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WAR DEPARTMENT

Report [illegible]

EVALUATION OF MINEFIELD CLEARING DEVICES

13 September 194[illegible]

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Corps of Engineers, U. S. Army
Fort Belvoir, Virginia

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ARMY SERVICE FORCES
THE ENGINEER BOARD
FORT BELVOIR, VIRGINIA

FILE NO. 400.1 (DMS 476)

SUBJECT: Transmittal of Report 951, Evaluation of Minefield Clearing Devices

TO: Chief of Engineers, U. S. Army
ATTENTION: Research and Development Division

1. Transmitted herewith is "Report 951, Evaluation of Minefield Clearing Devices," dated 11 September 1945, which was prepared by the Technical Staff and has been considered by the members of the Engineer Board.

2. This report covers the evaluation of explosive minefield clearing devices against Japanese mines. The tests covered by this report were conducted at the Engineer Board Field Station, A. P. Hill Military Reservation, Virginia.

3. From these tests, it is concluded that the effectiveness of explosive minefield clearing devices varies with the soil conditions and the length of time the mines have been buried; that the Snake, Demolition, M3, is the best all-around antitank minefield clearing device tested; that the carpet roll torpedo, although not yet completely developed, offers promise, under suitable terrain conditions, of being the most efficient of the antipersonnel mine clearing devices tested, from the standpoint of weight of explosives used; that the explosive minefield clearing devices are not as effective against Japanese Type-3 land mines, horn-mines, yardstick mines, and Type-93 mines as against German T.Mi.'43 mines, because of the greater blast resistance of the Japanese mines; that, of the mines tested, the Type-3 mine is the most difficult to function by blast, and is insensitive to sympathetic detonation; that, of the more well-known Japanese mines, only the Type-93 mines and Dutch mushroom-top mines can be calibrated with the existing universal indicator mine; that for calibration with Japanese Type-3 mines, horn-mines and yardstick mines, modification of the universal indicator mine can be accomplished; and that there is an area at the lip of the crater, produced by a linear charge exploded on the ground, in which the blast is relatively ineffective against mines, but air-burst explosive mine clearing devices produce no crater and therefore no "skip effect" is present.

4. The Engineer Board concurs in the recommendations of the report, which are as follows:

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a. That a limited series of additional tests be conducted further to evaluate the effectiveness of mine clearing devices against blast-resistant mines not yet calibrated, using for this purpose the modified universal indicator mines at present being developed.

b. That tests be conducted to determine the effectiveness of explosive mine clearing devices against aircraft bombs and artillery shells employed as land mines.

FOR THE BOARD:

John W. N. Schulz

1 Incl. (in dup)
Report as above

JOHN W. N. SCHULZ,
Brigadier General, U. S. Army,
President.

C O N F I D E N T I A L

Report 951

EVALUATION OF MINEFIELD CLEARING DEVICES

Project DMS 476

11 September 1945

Submitted to

THE ENGINEER BOARD

Fort Belvoir, Virginia

and

The Chief of Engineers

U. S. Army

Washington, D. C.

FOR OFFICIAL ACTION

by

Giles L. Evans, Jr.
Lt. Col., Corps of Engineers
Engineer Board
Fort Belvoir, Virginia

C O N F I D E N T I A L

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EVALUATION OF MINEFIELD CLEARING DEVICES

I. SUBJECT

1. Scope. This report covers the evaluation of explosive minefield clearing devices against Japanese mines. As a part of the basic program, an attempt was made to calibrate the universal indicator mine against the various types of Japanese antitank mines.

The tests pertinent to the investigation were conducted at the Engineer Board Field Station, A. P. Hill Military Reservation, Virginia, by Mr. Norward A. Meador, Engineer, Civil, under the direction of Major James L. Bisch, Corps of Engineers. Analysis of the test data was executed by the Statistical Research Group, Princeton University, for the Applied Mathematics Panel, National Defense Research Committee.

II. AUTHORITY

2. Authority. The authority for this investigation is contained in a letter from the Chief of Engineers to the President, The Engineer Board, dated 21 November 1944, subject: Test of Mine-clearing Devices Against Japanese Mines (Work Order DDM 3350). A copy of this correspondence is contained in Appendix A.

III. PREVIOUS INVESTIGATION

3. Previous Reports. Work done prior to the tests reported herein is described in the nine Engineer Board interim reports covering the development of equipment for the passage of enemy minefields and in the following Engineer Board Reports:

No.	Title	Date
776	Carpet Roll Torpedoes for Destruction of Enemy Mines	19 October 1943
778	Demolition Snakes	30 October 1943
-	Development of Snake, Demolition, M2B1	13 September 1944
-	Development of Snake, Mine Clearing, Antipersonnel, T-1	27 October 1944
892	Development of Launcher, Rocket, Multiple, 10.75-inch, T-59, and Rocket, H.E., 10.75-inch, T-91	27 November 1944

No.	Title	Date
906	Detonating Cord Cable Kit	15 January 1945
929	Mine Clearing Dragon, M1	1 May 1945

A description and preliminary calibration of the universal indicator mine is contained in the "Instruction Manual for the Universal Indicator Mine" published on 14 October by the Office of Scientific Research and Development, National Defense Research Committee, Division 17.

IV. PRESENT INVESTIGATION

4. General. The primary purpose of this report is to provide estimates of the amount of clearance of enemy mines by the available and development models of explosive mine clearing devices. The basic estimates of the amount of minefield clearance by the devices are contained in a report, "Expected Clearance of German and Japanese Antitank and Antipersonnel Mines by Explosive Mine Clearing Devices," (AMP Report 178.1R, SRG-P No. 136) published by the National Defense Research Committee. The estimates of the amount of mine clearance are expressed in percentages so that they may be applied to formulae published by the Applied Mathematics Panel, National Defense Research Committee, "Expected Percent of Tanks Passing Through Minefields Without Striking Mines," (AMP Memo No. 178.2M, SRG-P No. 122).

a. Mine Clearing Devices. The devices with which tests were conducted, together with their principal characteristics, are tabulated for comparison purposes in Fig. 1.

b. Enemy Mines. Universal indicator mines were used in all tests to provide basic data. However, the accurate range of this indicator mine was not sufficient to measure the blast impulses required to detonate the more blast-resistant Japanese mines. Only the Type 93 (tape measure mine) and the Dutch mushroom-top mines could be calibrated against the universal indicator mine. Therefore, in evaluating the effectiveness of mine clearing devices against other types of Japanese mines, American made replicas were used.

In addition to the known Japanese mines, simulated German mines were placed in the test minefields for the purpose of comparison, and in anticipation of the possibility that the Japanese might develop mines having similar characteristics. Listed below are the types of Japanese and German mines that were considered in this investigation:

Japanese

Type 3 Land Mine (Flowerpot)
AB, T13 Beach Mine (Double horn mine)

COMPARISON OF EXPLOSIVE MINE CLEARING DEVICES

Device	No. of Tests	Explosive Casing	Explosive	Charge Weight (lb/ft)	Overall Weight (lb/ft)	Length of Device (ft)
ANTITANK MINE CLEARING						
Snake, Demolition, M2	5	Steel	80/20 Amatol*	10.0	31.0+	400
Snake, Demolition, M2 (M1 bangalore loaded)	2	Steel	80/20 Amatol*	14.4	39.79	400
Snake, Demolition, M2A1	2	Aluminum alloy	80/20 Amatol*	14.0	37.5	400
Snake, Demolition, M3	2	Aluminum alloy	80/20 Amatol*	14.0	20.25	400
Mine Clearing Dragon, M1	5	Fiberglas impregnated with neoprene	Liquid Explosive EL382A or Methylite 25	4.5	4.69	300
Projected Line Charge, M1	1	Nylon	C-2	4.0	--	300
Rocket H.E., 10.75", T91	4	Steel	TNT	This rocket contains 250 lb of explosives and has a total weight of 330 lb.		
ANTIPERSONNEL MINE CLEARING						
Carpet Roll Torpedo	17	Textile	PETN Detonating Cord	0.216	0.9	100
Rocket Propelled Bangalore Torpedoes	4	Steel	80/20 Amatol**	1.8	2.8	100
Snake, Mine Clearing, Antipersonnel, M1	2	Paper	TNT	0.67	1.6	100
Cable, Detonating, Mine Clearing, Antipersonnel, M1	8	Textile	PETN Detonating	0.08	0.11	300

* Equipped with booster charge of 6" crystalline TNT at each section end.
** Equipped with booster charge of 4" crystalline TNT at each section end.

FIG. 1. COMPARISON OF EXPLOSIVE MINE CLEARING DEVICES.

AE, T14 Beach Mine (Single horn mine)
Yardstick Antitank Mine
Type 93 Antitank Mine
Dutch Mushroom-top Mine

German

Tellermine '43
"S" Mine
A-200, Mustard Pot Mine
Schumine

5. Description of Tests.

a. Antitank Mine Clearing Devices. Special minefield test patterns were designed by the Statistical Research Group, Princeton University, to provide mine placements offering the greatest variety of positions. With the exception of the Rocket, H.E., 10.75-inch, T-91, all antitank mine clearing devices tested were linear charges. Consequently, for linear charges the mines were buried at intervals in rows perpendicular to the charge, while for the Rocket, H.E., 10.75-inch, T-91, the mines were buried at intervals in concentric circles about the charge. Typical tests with each type of charge are illustrated in Figs. 2 and 3.

As previously stated, universal indicator mines were used in all tests. The determination of the location of indicator mines was based upon these considerations, quoted from AMP Report 178.1R, SRG-P No. 136:

"1. Mines were placed within the region where the mine-clearing device was reasonably effective in order that a large number of observations would be obtained in the critical region which is of primary interest. The most distant mines were located at a place where from 25 to 50 percent of the German T.Mi'43 mines were expected to be detonated. Some data on the effectiveness of the various explosive devices against T.Mi'43 mines were available in the Interim Reports of the Army Engineer Board on Equipment for the Passage of Enemy Minefields. These data were used to determine the maximum distance at which it was considered efficient to plant the Universal indicator mines.

"2. Some mines were placed near the edge of the crater to evaluate the "skip effect".*

"3. To study the effect of depth of burial, mines were buried at three depths -- 2, 4 and 6 inches.

"4. Approximately 10 mines were buried in each row on each side of the charge in order to determine the variation in clearance with distance from charge.

"5. Ten mines were planted at each distance for each depth in order to obtain reliable average readings.

"6. Since the blast is stronger at the middle of a linear charge than at the ends, the three depths of burial were made in adjacent rows. On the first two tests, the first and last rows were laid at the ends of the charged part of the device, and it was found that indicator readings within 10 feet of the ends were much lower than those nearer the middle. These data were not used in calculating the average readings. In all later tests, the first rows were planted 30 feet from the ends of the charge."

b. Antipersonnel Mine Clearing Devices. The same general methods used in setting up the field plans for testing antitank mine clearing devices were used to design the field plans for the antipersonnel mines. Since the clearing devices for antipersonnel mines were shorter than those for antitank mines, and more types of mines were being tested, it was possible to use only four groups of mines. Some of each type of mine under test were planted in each group, instead of having all of one type in one group, in order that the results would not be biased by possible variations in blast intensity along the length of the charge. Typical tests with each type of antipersonnel mine clearing device are illustrated in Figs. 4, 5, 6, and 7.

c. Ground Conditions. The effectiveness of explosive mine clearing devices depends to some extent on the ground conditions. As all of the tests were conducted at A. P. Hill Military Reservation, only one type of soil, clay loam, was available. However, as the tests were conducted during a period covering winter, spring and summer,

* The "skip effect" is the lack of effectiveness of an explosive charge against those mines on the lip of the crater produced by the charge.

a variety of climatic conditions was available, which considerably affected the condition of the available soil. It was indicated that wet soil, or frozen soil, considerably reduced the effectiveness of a mine clearing device. Likewise, mines that had been in the ground for a considerable length of time were observed to be somewhat more blast resistant. In one test with an M2 demolition snake against mines that had been in the ground for four weeks, fewer mines were cleared and the skip effect at the edge of the crater was more pronounced.

6. Methods of Analysis of Data. For mines calibrated with the universal indicator mine, the problem of analysis can be stated as follows: Given an average of several indicator readings, what percentage of the individual readings would, on the average, be equal to or greater than 30, 75 or 90? In order to solve this problem, the average indicator readings obtained from all the tests were divided into the following groups on the basis of the average reading: 20-29.9, 30-39.9, . . ., 140-149.9, 150-155.9, 156 and larger. For each group, the individual readings were then arranged in order of magnitude, and a record made of the readings which were exceeded by each of the following percentages of the total mines in the group: 99, 95, 90, 75, 50, 25, 10, 5, and 1 percent. Thus, if there were 20 averages of 10 readings in a given group, there would be 200 individual readings in this group. If these 200 readings were ranked from high to low, the 10 percent value, for example, would be the 20th reading from the top. In this way, nine percentage readings were obtained for each group. They are plotted in Fig. 8 for each group, and smooth curves drawn through them. Three horizontal lines have been drawn to indicate the readings necessary to detonate a Dutch mushroom-top, a German T.Mi.'43, and a Japanese J93 mine. These readings are 30, 75, and 90, respectively. The average indicator reading given by the intersection of the T.Mi.'43 line with the 95 percent curve, for example, is such that, on the average, 95 percent of the T.Mi.'43 mines would be detonated. It is seen that this average is 136. Hence, if the average indicator reading is 136, 95 percent of T.Mi.'43 mines buried under similar conditions would be expected to be detonated.

In order to estimate the expected percentage of Dutch mushroom-top, T.Mi.'43, and J93 mines which would have been detonated under conditions producing a given average indicator reading, the intersection of points of the Dutch, T.Mi.'43, and J93 lines, with the nine percentage curves in Fig. 8 were plotted on probability paper and three smooth curves drawn through the points in Fig. 9. From these curves, it is possible to estimate the expected percentage of Dutch, T.Mi.'43, and J93 antitank mines, which would have been detonated under conditions producing any given average indicator reading.

