at the same time

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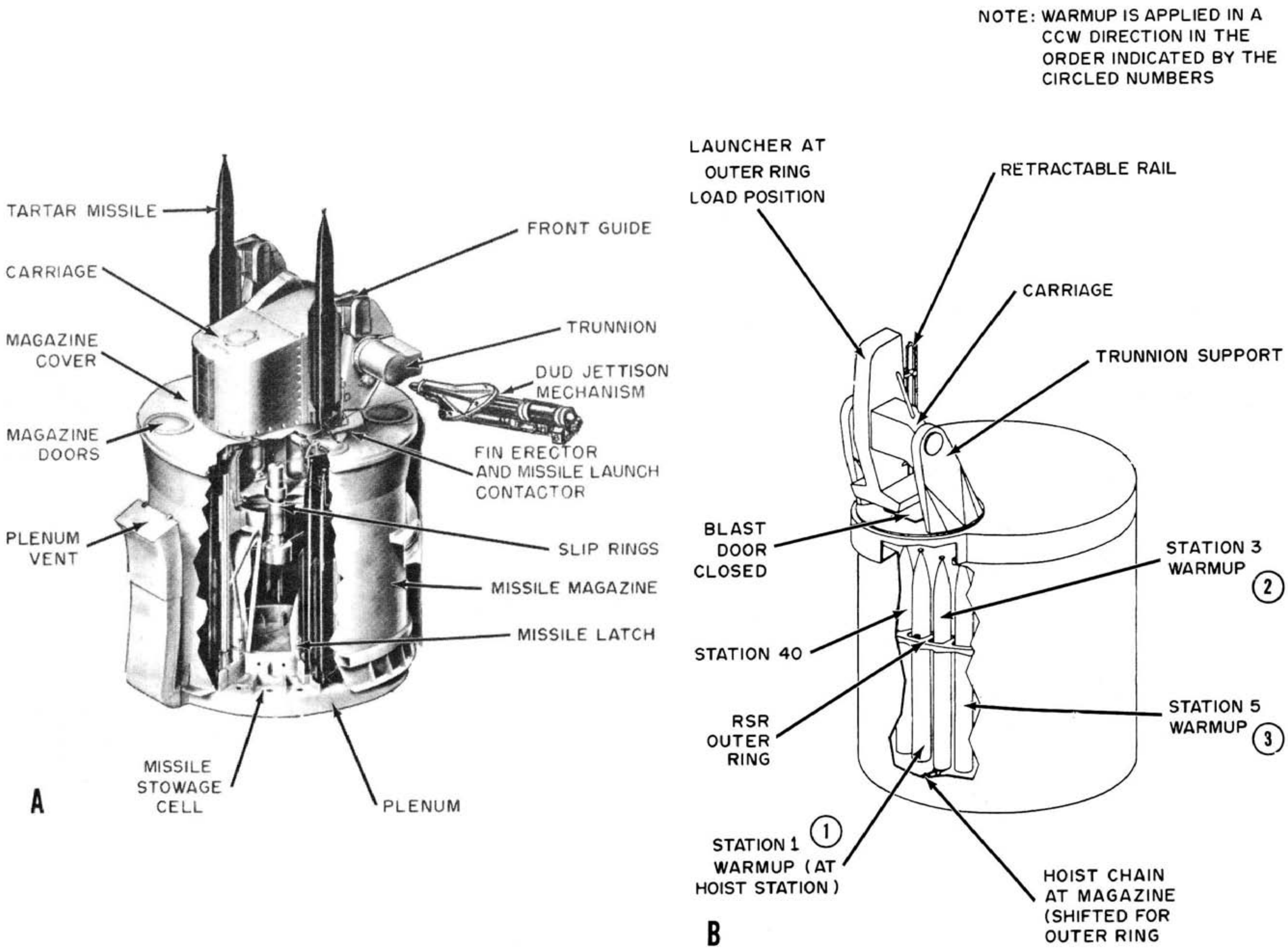

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Figure 3-10.—Types of Tartar launching systems: A. Mk 11 (two launcher arms); B. Mk 13 (one launcher arm).

actuates the rail-loaded indicator plunger. This plunger actuates the launcher-rail-loaded switch; this lights up an indicating light in the weapons control station and also on the launcher captain's panel. The weapons control station assigns a target to the launcher, at which time the missile fills are automatically extended. The launcher slews to the train and elevation positions ordered. The automatic tracking cutout system prevents the launcher from pointing into certain areas where a flfed missile would be hazardous to the ship's structure. The cutout system opens the firing circuit when the launcher points into an area unsafe for missile firing (non-pointing zones). The launcher synchronized light on the launcher control panel and an indicator in the weapons control station show when the launcher guide and carriage are positioned so the missile can be launched in the proper flight attitude (azimuth and elevation). The blast door must remain closed and the fins on the missile must be unfolded before the ready-to-fire signal is given. These two operations can be going on while the launcher is moving in train and elevation to the ordered and corrected position. The FINS UNFOLDED light on the launcher panel goes on when the fins are unfolded.

All these actions of the launching system components should have taken place in less than 6 seconds from the time minimum warmup elapsed in the magazine to launcher synchronization. A pre firing evaluation is made by the launcher captain and the weapons control officer. The firing safety switches must be closed at the launcher control panel and at the safety observer's position. The FIRING ZONE CLEAR light must be on (launcher control panel). Launcher warmup must have been applied after the fin opener was engaged, and the launcher was assigned. Time delay relays close after the minim um time has elapsed. The launcher warmup switch on the power panel must be on for the minimum number of seconds. The code set in the missile must correspond with the code of the assigned fire control system. The CODE SELECTED light on the launcher panel will go on if the codes match.

Only if all conditions are met, will the missile firing be ordered. The READY-TO-FIRE light will go on in the weapons control station and on the launcher control panel. The fin opener and contactor must be engaged at the time the firing key is pressed in the weapons control station. The circuit to the hot gas generator squibs (in the missile) leads through the launcher contactor. After the hot gas generator squibs have fired, the contactor and the fin opener cranks retract and all circuits through the contactor are broke.

Beneath the closed blast door, the hoist was lowered, and the ready service ring has indexed another missile to the hoist position. Warmup has been applied and the missile is ready to be loaded on the launcher. If only one missile was ordered, no further loading takes place.

This assumes that every valve, switch, etc., works perfectly. If any part fails to perform as expected, repairs must be made by the GMMs. As most of the smaller ships have only one launcher, a failure can be a critical matter. You need to become thoroughly familiar with the system on board so you can locate trouble quickly and remedy it. It is expected that application of the Planned Maintenance Subsystem will reduce such failures to a minimum.

MK 13 MODS 1, 2, AND 3.-A number of changes have been made to improve the performance of the Mk 13 launching system. The base structure of the magazine is completely redesigned. The water injectors (see ch. 8) have been extended below the bottom plates of the "base structure. The missile restraint rings now have vertical mounting brackets and are made of heavier material. The magazine rail assembly in each cell now has a latch lock on the magazine rail latch to prevent the latch from being jarred open. The hoist assembly has changes in the hoist pawl unit, the curved track assembly, the retractable rails, and the retractable rail valve blocks. A hand-operated nitrogen-booster pump has been added to boost the ship-supply pressure for charging the jettison accumulator. It is mounted inside the stand assembly just below the center hatch (fig. 3'-11).

Pressure-cutout switch assemblies and their associated valves and orifices have been relocated from the safety relief valve to the tank cover of the header tank for the train and elevation drives, and the header tank of the magazine power supply.

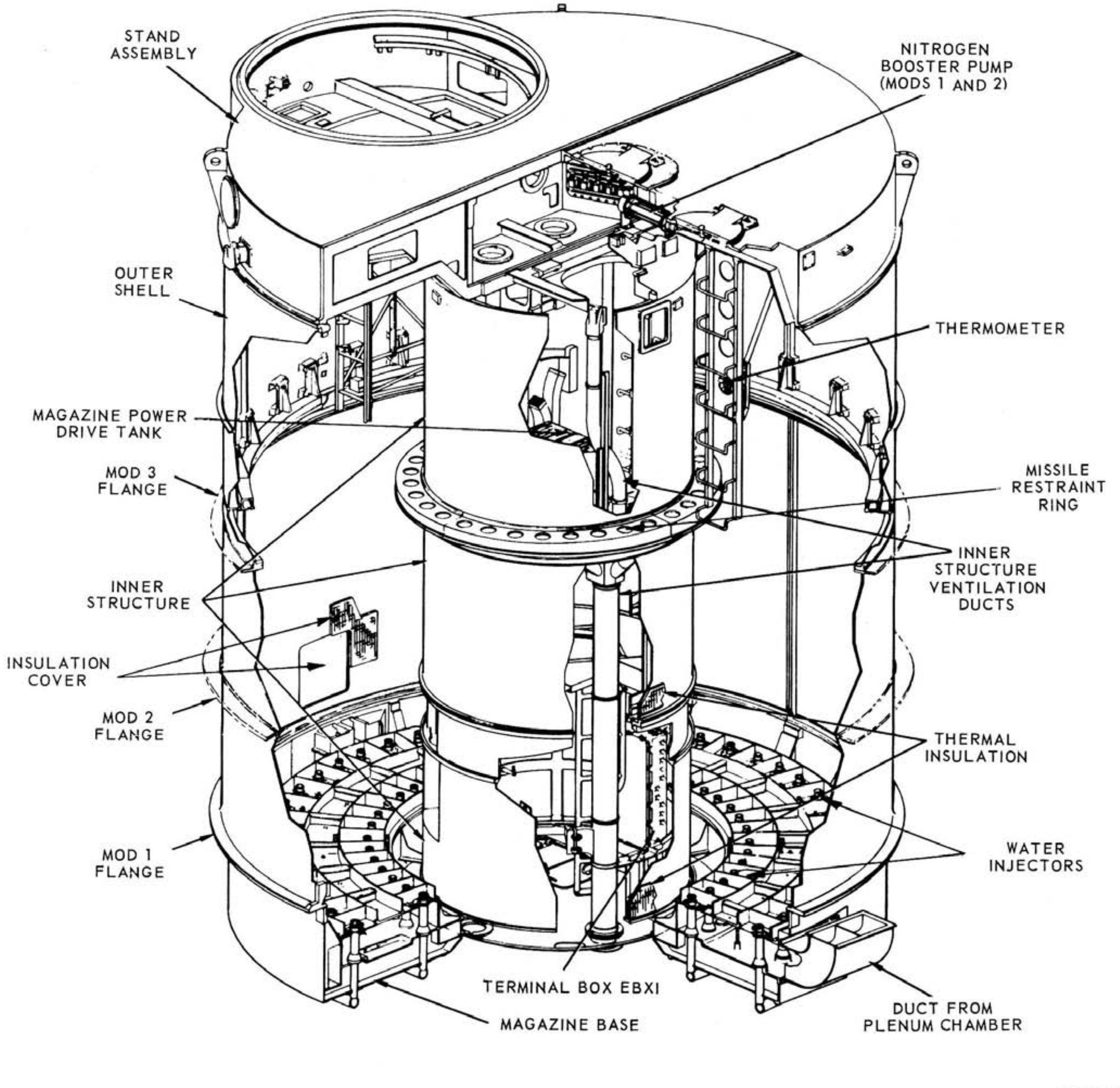

Figure 3-11.—Magazine structure, GMLS Mk 13 Mods 1, 2, and 3.

The launcher guide, too, has some changes. These are changes in the forward motion latch and lock, the igniters, the fm openers, and the fin opener and contactor assemblies. A :key-operated lock on the arming device permits the launcher captain to lock the arming device as a safety precaution during checkout of missiles on the guide arm. The forward motion stop latch has been changed from a movable stop to a fixed one. The igniters have been modified so they contact the missile only when the missile is armed. The changes in the fin opener and contactor assemblies are minor and do not change the operation of the assemblies. The fin opener housing is slightly smaller and shaped slightly differently than on the Mod 0.

The principal change in the train and elevation systems is the redesign of the electronic servo control units. There are also some changes in the train and elevation drive motors, the servo and supercharge hydraulic systems, and in the receiver regulators.

Some of the changes were necessary because of the larger size of the Improved Tartar. The magazine was modified to allow stowage of a mixture of X, Y, or Z type Tartar missiles. The Missile Station Assignment Switches are on the inside of the EP2 panel. To assign the missiles to their stations in the magazine, the EP2 operator unlocks the missile type assignment switch cover and assigns each empty station to the missiles to be on-loaded. Loaded stations are not changed by the operator.

Mk 22 Launching System

Guided Missile Launching System Mk 22 is installed on small ships (DDGs) where space, weight, and other considerations require a smaller and lighter system than the Mk 13. The Mk 22 is an extremely compact single-arm launching system designed to stow, load, and fife Tartar missiles, and may be adapted for handling, loading, and firing other missiles. It is attached to the ship's structure with a single mounting ring like that of the 5" /54 Gun Mount Mk 42. The missiles are stowed vertically in a single ready service ring, which is nonrotatable. The launcher rotates to the loading position over the selected cell. Figure 3-12 shows structural elements of the system in a cutaway view. The train/hoist and elevation power drives and their associated receiver-regulators and miscellaneous controls are supported on the launcher's center . column. The control panels are remotely located.

The launcher is bearing-mounted to the upper magazine section, and forms the top of the magazine. The launcher arm assembly provides the guide rail and latches which support and secure the missile, the fin erectors which unfold the missile tail fins, the launcher-to-missile electrical connector which feeds the pre firing intelligence to the weapon, mechanical input to arm the rocket motor, and firing contacts to ignite the rocket motor. The rail guides the missile for the first 20 inches of travel, then retracts, moving away from the. flight path. This gives extra clearance so that the missile will not strike the forward end of the guide under severe ship roll, wind, and other conditions. A dud-jettisoning device is provided in the guide arm to boost a faulty missile overboard if necessary.

Many of the components are the same as on the Mk 13 launching system. The guide arm in its entirety is interchangeable. A major difference is in the power drive. Both loading and training are tied to one power unit. The two operations cannot take place. simultaneously. The elevation power drive is a separate unit.

The operational characteristics and controls are similar to the Mk 13, and personnel training does not present unique problems. At General Quarters, three crewmen are required: an operator at the main control panel, a safety observer, and an emergency repair technician.

Operation of the system is normally automatic, and the crew merely monitor the system. At LOAD order, the launcher automatically trains and elevates to the selected loading position, the magazine blast door opens, the hoist chain engages the missile from below and pushes it into position on the launcher. The fin erectors engage the missile fins (opening them if the launcher has been assigned a target) and at the same time the contractor makes electrical contact with the missile. The hoist chain is then retracted and the blast door closes. If the launcher has been assigned, it synchronizes in train and elevation with' the computer signal. The missile may be fired any time after synchronization. An automatic warmup system ensures that enough missiles are kept on warmup to permit firing continuously but that any missile approaching a condition of excessive warmup will be taken out of sequence and allowed to cool. Indicators provide continuous information on orders received, status of launching system operations, number of missiles in the magazine, and missile warmup in the magazine.

Step control is used for system maintenance, exercise, strikedown, and missile checkout. Safety interlocks, firefighting installations, vents to limit magazine pressure, a plenum chamber under the missiles, and a wafer injection system are very similar to those in the Mk 13 Mod 0 system. If a missile should accidentally ignite in the magazine~ the plenum chamber receives the

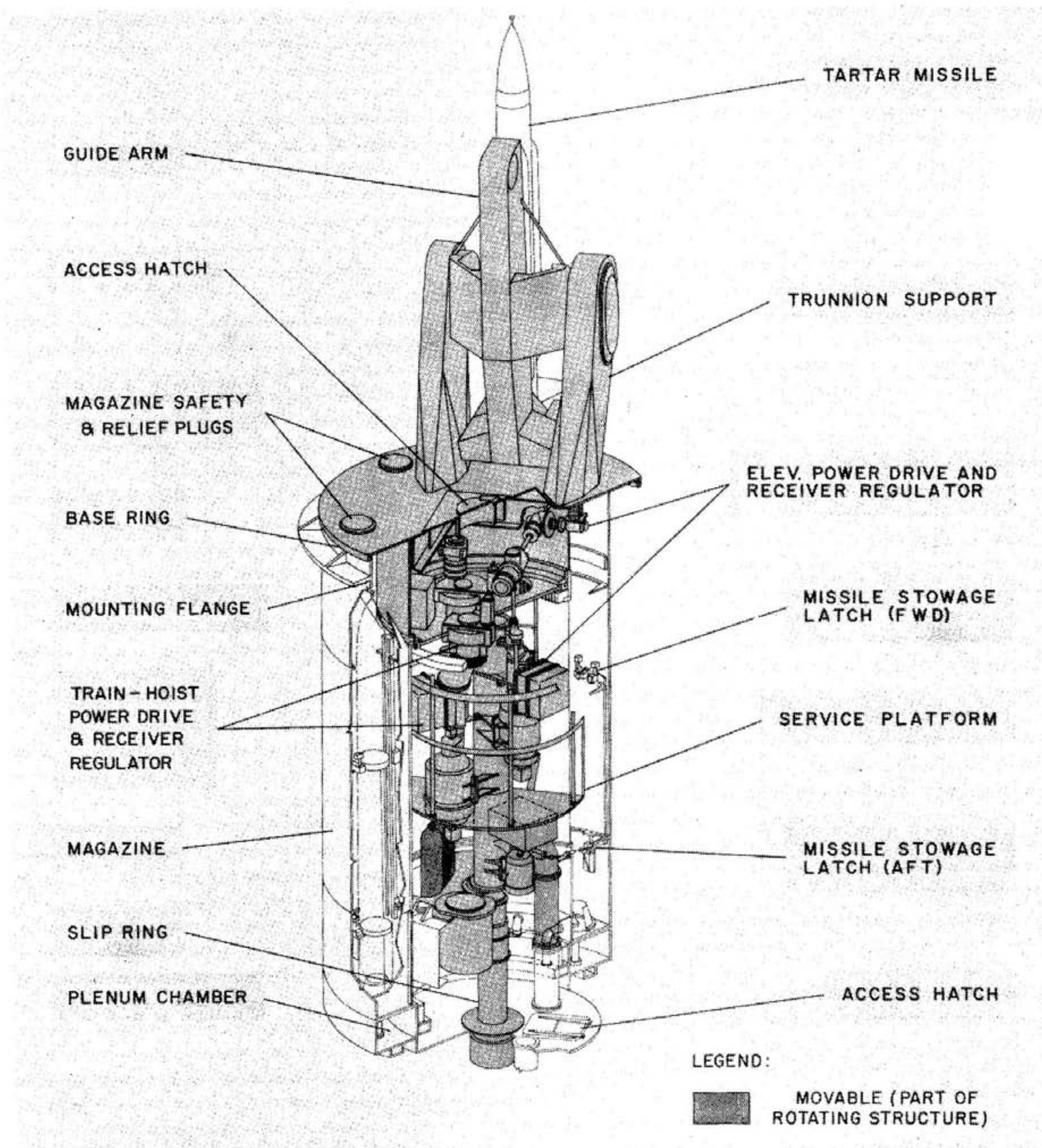

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Figure 3-12.—Guided Missile Launching System Mk 22 Mod 0 for Tartar missile.

exhaust gases and conducts them to an elbow: shaped duct at the edge of the chamber, where the gases escape to the atmosphere.

TALOS LAUNCHING SYSTEM

The Talos launching systems are capable of firing Talos weapons with conventional warheads (Talos S) and also those with nuclear warheads (Talos W). Talos S missiles may be fired in salvos from the dual-armed launcher, or singly, but Talos W must always be fired singly. The unique destruct capabilities of the Talos W make salvos unnecessary. The preparation for firing procedure is different because of the difference in the warhead.

The original launching system for the Talos, the Mk 7 Mod 0 launching system, has undergone some changes to become the Mk 12 launching system. Refer to table 3-1 and note which components have different mark numbers: launcher-feeder, magazines, assembler, feeder and control system. In the launcher and its components, there are only mod changes.

The Mk 7 and the Mk 12 launching systems both use a Mk 7 launcher.

Mk 7 Launching System

The early Talos launching systems were placed on converted CL-55 class cruisers. The entire system except for the launcher is enclosed in a deckhouse located on the after end of the ship. The deckhouse is divided into three compartments (fig. 2-13) by two athwartships bulkheads. The area nearest the launcher is the wing and fin assembly area. The ready service compartment, in the center, is where mated missiles are stowed, ready to be loaded on the launcher except for the wings and fills. The last compartment is the magazine where missiles are stowed, mated or unmated. The magazine is not considered a part of the launching system, as transfer of missiles and boosters from it is not normally part of the launching system's operating cycle in loading weapons.

When preparing for an attack (real or simulated), an alert signal is sent throughout the weapon system from CIC or the weapons control station. This signals the various equipment operators to place their equipment from STANDBY to READY status. Alert bells sound in the ready-service compartment and in the wing and fill assembly area of the launching system. Power is turned on to operate the system. The feeder system is fully energized and set up for automatic operation. The launcher train and elevation control is set up for remote operation. At the launcher captain's panel (EP-2) the Launcher Ready Switch is placed in . the READY position and the Firing Safety Switch in the FIRE position.

As soon as the launching system is ready, the Launcher Station Ready switch lights up on the launcher direction console in the weapons control station. The console operator then checks the number and type of missiles stowed in the ready service compartment, as indicated by numerals on his console, and double checks by sound-powered telephone to personnel on the launcher.

He resets numbers to agree. Then he places his warmup switches to ON. The operator of the feeder panel (EP-3) in the deckhouse places his Area 1 Warmup and Launcher Warmup switches in NORMAL or INTERNAL position.

The load order is received from the weapons control station, where the console operator pushes the button to start the selected rounds moving from the ready-service ring to the wing and fin assembly room. The wing and fin assemblymen attach the wings and fins, apply warmup power to the missile, and, on a nuclear missile, the assembly captain installs the missile arming plug. All this takes a. few seconds. As soon as the missile is ready, the blast doors open, and the missile is rammed on the launcher rails. The blast doors close and the launcher is ready for assignment of the target. Safety interlocks prevent firing while the blast doors are open.

The operators of the ready service panels (EP-6 and EP7) have to be alert to any delay in the loading or a change in loading orders. The ready service hoist can bring any selected round to the hoist position, but if the selected round is one or more stations away from the transfer station (hoist position), it takes longer. Only a few seconds are required to bring a missile to the transfer position. Suppose an "S" missile is wanted and there is an empty tray at the transfer position, then a "W" missile, and the third contains an "S" missile. It would take about three times as long for the "S" missile to reach the transfer station, ready to be hoisted to the loader rail and then rammed to the wing and fin assembly room.

Usually both rails are loaded simultaneously, but never with "W" missiles. Before anything can be done about loading a "W" missile, the weapons officer (or officer designated by him) must unlock the box in the weapons control station and position the "W Enable" switch to ON. Then launcher personnel are ordered by sound-powered telephone to remove the locked antiloading devices from the "W" missile booster shoes (fig. 3-13), and to unlock the safe (in the wing and fin assembly room) containing the "W" arming plugs. Notice that the antiloading device is locked with a key. This key is kept in the custody of the weapons officer.

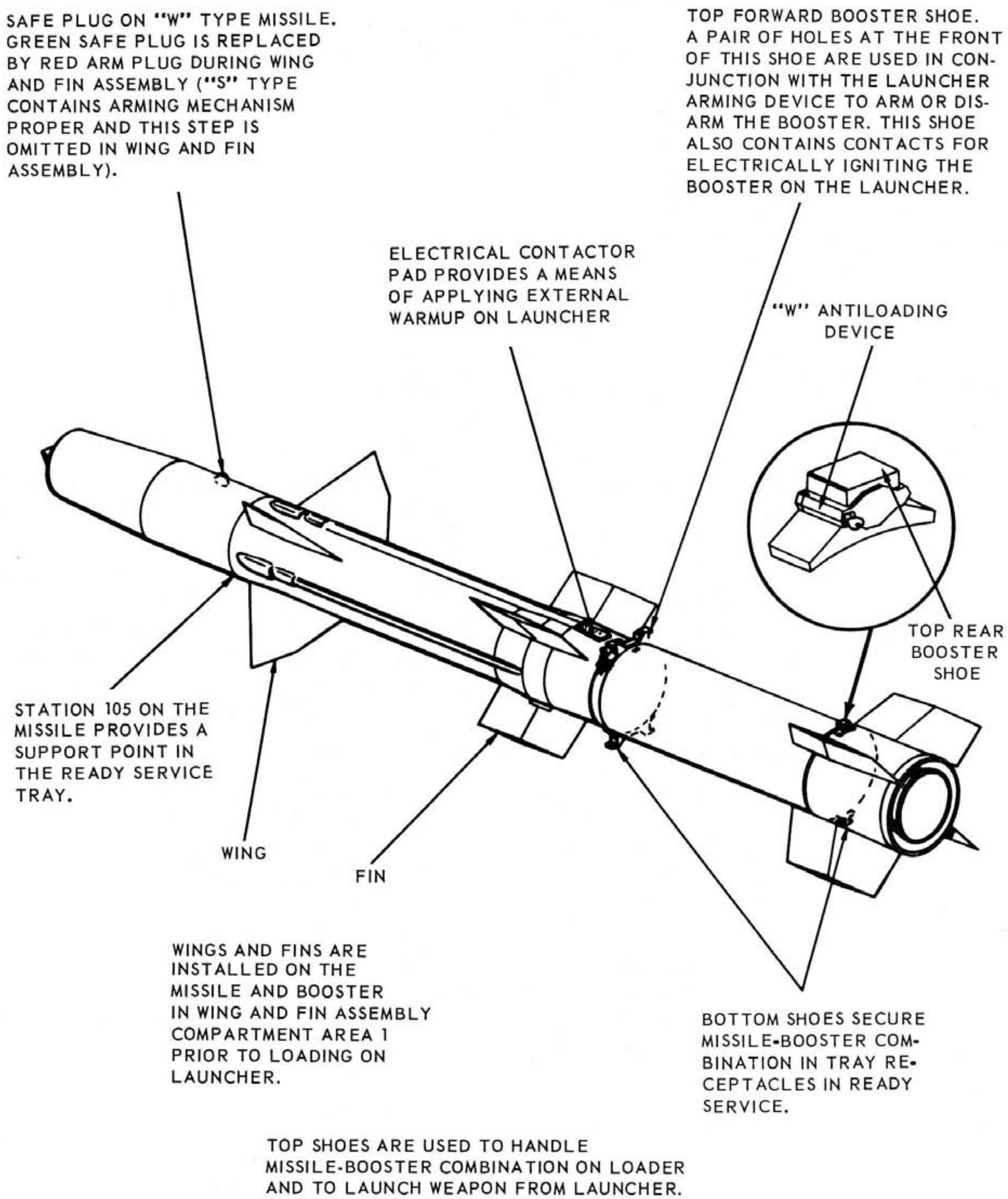

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Figure 3-13.—Talos weapon in outline, showing locations of wings, fins, contactors, safe and arming plug, antiloading device, and support points.

The Mk 7 launching system is similar to the Mk 12 launching system in many respects. The applications of basic principles of hydraulics and electricity are similar in both systems. The same mechanical and hydraulic aspects are found in both systems for the span track, the blast doors and the loader (excluding the power drive). The area 1 accumulator is the same in both systems, On these topics, OP 3590 volumes 2 and 3 applies equally well to both systems.

In the Terrier and Tartar systems, except the Mk 22 Tartar system, ready service rings are mechanisms that can be rotated to bring the selected missile to the loading position. The Talos ready service rings are not really rings either in appearance or functionally. Each is actually a horizontal rectangular assembly containing 8 trays, arranged in two layers. Each tray can hold one missile with assembled booster. Two pairs of end hoists in each ring can raise or lower the end trays in each row. A pair of center hoists in each ring can hoist the center tray high enough so that shoes on the booster can engage the loader rail. The trays in the ring can be translated laterally. Thus trays in the bottom row can be shifted to the upper row; those in the upper row can be shifted to the center of the row and hoisted by the center hoists to transfer their missiles to the loader rail.

The ready service compartments hold a total of 16 missiles in the A and B sides and the magazine holds an additional 30 missiles, mated or unmated. The Mk 12 launching system has 26 missiles in each side of the magazine, a total of 52 missiles, all assembled (except for wings and fills). For effective operation, one tray support must be empty of trays. In both systems, the missile (in its tray) is raised by a hoist, operated by a hoist power drive. A tray transfer mechanism provides for transferring a tray from the tray support to the hoist or from the hoist to the tray support. The loader receives the missile-booster combination from the tray via the loader rail. In the Mk 7, each tray holds one missile; in the Mk 12, each tray support holds two trays and the tray support remains in position when a tray with its missile is hoisted.

Mk 12 Launching System

As pointed out earlier, the location of the magazines and the resultant changes in the launcher-feeder mechanisms is the biggest area of difference between the Mk 7 and the Mk 12 launching systems. How does this affect the sequence of operations in preparation for firing? Several of the launching system control panels (table 3-1) are the same mark and mod as in the Mk 7 launching system, which means they have the same circuits and pushbuttons, and therefore the same steps in operation. The Mk 12 does not have a ready service ring (fig. 3-14), and there-fore has no need for ready service panels (EP-6 and EP7 in the Mk 7 system). Panels EP-6 and EP7 in the Mk 12 launching system are magazine control panels located on the mezzanine just above the magazines. The Mk 12 system has ten "'additional control panels located throughout the system; most of them are not manned in automatic operation. These provide for auxiliary and local control of the equipments for emergencies and also for checking equipment after maintenance or overhaul. They provide for extremely slow operation, not intended for tactical use. The number of men required for the launching crew is the same as for the Mk 7 system. No men are stationed in the magazine area below decks. In the Mk 12 launching system, all the missiles are stowed assembled into Magazines Mk 7 Mods 0 and 1; there is no additional magazine beyond this for unmated missiles as in the Mk 7 launching system.

As in the Mk 7 launching system, the orders come from the weapons control station; the operator at the EP-2 panel monitors his panel and operates the switches to comply with the orders. The order from the weapons control station causes a blinking light indicator on the EP-2 panel; turning the ordered switch changes the blinking light to a steady light. While the method of bringing the selected missile to the assembly area is different because of the magazine location and its design, the work of the men on the launching system is no different. There are only two manual operations, the attachment of the win~ and fins, and the installation of the red arming plug on! W type missiles. Operation checklists should be posted at each station in the launching system. The man (or men) at each station should follow the checklist to ensure that steps will be performed in proper sequence.

Safety switches in the wing and fin assembly area have been mentioned several times, sometimes as foot switches and sometimes as hand switches. In the Mk 7 launching system, each assemblyman has a foot switch which he presses when he has completed his assembly work and has stepped behind the safety screen. In the Mk 12 launching system, hand switches have replaced the foot switches. There is less likelihood of unintentional actuation of a hand switch. When the lights on the assembler panel

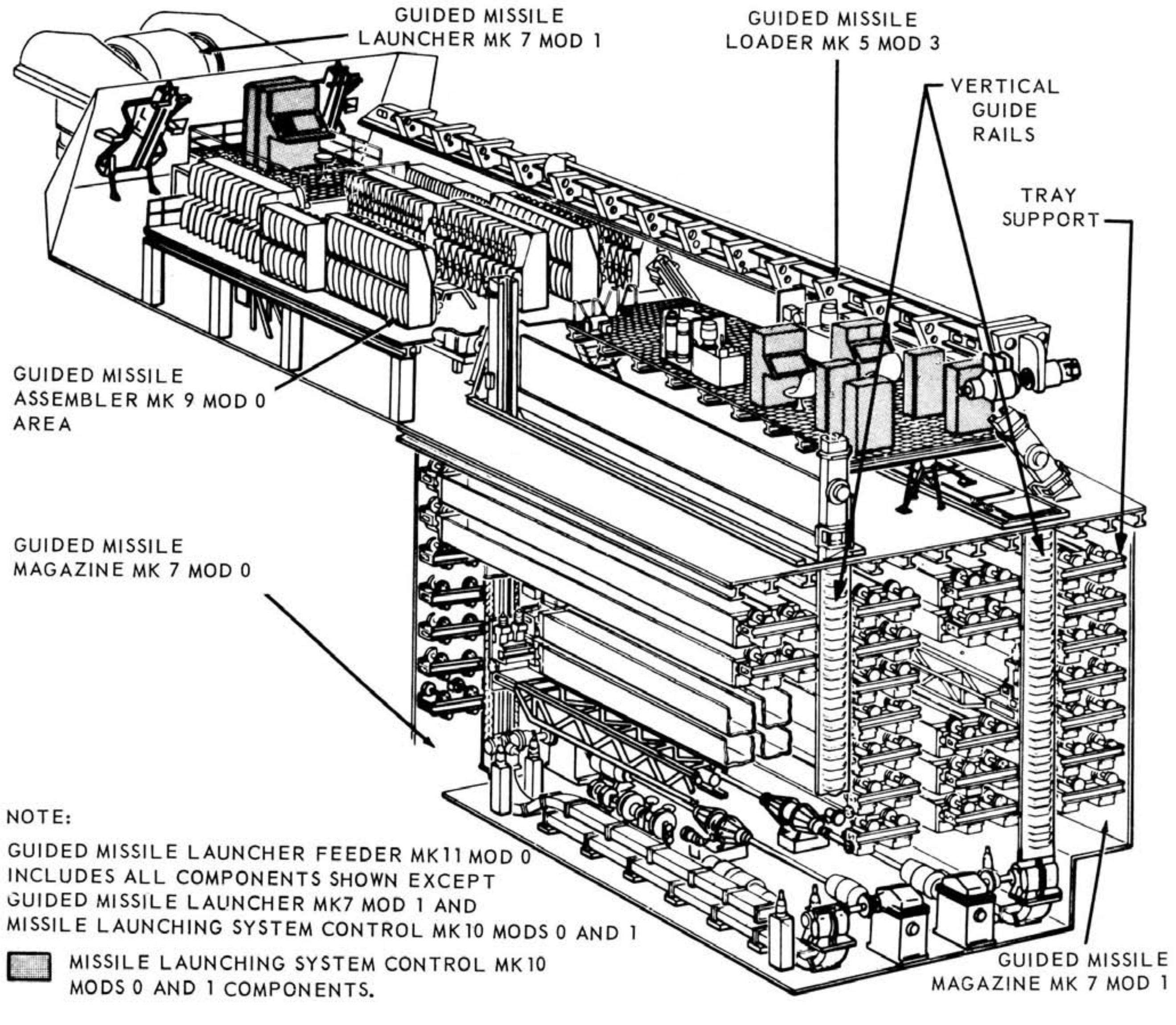

Figure 3-14.—Guided Missile Launching System Mk 12 Mods 0 and 1.

(EP-4 or EP-S) indicate that all the safety switches have been actuated, the assembler captain arms th~ missile (if required) and lets it move on through the blast doors, which open 10 seconds after assembly begins. It takes 5 seconds for the blast doors to open; assembly of wings and fins has to be completed in 10 seconds.

STANDARD MISSILE LAUNCHING SYSTEM

The already installed Terrier and Tartar launching systems will be used to launch the Standard missile when it is placed in service on ships. Modifications will be made to the existing launching systems to accommodate the two types of Standard missiles, the medium range (MR) and the extended range (ER).

To make the Standard missiles compatible with existing shipboard systems, some minor modifications must be made. Actually, two comparisons must be made: (1) between Terrier missile systems and Standard (ER) missile systems; and (2) Tartar missile systems and

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Standard (MR) systems. On some ships, either the Terrier or the Standard (ER) missile can be used, and on some Tartar ships, either the Tartar or the Standard (MR) missiles can be used.

Relatively minor changes to launching systems include: (1) Missile identification ~ circuits, (2) Warmup time delay bypass circuits, (Standard missiles need No warmup), (3) Circuits to delay missile firing until its one shot batteries are ready for use (stabilized) and (4) a signal comparison network to identify the Standard missile illuminator frequencies.

CHAPTER 4

LOADING, UNLOADING, AND DUD-JETTISONING

The preceding course of this series and the preceding chapter of this course gave you an overview of guided missile launching systems. The control panels operated by GMMs were described. The functioning cycles in three types of operation-automatic, step, and emergency were explained, and crew stations were illustrated.

LOADING is the process of bringing the round from the magazine, attaching any additional parts necessary (wings, fins, power supply, arming plug), and placing the complete missile on the launcher, ready for firing.

UNLOADING the missile consists of returning the round to the magazine or to a container for off-loading. Wings and fins have to be folded or removed, the arming plug and the thermal batteries removed, and the round stowed in the magazine, in the cell or tray designated for it (or packed in its container for shipment).

