AD-756 950

CHARACTERISTICS OF NAVAL GUNFIRE SUPPORT IN KOREA

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21 August 1953

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Characteristics of Naval Gunfire Support in Korea

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(LO)958-53
11 June 1953

OPERATIONS EVALUATION GROUP
STUDY NO. 506

CHARACTERISTICS OF NAVAL GUNFIRE SUPPORT IN KOREA

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When this study was issued originally is was classified Confidential. Subsequently it was assigned Group 4 in the Automatic Downgrading system and became unclassified in 1965.

Prepared by the
OPERATIONS EVALUATION GROUP
Office of the Chief of Naval Operations

(LO)958-53
11 June 1953

This study is based on a Pacific Fleet Evaluation Group Memorandum, entitled "Characteristics of Naval Shore Bombardment in Korea: May 1951-March 1952".

Editorial revisions have been made in the original text to make the version published here conform to the style and form of other OEG publications.

(LO)958-53
11 June 1953

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CHARACTERISTICS OF NAVAL GUNFIRE SUPPORT IN KOREA

ABSTRACT

Ships of the U. S. Navy fired over 414,000 rounds and 24,000 missions against shore targets in the period May 1951 through March 1952. The great bulk of these missions (over 90 percent) was 5-inch fire, mainly by destroyers.

Detailed reports of more than 5,000 of these missions have been received as part of a special data collection program by the Pacific Fleet Evaluation Group. These reports provide statistics descriptive of the employment of Naval gunfire during the period. They show that the enemy's transportation system was the primary target for the destroyers' fire, receiving about 1/3 of the missions. The main batteries of the heavy ships were used primarily against personnel targets, however, and their secondary batteries were used primarily against gun emplacements and other weapons installations. The majority of all missions was for the purpose of destruction, with harassment the second most frequent purpose. Neutralization was listed as the mission purpose less than 10 percent of the time, emphasizing the fact that Naval gunfire like other weapons in this static period was employed mainly with a long-term pay off in mind.

Economy of effort becomes a factor of importance under this condition of employment. An indication of the extent to which economy of effort could have been practiced is the extent to which gunfire missions were unobserved. In keeping with the general emphasis on destruction, this category of mission was comparatively well observed, with less than 1/4 to 1/3 going unobserved. Virtually all harassment missions, however, and most neutralization missions were unobserved. Over-all, nearly half the total missions were unobserved. Also, expenditures on unobserved missions were so small, it is unlikely they were very effective.

Over 2/3 the 16-inch destruction missions were claimed by observers to be highly successful. Over 1/2 the 8-inch destruction missions when observed were claimed highly successful, and about 1/3 the observed 5-inch missions were so regarded. The 6-inch destruction missions had the smallest percentage, about 1/5, in the highly successful category. However,

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more detailed study of effectiveness indicates that criteria for effectiveness differed from one caliber battery to another, so that comparisons between ship types which might be implied by the above are not reliable.

When an attempt is made to analyze the factors which should influence the effectiveness of the missions, a number of anomalous results are obtained. It appears that either too much credit for effectiveness was given the lighter projectiles by observers, or too little given the larger projectiles. On the other hand, all batteries and particularly the heavy batteries appear to be credited with unreasonably accurate shooting at longer ranges and against small targets.

There is an indication, confirming previous studies, that ship spotting leads to less effective missions than ground or air spot. Little difference between conventional air spot, helicopter spot, or ground spot could be found.

However, the major conclusion to be drawn from the attempt at detailed analysis of the Gunfire Support Forms is that the requirements for reliable analysis of the factors influencing economy and effectiveness are not met by the existing combat-data collecting program. The sole means of assessment of effectiveness was visual observation under very difficult conditions, and the criterion for this assessment depended mainly on the observer's judgement. Consequently, the reported assessments of mission effectiveness must be regarded as inadequate for reliable analysis, and absolutely no valid conclusions regarding the accuracy of the gunfire can be drawn.

Apparently visual observation of effectiveness and of accuracy under the difficult conditions of combat does not provide a firm basis for the study of the basic elements of weapons performance. A means for determining the physical effects capabilities of various caliber projectiles is in proving ground tests under controlled conditions. This should also be true of the determination of the relative capabilities of various spotting methods, although no such program now exists. However, for the evaluation of the accuracy of ships' gunfire under combat conditions and of the efficiency of spotters, it appears that photographic means for recording the fall of shot must be provided combat forces at least on a part time or small scale basis, and that present methods of observation are inadequate.

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CHARACTERISTICS OF NAVAL GUNFIRE SUPPORT IN KOREA

Ref: (a) OEG Study No. 448 "Analysis of Naval Gunfire Support in Korea" Secret 27 Apr 1951
(b) OEG Study No. 461 "Analysis of Certain Korean Gunfire Support Missions Performed by the USS MISSOURI (BB-63)" Secret 25 Oct 1951
(c) PacFltEvalGru Research Memorandum No. 19 Utilization of USS NEW JERSEY (BB-62) in Gunfire Support May-November 1951 Conf
(d) Operations Research Center Study 13 "Number of Rounds Required to Hit Small Targets" Conf 17 Feb 1945
(e) Operations Research Center Study 32 "The Relative Effectiveness of Naval Projectiles for Neutralization" Conf 17 Aug 1945

I. INTRODUCTION

During the Korean War, ships of the United States Navy have been opposed neither by an enemy surface fleet nor by an effective enemy air force. Naval gunfire has instead found employment almost exclusively against shore targets. With the very important exceptions of such operations as the Hungnam evacuation and the Inchon invasion, even this employment has differed considerably in its intent and nature from the traditional saturation type bombardment during amphibious operations which in World War II constituted the main use of Naval guns against land targets. Instead of an intense, concentrated, but fairly brief bombardment coordinated with friendly troop movements and with neutralization of the enemy as its primary objective, Naval gunfire has supplemented the role of artillery and air bombardment in what, since June 1951 at least, has been a fairly static land war.

In October 1950, in anticipation of the probable extensive use of Naval guns against land targets, the Pacific Fleet Evaluation Group began to supply U. S. Navy ships of the Pacific Fleet with special forms, called Gunfire Support Cards, for recording the details of missions against shore targets. A sample of such a form is shown in appendix A. It was hoped that analysis of these forms, besides providing statistics descriptive of employment and general effectiveness, would indicate what factors most greatly influenced effectiveness and how effectiveness and economy might be increased.

Preliminary results of the analysis of the Gunfire Support Cards received through December 1950 were reported in reference (a). The gunfire support missions of USS MISSOURI (BB-63) during February and March 1951 were analyzed in reference (b), and those of USS NEW JERSEY (BB-62) from May through November 1951 in reference (c). Many of the conclusions of these studies were necessarily tentative, since they had to be based on relatively few missions of a particular type. Since May 1951, however, more than 5,000 Gunfire Support Cards have been received from two battleships, five heavy cruisers, one light cruiser, and thirty-one destroyer types. Although over 20,000 missions have been fired during this period, it was hoped the sample reported was sufficiently large to draw conclusions which would be statistically reliable.

As will be shown, however, the criteria used by observers to assess mission effectiveness appears to have differed so much from battery to battery that it is impossible to obtain reliable comparisons of the relative effectiveness of the various calibers of projectiles against the targets encountered in combat. Furthermore, it appears that the salvo number of the first hit was reported only for the more accurate missions. Consequently, it has been impossible to obtain a realistic evaluation of the accuracy of ships' batteries under combat conditions.

However, the remainder of the data from the Gunfire Support Forms provides considerable information on the way Naval gunfire was employed, the distribution of effort over the enemy target system, spotting techniques used, and expenditures on various targets considered by the ships to have been required to give satisfactory results.

The purpose of this study is, therefore:

(1) to summarize the descriptive statistics which characterize the utilization of Naval gunfire in Korea and which are of historical interest, and

(2) to show that the requirements for reliable analysis of the factors influencing economy and effectiveness are not met by the present combat data collection program which relies solely on subjective and uncertain visual observation of results.

II. SOURCE OF DATA

With the exception of total rounds expended, which is available from another source, information on the Gunfire Support Cards covers only a portion of the total shore bombardment missions. This is because not all destroyers were asked to submit Gunfire Support Cards, and for those destroyers and heavy ships which were asked, there were inevitable breaks in the continuity and usability of the reporting. However, no systematic selection of ships and missions has been detected in the reporting and it will therefore be assumed that the Gunfire Support Cards which have been received are randomly distributed among the various elements constituting a mission and hence taken together they form a representative sample. Table I shows the size of the sample for each battery type, and the percent of the total rounds expended during the period which were reported on the Gunfire Support Cards.

TABLE I

SAMPLE SIZE AVAILABLE FOR ANALYSIS

Gun caliber	Number of missions	Number of rounds	Sample size by percent of total rounds expended
16 inch	391	4,411	83
8 inch	643	11,616	52
6 inch	171	3,185	70
TOTAL HEAVY	1,205	19,212	59
5 inch	4,051	67,768	18

It is apparent that the 6-inch and 16-inch firings have been fairly completely reported, with 70 percent and 83 percent respectively, of all rounds expended being included. Although only 52 percent of the 8-inch rounds and 18 percent of the 5-inch rounds were reported, so many of these missions were fired that an even larger sample of data is available than for the 6-inch and 16-inch batteries.

Not all reports are complete in all details, so that when further breakdowns are required the totals shown may not equal those in table I. Reports when eliminated from subsequent analysis were excluded because of illegibility, lack of entry of the element being considered, or inconsistent entries which could not be resolved. Such exclusions should not affect the representativeness of the remaining sample.

The ships reporting and the dates covered by the reports received are listed in appendix B.

III. THE CHARACTER AND EXTENT OF THE SHORE BOMBARDMENT

A. AREAS OF ACTIVITY

The areas of principal Naval gunfire activity in the period May 1951 through March 1952 were four:

(1) Bombline area - support of two offensives by UN troops (May-June 1951 and September 1951) and sustained but fairly low intensity harassment of enemy troops during the rest of the time.

(2) Wonsan area - continuous harassment and destruction of city, destruction of transportation targets, shore installations, and shore batteries.

(3) East coast area Hungnam to Chongjin - destruction of shore installations and the coastal rail and highway system.

(4) West coast Haeju to Chinnampo - support of commando and guerrilla raids.

B. OVER-ALL MAGNITUDE OF EFFORT

Information on the over-all magnitude of the shore bombardment effort cannot be obtained from the Gunfire Support Cards, since they were not consistently submitted by all ships on all missions throughout the period. Available from reports to COMSERVPAC however are figures on total ammunition expenditures by caliber of round. The average expenditure per mission can be obtained for each caliber gun from the sample of Gunfire Support Cards which is available. If it is assumed that the sample of missions reported on the Gunfire Support Cards is representative of the missions as a whole, an estimate of the total number of missions fired by each type of battery can be obtained by dividing the total expenditures by the average expenditure per mission. Table II shows these measures of total effort for each type of battery.

TABLE II

OVER-ALL MEASURES OF EFFORT:
NAVAL GUNFIRE IN KOREA, MAY 1951-MARCH 1952

Gun caliber	Total rounds* expended	Average rounds** per mission	Total missions** (estimated)	Percent of total missions
16 inch	5,344	11.3	473	2.0
8 inch	22,528	18.1	1,245	5.0
6 inch	4,528	18.6	243	1.0
5 inch	381,750	16.7	22,859	92.0
TOTAL	414,150	16.7	24,820	100.0

* Rounds expended through Dec 1951 obtained from PACFLTEVALGRU Interim Evaluation Report No. 3, Chapter 11. Rounds expended Jan-Mar 1952 furnished by COMSERVPAC.

** Missions estimated from total rounds expended by dividing by average expenditure per mission obtained from Gunfire Support Cards.

The significant feature of table II is the vast preponderance of 5-inch fire over all other types. The 5-inch batteries fired more than ten times as many missions and rounds as did all heavier calibers combined. Of the heavier batteries the 8-inch constituted the largest category for both missions and rounds. There is little difference in average expenditures per mission for 5, 6, and 8-inch batteries. The 16-inch batteries however fired on the average only about 2/3 as many rounds per mission as the lighter batteries. This will be discussed in more detail later.

C. DISTRIBUTION OF EFFORT BY TARGET TYPE

A large variety of targets was reported on the Gunfire Support Cards. In terms of military significance they can be classified into seven major categories. These are:

(1) Personnel targets - troops in various dispositions.

(2) Transportation targets - bridges, tracks and highways, vehicles, locomotives, etc.

(3) Weapons installations - shore batteries, gun emplacements, mortar positions, bunkers, etc.

(4) Shore installations - factories, warehouses, buildings, etc.

(5) Military installations - supply, fuel, and ammo dumps, command posts, headquarters, etc.

(6) Areas - towns, cities, assembly areas, etc.

(7) Naval targets - ships, landing craft, small boats, etc.

The specific targets which were reported by the various ships and classified into the seven major categories are shown in more detail in appendix C.

Since 5-inch batteries, and particularly the destroyer 5-inch batteries, accounted for the great bulk of the missions and rounds, the way in which the destroyer missions were distributed among the various targets shows the general division of effort as a whole over the target system. The distribution of effort of approximately 2,900 destroyer missions for which the Gunfire Support Cards specified the target is shown in table III.

TABLE III

DISTRIBUTION OF EFFORT BY TARGET:
DESTROYER MISSIONS

Target type	Rounds (percent)	Missions (percent)
Transportation targets	27	31
Weapons installations	19	15
Personnel targets	15	14
Areas	15	13
Shore installations	13	15
Military installations	8	7
Naval targets	3	5

By far the largest part of 5-inch destroyer missions and rounds (and of Naval gunfire as a whole) during the period was directed against the enemy's transportation system. This reflects the general importance of the interdiction campaign during this period. The remaining destroyer 5-inch missions were distributed among the other major categories of targets in the following order:

weapons installations,
personnel targets,
areas,
shore installations,
military installations, and
naval targets.

Weapons installations received somewhat more than their share of the rounds, much of this firing being of a counterbattery nature which continued until the battery was silenced.

The heavy guns were employed quite differently. Neglecting for the moment the one 6-inch cruiser reporting, the employment of the main batteries of the five heavy cruisers and two battleships which submitted Gunfire Support Cards is shown in table IV.