Percentages have been derived only for the T.Mi.'43 and J93 mines (Appendix B). However, the same method can be employed

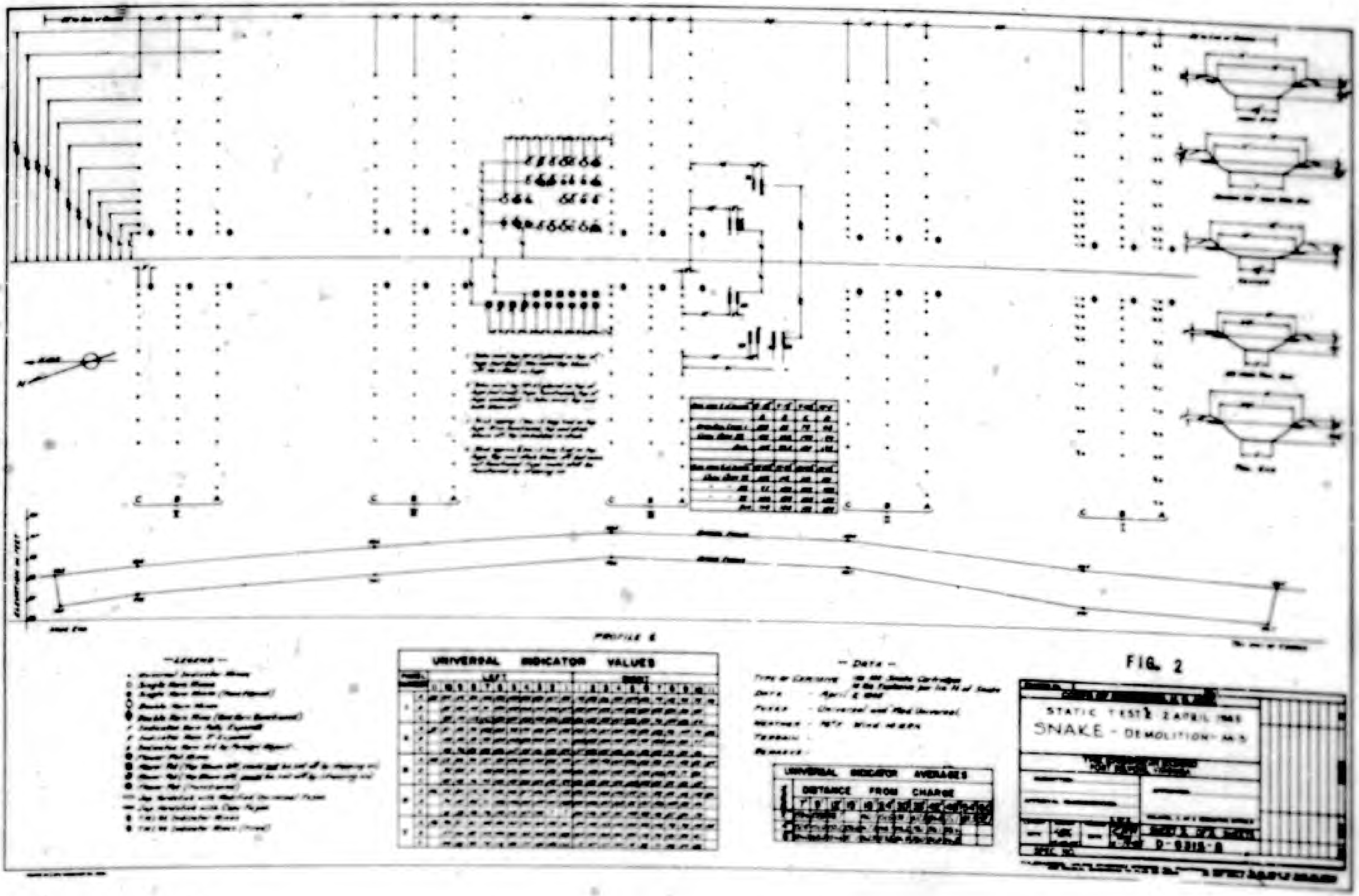

UNIVERSAL INDICATOR VALUES
- DATA -
UNIVERSAL INDICATOR AVERAGES
DISTANCE FROM CHARGE
STATIC TEST 2 APRIL 1963
SNAKE - DEMOLITION M3

FIG. 2

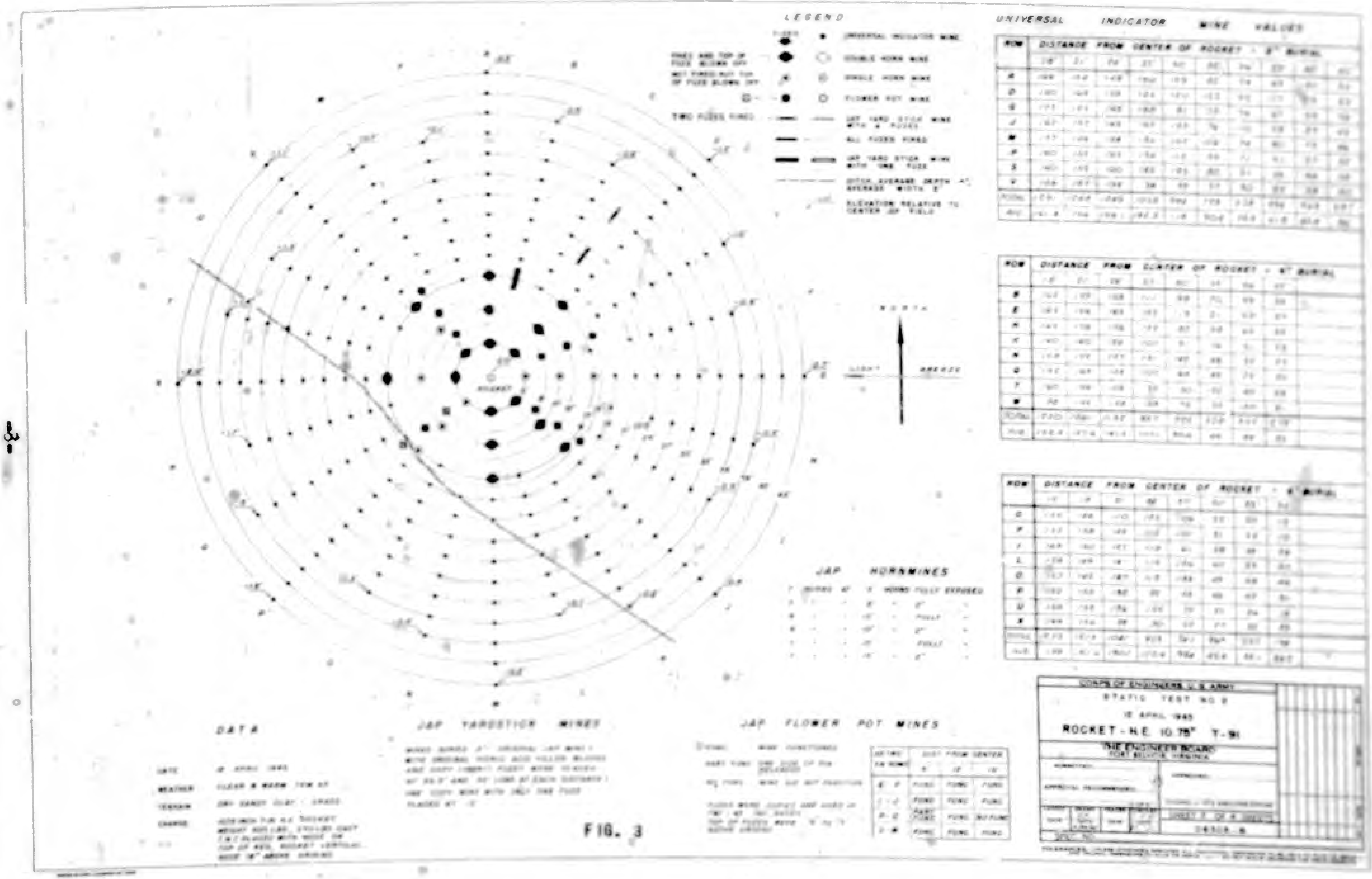
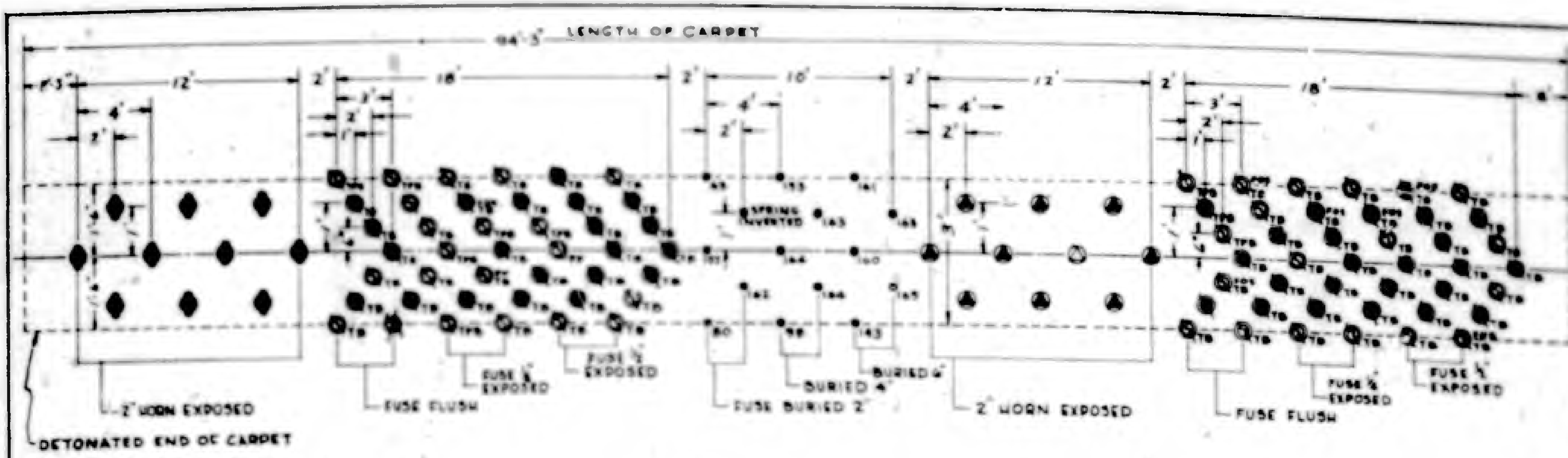

LEGEND
UNIVERSAL INDICATOR MINE VALUES
DISTANCE FROM CENTER OF ROCKET
NORTH
ROCKET
JAP HORNMINES
DATA
JAP YARDSTICK MINES
JAP FLOWER POT MINES
STATIC TEST NO 2
12 APRIL 1945
ROCKET - H.E. 10.75" T-91

FIG. 3



LEGEND

- UNIVERSAL INDICATOR MINE
- DOUBLE HORN MINE FIRED
- SINGLE HORN MINE
- SINGLE HORN MINE FIRED
- FLOWER POT MINE HAZARDOUS
- FLOWER POT MINE FIRED
- FLOWER POT MINE SHATTERED
- FLOWER POT MINE SHATTERED & FIRED
- T.B. TOP BLOWN
- T.P.B. TOP PARTIALLY BLOWN
- F.O.S. FUSE ON SIDE
- P.F. PARTIALLY FUNCTIONED

DATA

DATE • 31 MAY 1945 , 1430 HOURS
WEATHER • CLEAR , 75° F
TERRAIN • SANDY LOAM
FUSES • UNIVERSAL, JAP TYPE 3, JAP HORNS
TYPE OF EXPLOSIVE • CARPET ROLL TORPEDO 3'-0" x 94'-3"
24 SINGLE STRANDS OF DET. CORD PER FOOT. STRANDS PARALLEL TO LONG AXIS SPACED ½" APART
CARPET PLACED 4" ABOVE GROUND
.144 LBS. OF EXPLOSIVE PER SQ. FT.

FIG. 4

CORPS OF ENGINEERS, U. S. ARMY
THE ENGINEER BOARD, FORT BELVOIR, VIRGINIA

SUBMITTED:	STATIC TEST #18	DRAWN RH DATE 26 JUNE 45	TRACED DATE	CHECKED KH DATE 27 JUN 45
APPROVED:	11 MAY 1945	SHEET 18 OF 19 SHEETS		
	CARPET ROLL	B 6309-S		

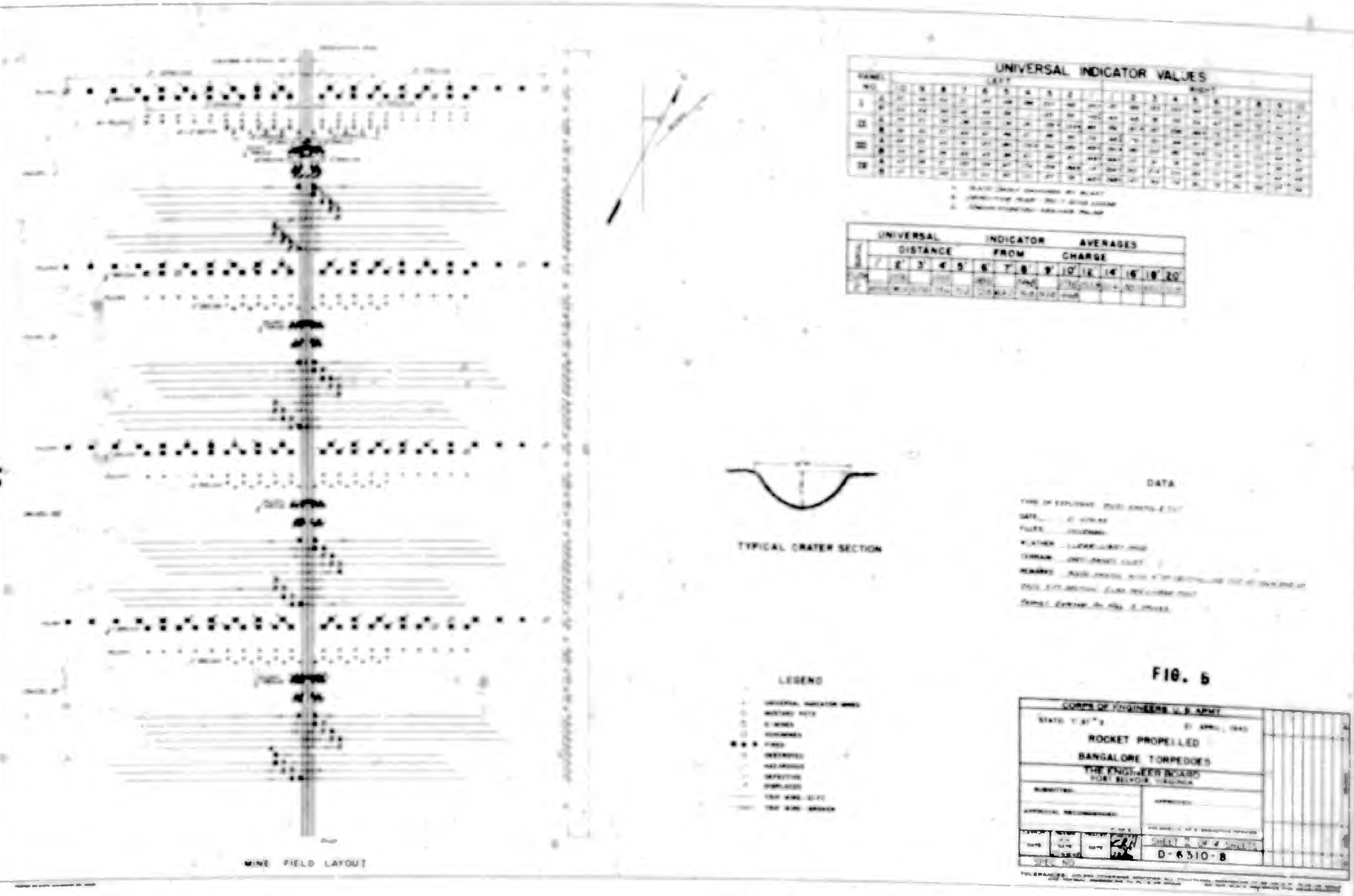

UNIVERSAL INDICATOR VALUES
UNIVERSAL INDICATOR AVERAGES
DISTANCE FROM CHARGE
TYPICAL CRATER SECTION
DATA
LEGEND
MINE FIELD LAYOUT
CORPS OF ENGINEERS U.S. ARMY
ROCKET PROPELLED
BANGALORE TORPEDOES
THE ENGINEER BOARD
FORT BELVOIR, VIRGINIA
D-6310-8