Since most of the work is done automatically by launching system, and lower rated men do most ,of the assembling and disassembling,. what does the GMM 1 or C do? He may operate a control panel, supervise the work of the assembly team, act as a safety observer, troubleshoot the equipment, and make the more difficult repairs, including overhaul and adjustment of equipments.

You need to become completely familiar with, the system or systems you have on board, but you also need to know about other types of systems.

This chapter emphasizes the role of the GMM 1 and C in loading and unloading missiles, and goes into detail on the operation of the dud-jettisoning methods for the different missiles in use on Navy ships. The quals relating to dud jettisoning are listed for lower grades, but you have the responsibility for supervising the activity. The decision to jettison a missile is made by higher authority.

TERRIER MISSILE SYSTEM

Each side of the Terrier launcher is serviced by a complete and independent loading system, and each of these systems is serviced by a corresponding handling system. Except for some minor differences, the operation of the two sides is identical. The installation on different ships accounts for other variations; the mark differences account for the greatest variations; mod changes may be simple ones. The changes required to accommodate the Asroc missile in the Mk 10 Mods 7 and 8, however, are more than minor although the principles of operation remain the same.

LOADING

The location of the loader in the Terrier launching system is pointed out in figure 2-8. Figure 3-8 points out the location of the loader power drive, and the loader rail view port. Table 3-1 shows that the Mk 8 loader has been used on Mk 9 and Mk 10 Terrier launching systems, with modifications. Ready service rings are identified in both of the above illustrations for the Mk 10 system. The comparable component in the Mk 9 system, the magazine cell rack, is shown in figure 3-5. The three ready service rings of the , Mod 7 and Mod 8 were shown in the preceding course, *Gunner's Mate M (Missiles) 3, & 2*, NAVTRA 10199.

The feeder includes the loader, the magazine and/or ready service rings, and the assembler, each with its components.

The sequence of steps in moving a round from the magazine to the launcher was given in chapter 3 for Mk 9 and Mk 10 launching systems. If you have had duty on a ship with Terrier capability these steps are familiar to you. If your experience has been with other missile systems, you will recognize the similarities. Now you need to know the launching system so well that you can explain it to lower rated men, and can direct and supervise their work in the loading process. The only manual work involved (if everything is working OK) is the assembling of the wings and fins in the assembly room. If any part of the system fails to act automatically on signal, you need to know how to find the trouble and correct it. The multiplicity of parts in the launching system makes this a real challenge. If you look at the whole complex, it might seem too intricate to master, but if you remember it is made up of applications of simple machines, operated by hydraulic or pneumatic power, electricity, and electronics, you can understand it and unravel its problems.

Warn trainees and other nonoperating personnel in the launching system compartments not to touch controls. Only authorized personnel are permitted in the launching system compartments. NO ONE is permitted in the magazine area when the system is being operated. New and inexperienced personnel must not be permitted to work alone, but must be under direct and continued supervision of skilled, and experienced personnel. All persons whose duties involve the operation of, or stationing on or near power-operated missile equipment, must be thoroughly familiar with the safety orders and precautions and operating instructions for that equipment. As a supervising petty officer, you must remind your men frequently of the safety rules and regulations and enforce them. Violation of safety precautions, willful or accidental, should be reported at once to the immediate superior. Safety devices should always be kept in good order and operative at all times.

The launcher captain monitors the launching system functions by watching. the indicating lights on his panel during automatic operation. (The step control lights and switches on the EP2 panel are covered and are not in operation during automatic procedure.) He reports any maloperation of the equipment, by telephone, to the feeder system captain and the operator of Guided Missile Status Indicator Mk 81 Mod 0 in weapons control. Under emergency conditions, or during any maloperation, the launcher captain stops the launcher movement with the train and elevation operation selector switch or with the train and elevation motor switches.

Grounds are a major cause of casualties, responsible for damage both to personnel and ordnance equipment. Particular attention should be given to watertight integrity of watertight packing, stuffing tubes, covers on junction boxes, switches, and all types of exposed equipment, as well as equipment in areas where condensation can take place. Damage from moisture is a severe problem in tropical climates; frequent inspections are necessary to detect mildew or other signs of moisture. Other unintentional grounds may be due to abrasion of insulating material on wires, contact of exposed wires, or poorly made connections.

Grounding of explosive components, handling equipment, and containers during handling was described in chapter 2.

When acting as assembly captain, do not allow the assemblers to remove wings and fins from the racks until the missile has stopped in position in the assembly area. Wait until all the assemblymen have completed their wing and fin assembly, have stepped back to the clear area, and have pressed their safety switches. Then signal the launcher captain that the assembly area is ready. If a safety switch is inoperative, or malfunctions in any way, check to see that all the assemblymen are in the clear area after completing assembly; then signal the launcher captain "CLEAR BY-PASS." The safety switch used by the assemblymen is a foot switch on some mods, while a hand switch is provided on others; but each man has one at his place in the assembly area.

UNLOADING

With some launching systems, all Unloading must be done in step control (LOCAL or MANUAL), but automatic unloading is possible with the Mk 10 launching system. The unload order is sent by WCS and will indicate the side, A or B, or both, causing a blinking light to appear on the launcher captain's panel. The missile may be in the assembly area or on the launcher when the unload order is given. The launcher captain positions the switches on his panel to conform to the unload orders, and this initiates the automatic unloading. The launcher synchronizes to load position and then proceeds through the unloading steps, the reverse of loading.

When the missile reaches the assembly area, the wings and fins must be removed and returned to the racks. During the unload operation, visually inspect to be sure the wings and fins are removed, the booster is unarmed, and the missile sustainer is in the SAFE position before returning the missile to the magazine area. A dud or misfired booster being returned to the magazine must not be removed from the wing and fin assembly area until the feeder system captain is notified that the booster and missile sustainer have been checked and reset to the UNARMED position.

The assembly area is the most dangerous section of the entire launching system during loading and unloading operations. It is the responsibility of the instructor (usually a GMM 1 or C) to ensure that all safety instructions are strictly adhered to. The trainees must not be permitted to, operate the equipment, to position control switches, ot to perform any other work on the system without direct and continuous supervision of the instructor. Although each trainee is responsible for his own safety, you, as a petty officer, must give frequent reminders of the safety precautions and be on constant watch to see that they are observed. When the feeder system is in operation, the assemblymen remain on the station with their foot switches depressed, except during actual assembly or disassembly of the wings and fills. The operator of the assembly captain's panel must not give the READY signal until he is completely sure that every man has stepped back to the safe area and has his safety switch depressed. There is an emergency wing and fin assembly bypass switch on the panel, but this must NEVER be used except in case of a malfunctioning foot switch and during equipment checkout when personnel are clear of the assembly area.

During continuous firing, there will be missiles in the assembly area as well as on the launchers. Before the missile to be unloaded from the launcher can be moved, the missile in the assembly area of that side has to be returned to the magazine. The launcher captain must be VERY SURE that there is no missile in the assembly area before he starts the unloading procedure. In automatic unloading, the launcher captain positions his unload assembly switch, the assemblymen remove the wings and fins, the assembly captain positions the assembly-ready switch on his panel to REMOVED, and the weapon is moved by the system mechanisms back to the magazine or ready service ring.

At the end of the firing, all missiles must be returned to the magazine before the system is deactivated.

An unloading cycle is necessary after every firing of an Asroc missile from a Terrier system because the adapter must be returned to the magazine tray.

Step Control Unloading

For checking or maintenance purposes, or in an emergency, the unloading operation may be carried out in step control. Step control is always used when moving the missile-booster combination from the ready service ring to the checkout area for routine care and maintenance or for repairing missiles previously struck down as duds. Step control must also be used for exercise and strikedown. The steps are initiated one at a time by use of the push buttons on the launcher captain's panel. The launching equipment is always started in step control. Use the OP for your launching system, the drawings, and the checklist for the procedural steps and the designations of the switches to be activated. The lights and switches on the control panels are plainly numbered and labeled, but it smoothes operation if you familiarize yourself with the panels so there is no long delay while you search the panel face for the right button or switch to operate next.

The indicating lights on the launcher captain's panel show switch actuation. Each pushbutton contains two light bulbs, separated by a center divider. One bulb (or one-half of the pushbutton) corresponds to the A side and the other to the B side of the launcher. When using the Step Control switches, depress the pushbutton and do not release it until the indicating light appears. To check for a faulty bulb, push the "Press to Test" pushbutton (fig. 4-1) at the bottom of the EP2 step control panel. If the bulb tests "good," but still no light shows, investigate for the source of trouble.

Before beginning the unloading procedure, the launcher must be latched in the load position. The launcher contractor (which warms the missile while it is on the launcher), and the arming tool must be retracted before the blast doors are opened. Sound the loader warning horn to warn everyone away from the loader area. After the loader has moved the missile from the launcher back to the assembly area, close the blast doors. The men in the assembly area quickly remove the booster or motor fins and stow them in the racks provided for them. Other assemblymen fold the fins on the missile. Before the magazine door can be opened, fm removal must be completed. The assembler captain must check. that the missile has been safed.

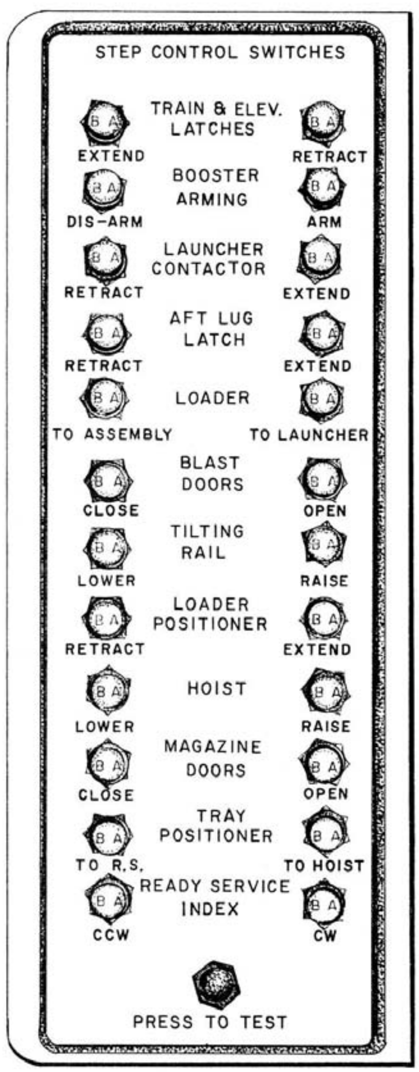

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Figure 4-1.—Step control switches, EP2 panel, Mk 10 Mod 7 Terrier launching system.

If only one type of missile is stowed in the ready service ring, any empty tray can be moved to the no. 1 position to receive the missile. If the ready service ring has more than one type of missile, the designated tray must be indexed to the no. 1 position. The designation of particular trays to specified missiles at replenishment was described in chapter 2. It is possible to change the assignment of trays if necessary; consult the OP for the procedure.

MALFUNCTIONS AND THEIR CORRECTION

The most common causes of malfunction (casualties), listed in the order they most frequently occur, are:

1. Personnel errors.
2. Improper switching conditions.
3. Power failure due to malfunctioning interlocks-switch not properly adjusted mechanically, fuse blown (short circuit), loose connection, dirty connection, improper grounding, broken lead (open circuit), faulty contacts.
4. Power failure due to malfunction of relays-loose connection, broken lead (open: circuit), faulty contacts, coil failure, overload on system.
5. Mechanical failure-improper lubrication (rust or corrosion), working surfaces burred or scored, improper adjustments, equipment out of . alignment (frequently caused by extreme shock or heavy weather conditions).
6. Hydraulic failure-oil supply insufficient, air in oil supply system, foreign matter in oil supply system, improper valve adjustment, scored valve or valve sleeve (foreign matter in system).

It is hoped to eliminate (or greatly reduce) many common failures by conscientious application of the 3-M System. No hydraulic system, for example, should be without sufficient oil if a ..daily check is made. The greatest cause of trouble will probably continue to be no. 1, "Personnel errors."

Troubleshooting

In spite of the best preventive maintenance, there will be some operational failures. The cause of the trouble may be hard to locate, so you have to trace it down. The ability to use schematics and wiring diagrams is essential.

Troubleshooting (casualty analysis) is a very important part of maintenance. Before starting any repairs of a system, determine which of the components is (are) faulty. It frequently happens that the person doing the troubleshooting finds the faulty component, replaces it, but fails to locate the origin of the trouble. The origin of the casualty must be located before replacing a component, otherwise the trouble will recur and the new component will be damaged.

Before performing any casualty analysis or repair work, you should be thoroughly familiar with the equipment, the sequence of operations, the control panels, manual and interlock switches, indicating lights, mechanical and hydraulic functions, and the relation of the control system to the weapons control station. Troubleshooting is discussed in several chapters in connection with different types of components. It may require considerable persistence and patience or it may be quick and easy, but it should always be methodical and thorough.

DUD-JETTISONING

Jettisoning of missiles may be necessary in an extreme emergency or if hazardous conditions exist, such as fire on deck in the vicinity of the launcher, or if the weapon is damaged by enemy action, or if it failed to fire and circumstances do not permit returning it to the magazine or the checkout area. DO NOT JETTISON A MISSILE WITH A NUCLEAR WARHEAD. The decision to jettison comes from the commanding officer via the weapons control station.

The dud-jettisoning unit (fig. 4-2) is associated with each launcher to permit the ejection of missile rounds from the launcher. Each unit consists of two ejectors and a control panel (fig. 4-3). The dud-jettison units are mounted in such a way that ejection can be performed at approximately 95° or 275° of train and at 34° of elevation. (The train and elevation are different on each ship.) The launcher automatically trains and elevates to bring the after end of the round in line with the dud-jettisoning ejector, and a pneumatic mechanism in the ejector elevates a piston in line with the round. The piston extends slowly, under low pressure air, until its mushroom-headed piston mates with the after end of the round, then extends rapidly with a short, powerful pneumatic stroke (3500psi), forcing the round off the launcher and over the side.

The control panel for the dud-jettison unit is mounted in the deckhouse, and is operated by the launcher captain (or the port side assembler captain) upon orders from the WCS by sound-powered telephone. In the Mk 10 Mod 8 system, the control panel is adjacent to the A-side blast doors, within the aft compartment. When the ship's roll exceeds 20°, jettisoning must be performed only on the downroll. A standard bubble type inclinometer with a 45° index scale is mounted next to the dud-jettison control panel to indicate ship's roll.

The launcher captain initiates jettisoning by positioning the DUD-JETTISON switch at the EP-2 panel, which causes the launcher to synchronize automatically to the dud-jettison position.

The dud-jettisoning procedure may be applied to a dud missile, a misfired booster, or any other condition which necessitates a decision to jettison a weapon.

Operation

Whenever the firing key is depressed, the DUD and MISFIRE lamps light momentarily, until the missile has cleared the rails. However, if the missile is a dud, the DUD lamp continues to be lighted. The contractor fails to retract. The operator may try to fire the missile by placing

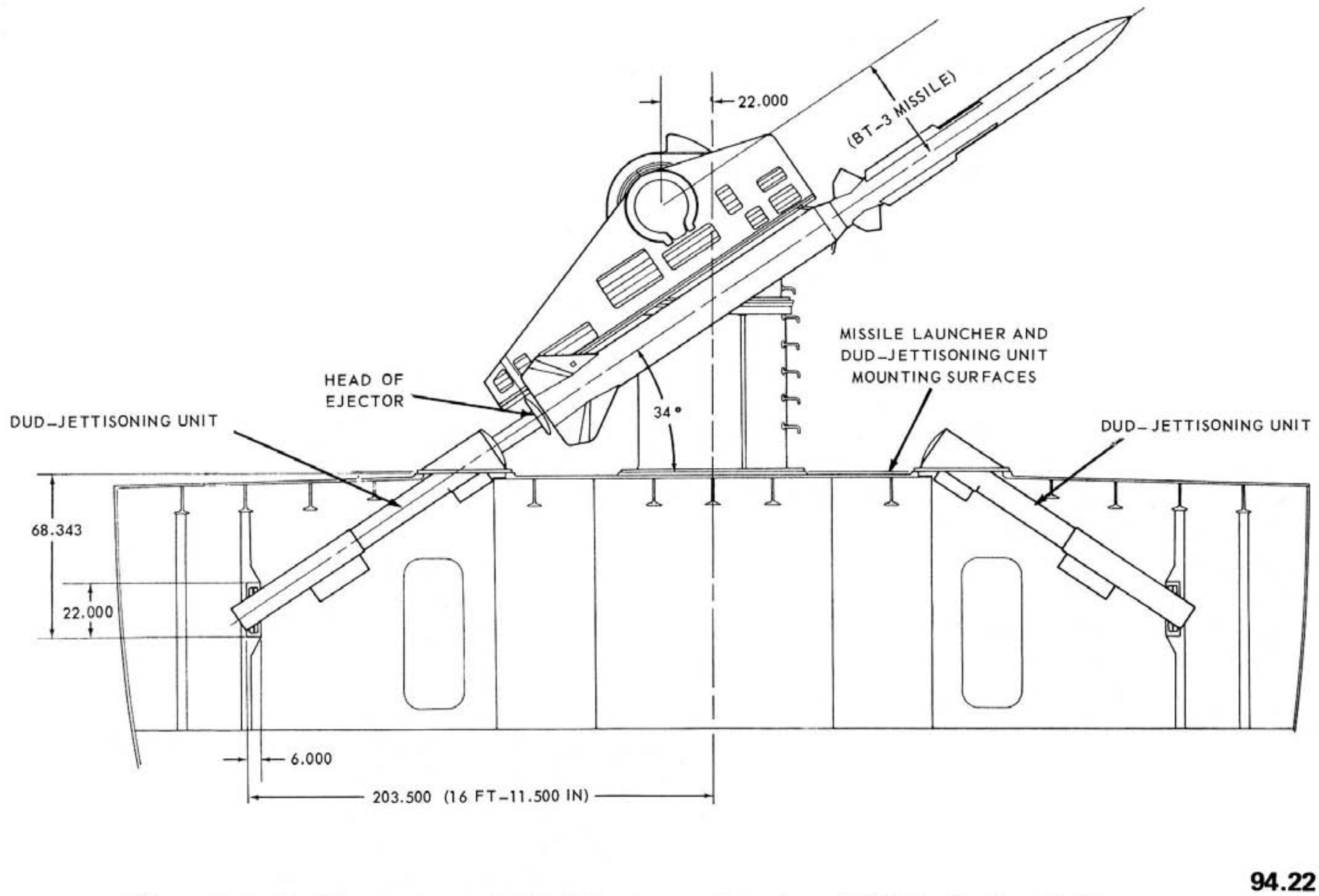

Figure 4-2.—Dud-jettisoning unit Mk 108; cross section view. DLG Terrier installation.

the dud switch in the ON position. If this succeeds, the contactor retracts and the DUD lamp, the RAIL lamp, the WARMUP TIMER RAIL lamp, and the READY TO FIRE lamp all go out. When the arming tool unwinds, the READY lamp also goes out.

If attempts to fire the missile are unsuccessful, it may be returned to the magazine for later inspection and possible repair; its location is marked on the control panels. In some situations (emergency or combat), it may be necessary to jettison a dud missile; wait for the order to do so.

A DUD indication will also occur if the firing key is released too quickly (before 1.5 seconds have elapsed). The booster firing relay will not be energized and as a result a dud missile is left on the launcher.

OPERATING THE DUD-JETTISON PANEL. - Suppose jettisoning of a missile has been ordered. On a Mk 10 launching system the port side assembler captain mans the dud-jettison panel. He must have sound-powered telephone communication established. At the control panel (fig. 4-3) he opens the positioner air supply valve. This connects to low pressure air. Next, he rotates the positioner control lever to POSITION I for a BT -3 missile or POSITION II for a BW-1, for ejector side A or B, whichever side is to be used. When the ejector is in the raised position, rotate the jettison lever to CHARGE and hold the lever in this position until the air pressure meter reads 3500 psi. (Pressure requirements for your installation may be different.) A light ("Safe to Jettison") on the control panel indicates when the ejector is fully raised to "Firing Position."

WARNING: Do not cycle below the designated operating pressure.

Rotate the jettison lever to READY and wait for the command. Upon receiving the command to "Jettison," check that the air pressure meter

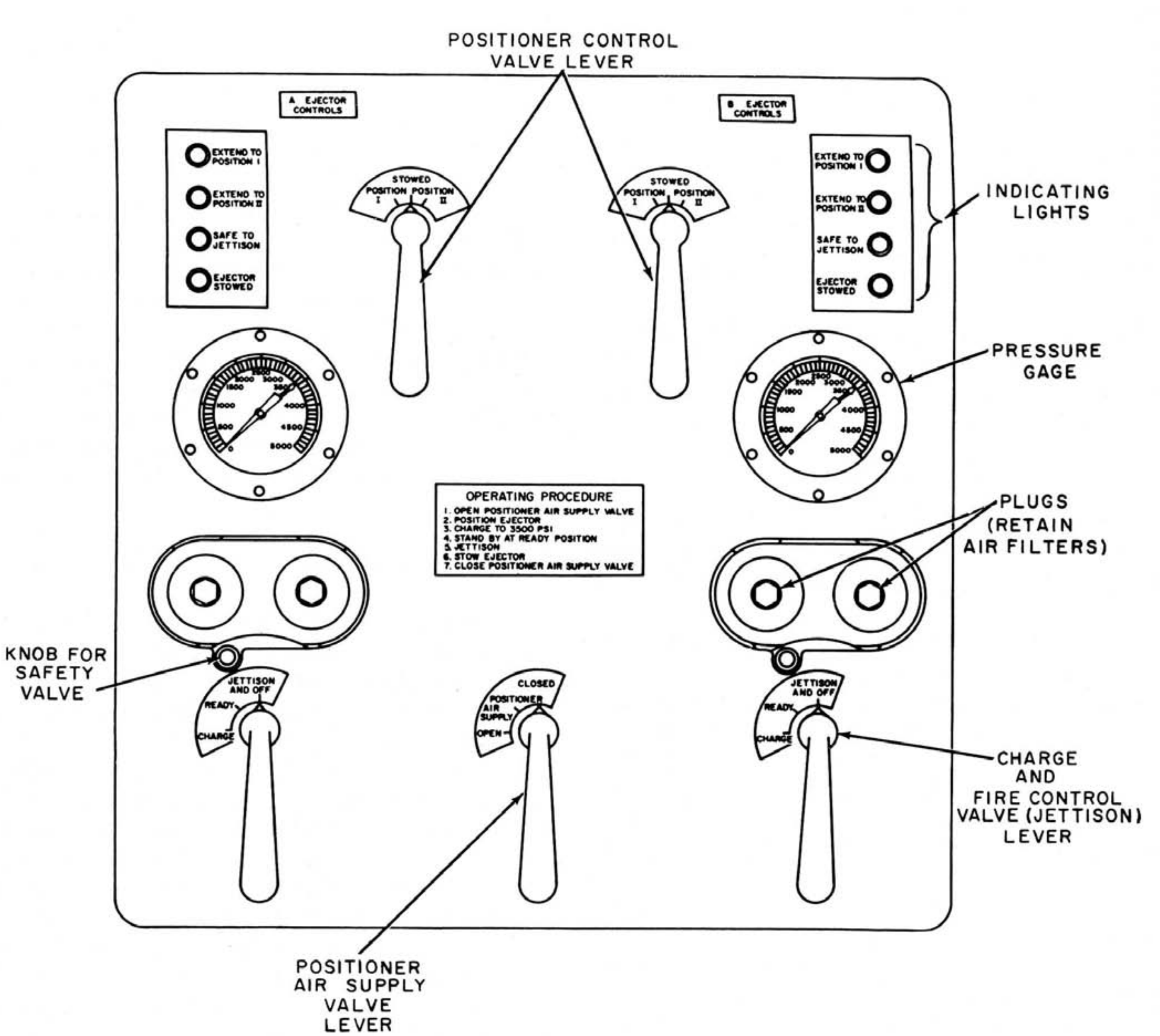

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Figure 4-3.—Dud-jettisoning panel, Terrier launching system Mk 10 Mod 0.

reads in excess. of 3400 psi and rotate the jettison lever to JETTISON. The head of the ejector is forced against the missile base by the air pressure and spring pressure from the spring side of the firing valve, and the missile is forced overboard from the launcher. Note that the air. pressure drops rapidly. Lastly, rotate the positioner control lever to the STOW position. The dud-jettison unit must be lowered ALL the way before the launcher power brake can be released and the launcher trained and elevated for reloading.

There are differences in control panel switches and nomenclature, but the principles of operation are very similar. The steps in operation of the dud-jettison panel on your ship should be posted beside the panel. On some mods, a metal instruction plate is permanently fastened to the dud-jettison panel, directly in front of the operator. After the jettison operations are completed, the dud-jettison panel operator moves the lever of the Positioner Air Supply valve to CLOSED, and the launcher captain returns control to the EP2 panel by repositioning the switches to the desired type of operation.

If the round is considered dangerous to the ship, the launcher captain positions his emergency enabling switch to ENABLE upon telephoned order from the WCS operator. The WCS operator then holds down the dud emergency firing switch until the round leaves the rail (RAIL LOADED light goes out). This is dud firing (not jettisoning), and is carried out in WCS without action by the launching system crew. This method of dud firing disables one side of the launching system. It is used only in case of real danger from the missile on the launcher. This method of dud firing disables one side of the launching system. It is used only in case of real danger from the missile on the launcher.

SAFETY RULES FOR DUD JETTISONING. - Under emergency conditions or during any maloperation, the launcher captain must stop the launcher movement with the train and elevation operation selector switch or with the train and elevation motor switches.

In case of booster misfire, do not permit personnel to approach the launcher for at least 10 minutes after the last attempt to fire, and the firing circuits have been known to be open. The time limit is at the discretion of the commanding officer and is not obligatory in time of action.

The return of a dud or a misfired booster to the magazine, or dud jettisoning, it should not be started until the firing safety plug in the EP-2 control panel has been removed.

During all operations for disposal of misfires or dud, the launcher captain should remain at his control panel to guard the firing safety plug and to observe and make certain the launcher and the guide remain in a SAFE and UNLOAD position.

Do not position the emergency enabling switch to ACTIVATION and ENABLE during firing, unless specifically ordered to do so by weapons control. Use caution as to the proper side and the position ordered.

During unload operations, visually inspect to be sure that wings and fins are removed, booster is unarmed, and the missile sustainer is in the SAFE position before returning the missile to the magazine area.

A dud or a misfired booster being returned to the magazine must not be removed from the wing and fill assembly area until the feeder system captain is notified that the booster and the missile sustainer have been checked and reset to the UNARMED position.

WHAT TO DO WITH ASROC. With the extensive missile tests and circuitry checkout required for Asroc missiles, it is not likely that an Asroc missile will have to be jettisoned, as duds will be discovered before the missile is placed on the launcher. If it is necessary to jettison an Asroc missile, the adapter rail is jettisoned with it. It is jettisoned in the same manner as a Terrier missile. If a dud results from loss of synchronization, it should be handled according to ship's doctrine.

Is It a Dud or a Misfire?

Note the difference between a dud and a misfire. If the DUD lamp lights on the weapons assignment console (WAC) when the firing key is pressed, nothing happens to the missile-it does not transmit the electrical energy to set off any explosive components. Except under certain tactical situations, when the launcher has to be cleared quickly for firing, the dud missile can be returned to the magazine for later examination and repair. In a misfire, some part or parts of the explosive system were actuated when the missile firing key was depressed, but not enough to send the missile off the launcher. A misfire presents a dangerous situation. If the MISFIRE lamp lights at any time during the firing cycle, there are three alternatives: (1) emergency firing procedures may be used; (2) the launcher may be aimed in a safe direction for a waiting period prescribed by ship's doctrine. If nothing happens, the missile may be returned to the magazine for later examination and repair; or (3) the round may be jettisoned.

A missile is considered to have misfired when its booster fails to fire after its electrical and hydraulic systems have been activated and the booster firing relay has been energized. When the firing key is depressed, the DUD lamp lights and the MISFIRE lamp flashes. When the missile fails to clear the rail, the MISFIRE lamp continues to flash and the DUD remains lighted.

You cannot tell whether the explosive train inside the missile will sputter and go out, or if it will burn and explode on the launcher, or if it will fire in a short time. All factors of the situation - known, calculated, and surmised - have to be considered in deciding whether to wait and see what happens or jettison the missile. In a battle situation, it may be necessary to fire a missile from. the other side of the launcher while leaving the misfire on the first side. Several attempts may be made to fire the missile, by means of the emergency firing key. When the emergency enabling switch is at NORMAL, the emergency firing key can be held down as long as desired in an attempt to activate and fire the missile. If it is placed at ACTIVATION AND ENABLE, the booster firing transformer is energized through an alternate circuit and many of the normal firing relay contacts are bypassed. If the firing is successful, it shows the relays were at fault on the first try. If the missile cannot be fired by this method, most likely it will have to be jettisoned. Decision must be made in WCS.

The two emergency firing circuits in the Mk 10 Mod 7 launching system, EMERGENCY ACTIVATION AND ENABLE, and EMERGENCY ENABLE, are used only in the Terrier mode.

Malfunctioning of Dud-Jettisoning Units

The dud-jettisoning unit has been designed to provide maximum service with a minimum of maintenance. A major difficulty that may be experienced with dud-jettisoning units is that of ice forming in the valve passages. This is caused by rapid expansion of moist, compressed air. Any moisture traps in air lines should be drained regularly. Deicing lines port heated fluid to the cover door sections to prevent formation of ice during cold weather, permitting operation of the jettisoning unit in the most adverse weather conditions. The anti-icing system which also protects the launcher from icing.

MAINTENANCE.-Since the dud-jettisoning unit is intended for emergency use, it must be kept in operating condition, ready for instant use when needed. Check out the equipment at: regular intervals by exercising each dud ejector (no missiles on launcher rails). Replace indicator lamp bulbs on the control panels when necessary. The outside of the panel should be cleaned periodically. Usually wiping with a dry cloth is enough; a damp, soapy cloth may be needed .to remove grease spots or fingerprints. Wipe dry. The dud jettison unit does not require lubrication. In particular, take care NOT to lubricate the firing piston head or stem.

WARNING: If it is necessary to disassemble any of the air lines, be sure the valve in the ship's high pressure line (4500 psi) is closed, and also the nearest shutoff valve in the 100-psi ship supply line. Bleeder valves in the ejector unit accumulators should be open. Tag all valves while working. Protect any open ends of pressure lines with suitable caps or plugs to prevent entry of dirt, moisture, or other foreign matter.

It may be necessary to replace a gasket on an ejector unit, or a defective limit switch. The need for a new gasket may be discovered when checking the air-charging chamber of the ejector for hydraulic fluid or moisture. To make the check, remove the drain plug from the lower end of the ejector assembly. If there is any drainage, wipe the drain port clean, check the gasket and plug for signs of deterioration, and replace if necessary. Wait at least 2 hours after a unit has been cycled before making the drainage check. Further disassembly of ejector units is not contemplated, short of battle damage.

Air filters and air breathers, of which there are six: each in the Terrier jettisoning equipment, require regular inspection to see if they need cleaning. Cleaning is done by washing the filter or breather in solvent, rinsing in clear water, and drying with a stream of compressed air. Never direct compressed air at yourself or others; it can be fatal.

Before unscrewing a plug that holds a filter, be sure the manual shutoff valve on the jettison panel is closed and that the pneumatic lines leading to. the ejector are vented {JETTISON AND OFF on panel). (Seer figure 4-3.) There are four of these plugs (and filters) on the face of the panel.

The sensitive switch assemblies, solenoid assembly, and dud-jettison synchro-transformer all need periodic inspection, and adjustment or replacement as required. The adjustment is determined at installation and is not changed later, but units are brought back into adjustment if they vary from it. Two sensitive switch assemblies are located on each ejector. The four solenoid assemblies are all located in the jettison control panel. Any malfunctioning parts are replaced. The synchros are located within the EP2 panel. The synchro control transformers are adjusted or replaced. Instructions for this are given in OP2350.

Manual switches are not repaired but are replaced if they do not function. (The foot-operated safety switches in the assembly area are an exception.) These include indicating pushbutton switch assemblies, pushbutton switch assemblies, toggle switch assemblies, and rotary switch assemblies used on control panels.

Maintenance of the electrical cables includes periodic checking of the cables, connectors, or other associated components: Measure the insulation resistance of power supply cables with a megger. A ground-detection indicator on the EPI panel continuously monitors the control supply circuit. Disconnect this indicator before making a megger test of a cable in the system. If an insulation breakdown is indicated, trace it down and correct it, then test again. If a cable is damaged so it requires replacement, get a spare cable of the same kind from spare parts stock and install it. Umbilical cables are always replaced, not repaired. Do not splice a cable except in an emergency. Attach identification markers to all cables. All terminal lugs should be crimped to their connectors.

TESTS.-Maintenance tests are conducted in cooperation with other ratings and all components of the missile system are tested. System readiness tests are performed every day; system maintenance tests are performed weekly or monthly. Use the OP for your weapons system when each test is performed. OP 2629, Volume 3, *CLG (Terrier) Guided Missile and Anti-aircraft Weapon System, Maintenance Test Procedures* (U;C), consists almost. entirely of tables that list the tests to be made. The equipment to be used, the settings to make on the control panels, directors, computers, etc., and the response expected are all given in the tables. Step No. 29 is a test of the dud-firing circuits. Steps Nos. 27 and 28 are for misfire circuit testing. Referring to table 3.2, you find that steps 26, 27, 28, 29 and 30 must be performed weekly and must be conducted together and in sequence. Turning to step No. 27 in the table of test procedures, you find that the EP-3 panel on the launcher and the weapon assignment console in the weapons control station must be manned. The actions to take (buttons to push) and the desired response for each are listed. Sample log sheets are shown for recording performance of tests. If any failure is indicated on the EP-3 panel, obtain the circuit diagrams of the system, schematics, and the maintenance instructions for your equipment, trace the trouble to its source, and correct it. It may be only a burned-out signal light, or it may be some trouble very hard to locate; Check out the simplest or most obvious cause first. Work in cooperation with the men from the weapons control room to locate and correct the trouble.

Operation of the dud-jettisoning equipment is part of the regular training schedule. If any part fails to function as it should, it is up to you to locate and remedy the trouble with the aid of your men. If the air pressure does not build up enough to eject the missile, check the air lines and valves of the system. The publications custodian of your division has all the drawings, OPs, and other publications needed for the care and repair of the equipment aboard.

TALOS MISSILE SYSTEM

Talos, the largest of the Navy surface-to-air missiles, is stowed as a complete round in the magazine. The missile and booster are mated before stowing in the ready service compartment, but the wings and fins are added in the wing and fin assembly area when the missile is being moved to the launcher.

AUTOMATIC LOADING OPERATION

Normally the launcher rails are loaded simultaneously. This provides maximum fire power as well as backup in the event of a dud, misfire, failure to capture the missile in flight, or any other contingency rendering the fired missile useless. The load order comes from the Launcher Direction Console (LDC) in the

Weapons Control Station (WCS). It is an order to transfer missiles, selected according to type ordered, to the launcher rails. Initiation of the load orders on the LDC causes the center hoist mechanisms (Mk 7 system) to automatically lift the desired weapons to the load position. The missiles are raised by the magazine hoist (Mk 12 system), which rides on vertical rails, up to the main deck level, where the missile is received by the loader. The empty tray is returned to the magazine by the hoist. The magazine door closes after the hoist and tray have been returned. The magazine doors are operated by a hydraulic accumulator power drive. Power for the hoist operation is supplied by the hoist power drive, located on the machinery deck of the magazine. In both Mk 7 and Mk 12 systems, shoes on the booster engage the loader rail by which the missile is moved onward to the wing and fill assembly area.

In the wing and fill assembly area, warmup power is applied, the missile arming plug (W missile) is installed, and the wings and fins are attached. When the assembly operations are completed, the blast doors open and the missiles are rammed onto the launcher rails. Then the blast doors close and the launcher is ready for assignment to its first target. As missiles are used during combat, the initial setup of missiles in the ready service ring may become changed considerably. A tray that held a missile round at the beginning of operations may now be empty, or the reverse may be true. Monitoring of the ready service missile distribution by the operators of the ready service panels (EP-6 and EP-7) is of special importance. To prevent delay in loading, the operators need to index rounds to the hoist position, ready for the next load order without loss of time, indexing past one or more empty trays (or wrong type rounds) to get to the desired round. If there is a delay, the DELAY lamp lights on the LDC panel, indicating to the panel operator that the loading delay is not caused by a malfunction of any of the equipment. It also indicates whether the delay is on Rail A or B, and whether an S or a W missile is to be loaded.