TABLE IV

DISTRIBUTION OF EFFORT BY TARGET:
HEAVY CRUISERS AND BATTLESHIP MAIN BATTERIES

Target type	Rounds (percent)	Missions (percent)
Personnel	35	38
Transportation	28	21
Military installations	14	17
Weapons installations	14	17
Other	9	7

Thus, the primary employment of the 8-inch and 16-inch guns during the period was against personnel targets, and most of this was along the bombline on missions requested by friendly troops.

Transportation targets received slightly more than half as many heavy battery missions as did personnel targets, although somewhat more than this proportion of rounds. Weapons installations and military installations shared fairly equally the bulk of the remainder of heavy battery fire. As can be seen from appendix D, where detailed statistics on each battery are presented, more of the 16-inch fire went to military installations than to weapons installations, but the reverse was true for 8-inch.

The 6-inch cruiser missions reported show that expenditures were almost evenly divided among personnel targets, transportation targets, military installations, and weapons installations. However, because of very high expenditures per mission against bridges, transportation targets received 21 percent of the rounds but only 10 percent of the missions (appendix D).

Heavy ship secondary battery fire was used primarily against weapons installations which received 35 percent of the rounds fired and 34 percent of the missions. Transportation, and two battleships which submitted Gunfire Support Cards is shown in table IV.

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Heavy ship secondary battery fire was used primarily against weapons installations which received 35 percent of the rounds fired and 34 percent of the missions. Transportation, military installations, and area targets shared the remaining missions fairly evenly, although transportation targets again received proportionately more than their share of rounds.

In general then, transportation targets received most of the rounds fired by U. S. Navy ships during this period since these were the primary targets of the destroyers which did by far most of the firing. The primary target of battleships' and 8-inch cruisers' main batteries was personnel, while heavy ship 5-inch batteries were used primarily against weapons installations. Detailed statistics are shown in appendix D.

D. DISTRIBUTION OF EFFORT BY MISSION PURPOSE

For most missions, destruction was listed as the mission purpose, with harassment and interdiction the second most frequent purpose. Neutralization and other purposes (close support, deep support, counterbattery, and illumination) were listed comparatively infrequently, although it is understood that much of the fire against weapons installations listed as destruction might equally well have been listed as counterbattery. The use of the designation "harassment and interdiction" should be understood to mean primarily harassment and the hampering of enemy movement, rather than as directly contributing to the interdiction campaign. Table V shows the relative frequency with which various mission purposes were listed for each battery.

TABLE V

DISTRIBUTION OF EFFORT BY MISSION PURPOSE

Gun caliber	Destruction (percent)	Harassment and interdiction (percent)	Neutralization (percent)	Other (percent)
5-inch (destroyer)	51	39	6	4
5-inch (heavy ship)	22	64	11	3
6-inch	68	28	3	1
8-inch	63	24	4	9
16-inch	56	26	11	7

It is seen that for most batteries over one-half to two-thirds the missions were for destruction and about one-quarter to one-third for harassment and interdiction. The single exception is the 5-inch batteries of the heavy ships which fired 64 percent of their missions for harassment and interdiction and only 22 percent for destruction, reversing the above distribution.

The great preponderance for destruction and harassment and interdiction missions and the relative infrequency of neutralization missions emphasizes again that Naval gunfire during this period was employed with a long term pay-off in mind rather than in its more traditional role of saturation bombardment closely coordinated with the immediate movement of friendly troops.

E. ECONOMY OF EFFORT

Since the character of the Korean War became that of a static holding action, the principle of economy of effort over the long pull has been generally emphasized as desirable. One way in which economy of effort enters Naval shore bombardment operations is in the observation of effect, and the cessation of fire when the desired effect has been attained. Consequently, the amount of unobserved fire is an indication of the extent to which this principle could have been applied. Table VI shows the amount of unobserved fire for each type of mission reported on the Gunfire Support Cards.

TABLE VI

PERCENT OF MISSIONS WHICH WERE UNOBSERVED

Gun caliber	Destruction	Harassment and interdiction	Neutralization	Other	Total
5-inch (destroyer)	23	72	19	45	43
5-inch (heavy ship)	38	96	66	42	78
6-inch	32	91	83	25	50
8-inch	21	96	25	53	42
16-inch	25	97	49	13	45

It is seen from table VI that in general nearly half the fire was unobserved (78 percent of the heavy ship 5-inch fire), but that this varied considerably with the purpose of the mission. For example, virtually all the harassment and interdiction missions of the heavy ships were unobserved, also a high percentage of their neutralization missions. However, when the purpose of the mission was destruction only one-quarter to one-third went unobserved.

It should be noted that the destroyers were outstanding in the extent to which they observed harassment and interdiction, and neutralization missions, but that even so, 43 percent of their firing which constituted the bulk of that done by U. S. ships was unobserved, at least in the sample of missions reported on the Gunfire Support Cards.

F. EFFECTIVENESS OF EFFORT

The assessment of mission effectiveness was made for only those missions which were observed, of course. From table VI it can be seen that a fairly large percentage of the destruction missions were observed for all batteries and that in addition a sufficiently large percentage of the harassment and interdiction missions and neutralization missions of the destroyers were observed, giving a sizable data sample.

Since destruction missions constituted over half of the effort of all batteries (except 6-inch) and since the assessment of destruction can be made with least uncertainty, the difference in effectiveness which characterized the main effort of the different batteries can be most reliably indicated by analyzing their destruction missions. The relative effectiveness of the various types of missions experienced by the enemy can be most characteristically indicated by analyzing the destroyer fire, which constituted most of the over-all effort.

Two limitations in the assessment of effectiveness should be kept in mind. The first is that visual observation often under very difficult conditions was the sole means of assessment available. A subjective element is present in that observers were asked to report the degree to which the mission achieved its purpose, whatever that might be, and the criterion of this depended strongly on the observer's judgment. It was realized that this was undesirable, but without photographic means no better method could be devised. Also no very objective criteria were known for degree of neutralization or degree of harassment achieved. Further, later analysis shows that the standards for successful results differed from battery to battery. For example, the number of large-caliber rounds required for a given effect was larger than would be expected in view of the number of smaller-caliber rounds required for the same effect. Therefore, the reliability of the assessment of mission effectiveness is rather questionable, although destruction should be the least unreliable.

A second limitation in evaluating the effectiveness of the firing comes from the fact that much of it was unobserved. As will be shown later, for observed missions the expenditures per mission for satisfactory results averaged higher than those for negligible or partial success. On the average the expenditure per mission for the unobserved missions averaged less than those for missions observed to be negligibly or only partially successful. Therefore, since it appears degree of success tends to be proportional to expenditures on the mission, the unobserved fire would be expected to have a smaller percentage of successful missions than is reported for the observed fire.

The following percentages of missions reported in each success category then probably show a more favorable picture than would be true of the firing as a whole.

With the above qualifications in mind, figure 1 shows the varying degrees of success reported on destruction missions for each type of battery.

The categories plotted are:

no success	=	negligible effect observed;
limited results	=	small effect observed;
satisfactory results	=	large effect observed or mission completely successful.

The 16-inch firing which was observed resulted in the highest percentage (70 percent) of highly successful missions, and the smallest percentage (6 percent) of missions with negligible success. The 8-inch fire ranked second in percentage of highly successful missions (52 percent) although a somewhat higher percentage (20 percent) had no success than for other batteries. The 6-inch firing resulted in the lowest percentage (18 percent) of satisfactory missions, but on the other hand only a small percentage (8 percent) had negative results. Results for the 5-inch batteries on destroyers and the 5-inch batteries on the heavy ships were almost identical, with about 35 percent satisfactory, about 15 percent with no results, and 50 percent with limited results. Over-all, more than 4/5 of the observed destruction missions claimed at least limited results and over 1/3 very satisfactory results with the 16-inch batteries reporting more than 2/3 completely successful and the 8-inch batteries more than 1/2 completely successful.

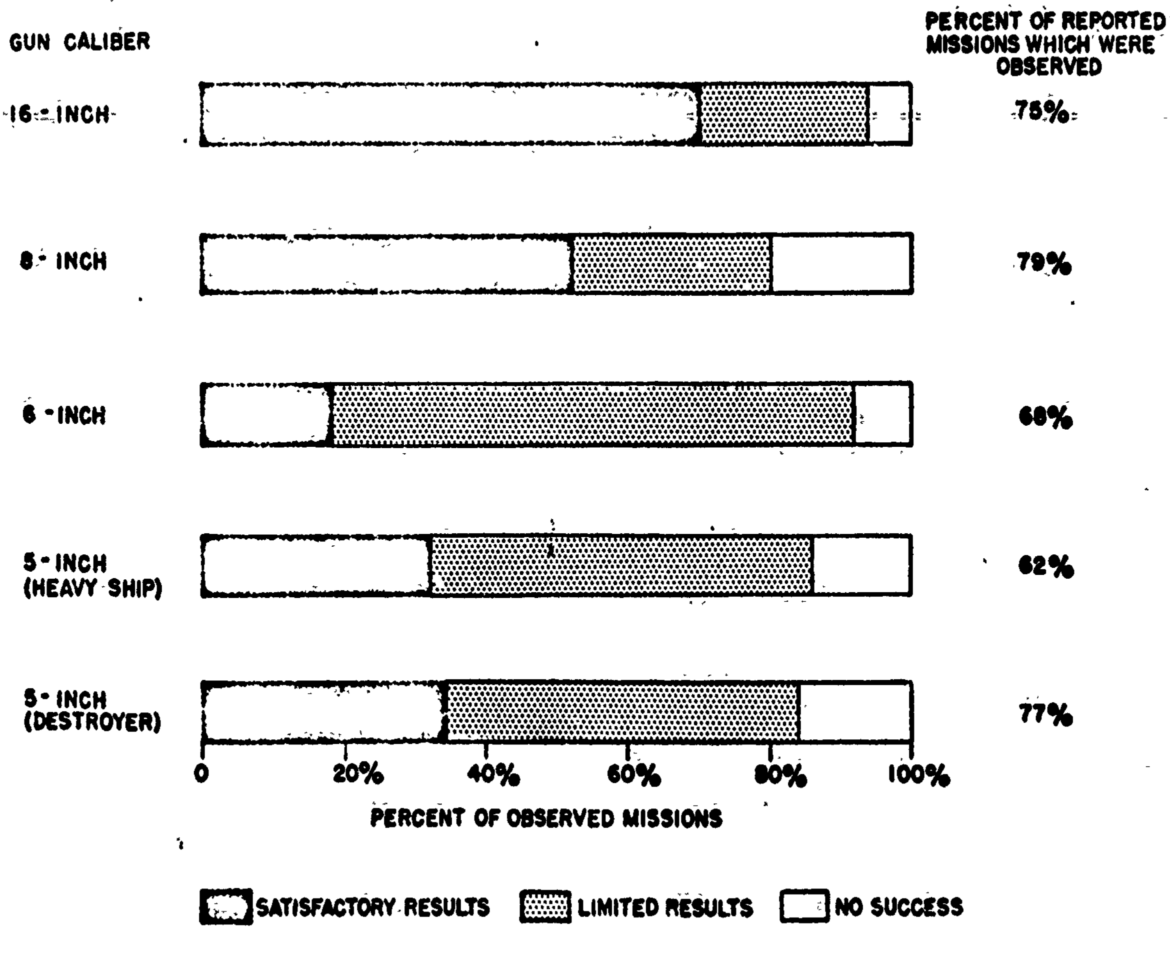

FIG. 1: DISTRIBUTION OF DESTRUCTION MISSIONS ACCORDING TO EFFECTIVENESS

In figure 2 the destroyer missions which were observed to have varying degrees of success are shown for the more frequent type missions.

Harassment and interdiction missions and neutralization missions were observed to be carried out less successfully than destruction missions, with fewer observed to be highly successful and more observed to have had no results. Besides being least successful when they were observed, the harassment and interdiction missions were largely unobserved so that if it is assumed that the unobserved missions were even less successful than the observed mission, this fairly large category (39 percent of the destroyer missions) probably had a fairly high percentage of negligibly effective missions.

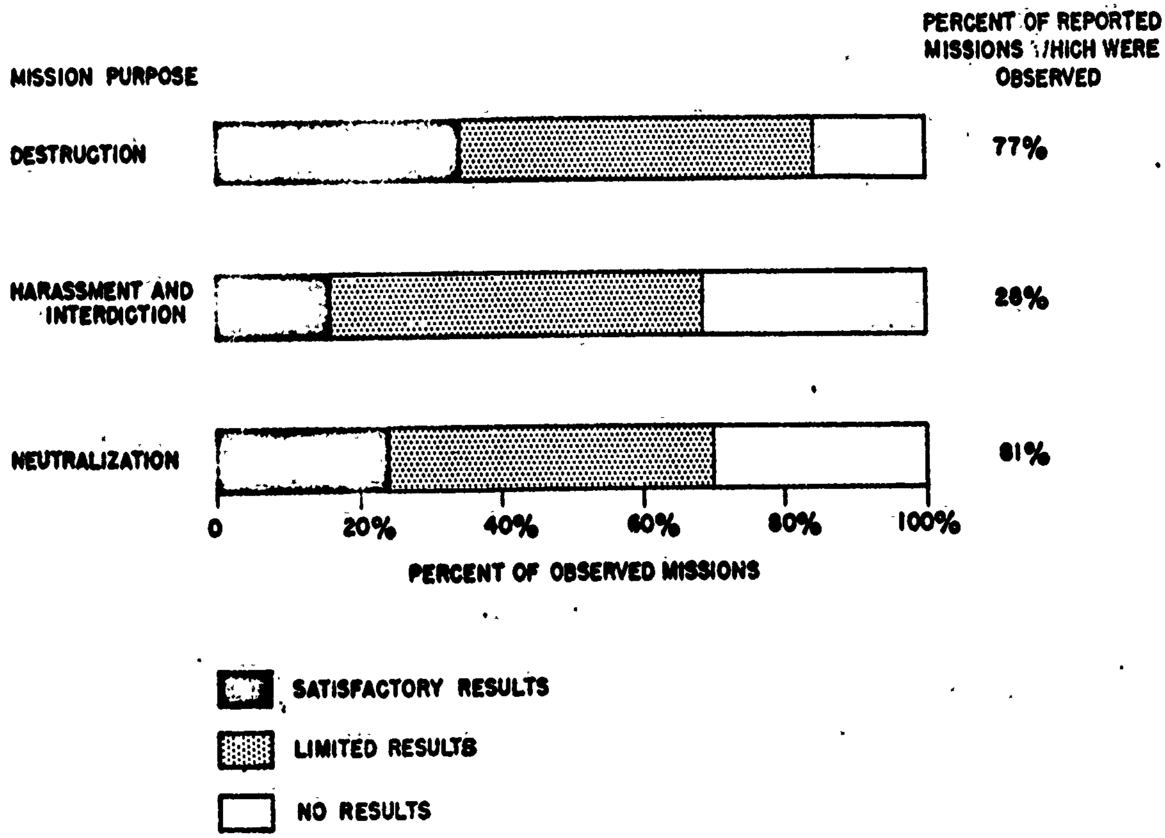

FIG. 2: DISTRIBUTION OF DESTROYER MISSIONS ACCORDING TO EFFECTIVENESS

G. USE OF SPOTTING

As will be shown later, the effectiveness of fire depends on the type of spotting used. In general, greatest success was achieved with ground spot, generally utilizing shore fire control parties. Air spot by conventional aircraft and helicopters gave second best results, spotting by the ship next, and poorest results when no spotting was used. Table VII shows the extent to which various spotting methods were used by each type of battery.