FIG. 5

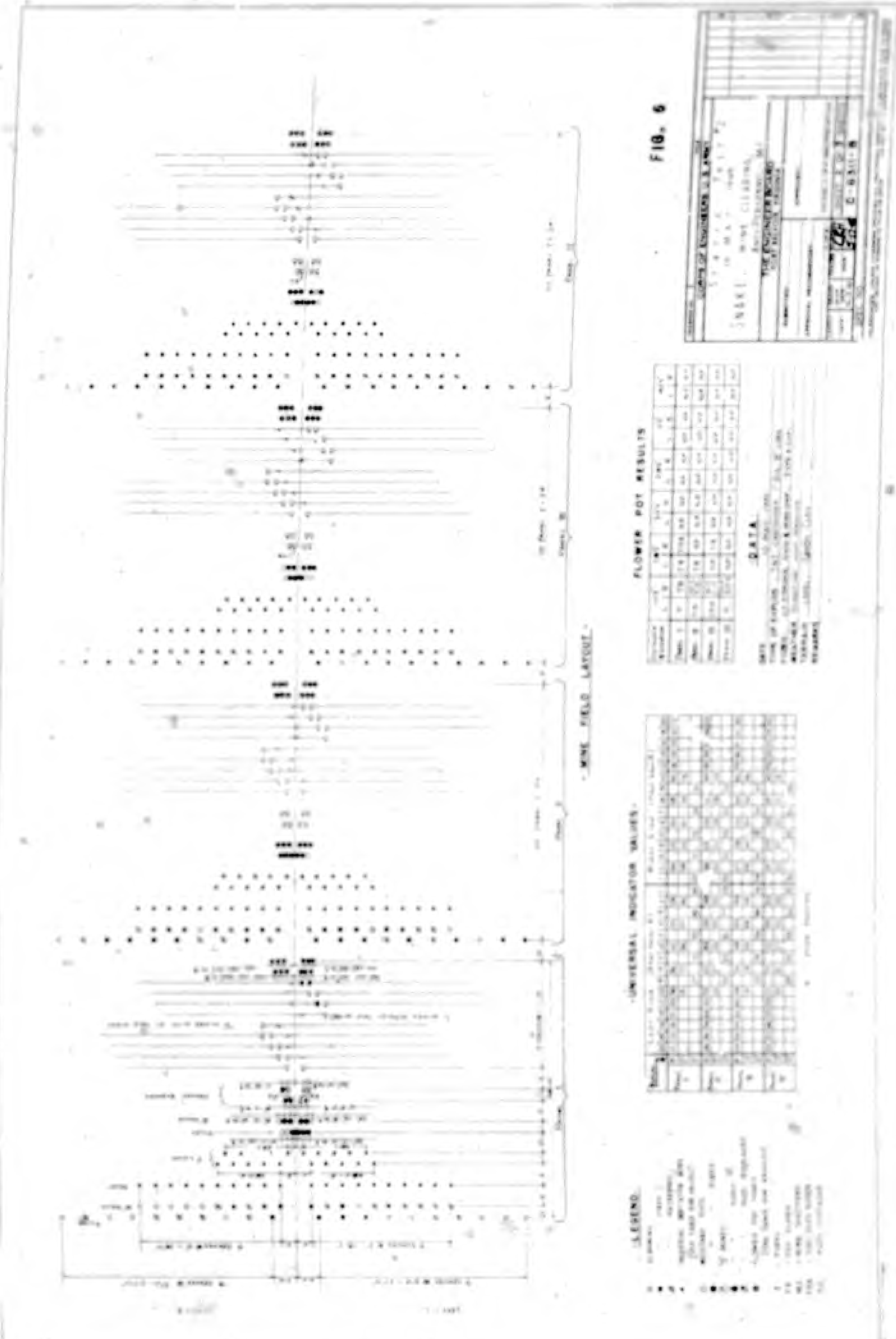
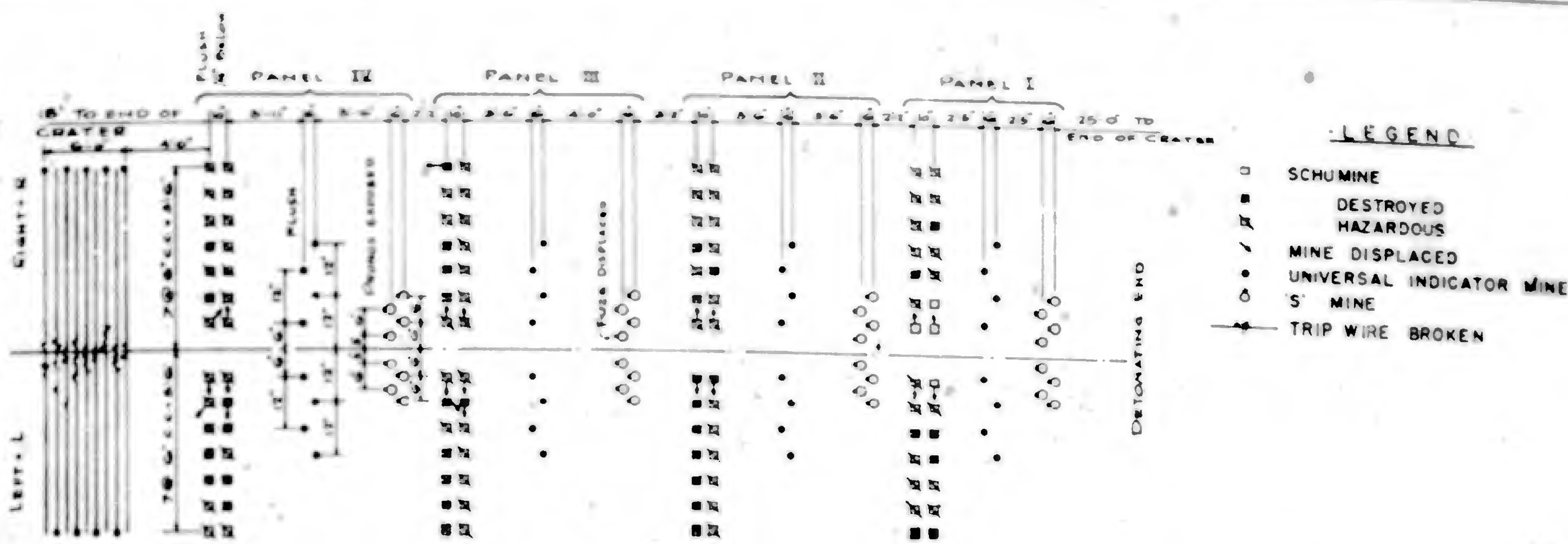


FIG. 6
MINE FIELD LAYOUT
UNIVERSAL INDICATOR VALUES
FLOWER POT RESULTS
DATA
LEGEND
CORPS OF ENGINEERS, U.S. ARMY
THE ENGINEER BOARD



MINE FIELD LAYOUT

UNIVERSAL INDICATOR VALUES									
DISTANCE FROM CENTER		6"		12"		18"		24"	
		L	R	L	R	L	R	L	R
PANEL Nº	I	18	10	12	19	14	19	22	25
	II	34	15	16	11	23	40	18	28
	III	83	16	18	15	17	23	20	31
	IV	27	20	13	30	20	16	30	59
TOTALS		162	59	59	73	74	98	90	144
AVERAGE		28		11		21		29	

DATA

DATE 9 MAY, 1946
FUZES M00 M2, US 3 PRONG & UNIV
WEATHER COOL, CLEAR
TERRAIN FLAT, MOIST, SANDY LOAM
TYPE OF EXPLOS. 80' LENGTH OF TNT CABLE WITH 1 STRAND DETONATING AND 1/8" WIRE CORE

FIG. 7

CORPS OF ENGINEERS, U. S. ARMY
THE ENGINEER BOARD, FORT BELVOIR, VIRGINIA

SUBMITTED:	STATIC TEST 3 9 MAY, 1945	DRAWN W.F. DATE 28-5-45	TRACED DATE	CHECKED KRH DATE 5/29/45
APPROVED:	CABLE, DETONATING, MINE CLEARING, ANTI-PERSONNEL.	SHEET 3 OF 8 SHEETS		
		B-6312-C		

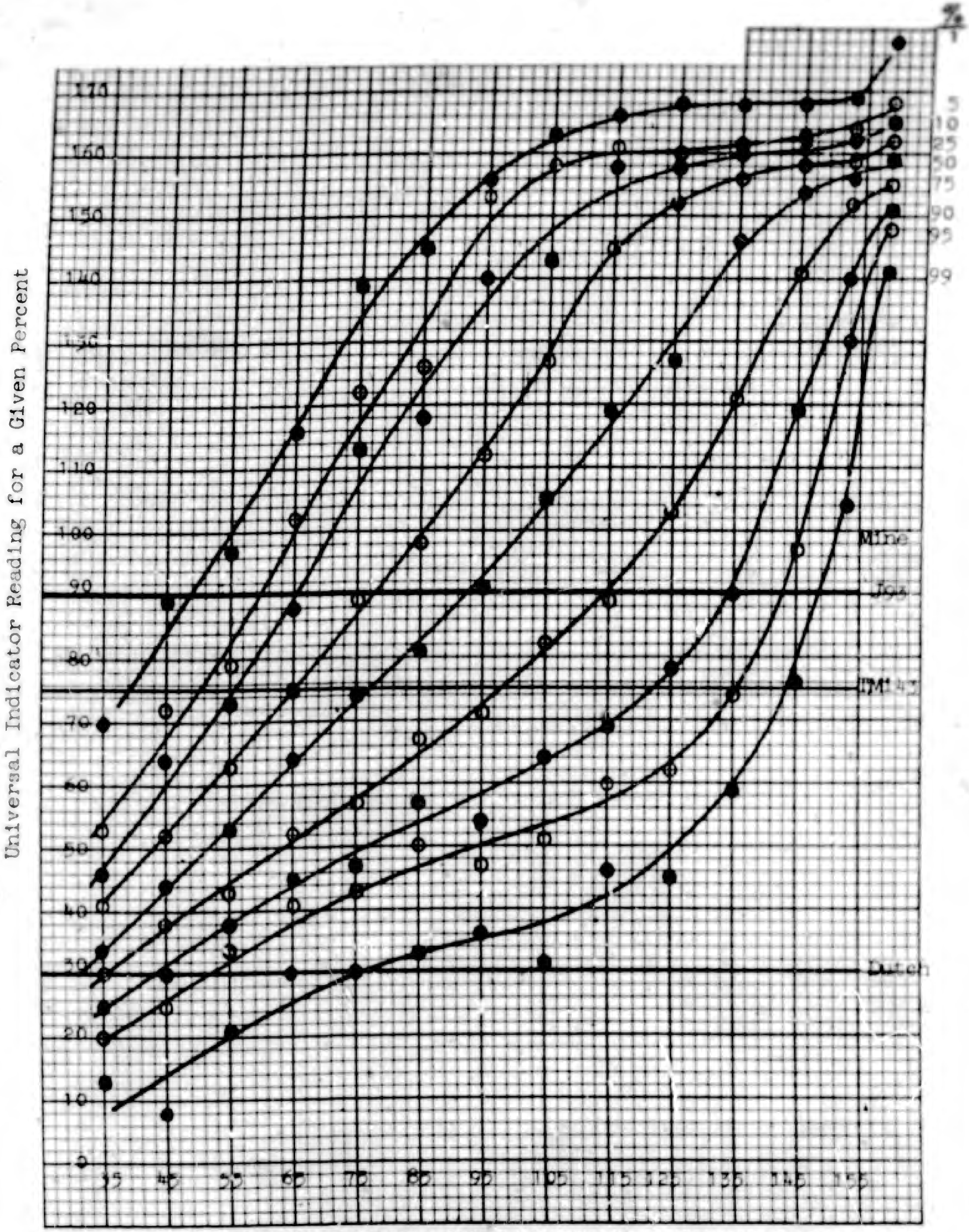


FIG. 8. PERCENTAGE POINTS FOR A GIVEN AVERAGE UNIVERSAL INDICATOR READING.

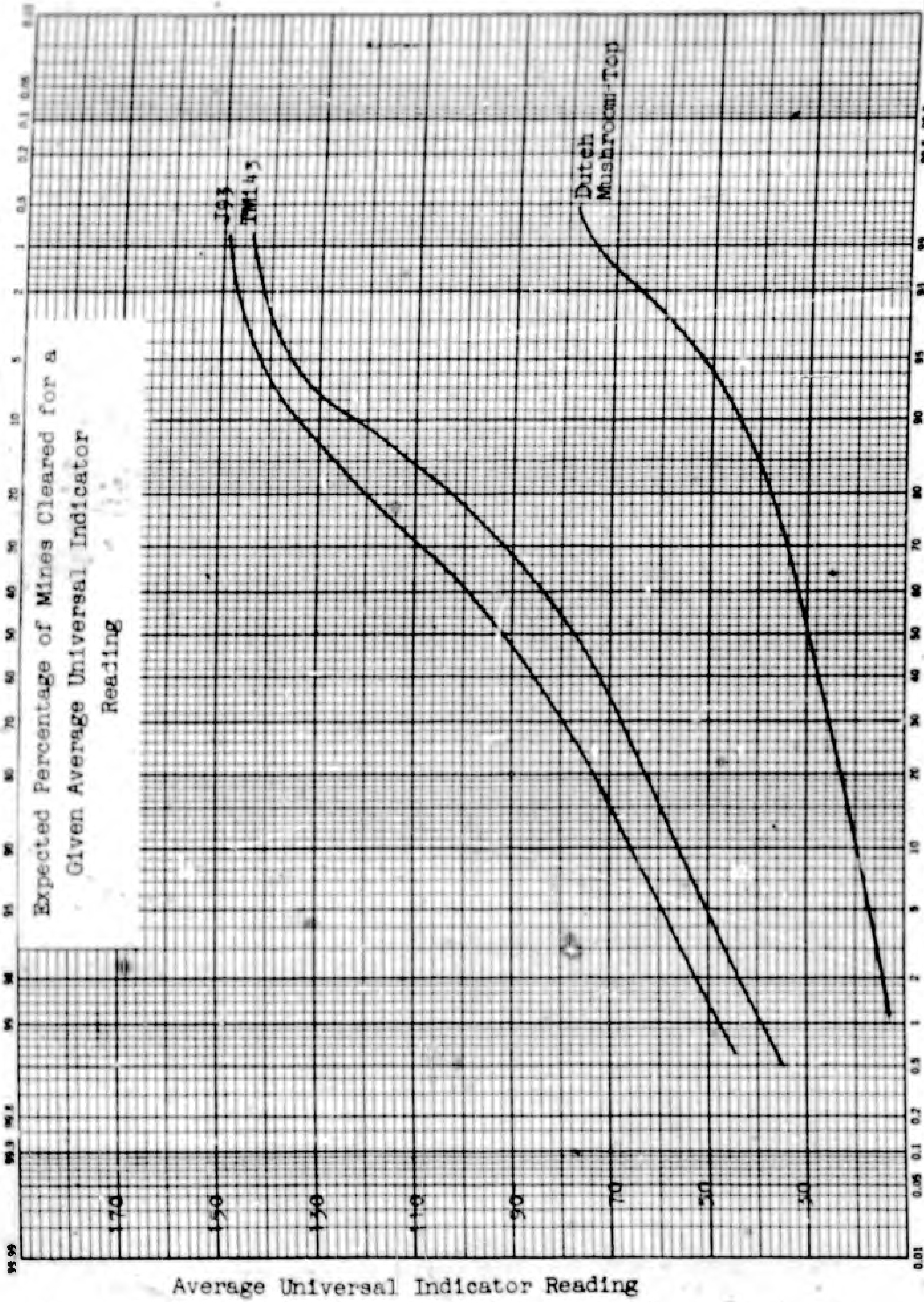


FIG. 9. EXPECTED PERCENTAGE OF MINES CLEARED FOR A GIVEN AVERAGE UNIVERSAL INDICATOR READING.

for any mine which is calibrated with the universal indicator mine. All that is needed is the detonation value corresponding to the 75 and 90 readings for the T.Mi.'43 and J93 mines, respectively. Using this value, a straight line would be drawn parallel to the 75 and 90 lines. The nine intersection points of this line with the nine percentage curves would determine a probability curve like those in Fig. 9. From this curve, one could read the expected percentage of mines detonated at a given distance from the charge, knowing the average indicator reading at that distance.