As the missile passes through the launching system, lights on the LDC panel in the weapons control station, and on the launcher control panels, indicate to the panel operators the location of the missile and the stage of operation at all times.

While wings and fins are being assembled to weapons, the assembly captain checks the TWO SAFE lamps on the safing plug on a W missile. If ONE of them lights, he removes the safing plug and inserts the arming plug. If none of the SAFE lamps light he must obtain further instructions from the weapons officer.

As in Terrier systems, each assemblyman has a safety switch which he depresses when he has finished his part of the wing and fin assembly. All assembly switches must be depressed before the missile is loaded on the launcher rail. The Mk 7 launching system has foot switches in the assembly area; the Mk 12 system has hand switches.

The normal mode of loading is automatic. Only two manual operations are involved - attaching the wings and fins, and installing the arming plug in W missiles. As long as everything is operating normally, the panel operators merely monitor their panels. If anything goes wrong, however, you have to locate the trouble and correct it as quickly as possible. The OP for the launching system, for example, OP 3590 Guided Missile Launching System Mark 12 Mods 0 and 1, contains schematics for the circuits. The sequence of action is described in the accompanying text. These aids will help you pinpoint the area of failure. If the fault is in the hydraulic system, or in pneumatic components, refer to the OP.

Unloading

In the Mk 12 launching system, missiles may be moved automatically from the launcher to Area 2, above the magazines, or from Area I (wing and fin assembly area) to Area 2. The operations for bringing the missiles from Area 2 to the magazine are not automatic. Step control switches at EP-6 and EP:, 7 magazine panels are used to bring. the missiles to the magazine and stow them. The missiles must be halted in Area I so the wings and fins can be removed and stowed in their racks. If a W missile is being returned to the magazine, the (magenta) arming plug must be removed and locked in its locked storage space, and a safing plug installed in its place. The weapons officer has charge of the plugs; removal and insertion of the plug must be done according to the checkoff list for this procedure. The antiloading devices, sometimes called handcuffs, are put back on the W missile booster shoes. These devices lock the booster shoes preventing the transfer from the magazine to the loader.

The safety switches in the assembly area, are used in the same manner as in the loading operation. Each assembler steps behind his safety screen and actuates his safety switch as soon as he has finished removing the wing or fin. When all 12 switches are actuated, the next step in unloading can be initiated, that is, to return the missile to the ready service compartment. The man at the EP 6 (or EP 7) panel operates the push buttons for unloading. The man at the EP3 panel monitors the operation.

In the Mk 7 launching system, unloading cannot be done automatically, but is done in step mode. This is relatively slow.

Step Control

Step control is used for training, practice, and checkout. All or part of the loading cycle may be in step control. Talos missiles are not fired in step control. The sequence of actions of the launching system are the same as in automatic loading, but each step must be initiated by turning a switch or pushing a button on a control panel. The step control switches on the EP-2 panel are covered when not in use. Each switch has a light or a pair of lights to indicate the position of the component. The pairs of lights indicate the position of similar components on A and B sides of the launcher. The fourth letter in the light designation indicates the side. For example, amber indicator light DSAB1 indicates that the booster arming device on the B side is extended.

The launching system captain operates the -step control switches on the EP-2 panel. He maintains telephone contact with the weapons control station and the officer in charge of the launching system. The operators of the magazine control panels, EP-6 (A-side) and EP-7 (B side) operate the equipment in compliance with phone orders from the officer in charge of the launching system or indicator light orders from the launching system captain. They sound the warning horn when activating magazine equipment, operate the magazine equipment, and, when unloading, strike down the booster-missile combinations.

TALOS DUD JETTISONING

The Talos launching system does not have dud-jettisoning equipment. The launcher is used if a dud must be ejected. The procedure with the Mk 7 and Mk 12 launching systems is essentially the same. If, after the firing key has been depressed at the console in the weapons control station, the missile does not fire and the DUD indicator lamp lights on the launcher control panel, the missile is considered a dud. Ordinarily, the wings and fins are removed and the missile is returned to stowage as a dud for subsequent repair. In a tactical situation, it may be necessary to clear the launcher quickly so as not to lose half the fire power of the launcher. In that case, the dud-firing switch (for A or B side, as appropriate) is closed until the DUD lamp goes out. The closing of the dud-firing switch bypasses the missile activation circuits in firing the booster squibs. Only single-rail firing is possible from a dud-firing key. Although there are no interlocks to prevent dud firing simultaneously by using both dud-firing keys, this should be avoided because an inactivated missile is aerodynamically unstable, and its flight path is highly unpredictable. Two missiles fired simultaneously might collide near the ship.

Misfire

If the MISFIRE light goes on, it indicates that firing was initiated and the missile internal power switchover circuits were completed; the booster firing relay energized, but the weapon did not clear the rail. This light is always on momentarily after the firing key is pressed (in the WCS), but if the weapon does not clear the rail in the time limit prescribed by the delayed misfire relay, the MISFIRE light remains on. If firing circuit troubles are suspected, emergency firing can be attempted after the guidance circuits have been reset and the missile gyros have been recaged. If a misfire is indicated again, the missile should be treated as a potential "hangfire." It is kept on the launcher rail for 30 minutes with both blast doors closed, and if nothing happens, it is returned to the ready service compartment and stowed as a dud. A missile already on the other rail may safely be fired, but do not reload for 30 minutes.

EMERGENCY FIRING.-Under emergency conditions, missile firing can take place from the emergency firing panel in WCS. Firing from this panel bypasses all system safety interlocks except those involving the blast doors, firing cutout cams, and the firing safety switch. Unlike dud firing, the emergency firing sequence energizes the missile activation circuits, making the launched missile capable of normal flight. Determination of when to use emergency firing procedures should be based upon established ship doctrine and the tactical situation. When emergency firing is authorized, WCS notifies the EP-2 panel operator by sound-powered telephone to set the EMERG. FIRING, ENABLE switches. WCS closes the emergency firing key when the EMERGENCY READY TO FIRE light goes on. The launcher may be damaged if the emergency firing key is pressed before this light is on. It goes out when the rail has been cleared by the missile and the firing key can be released. Only single-rail firing is possible in emergency firing.

EMERGENCY IGNITIER.-If the missile is not fired by emergency firing, the use of an emergency igniter injector may be ordered. It was designed for combat use to dispose of a misfired missile and booster, and to fire a missile tactically with the hope that it might be a successful shot. The emergency igniter injector has been placed an all Mk 12 Mods 0 and 1 launching systems; later mods will have them installed with the launchers. Mk 7 launching systems have been modified to include them; figure 4-4 A shows the igniter injector installed on each launcher arm, and figure 4-4B indicates the parts of the igniter injector. It is hydraulically operated and is remotely controlled through the launching system .firing circuits. In its normally stowed position (fig. 4-4A), the injector is locked to the guide arm by a hydraulically operated latch (fig. 4-4B), out of the path of the missile blast. The emergency igniter cartridge (fig. 4-4B) contains an igniter which is a plastic cylinder about 4 inches in diameter and 8 inches long, filled with 1500 grams of boron-potassium nitrate pellets. This explosive provides sufficient ignition to the booster to develop full normal booster thrust. The cartridges containing the igniters are carried by the ship as ammunition components and are loaded into the injectors when their use is anticipated.

A test unit that simulates the emergency igniter and cartridge is kept in the injector at all times except when it is desired to use the emergency igniter cartridge. It is used for the periodic cycling of the injector mechanism, for checking the firing circuit, and for sealing the cartridge housing in the injector unit against the weather. When the use of the emergency igniter injector is ordered, the launcher captain places the EMERG. FIRING ENABLE switch at EMERG. IGNITER position. The launcher then automatically positions at 30° elevation with respect to the deck (fig. 4-5A), the hydraulic latch on the guide arm is released, and the injector unit is rotated to LOAD position in line with the longitudinal axis of the booster. The hydraulic piston of the unit then extends and carries the igniter cartridge and igniter to the booster closure disc. The cartridge travel is stopped as its forward flange contacts the Styrofoam closure disc of the booster. The piston, continuing its travel, pushes the igniter out of the cartridge, punctures the center disc, and catapults the igniter inside the booster cavity aft of the booster grain (fig. 4-5B). The piston then retracts, carrying the empty igniter cartridge back into the ejector housing, and uncoils the umbilical ignition wire from the igniter in the booster (fig. 4-5C). The injector rotates back into it stowed position, and the igniter is then fired through the fire control panel (fig. 4-5D). The total cycle is completed in about 6 seconds.

WARNING: Do not operate launcher in local control with the emergency igniter extended.

WARNING: Do not operate upper blast door in local or manual control when the igniter is extended.

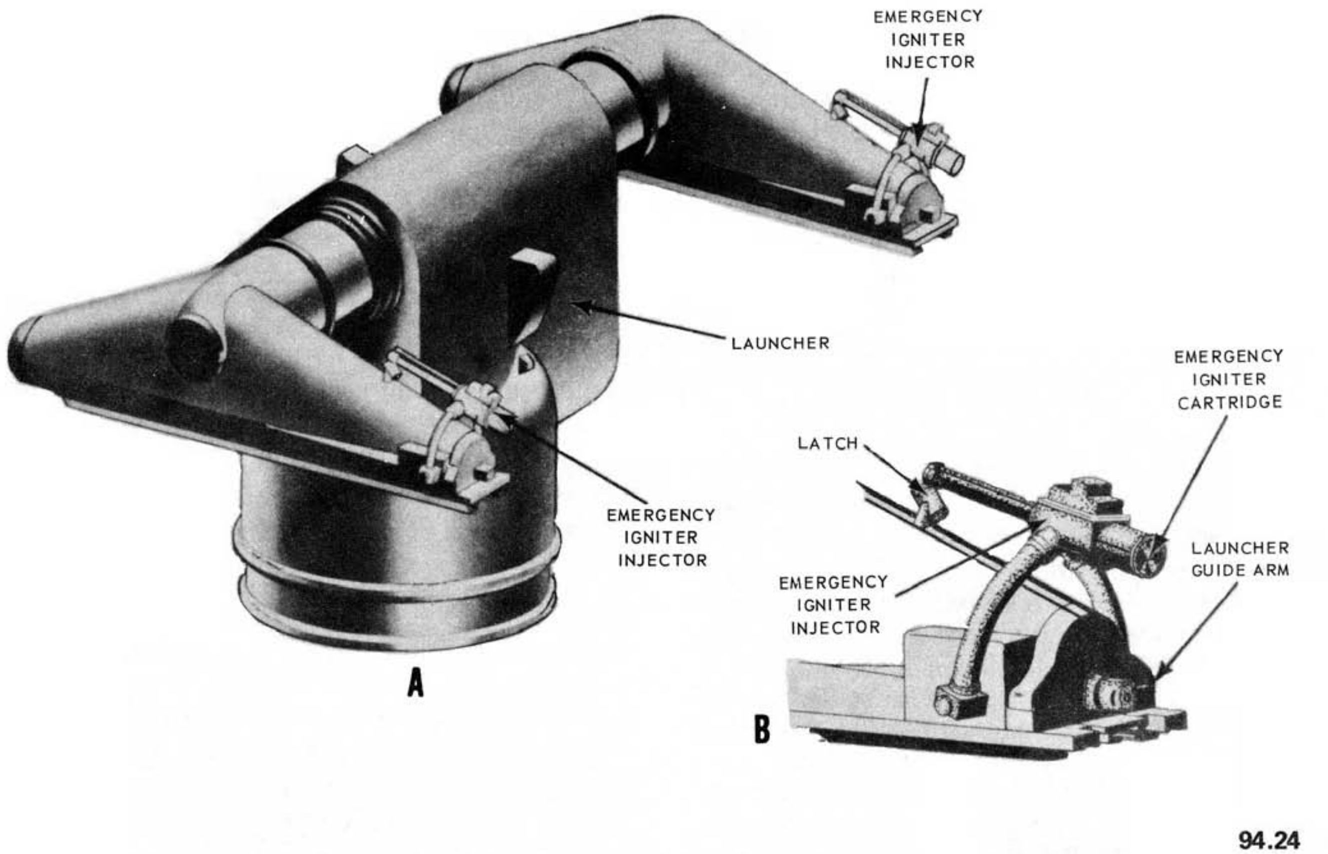

Figure 4-4.—Talos emergency igniter injector: A. Installed on launcher arm of Mk 7 system; B. Parts of the emergency igniter injector.

In addition to the systems indicating circuits, telephone communications should be used between WCS, the launcher captain's panel, and the safety observer.

If a Talos W Missile is a dud or misfire, notify the nuclear weapons officer at once and follow his instructions.

Once the missile battery is activated, its power is rapidly dissipated. If the missile cannot be fired within 5 minutes, it will be unstable and cannot be used for target intercept. The launcher must be trained into a safe area to fire the missile after depletion of its internal power.

The emergency igniter injector is reloaded manually by inserting a new cartridge. This should be done as soon as possible after firing, so the equipment is ready.

Remember that the emergency igniter injector is to be used only in a real emergency, such as imminent danger of the missile exploding on the launcher. Its use must be authorized, and authorization is given only if it appears that it is not possible to save the missile, to be repaired later.

ADJUSTMENT OF LAUNCHER TO MISSILES

Although there are some differences in size in Talos missiles Mk 11, Mods 0, 2, 3, and 4, the launching systems in use (Mk 7 and Mk 12) can handle any of the missiles without special adjustments or adapters. All mods of Talos missiles and boosters have been built to the same diameter. The length has been increased from 30 ft 10 in. for the RIM-8A missile to 32 ft. 4 in. for the RIMBE missile. The booster weight has remained the same for all mods, 4425 lb, but the missile weight has been increased from 3145 lb to 3360 lb. A comparison of the components of the launching systems (Table 3-1) will show that many of the components are the same for the

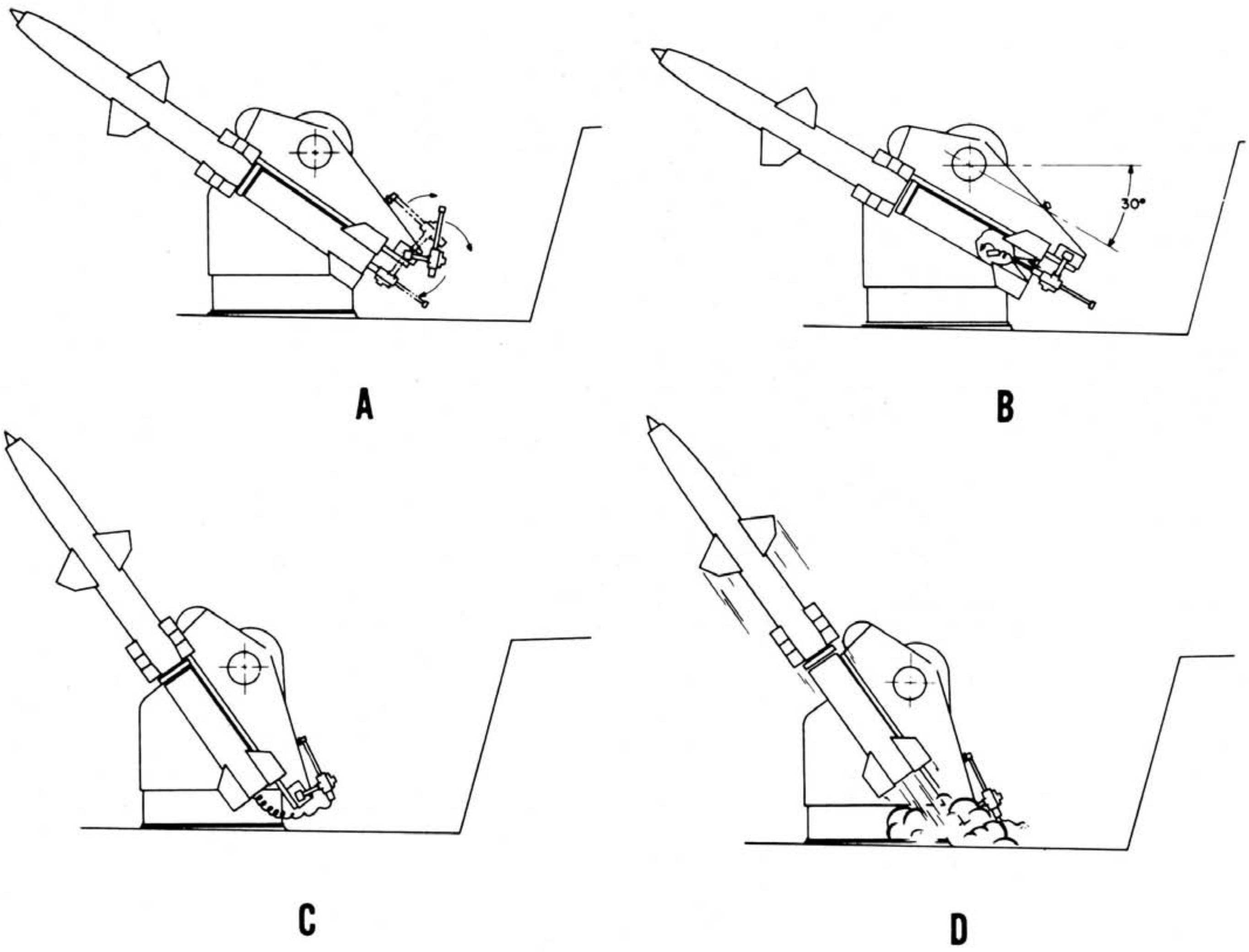

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Figure 4-5.—Operation of emergency igniter injector, Talos missile: A. Stowed-to-load position; B. Loaded position; C. Firing position; D. Fired.

Mk 7 and the Mk 12 launching systems, and some have only a mod change. The fewest changes are in the launcher and its components. The differences in the arrangement and operation of the magazine and ready service compartment has been pointed out. To take care of these differences, the controls also have to be changed, and it is in this area that you find many changes in detail although the principles applied are the same.

A comparison of the control panels listing for the Mk 7 and Mk 12 launching systems (table 3-1) shows that there is at least a mod change in every instance, and many are different mark numbers. That means that the wiring from the panels to the launching system components is changed from the Mk 7 system.

LOCATION AND DUTIES OF PERSONNEL

Location on shipboard will vary with the. installation; we refer here to location in relation to the launching system. Where there are differences between the Mk 7 and the Mk 12 launching system, these will be pointed out. This does not include the men in Fire Control, Weapons Control Station, CIC, or other control rooms.

The officer in charge supervises the operation and testing of the system. His position is on a platform near the EP2 panel. The launching system captain operates the EP2 panel. On the Mk 7 system, the EP3 panel is adjacent to the EP2 and is a control panel, but on the Mk 12 system, the EP3 is a test panel and is manned only during tests, also by the launcher captain. The test panel on the Mk 7 is the EP9. In both systems, the relay panel is the EP8, and it is not manned. The power panels, EP1A and EP1B, are energized at the beginning of operations, also by the launcher captain. The assembly captains' panels, EP4 and EP5, are operated by the assembly captains, each on his side, in the wing and fm assembly area. The assembly captain is also responsible for arming or disarming a W missile, carefully following the checkoff list from the OP, Each assembly area (A and B) has 12 wing-and-fm assemblymen who attach the wings, missile fins and booster fins.

The EP6 and EP7 panels are called Ready Service Panels on the Mk 7 system, and are monitored by operators during step control. In the Mk 12 system they are called Magazine Control panels and also are used for step control. The Mk 7 system does not have local control panels comparable to EP9, EP10, EP11, and EP12 of the Mk 12 system. They are used to operate the loader and the hoist power drives in local control. By using the local control panels, individual drives can be operated. An additional method of control, also controlled from the Local Control panels, is the Auxiliary Drive System, whose separate power drive is located next to the A side power drive. It is slow and it is used chiefly for maintenance purposes. Exercise control, a form of step control, is used while making tests.

Two feeder technicians should be stationed in the feeder system, ready to perform emergency repairs on the feeder.

TARTAR MISSILE SYSTEM

The steps in the operation of the Tartar launcher in bringing a missile from the magazine to the launcher arm were described in chapter 3. In automatic loading, no one is permitted in the magazine; no manual operations are needed in the magazine. This is true of all Tartar systems. There are no wings nor fins to be assembled; the TARTAR fins are erected automatically by launcher equipment. Figure 3-3 lists the activation procedures for the Mk 13 Mod 0 launching system; warmup of the missiles is shown in figure 3-1 O.

AUTOMATIC LOADING

The operational sequence in automatic loading with a Mk 13 launching system is as follows. The launcher guide arm is empty and the launcher is at LOAD position.

1. Missile warmup is applied automatically for a minimum of 24 seconds to the selected number of missiles (1, 2, or 3).
2. Ready service ring rotates. The ready service ring inner and outer magazine latches retract, the ready service ring positioner retracts, and the ready service ring indexes CW (clockwise) to place a missile at the hoist. The ready service ring positioner extends, and missile warmup is applied for a minimum of 24 seconds.
3. Hoist hydraulic control is selected. After the warmup period, hydraulic control is transferred from the ready service ring to the hoist.
4. Hoist raises to intermediate position. The raise latch retracts and the hoist raises to the intermediate position, where the hoist pawl contacts the missile aft shoe.
5. When the hoist is at the intermediate position, the magazine retractable rail extends to align the fixed magazine rail (track) with the magazine door span track (rail).
6. The blast door opens and extends a span track. The span track completes the missile track from the magazine retractable rail to the launcher rail.
7. The elevation positioner extends into the open blast door to secure and align the launcher in elevation (90°) during a load or unload cycle.
8. The hoist intermediate raise latch retracts and the hoist raises a missile to the launcher.
9. Aft motion latch extends. When the loaded hoist completes its raise cycle, the launcher aft motion latch extends to secure the missile on the guide arm. The warmup contactor on the launcher engages the missile (fig. 4-6) and warmup power is applied for a minimum of 1.8 seconds. The fin openers engage the fins for

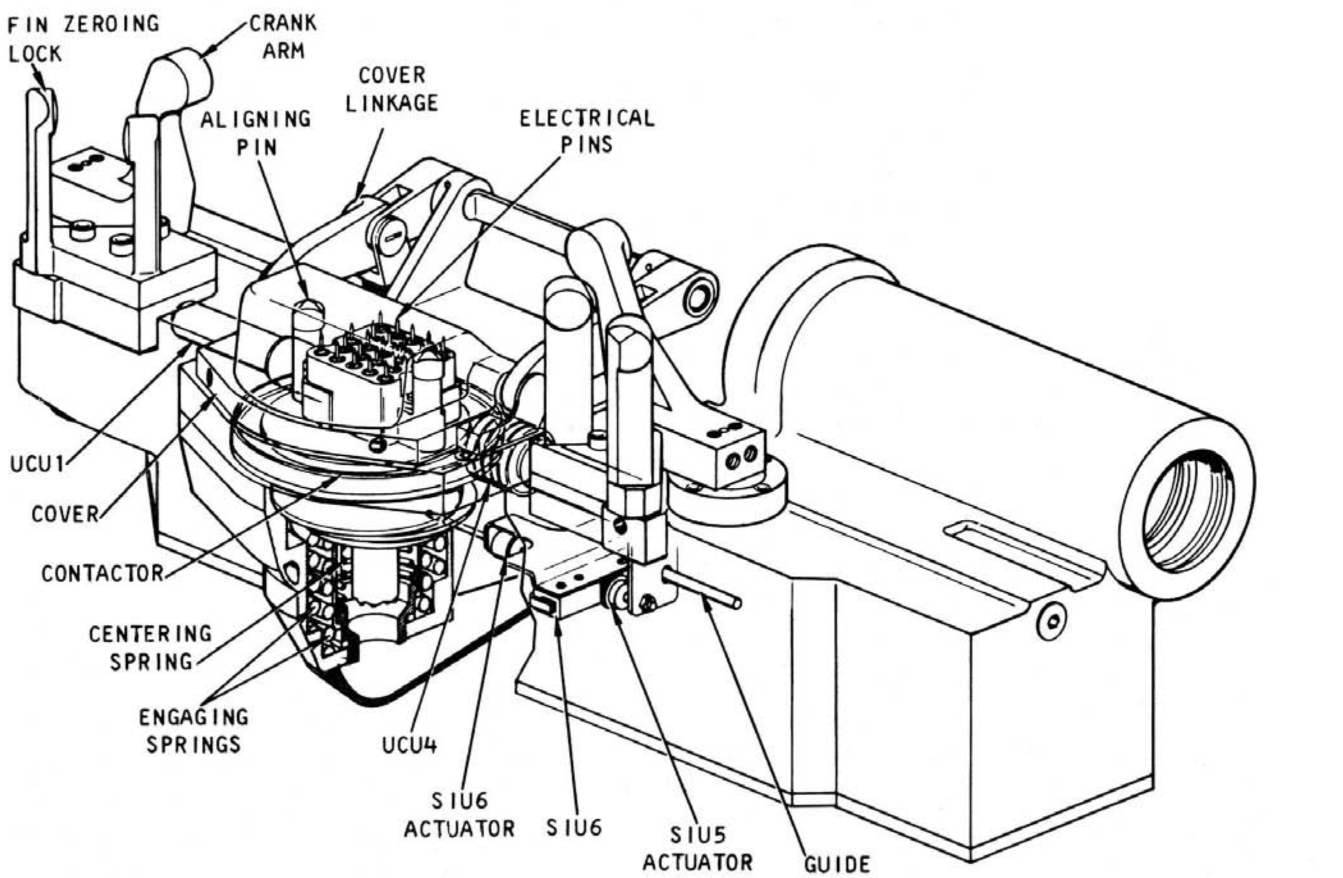

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Figure 4-6.—Fin opener and contactor, Mk 13 launching system (Tartar).

unfolding. Mods 1, 2, and 3 have minor differences in the fm opener and housing.

10. Hoist lowers to magazine position. When the hoist is below the launcher, the train positioner retracts, freeing the launcher in train. The elevation positioner retracts into the launcher guide arm, clear of the blast door. (See figure 4,7).

11. Blast door closes and retracts span track. The closed blastdoor provides a flameproof seal to the magazine.

A new loading cycle starts if continuous loading has been ordered by the weapons control station. Up on the launcher, a target is assigned and the launcher slews to the ordered train and elevation positions and the missile fins are unfolded. As soon as the blast door is closed, the missile may be armed and ignited, and the forward motion latch unlocked. When the missile is ignited, the contractor and the fin-opener cranks retract behind shields that protect them from missile blast. The forward motion latch holds the missile on the guide arm until thrust reaches 2330 pounds. Then the latch retracts, allowing free forward movement of the missile. When the missile has moved approximately 11 inches, the forward missile shoe contacts the rail retract trigger, causing the rail to retract. When the guide arm is empty, the fin-opener cranks reset in position for receiving another missile, the aft motion latch retracts, the forward motion latch extends and locks, the arming tool retracts, and the launcher returns to LOAD position. As the launcher returns to LOAD position to either the inner or outer ring, depending on the position of the hoist chain shifter the launcher rail extends. The launcher is then ready to accept the next missile.

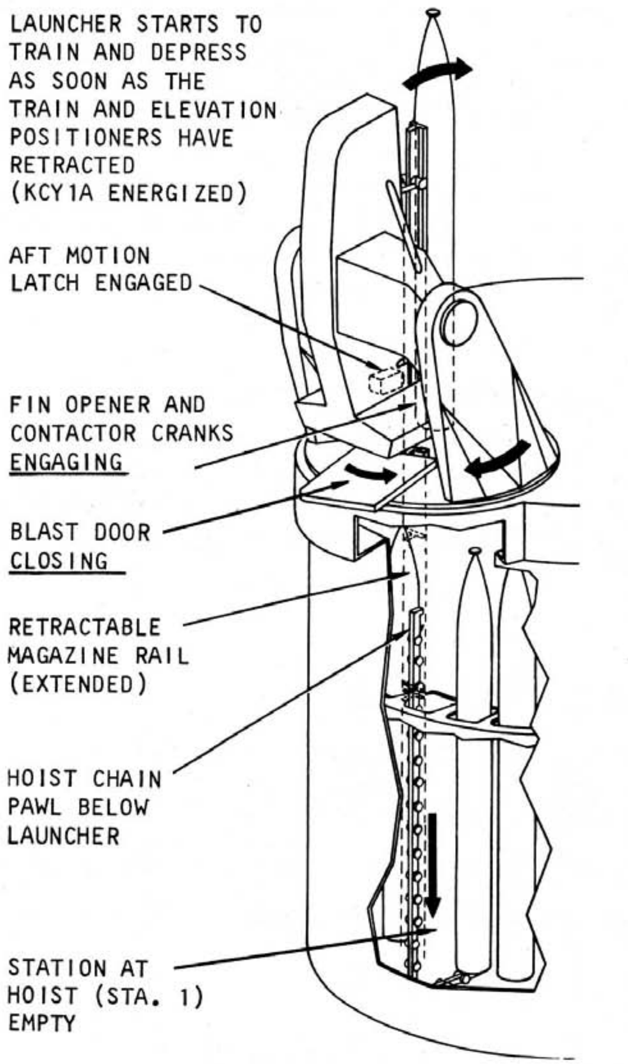

Figure 4-7.—Mk 13 launching system: Missile on launcher, hoist lowered below launcher, and blast door closing.

AUTOMATIC UNLOADING

Unloading may be ordered if the tactical situation changes and the weapons control station decides to stow the missile, or if the missile is a dud or a misfire and WCS decides to stow the missile for future servicing. The steps in unloading depend on the location of the missile at the time the decision is made to stow the missile. In the first situation, the missile may be on the launcher or it may be on its way. It would continue to finish the load cycle in normal operation and could be considered as on the launcher. In the second and third situations it is on the launcher but the conditions are not the same. In the misfire, the arming device must be retracted; but the contactor and the fin-opener cranks do not have to be retracted, as they are already disengaged. In all situations the fins are manually folded after the fin cranks are disengaged. Folding the fins after the launcher has trained and elevated to the LOAD position may be difficult, but sometimes it is necessary to use that position. Remember the warning about danger from launcher movements. Place the firing safety switch on the EP-2 panel at SAFE (which breaks the power lines to the motors in the train, elevation, and launcher power units), remove the switch lever, manually fold the fins of the missile on the launcher, then return the switch lever to the panel and reposition the switch to close the motor circuits, and re-start the motors. Then depress the fins manually-folded switch, and automatic unloading resumes.

The missile has to be returned to the same ready-service ring from which it was taken. If the hoist chain positioner has been moved to the other ring, reposition it. In automatic unloading the chain shifter will automatically shift to the proper ring; The ready-service ring then rotates counterclockwise (CCW) to the empty cell position. Hydraulic control then shifts to the hoist, the blast door opens and extends the span track, and the hoist rises to intermediate position. The retractable rail extends when the hoist leaves the magazine. When the hoist reaches the launcher, the aft motion latch retracts and the hoist pawl engages the missile aft shoe. The hoist (with the missile) then retracts to the intermediate position. As soon as the hoist is below the launcher, the elevation positioner retracts into the guide arm, clear of the blast door, which then closes and retracts the span track. Beneath the blast door, the hoist moves from the intermediate position, where it separates the hoist pawl from the missile aft shoe, to the magazine.

During automatic load and unload the associated step control circuits are required to be open. The Mk 11 launching system cannot be unloaded in automatic control.

STEP CONTROL

During step operations, the control selector switch on the EP-2 panel is on STEP. This breaks the automatic load and unload circuits, and prevents feed-back into the automatic circuit. Step operation is used for all exercise operations and if the automatic mode malfunctions. (Parts of exercise circuits and step control circuits are not the same.)

Strikedown, off-loading, and checkout procedures are alo done in step control. The same equipment is used in both strikedown and offloading, but the procedures are reversed. The same switching conditions are used for both procedures. A slower speed is used during offloading. Reducing the air pressure that drives the air motor on launcher reduces the speed when transferring a missile from the launcher to the transfer dolly in off-loading. The pressure reduction prevents the chain from buckling when the chain engages the missile off the guide arm. The weight of the missile and the steep angle of unloading would move the missile at too great a speed if it were not slowed down.

Figure 4-8 is a schematic of step operation of fm openers and contactors on the Mk 13 launching system. The step control switches on the EP-2 panel are manually actuated after the system is placed in step control. The broken lines in the drawing represent unload and exercise circuits; the solid lines are load circuits.

TARTAR DUD JETTISONING

The dud-jettisoning equipment for the Mk 11 and the Mk 13 Tartar launching systems differ in a number of important details, so they will be treated separately.

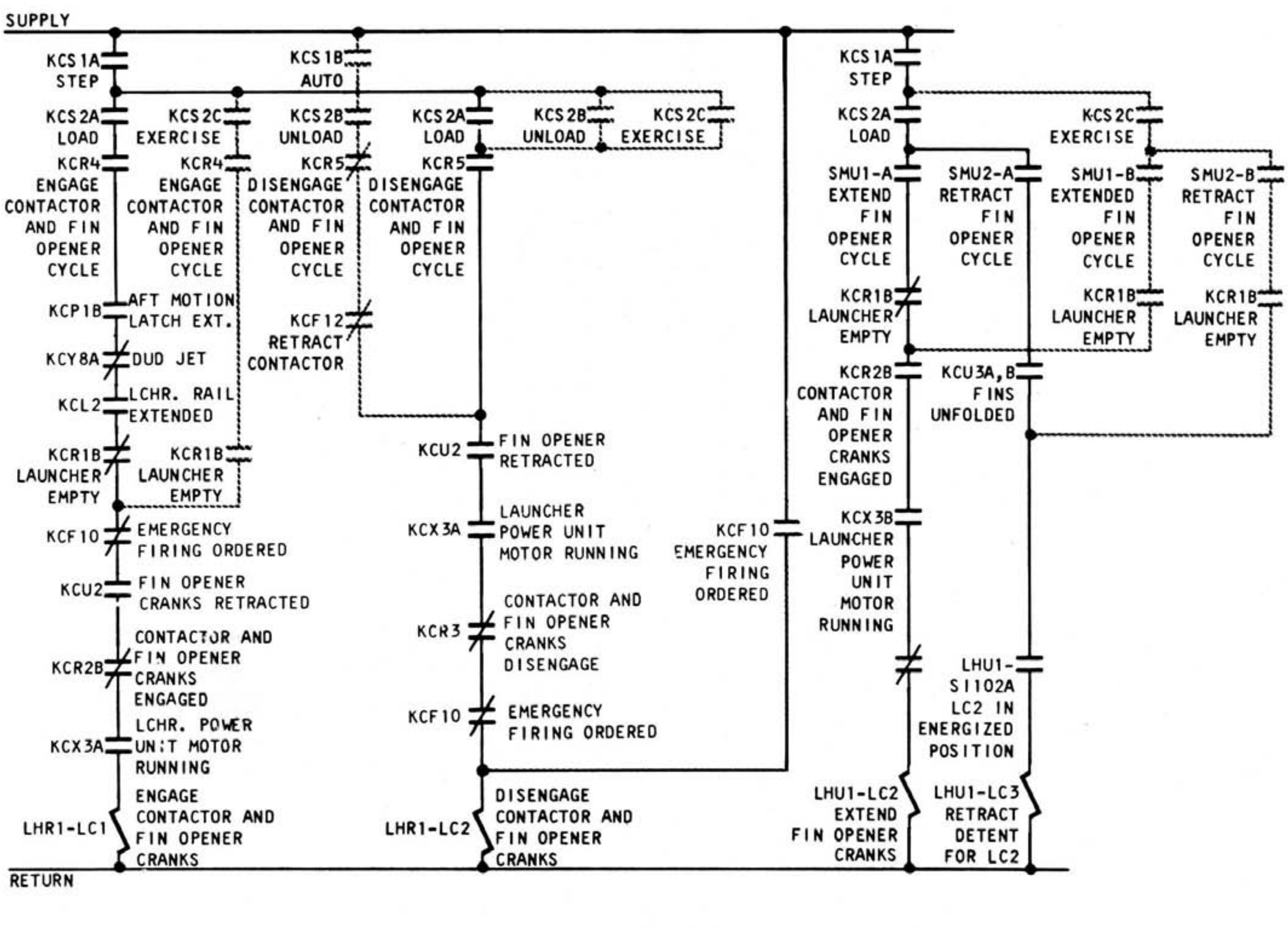

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Figure 4-8.—Step operation of fin openers and contactor, load circuits, Mk 13 Mod 0 launching system.