TABLE VII

DISTRIBUTION OF SPOTTING METHODS
(PERCENT OF MISSIONS)

Gun caliber	Ground spot	Air and helo spot	Ship spot	Other	No spot
5-inch (destroyer)	19	12	36	1	32
5-inch (heavy ships)		8	14	5	73
6-inch	44	16		5	35
8-inch	31	32	10	1	26
16-inch	14	35	5		46

About 2/3 of the destroyer missions used spotting of one kind or another. When spotting was used by the destroyers, slightly over half the time it was ship spot, with ground and air spot sharing the remainder of the missions. The 8-inch fire had benefit of spotting on a higher percentage (74 percent) of their missions than other types, while the heavy ship secondary batteries had to do without spotting on three-fourths of their missions. It is interesting that the heavy ships' main batteries had the benefit of the more effective types of spotting (ground or air) on about 60 percent of their missions.

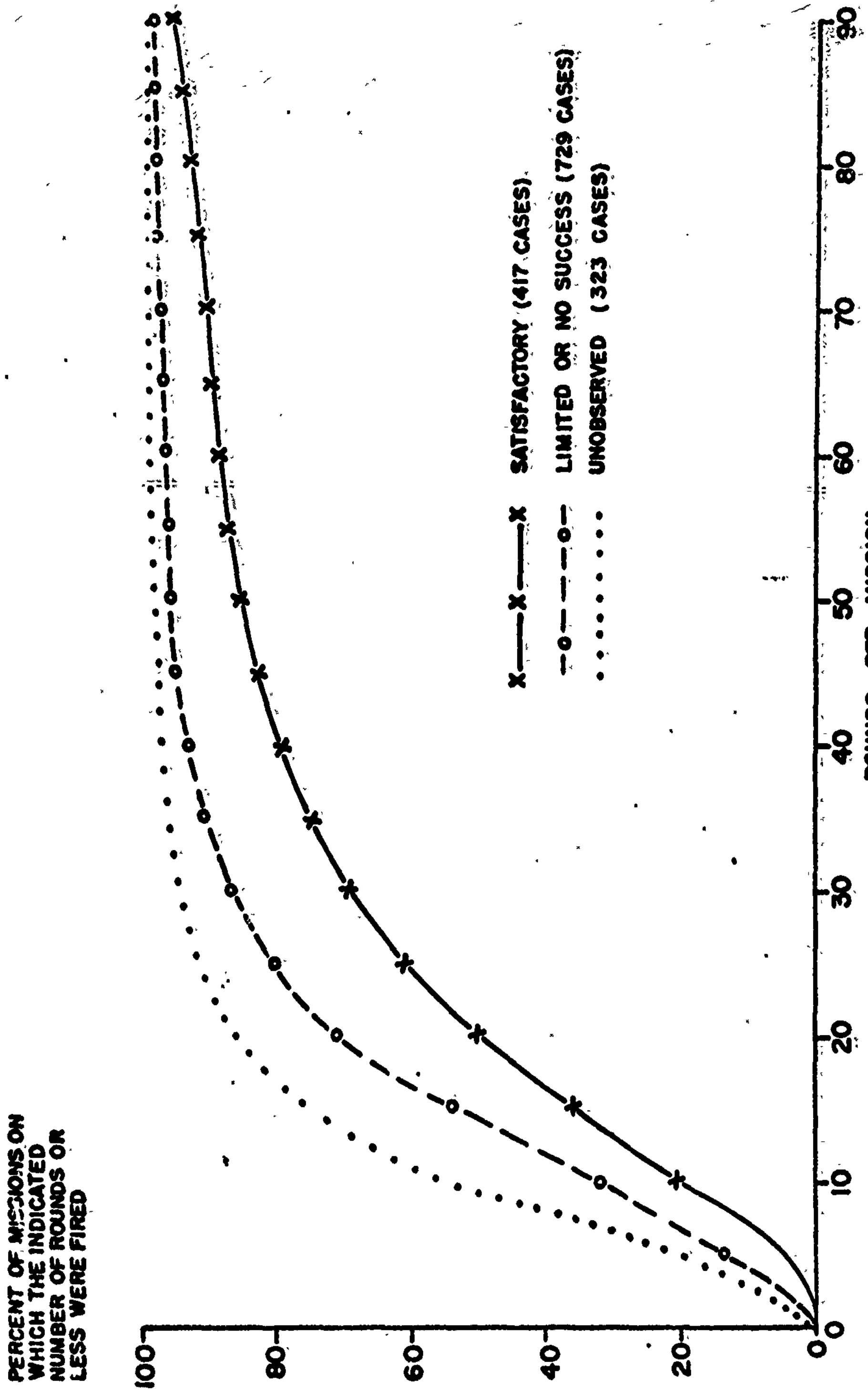

FIG. 3: CUMULATIVE DISTRIBUTION OF ROUNDS PER MISSION: DESTRUCTION MISSIONS OF DESTROYERS

IV. FACTORS INFLUENCING EFFECTIVENESS

A. EXPENDITURES PER MISSION AND UNOBSERVED FIRE

It is reasonable to suppose that the greater the fire on a particular mission the greater the effect which that mission will have, other things being equal. The distribution of destroyer 5-inch destruction missions according to the expenditures per mission are shown in figure 3 for satisfactory missions, limited or no-success missions, and unobserved missions. The abscissa in figure 3 indicates number of rounds per mission, and the ordinate the percentage of missions on which the indicated number of rounds or less per mission was fired.

It is seen that a smaller percentage of the successful missions is in the low expenditure category, a higher percentage of limited or no-success missions, and an even greater percentage of the unobserved missions. For example, 20 rounds or less per mission characterized only about 50 percent of the successful missions, but over 70 percent of the limited or no-success missions, while nearly 90 percent of the unobserved missions were this parsimonious. On over 50 percent of the unobserved missions fewer than 10 rounds were fired. It appears from figure 3 then that on the destroyers 5-inch destruction missions, high expenditures and success go together and that in general the unobserved fire was characterized by such low expenditures that a high degree of success is unlikely.

Figures 4a and 4b show a generally similar picture for the destroyer harassing and interdiction missions and the destroyer neutralization missions. However, there is only a slight difference between the limited or negligible success expenditures and the unobserved expenditures, so that the unobserved fire may perhaps have had a fair chance for limited success. However, the unobserved missions were largely unspotted; crediting them, on the basis of expenditure alone, with the same chance for success as the limited or no-success missions which were observed and generally spotted is giving them the benefit of a very considerable doubt.

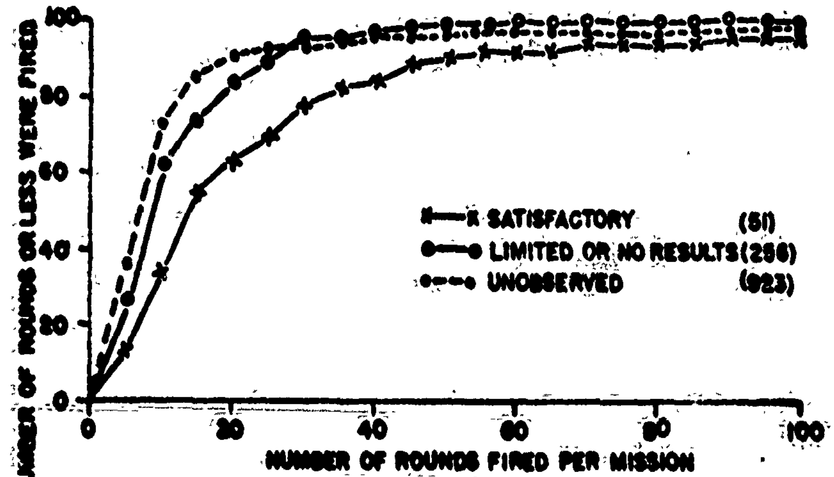

FIG. 4a: CUMULATIVE DISTRIBUTION OF DESTROYER 5-INCH HARASSING AND INTERDICTION MISSIONS WITH RESPECT TO NUMBER OF ROUNDS FIRED

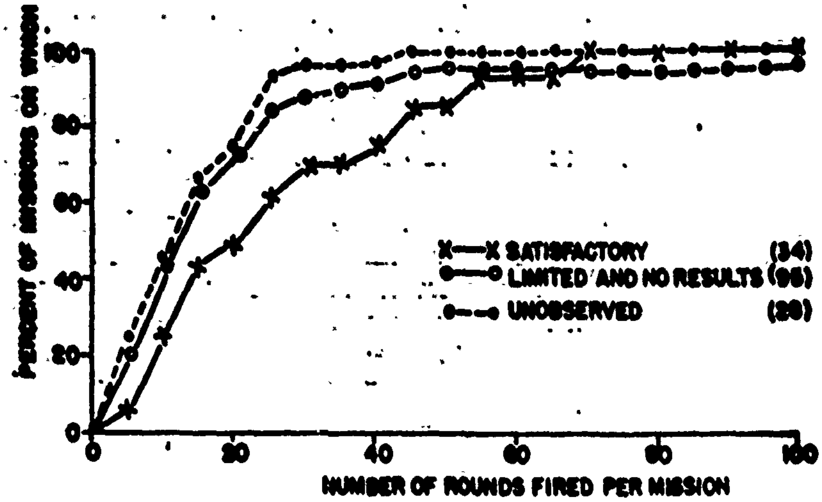

FIG. 4b: CUMULATIVE DISTRIBUTION OF DESTROYER 5-INCH NEUTRALIZATION MISSIONS WITH RESPECT TO NUMBER OF ROUNDS FIRED

In figure 5 the 16-inch and heavy ship 5-inch batteries again show higher expenditures associated with greater success on the observed missions, and such low expenditures on the unobserved missions as to make it doubtful whether even limited success was likely.

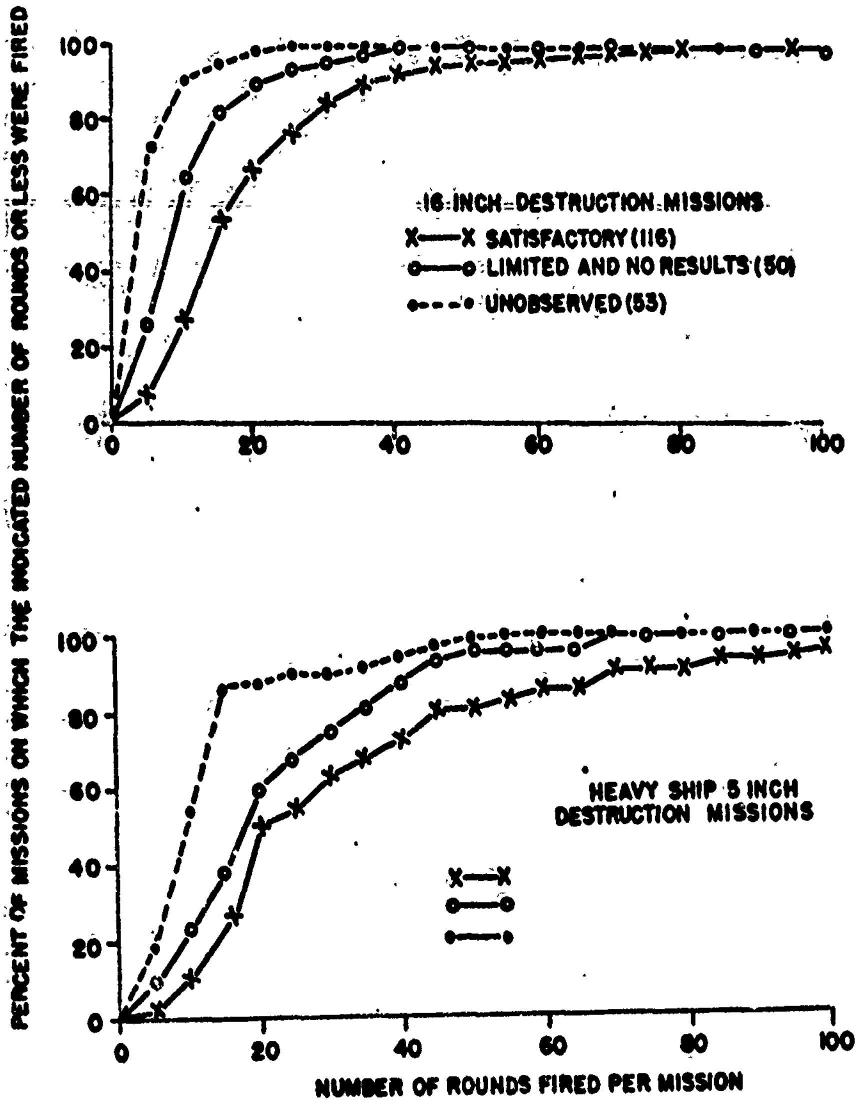

FIG. 5: CUMULATIVE DISTRIBUTIONS OF 16-INCH AND HEAVY SHIP 5-INCH DESTRUCTION MISSIONS WITH RESPECT TO NUMBER OF ROUNDS FIRED

Figure 6 for 8-inch destruction missions indicates that although on observed missions the same tendency for high expenditures is associated with greater success, the unobserved missions exhibit high enough expenditures to credit them with a fair chance for limited success if the benefit of the doubt with respect to spotting is given them.