Graphs showing the effectiveness of the various explosive devices against Dutch mushroom-top mines have not been drawn. However, the horizontal line for this mine is given in Fig. 8, and the intersection points with the percentage curves are used to determine the probability curve in Fig. 9.

No antipersonnel mines and few Japanese antitank mines have been calibrated with the universal indicator mines. The results of explosive tests against mines not calibrated with the universal indicator mines have been summarized simply by tabulating the number of mines tested and detonated at a given distance from the device. However, the expected percentage of antipersonnel mines cleared has been computed and is also shown in the graphs contained in Appendix B.

Some universal indicator mines were used on the tests of antipersonnel mine clearing devices. The average indicator readings can be used to estimate the effectiveness of these devices against antitank mines. For example, the carpet roll 18 inches above the ground had an average indicator reading of 155 for mines buried 4 inches, and 168 for mines buried 2 inches, when these mines are under the carpet. All J93 and T.Mi.'43 mines would be expected to be cleared at either depth. For those mines buried on the edge of the carpet, the averages were 74 for mines buried 4 inches and 127 for mines buried 2 inches. The universal indicator reading of 74 corresponds to a 21 percent chance of detonating J93 mines and a 44 percent chance of detonating T.Mi.'43 mines. The 127 reading corresponds to an 85 percent probability of detonating J93 mines, and 91 percent for T.Mi.'43 mines.

7. Results of Antitank Mine Clearing Devices for Japanese Mines Not Calibrated with the Universal Indicator Mine. The data are limited on Japanese mines (AB-T13, AB-T14, yardstick, and Type 3) which cannot be calibrated with the universal indicator mine, because adequate replicas were not procurable until late in the testing program. Consequently, curves showing the expected percent of the mines cleared have not been constructed. In lieu of the curves, the results are presented in Figs. 10 and 11.

A consolidated analysis including the data given in the above-mentioned tables is given in Figs. 12, 13, 14, 15, 16, and 17.

ANTITANK MINE CLEARING DEVICES VERSUS JAPANESE HORN MINES
(AB-T13 and AB-T14 MINES)

Device	Soil Condition	Distance from Device							
		8 feet		15 feet		20 feet		25 feet	
		Horns Tested	Horns Fired	Horns Tested	Horns Fired	Horns Tested	Horns Fired	Horns Tested	Horns Fired
		Horns Fully Exposed (4")							
M2 Snake	Ball in hand	14	10	15	5	10	2		
M2 (Bangalore Snake)	Fairly Dry	4	4	5	3				
M2A1 Snake	Wet	7	3	7	0	2	0	2	1
M3 Snake	Fairly Dry	6	5	8	5	7	7	5	1
3" Hose	Fairly Dry	10	10	10	7	10	0	10	0
3" Hose (1)	Wet	10	10	10	0	10	0	10	0
10.75" Rocket	Dry	6	6	7	7				
10.75" Rocket	Ball in hand			8	8	8	7	16	3
		Horns 2" Exposed							
M2 Snake	Ball in hand	10	0	10	0	10	1		
M3 Snake	Fairly Dry	5	0	5	2	5	4	5	1
3" Hose	Fairly Dry	10	7	10	4	10	0	10	0
3" Hose (1)	Wet	10	8	10	0	10	0	10	0
10.75" Rocket	Dry	6	6	7	7				
10.75" Rocket (2)	Ball in hand	8	8	8	8	8	5		

(1) 10 horns each of 4 and 2 inch exposure were also buried 4 feet from the nose on this test; all were fired.

(2) 8 horns were buried completely at each of 5 and 10 feet from the charge; 4 and 3 were fired, respectively.

FIG. 10. ANTITANK MINE CLEARING DEVICES VERSUS JAPANESE HORN MINES AB-T13 AND AB-T14.

ANTITANK MINE CLEARING DEVICES VERSUS JAPANESE YARDSTICK MINES

Device	Soil Condition	Distance from Device							
		8 feet		12 feet		15 feet		20 feet	
		Fuzes		Fuzes		Fuzes		Fuzes	
		Tested	Fired	Tested	Fired	Tested	Fired	Tested	Fired
M2 Snake (1)	Ball in hand	18	4			4	3		
M2 Snake (2)	Ball in hand	12	3	8	0	6	1		
M2A1 Snake	Wet					15	1		
M3 Snake	Fairly dry	16	16			4	4	12	12
3" Hose	Fairly dry	4	4			4	2	4	1
3" Hose (3)	Wet			4	4	12	6		
10.75" Rocket (4)	Dry					1	1	4	4
10.75" Rocket (5)	Ball in hand							12	12

(1) Mines in ground one week.
(2) Mines in ground four weeks.
(3) 3 out of 9 fuzes were fired at 3 to 4 feet, and 3 out of 3 fuzes at 5 feet.
(4) 2 out of 4 fuzes were fired at 30 feet.
(5) 0 out of 12 fuzes were fired at 30 feet.

ANTITANK MINE CLEARING DEVICES VERSUS JAPANESE CERAMIC TYPE 3 MINES (FLOWER POTS)

Clearing Device	Soil Condition	Number of Fuzes Tested and Fired*					
		Distance from Device					
		4 feet	8 feet	12 feet	15 feet	18 feet	21 feet
M2 Snake	Ball in hand		11(0,0,0)	11(0,1,0)	11(0,1,0)	1(0,0,0)	10(0,0,0)
M2A1 Snake	Wet		1(0,0,0)	1(0,0,0)			
M3 Snake	Fairly dry		7(0,3,0)	11(2,2,0)	1(0,0,0)	1(0,0,0)	
3" Hose	Fairly dry		6(0,4,0)	3(0,2,0)			
3" Hose	Wet	10(5,0,0)	10(1,1,5)	10(1,0,3)	10(0,0,0)		
10.75" Rocket	Dry		4(3,1,0)	4(4,0,0)	4(3,1,0)		
10.75" Rocket	Ball in hand	4(4,0,0)	8(4,0,4)	8(2,0,6)	8(0,0,8)	8(3,0,4)	8(4,0,2)

* First number is number tested. Of the numbers in parentheses, the first is the number of fuzes fired or displaced; the second is the number of fuzes with tops broken off so that they could not be fired by pressure but could be fired if trip wires were attached; the third is the number of mines shattered but with the fuzes lying on their sides on top of the mines.

FIG. 11. ANTITANK MINE CLEARING DEVICES VERSUS JAPANESE YARDSTICK AND FLOWER POT MINES.

These illustrations show the minimum percentage of mines cleared within a specific area. However, for a particular point within the area, the percentage of mines cleared may be greater than that shown. Because of the skip effect produced by a linear charge exploded on the ground, there is an area adjacent to the crater, in some circumstances, where the percentage of mines cleared is less than the accepted minimum. Accordingly, these critical areas have been omitted, as they are not considered safe for the passage of tracked vehicles.

Using from the above-mentioned charts the percentage of mines cleared, it is relatively simple to estimate the probability of effecting a passage through the partially cleared minefield (Figs. 18 and 19). If the percentage of mines remaining in the partially cleared area is multiplied by the original density of the mines in the field and applied to the curve for the total width of path affected by the tank, the resulting figure will be the expected percentage of probability for all vehicles passing through the specified area without striking mines.

The width of path affected by a tank is considered to be twice the single track width plus four times the radius of detonation of the mines. For example, if the mines have a 6-inch pressure plate, and are laid every 25 feet in three rows, and the mined area is to be traversed by a tank having 18-inch wide track, the width of the path affected by the two tank tracks is 48 inches (2 x 18 + 4 x 3). The particular curve in Fig. 18 or Fig. 19 which applies in this example is the one labelled 48 inches. From the assumption that the mines are laid every 25 feet in three rows, it follows that there will be

$$\frac{25/3}{3} \sim 2.8 \text{ yards of front per mine, or}$$

$$\frac{3}{25/3} = 0.36 \text{ mines per yard of front.}$$

If it is assumed that 80 percent of the mines along the path to be traversed by the tanks have been detonated by some mine clearing device, then the value of the density becomes 20 percent of 0.36, or 0.072 (mines per yard). Reference to the 48-inch width curve shows that 91 percent of the tanks may be expected to traverse the field without striking mines.

The foregoing example considers mines with pressure plates, but Japanese mines can be computed on the same basis. The Type 3 (flowerpot) must be struck within a radius of 1 inch. The yardstick mine will present a radius of 18 inches if perpendicular to the path of a tank, and practically zero radius if parallel. However, if it is assumed that any angle to the tank path is equally likely, the average radius is approximately 11.5 inches. The horn-mine, with

EXPECTED CLEARANCE OF
JAPANESE ANTI-TANK MINES BY M2 SNAKE
(SOIL DAMP)

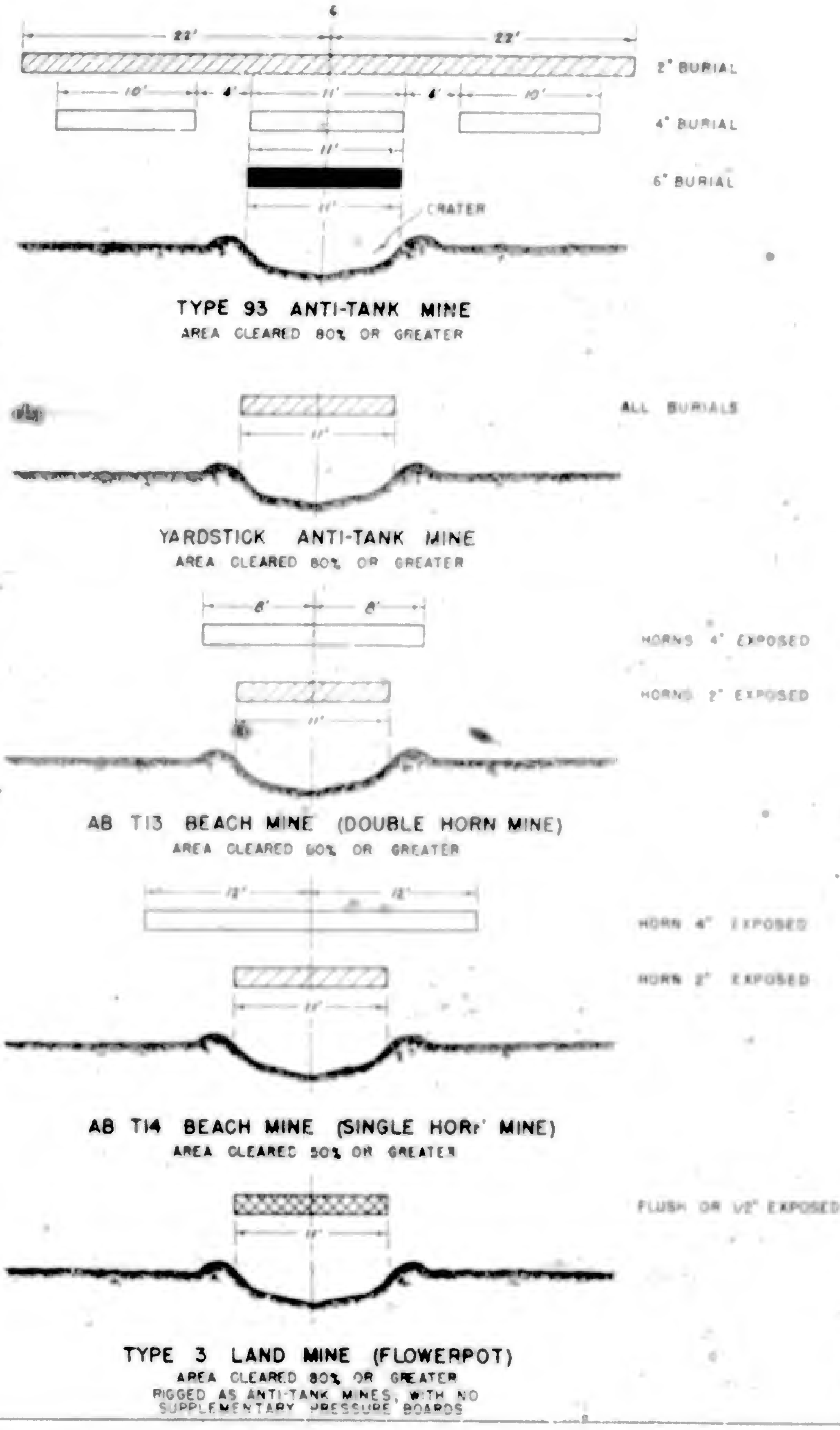


FIG 12
CONFIDENTIAL

EXPECTED CLEARANCE OF JAPANESE ANTI-TANK MINES BY M2 SNAKE (BANGALORE LOAD)

(AVERAGE SOIL)