Dud and Misfire Handling in the Mk 11 Launching System

The dud jettisoning unit, figure 4-9, jettisons defective missiles from the guide arms when the tactical situation requires it or if the missile is unsafe for return to the magazine. The dud jettisoning unit consists of two ejectors, one for each guide arm, and a dud jettisoning control valve panel. The ejectors align with the aft end of the

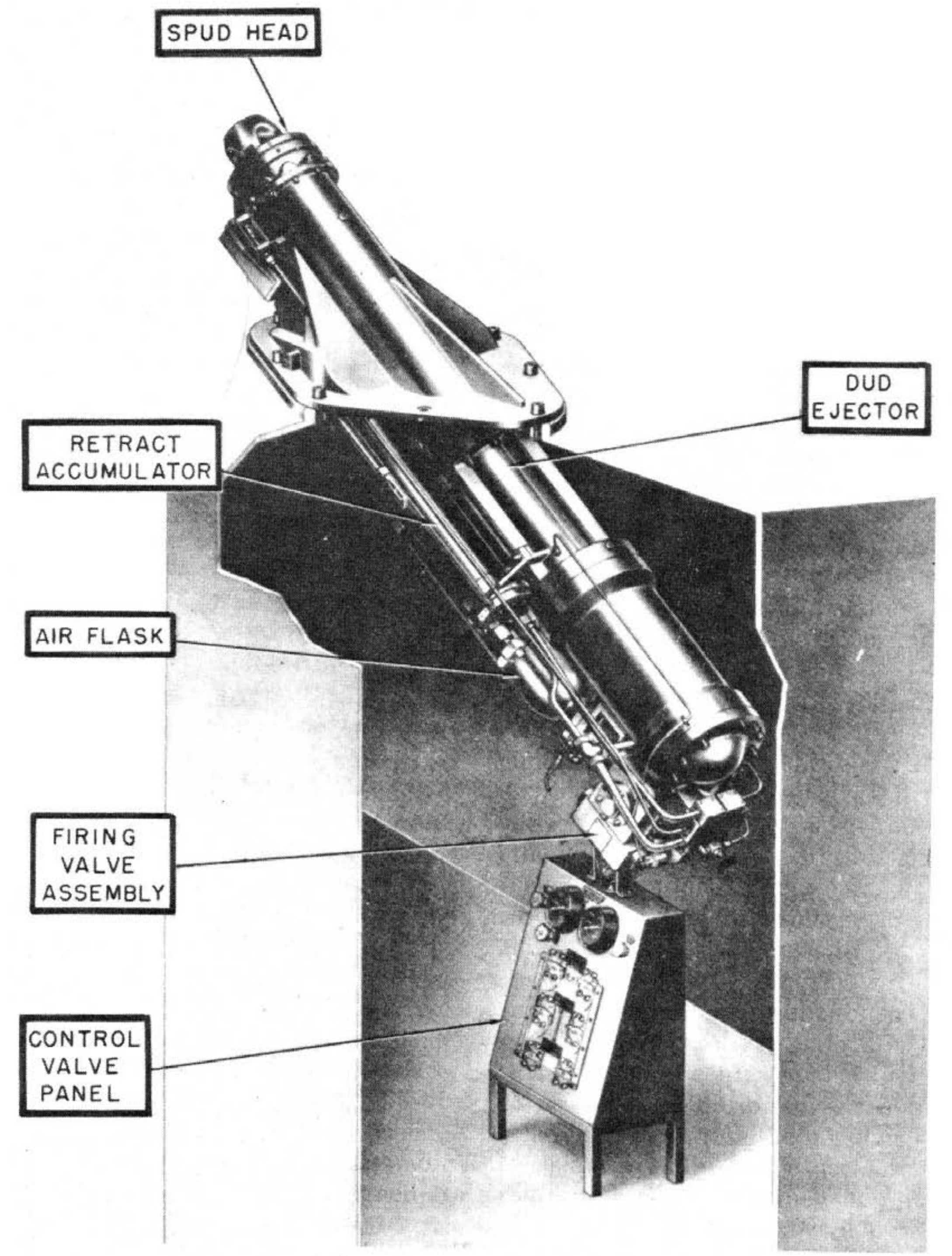

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Figure 4-9.—Dud-jettison unit in position to ram, Mk 11 launching system.

missile on the launcher when the launcher is moved to either dud jettison position. The ejector spud extends hydraulically to contact the missile. Air pressure from the accumulator, in conjunction with hydraulic pressure, acts on the ejector piston to move the spud forward and force the missile off the guide arm and overboard. The dud jettisoning unit can be operated either automatically or manually.

To jettison a missile, the launcher is trained and elevated to either the "A" or "B" dud jettison position, where the applicable guide arm aligns with a dud ejector unit. A spud attached to the booster piston, extends to contact the missile, then ejects the missile at sufficient velocity to clear the ship structure. The spud then retracts, and the launcher returns to a load position if missile firing is to be continued.

The dud ejector unit is controlled and operated by a combination of compressed air and hydraulic pressure. Pressurized hydraulic fluid controlled by pneumatic-hydraulic accumulators generates the fluid pressure. Low pressure air (100 psi) generates the hydraulic pressure to extend and retract the spud; high pressure air (2100 psi) generates the hydraulic pressure to eject the missile from the guide arm.

Dud and Misfire With the Mk 13 Launching System

The jettison device, is identical in the Mk 13 Mods 0, 1, 2, and 3 except that in Mods 1 and 2 there is a nitrogen booster pump to aid in charging the jettison accumulator. It is mounted to the top of the inner structure inside the magazine assembly. It is manually operated.

The dud-jettisoning device in the Mk 13 launching system is in the launcher arm (fig. 4-10). It is a nitrogen-actuated piston that applies force to the aft face of the forward missile shoe. The piston is hydraulically retracted after jettisoning. It is controlled locally from the launcher control panel. When switch SMY1 (located on EP2 panel) is positioned to dud jettison local or remote and when the train positioner is retracted, the launcher will slew to a fixed dud jettison position. The difference between dud jettison local and dud jettison remote is that the fire control stable element is introduced into the launcher elevation control system to compensate for the ship's pitch and roll when SMY1 is positioned to dud jettison remote. When the dud jettison push button is pressed, the jettison piston extends to jettison a missile. The following safety precautions apply during dud jettisoning.

WARNING: Make sure that communications have been established between the safety observer, and the launcher captain before jettisoning. Obtain permission from the weapons control station before jettisoning.

CAUTION: Do not attempt to jettison with less than 2000 psi nitrogen pressure.

Do not jettison when the ship is rolling excessively in the direction away from the anticipated path of the missile. Observe the inclinometer to determine the degree and direction of roll (local control only).

Operation of the jettisoning device consists of four steps: (1) positioning the launcher, (2) jettisoning, (3) retracting the piston, and (4) returning to a load position to resume launcher operations (re-extending the launcher rail).

The launcher must be positioned broadside, the launcher rail retracted, and the arming tool extended (forward motion latch lock retracted). In step control, the EP-2 operator initiates launcher rail retraction and extension of the arming device. If the control selector switch is on AUTO, these operations take place automatically. Setting the dud-jettison remote switch energizes the jettison relay to retract the launcher rail, extend the arming tool, and unlock the forward motion latch. The launcher moves to the jettison position, which is a 40° fixed-in-space position controlled by the stable element. In local control, the elevation position of the launcher guide is fixed relative to the deck of the ship. Observe the inclinometer near the EP-2 panel and do not jettison until the ship is on the downroll.

When the LAUNCHER SYNCHRONIZED light is on, depress the dud-jettison-extend pushbutton on the EP-2 panel. Since nitrogen pressure is always present inside the jettison piston, the piston creeps forward. As the piston creeps, the aft shoe of the missile forces the forward motion latch out of the way, and the dud-jettison pawls engage the missile forward shoe.

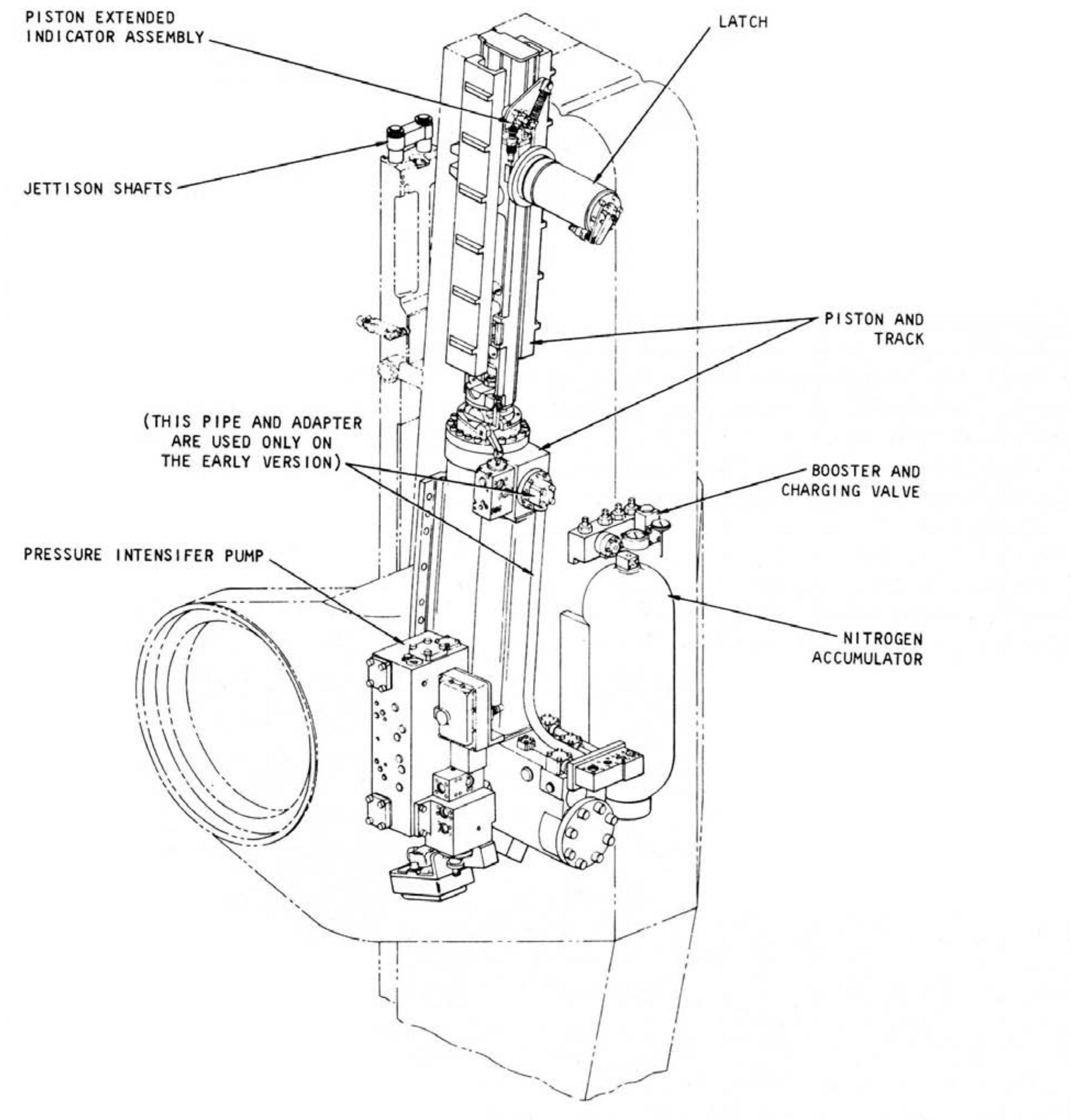

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Figure 4-10.—Jettison device components in launcher arm, Mk 13 launching system.

After the piston jettisons the missile, the jettison pushbutton light goes on, showing that the piston is extended. The next step is to retract the piston by depressing the dud-jettison-retract pushbutton, and the retractable-rail-retract button. After that, loading operations can be resumed.

When the jettison device is exercised (operated when the guide is empty), it operates the same as when jettisoning except that the rate of travel of the piston is retarded while it is extending. If it were not retarded when not loaded with a missile, damage to the equipment . would result. The throttle valve and the main check valve control the speed by restricting the passage of hydraulic fluid from the front side to the back of the jettisoning piston land. During jettisoning, the main check valve lifts. permitting the hydraulic fluid to flow to the back of the piston land and accelerating the piston to eject the missile. Two seals near the forward end of the piston spud prevent leakage of the nitrogen pressure, and thus prevent mixing of the hydraulic fluid and the nitrogen.

The OP for the equipment contains schematics, circuit diagrams, and detailed illustrations of the parts of the jettisoning equipment. In order to be able to make repairs and adjustments, you need to have a grasp of what happens inside the equipment when you push a certain button on the control panel. Study the OP for the system you have aboard. On the schematics, trace through the actions as they are described in the OP.

The nitrogen booster pump used with the jettison device of Launching Systems Mk 13 aids in charging the jettison accumulator. This pump is mounted to the top of the inner structure inside the magazine assembly. It is a manually operated pump (fig. 4-11) that boosts the pressure of the nitrogen supply system. When the jettison tank is to be recharged and the pressure is found to be low, run a temporary line from the discharge port of the nitrogen booster pump to the nitrogen-charging valve block for the jettison accumulator tank. The nitrogen line that connects to the adapter block (supply connection) is a permanent one. Opening the supply valve when the handle of the booster pump is in stow position permits nitrogen to flow until pressure stabilizes. If the pressure then is less than that required by the jettison device, turn the pump handle to the pressure (PRESS.) position. This permits nitrogen from the supply area

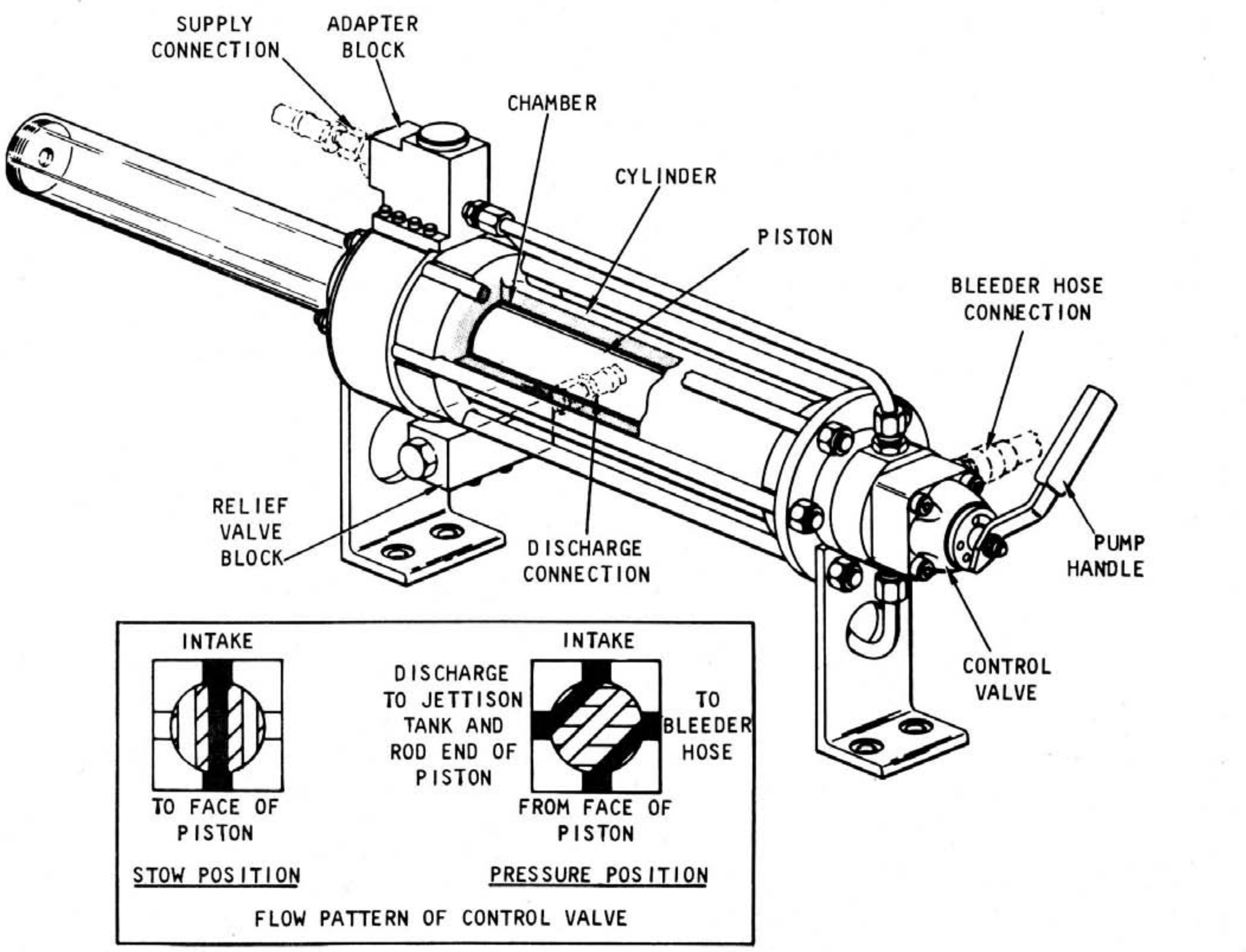

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Figure 4-11.—Nitrogen booster pump assembly for jettison device.

to push against the piston head, forcing back and permitting nitrogen to flow to the jettison accumulator and increase the pressure. When the piston is fully extended, move the pump handle to the stow position. In this position, nitrogen on the face of the piston escapes to the atmosphere and nitrogen pressure on the back of the piston forces it to its former position. Continue stroking the piston by moving the handle as above until the required pressure is reached. A safety valve prevents excessive buildup of pressure.

MAINTENANCE AND REPAIR OF JETTISON DEVICE.-The nitrogen pressure in the jettison accumulator tank should be checked every week, and the tank recharged as necessary. The nitrogen charging assembly, located in the righthand yoke of the launcher guide, is reached by opening the hinged access door with the special tool provided.

WARNING: Before doing; any work on the launcher, remove the firing safety switch handle from the EP-2 panel so the launcher cannot be activated inadvertently.

The pressure required varies with the temperature and depends on whether the jettison piston is retracted or extended. There should be a table posted on the inside of the access door; but if there isn't, refer to the table in the OP. It the nitrogen pressure is normal (within 15 psi of required pressure), be sure all the valves are positioned for system operation and nitrogen plug is firmly secured. Then close and secure the access door and return the firing safety switch handle to the EP-2 panel. However, if the pressure is not within limits, proceed to charge or bleed the tank to the required pressure. Follow the instruction in Navord PMS/SMS 2665 volume 2. Be sure the launcher is inactivated by removing the handle of the firing safety switch from the EP-2 panel. The method of charging differs with , the source of the available nitrogen supply: 3500 psi, 2200 psi, or 2015 psi (70°F).

In addition to weekly checking of the pressure, once every two weeks cycle the jettison device to keep the lubricants distributed and to detect (and correct) any malfunction. At the same time check the jettison device for sign of corrosion.

WARNING. If the nitrogen tank must be disconnected for repair work, first vent nitrogen to the atmosphere by opening SV 4, SV3, SV2, and SV1 (fig. 4-12).

The HYDRAULIC FLUID LEVEL in the jettison booster piston also must be checked daily. This cannot be done with the launcher system inactivated, so you do not remove the safety switch handle. Instead, station a safety man at the EP-2 panel to make sure that the train and/or elevation power drives are not J started. The hydraulic booster assembly is located in the nitrogen-charging valve block (fig. 4-12A),. and is reached by the same access door in the launcher guide. The hydraulic pressure sight gage (fig. 4-12B) is marked with red lines to indicate the recharging area. If the indicator (rod end of the booster piston) can be seen in the marked area; the fluid level is unsatisfactory and recharging is necessary. Follow the instructions in the OP for the launching system. When preparing a checksheet you need the correct designation for each pushbutton, switch, and valve to be used. In figure 4-12, valves SV 1, SV2, SV3, and SV4 are shown for the Mk 13 Mod 0 launching system

MISFIRE.-If the rocket motor fails to ignite when the missile-firing relay is energized, the firing relay remains energized and gives a misfire indication on the EP-2 panel, and in weapons control. The misfire light remains on until the missile is cleared from the rail, whether by dud-jettisoning, emergency firing, or unloading. The course of action will be determined by ship's doctrine, and the situation. In practice sessions, the missile is unloaded and stowed for repair, or, if it is dangerous, it is jettisoned. Under combat conditions the Dud/Emergency Firing Key may be used to clear the rail quickly and with some chance of a tactical launching resulting.

The Dud/Emergency Firing key is pressed in weapons control. If the missile still does not fire, another circuit energizes and starts contactor retraction and missile arming. After a brief delay, the rocket squibs fire, regardless of the contactor position.

The daily operation of the equipment, using a training missile, includes checking of Normal firing and misfire, and Normal firing resulting in a dud. Firing of a dud and emergency firing, using the Dud/Emergency Firing key, are tested

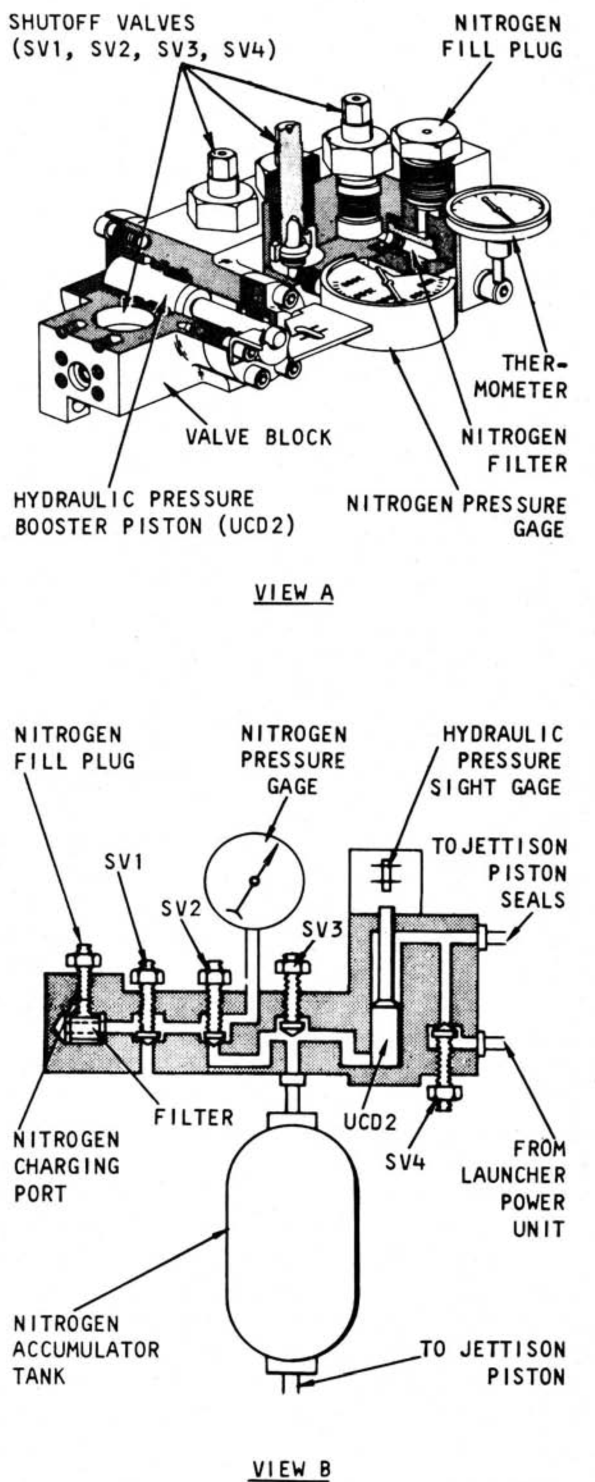

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Figure 4-12.—Nitrogen-charging valve block and booster for jettison device on Mk 13 launching system.

weekly. In any testing of circuits, be sure that switch SMW2 on the EPI panel is on EXERCISE, so that no missiles in the magazine will be put on warmup. Tartar Dud Jettisoning Slug Mk 1 Mod 0 is used to test the operability -of the dud jettison device. Emergency firing is tested with a training missile in three phases: for normal firing conditions to simulate an attempted firing; with the training missile set for dud; and with the training missile set for dud but with the electrical contactor extended. The operator of the EP2 panel notes the sequence of action in each case by the lights on his panel. The correct sequence is given in the OP.

Timing tests are made at 3-month intervals. . To test the timing of the jettison device, use a stop watch and record the time it takes for the jettison piston to retract. The allowable time is 20 seconds after depressing the Dud Jettison RETRACT pushbutton. No missile is on the guide arm for this test. The conditions of the test are simple; tey are ye the OP.

Once a year the jettison device is serviced by : draining any seepage of hydraulic fluid. The drain plug is at the base of the jettison cylinder. Before attempting to do this, the nitrogen in the accumulator tank must be vented to the atmosphere. This nitrogen is under 2400 psi pressure. Open SV1 and SV2 (fig. 4-12) on the nitrogen-charging valve assembly. After cleaning up the seepage and replacing the drain plug, the accumulator must be recharged, the same as in daily maintenance procedures.

Use only compressed nitrogen gas to charge accumulator flask bladders. Never charge with oxygen or compressed air. A mixture of oxygen and hydraulic fluid is extremely explosive.

NOTE: Since nitrogen and oxygen are both furnished in metal cylinders, use extreme caution to avoid taking the wrong cylinder by mistake. An oxygen cylinder is green colored; a nitrogen cylinder is gray colored with one or two black bands near the top.

Mk 22 Launcher Dud-Jettison System

The dud-jettison device in the Mk 22 launching system is in its guide arm (it has only one). The complete description of its operation is given in OP 3115 volume 2, *Guided Missile*

Launching System Mk 22 Mod 0,. Magazine Launcher Miscellaneous Subsystems. If normal firing was ordered on an Auto-Load cycle and the missile does not leave the rail, a light on the EP2 panel gives a dud indication. If the missile firing relay energizes but the missile does not fire, a misfire indication appears on the EP2 panel. WCS must then decide whether to jettison the missile or return it to the magazine for later rework. If the decision is to jettison, the EP2 operator turns SMY1 to Remote Dud Jettison. The remote-jettison sequence automatically disengages the contactor and the fin-opener cranks, extends the arming device, and unlocks the forward motion latch, if these actions did not take place during the Auto-Load sequence as they should have. The retract-launcher-rail cycle then starts. When the Launcher Synchronized Light goes on, indicating that the launcher has trained and elevated to the jettison position, the EP2 operator pushes the JETTISON pushbutton and the jettison piston ejects the missile overboard. The aft motion latch retracts, and when the JETTISON light turns steady, the EP2 operator pushes the Jettison RETRACT button. While the jettison piston retracts, the operator returns switch SMY1 to REMOTE.

Loss of launcher synchronization breaks the firing circuit. If the period of loss is short, the firing sequence resumes from the point of interruption, but if synchronization is lost for some time, the missile may have to be fired as a dud or misfire. The internal power supply of the missile is reduced rapidly once it is activated, so if the missile is not fired quickly, its range may be greatly reduced. In each case, Weapons Control will decide how to dispose of the missile. If possible, the missile will be returned to the magazine, marked as a dud, to be repaired later. The emergency firing circuit has a power supply independent of the normal firing circuit; it is resorted to in a tactical situation when a dud or misfire missile must be disposed of. The Dud/ Emergency key in the Weapons Control Station is closed in a second attempt to activate the APS squibs in the missile. If this does not clear the rail, the dud firing circuit switches to the emergency firing circuit. If the failure was in the contactor retract circuit, and the contactor did not retract, this method of firing will damage the contactor pad, and therefore it is used only as a last resort if the missile endangers the ship or its personnel.

Time intervals mentioned actually are very short. From the moment the Dud/Emergency Firing Key is pressed until the rocket motor ignites and launches the missile is less than two seconds.

LOADING ASROC MISSILES

Loading the Asroc missile from the magazine of the Terrier Mk 10 Mod 7 launching system is similar to loading Terrier missiles but has a few different steps. If the decision is made to use an Asroc weapon (torpedo or depth charge form), the ASROC MODE switch on the EP-2 panel is pushed upon orders from Weapons Control, to change the launching system to the Asroc mode of operation. Automatic control is used except for exercise, testing, or in an emergency. The indicating lights on the EP2 panel show the steps taking place in the loading operation.

In the assembly area, motor fins are attached to the Asroc. The missile fin assemblymen assist the motor fin assemblymen, as there are no missile fins on the Asroc. The snubbers on the Asroc adapter rails have to be retracted and secured, after firing. The ready service ring tray does not shift from hoist to ring after bringing the missile to the assembly area, as it does with Terrier, because the adapter tray must first be returned to it, which is done after the Asroc is launched.

The type of Asroc missile must be visually identified when it arrives in the assembly area. If it is not the one ordered, it must be returned to the magazine and the correct one brought up. The circuit to identify the missile in the adapter is energized through the loader pawl warmup contactor. This causes the identification light to blink on the EP-4 or EP-5 panel and the operator can notify WCS and the EP-2 operator.

When the Asroc is at assembly, the Asroc arming tool is energized. (There is another arming tool for Terrier.) If the missile is a Y-type, the Y stop keylock switch must be positioned to LOAD, or the blast doors will not open to permit loading the launcher. When the missile is on the launcher, the arming tool winds and retracts, and this opens the snubbers on the adapter rail. The missile battery is then activated, and the battery ignites the motor.

Although the Asroc does not have an APS (auxiliary hot-gas power generation system), the missile activation indication is supplied to the Asroc relay transmitter and is required by Asroc fire control before it supplies the Asroc missile ready indication on the panel. However, as mentioned before, an Asroc failure on the launcher is very unlikely.

When enough thrust has developed, the Asroc travels the length of the adapter rail into ballistic flight. After firing, the adapter rail is then returned to the magazine tray in an unload sequence. When it arrives in the assembly area on its return trip, the snubbers must be closed manually (with the aid of special tools). A new umbilical cable will need to be inserted in the adapter, and this is done in the checkout area. This may be done later, depending on tactical circumstances.

Care of Cable Assemblies

The umbilical Cable Mk 10 provides the necessary electrical connection between the adapter and the Asroc missile. Each time an Asroc missile is launched from an adapter, the umbilical cable must be removed and replaced with a new cable. The replacement cables are supplied with the replacement missiles. The cables are enclosed in a dust cover (fig. 4-13). Do not remove the dust covers from Cable Mk 10 until just before installing the cable.

Remove the cable cover by loosening the locking studs (fig. 4-13A) with a snubber cam wrench. Lift the forward end of the cover upward, and slip the after end of the cover free of the cover retainer bar. Remove the expended cable by disconnecting the cable connectors at the after end and disengaging the missile retractor-connector from its support. The location of the cable is shown in figure 4-13 B on the after handling shoe support. The new cable is placed in the trough of the after handling shoe support and the cable connectors are attached to the adapter wiring connectors.

Cable assemblies frequently are damaged while being connected or disconnected. The keyways must be properly aligned; proceed carefully when connecting the cable plug to the ISA (Ignition Separation Assembly) receptacle to avoid breaking or bending the receptacle pins. Lubricate the rubber ring on the receptacle and inspect the seating surfaces. Consult the OP or the SWOP for the correct lubricant. If the rubber ring has raised out of the groove, it prevents proper plug latching or positive electrical connection of the cable assembly. This work is done in the checkout area when loading an Asroc missile into the adapter before loading it into the magazine.

Loading Depth Charges

Before loading depth charges into the launcher, remove all four tapes so the depth charge will operate properly. The tapes, with lead foil barrier, are placed over the hydrostatic ports of the depth charge fuze to prevent entry of dirt, etc. The tape is not a safety device. The red streamers attached to the tape are merely a reminder to remove the tapes.

As the Rocket Thrown Depth Charge Mk 2 is shorter than the torpedo configuration and somewhat larger in diameter, the magazine trays :lave to be adjusted. Side and bottom snubbers in the adapter prevent lateral movement of the missile; a missile-restraining mechanism prevents fore-and-aft motion.

When the Asroc is fired, as the arming tool winds it triggers the release of the snubbers. It requires approximately 2000 pounds of thrust to cause the forward restraining latch to release. A positive stop on the launcher guide arm holds the adapter rail so it is not fired with the missile. The blast doors will not open for the Y -type missile until the Y stop key-lock switch is positioned to LOAD. When the missile is on the launcher and the missile type indications appear on the EP-2 panel and the attack console panel, the operator of the attack console panel immediately checks out the missile.

As the depth charge is larger in diameter than the torpedo configuration of Asroc, inserts are not needed in the adapter rail when the depth charge is to be loaded.

The steps in loading an Asroc into the adapter must be followed exactly. Be sure to stand clear of the snubbers when they are being unlocked before placing the missile on the adapter. In the

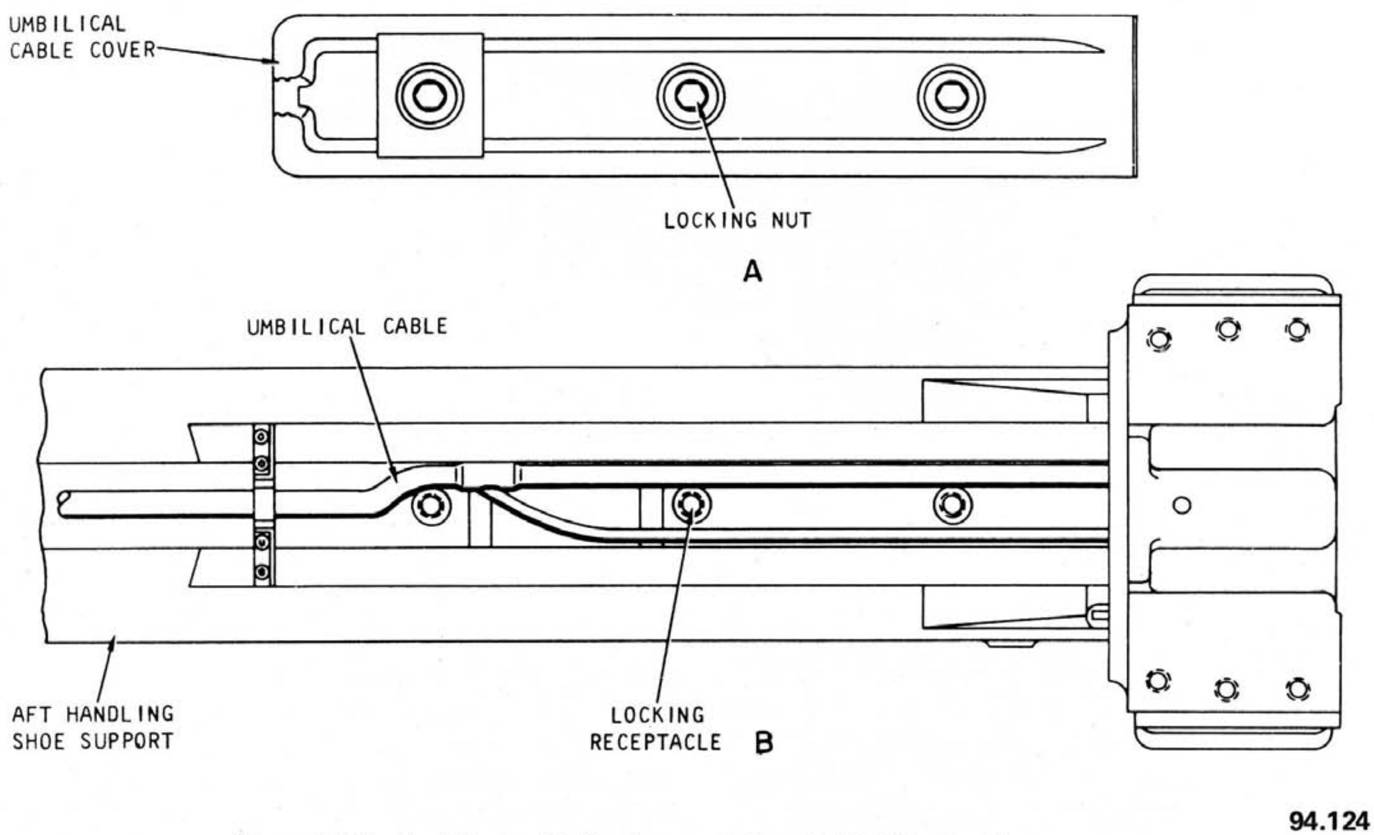

Figure 4-13.—Umbilical cable for Asroc missile: A. Umbilical cable cover; B. Location of umbilical cable on aft handling shoe support.

launch cycle, the snubbers are operated hydraulically, but they have-to be released or closed with a special wrench when the Asroc is being loaded (or unloaded) into the adapter.

UNLOADING ASROC MISSILES

To return the Asroc to the magazine or to the assembly area, automatic unloading may be used. After each firing of an Asroc, the adapter must be unloaded before another missile can be brought up and placed on the launcher. If there are any weapons in the assembly area, they must be unloaded before a weapon or an adapter can be brought back from the launcher. The assemblymen must remove and store the fins or fold the fins of the weapons in the assembly area before giving the signal to return the missiles to the magazine. When the assembly area is clear, the EP-2 operator can proceed to return the missile (or the adapter) that is on the launcher guide arm.