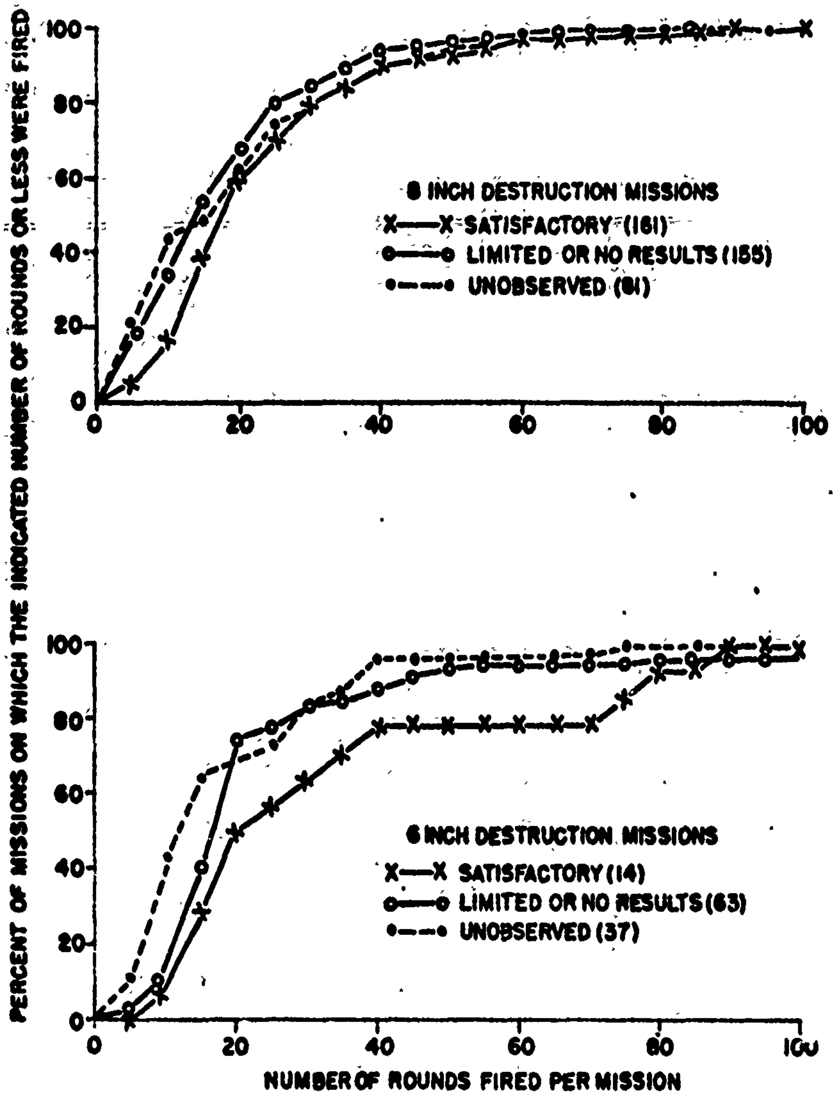

FIG. 6: CUMULATIVE DISTRIBUTIONS OF 8-INCH AND 6-INCH DESTRUCTION MISSIONS WITH RESPECT TO NUMBER OF ROUNDS FIRED

The reasonable relationship shown below between expenditures by a particular battery type and the degree of effectiveness claimed for the battery indicates that there was apparently some degree of consistency in the standards of success for a given caliber of projectile.

B. SPOTTING METHOD

The largest and most reliable sample of data with regard to the effect of spotting method on success is for the destroyer 5-inch destruction missions. Figure 7 shows how missions were assessed with respect to success for various types of spot.

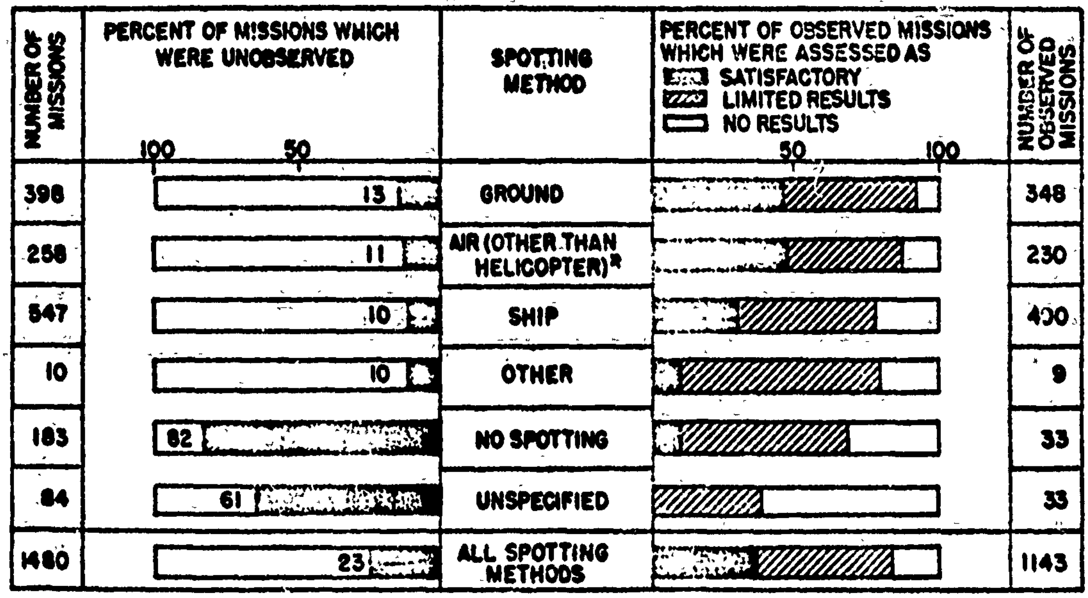

FIG. 7: EFFECTIVENESS OF DESTROYERS' 5-INCH BATTERIES IN DESTRUCTION MISSIONS (BY SPOTTING METHOD)

* 3 Helicopter spotting missions included in "other".

From figure 7 it is seen that very few highly successful missions were reported when no spotting was used, although the sample size is too small to be very significant, since most unspotted missions also went unobserved. There is little difference noted between air (other than helicopter) spot and ground spot, but both are significantly more effective than ship spot. Unfortunately there were too few helicopter spotted missions to permit comparison with other air spot.

There were too few missions in each spotting category for the other batteries and mission purposes to show statistically significant differences between them. Uniformly however, the order of effectiveness shown in figure 7 was confirmed by the sample available, with no spot least effective, ship spotting more effective than no spotting but less effective than ground or air spot. The specific figures are shown in appendix E. This order is in agreement with opinions expressed by ANGLICO personnel at FMFPAC and indicates again some consistency in assessing the effectiveness for a given caliber type.

The relative effectiveness of the various spotting methods should also show up in the accuracy of the fire. Unfortunately, a rather small number of reports included information on accuracy. Less than half of the heavy battery Gunfire Support Cards and about one-third of the destroyer Gunfire Support Cards reported the salvo number of the first hit. When the salvo number of the first hit was reported, on 1 to 2 cases out of every 10 it was claimed that the first salvo hit the target, so that the efficiency of spotting had nothing to do with obtaining the first hit. For the remainder of the missions reporting the salvo number of the first hit, table VIII shows the average salvos required for each battery and spotting method when more than one salvo was needed to score the hit. The number of cases in each category is shown in parenthesis.

Table VIII shows relatively small differences either between batteries or spotting methods. When statistical tests of significance (which take account of the size of the sample and the amount of spread around the average in each sample) are applied, it is found that no significance can be attached to any of the differences. That is, the laws of chance are enough to explain the difference between spotting methods and batteries and the most logical assumption to make is that all the data samples come from the same population. This is disconcerting, but may be true. However the next section shows that if the accuracy reports are taken at face value, and if success against specific target types was assessed in a constant fashion, unreasonable conclusions are indicated about the relative effectiveness of rounds of different calibers. Consequently, either the accuracy-of-fire data or the consistency of assessment of effect criteria or both must be unreliable.

TABLE VIII

AVERAGE SALVO NUMBER OF FIRST HIT VERSUS SPOTTING METHOD
(FOR CASES WHERE MORE THAN ONE SALVO REQUIRED)

Spotting method	Destroyers	Cruisers: 8-inch	Battleship: 16-inch
No spot	4.5 (13)		
Ship spot	4.4 (330)	5.1 (38)	3.8 (8)
Ground spot	4.4 (256)	4.8 (114)	4.5 (42)
Conv. air spot	4.9 (167)	5.2 (92)	4.4 (87)
Helicopter spot	7.6 (8)	5.6 (24)	3.8 (19)

C. RANGE TO TARGET AND CALIBER OF ROUND

It was not possible to obtain samples large enough for each target type to show whether a significant difference existed between the range of the mission and the effectiveness. According to reference (d), the average number of salvos required to obtain a given number of hits on a target of a given presented area normal to the trajectory of fire should increase with the square of the range (unless both ballistic errors and random aiming errors are small with respect to the target's area), so that the average salvo number of first hit should also increase with the square of the range.

It is surprising that in the region from 4,000 to 15,000 yards, where the data samples are large, no increase in the salvo number of first hit with increase in range is indicated. Since targets of all types are included in figure 8, the expected increase in salvos required to hit at the larger ranges might be obscured if the longer range missions were also uniformly associated with larger targets. To see whether this would account for the anomaly, the data for a number of specific target types were analyzed for all batteries. Results for those targets and batteries where a significant amount of data existed are shown in Figure 9.

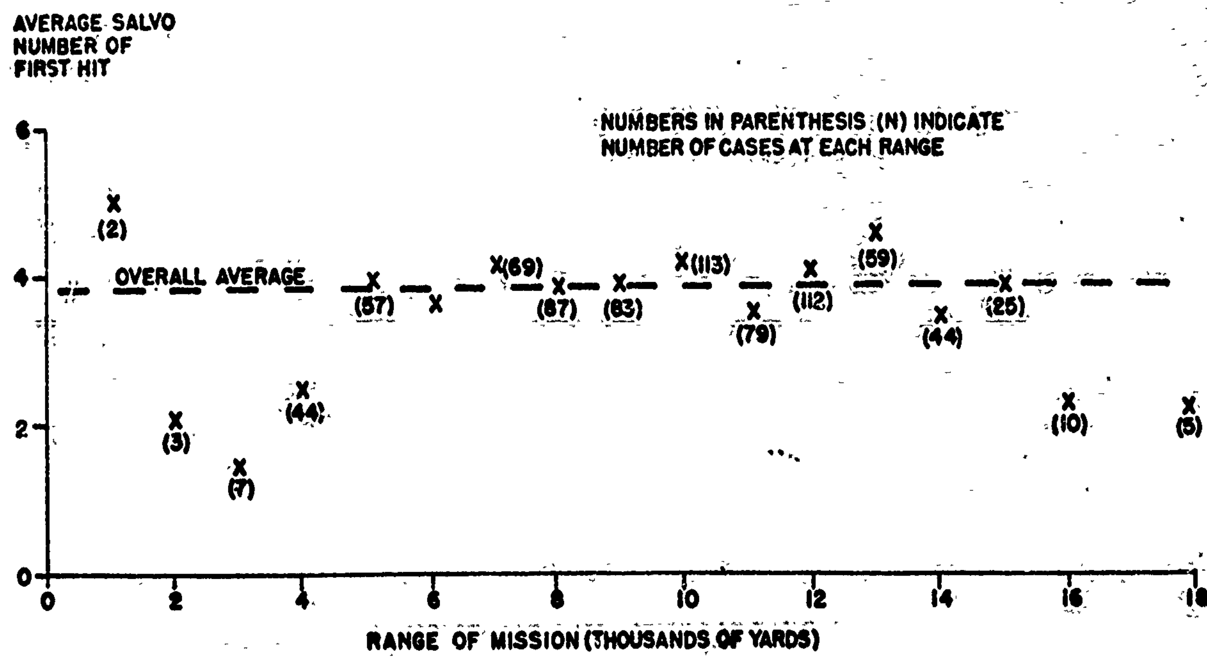

FIG. 8: EFFECTS OF RANGE OF MISSION ON SALVO NUMBER OF FIRST HIT: DESTROYER MISSIONS

Again, figure 9 shows the surprising result that, except for railroad bridges, no relationship between range and salvo number of first hit appears to exist. Furthermore, no significant difference exists between the 5-inch, 8-inch, and 16-inch batteries, and very nearly the same quite small average number of salvos (4) is required to hit all targets.

If figure 8 and 9 are taken at face value, the relative value of various calibers of projectiles can be estimated from the average number required for successful missions against various targets. The average numbers of rounds expended on successful missions against a number of specific targets are shown in table IX. The numbers in parenthesis indicate the number of cases included.