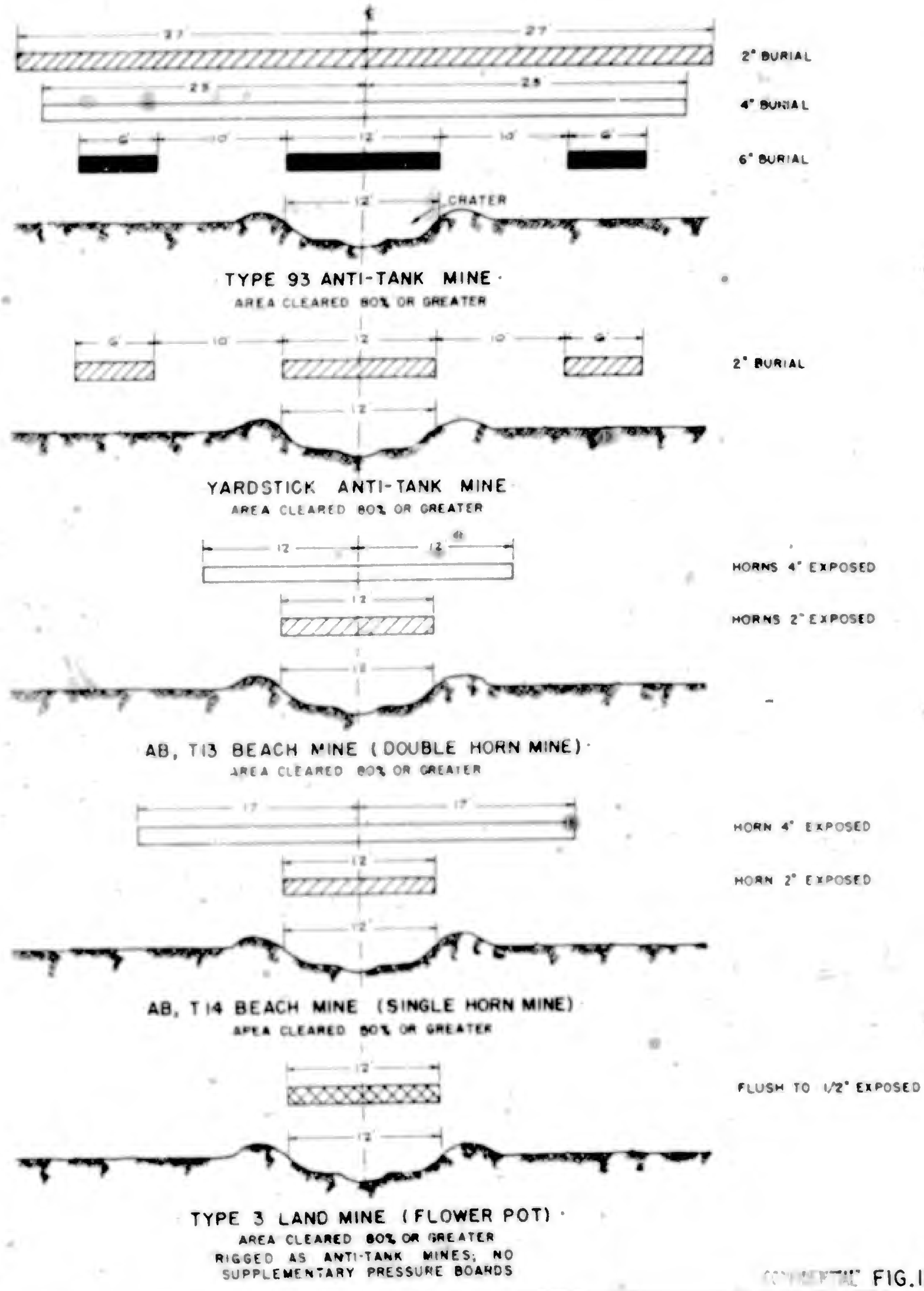
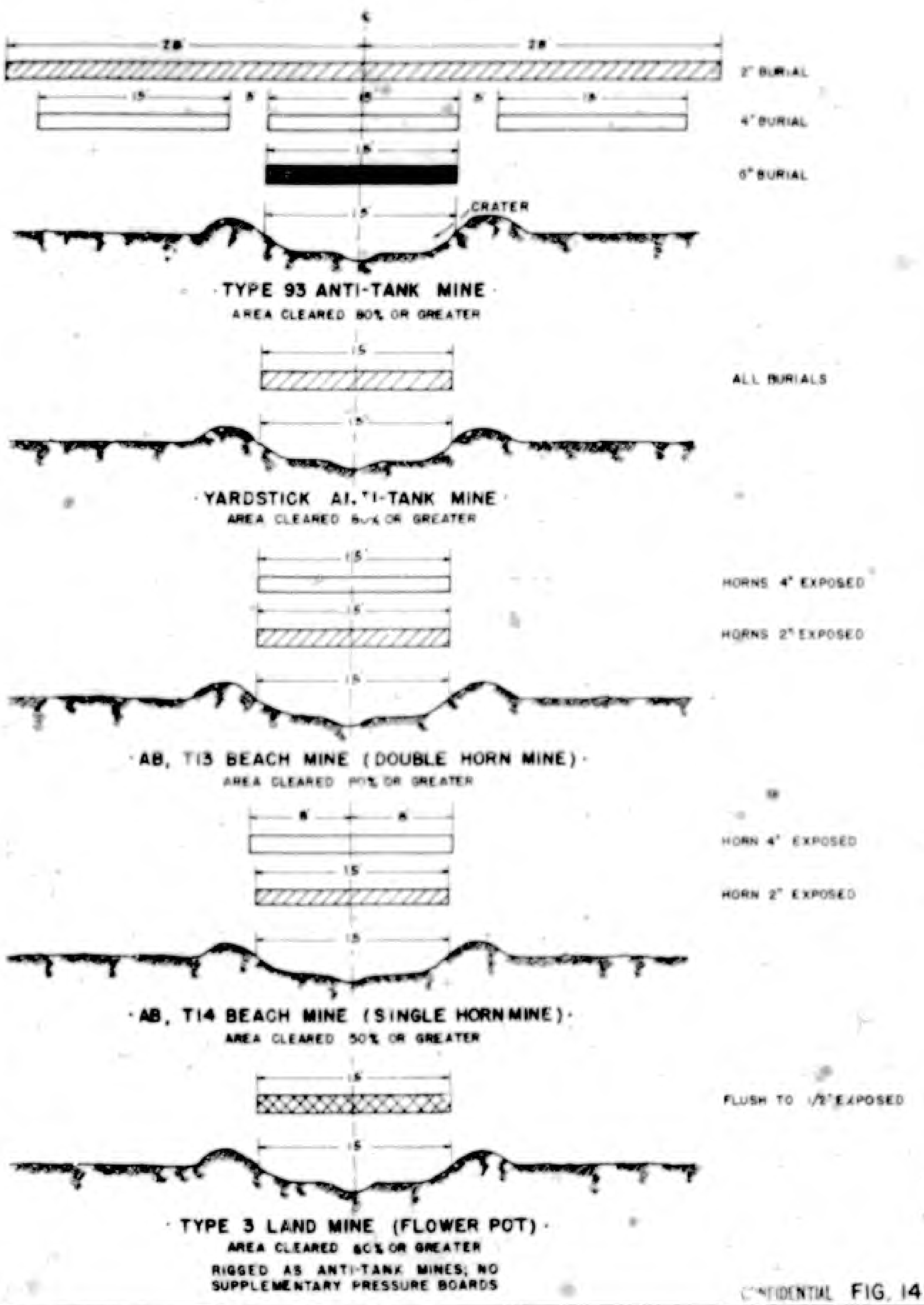


FIG. 13

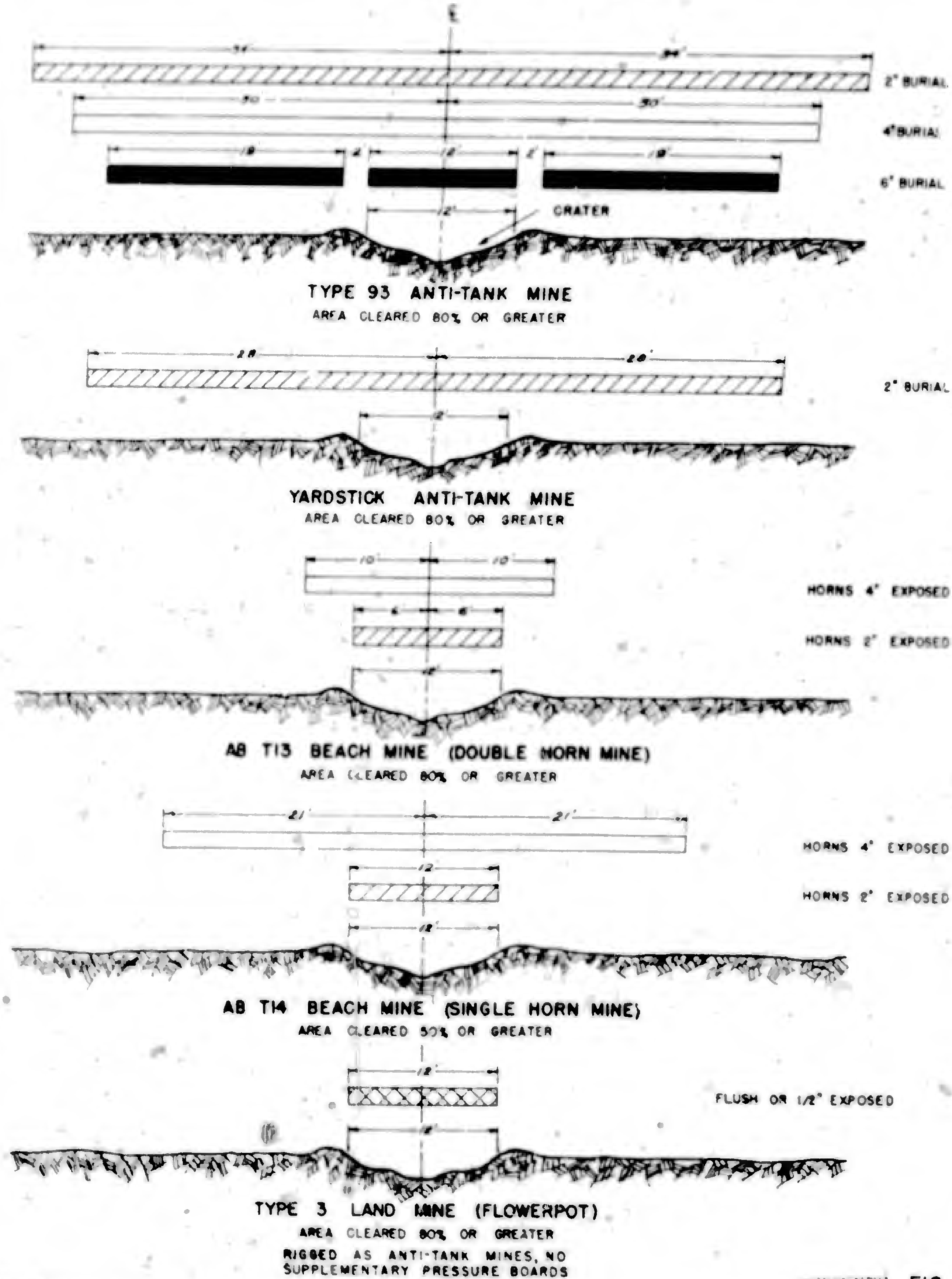
EXPECTED CLEARANCE OF
JAPANESE ANTI-TANK MINES BY M2 A1 SNAKE
(SOIL WET)



CONFIDENTIAL FIG. 14

EXPECTED CLEARANCE OF JAPANESE ANTI-TANK MINES BY M3 SNAKE

(SOIL DAMP)



CONFIDENTIAL FIG. 15

EXPECTED CLEARANCE OF JAPANESE ANTI-TANK MINES BY M1 DRAGON

(AVERAGE SOIL)

FIG. 16

EXPECTED CLEARANCE OF
JAPANESE ANTI-TANK MINE BY ROCKET, 10.75" H.E., T-91
(CLAY LOAM SOIL)