Unloading the Asroc Torpedo

The Asroc with a torpedo warhead uses a torpedo exploder, which must be in the safe position when the missile is in the magazine, or the assembly area, and until it is to be fired. It must be returned to the safe position before it can be unloaded. Figure 4-14 shows one type of exploder. Follow the instructions in the OP for the exploder that is on your missile. It must be safed before the missile can be returned to the magazine or the check-out area.

Unloading Depth Charges

Before starting unloading operations for an Asroc Depth Charge, verify that the Safety Plug PI is on the Launcher Captain's control panel and is not inserted. It may be kept in the custody of the ASW officer or it may be locked in a dummy receptacle on ,the panel. The depth charge is disarmed by installing the thrust

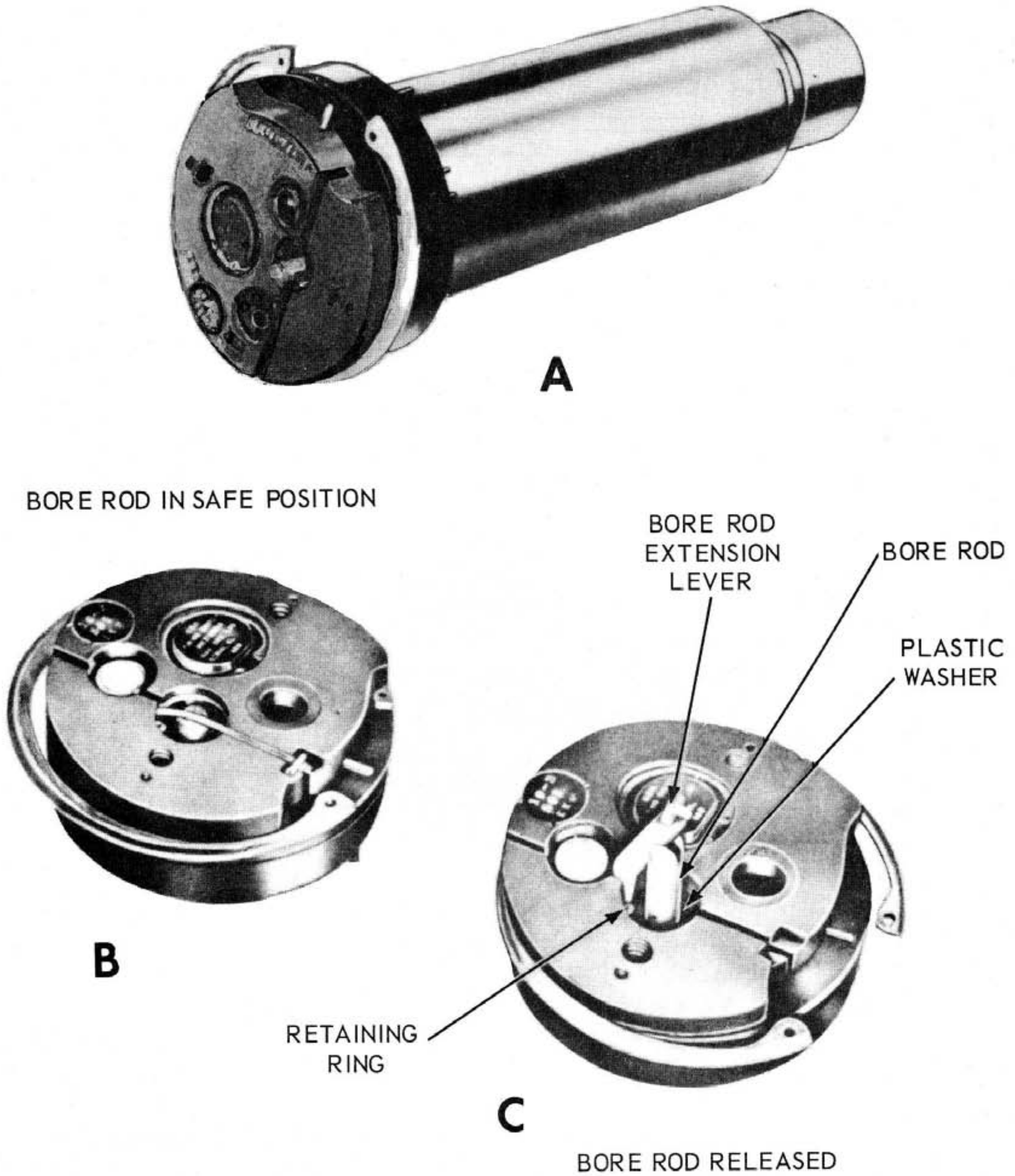

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Figure 4-14.—Torpedo Exploder Mk 19: A. Assembled exploder; B. Safe position of bore rod; C. Unsafe position of bore rod.

neutralizer (fig. 4-15A) on the missile. Note that a special wrench is used. Do not tighten the screws too much, or the pins in the nozzle plate may be sheared off. The torque requirement is 100±25 foot pounds.

If the power supply (fig. 4-15B) is to be removed from the depth charge (and this is not always the policy), replace it with the blanking plate (fig. 4-15C) and seal which had been removed from it and placed in storage. If the depth charge is being returned to the ready service ring in the Mk I 0 Mod 7 or 8 Terrier system, the only change involved is the removal of the fins as the missile halts in the assembly area. If the missile is to be off-loaded, have the container placed in position on deck so the missile can be lowered into it with the trolley hoist, without striking or bumping the missile. Attach the container ground wire to the thrust

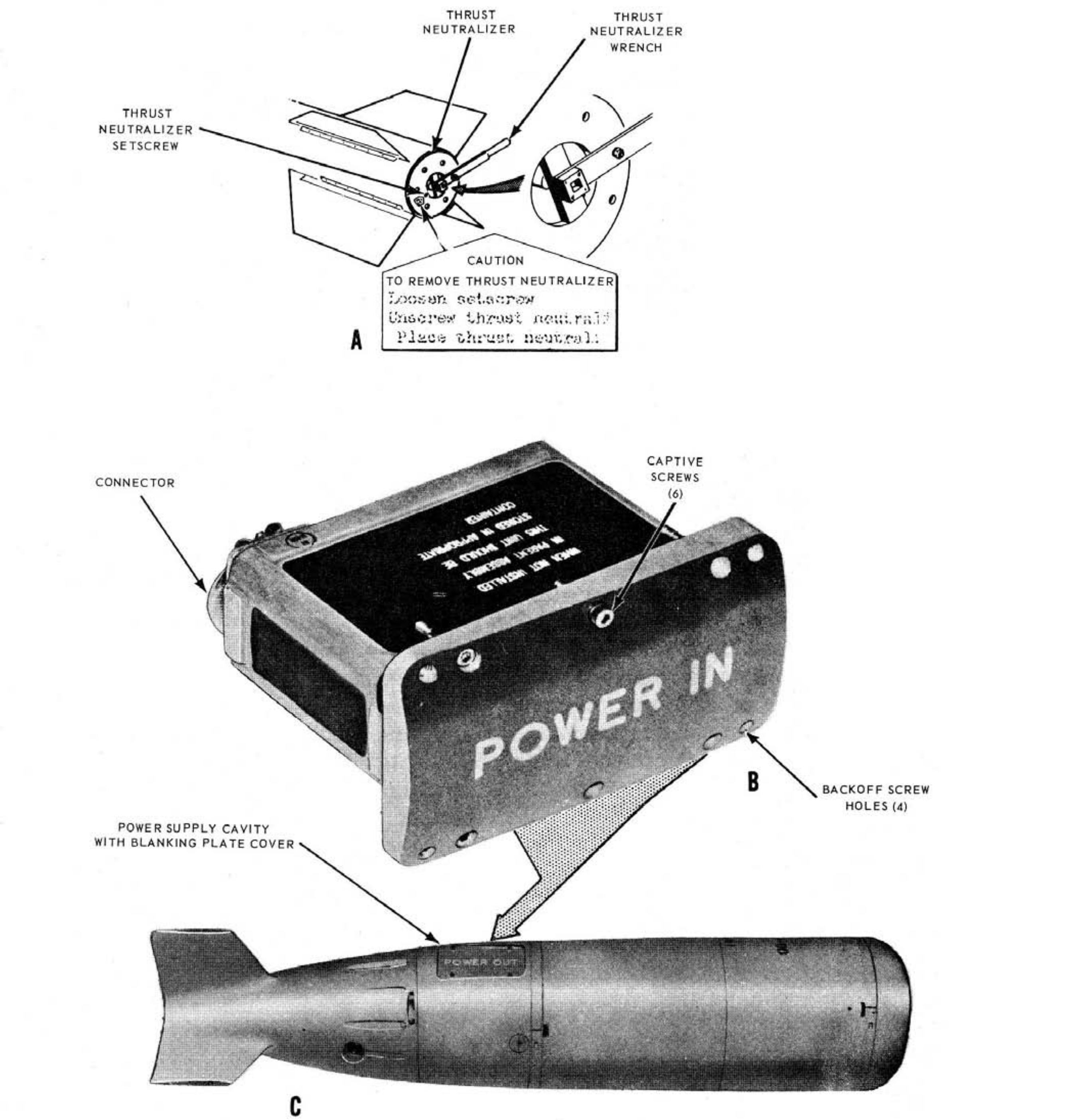

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Figure 4-15.—Safing devices restored to Asroc weapon when unloaded: A. Thrust neutralizer; B. Power supply with cover; C. Asroc Depth Charge, showing blanking plate cover placed over power supply cavity.

neutralizer (fig. 4-16) before disconnecting the hoist from the missile. The ground strap receptacle to which the wire is to be attached is on the neutralizer and should NOT be removed at any time. Secure the missile in its container so it cannot shift. As a GMM 1 or C you may be supervising and directing the work of unloading and packaging the missile or you may be operating the launcher captain's panel.

ASROC DUDS AND MISFIRES

As described earlier in this chapter, an Asroc dud or misfire is handled by the Mk 10 Mod 7 or 8 system in the same manner as a Terrier dud or misfire. The methods of safing the torpedo and the depth charge forms are different.

Depth Charge Mk 17

The missile configuration that carries the depth charge payload is designated as Rocket-Thrown Depth Charge Mk 2. If a dud or restrained firing occurs, notify the ASW officer. He will decide whether to return the missile to the magazine or to package it into a container and return it to a depot for repair. A dud is stowed, inspected and repaired later. You will check the missile and the warhead. The missiles in the other trays of the magazine may be used to continue the firing exercise (or in action). If a misfire signal shows on the launcher captain's control panel and/or the attack console, you must safe the depth charge at once, before it is removed from the launcher. The nuclear weapons officer must decide, in accordance with rules established for these weapons, what to do with it. After the weapon has been safed, proceed with unloading according to the checklist, observing all the safety precautions. If the weapon is to be off-loaded you will need to have a missile container for it, and two Hand Lift

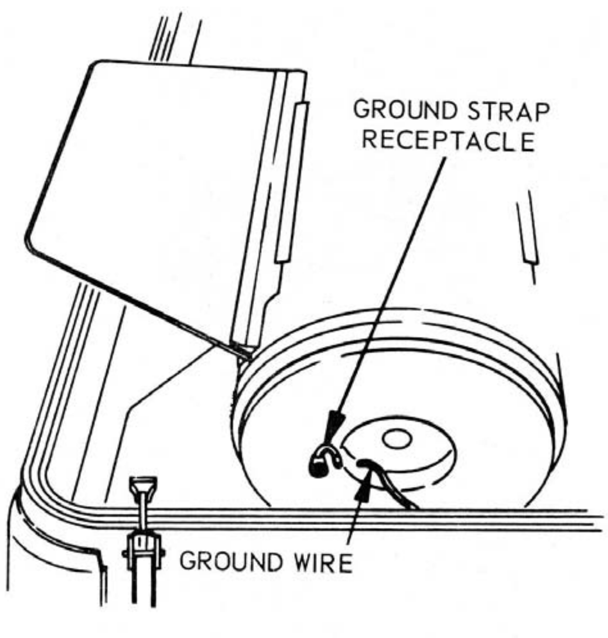

Figure 4-16.—Thrust neutralizer ground connection to container.

Trucks Mk 41 or Mk 42. If your ship does not carry these, you have to store the missile, order the missile container, the hand trucks, and other needed material, and when these arrive, unload the missile into the container. You will need thrust neutralizers and ISA shorting plugs, but these are normally carried on the ship; check the supply and order replacements if necessary. The thrust neutralizer and shorting plug (fig. 4-15) were removed when the missile was stowed during replenishment. The blanking plate and power supply seal were placed in stores at the time they were removed when the depth charge was loaded into the magazine. These are drawn from stores and reused when the power supply is removed from the depth charge.

Few ships have GMTs aboard; you need to know how to safe the depth charge. Depth charge safing (disarming) consists of resetting the ARM/SAFE switch to the SAFE position and removing the power supply (fig. 4-15B). Use the checkoff list from SWOP W44.34.1 and follow it precisely.

Asroc Torpedo

There is no provision for jettisoning the Rocket-Thrown Torpedo Mk 3. If, upon attempting to fire the torpedo, the DUD light goes on, auxiliary firing may be tried, or the missile can be returned to the magazine to be inspected and repaired later. It might be unloaded into a container and returned to a depot for repair.

To remove the dud or misfire missile to a shipping container, follow the checkoff list for unloading.

Safing the Asroc for Unloading

Asroc torpedoes must be returned to a tender; or deport every 6 to 12 months for maintenance procedures, and therefore must be unloaded from the cell. If a warshot torpedo has to be unloaded, the position of the torpedo exploder (fig. 4-14A) must be checked before the torpedo can be moved. (Torpedo exploders may also be installed in exercise heads to give an electrical "hit" signal.) The exploder bore rod must be in the cocked depressed position (fig. 4-14B); if it has moved (fig. 4-14C), it must be sterilized by turning the sterilizing switch (fig. 4-17). To reach the switch, break the foil seal in the top of the exploder, then turn the itch 90 degrees in either direction by using a screwdriver. This short circuits the exploder power supply. (The arming device is the part of the exploder that contains the explosive, and must be handled with great care. Spares are packaged and shipped separately, not assembled in the exploder.) All exploders must be considered armed if the bore rod has released. If you have to offload a warshot torpedo and the bore rod on the exploder is

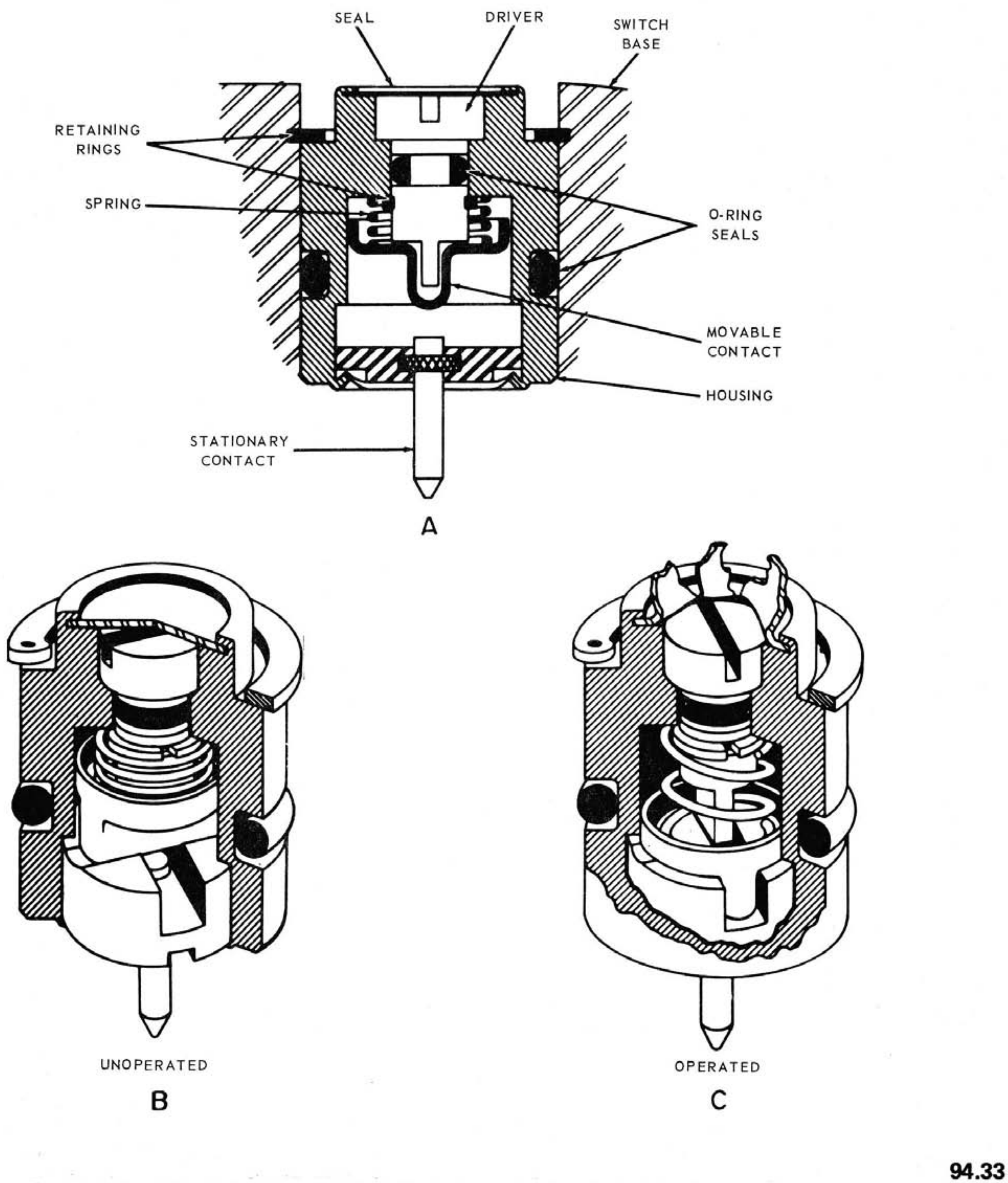

Figure 4-17.—Sterilizing Switch Mk 1 Mod 0: A. Sectional view; B. Unoperated; C. Operated (foil seal broken, switch turned).

released, sterilize the exploder before moving the torpedo. Once the sterilizing switch has been used, the exploder is useless for firing until a new sterilizing switch is installed (at overhaul). The exploder is removed from the torpedo after it is unloaded from the launcher. Details of different mods of the exploder vary; Exploder Mk 19 Mod 12, for example (used with Asroc), does not have a floor switch, but has a ceiling switch and sterilizer switch. Some mods do not have the bore rod extension lever shown in figure 4-14C. The Mod 12 has a double-acting type of bore rod, with a bore rod latch to lock it in the cocked position. On dummy training missiles, inspection of the exploder bore rod is not necessary, but operation of the depth charge Arm/Safe switch (when the missile is on the launcher) is required for training purposes. Removal and replacement of the thrust neutralizer is also practiced on dummy training missiles. You are not likely to have a dummy training missile on board a firing ship, but will have exercise torpedoes.

SUMMARY

Loading, used in this chapter to mean the placing of missiles on the launcher in preparation for firing, is described in automatic and in step control for .each of the types of missiles currently used by the Navy. When everything works perfectly, loading of missiles (with the possible exception of Asroc) consists chiefly of pushing the right buttons in the right sequence. However, the GMM 1 and C must be prepared to .locate and correct trouble in the intricate complex of the weapon system. The chapter points out differences between systems. Study the OP of the system you have aboard to acquire detailed knowledge of the mechanical, electrical, pneumatic, and hydraulic operating components of the system. Locating the trouble is a big step in the maintenance of a missile launching system.

The method of disposing of missiles that fail to fire is given with considerable detail for the different missile systems. A missile is too big and expensive an item to be discarded lightly; it must be saved and repaired if possible. (Repair of the missile is usually done at depots.)

At all times, safety rules must be remembered and enforced. You are expected to be, ready to risk your life in battle; but do not throwaway your life, or that of any of your men, by neglect of safety precautions.

CHAPTER 5

ELECTRICITY AND ELECTRONICS

INTRODUCTION

The preceding course and the basic courses, Basic Electricity, NAVTRA 10086 and Basic Electronics, NAVTRA 10087, have discussed the principles of electricity and electronics and explained how they apply to missile launching systems. The extensive application of electricity and electronics in missile systems make understanding of the principles and their applications a necessity for the GMM. Practically every part of a weapon system is operated or activated by electrical and electronic parts. The ET, FT, and other ratings are responsible for the care and maintenance of some parts of the weapon system, but there are numerous electric and electronic parts in the launching system whose maintenance is your responsibility.

A typical firing circuit and a power control : circuit were described and illustrated in the preceding course. We explained the action of each component, so that you could trace the functioning on the drawings. Troubleshooting techniques as applied to circuits were explained and troubleshooting charts were presented. You were instructed in the use of various meters in testing and measuring electrical and electronic components. Now you should be able to teach others how to use those meters and testers. If there are some weak or fuzzy areas in your knowledge, go back and review. You cannot build advanced knowledge on a weak foundation.

This chapter will tell you more about applications of electrical and electronic components in the operation of missile systems to help you see how the principles are applied to these components. From these you should advance to the more complicated problems of adjustment, alignment, and troubleshooting of electrical and electronic equipment.

GMM AND ELECTRIC AND ELECTRONIC PARTS

All the electrical and electronic components used to operate and test the launching system are part of the GMM's responsibility. While this is no small assignment, it does leave out (for other ratings to operate and service) a complicated assortment of equipment, such as radars and radar test sets, computers, weapon direction equipment, target detection equipment, and target tracking and missile tracking apparatus.

A review of the quals (Electricity and Electronics) show that nearly all the knowledge factors in these fields are required of the GMM 3 and 2. In the practical factors, the GMM 1 and C are expected to do the troubleshooting, casualty analysis, overhaul, repair, and adjustment on electrical and electronic components of the launching system. You have learned to use the test instruments for simple maintenance and repairs. Now you must learn to use the most sophisticated testers, and to locate electrical and electronic troubles and correct them. This is practical application of the principles you have learned.

CONTROL PANELS IN LAUNCHER SYSTEMS

Table 3-1, in chapter 3, lists the control panels by Mk and Mod numbers for all the missile launching systems currently used. As development of launching systems has advanced from experimental stages, standardization has increased. This not only reduces production and maintenance costs, but simplifies training of personnel. There are still many differences in the control panels for the different systems,. and there always will be some, but the similarities are greater. However, it is still far from "if you know one you know them all." Review chapter 3. Similarities and differences in the missile launching systems were discussed in that chapter.

CONTROL PANELS OUTSIDE THE LAUNCHER SYSTEM

It is impossible to describe the operation of the launcher control panels without constant reference to the control panels in the weapons control station, CIC, and controls on the bridge. There is a constant flow of information and direction to and from the various components of the weapon system. (See fig. 3-1 in chapter 3.) Figure 5-1 shows typical location of component of a weapons system. Communication between components must keep open. In addition to indicating lights on panels, telephone communication between stations is used to relay report or orders. An alternate system must be ready to take over in the event of failure or destruction of the other.

Many of the circuits in the launcher power panels are activated from control panels outside of the launching system. They are tested in cooperation with the operator of the panel sending the activating signals. When there is any failure, the GMM checks out the connection to his panel and works with the other operator to check out the whole circuit.

Training and elevation power drives are controlled by orders from the director, relayed through the launcher captain's control panel. Load orders and firing orders are transmitted to the launchers through the weapons control station and the launcher control panel. There may be a breakdown anywhere along the system and the GMM must help to find the trouble and correct it.

CIRCUIT TESTING BY THE GMM

The preceding course, *Gunner's Mate M (Missiles) 3&2*, NAVTRA 10199 contains a chapter on use of meters for testing, making electrical measurements, and troubleshooting circuits. Review any parts about which you are not clear. A solid understanding of the underlying principles is necessary before trying to understand complicated variations.

NOTE: The routine testing of ship's weapons control circuit wiring makes use of 500-to 1000-volt meggers. These checks are performed periodically as a regular part of preventive maintenance procedures. Repeated high potential tests (over 300 volts peak) can damage synchros and other small rotating components. High potential tests involving these components should be limited to those required for qualification and acceptance at the time of manufacture. Synchros, servomotors, resolvers, tach-generators, etc., should be disconnected from the circuit when megger or ground tests are being conducted.

Missile system installations greatly increased the requirement for 400-hertz power supplies having varying degrees of voltage and frequency regulation. Missile ships have had, to install 400-hertz generating plants to satisfy the demand. All missile ships have three separate 400-hertz power systems, each consisting of two or more motor generators. One is used for the ship's service system; another supplies the continuous wave illuminators used with guidance radars, and the third the most closely regulated (voltage and frequency) 400-hertz system, is used on ships for missile systems.

Launcher electric motors are started and run under the power of a 440-volt 60-hertz ship's power supply. The slipring assembly, on the launcher stand and carriage, provides continuous interconnection between on-launcher and off-launcher electrical connections while allowing unlimited train motion of the launcher. Qn the Talos launcher, the slipring (fig. 5-2) consists basically of a 440-volt collector ring assembly, a 115-volt collector ring assembly, and a fluid slipjoint. Each collector ring assembly has a rotating and a nonrotating section (fig. 5-3). The rotating sections mount collector brushes that are connected by cabling to circuits of on-launcher equipment. The nonrotating sections mount collector rings which are connected by cabling to the circuits of the off-launcher power and control components. The rings are engaged

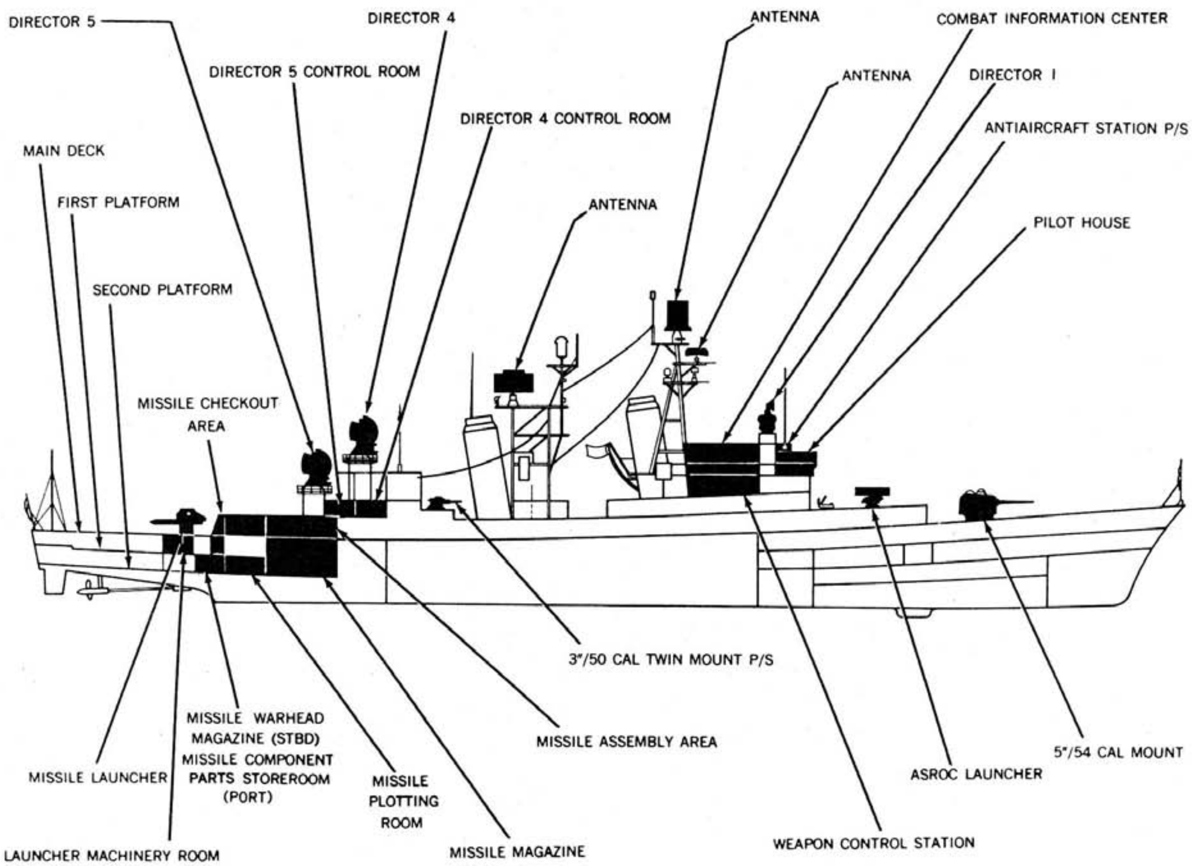

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Figure 5-1.—DLG class 9 weapons system.

by the brushes of the rotating sections to complete the electrical circuits. The four brushes contained in each brush ring are electrically connected to a terminal on the outer surface of the ring (fig. 5-3). The launcher cabling connects to the terminals of the assembled brush rings.

Close voltage and frequency regulation are necessary for use in the missile system. Voltage and frequency regulated equipment can now be provided in 30-, 60-, 100-, 200-, and 300-kw sizes, with voltage balance regulators supplied when necessary. Supplying the power needed for the missile system is in the province of the ship's engineering department.

While depending on the engineering department to supply the power in the voltage and frequency desired, you have tested circuits and tubes and have used schematic diagrams, block diagrams, voltage and resistance charts, and troubleshooting charts. Experience and study will help you improve your ability to interpret the results of the tests and trace a malfunction. It is possible to track down a malfunction by checking each part or component in the circuit-following the circuit diagram until you come to the defective part. But that may take hours of tedious work. A study of the problem may reveal a shortcut that will locate the trouble in much less time. While there is much to be said for patient, dogged, stick-to-it-iveness in a troubleshooting job, the application of brainpower to locate the trouble in short order is more commendable. You cannot do this with much success, however, if your knowledge of your weapon system is superficial.

Troubleshooting Control Panel Circuits

With the enormous amount of wiring and electrical components required in a weapons system, it is not surprising that a high proportion of the failures are in the electrical system.

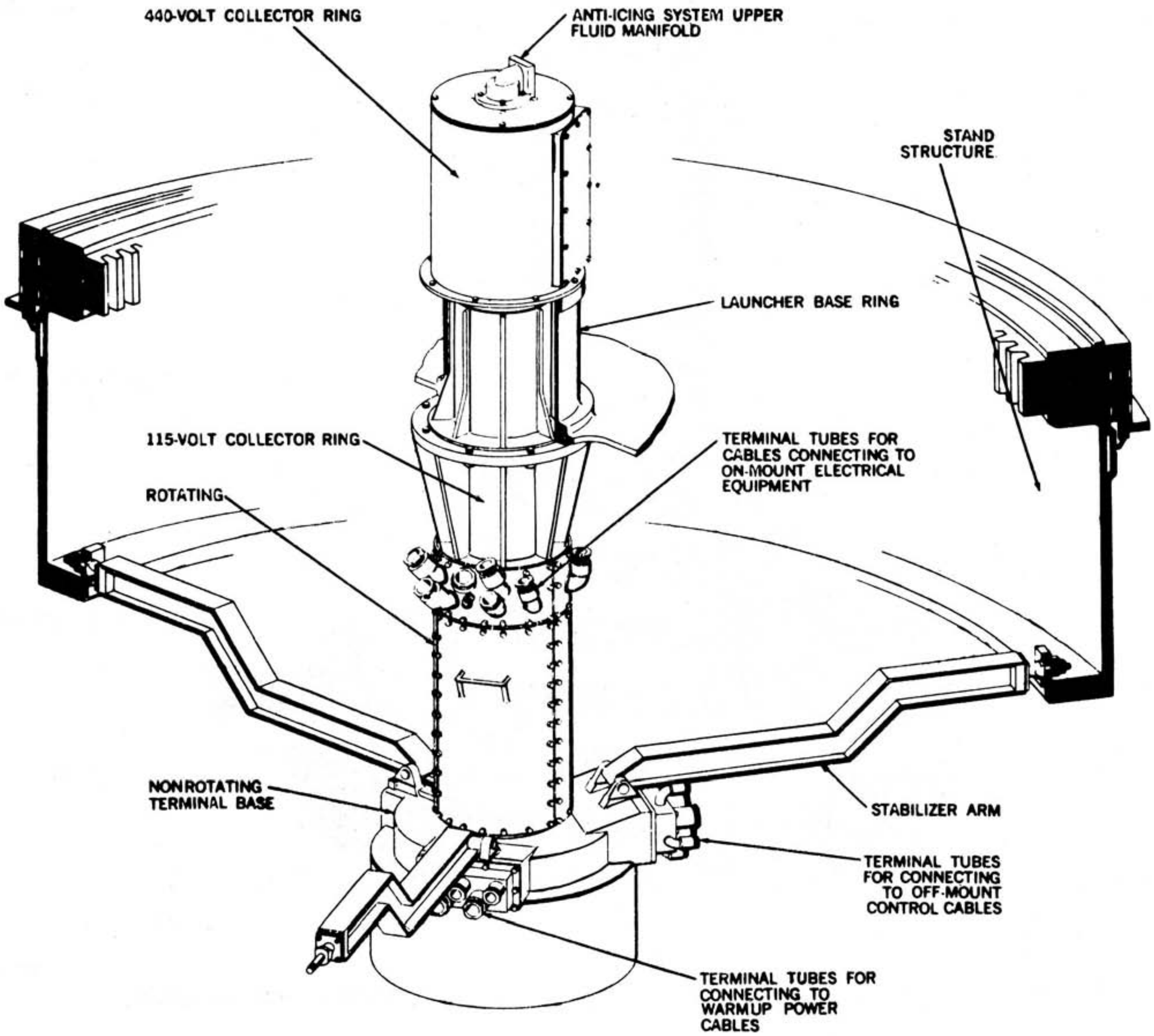

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Figure 5-2.—Slipring Mk 6 Mod 1, installed arrangement on stand and carriage of Mk 7 Mod 1 launcher (Talos).

The control and power relays of the Mk 10 Terrier launching system, for example, consist of more than 400 miniature rotary relays, 6 subminiature relays, 46 medium-size rotary relays, and 6 small-size rotary relays. These relays are in the EP1, EP2, EP4, and EP5 panels.

Conscientious application of the 3-M system is intended to reduce the incidence of failure. The MRCs give step-by-step detail of what to do for routine maintenance, but when any part of the equipment fails to perform as it should, you have to turn to the OPs for aid in troubleshooting. The OP also gives the frequency of tests, checks, inspections, and servicing of the different components. If the OP differs from the MRC in this, follow the MRC instructions.