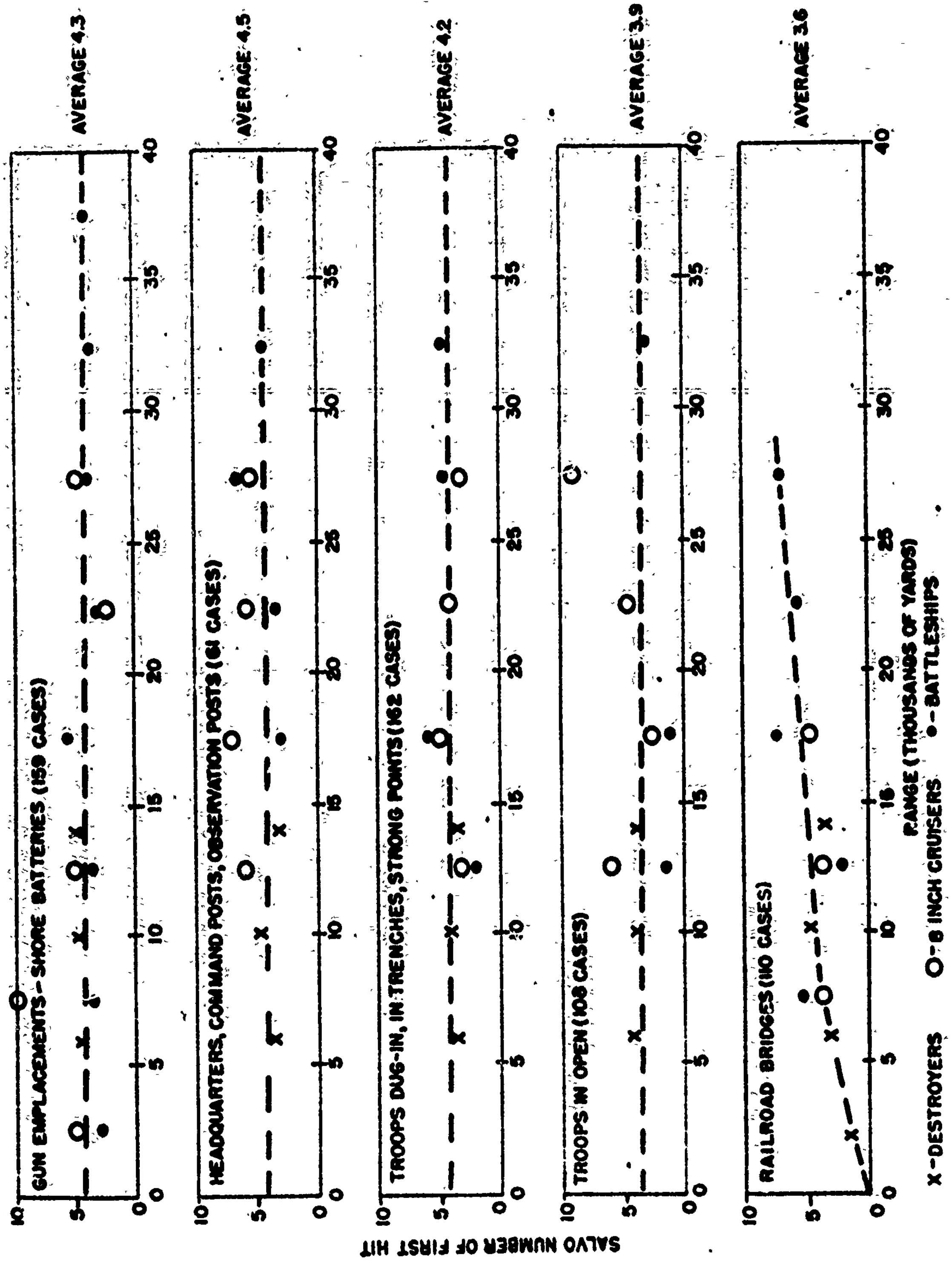

FIG. 9: RANGE VERSUS SALVO NUMBER OF FIRST HIT, ALL BATTERIES, REPRESENTATIVE TARGETS

TABLE IX

AVERAGE EXPENDITURES ON SUCCESSFUL MISSIONS
(NUMBER OF CASES IN PARENTHESIS)

Target	5-inch	8-inch	16-inch
Warehouses	14 (14)		
Landing craft and small boats	16 (33)		
Headquarters, command and observation posts	18 (17)	15 (12)	20 (11)
Machine gun emplacements and mortar positions	20 (11)	13 (10)	
Troops in open	20 (56)	16 (15)	15 (6)
Troops dug-in, in trenches, strong points	23 (31)	20 (45)	19 (40)
Highway bridges	25 (9)		16 (6)
Buildings	27 (34)		
Railroad bridges	30 (22)	28 (11)	25 (9)
Supply, fuel, ammo dumps	38 (24)	16 (11)	15 (4)
Areas (unspecified)	39 (92)	25 (7)	12 (6)
Railroad yards	40 (16)	38 (5)	22 (13)
Gun emplacements and shore batteries	44 (84)	29 (17)	13 (18)
Factories	45 (8)		
Railroad tracks	63 (8)	31 (11)	
Railroad tunnels	93 (5)		

If it is assumed the effect produced is proportional to the number of hits obtained and that, in accordance with figures 8 and 9, the expectation of a hit is independent of range and battery, the relative effectiveness per round of 16-inch rounds and 8-inch rounds compared to 5-inch rounds is shown in table X.

Reference (a) indicates that where fragmentation is the primary damage mechanism, the 16-inch projectile should theoretically be 5.9 to 10.6 times as effective as the 5-inch, and that the 8-inch should be 2.2 to 2.6 times as effective as the 5-inch. The comparable values in table X are uniformly much smaller, and cannot be entirely accounted for by the small size of the samples. It seems likely that considerable bias existed in the reporting of the salvo number of the first hit with the missions at longer ranges being credited with too great accuracy, so that the assumption of range independence for the probability of hitting based on these reports is not valid. This bias would occur if there were a uniform tendency to record the salvo number of the first hit only if it were small, for example.

TABLE X

RELATIVE EFFECTIVENESS OF 16-INCH AND 8-INCH ROUNDS COMPARED TO 5-INCH
(ASSUMING PROBABILITY OF A HIT IS INDEPENDENT OF RANGE)

Target	5-inch	8-inch	16-inch
Headquarters, command and observation posts	1	1.2	0.9
Troops in open	1	1.25	1.33
Troops dug-in, in trenches, strong points	1	1.15	1.20
Railroad bridges	1	1.07	1.2
Supply, fuel, ammo dumps	1	2.4	2.5
Areas	1	1.56	3.25
Railroad yards	1	1.05	1.82
Gun emplacements	1	1.5	3.4
Average (all targets)	1	1.41	1.79

An alternative explanation for the discrepancy between the results of table X and theory is that the standards adopted for assessing the 16-inch and 8-inch missions as successful were higher than for 5-inch. This would occur if observers were unable to see the effect produced very precisely and were influenced unduly by the number of projectiles fired. Since more 5-inch rounds were fired per mission, they would be credited with an undue effectiveness relative to heavy rounds. Also, observers might wish to give the small batteries a sense of accomplishment even when not very successful. It seems unreasonable that 5-inch projectiles should be more effective per round than 16-inch on headquarters, command posts, or observation posts, and nearly as effective against troops dug-in or against railroad bridges, as shown by table X.

Table XI shows the relative effectiveness of the heavy rounds compared to 5-inch if it is assumed the chances of hitting are inversely proportional to the square of the range, using the figures in table IX for expenditures per successful mission. The average ranges corresponding to the missions fired against each target are shown.

TABLE XI

RELATIVE EFFECTIVENESS OF 16-INCH AND 8-INCH ROUNDS COMPARED TO 5-INCH
(ASSUMING PROBABILITY OF HIT INVERSELY PROPORTIONAL TO SQUARE OF RANGE)

Target	16-inch		8-inch		5-inch	
	Average range (yards)	Relative effec-tiveness	Average range (yards)	Relative effec-tiveness	Average range (yards)	Relative effec-tiveness
Headquarters, command and observation posts	27,000	7.7	22,700	6.7	9,500	1
Troops in open	21,900	6.7	20,300	5.9	9,400	1
Troops dug-in	26,600	9.1	23,000	6.3	9,800	1
Railroad bridges	15,400	7.7	11,700	1.4	13,500	1
Supply, fuel, ammo dumps	26,800	16.7	21,500	9.1	10,800	1
Areas	20,500	14.3	17,600	5.0	9,800	1
Railroad yards	15,400	2.4	11,700	0.6	13,500	1
Gun emplacements	21,700	20.0	15,400	2.6	9,100	1
AVERAGE (all targets)	22,700	9.8	18,700	5.5	9,700	1

The ratios of effectiveness per round for the 16-inch projectile compared to 5-inch are more in line with the theoretical values. Now, however most of the ratios for 8-inch compared to 5-inch are very much on the high side and very nearly equal to those for the 16-inch. Either the 8-inch batteries were much more accurate than the 16-inch, or they were given too great credit for effect per hit.

Thus, it seems certain that standards of satisfactory results were not consistent for all battery types, and that accuracy-of-fire reports also may be unreliable. Consequently, reliable conclusions regarding mission effectiveness and combat accuracy cannot be drawn even from the large body of reports available for this study, and the tentative conclusions regarding accuracy and effectiveness in references (a), (b), and (c) are not verified.

V. WEAPONS SELECTION AND FORCE REQUIREMENTS

The previous section illustrates the impracticability of using visual observations of effectiveness and accuracy reported on the Gunfire Support Forms as the basis for weapons selection or estimates of force requirements, since none of the basic elements of the problem are derivable with sufficient reliability from these records. The use of proving ground tests of physical effects produced by various calibers or projectiles is probably the most efficient as well as the most reliable way to determine the relative value of the projectiles and fuzes for destruction of representative targets. Their relative value for harassment and neutralization is probably somewhat more difficult to determine, since their effectiveness for these purposes may be out of all proportion to physical effects produced and it may be difficult to establish the relationship outside a combat situation. Some studies during the last war indicated a relationship between degree of neutralization (as measured by friendly casualties per enemy tro , engaged) and the enemy casualty rate produced by the bombardment, which in turn was proportional to the size of the area of lethal fragments produced. Other studies implied a psychological effect proportional to duration and intensity of bombardment even with very small casualties. Considerable insight into the conditions producing neutralization or harassment might be gained from a study of the effects produced on our own troops by enemy fire of various intensities and estimated calibers. It is apparent that an observer some distance from impact area cannot obtain more than a very qualitative impression of the reactions of enemy troops under fire.

The study of the quantitative differences between spotting methods is also probably best done under controlled conditions not found in combat, and requires accurate measurement of the fall of shot and hits on target. However, no such program now exists.

The evaluation of the accuracy of shooting under combat conditions, another element in the estimation of force requirements, cannot at present be obtained from the Gunfire Support data. Again the use of photographic measurement of the fall of shot on at least a sample of missions appears to be required.

Available then as the only quantitative information on force requirements under combat conditions against various targets for various projectiles is table IX. However, as discussed previously, table IX applies strictly only to the conditions of employment during the period studied here, in particular the range to the target and the standards of success used by the observers, so that it is not very useful for predictive purposes. Also, no insight is gained into the conditions which would make one caliber projectile more desirable than another. Table IX indicates that as employed in Korea the 5-inch was always the most efficient battery, in terms of weight of rounds expended per satisfactory mission, since it takes 38 to 40 5-inch projectiles to equal the weight of a 16-inch round, and about 5 to equal the weight of an 8-inch round. The 5-inch satisfactory missions were also much cheaper than the heavier caliber satisfactory missions in cost of rounds expended, since about 22 5-inch rounds costs the same as a 16-inch round, and about 5 cost the same as an 8-inch round.

The importance of firm knowledge of the number of rounds of various projectiles required to give equivalent results at a given range against a specific target is illustrated in table XII. Table XII shows the fraction of 8-inch and 16-inch missions fired at various ranges, and consequently the extent to which they took targets under fire which were within range of the smaller guns.

About 1/5 of the missions for both batteries were fired within 5-inch range of the target, taking 15,000 yards as a conservative estimate of maximum effective 5-inch range. About 2/3 of the 16-inch missions were fired within 8-inch range of the target, assuming effective maximum range for 8-inch to be about 25,000 yards. However, about 20 percent of the 16-inch missions were at ranges greater than 30,000 yards, well beyond the reach of cruiser main batteries.

A question of interest, at present unanswerable, is whether the use of the heavy batteries at the ranges indicated in table XII represents an uneconomical or inefficient selection of caliber of gun for the target.

TABLE XII

DISTRIBUTION OF 16-INCH AND 8-INCH MISSIONS BY RANGE

Range (thousands yards)	16-inch Percent of missions	8-inch Percent of missions
Less than 5	0.2	1.3
Less than 10	5.0	9.0
Less than 15	19.1	21.3
Less than 20	31.0	50.0
Less than 25	67.3	90.1
Less than 30	80.0	100.0
Less than 35	93.0	
Less than 40	100.0	

VI. SUMMARY

During the eleven-month period from May 1951 through March 1952, 414,150 rounds and over 24,000 shore bombardment missions were fired by U. S. Navy ships off Korea.

Over 90 percent of these missions were fired by 5-inch batteries, mainly by destroyers.

The primary target of the destroyers was the enemy's transportation system.

The primary target of heavy cruisers and battleship main batteries was personnel.

Over half the destroyer missions and nearly two-thirds of the main battery missions of the heavy ships were for the purpose of destruction. The bulk of the remaining missions were for harassment, with neutralization accounting for less than 10 percent of the effort.

Over-all nearly half the missions were unobserved. Virtually all harassment missions were unobserved, but destruction missions were observed 70 to 80 percent of the time.

Expenditures on unobserved missions were generally so small that little success was likely.

On destruction missions over 2/3 of the 16-inch fire which was observed was reported highly successful. Over 1/2 the 8-inch observed fire was reported highly successful, and about 1/3 the 5-inch fire. Less than 1/5 the 6-inch observed fire was reported highly successful. However, there is evidence that criteria for success tended to favor the smaller batteries.

On destruction missions, over 80 percent of the observed fire was reported to be at least partially successful.

About 20 percent of the harassment and neutralization missions which were observed by destroyers were considered to be highly successful. Over 30 percent was estimated to have produced negligible results. Insufficient data are available for other ships.

The least effective type of spot is ship spot based on claims of mission effectiveness. No significant difference was found between ground spot and conventional aircraft or helicopter spot.

No spotting was used on about 1/3 of the missions. Heavy ship 5-inch batteries went without spot on nearly 3/4 their missions, however.

Cruisers and battleships had the more effective types of spotting available to them on nearly 2/3 their missions, while destroyers relied primarily on ship spot.

Accuracy of fire data appears biased and unreliable. The data available indicate an average of 4 salvos for first hit for all targets, all ranges, all spotting methods and all batteries. It is probable that only the more accurate missions were reported.

About 20 percent of the cruiser and battleship main battery missions were fired within 5-inch gunfire range of the target.

About 67 percent of the battleships 16-inch missions were fired within 8-inch cruiser range of the target.

Before reliable evaluation of the combat performance of ships' batteries against shore targets is possible, more accurate and reliable means for measuring accuracy and effectiveness than at present must be used.