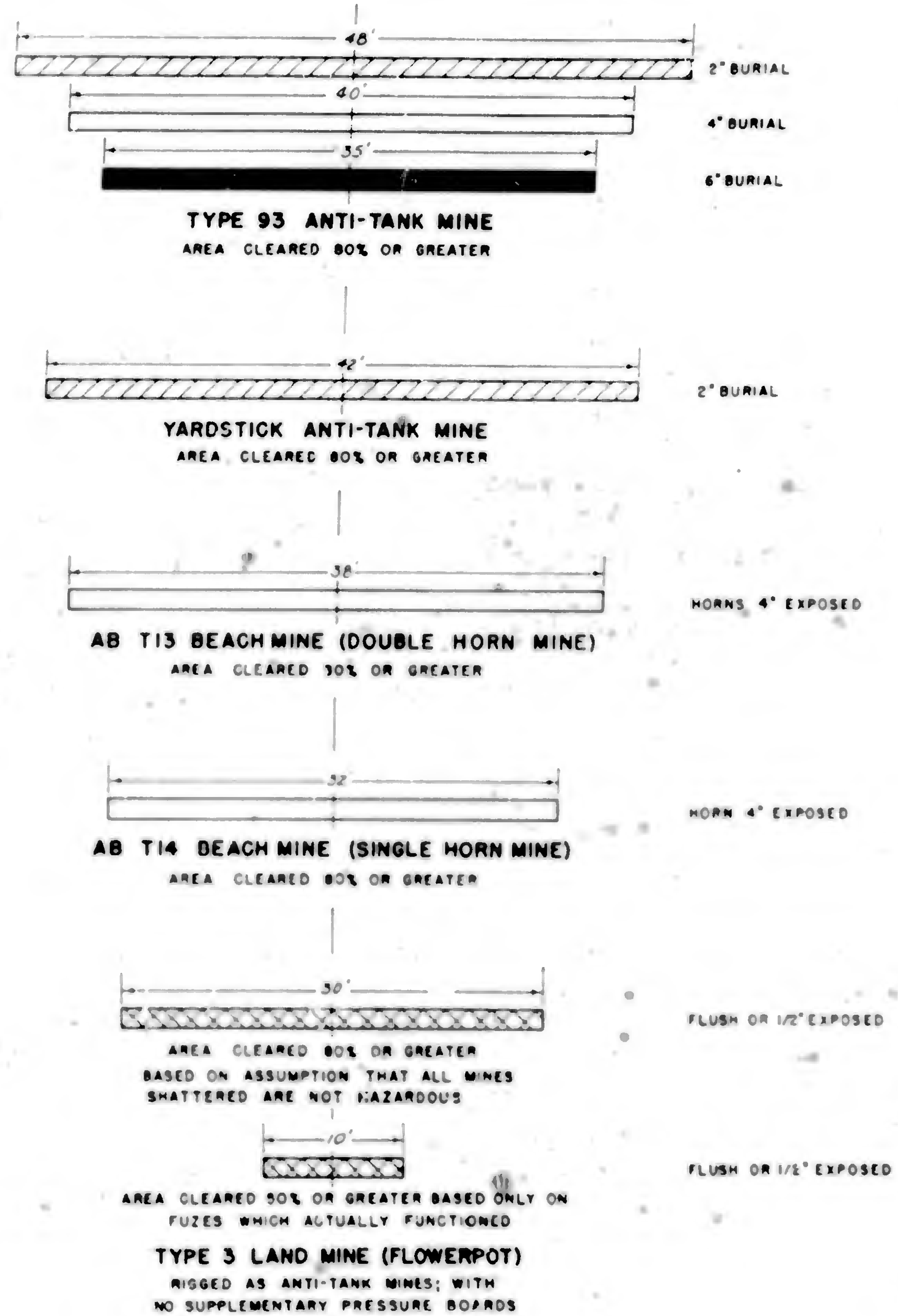


FIG. 17
CONFIDENTIAL

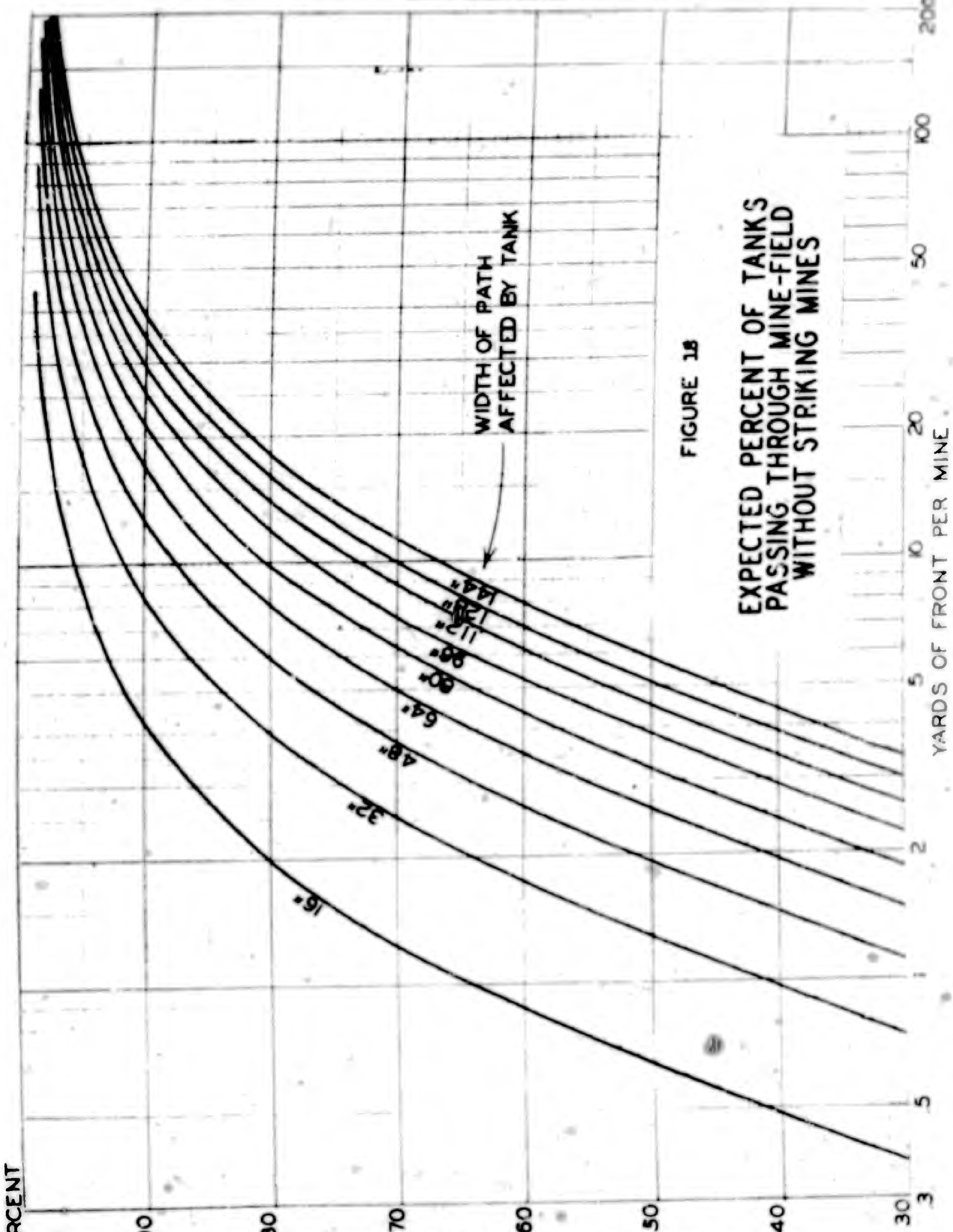


FIGURE 18

EXPECTED PERCENT OF TANKS PASSING THROUGH MINE-FIELD WITHOUT STRIKING MINES

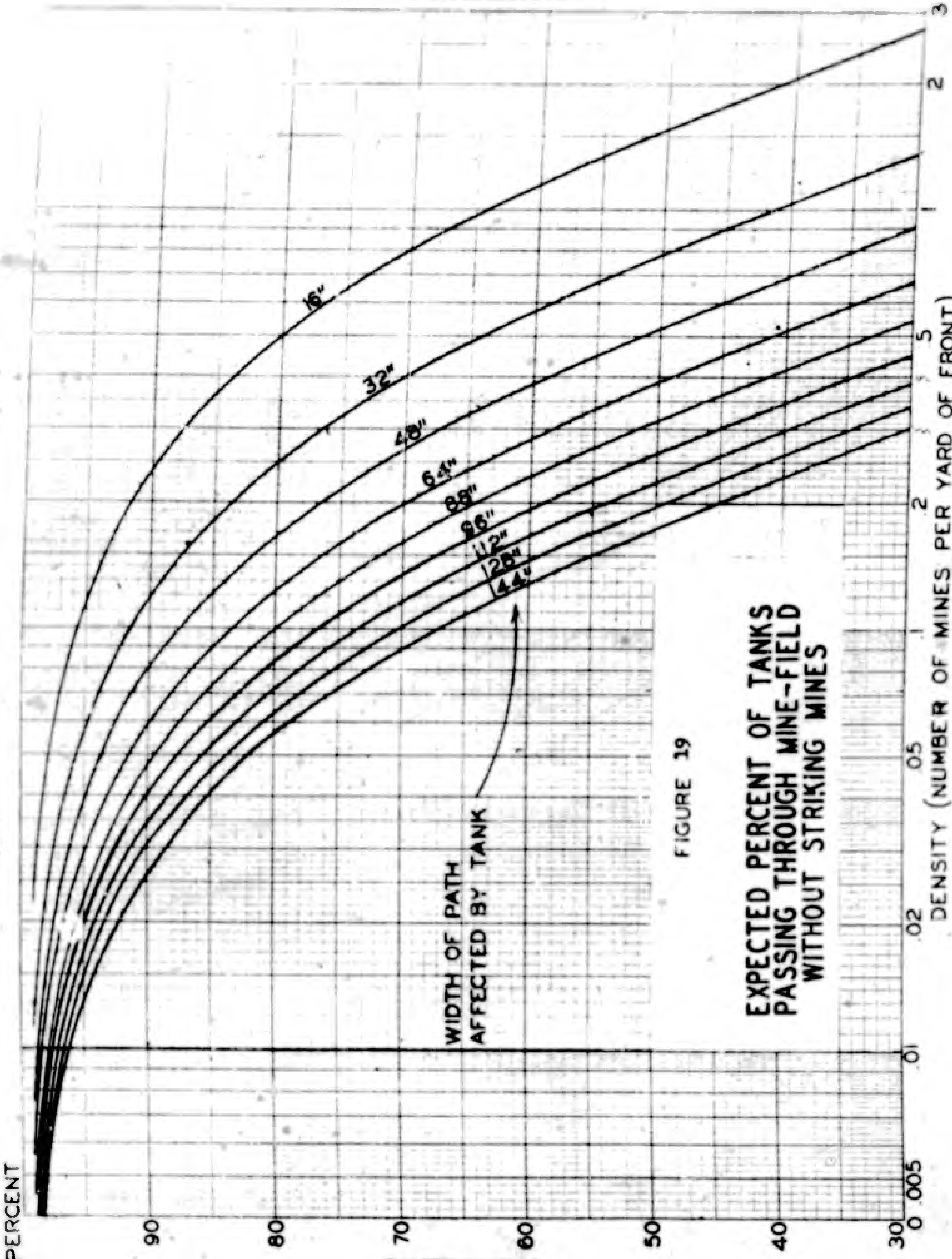


FIGURE 19

EXPECTED PERCENT OF TANKS PASSING THROUGH MINE-FIELD WITHOUT STRIKING MINES horns about 15 inches apart, will present a radius of 7.5 inches if the line of the horns is perpendicular to the path, and practically zero if parallel. The average radius for all angles is 4.8 inches.

8. Results of Tests with Antipersonnel Mine Clearing Devices. The results of the tests with antipersonnel mine clearing devices are shown in the following tables. Of the devices tested, the carpet roll torpedo was an experimental model; the Snake, Mine Clearing, Antipersonnel, M1, was a standard item of issue; the Cable, Detonating, Mine Clearing, Antipersonnel, M1, was a development model, but which is now in production; and the bangalore was a standard M1A1 bangalore torpedo.

a. Carpet Roll Torpedoes.

CARPET ROLL TORPEDO VERSUS S MINES BURIED WITH PRONGS EXPOSED

Height of Carpet (Inches)	Without Trip Wires					
	Under Carpet		Edge of Carpet		6" from Edge	
	Number		Number		Number	
	Tested	Fired	Tested	Fired	Tested	Fired
0	100	100	40	21	40	3
4	60	60	24	10	24	1
6	19	18	8	5	8	2
10	20	20	8	2	8	0
18	80	75	32	5	32	2

Height of Carpet (Inches)	Position* of Trip Wire	With 21-Foot U.S. Army Trip Wires					
		Edge of Carpet			6" or more from Edge*		
		Tested	Number Fired	Wires Cut	Tested	Number Fired	Wires Cut
0	Parallel				16	15	0
	Across	32	22	8	112	5	10
	Not across	16	15	0	48	0	0
4	Parallel				8	3	0
	Across	24	9	0	80	4	0
	Not across	8	4	0	48	0	0
6	Across	16	9	0	64	3	0
	Not across				48	4	0
10	Across	16	5	0	64	3	0
	Not across				48	0	0
18	Across	64	11	1	256	9	0
	Not across				192	7	0

* Trip wires were on the ground. When the trip wires were parallel to the carpet, all mines were placed 6 inches away from the edge of the carpet. In all other tests the mines were perpendicular to the carpet, and most mines were 6 inches to 24 inches from the carpet, although a few were placed 3 to 6 feet away.

CARPET ROLL TORPEDO VERSUS A-200 MUSTARD POT MINES

Height of Carpet (Inches)	Depth* of Mine	Under Carpet Number Tested	Under Carpet Number Fired	Edge of Carpet Number Tested	Edge of Carpet Number Fired	6" Outside Edge Number Tested	6" Outside Edge Number Fired
0	Flush	60	60	24	24	24	1
	1/2" above	40	40	16	16	16	1
	1/2" below	40	40	16	14	16	0
4	Flush	40	40	16	16	16	4
	1/2" above	20	20	8	8	8	2
	1/2" below	20	20	7	5	8	1
6	Flush	20	20	8	8	8	3

* Mines were buried with the top of the fuze flush, with 1/2 inch above ground level, and with 1/2 inch below ground level.

CARPET ROLL TORPEDO VERSUS SCHUMINES

Height of Carpet (Inches)	Depth of Mine	Under Carpet Number Tested	Under Carpet Number Fired	Edge of Carpet Number Tested	Edge of Carpet Number Fired	6" to 78" from Edge Number Tested	6" to 78" from Edge Number Fired
0	Flush	40	40	16	16	152	133*
	1/4 inch	24	24			56	34*
	1/2 inch	24	24			56	19*
4	Flush	28	28	16	15	92	78
6	Flush	16	16	16	16	95	90
10	Flush	16	16	16	16	95	83
18	Flush	63	61	64	47	376	329

* On one test the ground was frozen. This had no effect on clearance of mines under the carpet but considerably reduced the clearance away from the carpet. The carpet was on the ground in this test, and the following results were obtained:

Mines Buried	Number Tested	Number Fired
Flush	56	28
1/4 inch	56	1
1/2 inch	56	1

AVERAGE UNIVERSAL INDICATOR READINGS OBTAINED WITH CARPET ROLL TORPEDO*

Height of Carpet (Inches)	Number of Tests	Mines Buried Under Carpet			Mines Buried on Edge of Carpet		
		2"	4"	6"	2"	4"	6"
0	3		161(28)			89(8)	
4	4	164(5)	157(22)	152(6)	135(4)	102(12)	
6	2		160(7)	165(3)	153(2)	109(10)	
8	1	163(3)	156(3)	121(3)	158(2)	55(2)	45(2)
10	1		155(4)			89(8)	
12	1	163(3)	159(3)	156(3)	112(2)	84(2)	50(2)
18	4	168(16)	155(16)		127(32)	74(32)	
Average		166(27)	158(83)	149(15)	129(42)	86(74)	48(4)

* Numbers in parentheses refer to numbers of mines pertaining to a given average.

CARPET ROLL TORPEDO VERSUS JAPANESE TYPE 3 ANTITANK MINES (FLOWER POT MINES)*

Fuzes Exposed	Explosive lb/ft	Under Carpet		Edge of Carpet	
		Number Tested	Number Fired**	Number Tested	Number Fired
0	0.216	15	0,15	6	2,0
0	0.432	30	25,5	12	3,9
1/4-1/2"	0.216	19	11,8	6	2,3

* Carpet 4 to 8 inches above the ground.

** First number indicates number of fuzes fired or displaced, and second number the number of mines shattered but fuzes not fired.

YARDSTICK MINES*

Soil Condition	Depth of Burial	Under Carpet		Outside Carpet	
		Number Tested**	Number Fired	Number Tested	Number Fired
Ball in hand	4 inches	10	10	2	0
Wet	2 inches	7	7	5	0
Wet	4 inches	7	3	5	0
Wet	6 inches	4	0		

* Carpet 4 to 8 inches above the ground.

** Number refers to fuzes not mines.

HORN MINES*

Horns Exposed	Explosive lb/ft	Under Carpet		Edge of Carpet		Outside Carpet	
		Horns Tested	Horns Fired	Horns Tested	Horns Fired	Horns Tested	Horns Fired
2 inches	0.216	17	7	8	0	4	0
2 inches	0.432	30	29				
4 inches	0.216	17	11	2	1	4	0
4 inches	0.432	30	30				

* Carpet 4 to 12 inches above the ground.

b. Snake, Mine Clearing, Antipersonnel, M1.