Let's concentrate on the EP I panel, which is the basic distribution panel for all electrical power to the launching system. It contains switches, circuit breakers, fuses, relays, and

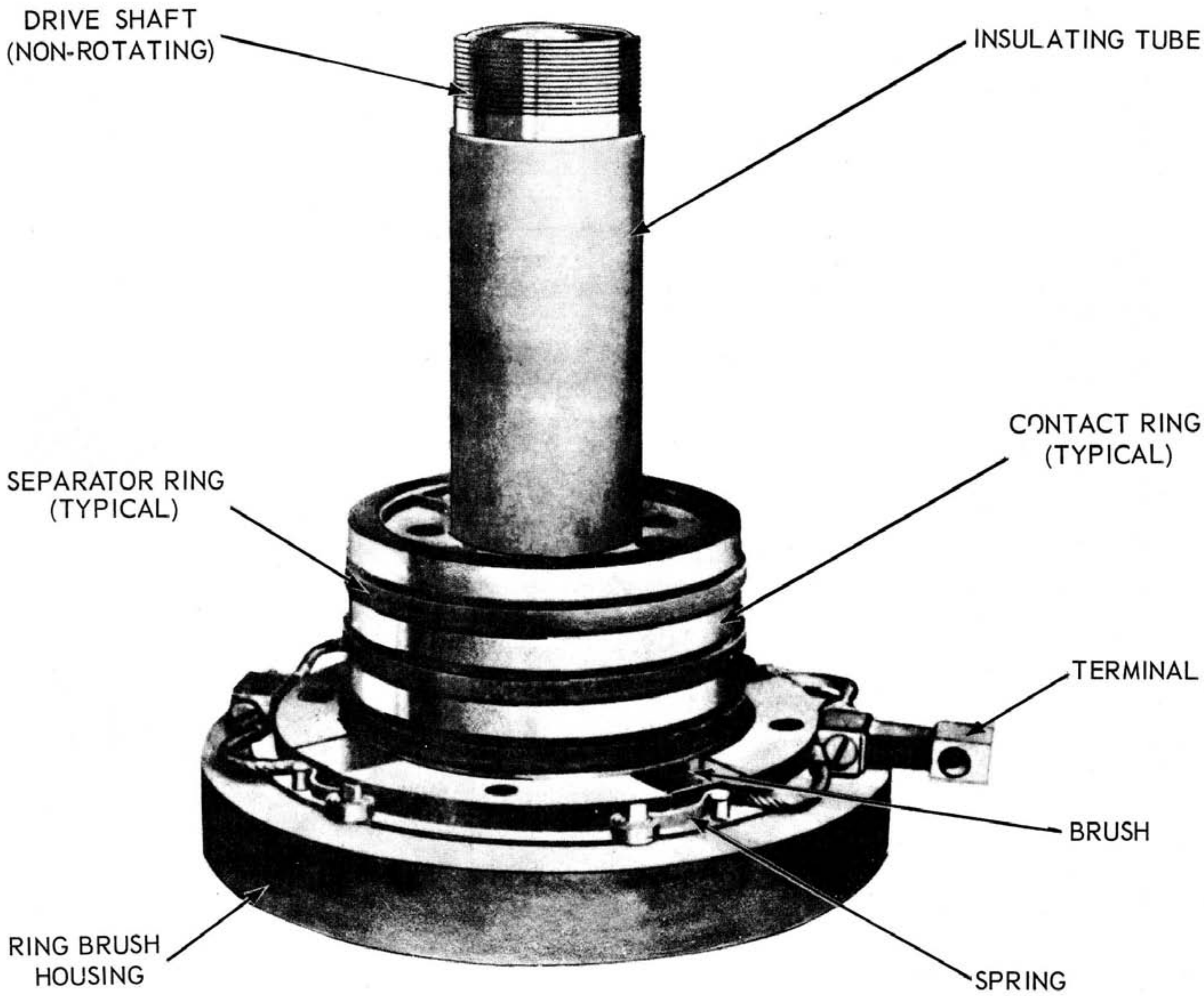

Figure 5-3.—Partially disassembled 400-volt collector ring assembly (Mk 7 Mod 1 launcher).

contactors for the power and control circuits. The launcher captain turns on the various circuits before he goes to the EP2 or launcher captain's panel, which he mans during operations. In figure 5-4 the items are identified by number. Lights in section no. I indicate that the 440-volt power has been turned on and is available on the panel. As the motors in the launching system are energized, lights in section 2 come on: (a) B-side magazine motor; (b) Train motor; (c) Elevation motor; and (d) A-side magazine motor. The circuit breakers for these motors are in section 3. Lights in section 4 indicate that the following motors are energized: (a) B-Side loader motor; (b) Launcher rails motor; (c) Circulating system motor; and (d) A-side loader motor. Section 5 has the circuit breakers for these motors. The two lights in section 6 are for A and B-side loader accumulator motors, and the circuit breakers for these are in section 7, with a third circuit breaker for the control system. When you activate the panel, you turn on all these switches and circuit breakers unless only one side of the launcher is to be used, and then you turn on only the circuit breakers and switches for that side.

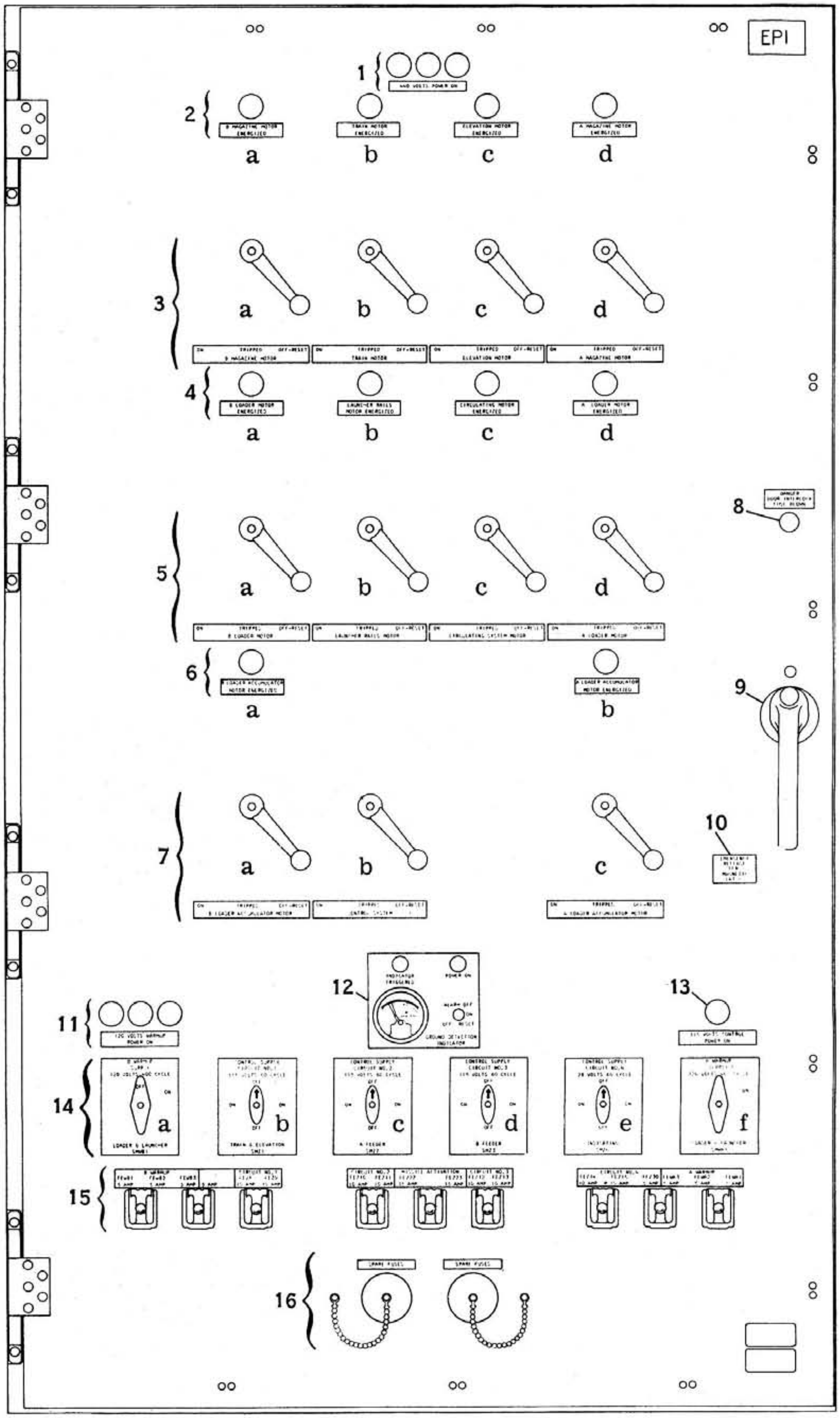

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Figure 5-4.—EP 1 panel, Terrier Mk 10 Mod 7 launching system.

Lights in section 11 indicate that power is available for the 120-volt warmup circuits and the light in section 13 indicates power available in the 115-volt control circuits. The On-Off switches for warmup supply circuits and control supply circuits are in section 14 and the fuses are in section 15. Each fuze block has two fuses and two fuse-blown indicating lights. Two extra fuses are in section 16, with screw-on watertight caps.

If light No. 8 is on, it indicates that the door interlock on the panel is inoperative. A magnetic latch on the door prevents opening it while the power is on. Before the door can be opened to , make repairs, etc., the 440-volt power must be turned off and then the door handle (no. 9) can be turned to open the door. No. 10 is an emergency release for the magnetic door latch. No. 12 is a ground detection indicator. It monitors the 117-volt control supply circuits and triggers an alarm if there is a grounded circuit. Figure 5-5 shows in outline the EP1 functions.

PRELIMINARY ISOLATION. - Let's assume that you have turned on all the switches and circuit breakers on the EP1 panel to activate the system. You notice that a fuse-blown light for switch d in section 14 is on. This means that control supply circuit No. 3 for the B-side feeder is disabled in some way. You have to find where the trouble is. Check the fuse blown light first. You will need to look inside the panel. Before you can do that, you must disconnect the power supply; the panel door will not open while the power is on. Besides, you may not work on energized electrical equipment without an express order from the ship's commanding officer: Remember safety rules for working with electrical equipment: were no rings, wristwatches, bracelets, or similar metal objects. Do not work with wet hands or wet clothing Wear no loose or flapping clothing. Discharge any capacitors before touching them - they retain a charge after they are disconnected from their power source.

You may see; the cause of the failure as soon as you look behind the panel door, but more than likely you will need to get the electrical drawings and trace the wiring until you find the trouble. The power distribution cables are numbered 0 to 99, and the wires are numbered 0 to 999. Loading control cables for the "A" side are numbered 200 to 299, and for the "B" side the numbers are 300 to 399. Wire and cable numbers are assigned in groups, with "A" or "B" added to indicate the side served by the wire or cable. For example, "WSA2022" means "Wire, single conductor, no. 2022 of the A-side loaded circuitry." The cabling schematic also identifies the type and size of wire used in each application. The drawing explains the component type designations used, such as "WS" above, and the major assembly designations, such as "LB" for Loader, B-side, or "BA" for dud jettison, A side. All electrical and hydraulic

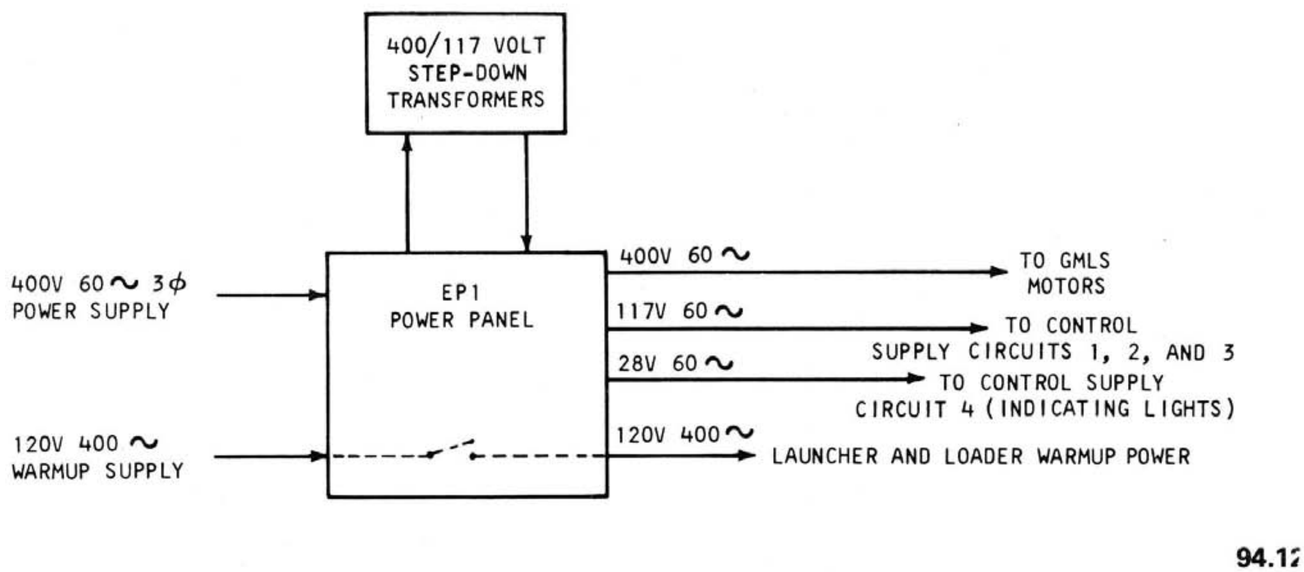

Figure 5-5.—EP 1 control panel functions.

components are identified by a combination of letters and numbers that indicate the kind of device or component, the identification of the major assembly of which it is a part, and identification of the specific component. These reference designations do not replace drawing, part, or stock numbers. They identify the part on the schematic. For example, KCLA1-1AB can be interpreted as follows:

KC-relay, control

LA-Loader, A side

1 - No. 1 among the relays associated with the A-side of the loader.

lAB-the A and B contacts on the first wafer or section of the relay. It also indicates that the A and B contacts on the first section of the relay are wired in that circuit application.

To return to the EP-1 panel and your problem. If the trouble is only a faulty fuse, replace it. However, remove and replace fuses only when the associated circuit is completely deenergized. Use a fuse puller made of insulating material. Use a fuse of the same rated voltage and amperage capacity. Never short a fuse. After you have replaced the fuse, replace the fuse cover (if it has one), then energize the circuit. A fuse may explode when the circuit is energized.

When you have located the trouble that caused the fuse to blow, and have repaired it, reactivate the panel to check the work you have done.

Since the EP1 panel is connected directly to the ship's electrical system for its power supply, you need to work with the ship's electricians when there is a failure in any of the lines connected to the ship's power supply.

CIRCUIT TROUBLE AT THE EP2 PANEL.- Assume that you have turned on all the connections at the EP1 panel and power is available for all the circuits. You are now ready to take your position at the EP2 panel. You receive orders from Weapons Control regarding the mode of operation, the type of missiles to be used, single loading or continuous loading, and whether A-side or B-side or both are to be used. You are ready to activate the EP2 panel, through which electrical power is supplied to the different units of the launching system.

The magazine, which consists of the ready service ring, the load status recorder, the hoist mechanism, and the magazine doors, is operated by hydraulic power from Power Drive Mk 64. One power drive is located on the A side and the other on the B side. Individual controls for the units are on the EP2 panel. Circuit No. 2 for control supply furnishes the l17-volt a-c electricity to operate the motor that drives the pump to develop accumulator pressure. The start circuit for the magazine accumulator motor is controlled from the EP2 panel. When the contactor (KPXA1 in fig. 5-6) is energized, it closes contacts which complete the 440-volt supply to the magazine accumulator motor (BPXA1).

Normally there will be no trouble starting the magazine accumulator motor by depressing the START-RUN pushbutton switch SMXA16A (fig. 5-6). However, a malfunction may occur at any time in such a complex equipment. It is important, therefore, to understand the motor start circuit and the relay elements it includes.

To complete the Start circuit, you position SMS1 (Control Selector Switch) at STEP, SMS2 (Operations Selector Switch) at OFF, and SMX3 (A- or B-Side Selector Switch) at A or A AND B for A-side operation, or B or A AND B for B-side operation. Control Selector Switch SMS1 must be positioned at STEP during activation in order to start the motors, and switch SMS 2 must be at OFF during that time to prevent system operation until activation is completed.

With these manual switches positioned, it is time to position the switches or relays for the , components powered by the accumulator unit. The positioning latches, both clockwise and counterclockwise, for the ready service ring must be extended so the ready service ring will not start indexing before the system is ready. Both tray shift solenoids (LHDAl-LCl and LHDAl-LC2) must be deenergized and the associated solenoid rocker arm must be at neutral to prevent indexing ahead of readiness. The normally closed (N.C.) contacts of these switches are wired into the Start circuit, so the switch elements are closed when not actuated. Hoist solenoid switches (LHHAl-SIl0l and LHHAl-SIl02) and magazine door solenoid switches (LHGAl-SI101 and LHGAl-SIl02) perform the same function - prevent premature activation of the associated parts of the launching system.

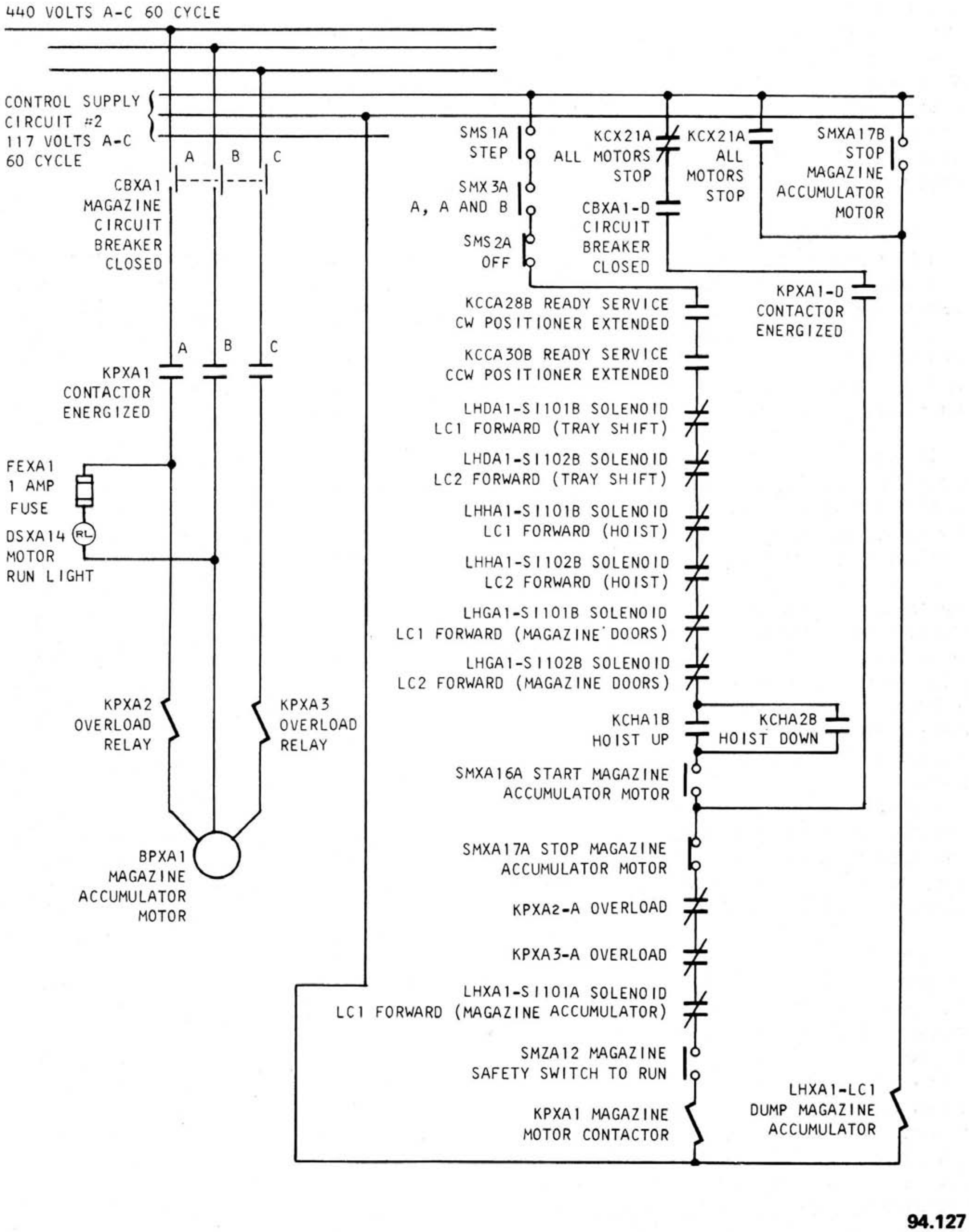

Figure 5-6.—Start and Run circuits for accumulator system motor.

Relay elements KCHA1 and KCHA2 keep the hoist in either the latched up or latched down position so it will not be stopped in midcycle. The magazine door solenoid switches (LHGA1-SI101 and LHGA1-SI102) remain deenergized at this time so the doors will not open. Both overload relay elements (KPXA2) and (KPXA3) are closed because there is no overload in the 440-volt power supply to magazine motor BPXA1. The remaining elements between SMXA16A and the KPXA1 coil remain closed during the motor-state procedure. The Magazine Motor STOP switch (SMXA17) is spring-held in the closed position unless it is depressed to stop the motor. Also closed is LHXA1-SI101, the solenoid switch to dump magazine accumulator pressure if it becomes necessary. The solenoid LCI will not energize until the motor has been stopped.

Now, with all the manual switches properly positioned and the associated interlocks closed, you are ready to press the Magazine-Motor START-RUN button, SMXA16. This completes the 117-volt circuit to the coil of the motor contactor KPXA1.

When the contactor coil is energized, it closes contacts A, B, and C of relay KPXA1 in the 440-volt motor power circuit and contact D in the motor run circuit. The motor should start and begin driving the parallel piston pump.

Suppose the motor doesn't run after you have pressed the start button. Maybe somebody forget to push Magazine Safety Switch to RUN (SMZA12), a manual switch on the EP4 panel which must be positioned to RUN. If that is not the cause of the nonoperation, you will need to get the drawings for the system to trace down the cause of the failure. The schematic helps you picture the layout of the system, but you will need the electrical diagrams to make the proper corrections. Review the check list to make sure you did not omit any step in the activation. The checklists posted at the panel should be used every time the panel is activated.

COMPONENT ISOLATION. - Once the source of trouble has been isolated to a particular circuit, several aids and short-cuts are available for isolating the defective component. Three probable sources of trouble in circuits are: an open relay coil, an open diode, or a shorted diode. When isolating troubles, first determine which coils of the relays are energized when a pushbutton is pressed. The drawing or the maintenance manual may have a listing of the coils of the relays for each circuit. Check each circuit systematically for opens, and for shorts. There is little likelihood of a shorted relay coil, but a diode wired across the coil of the relay may be shorted, and that would cause a fuse to blow as soon as the circuit to the relay is completed. Shorted diodes in other circuits may cause no such giveaway reaction but may permit current to pass through other diodes. Those are more difficult to locate. When the shorted diode is isolated from the associated circuitry, do not assume it is bad; its forward and backward resistance should be checked.

CHECKING RELAYS. - Relays suspected of faulty action may be checked with the relay test equipment mounted on the inner side of the EP2 panel front door (fig. 5-7), next to the door latch. Before testing relays, the pins should be examined to be sure that they are not bent. To straighten bent pins, firmly seat the relay in the pin straightener mounted in the top of the test panel (fig. 5-7). Terminal pins on a plug-in type of relay are shown in figure 5-8B. After any necessary straightening, insert the terminal pins into the test socket (fig. 5-7). The toggle switch SMZl9 applies (or removes) power to the coil of the relay being tested. SMZl9 also switches the circuitry of the test socket to permit testing of the normally open or normally closed internal circuits of the relay as desired. Selector switch SMZl8 permits checking the individual internal circuits of the relay, normally on or normally closed, as determined by the position of SMZI9. As each internal circuit of the relay is tested by positioning SMZI8, indicator light DSZl3 indicates whether the relay is operating properly.

INTERLOCK SWITCHES. - The switches on the control panels are chiefly manual switches of pushbutton, rotary, or toggle types. Numerous interlock switches are used throughout the launching system. They are actuated by mechanical motion or hydraulic pressure, and are used to monitor equipment functions. The design varies with the application, but usually consists of one or more switch elements

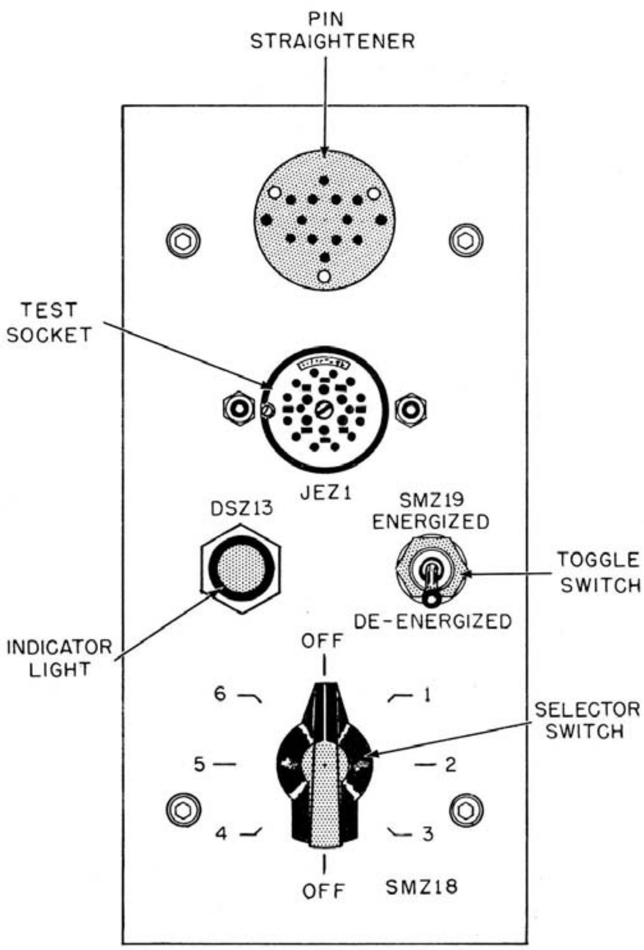

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Figure 5-7.—Relay test panel on the EP 2 panel, Mk 10 launching system.

mounted to an actuating device. They assume that related equipment is at a certain position or has performed a certain function, so that operation will be in sequence. For example, the hoist cannot raise a missile to the loader if the magazine doors are closed. The circuit energizing the solenoid which controls hoist raise operation contains an interlock that does not allow circuit completion until the magazine doors are open and secured. This interlock is a relay wired into the solenoid circuit. When the relay is energized the interlock is closed. The relay energizes when the associated interlock switch, mounted to the magazine door equipment, is actuated. This switch actuates when the magazine doors have fully opened and the door lock latch is engaged. Other interlock switches in the circuit assure that the loader is in position (retracted) above the magazine doors and that the tray shift on the ready service ring is positioned to hoist. Even the motor start circuit includes interlocks. They assure that powered equipment is not halted in midcycle.

When interlock switches malfunction, the entire switch assembly is removed and a replacement unit is installed. Before the replacement unit is installed, it should be checked electrically with the switch test device (special tool 1614018) to be sure that it functions properly.

The interlock switches of the Mk 10 Mod 0 launching system control are of two types. The majority of the switches are sensitive switch assemblies, and the rest are microswitches mounted in the solenoid housings and in the load status recorder assembly. The OP for the system has a listing of all the sensitive switches, the location of each, its function, the reference drawings, and instructions for adjustment, with an additional listing of solenoid, interlock switches mounted on brackets and secured to the supporting frames of the primary solenoids in the switch housing (fig. 5-9). The assemblies are of right-hand and left-hand configuration, so when you are replacing one, be sure to get the correct one.

Before disconnecting any switch for replacement, be sure to mark down or note the connection of each lend so you can connect the leads of the replacement in exactly the same way. Use a soldering iron to remove the leads, and when attaching the new leads, solder them in place, after placing the switch assembly in position and securing it lightly. Adjust the air gap (fig. 5-9) with the solenoids deenergized, according to the reference drawing for that switch. Tighten the locknuts after making adjustments.

LOAD STATUS RECORDER. - We mention the lead status recorder here as an example of a complex electromechanical assembly (fig. 5-10). One is located on each ready service ring, mounted on the outboard side of the truss. Its two basic sections are a relay board assembly and a switch and cam actuator assembly. It monitors the missile type and condition at all 20 stations in the ready service ring and sends this information to the control panels (EP2, and EP4 (5) in the form of interlock switch and visual

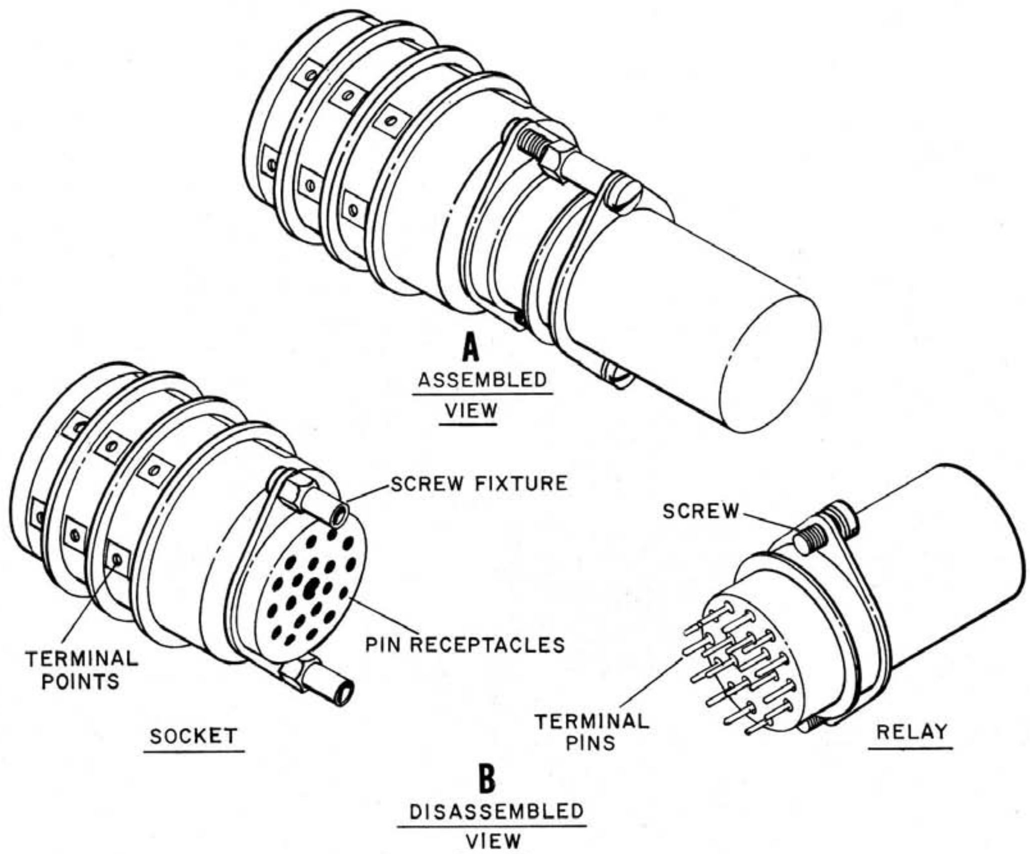

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Figure 5-8.—Plug-in relay and socket assembly: A. Assembled view; B. Disassembled view.

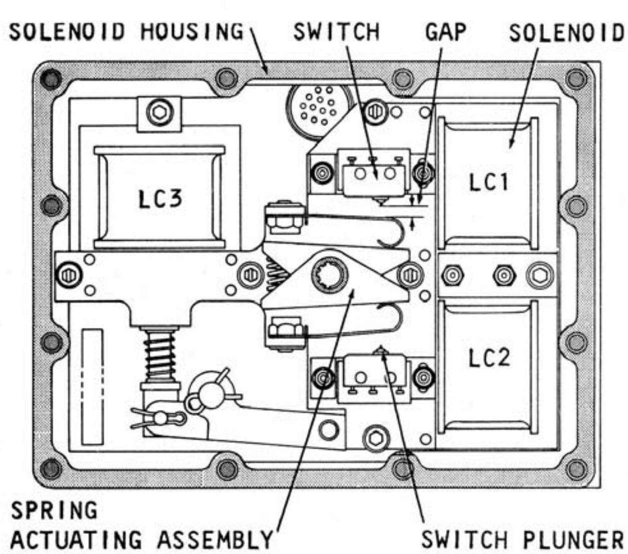

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Figure 5-9.—Typical solenoid switch assembly.

light indications. The ring of lights on the EP2 panel shows what the recorder tells; it is in the ready service ring at each station. Shipboard correction or adjustment of the electrical components should not be attempted; remove the defective unit, such as a triple switch or single switch element, return it for repair, and install a new unit. If the load status recorder malfunctions mechanically, order a replacement from the supply system.

The proper operation of the load status recorder can be checked during the daily exercise of the launching system. Each time the ready service ring is indexed to another station, notice if the lights representing the stations in the ready service ring rotate in the same direction and amount. If there are empty trays or trays with dud missiles, the EMPTY and DUD indications can be checked. The checking must be done in Step operation, operating from the EP2

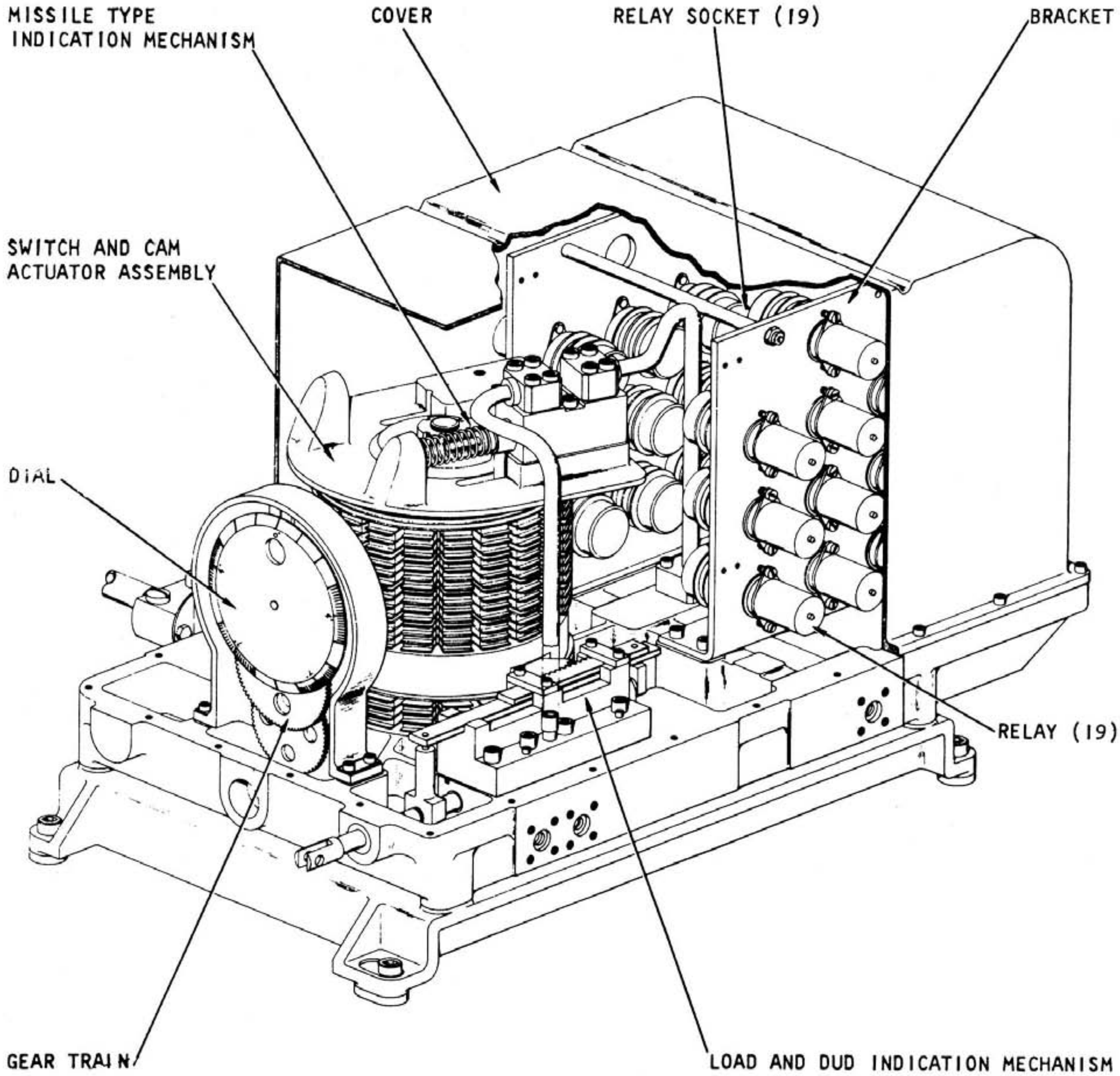

Figure 5-10.—Load status recorder.

panel. For unload assembly, unload launcher, checkout, or strikedown, the EP4 (or EP5) panel must be used to rotate the ready service ring. The loading pattern was set into the load status recorder at the time the missiles were loaded, and if the recorder is operating properly, the lights on the control panels should read back the same as the loading pattern. The color of the light indicates the type of tray or round. Three amber lights inside each circle of lights (representing the ready service rings) indicate the meaning of the lights in the circular pattern as DUD, EMPTY, or LOADED. If you push the DUD button (of those three), the lights should go on for all the trays that hold dud missiles. If you push the EMPTY button, the lights representing trays that are empty should come on. If you activate the LOADED button, the lights for all the trays containing missiles should come on, the color indicating the type of missile in each. In each case, the light indications should agree with the loading pattern established at the time of loading, unless the tray assignment has been changed, or the missile has been unloaded.

SAFETY RULES

It is your duty as a supervising petty officer to instruct and remind your men of the safety rules and see that they obey them. The first class and CPO should conduct lessons on safety. Chapter 12 contains safety rules for electricity and electronics, as well as for other situations.