Submitted by:

C. W. KARNS
Operations Evaluation Group

D. L. BROOKS
Deputy Director
Operations Evaluation Group

(LO)958-53
11 June 1953

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APPENDIX A

SAMPLE GUNFIRE SUPPORT CARD

GUNFIRE SUPPORT RECORD — **PACFLT EVALUATION GROUP**

Mail one (1) copy to:
PACFLT EVALUATION GROUP
CINCPACFLT HEADQTRS.
FLEET P.O., SAN FRANCISCO, CALIF.

CONFIDENTIAL WHEN FILLED IN

SHIP	NUMBER	DATE	SUNRISE	SUNSET
			HRS.	HRS.

LOCATION (LAT) (LONG)	PLACE NAME

TARGET (Type, Coordinates, Terrain) (One Mission Only Per Sheet if Possible)

✓	REQUESTED BY — CHECK APPROPRIATE BOX(ES)	✓	METHOD OF SPOTTING — CHECK APPROPRIATE BOX(ES)	✓	CLASSIFICATION — CHECK APPROPRIATE BOX(ES)
	1. PREINVASION BOMBARDMENT		0. NO INFORMATION		0. CLOSE SUPPORT
	2. SATURATION BOMBARDMENT		1. NO SPOTTING		1. DEEP SUPPORT
	3. SHORE FIRE CONTROL PARTY		2. DIRECT VISUAL SHIP SPOT		2. HARASSING
	4. AIR SPOT		3. SFCP OR OTHER GROUND SPOT		3. INTERDICTION
	5. TARGET OF OPPORTUNITY		4. AIRSPOT (OTHER THAN HELICOPTER)		4. COUNTERBATTERY
	6. DEFENSIVE (PROTECT OWN SHIP)		5. HELICOPTER		5. ILLUMINATION
	7. OTHER (SPECIFY)		6. OTHER (SPECIFY)		6. NEUTRALIZATION
					7. DESTRUCTION
					8. OTHER (SPECIFY)

TIME REQUESTED →	HOURS	MINUTES	TYPE OF FIRE → ☐ DIRECT ☐ INDIRECT

TIME TAKEN UNDER FIRE	TIME OF CEASE FIRE	SALVO NUMBER OF FIRST OBSERVED HIT (After Open Fire)

APPROXIMATE MEAN RANGE	TIME (After Open Fire) TO FIRST OBSERVED HIT

✓	EFFECT OF MISSION* — CHECK APPROPRIATE BOX(ES)	✓	VERIFICATION* — CHECK APPROPRIATE BOX(ES)	✓	VERIFICATION* — CHECK APPROPRIATE BOX(ES)
	0. UNOBSERVED, UNREPORTED OR NO REPORT AVAILABLE		0. NO INFORMATION		5. SPOTTER UNSUCCESSFUL IN ATTEMPT
	1. NO APPARENT RESULTS		1. UNOBSERVED (NO ATTEMPT MADE TO OBSERVE)		6. AERIAL RECON. BY HELICOPTER
	2. SOME EFFECT OBSERVED		2. OBSERVED BY SPOTTER		7. OBSERVED FROM SHIP
	3. LARGE EFFECT OBSERVED		3. OBSERVED AT A LATER TIME		8. PHOTOGRAPHIC RECONNAISSANCE
	4. MISSION COMPLETELY SUCCESSFUL		4. ESTIMATED FROM EFFECT UPON OPERATIONS		9. OTHER (SPECIFY)

NUMBER OF TARGETS IF MULTIPLE (Report Single Mission on Each Sheet if Possible)	WIND VELOCITY (Knots)

WEATHER & VISIBILITY (If Considered They May Have Affected Operations)

NUMBER OF ROUNDS

NUMBER	CALIBER & TYPE	CHECK ONE: FULL	CHECK ONE: REDUCED	FUZE

✓	CHECK APPROPRIATE BOX(ES) — COMMUNICATIONS
	1. SATISFACTORY
	2. NOT COMPLETELY SATISFACTORY BUT DID NOT IMPAIR SUCCESS OF OPERATION
	3. UNSATISFACTORY TO THE POINT OF MAKING MISSION DIFFICULT
	4. UNSATISFACTORY TO THE POINT OF MAKING MISSION UNSUCCESSFUL

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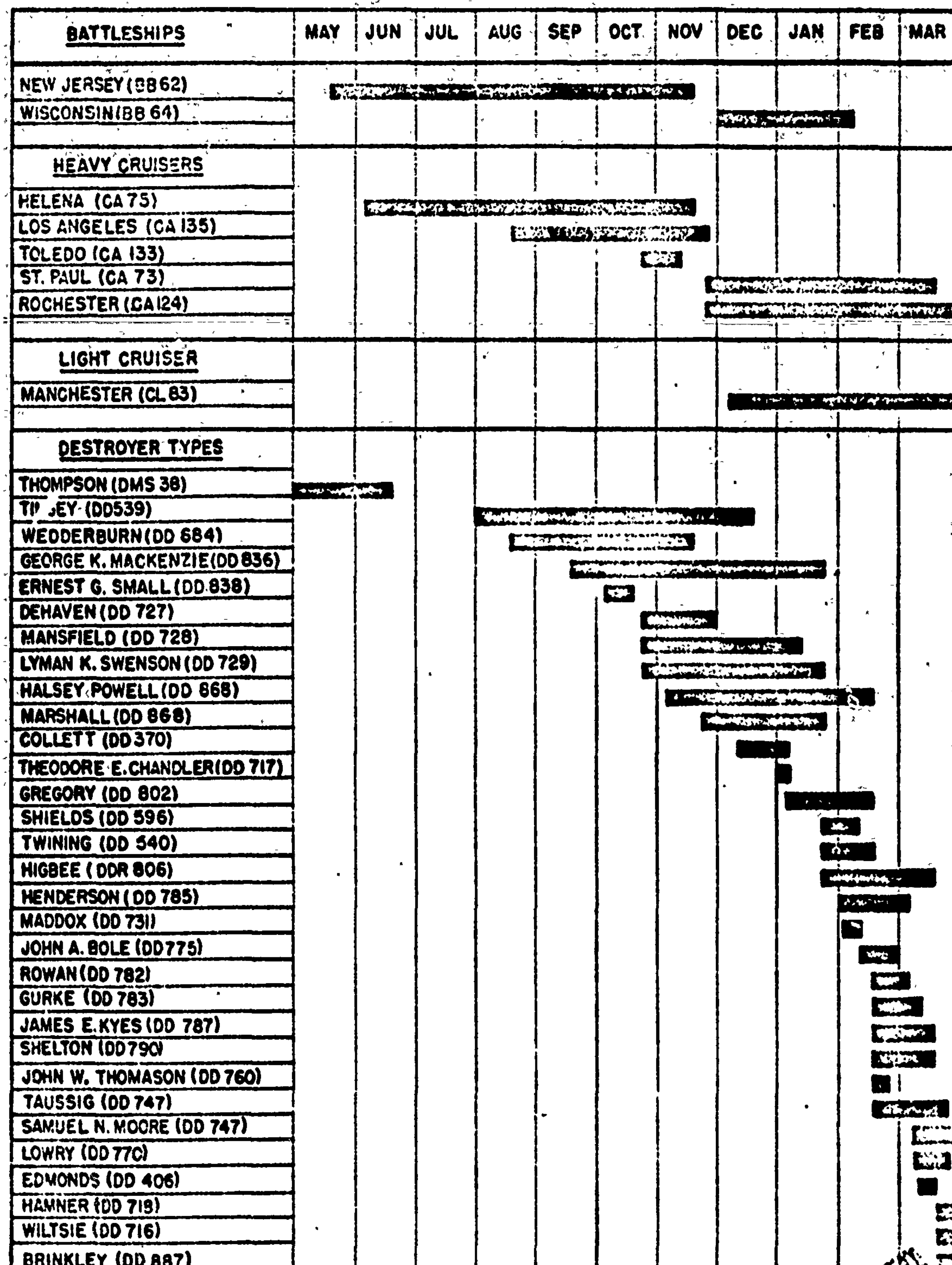
APPENDIX B

SHIPS AND PERIODS FOR WHICH GUNFIRE SUPPORT CARDS HAVE BEEN SUBMITTED SUBSEQUENT TO 1 MAY 1951



APPENDIX C

TARGET CLASSIFICATION

Weapon installations	Personnel	Transportation	Military installations	Areas	Shore installations	Naval
Gun emplacements	Troops in open	RR tracks	Supply dump	Assembly	Factory	Moored vessel
Machine gun emplacements	Troops dug-in	RR bridge	Fuel dump	Industrial	Dock	Beached vessel
Shore battery	Troops on roads	RR tunnel	Ammo dump	Waterfront	Warehouse	Landing craft
	Troops concen.	RR yard	Headquarters	Dock area	Ramping station building	Small boat
Bunker	Troops and guns	RR junction	Command post	Cities & towns		
Cover emplacement	Troops and tanks	RR rolling stock	Observation post	Warehouse area	Oil tanks	Tugs and barges
Mortar position	Troops and vehicles	Locomotive	Airfield		Electric power installation	
	Troops, tanks and artillery	Grade crossing highway	Radio station troop trenches or strong point	Illumination Town with troops		
	Troops and supply	Highway bridge Highway tunnel Highway traffic (moving) Highway junction Vehicle Concen. Horses, Bypass, Truck				

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11 June 1953

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APPENDIX D

DISTRIBUTION OF MISSIONS AND ROUNDS OF ALL BATTERIES BY MISSION PURPOSE AND TARGET CATEGORY

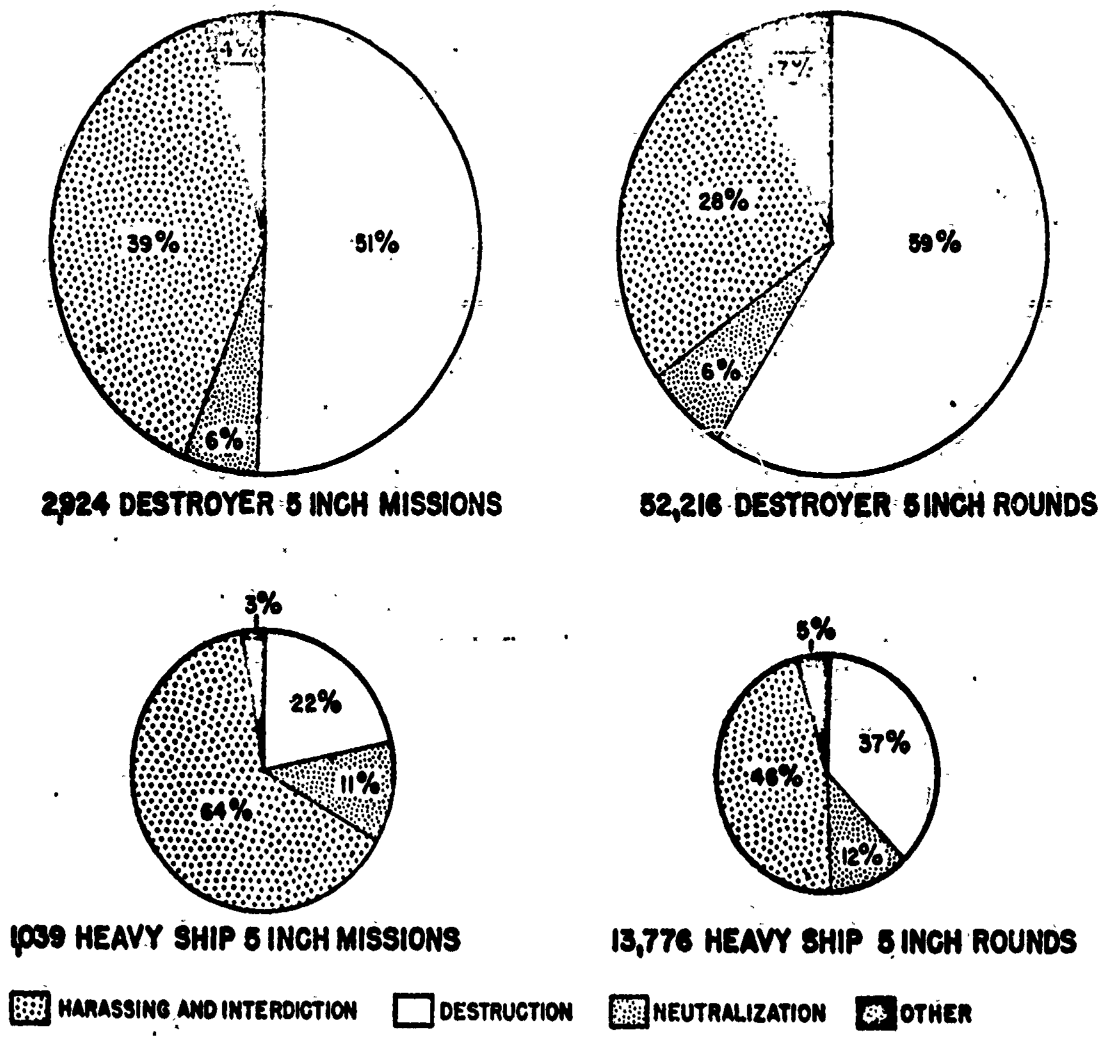

FIG. D-1: DISTRIBUTION OF 5-INCH MISSIONS AND ROUNDS WITH RESPECT TO MISSION PURPOSE
(AREAS OF CIRCLES ARE PROPORTIONAL TO NUMBERS OF MISSIONS (OR ROUNDS))