SNAKE, MINE CLEARING, ANTIPERSONNEL, M1. VERSUS "S" MINES

Distance of Mine from Snake	Position of Trip Wires	Number Tested	Number Fired	Number Wires Cut
0 - 6 inches	No trip wires	40	40	
9 inches	No trip wires	16(8)	16(4)	
12 inches	No trip wires	16(8)	16(0)	
16 -20 inches	No trip wires	(16)	(3)	
12 inches	Across Snake	8(8)	8(1)	8(8)
12 inches	Not across	16(8)	16(0)	0(1)
24 inches	Across	8(8)	2(0)	8(8)
24 inches	Not across	16(8)	9(1)	0(0)
36 inches	Across	8(8)	0(1)	8(8)
36 inches	Not across	16(8)	6(0)	0(0)
48-120 inches	Across	56(8)	9(0)	56(8)
48- 72 inches	Not across	48(8)	9(0)	0(0)

* Figures in parentheses refer to the second test; others for first test.

SNAKE, MINE CLEARING, ANTIPERSONNEL, M1, VERSUS SCHUMINES

Distance from Snake*	Mines Buried Flush		Mines Buried 1/4 Inch	
	Number Tested	Number Fired or Destroyed	Number Tested	Number Fired or Destroyed
18 - 90 inches	56	51	64	53
108 -180 inches	64	50	72	49
198 -270 inches	40	31	48	16
288 -324 inches	16	10		
360 inches	8	1		

* Mines were buried 18 inches apart on first test; 3 feet for flush and 2 feet for 1/4 inch burial on second test.

SNAKE, MINE CLEARING, ANTIPERSONNEL, M1,
VERSUS A-200 MUSTARD POT MINES

Distance from Snake	Mines Buried Flush		Mines with 1/4" Prong Exposed	
	Number Tested	Number Fired	Number Tested	Number Fired
4 inches	8	8		
8 inches			8	8
12 inches	8	6		
16 inches			8	7
20 inches	8	2		
24 inches			8	5

SNAKE, MINE CLEARING, ANTIPERSONNEL, M1, VERSUS JAPANESE TYPE 3 MINES (FLOWER POT MINES)

	Distance from Snake					
	12"	18"	24"	30"	36"	42"
Number Tested	8	8	8	8	8	8
Fuzes Fired	3	0	0	0	0	0
Mines Shattered	2	0	0	0	0	0
Top blown off	2	3	0	0	0	0

o. <u>Bangalore Torpedo, M1A1.</u>

M1A1 BANGALORE TORPEDOES VERSUS "S" MINES

Distance from Charge	Position of Trip Wires	Number Tested	Number Fired	Number Wires Cut
6 - 9 inches	No trip wires	40	39	
12 inches	No trip wires	23	14	
15 -21 inches	No trip wires	61	23	
24 inches	No trip wires	15	1	
1 foot	Across	16	14	16
2 feet	Across	16	7	16
3 feet	Across	16	6	16
4 feet	Across	16	1	16
5 - 6 feet	Across	16	0	15
7 -10 feet	Across	32	1	32
1 foot	Not across	24	19	10
2 feet	Not across	24	13	6
3 feet	Not across	24	13	9
4 feet	Not across	24	10	4
5 - 6 feet	Not across	16	7	4

M1A1 BANGALORE TORPEDOES VERSUS SCHU MINES*

Distance from Bangalore (Feet)	Mines Buried Flush		Mines Buried 1/4"	
	Number Tested	Number Fired	Number Tested	Number Fired
2 - 10	23	23	40	40
12 - 15	16	16	16	15
16 - 20	16	15	23	20
21 - 25	16	16		
26 - 30	16	11		

* These results are for the second test only. On the first test mines were placed on the ground as well as buried flush and 1/4" deep; most of the mines were blown so far from the original position that it was not possible to determine exactly where the non-fired mines had originally been buried. Out of a total of 144 mines planted 6 feet or less from the device only 2 were not fired; and out of a total 256 mines within 24 feet, 16 were not fired.

M1A1 BANGALORE TORPEDOES VERSUS A-200 MUSTARD POT MINES*

	Mines Buried Flush			Mines with Fuzes 1/4" Exposed		
	Distance from Bangalore (in inches)					
	4"	12"	20"	8"	16"	24"
Number Tested	8	8	8	8	8	8
Number Fired	8	7	7	8	8	8

* Used on second test only.

M1A1 BANGALORE TORPEDOES VERSUS JAPANESE ANTITANK MINES*

	Distance from Charge (in inches)					
	[illegible]	[illegible]	24"	30"	36"	42"
Horn Mines (Horns [illegible]" exposed)						
Horns Tested	16	24	24	24	24	8
Horns Fired	16	24	23	20	21	4
Flower Pots (1/4- to 1/2-inch exposed)						
Number Tested	16	16	16	16	16	8
Fuzes Fired or Displaced	16	10	4	2	3	1
Top Blown off	0	2	7	6	3	0

* Used on only the last two tests (May 15 and 17).

d. Cable, Detonating, Mine Clearing, Antipersonnel, M1.

CABLE, DETONATING, MINE CLEARING, ANTIPERSONNEL, M1, VERSUS A-200 MUSTARD POT MINES*

Distance from Cable (Inches)	Mines Buried Flush		Mines Buried 1/4"	
	Number Tested	Number Fired	Number Tested	Number Fired
0	8	8	8	8
3	16	13	16	9
6	16	5	16	2
9	16	2	16	1
12	16	5	16	0

* First test; none used on second test.

CABLE, DETONATING, MINE CLEARING, ANTIPERSONNEL, M1, VERSUS UNIVERSAL INDICATOR MINES

Distance from Cable (Inches)	Average Reading*		Range of Readings*	
	Test 1	Test 2	Test 1	Test 2
6		91		24-182
9	66		35-86	
12		75		48-118
18	91	106	40-129	69-140
24		86		71-105
27	59		41-100	
36	46		35-50	
45	34		26-45	
54	29		22-35	
63	24		6-41	
72	20		12-27	
81	18		12-25	

* Based on 8 readings.

CABLE, DETONATING, MINE CLEARING, ANTIPERSONNEL, M1, VERSUS "S" MINES (With Prongs Exposed)*

Distance from Cable	Position of Trip Wires	Number Tested	Number Mines Fired	Number Wires Cut
3 inches	No trip wires	8	2	
6-12 inches	No trip wires	24	0	
0	Edge of cable	8	8	1
1-5 feet	Not across	40	2	2
1-10 feet	Across cable	80	4	80

* Mines with no trip wires on second test; others on first test.

CABLE, DETONATING, MINE CLEARING, ANTIPERSONNEL, M1, VERSUS SCHUMINES*

Distance from Cable (Inches)	Mines on Ground		Mines Buried Flush		Mines Buried 1/4"	
	Number Tested	Number Fired	Number Tested	Number Fired	Number Tested	Number Fired
0 - 9	8	8	10(8)	10(8)	11(8)	11(8)
18 - 27	10	10	15(16)	15(16)	13(16)	12(16)
36 - 45	16	15	16(16)	15(16)	15(16)	7(15)
54 - 63	16	13	16(16)	11(13)	14(16)	5(16)
72 - 81	14	4	13	4	15	5

* Figures in parentheses refer to second test and others to first test.

V. DISCUSSION

9. General. The tests and evaluation described in this report indicate the feasibility of predicting the probability of effectiveness of explosive minefield clearing devices. However, although the data contained herein are useful, the problem is so extensive that further testing is advisable in order thoroughly to evaluate the effectiveness of mine clearing devices against the four Japanese mines not calibrated with the universal indicator mine. Likewise, consideration should be given to the effectiveness of the devices against artillery shells and aircraft bombs that are fused and used as land mines.

Moreover, considerable research is required to develop further the universal indicator mine. Such an investigation is proceeding at the present time, and the solution appears to be at hand. It has been found that by decreasing the area of the mine's pressure plate, the higher blast pressures required to actuate Japanese mines can be recorded. Of course, the dial gauge readings for measuring the displacement of the indicator mine fuze measuring pin are not as great when a small area pressure plate is used. Consequently, although the range of the indicator mine is increased, an entire recalibration is required if the small area pressure plate is adopted.

10. Japanese Mines. All previous experience has been with German mines - in particular, with the Tellermine '43, schumine and "S" mine. Tellermines and schumines are relatively easy to actuate with explosive minefield clearing devices, due to the size of the area susceptible to pressure. However, most Japanese mines, like the "S" mine, present a small area upon which explosive force can operate. As a result, the only blast resistant mines that can be functioned with a high degree of reliability by an explosive mine clearing device are those mines within the immediate vicinity of the device - in other words, those mines within the crater produced by the explosion.

a. Type 3 Land Mine (Flowerpot). The Type 3 ceramic mine, in particular, is very difficult to clear. Several things may happen to Type 3 mines when they are subjected to an explosive blast; the fuse may be actuated; the top of fuse may be broken off so that it can not be actuated by pressure, but may remain dangerous if an uncut trip wire is attached; the fuse may be blown out of and away from the mine; the mine may be shattered with the fuse left unharmed and lying on its side over the broken mine. In this last situation, which occurs frequently, it is not possible to say how hazardous the mine is (Fig. 20). Until this matter is settled, the clearance of these mines remains in doubt.

Tests in which a few live Type 3 mines were used indicated that they are not affected by "sympathetic" detonation. That is, the explosion of a mine will not necessarily cause detonation of a nearby mine.

b. Horn-Mines. Both single and double horn-mines are very difficult to function by blast. These mines, although usually placed in shallow water as antiboat mines, are frequently used as land mines. There appears to be no standard method of placement, as they are often found buried or lying on the ground surface. In tests, the more difficult positions were used; the mines were buried (a) with the top of the horns level with the ground surface, (b) with the horns projecting 2 inches, and (c) with the horns fully exposed. The horns, which are easily crushed by a tracked vehicle, withstand considerable blast pressure and shrapnel hits (Fig. 21).

c. Yardstick Mines. Yardstick mines, which normally have four shear pin type fuzes, present a peculiar problem, since their position in relation to the explosive mine clearing charge varies the potential results. The probability of functioning a yardstick mine that is parallel to a linear explosive mine clearing charge is greater than if the mine is at right angles to the charge. Moreover, recent intelligence reports indicate that the Japanese frequently employ the yardstick mine with three instead of the customary four fuzes. This method of employment reduces the probability of functioning these mines.

d. Type 93 and Dutch Mushroom-Top Mines. The Type 93 and the Dutch mushroom-top mines are relatively easier to function by blast. On the basis of comparative universal indicator mine values, the J93 mine requires twenty percent more energy to be functioned than the Tellermine '43, and the Dutch mushroom-top mine 60 percent less than the Tellermine '43. However, the mushroom-top on the Dutch mine fits loosely on the base, permitting the accumulation of earth and sand in the space between the top and the base. As a result, the mine becomes more difficult to detonate. The calibration value of 30 that was used in the tests described in this report is considered representative of a Dutch mine that is partially jammed by earth between the top and the base.

4

11. Mine Clearing Devices. Perhaps the most outstanding phenomenon revealed by the investigation was the "skip" or "crater effect." From some of the earliest experiments, it was realized that, for some inexplicable reason, mines on the lip of the crater produced by an explosive device were often not functioned. While it is not within the scope of the present project to determine the cause of the "skip effect," the effect can accurately be determined, and can be circumvented by the selection of the route for tanks to travel through a partially cleared minefield. It follows that the crater produced by an explosive minefield clearing device is the safest route through a minefield. However, more often than not the crater is not wide enough to accommodate a tracked vehicle. In such a situation, the alternate recommended route would be outside the crater adjacent to the skip area. Under no circumstances is it considered advisable to straddle the skip area with a tracked vehicle. If a tank were to straddle the skip area by placing one track in the crater and one track outside of the skip area, the tank's belly would be vulnerable to mines that may have been rendered hypersensitive by the explosion of the mine clearing device.

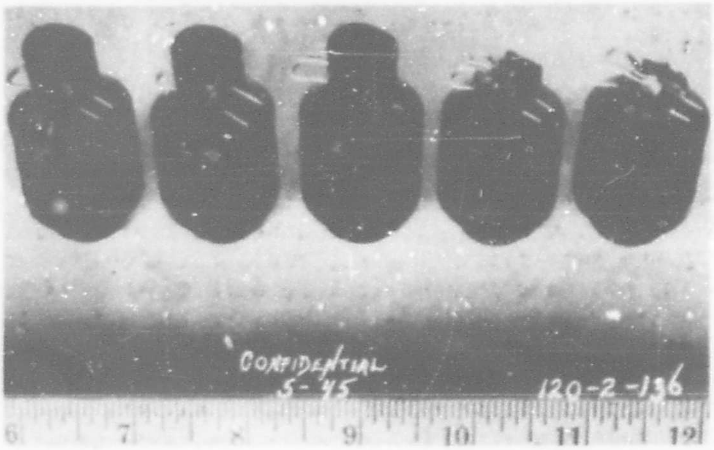
The "skip effect" is negligible with antipersonnel mine clearing linear charges, and it does not exist with airburst charges. The 10.75-inch rocket, H.E., T-91, has an 18-inch fuze extension which eliminates any cratering. This indicates that the "skip effect" may be closely related to the physical formation of a crater. Likewise, the carpet roll torpedo produces no crater and thus has no "skip effect."

a. Antitank Mine Clearing Devices. The choice of a device for breaching an antitank minefield depends largely on the availability of the various devices, the type of mines to be breached and the tactical situation. From the tests conducted, it appears that the demolition snakes produce the best all around results. Evaluated on the same general basis, the 10.75-inch Rocket, T-91, is equivalent and possibly more desirable, because it does not produce a crater. A single length of 3-inch hose filled with liquid explosive is effective against Japanese mines on the basis of the comparatively small amount of explosives utilized. However, the lanes produced through Type 3 mines are not suitable for the passage of vehicles. The projected line charge, which contains about the same amount of explosive per linear foot as the 3-inch hose, produces comparable results.

Of the four demolition snakes tested, the M3 snake is preferable, due to its greater mine clearing ability and comparative lightness. The explosive loading, 14 pounds per linear foot, is equivalent to the M2A1 snake and the M2 Bangalore torpedo-loaded snake. However, both of these snakes weigh in excess of 3 tons more than the M3 snake.

120-2-124

Condition of Type 3 Land Mine fuzes after test. Left: fuze not fired. Right: fuze fired and top partially blown away.



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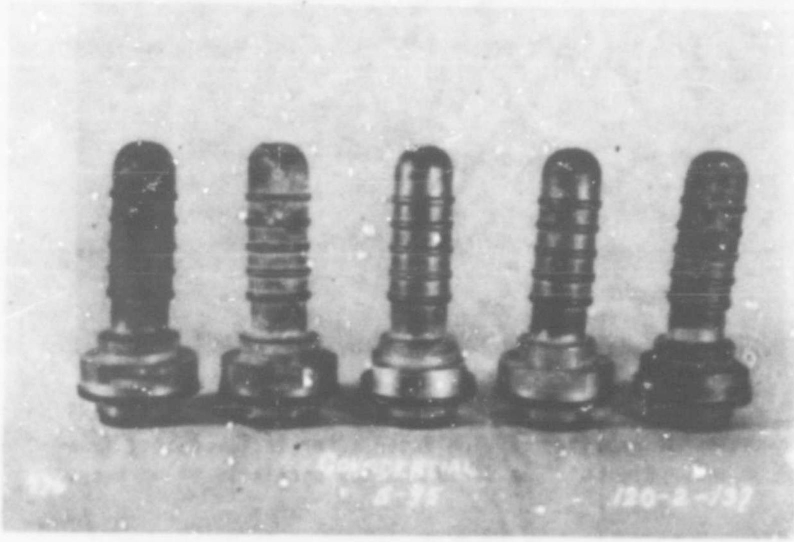
Various conditions of fuzes. Left to right: fully cocked fuze; partially functioned fuze (note prongs slipped on one side); prong partially "pulled" (fuze will not function under weight of man but may be actuated by trip wire); top broken but can still be actuated by direct pressure or trip wire; top broken and fuze cannot be functioned by direct pressure but may be actuated by trip wire.