SERVOMECHANISMS

An apparatus that includes a servomotor (or servo for short) is often called a servomechanism. And what is a servomotor? It is a power-driven mechanism, commonly an electric motor, which supplements a primary control operated by a comparatively feeble force. The primary control many be a simple lever, an automatic device such as a photoelectric cell or a meter for measuring position, speed, voltage, etc., to whose variations the motor responds, so that it is used as a correctional or compensating device. A servo is a control device, a power amplifier, and a closed-loop system. *Gunner's Mate M (Missiles) 3&2*. NAVTRA 10199 described and illustrated the fundamentals of servomechanisms. They are used m all the power drives, and the principles apply to all of them - only the details of application vary in the different launching systems. Servos may be electrical, mechanical electronic, hydraulic, or combinations of these, but all use the feedback principle. One or more power amplifier are part of any servosystem. There must be an input and an output, and between these, an error detector and an error reducer. Each of these essential components may have many parts, so that even a simple schematic may seem like a complicated maze. Remembering the essential parts of a servo d the direction of the signals are helpful in tracing through the schematic.

Troubleshooting

Since the launchers must be trained and elevated every day as part of routine training and maintenance, any defects or failures in the servomechanisms of those systems will be evident. Servomechanisms are used in connection with so many parts of a missile launching system, no one application can be considered as typical. Their use in the training and elevating system is one of their most extensive applications. The receiver-regulators are described in the next chapter. The emphasis there is on the hydraulic of the system. Following are some suggestions for trouble-shooting the electrical parts. But first review the four steps:

Step 1.-Observe the equipment's operation.

Step 2.-Make an internal visual check.

Step 3.-Localize the trouble to the faulty parts, using meters, electrical prints, and maintenance publications.

Step 4.-Replace or repair the defective part; test the system's operation afterward.

Electrical Prints

Locating components and tracing circuits is generally easier when using electrical prints than working on the wiring itself. Tracing the mass of wiring, terminal strips, and obscured test points is virtually eliminated when using the prints. The components are grouped in the prints in a more orderly manner. There are several types of circuit diagrams. Those most commonly found in your OPs and MRCs are wiring diagrams.

These diagrams are especially helpful in understanding the operation of the equipment. They show the parts of the circuit and how they are connected. They do not show how the parts look or how they are constructed - the components are illustrated by symbols.

SYMBOLS. - There are several publications containing lists of symbols, and from past experience you can probably identify many of them. As a first class or chief you must enlarge your knowledge in this field, beyond the basics required for the third class.

For the most part symbols are standard, but there are variations. For all their variations, symbols are really simplified sketches of the devices they stand for. If you are reasonably familiar with the devices they represent, you should have little trouble identifying the symbols in the schematics. Unusual or special ones are explained on the drawing.

STRAIGHT LINING.-As there are tricks in all trades, there is one in circuit tracing. It is called "straight lining."

Wiring diagrams and schematics are often a complicated maze of many circuits, accomplishing many functions. You must acquire the ability to disregard all circuits that are unnecessary to the one you are attempting to trace. The resulting circuit, depicted on one drawing, will show only the circuits necessary for one particular function. This important feature of circuit tracing is called straight lining.

Faulty Switches

The preceding course, *Gunner's Mate M (Missiles) 3&2*, NAVTRA 10199, traced for you a typical power control circuit and a typical firing circuit, and showed you how interlocking worked in the circuits, and how parts of the circuit operated in a definite sequence. When you are tracing a circuit to locate a casualty, remember to include the interlocking switches that can prevent activation along any part of the circuit. If a faulty switch is found, it should be replaced or adjusted. Be absolutely certain that a switch is faulty before replacing it. It may only need adjustment to operate properly. If a switch is replaced, it must be adjusted within the equipment. Adjustment of interlock switches requires familiarity with the function of the switch contacts in the associated control circuits. Study the applicable schematic wiring diagrams. The complete control circuit is shown in the applicable elementary wiring diagrams for the system control.

Interlock switches must be checked periodically to be sure they are actuating and deactuating properly. Check them electrically to make sure that they are making and breaking as required. When an interlock switch malfunctions because of mechanical wear or damage, replace the entire switch. The Mk 10 Mod 7 Terrier launching system uses eight types of interlock switches: (1) sensitive switch assembly, used throughout the system; (2) microsensitive switch, two used in the EP1 panel; (3) 2PB switch assembly, used within the loader-control cam housing; (4) type A rotary switch, used in, the Asroc adapter rail; (5) single switch assembly, used within the dud-jettison solenoid housings and within the load status recorders; (6) paired switch elements used within the solenoid housing, loader-control cam housing, contactors, and magnetic circuit breakers; (7) paired switch-element assemblies, used throughout the system in standard solenoid assemblies and in loader-control solenoid assemblies; and (8) triple switch-element assembly, used in the load status recorder

The maintenance instructions for the different switches usually are included in the OP with the instructions for the component to which each is attached or which it activates. The MRCs give the most up-to-date routine maintenance instruetions for each component. Pull the appropriate MRC card for each day's maintenance work.

AMPLIFIERS

Amplification of signals is necessary in the launching system and in the missiles, as well as in the fire control system. In electronics and electrical engineering, vacuum tube amplifiers, transistors, and magnetic amplifiers are widely used. There are many types and arrangements of these, but the purpose of all is to increase the magnitude of a quantity. Amplifiers associated with electric and electronic components are arranged to reproduce in their output circuits a voltage or current greater in magnitude than that applied to their input circuits. Electron tube amplifiers may be grounded-cathode, grounded-grid, or grounded-plate (cathode follower) type. There may be a chain of amplifiers, called cascade or multistage amplifier.

The conventional electron tube amplifier is the grounded-cathode type, which has the cathode at ground potential at the operating frequency, and the input applied between the control grid and ground, and the output load connected between plate and ground.

The grounded-grid amplifier is an electron-tube circuit in which the control grid is at ground potential at the operating frequency, with input applied between cathode and ground, and output load connected between plate and ground. The grid-to-plate impedance of the tube is in parallel with the load instead of acting as a feedback path.

A grounded plate amplifier has a large negative feedback and is often used as an impedance matching device. The plate is at ground potential at the operating frequency, with input applied between grid and ground, and output load connected between cathode and ground.

MAGNETIC AMPLIFIERS

The magnetic amplifier is rapidly becoming an important device in electrical and electronic equipment. Amplifiers of type have many features which are desirable in missile systems. The advantages include (1) high efficiency (90%); (2) reliability (long life, freedom from maintenance, reduction of spare parts inventory); (3) ruggedness (shock and vibration resistance, overload capability, freedom from the effects of moisture); (4) stability; and (5) no warmup time. The magnetic amplifier has no moving parts and can be hermetically sealed within a case similar to the conventional dry type transformer.

The magnetic amplifier has a few disadvantages. For example, it cannot handle low-level signals (except for special applications); it is not useful at high frequencies; it has a time delay associated with magnetic effects; and the output waveform is not an exact reproduction of the input waveform. The term "amplification" in general refers to the process of increasing the amplitude of the voltage, current, or power.

The term "amplification factor" is the ratio of the output to the input. The input is the signal that controls the amount of available power delivered to the output.

Until comparatively recent times, magnetic control has had little application in missile electronic equipment since existing units were slow in response and were of excessive size and weight. But with the development of new and improved magnetic materials, there has been a parallel development of magnetic circuits for tubeless amplification; and many of these units are now employed in automatic pilots, static a-c voltage regulators, and in associated test equipment. .

Magnetic amplifiers are devices which control the degree of magnetization in the core of a coil to control the current and voltage at the load or output. One of the oldest forms of magnetic amplifiers, the SATURABLE REACTOR, contains at least two coils wound ,on a common core made of magnetic material. A d-c control voltage is applied to one of the coils; and the resulting current serves to modify the reactance of the second winding by causing magnetic saturation of the common core. The second coil is a series element in the a-c load circuit so that current. variations take place in the load in accordance with those made in the control voltage. In more complex magnetic amplifiers, the input, or control signal, may be either d-c or a properly phased a-c voltage.

In addition to saturable reactors, there are numerous types of magnetic units in use, including voltage regulators, low- and high- frequency amplifiers, and servomotor controllers. The purpose of this discussion is to present the operating principles of these devices and to give representative examples of magnetic circuits employed in missile electrical equipment. To understand the theory of magnetic amplifiers, it is necessary that you understand the theory of magnetism and magnetic circuits. This information may be found in the Navy training course *Basic Electricity*, NAVTRA 10086. The basic principles of operation of magnetic amplifiers are also discussed in that text. The quals require this knowledge at the B-4 level.

Magnetic amplifiers are not new; saturable core control has been used as early as 1885. In the United States, saturable core devices have been used to control heavy electrical machinery since about 1900. Refinement and improvement have made magnetic amplifiers usable for more delicate and accurate controls. They are now used for gun and launcher servo systems; high- speed digital computers; and pulse-forming, memory, and scanning circuits in radio, radar, and sonar equipment. Development of reliable semiconductor rectifiers, magnetic-core material of high permeability, improved input and output devices, automatic means of winding toroidal cores, use of sealed, self-contained units, and new means of testing, matching, and grading have greatly expanded the use of magnetic amplifiers.

APPLICATIONS OF MAGNETIC AMPLIFIERS

The magnetic amplifier has found application in many different type circuits. These circuits may employ diodes, vacuum tubes, and transistors. Such circuits may be found in voltage regulators (d-c and a-c), servoamplifiers, and audio amplifiers. The GMM will be mainly concerned with their application in servo systems and voltage regulators.

The application of magnetic amplifiers varies with the different launching systems. In the Mk 9 launching system, the EP8 and EP9 control panels house the amplifiers. They are located on the transfer cars, A side and B side. The transfer cars are operated by hydraulic power, but the amplifiers amplify the electrical signals that actuate the switches. The power panel is the voltage supply source for magnetic amplifiers in the system. There are magnetic amplifiers in the lift assembly and power drive unit, in the cell door and missile stop mechanism assembly, in the extractor assembly, subassemblies, and power drive. This transfer car is used to move a selected missile from its cell to the stage 1 rammer rail in a loading operation, or to move the missile to the checkout handling rail for a checkout or strikedown operation. In stow operation, the car will return the missile from the stage 1 rammer rail to a selected cell and it will also return a missile from the handling rail to a selected cell after completion of checkout or when arming the ship. In all these functions, magnetic amplifiers are used to amplify the signals. If the magnetic amplifier is out of adjustment, the transfer car movement will be slow or sluggish or it will hunt. You need the OP for the launching system for detailed steps in the adjustment of magnetic amplifiers.

APPLICATIONS IN SERVOMECHANISMS

One of the most frequent uses of magnetic amplifiers in electrical equipment is in servomechanism systems. In these applications, the magnetic units have the desirable features of long life, minimum need for servicing, and the ability to handle large amounts of power for energizing electric motors and other load actuating devices.

Motor Controller

Figure 5-11 shows a magnetic servoamplifier which controls the voltages for both phases of a two-phase electric motor. The input signals for the magnetic amplifier are produced by a phase detector. These drive V1 and V2, which are

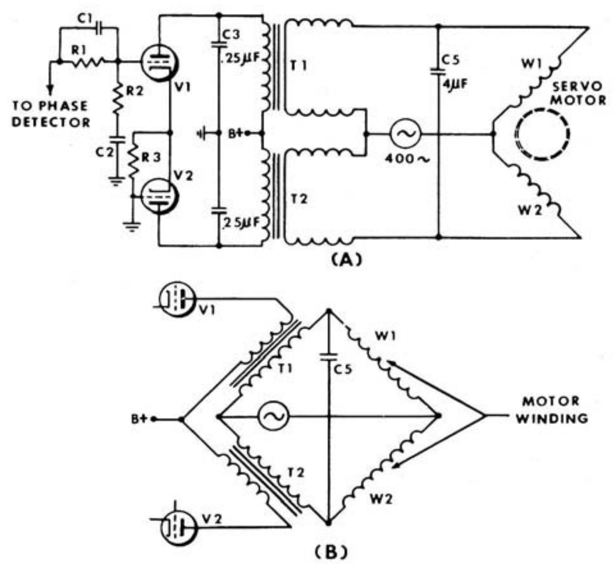

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Figure 5-11.—Magnetic amplifier used to control a two-phase induction motor.

connected as a cathode coupled paraphase amplifier working into two saturable reactors. Note that the magnetic amplifier is working with cathode tube amplifiers.

With zero input, both tubes (fig. 5-11) draw equal amounts of current in the plate circuits. These currents are insufficient to saturate the cores of the reactors; and therefore, the impedance of each load winding is very high and the resulting load currents of each load winding is very small. In this condition the circuit is a balanced bridge as indicated in part (B) of figure 5-11, and the motor does not rotate since in-phase voltages are applied to the motor windings.

When an input control signal is supplied from the phase detector, one of the tubes (depending upon the polarity and amplitude of the signal) goes into heavier conduction than the other. Under full conduction conditions, the reactor in one plate circuit then appears as a low impedance and the other reactor approaches the open-circuit condition. The bridge is then unbalanced; and capacitor C5 is effectively connected in series with one of the motor windings, where it causes a phase shift and the motor begins to rotate.

Assume, for example, that V1 (fig. 5-11) goes into heavy conduction and that V2 is at effective cut-off. The inductance of the secondary of Tl is then practically zero and motor winding WI is connected across the a-c source. The inductance of the secondary of T2 is high so that the winding resembles an open circuit; and motor winding W2 is then connected across the a-c source through the phasing capacitor. The phase relations, of the resulting currents cause the motor to rotate in a direction determined by which winding is connected in series with the capacitor. Upon reversal of the control signal, the conditions described also reverse; and W1 is placed in series with the capacitor so that the motor then turns in the opposite direction.

POWER SUPPLY REGULATOR

The equipment power supplies of missile systems must meet certain basic requirements which include ruggedness, long life, and freedom from excessive maintenance problems. To meet these requirements, the development of power supply equipment has resulted, in many cases, in the elimination of the electron tube as the chief cause of failure. The magnetic amplifier has been used to replace the complex arrangements usually necessary for good voltage regulations; and the solid-state power diode is often employed instead of the fragile vacuum tube. An example of a circuit with these components is shown in figure 5-12.

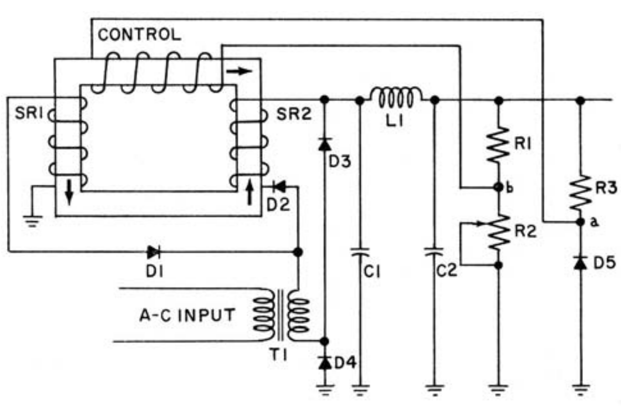

Figure 5-12.—Power supply using magnetic amplifier voltage regulator

Magnetic Amplifier Control

The circuit is a conventional full-wave bridge rectifier utilizing a magnetic amplifier to control the output and also a Zener diode as a part of the regulating system. The Zener diode element is a solid-state equivalent of the gaseous regulator tube and maintains a constant voltage across the terminals regardless of variations of the current it conducts, within the specified operating range. In the schematic shown (fig. 5-12), the connection of the Zener diode is the reverse of that of an ordinary rectifying diode since in this example it is the inverse breakdown voltage characteristic which is employed for regulation.

Current flow (fig. 5-12) during one half cycle is through the load, choke Ll, diode D3, the secondary of Tl, and diode Dl, then returning to ground through SRI of the reactor. During the other half cycle, the current flows through the load, Ll, SR2, D2, the secondary of Tl, and D4 to ground. In addition to the load current, there is conduction through D5 and R3 and also through R2 and Rl.

The control winding of the magnetic amplifier is energized by the voltage between the junction of Rl and R2 and the upper terminal of the Zener diode, D5. When the output voltage is of the proper value, the potential across the control winding (and therefore the current through it) sets the magnetic bias of the reactors at the operating point, which is well up on the magnetization curve to obtain a high percentage of the source voltage.

If the output voltage tends to rise, the voltage at point a remains constant due to the action of the Zener diode; but the voltage at point b increases. This causes a change in the current flowing in the control winding so that the bias point is shifted to a value that results in lower conduction in the load coils. As a result, the voltages across SR1 and SR2 are increased and the output voltage decreases.

When the output voltage tends to decrease, the potential at point b falls with respect to that at point a and the control current changes the bias to a point of higher conduction.. This lowers the voltage drops across the a-c coils of the reactors and increases the valve of the output. Capacitors Cl and C2, together with Ll, are connected to form a pi-section filter which smoothes the output to give a nearly pure d-c voltage. Resistor R2 is adjustable, being set to the value for optimum operating voltage in normal use. It also provides a means for making adjustments to compensate for any changes that occur in the circuit components.

A gas-filled regulator tube (VR-75) could be used in place of the Zener diode. The voltage regulation and operation would be the same, but a VR tube requires much higher power supply voltages.

ZENER DIODES. - If you looked in the index of any of the basic texts previously mentioned you would not find the word Zener listed. Zener effect and Zener diodes, however, are given some discussion in chapters 2 and 3 of *Basic Electronics*, NAVTRA 10087. Avalanche breakdown is sometimes called Zener effect, after the American physicist Clarence Zener, who made theoretical investigations of the problem of electrical breakdown of insulators. The breakdown mechanism in PN transistor junctions is not the same as in insulators but, in spite of this, the name Zener voltage is often given to breakdown voltage of junctions. The reverse voltage at which the current suddenly begins to make its sharp descent is called Zener breakdown voltage. The use of the word "breakdown" does not mean that the diode is destroyed, but rather that the normal negative reverse current increases suddenly and sharply. A typical Zener diode curve is shown in figure 5-13.

Zener diodes are used chiefly as regulation and reference elements. When a reverse voltage is applied, no current will be passed until there is a breakdown in the convalent bond of the atoms, causing a sharp increase in current flow in the reverse direction. If this happened in a regular PN junction diode, it would be considered defective, but Zener diodes are designed to be self- healing and can be used repeatedly without damage. The point of breakdown or avalanche is built into the diode and can be made to occur at various voltages. In figure 5-13, approximately 20 volts is applied.

PUSH-PULL. - A push-pull amplifier is a balanced amplifier. There are two identical signal branches connected so as to operate in

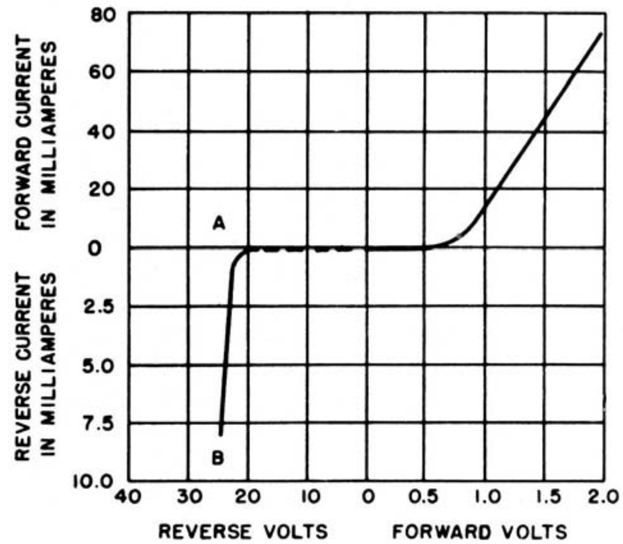

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Figure 5-13.—Zener diode characteristic curve.

phase opposition and with input and output connections each balanced to ground.

A paraphase amplifier is essentially a combination amplifier and phase inverter. It is sometimes used in place of transformers to operate push-pull circuits. Paraphase amplifiers are described in *Basic Electronics,* NAVTRA 10087.

Transistor Amplifiers

Transistor amplifiers may be used in place of electron tube amplifiers. A transistor amplifier must have three-element (two-junction) semiconductors to amplify a signal, just as a three-element electron tube is needed for amplification. There are also three types of transistor amplifiers, according to which part is grounded: grounded emitter, grounded base, and grounded collector. The above text describes the theories and operating characteristics of vacuum tubes and of transistors. Transistors are designed to perform the same functions as vacuum tubes. As they are solid-state semiconductors, they are much less fragile than vacuum tubes. Of course, failure can be caused by misuse, such as current overloading, or application of too high a voltage. Faults in manufacturing, or flaws in the material can cause mechanical failure. Radiation affects them so they must be shield. Most failures are caused by the effects of moisture on the surface. Hermetic sealing of the transistors by manufacturers is now the usual practice. Since transistors are so very small, a speak of dust falling across a junction can completely short-circuit it. A dust free atmosphere is a practical necessity in a transistor-fabrication plant.

It is believed that transistors will far outlast vacuum tubes. At present no missile launching system has changed completely over to transistors, but one gun system has, so you can expect this change in the future. Magnetic amplifiers will continue to be used, alone and with transistors instead of vacuum tubes.

SERVOAMPLIFIER

The purpose of a servoamplifier is to control an output in a manner dictated by an input. Normally, the servosystem's signal input is at a low energy level and must be greatly increased to perform an appreciable amount of work. This is the job of the servoamplifier. The amplifier controls a large power source which is activated by a low-powered error signal. This is shown in figure 5-14A. Figure 5-14B shows a simple power control using a triode as the controlling element and a battery as the power reservoir.

There are just about as many different amplifiers as there are jobs for amplifiers to do. Each part of the amplifier is selected to do a particular part of the total job. You can't just look at a circuit and understand why everything is there. The best way to analyze an amplifier is to divide it into stages, coupling circuits, decoupling circuits, and biasing networks. In *Basic Electronics*, NAVTRA 10087 you studied each of these circuits-you know what they are supposed to do. *Basic Electricity*, NAVTRA 10086 tells you that servoamplifiers may be of the vacuum-tube type or the magnetic type, and combinations of these. *Basic Electronics*, has a chapter on the use of electron tubes for amplifying voltage and power, and another chapter on servosystems, including servoamplifiers.

Servoamplifiers can be broadly divided into functional stages. You have learned how the error signal is selected, and modulated or demodulated to suit the individual amplifier. The first stage or stages of amplification increase the voltage of the error signal. When the signal voltage is amplified a sufficient amount, it is used as the input to the power stage. Here the primary concern is current delivered at a steady voltage under load conditions. The push-pull type amplifier is extensively used in missile servo- systems. A push-pull amplifier is preceded by a phase inverter or paraphase amplifier. The power stage may be one or more stages, depending on the power output needed.

In general, the higher the gain of the amplifier, the tighter the control and the more accurate the servosystem. An increase in the system gain will reduce the system velocity errors and increase the speed of response to inputs. An increase in system gain also reduces those steady-state errors resulting from restraining torques on the servo load. However, to obtain these advantages, the servosystem must pay a price in the form of a greater tendency toward instability. A linear servo system is said to be stable if the response of the system to any discontinuous input does not exhibit sustained or growing oscillations. The highest gain that can be used is limited by consideration of stability.

Review of Use in Launching System

The preceding course, *Gunner's Mate M (Missiles), 3&2*, NAVTRA 10199, described and illustrated servosystems (with amplifiers) used to control error signals in launcher power drives. Amplifiers associated with ordnance actually do more than amplify. Some power drive amplifiers change the incoming a-c synchro signal to a d-c signal that can be used-to control a servomotor. In amplifiers associated with ordnance equipment, the power supply normally is built into, and therefore is physically part of the amplifier. Many amplifiers in ordnance equipment have two rectifiers: one in the power supply to provide the required d-c voltages and the other to convert the a-c input signal to a d-c signal.

Examples of other amplifier functions include stabilizing, synchronizing, speed limiting, position limiting, and current limiting. Amplifiers associated with ordnance equipment are nearly always classed as power amplifiers. A voltage amplifying stage is used only if it is necessary to increase an input voltage. The number and type

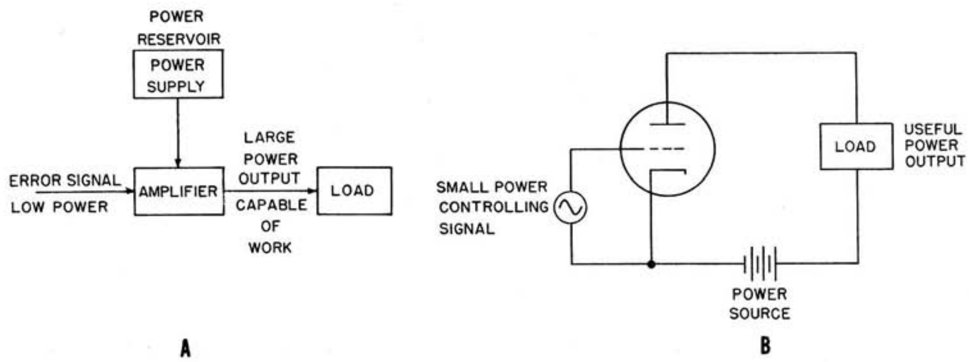

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Figure 5-14.—Amplifier's job in a servo; A. Controlling a large power source; B. Power control with a triode.

of amplifier functions is determined to some extent by the type of output controlled by the amplifier.

Gain, Phase, and Balance Adjustments

In many servo systems the gain of the amplifier can be varied by an adjustment. The gain adjustment governs the amplitude or amount of the signal voltage applied to the amplifier or one of its stages. Normally, the highest gain possible, with the servosystem posessing a satisfactory degree of stability, is the most desirable.

In a-c servosystems another adjustment which can control the sensitivity of the system is the phase adjustment. The phase adjustment is used to shift the phase relationship between the signal voltage and a reference voltage. In an amplifier with phase shift control the grid signal is shifted in phase with reference to the plate voltage of a tube. The tube's firing point is delayed or advanced, depending upon the phase Shift of the grid signal. The phase shift can vary the firing time of the tube over the plate's entire positive alternation.

A phase control is included in some servo-systems using a-c motors. The two windings of the a-c servosystems using a-c motors. The two windings of the a-c servomotor should be energized by a-c voltages that are 90° apart. This phase adjustment is included in the system to compensate for any phase shift in the amplifier circuit. The adjustment may be located in the control amplifier, or, in the case of a split-phase motor, it may be in the uncontrolled winding.

Servosystems using push-pull amplifiers must be balanced so that when there is no signal input to the amplifier, its output will be zero, and the servomotor will stand still with no creep. The push-pull amplifier must ensure equal torque in both directions of the servomotor.

Gain, phase, and balance adjustments are often present in one amplifier. These adjustments tend to interact so that when one of them is changed, it may affect the others. Therefore, after making anyone adjustment it is a good practice to check the other adjustments.

Magnetic Amplifiers Used as Servocontrol Amplifiers

A somewhat different type of servoamplifier used in launching equipment is the magnetic amplifier.

The servomotor used in conjunction with the magnetic amplifier shown in figure 5-15 is an a-c type. The uncontrolled phase may be connected in parallel with transformer T1 by utilizing a phase-shifting capacitor, or it may e connected to a different phase of a multi phase system. The controlled phase is energized by the magnetic amplifier, and its phase relationship is determined by the polarity of the d-c error voltage.

The magnetic amplifier consists of a transformer (Tl) and two saturable reactors, each having three windings. Notice that the d-c bias current flows through a winding of each reactor and the windings are connected in series-aiding. This bias current is supplied by a d-c bias power source. The d-c error current also flows through

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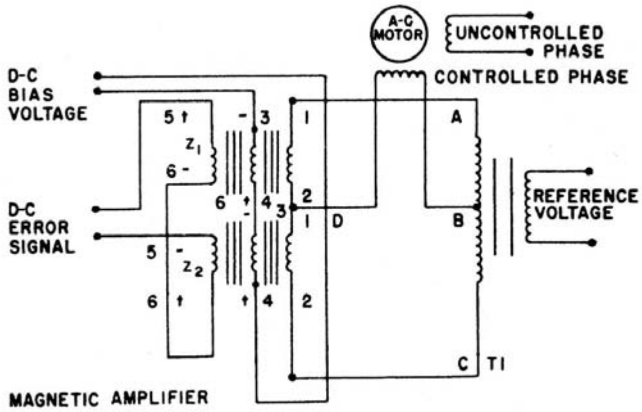

Figure 5-15.—Magnetic servoamplifier, schematic.

a winding in each reactor; however, these windings are connected in series-opposing.

The reactors, Z1 and Z2, are equally and partially saturated by the d-c bias current when no d-c error signal is applied. The reactance of Zl and Z2 is now equal, resulting in points Band D being at equal potential. There is no current flow through the controlled phase winding.

If an error signal is applied, causing the current to further saturate Z2, the reactance of its a-c winding is decreased. This current through Z1 will tend to cancel the effect of the d-c bias current and increase the reactance of its a-c winding. Within the operating limits of the circuit, the change in reactance is proportional to the amplitude of the error signal. Hence, point D is now effectively connected to point C, causing motor rotation. Reversing the polarity of the error signal will cause the direction of rotation to reverse.

The basic magnetic servoamplifier discussed above has a. response delay equal to approximately 6 to 20 Hz. In some applications this delay would be excessive, creating too much error. However, this delay can be reduced to about one Hz. by using special push-pull circuits.

Polarized magnetic amplifiers can distinguish between control current polarities, but they can change only load current magnitude, not load current direction (polarity). Nearly all servo devices associated with ordnance equipment power devices require magnetic amplifiers with an output that varies in both polarity and magnitude. The push-pull (sometimes called duodirectional) magnetic amplifier meets those requirements. If control current is zero, load current also is zero. Likewise, if the control current increases in a positive direction, load current also increases in a positive direction.

Servoamplifiers in Launching Systems

The amplification of the train and elevation signals is an outstanding example of the use of servoamplifiers in launching systems. It was applied in the training and elevation of guns on gun mounts, and when missile launching systems were designed, the devices and methods were borrowed for this new application.

The small electrical input signals must be amplified into usable signals of sufficient magnitude to operate the electrohydraulic servo-valves of the receiver-regulators. The amplification system is common to both power drives and consists of a dual channel magnetic amplifier, made up of four magnetic amplifier stages mounted on a common chassis, and a power supply. One channel of the amplifier services the train power drive and the other channel services the elevation power drive. In each channel, one magnetic amplifier stage is the primary servo- system amplifier and the other is the velocity system servoamplifier.

The primary system servoamplifier receives position error voltage signal from the 1- and 36-speed synchro control transformers in the receiver-regulator. The amplifier also receives an unfiltered velocity signal from the rate generators in the remote, local, or dummy director. It mixes and amplifies these signals and uses the resultant output to operate the primary electro- hydraulic servovalve. The input circuit of the primary amplifier limits the voltages to the magnetic amplifier stage control windings and provides automatic changeover from the l-speed signal control to the 36-speed signal control when the launcher position error reduces to less than five degrees of correspondence with the order signal. It also receives an amplifier load supply voltage and a synchro offset voltage from the power supply. The train primary amplifier input circuit applies the offset voltage to the output of the I-speed synchro control transformer for stick-off purposes. The offset voltage is not applied to the elevation primary amplifier.

The velocity system servoamplifier receives a filtered velocity signal from the rate generators in the remote, local, or dummy director. The amplifier also receives an electrical feedback signal from the velocity and integration potentiometers of the receiver regulator. The velocity amplifier mixes and amplifies these signals and . uses the resulting output to operate the velocity electrohydraulic servovalve. The input circuit of the velocity amplifier provides the gain control I for the velocity input and voltage controls for the potentiometers; it mixes the velocity signal input with the potentiometer signals, and applies the resulting signal to the control windings of } the magnetic amplifier stage.

The potentiometer voltage supply circuit provides a frequency-sensitive, regulated, and filtered voltage for the velocity and integration potentiometers of the receiver regulator. The regulated voltage supply prevents fluctuation of the integration and velocity system outputs and compensates for the varying line frequencies to stabilize the electric drive motor and B-end error of the power drive.

Repair, Replacement, or Adjustment

Unless specifically directed otherwise, defective amplifier units are removed as a unit and ; replaced. They may be returned to the vendor for repair. Only one adjustment is normally J necessary on the power panel. VOLT ADJ should be set to give an output of 48.0 v at terminals 1 and 2 with all amplifier panels connected, and 115 v 400 hertz applied to the power panel inputs 28 and 29 (Mk 9 Mod 0 launching system).

Some adjustments made at the factory are not changed on shipboard. Hermetically sealed components are always replaced rather than repaired. Before replacing such a unit, double check all associated circuitry (resistors, wiring, etc.). When a defective component is replaced, adjust it and the channel in which it operates, following the instructions for your equipment.

All amplifier channel balance adjustments have been set at the factory. On installation, and weekly thereafter, the balance of both stages of amplification should be checked, using the meters installed in the amplifier panel.

Demodulators are balanced at the factory and no further adjustment should normally be necessary except on replacement, or in case the setting at balance adjustment is disturbed.

Rectifiers are very important components of magnetic amplifiers. Series rectifiers may be checked by the use of a cathode-ray oscilloscope. Whenever possible,. the waveform across a rectifier suspected of being defective should be compared to waveforms observed across other rectifiers in the same circuit.

SYNCHROSYSTEMS

The preceding course, *Gunner's Mate M (Missiles) 3&2*, NAVTRA 10199 described and illustrated uses of synchros and synchro data in missile launching systems, so we'll just have a brief review.

Synchros are seldom used alone. They work in teams and when two or more synchros are interconnected to work together, they form a synchro system. Such a system may, depending on the types and arrangement of its components, be put to uses which vary from positioning a sensitive indicator to controlling the motors which move a launcher weighing many tons. If the synchro system provides a mechanical output which does the actual positioning, as in the case of the indicator, it is a torque system. If it provides an electrical output which is used only to control the power which does the mechanical work, it is a control system. Control synchros are usually part of a larger system called a servo (automatic control) system. In many cases, the same system is called upon to perform both torque and control functions.

The individual synchros which make up a torque system are designed to meet the demands placed on them by the mechanical load, which such a system is expected to handle. However, the comparatively small mechanical output of a torque synchro system is suitable only for very light loads. Even when not heavily loaded, a torque system is never entirely accurate. When larger amounts of torque, or a higher degree of accuracy, or both are required, torque synchro systems give way to control synchros used as components of servosystems. Synchros control, and servos provide the torque. The distinguishing unit of any synchro control unit is the control transformer (CT).

Servosystems Using Synchros

A servo, servosystem, or a servomechanism (the three terms mean the same thing) is an automatic control device widely used in the Navy and distinguished by several special characteristics. There are many different types of servosystems, and not all of them use synchros. The purpose of servo systems in which control synchros are used is to supply larger amounts of power and a greater degree of accuracy than is possible with synchros alone.. Another equally important characteristic of the servo is its ability to supply this power automatically, at the proper time, and to the degree regulated by the need at each particular moment. All that the system requires. To perform the specific task for which it is designed is an order defining the desired results. When such an order is received, the servo compares the desired results with the existing conditions, determines the requirements, and applies power accordingly, automatically correcting for any tendency toward error which may occur during the process.

There are various ways in which these results are obtained. Whether it be amplidyne or hydraulic power drives of many different types, the end result is always the same and that is the positioning of the launcher in accordance with input orders received from remote control stations. To function in this manner a servosystem must meet five basic requirements:

1. It must be able to accept an input order defining the desired result, and translate this order into usable form.
2. It must feed back, from its output, data concerning the existing conditions over which it exercises control.
3. It must compare this data with the desired result expressed by the input order and generate an error signal proportional to any difference which this comparison shows.
4. It must, in response to such an error signal, issue the proper correcting order to change existing conditions to those required.
5. It must adequately carry out its own correcting order.

In functional terms the components normally found in a servosystem using synchros are identified as a data input device, a data output device, an amplifier, a power control device, a drive motor, and a feedback device.

Servo Terminology

In addition to those already mentioned, a number of specialized terms are used in connection with servosystems: The more common of these are defined here.

OPEN-CYCLE CONTROL of a servosystem means actuation of the servo solely by means of the input data, the feedback device being either removed or disabled. It should be clearly understood here that any mechanism must include a feedback provision to be classified as a servo; but in testing certain servo characteristics, an open-cycle control is often useful. Under such conditions the elements involved are frequently referred to as an open servoloop.

CLOSED-CYCLE CONTROL refers to normal actuation of the system by the difference between input and output data, with the feedback device operative.

CONTINUOUS CONTROL is used to describe uninterrupted operation of the servosystem on its load, regardless of the smallness of the error.

DEVIATION or error of a servo, is the difference between input and output.

ERROR SIGNAL or error voltage is the corrective signal developed in the system by a difference between input and output.

INSTRUMENT SERVOS and POWER SERVOS are designations used to classify servo-mechanisms according to their power output. An instrument servo is one rated at less than 100 watts maximum continuous output; a servo whose rating exceeds this amount is a power servo.