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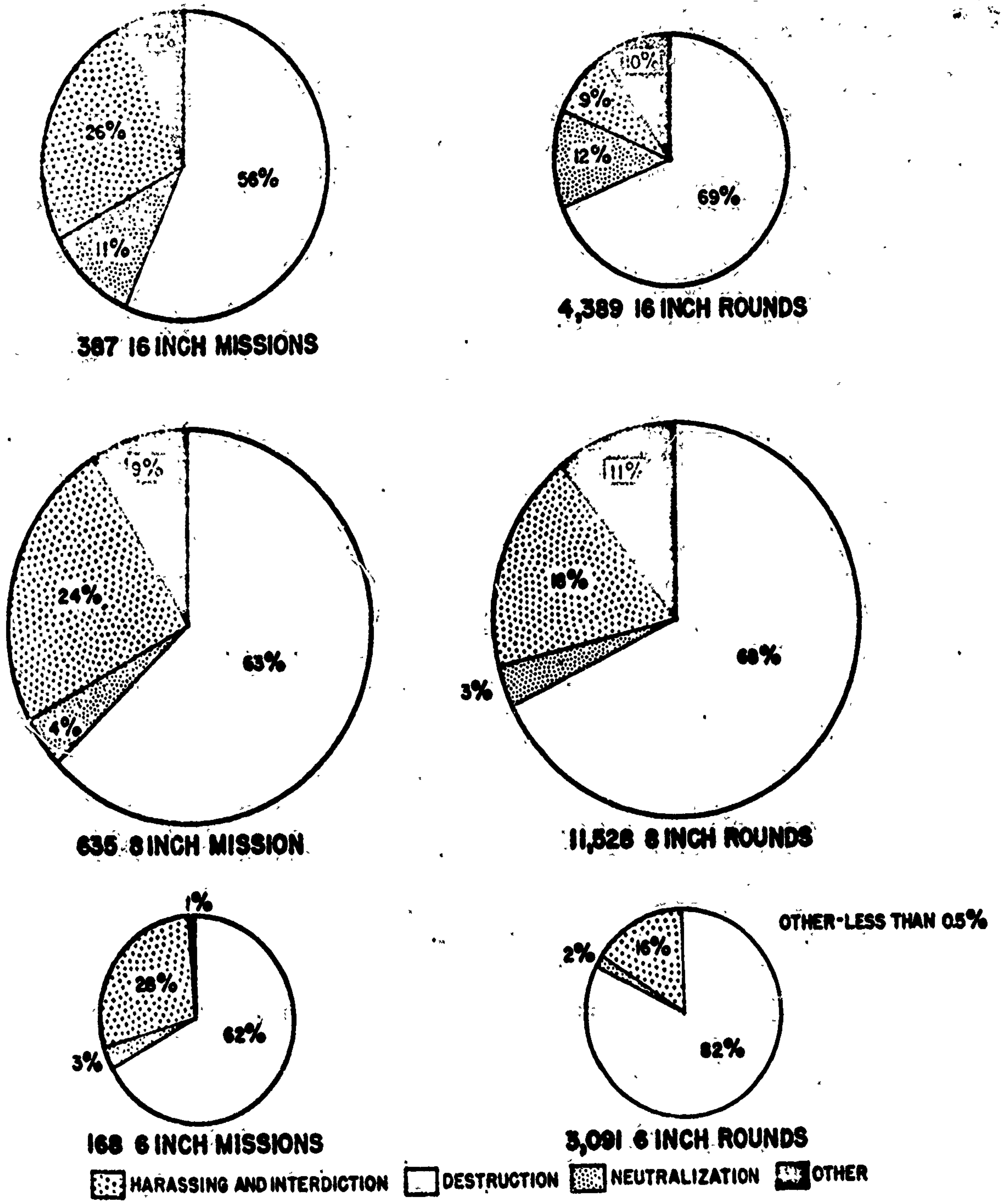

FIG. D-2: DISTRIBUTION OF 16-INCH, 8-INCH, AND 6-INCH MISSIONS WITH RESPECT TO MISSION PURPOSE
(AREAS OF CIRCLES ARE PROPORTIONAL TO NUMBERS OF MISSIONS (OR ROUNDS))

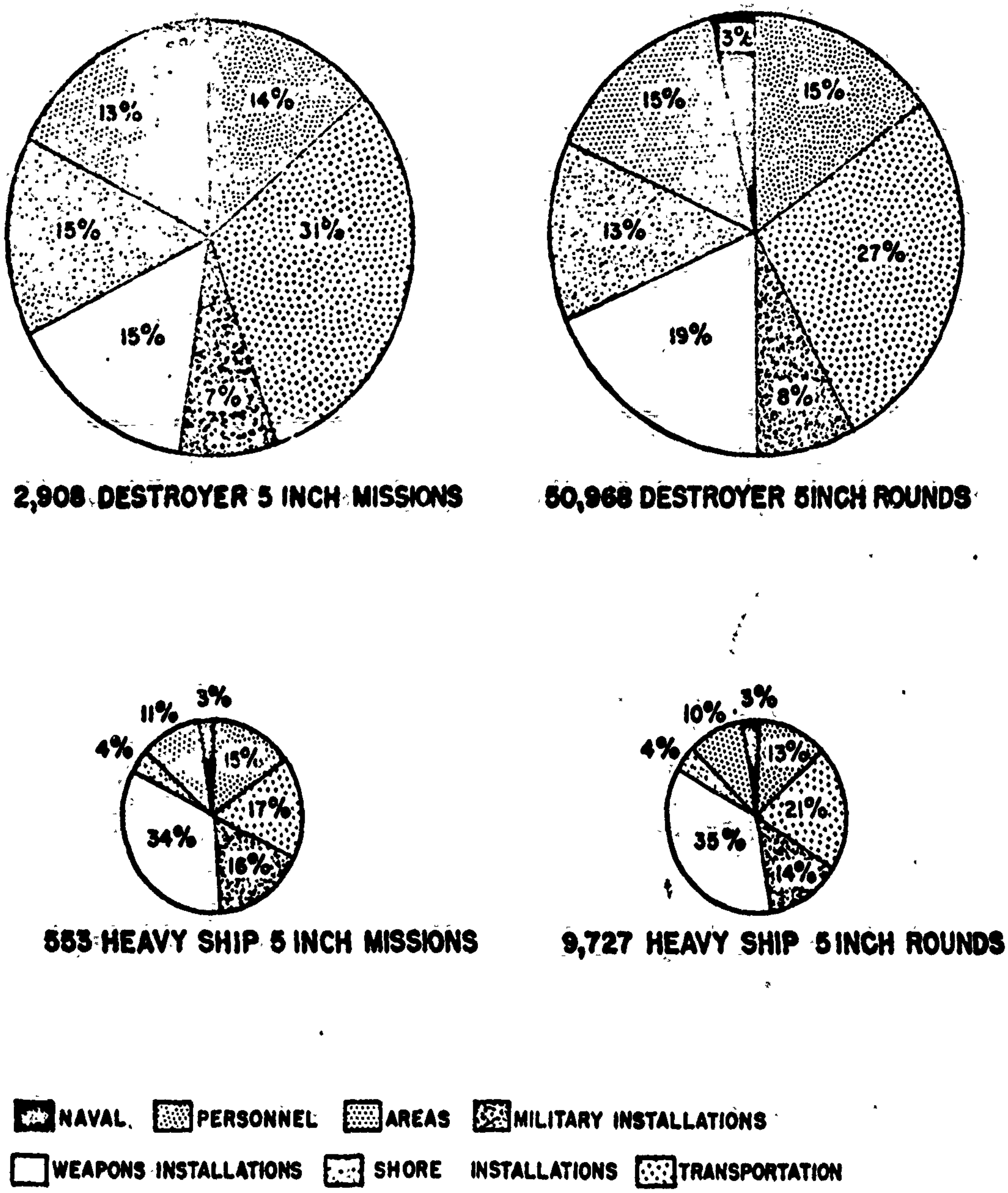

FIG. D-3: DISTRIBUTIONS OF 5-INCH MISSIONS AND ROUNDS
WITH RESPECT TO TARGET CATEGORY
(AREAS OF CIRCLES ARE PROPORTIONAL TO NUMBERS OF MISSIONS (OR ROUNDS))

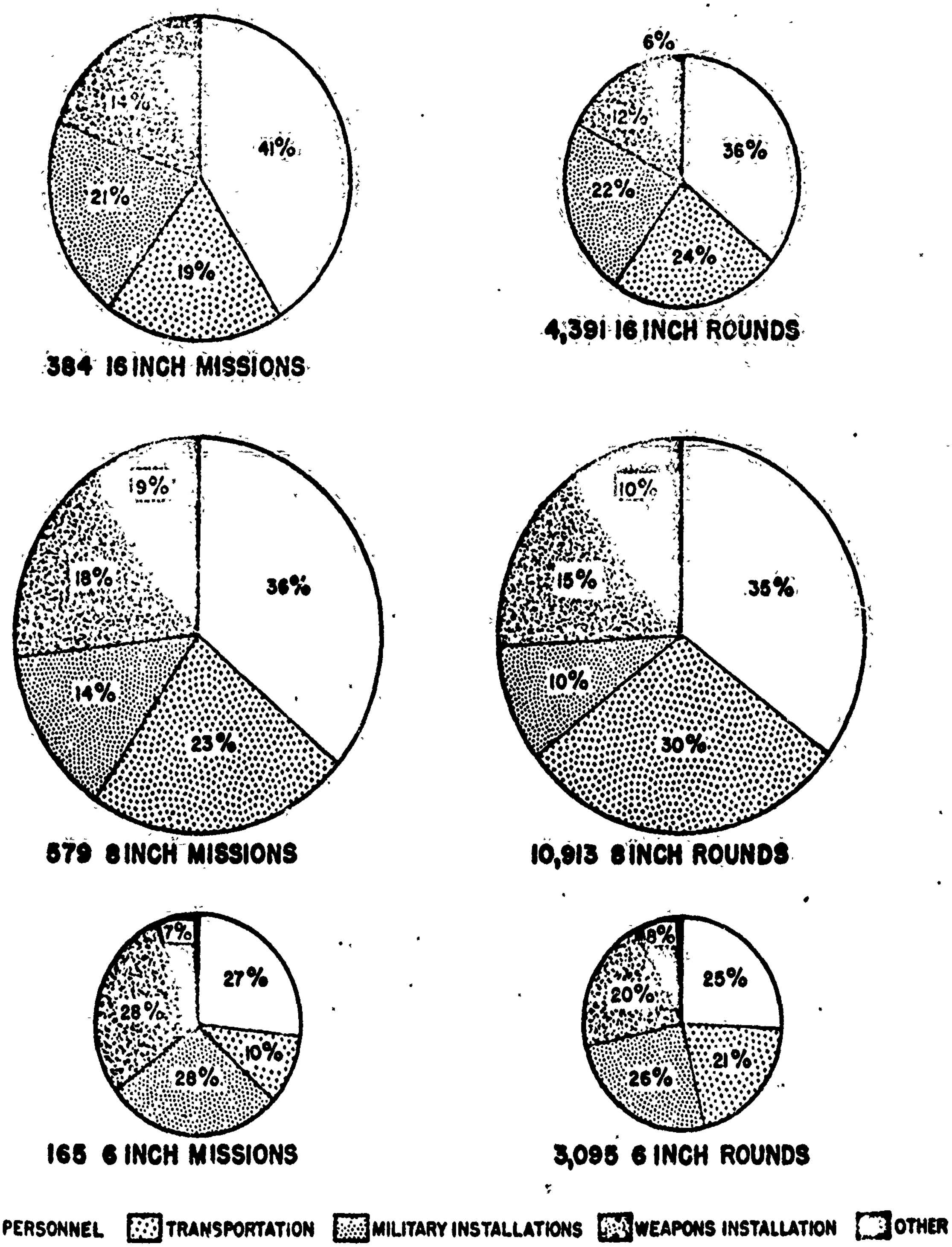

FIG. D-4: DISTRIBUTION OF 16-INCH, 8-INCH, AND 6-INCH MISSIONS AND ROUNDS WITH RESPECT TO TARGET CATEGORY
AREAS OF CIRCLES ARE PROPORTIONAL TO NUMBERS OF MISSIONS (OR ROUNDS))

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APPENDIX E

DISTRIBUTION OF MISSIONS AND ROUNDS OF ALL BATTERIES BY SPOTTING METHOD

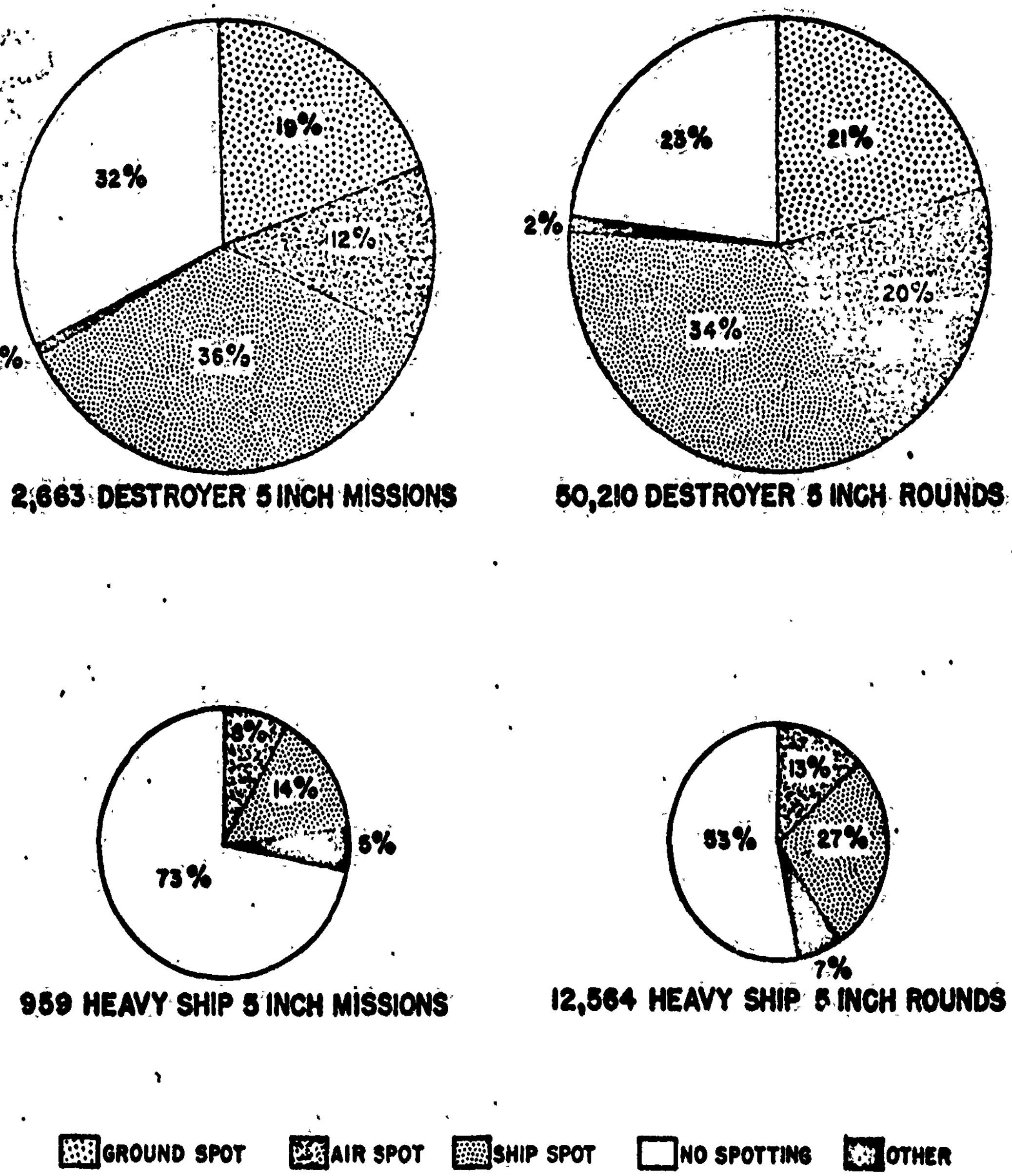

FIG. E-1: DISTRIBUTIONS OF 5-INCH MISSIONS AND ROUNDS WITH RESPECT TO SPOTTING METHOD
(AREAS OF CIRCLES ARE PROPORTIONAL TO NUMBERS OF MISSIONS (OR ROUNDS))

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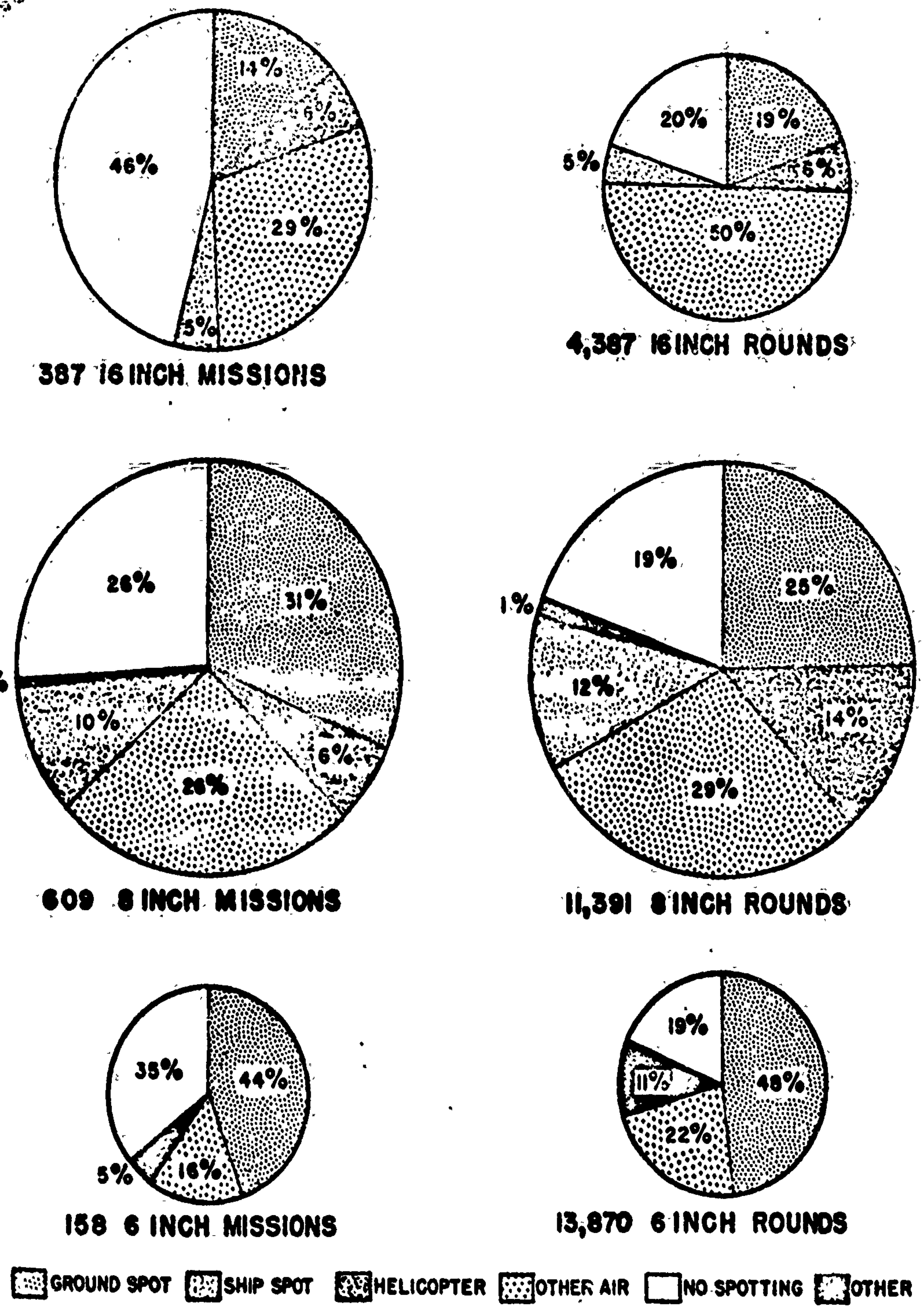

FIG. E-2: DISTRIBUTIONS OF 16-INCH, 8-INCH, AND 6-INCH MISSIONS AND ROUNDS WITH RESPECT TO SPOTTING METHOD
(AREAS OF CIRCLES ARE PROPORTIONAL TO NUMBERS OF MISSIONS (OR ROUNDS))

NUMBER OF MISSIONS	PERCENT OF MISSIONS WHICH WERE UNOBSERVED	SPOTTING METHOD	PERCENT OF OBSERVED MISSIONS WHICH WERE ASSESSED AS SATISFACTORY / LIMITED RESULTS / NO RESULTS	NUMBER OF OBSERVED MISSIONS
398	13	GROUND		348
258	11	AIR (OTHER THAN HELICOPTER)*		230
547	10	SHIP		490
10	10	OTHER		9
183	82	NO SPOT		33
84	61	UNSPECIFIED		33
1480	23	ALL SPOTTING METHODS		1143

FIG. E-3: EFFECTIVENESS OF DESTROYER 5-INCH BATTERIES IN DESTRUCTION MISSIONS (BY SPOTTING METHOD)

* 3 helicopter spotting missions included in "other"

NUMBER OF MISSIONS	PERCENT OF MISSIONS WHICH WERE UNOBSERVED	SPOTTING METHOD	PERCENT OF OBSERVED MISSIONS WHICH WERE ASSESSED AS SATISFACTORY / LIMITED RESULTS / NO RESULTS	NUMBER OF OBSERVED MISSIONS
20	10	GROUND		18
14	14	HELICOPTER		12
41	20	OTHER AIR		33
80	10	SHIP		72
46	98	NO SPOTTING		1
23	87	UNSPECIFIED		3
224	38	ALL SPOTTING METHOD.		139

FIG. E-4: EFFECTIVENESS OF HEAVY SHIPS' 5-INCH BATTERIES IN DESTRUCTION MISSIONS (BY SPOTTING METHOD)

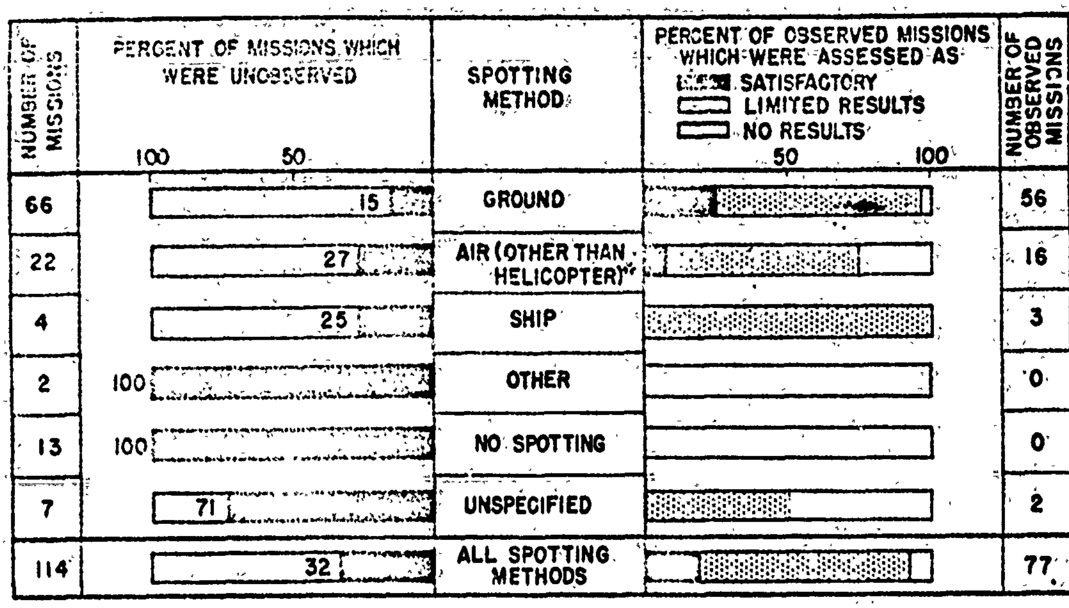

FIG. E-5: EFFECTIVENESS OF LIGHT CRUISER'S 6-INCH BATTERY IN DESTRUCTION MISSIONS (BY SPOTTING METHOD)

* No helicopter spotting

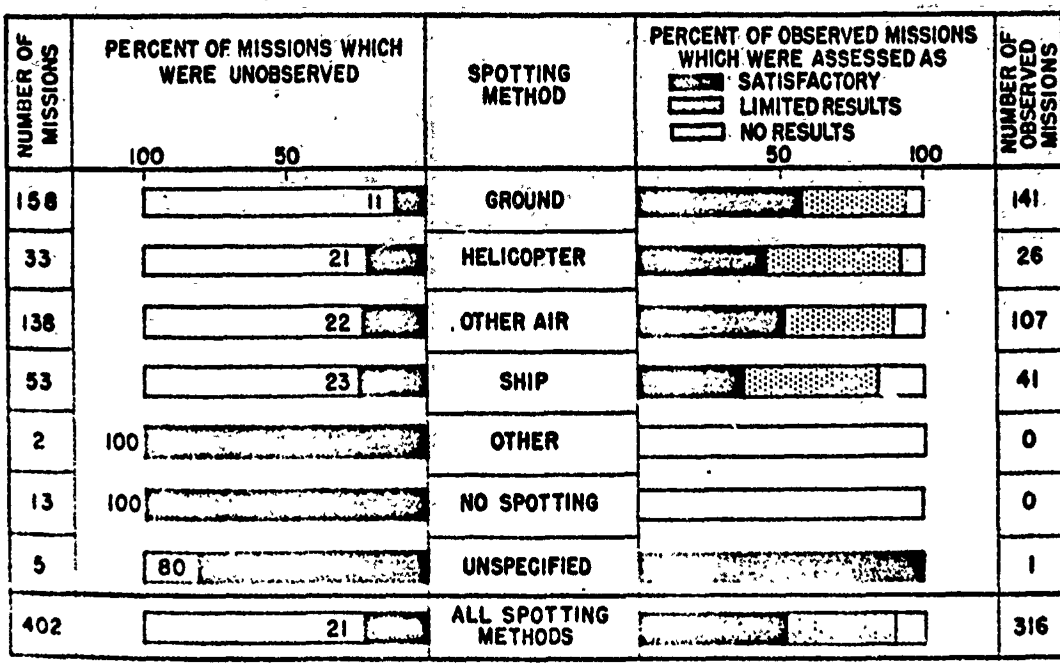

FIG. E-6: EFFECTIVENESS OF HEAVY CRUISERS' 8-INCH MISSIONS IN DESTRUCTION MISSIONS (BY SPOTTING METHOD)

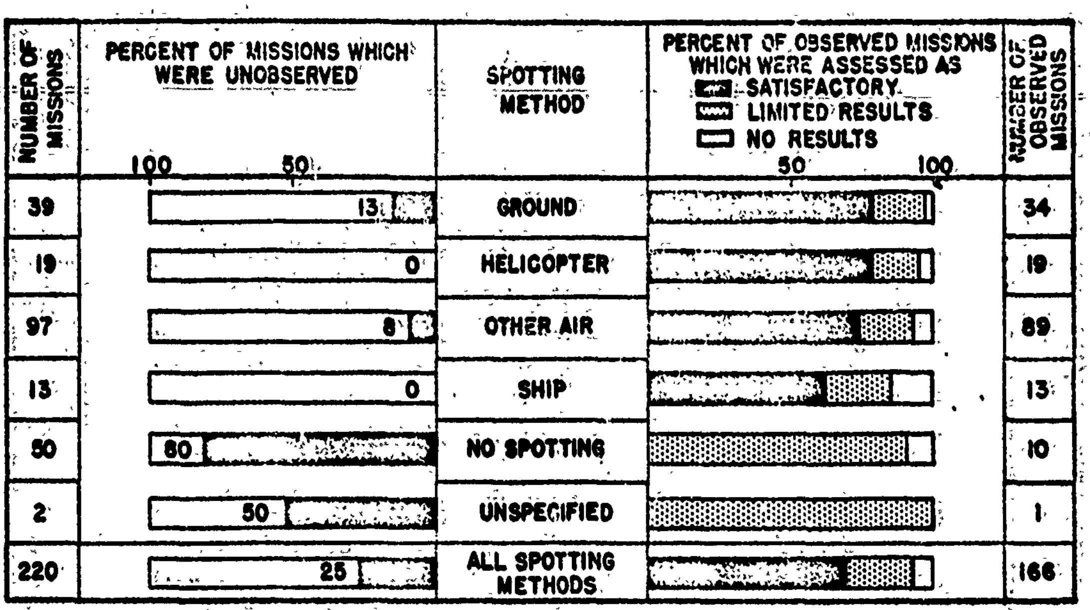

FIG. E-7: EFFECTIVENESS OF BATTLESHIPS' 16-INCH BATTERIES IN DESTRUCTION MISSIONS
(BY SPOTTING METHOD)