Classification of Servos by Use

A convenient classification of servosystems can be made in accordance with their use, the most common of which are as position servos and velocity servos. The position servo is used to control the position of its load and is designed so that its output moves the load to the position indicated by the input. The velocity servo is used to move its load at a speed determined by the input to the system.

Many servosystems cannot be fitted into either category. For example, a third type of servo is used to control the acceleration rather than the velocity of its load. And special applications of the different types are used for calculating purposes, the servo making a desired computation from mechanical or electrical information and delivering the answer in the form of mechanical motion, an electrical signal, or both.

ZEROING SYNCHROS

If synchros are to work together properly in a system, it is essential that they be correctly connected and aligned in respect to each other and to the other devices, such as directors and launchers with which they are used. Needless to say, the best of ordnance equipment would be ineffective if the synchros in the data transmission circuits were misaligned electrically or mechanically. Since synchros are the heart of the transmission systems, it only stands to reason that they must be properly connected and aligned before any satisfactory firing can be expected.

Electrical zero is the reference point for alignment of all synchro units. The mechanical reference point for the units connected to the synchros depends upon the particular application of the synchro system. As a GMM on board ship, .your primary concern with mechanical reference point will be the centerline of the ship for launcher train and the standard reference plane for launcher elevation. Remember that whatever the system, the electrical and mechanical reference points must be aligned with each other.

There are two ways in which this alignment can be accomplished. The most difficult way is to have two men, one at the transmitter and one at the receiver or control transformer, adjust the synchros while talking over sound powered telephones or some other communication device. The better way is to align all synchros to electrical zero. Units may be zeroed individually, and only one man is required to do this work. Another advantage of using electrical zero is that trouble in the system always shows up in the same way. For example, in a properly zeroed TX-RT system, a short circuit from S2 to S3 causes all receiver dials to stop at 60 degrees or 240 degrees.

In summary, zeroing a synchro means adjusting it mechanically so that it will work properly in a system in which all other synchros are zeroed. This mechanical adjustment is accomplished normally by physically turning the synchro rotor or stator. Synchro, Servo and Gyro Fundamentals, NAVTRA 10105, describes standard mounting hardware and gives simple methods for physiclly adjusting synchros to electrical zero. Additional information about synchros may also be obtained from Military Handbook MIL-HDBK-225 (AS) Synchros Description and Operation (supercedes OP l303).

Electrical Zero Conditions

For any given rotor position there is a definite set of stator voltages. One such rotor-position-stator-voltage condition can be established as an arbitrary reference point for all synchros which are electrically identical.

CONTROL TRANSFORMERS. - A synchro control transformer is zeroed if its rotor voltage is minimum when electrical zero voltages are applied to its stator. Turning the CT's shaft slightly counterclockwise will produce a voltage between R 1 and R2 which is in phase with the voltage between Rl and R2 of the synchro transmitters, CX or TX, :supplying excitation to the CT stator. Electrical zero voltages, for stator only, are the same as for transmitters and receivers.

Zeroing Procedures

The procedure used for zeroing depends upon the facilities and tools available and how the synchros are connected in the system. Synchros may be zeroed by use of only a voltmeter synchro testers, or other synchros in the system.

When zeroing differentials and control transformers, it is helpful to have a source of 78 volts (10.2 volts .for 26-volt umts).

Regardless of the method used, there are two major steps in each zeroing procedure: first, the coarse (or approximate) setting, and second, the fine setting. Many units are marked in such a manner that the coarse setting may be approximated physically on standard units; an arrow is stamped on the frame and a line is marked on the shaft extension.

ZEROING A CONTROL TRANSFORMER USING AN A-C VOLTMETER.-Using a voltmeter with a 0- to 250- and 0- to 5-volt scale, control transformers may be zeroed as follows:

1. Remove connections from control transformer and reconnect as shown in figure 5-16A.
2. Turn the rotor or stator to obtain minimum voltage reading.
3. Reconnect meter as shown in figure 5-16 B, and adjust rotor or stator for minimum reading.
4. Clamp the control transformer in position and reconnect all leads for normal use.

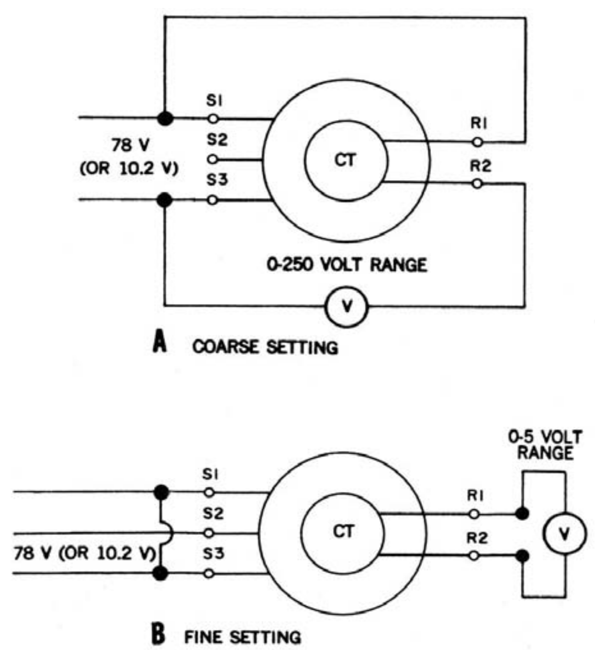

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Figure 5-16.—Zeroing a CT, using a voltmeter.

SYNCHRO TESTERS

Synchro testers of the type shown in figure 5-17 are used primarily for locating a defective synchro. They also provide a fairly accurate method of setting synchros on electrical zero. To zero a synchro with the tester, connect the units as shown in figure 5-17 and turn the synchro until the tester dial reads 0 degrees. This is the approximate electrical zero position. Momentarily short S1 to S3 as shown. If either the synchro or tester dial moves, the synchro is not accurately zeroed, and should be shifted slightly until there is no movement when Sl and S3 are shorted.

NOTE: By exercising proper caution it is possible to perform all the preceding zeroing procedures using 115 volts where a source of 78 volts is not available. If 115 volts is applied instead of 78 volts, do not leave the synchro connected for more than 2 minutes or it will over- heat and may be permanently damaged.

Summary

The described zeroing methods apply to all standard synchros and prestandard Navy synchros.

Before testing a new installation and before hunting trouble in an existing system, first be certain all units are zeroed. Also, be sure the device's mechanical position corresponding to electrical zero position is known before trying to zero the synchros. The mechanical reference position corresponding to electrical zero varies; therefore, it is suggested that the instruction books and other pertinent information be care. fully read before attempting to zero a particular synchro system. The MRCs and the OP for the system should be studied, as there are likely to be some differences from the general instructions given in NAVTRA 10105. For example, OP 2665, volume 3, *Guided Missile Launching System Mark 13 Mod 0*, gives step-by-step instructions for replacement and adjustment procedures for train and elevation regulator CTs. If an operational check indicates that a synchro control transformer in the regulator is not operating properly, replace and adjust the synchro.

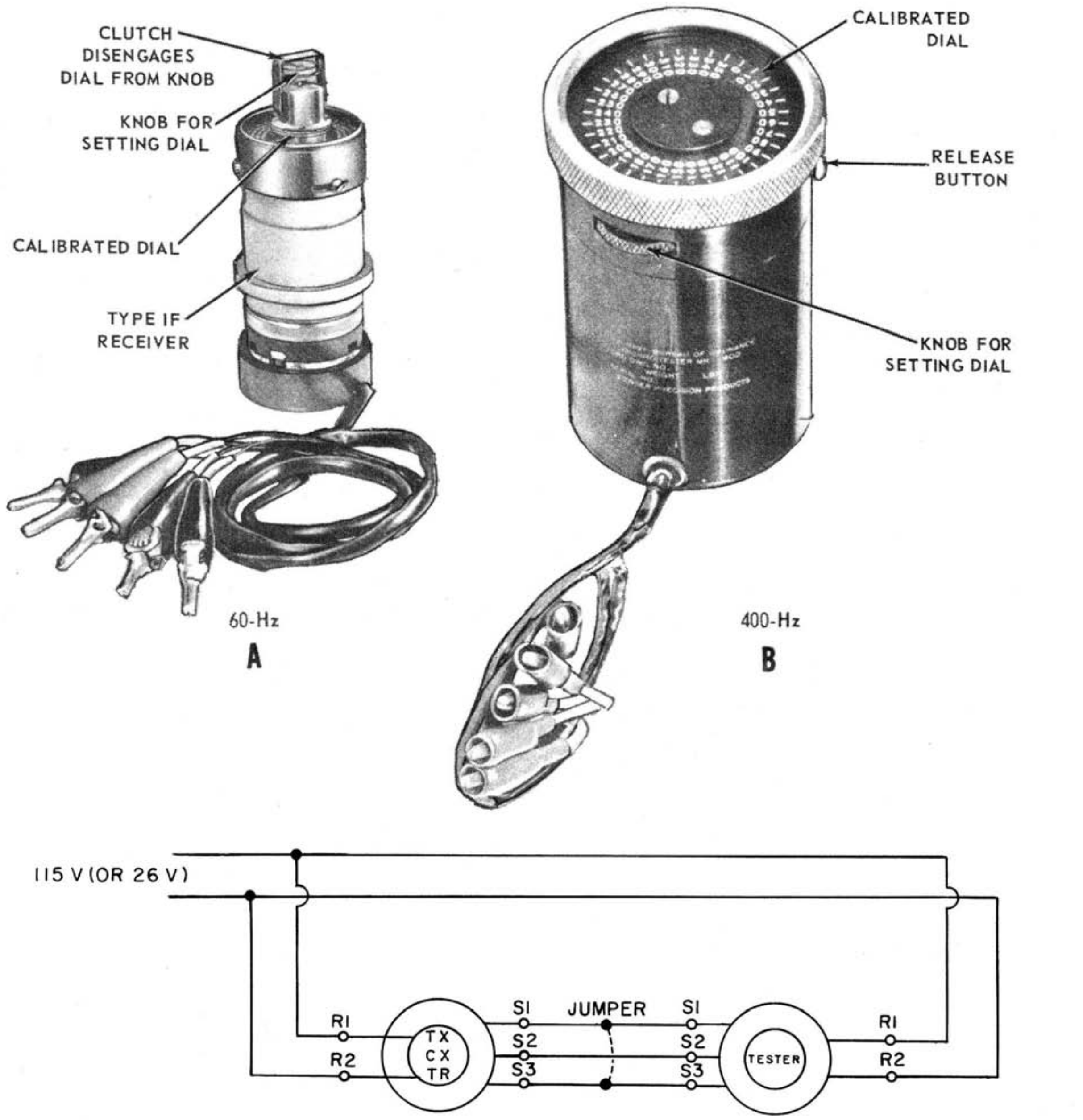

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Figure 5-17.—Zeroing a CT, using a synchro tester.

Note that you do not attempt to adjust. the malfunctioning synchro; you remove that one and put in a new one, then adjust that. Two tests with a voltmeter are described for zeroing the synchro, and then the method of checking that the newly installed synchro is not 180 degrees out of phase. The power source used is 115-v, 400-hertz supplied from the launcher position generators to the S1 and S3 terminals through R1 and R2 terminals.

Figure 5-18 shows a train synchro gear assembly which points out the synchros and the dials. The elevation synchro gear assembly is very similar, but it has a sixth synchro which supplies the coarse (2X) elevation error signals in a remote jettison operation. It is mounted on the bracket holding the indicating dials. All the synchros are held in position with capscrew held lugs, making alignment easier.

MAINTENANCE

Synchro units require careful handling at all times. NEVER force a synchro unit into place, NEVER drill holes in its frame, NEVER use pliers on the threaded shaft, and NEVER use force to mount a gear or dial on its shaft. Two basic rules exist:

1. IF IT WORKS- LEAVE IT ALONE.
2. IF IT GOES BAD-REPLACE IT.

Synchros are no longer considered as repairable items. Replaced synchros should be disposed of in accordance with current instructions. Unless in an emergency with no replacement available, NEVER take a unit apart or try to lubricate it. The gearing (fig. 5-18) should be lubricated, using an atomizer, any time the cover of the receiver-regulator is removed, but do not lubricate switches, or the tachometer. Use the MRC for instructions.

TROUBLESHOOTING SYNCHRO SYSTEMS

Shipboard synchro troubleshooting is limited to determining whether the trouble is in the synchro or in the system connections; but if something is wrong with the unit, replace it. Generally, there are two major categories of troubles occurring in synchro systems. These are (1) those likely to occur in new installations, and (2) those likely to occur after the system has been in service a while.

All synchro casualties are not electrical, however, and do not require special equipment to uncover. One fairly common trouble affecting synchro operation is friction. Bearings must be especially clean, allowing the synchro rotor to turn freely. The slightest sticking will cause an error in route position, because there is little torque on the rotor when it is nearly in agreement with the incoming signal. Friction may also be caused by bent shafts and improper mounting of the synchro in the equipment. Early consideration should be given to the possibility of friction when troubleshooting faulty synchro operation. The synchros are not tested individually but are checked in the shipboard performance tests. If the test does not meet the standard requirements, then a search is made for the faulty component

Adjustments

While adjustments are a vital part of maintenance, they are too numerous to be covered here. Instead, a word of caution: At the time of installation, your control equipment was adjusted by well qualified personnel using special tools and equipment. For this reason, adjustments should be undertaken only after qualified personnel have verified that an adjustment is necessary. A good habit to cultivate when making adjustments is to scribe gears at their original point of mesh, and count threads or teeth to the position of the new adjustment. These measures will prove most valuable when an adjustment is later found to be incorrect or unnecessary.

New Installations

In a newly installed system, the trouble probably is the result of improper zeroing or wrong connections. Make certain all units are zeroed correctly; then check the wiring. Do not trust the color coding of the wires. Best check them out with an ohmmeter. A major source of trouble is improper excitation. Remember, the entire system must be energized from the power source for proper operation.

Existing Installations

In systems which have been working, the most common trouble sources are:

Switches-Shorts, opens, grounds, corrosion, wrong connections.

Nearby equipment-Water or oil leaking into synchro from other devices. If this is the trouble, correct it before installing a new synchro.

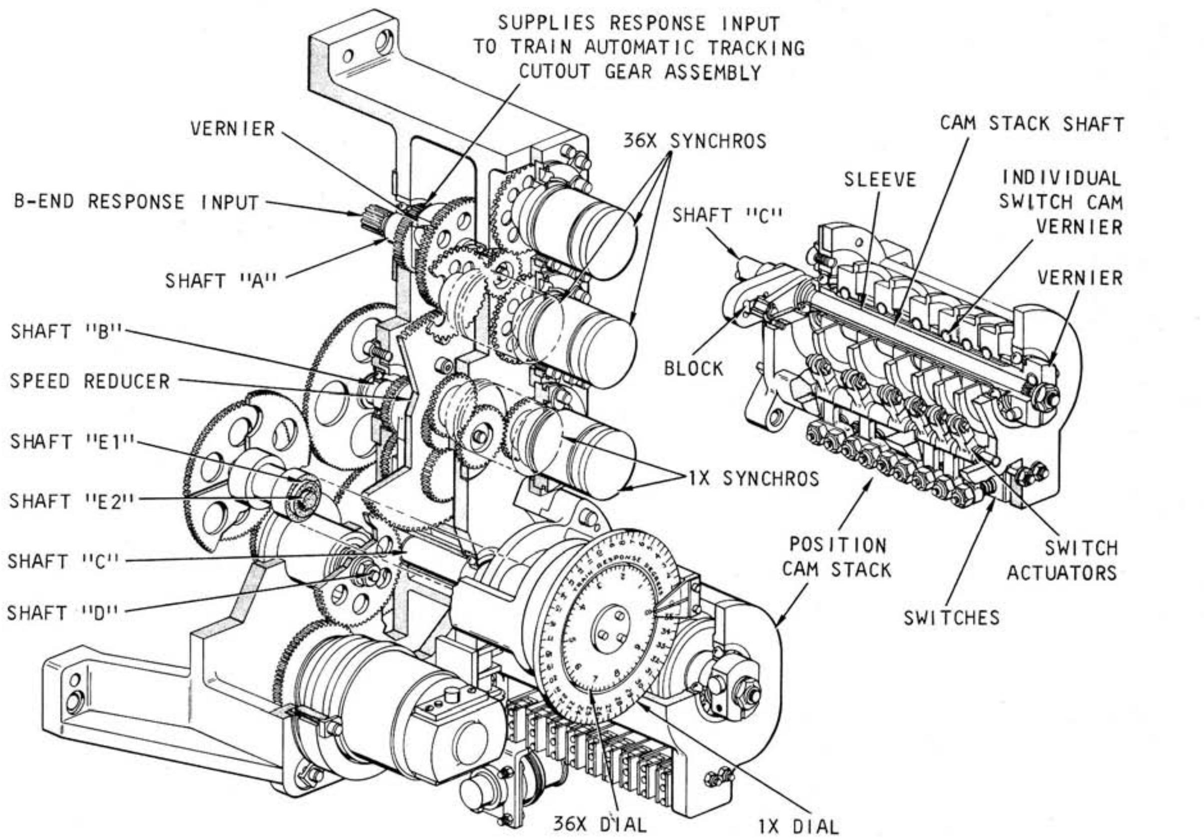

Figure 5-18.—Train synchro gear assembly.

Terminal boards-Loose lugs, frayed wires, correction, and wrong connections.

Zeroing-Units improperly zeroed.

Wrong connections and improper zeroing in any system are usually he result of careless work or inadequate information. Do not rely on memory when removing or installing units. Refer to the applicable instruction book or standard plan. Tag unmarked leads or make a record of the connections. Someone else may need the information.

OSCILLOSCOPE, DUMMY DIRECTOR, AND DUAL TRACE RECORDER

The words oscilloscope and oscillograph are sometimes used interchangeably, but they do not represent the same equipment. An oscilloscope shows on a fluorescent screen the changes in a varying voltage. These changes show as wavy lines, and are not recorded. An oscillograph records the alternating-current wave forms or other electrical oscillations, using a pen (or pens) to mark the trace on graph paper. The trace can be studied and compared with previous traces on the same equipment, or traces on similar equipment as part of testing and troubleshooting procedures. Both forms of the instrument make use of cathode rays. The cathode ray oscilloscope was described in the preceding course, and its electrical-electronic operation explained.

OSCILLOGRAPHS

The use of Error Recorder Mk 12, or Mk 12 Mod 1, which is primarily an oscillograph, is described in chapter 10. It is used with the Asroc, Tartar, and Talos missile launchers; Mk 9 is used with Terrier systems in the missile plotting room to check the performance of the computer. Telemetric Data Recording Set AN/SKH-l, located in the director control room, includes a direct reading oscillograph. A 20-pen Operations Recorder is located in the missile plotting room to record event signals from the two missile fire control systems. Operational faults in the missile system can be located by analysis of the tracings made by the error records.

Telemetric Data Receiving, Recording, and Scoring Set AN/SKQ-2 is used to receive and record telemetric signals from guided missiles in flight. It also can be used to provide 5-track oscillographic records of the missile preflight checkout.

Dummy Directors

The error recorder used by GMMs is used in connection with the dummy director, described in chapter 10.

The dummy director is a portable instrument designed to produce dynamic signals required to test launcher power drive performance. The Talos launching system uses two Mk 1 Mod 6 dummy directors, one for train and one for elevation tests. They are used in conjunction with the launcher test panel (EP3 panel of MLSC Mk 10 Mod 0). Other test equipment supplied with the Mk 7 Mod 1 launching system includes: (1) one frequency signal generator, (2) two limiter and demodulator units, Model E, (3) a dual-channel oscillograph with chart paper, black ink, and spare pens, (4) a Triplett Model 630NA volt ohm-milliammeter or equivalent, with test leads, and (5) test instrumentation cabling. They are all used with the launcher test panel.

Missile Stimulator Section

Do not confuse the missile simulator (chapter 10) with the missile stimulator section in the Guided Missile Test Set AN/DSM-54(V), and later models. The missile stimulator section provides simulated flight and guidance control signals to the missile, upon command of the program section. The following modules make up the missile stimulator: reference signal generator, integrator, FM generator, synchronizer, pulse delay, pulse signal generator, RF signal generator, function generator, and missile relay control. It is not used to test the launcher.

Dual Trace Recorder

Since the oscillograph has two channels, two different traces may be taken at the same time. This allows corresponding trace results to be compared to learn more about the launcher operation. Normally, three types of test traces are taken: B-end error traces, velocity .traces, and position traces (fig. 5-19 A, B, C).

NOTE: Always calibrate the Brush oscillograph before recording any traces.

The voltages for the B-end error trace are obtained from the 36-speed synchro (in the receiver-regulator), geared to the B-end response. The synchro rotor is geared to rotate at 36-speed while the stator is electrically connected to the 36-speed synchro generator in the controlling test director. The rotor output voltage (a 400-hertz alternating voltage) indicates the error between the generating director and the B-end response shaft. The CT rotor output volt ages are circuited through the control test panel to the limiter and demodulator unit and then to the oscillograph.

The B-end position trace voltages also are obtained from the 36-speed CT. Through the proper switching on the control test panel, the output voltage produced will indicate the B-end position, and not error. The position output voltage also goes through the limiter and demodulator unit, and is recorded by the oscillograph.

The B-end velocity trace voltages are obtained from the d-c tachometer generators located in the receiver-regulator. The tachometer generators are geared directly to the regulator B-end response input shafts and furnish a d-c voltage which is proportional to the B-end velocity. The tachometer output is circuited through test instrumentation to the oscillograph.

READING TEST TRACES.- Test traces are read like ordinary graph curves. They illustrate the error, position, or velocity of the launcher at the time the tests were made. Traces below the

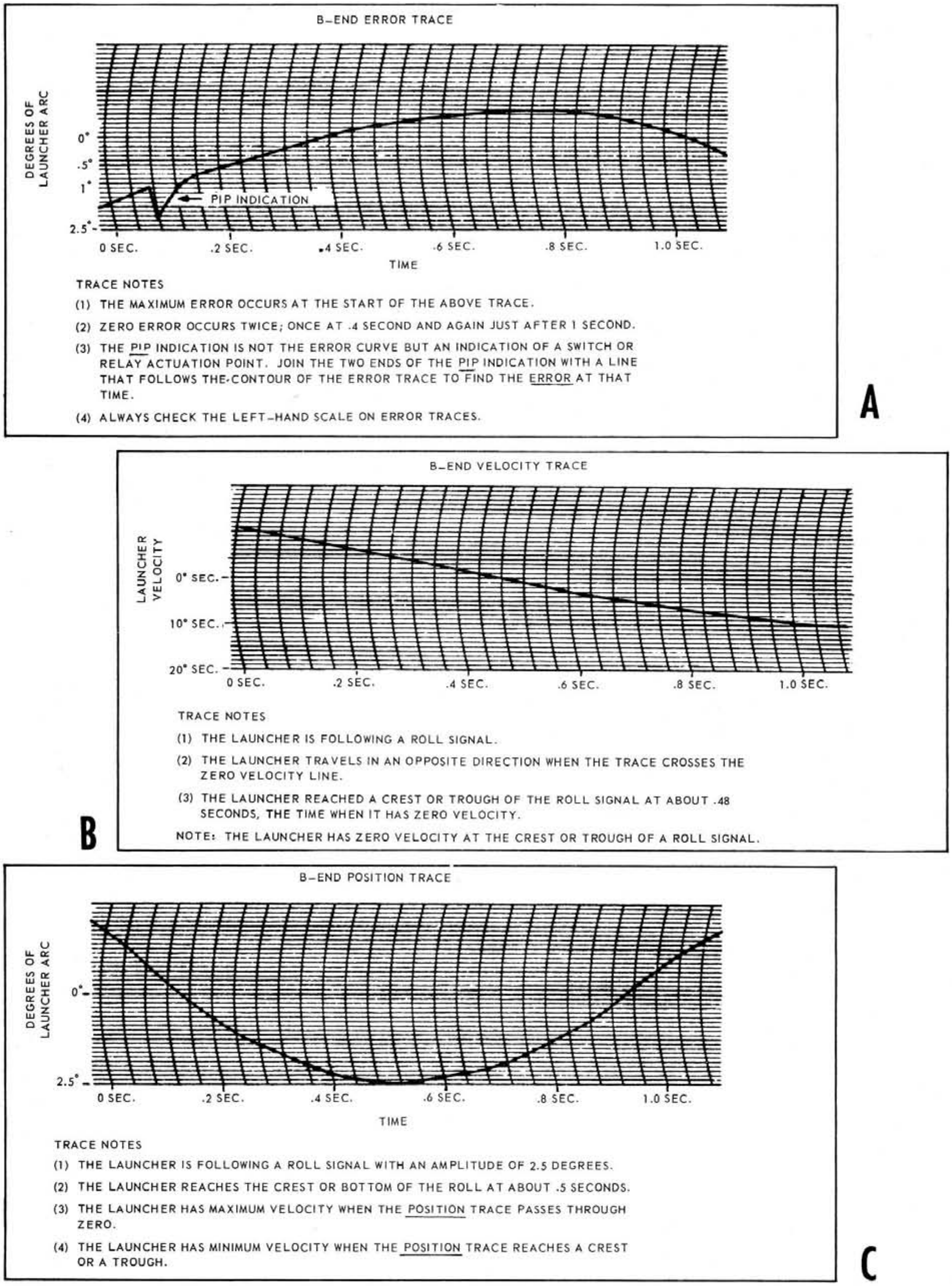

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Figure 5-19.—Oscillograph traces of launcher response: A. Sample error trace; B. Sample position trace; C. Sample velocity trace.

zero reference line are of the opposite phase from traces above the zero reference line. Be certain to check the following when reading test traces: (1) type of test being checked; (2) type of trace being.. used; (3) test conditions; (4) calibration on the left margin of the graph; and (5) the time allotted for each of the vertical graph divisions.

Use the calibration curve shown in figure 5-20 to determine the exact B-end positions when they are less than 5 degrees.

As the error and position trace voltages are generated by the 36-speed synchros, difficulty may arise in reading test traces if the error or position reading is greater than 2.5 degrees. The 36-speed sysnchro is geared to rotate 36 degrees for each 1-degree movement of the launcher. A launcher movement of 2.5 degrees therefore corresponds to 90 degrees rotation of the synchro. Since a synchro generates maximum output with a 90-degree rotor or stator displacement, the maximum trace indication occurs at an error or position displacement of 2.5 degrees. Error or position traces greater than 2.5 degrees require a special method of indication.

Since a complete revolution of a 36-speed synchro corresponds to 10 degrees of launcher movement, one complete cycle of a position or error trace corresponds to 10 degrees of launcher movement. For example, if the error or trace position consists of 6 1/2 cycles, the trace will measure 65 degrees of position or error (10 x 6.5).

CALIBRATION OF TRACE RECORDER.- The missile launching system control and its test panels may differ in switch arrangement, identification, and circuitry not only for different missile systems, but for different installations of the same missile system. You will need the elementary wiring diagrams to determine actual identification of switches and positions, and what each switch controls. Use only the special cables supplied for interconnections of test instruments and the test panels of the missile launching system control.

The oscillograph is calibrated during launcher testing procedures; and the before any launcher shipboard tests are made, the following general checkoffs must be performed.

1. Check the oil level at the main supply tank.
2. Check the oil level and all gear housings associated with the train and elevation power drives.
3. Lubricate the launcher components properly.
4. Charge the launcher accumulators properly.
5. Vent all hydraulic units properly.
6. Check the train warning bell operation.
7. Train the launcher through its maximum limits to verify free and unobstructed launcher train movements.
8. Elevate and depress the launcher guide arms to their maximum limits of travel to verify free and unrestricted guide arm movements.

On systems that have train and elevation air motors, those are used for items 7 and 8. Power drives are not activated for these checks.

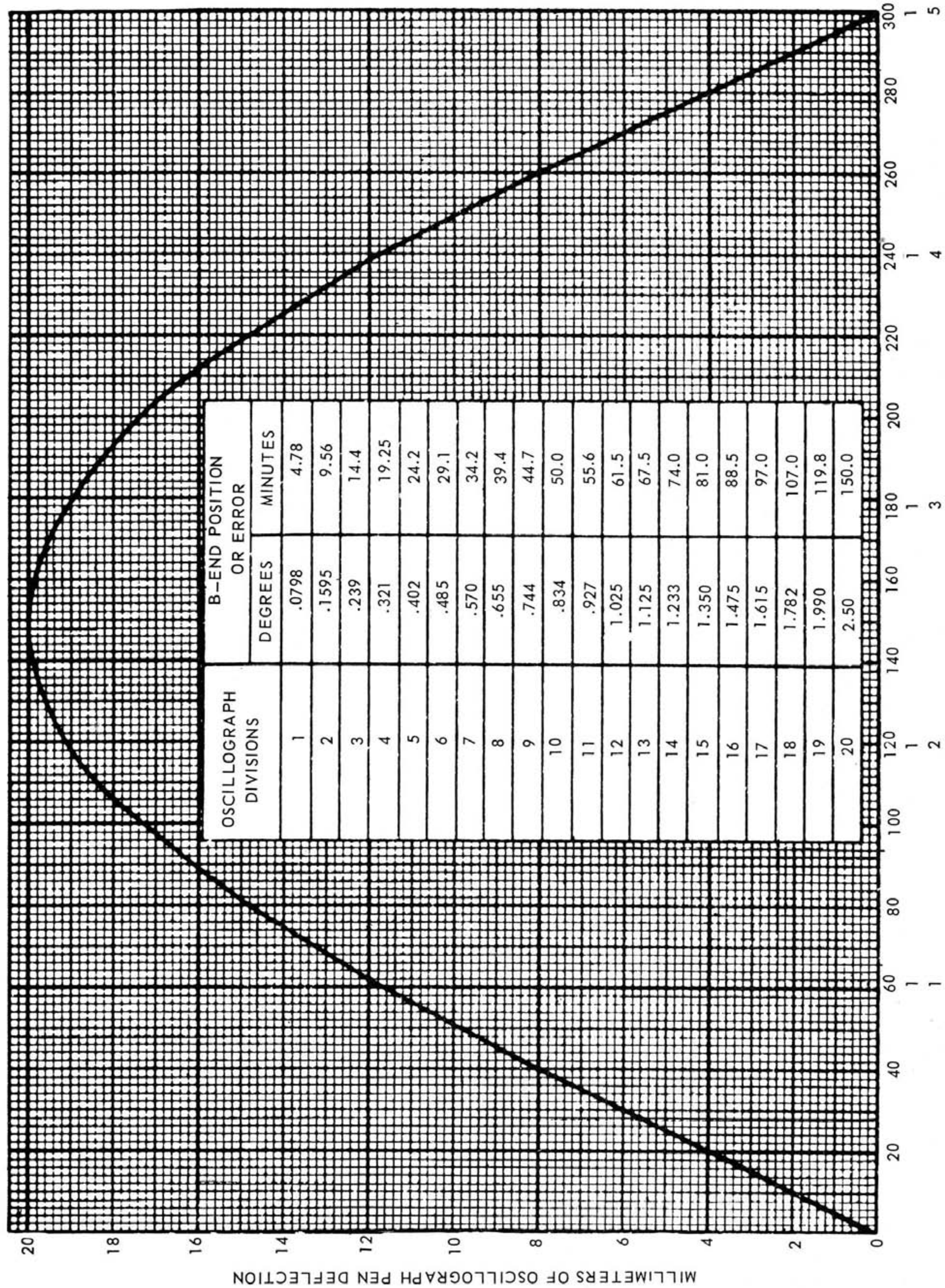
CAUTION: Do not move the guide arms or start power drives unless it is known that the firing cutout mechanism is adjusted properly. Failure to do so may result in extensive damage to the firing cutout mechanism.

9. Load the launcher rails with standard inert missiles or equivalent unless specified otherwise for the individual test being performed.
10. Check general condition of test instrumentation and service as required. Use black ink in the oscillograph so that test traces can be reproduced clearly.

After all these preliminary checks are made, activate the launcher by switching on the EP1 power panel, and start the train and elevation motors. The BP2 panel should be switched to STEP control, and control switched to the EP3 panel. The test cables are connected to the EP3 panel. Allow the train and elevation power drives to operate at least 30 minutes before making test traces.

Two different methods of calibration are used. Error and position traces are calibrated by one method and velocity traces are calibrated by a second method.

The error trace uses three possible calibration scales: a 10-minute full-scale calibration, a



OSCILLOGRAPH DIVISIONS	B-END POSITION OR ERROR	
	DEGREES	MINUTES
1	.0798	4.78
2	.1595	9.56
3	.239	14.4
4	.321	19.25
5	.402	24.2
6	.485	29.1
7	.570	34.2
8	.655	39.4
9	.744	44.7
10	.834	50.0
11	.927	55.6
12	1.025	61.5
13	1.125	67.5
14	1.233	74.0
15	1.350	81.0
16	1.475	88.5
17	1.615	97.0
18	1.782	107.0
19	1.990	119.8
20	2.50	150.0

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Figure 5-20.—Position and error trace calibration curve.

20-minute full-scale calibration, and a 2.5-degree full-scale calibration.

The position trace is normally calibrated with only one scale, a 2,5-degree full-scale calibration.

The velocity trace uses one calibration scale for elevation and train tests. The train velocity trace is calibrated with a forty-degree-per-second full-scale calibration.

Allow the test equipment at least 10 minutes to warm up before attempting any calibration procedures. (Varies with different systems; check your OP and the MRC.)

Obtain the instructions for calibrating the oscillograph (error recorder) used with your missile launching system and proceed with the calibration. After you have completed the calibration of the oscillograph, it is ready to be used in testing the accuracy of the launcher. With the; Talos system, these tests are numbered consecutively through test No. 51 B. They are described in OP 3590 *Guided Missile Launcher, Mark 7 Mod 1, Description, Operation, and Maintenance*. There are many similarities between the train and elevation tests, but each power drive must be tested separately. For example:

Elevation (Train) Accuracy Test

Test 1. Simple harmonic motion test.

Test 2. Static test.

Test 3. Five-degree-per-second constant veocity test.

Test 4. Ten-degree-per-second constant veocity test.

Test 5. Fifteen-degree-per-second constant velocity test.

Test 6. Elevation (train) velocity and acceleration test.

Tests 6A and 6B. Launcher elevation (train) synchronized indicator tests

The train power drive requires an additional t{ test in this series-25-degrees-per-second constant velocity test.

Other tests in this group of fifty-one are elevation (train) synchronizing tests, fixed displacement; elevation (train) harmonic motion synchronizing tests; elevation (train) synchro power failure tests; elevation (train) main power. failure tests; elevation (train) return to load tests; and elevation (train) frequency response tests.

The error recorder is used to make traces in each of the tests, the maximum operating errors are calculated, and the traces are compared with typical traces. Copies of typical traces are included in the OP or OD. The traces made at installation of the launching system on the ship are kept aboard for comparison.

Elevation accuracy tests on shipboard include a simple harmonic motion test, a static operation test, and constant velocity tests. The same types of tests are made for train accuracy. Constant velocity and synchronizing tests are performed at different speeds and at different angles of train and elevation, each performed according to specific instructions in the OP.

These tests are performed annually unless circumstances require otherwise. A suspected malfunction may require certain tests to be performed more frequently. Operational tests may be needed to determine if the launcher follows order signals accurately, or to check some other function of the launcher. All the men who perform the test must be familiar with the equipment and the procedure. Although you follow the steps according to a checkoff list, studying the procedure beforehand will do much for a smooth operation. If you are the leading petty officer, you will check the work of the other men.

The launcher test equipment is stowed in the shipboard instrument storage cabinet when not in use.

SIMILARITIES AND DIFFERENCES

The principles explained in *Basic Electricity*, NAVTRA 10086 and *Basic Electronics*, NAVTRA 10087 apply to all the missile systems. The details of application of these principles in the different weapon systems must be left to the OPs and ODs for each system. If you have acquired a firm knowledge of the basic principles, you can understand the use of them in the system in your ship. If you are not so sure of your knowledge in some areas, make a careful re-study of any part you do not understand. Other petty officers can help you. The complicated network of electrical and electronic parts in a weapons system cannot be kept in working order if you do not understand how it works. It is too sophisticated a system to maintain by guesswork.

SUMMARY

This chapter points out the uses of different electric and electronic devices in launching systems. It tells how they function and how you are to test them, The basic principles of servos, amplifiers, and synchros are applied to specific functions in the launching system.

Some of the newer electronic items that have been placed in launching systems were introduced. As more use is made of transistors, printed circuits, and miniaturized units, you need to apply the knowledge of the principles to the particular uses. You will also need to develop skill in maintenance of these items.

While safety needs to be emphasized every day, and caution can never be relaxed around electrical equipment, the applicable safety regulations are placed in chapter 12.