FIG. 20. JAPANESE TYPE 3 LAND MINES.



Condition of horns after test with explosive mine clearing device. Center horn is new, other horns were not functioned by several shrapnel hits.

FIG. 21. JAPANESE HORN MINES.

The Rocket, H.E., 10.75-inch, T-91, is intended to be launched from a special vehicle towed by a tank. In tactical use the rockets would be fired at intervals of 15 feet along the proposed path. Each rocket weighs 330 pounds, of which 250 pounds is explosive. Approximately 3½ tons of rockets are required to obtain a path equal in length to that produced by a demolition snake. The combined weight of the rockets and the launching vehicle is considerably greater than any demolition snake.

The 3-inch explosive-filled hose and the projected line charge are light in weight, easy to maneuver and very effective per pound of explosive. A separate investigation is presently under way to determine the usefulness of these devices when two or three of them are exploded simultaneously in a minefield.

b. Antipersonnel Mine Clearing Devices. Of the antipersonnel mine clearing devices tested, the carpet roll torpedo produces the most effective results. While this device is not fully developed, and there remains the problem of tactically placing the explosive carpet in a minefield, it is evident that the explosive carpet when properly positioned, can clear a foot path at least two feet wide through all types of mines. The two heavier charges (M1 mine clearing snake and bangalore torpedoes) clear schumines over a wider range than does the carpet roll, but they clear only a very narrow path (less than 2 feet) through "S" mines and similar mines. The M1 detonating cable is useful for clearing a footpath through schumines and exposing the more blast resistant antipersonnel mines.

The detonating cable has the least weight and bulk and requires no prior preparation for use. These desirable characteristics are presently being exploited in the development of a new cable of greater explosive weight that will probably be more effective against blast resistant mines.

A kit has been developed which will enable a 100-foot string of bangalore torpedoes to be projected into a mined area and detonated. The kit will thus permit greater usage of the M1A1 bangalore torpedoes which are generally available in the theaters.

The M1 antipersonnel mine clearing snake is currently in production and is available. It is satisfactory for clearing narrow footpaths through fields of antipersonnel mines, for cutting trip wires, and for clearing vegetation that may conceal undetonated mines.

The carpet roll torpedo, if suitably developed, could, from the criterion of the weight of explosives used, be the most efficient mine clearing charge. It is useful against both antipersonnel and antitank mines. This feature is worthy of consideration, inasmuch as the Japanese Type 3 mine is employed as both an antitank and antipersonnel device. The carpet roll torpedo does not cut trip wires, but it does detonate all mines immediately under the explosive mat.

VI. CONCLUSIONS

12. Conclusions. From the investigation and tests described herein, it is concluded that:

a. The effectiveness of explosive minefield clearing devices varies in accordance with the condition of the soil and the length of time the mines have been buried; mine clearance is reduced in wet soil and in fields in which the mines have been buried for several weeks.

b. The Snake, Demolition, M3, is the best all-around antitank minefield clearing device tested. The carpet roll torpedo, although not yet completely developed, offers promise, under suitable terrain conditions, of being the most efficient of the antipersonnel mine clearing devices tested, from the standpoint of weight of explosives used.

c. Japanese Type 3 land mines, horn-mines, yardstick mines and Type 93 mines are more blast resistant than German T.Mi.43 mines, and explosive minefield clearing devices effective against T.Mi.43 mines are not equally effective against Japanese mines.

d. Of the mines tested, the Type 3 mine is the most difficult to function by blast, and is insensitive to sympathetic detonation.

e. Of the more well-known Japanese mines, only the Type 93 and Dutch mushroom-top mines can be calibrated with the existing universal indicator mine.

f. The universal indicator mine can be modified, probably by reducing the area of the pressure plate, so that indicator mine values for the Japanese Type 3 mine, horn-mines and yardstick mines can be calibrated.

g. There is an area at the lip of the crater produced by a linear charge exploded on the ground, in which blast is relatively ineffective against mines.

h. Airburst explosive devices, such as the Rocket, H.E., 10.75-inch, T-91, produce no craters and have no "skip effect" on mines.

i. Further limited tests should be conducted in order to calibrate blast-resistant mines, as well as aircraft bombs and artillery shells used as mines, against a modified universal indicator mine.

VII. RECOMMENDATIONS

13. Recommendations. It is recommended that:

a. A limited series of additional tests be conducted further to evaluate the effectiveness of mine clearing devices against blast-resistant mines not yet calibrated, using for this purpose the modified universal indicator mines at present being developed.

b. Tests be conducted to determine the effectiveness of explosive mine clearing devices against aircraft bombs and artillery shells employed as land mines.

Submitted by:

GILES L. EVANS, JR.
Lt. Colonel, Corps of Engineers
Director, Technical Division I

APPENDIX A

AUTHORITY

WAR DEPARTMENT
Office of the Chief of Engineers
Washington

CE (21 Nov 44)SPENF 21 November 1944

Subject: Test of Mineclearing Devices Against Japanese Mines.
(Work Order DDM 3350)

To: The President,
The Engineer Board,
FORT BELVOIR, VIRGINIA.

1. Most of the equipment for clearing enemy mines under development at present probably will not be procured and issued in time to be of much value against Germany and all developments are being oriented toward the war against Japan. In this connection it is necessary that all mineclearing equipment be evaluated as to effectiveness for clearing Japanese mines.

2. Therefore, it is requested that:

a. As many Japanese mines, as possible, including Type 93, Yardstick, and Dutch Mushroom Mines, be calibrated against the T. M1. 43 and Universal Indicator Mines.

b. From the results of these calibrations, minefield clearing devices, both standard and development types, be evaluated as to their effectiveness in clearing Japanese type mines.

c. For those Japanese Mines which it may not be possible to calibrate with the indicator mines, such as the Yardstick Mines, limited tests against captured samples or simulated models of such mines be conducted with the mineclearing devices to provide sufficient data for adequately evaluating the devices.

d. This work be carried under Group 2 Classification.

By order of the Chief of Engineers:

/s/ SHERWOOD B. SMITH,
Lt. Colonel, Corps of Engineers,
Chief, Fortifications Branch,
Engineering and Development Division.

APPENDIX B

EXPECTED PERCENTAGES OF MINES CLEARED AT GIVEN DISTANCE FROM CHARGE

FIGURE 22

M2 Snake versus German TM143 Mines
in Ground one week
Ground: Ball in hand

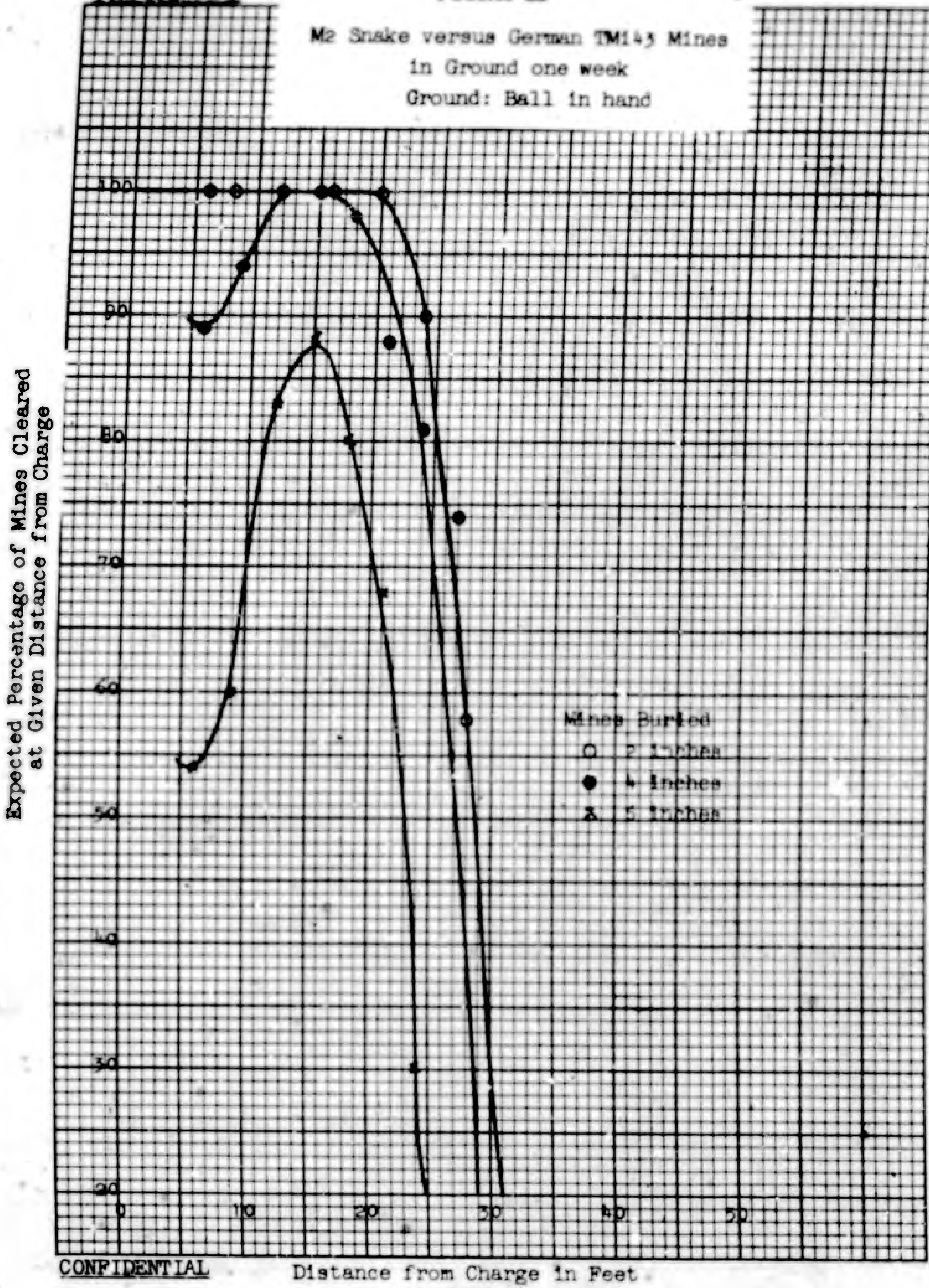
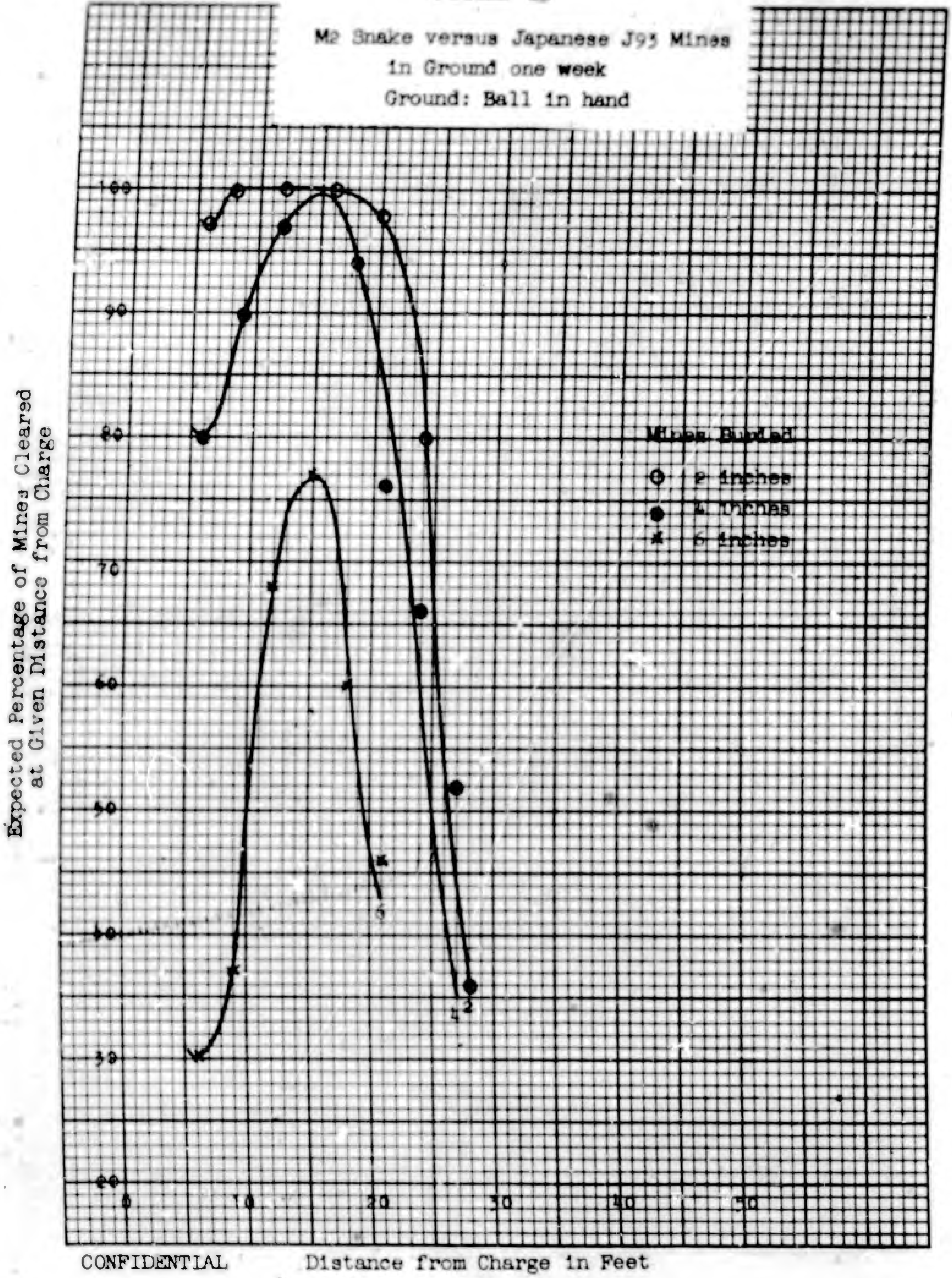


FIGURE 23


M2 Snake versus Japanese J93 Mines
in Ground one week
Ground: Ball in hand
Expected Percentage of Mines Cleared at Given Distance from Charge
100
90
80
70
60
50
40
30
20
0
10
20
30
40
50
Mines Buried
2 inches
4 inches
6 inches
6
4
2
Distance from Charge in Feet

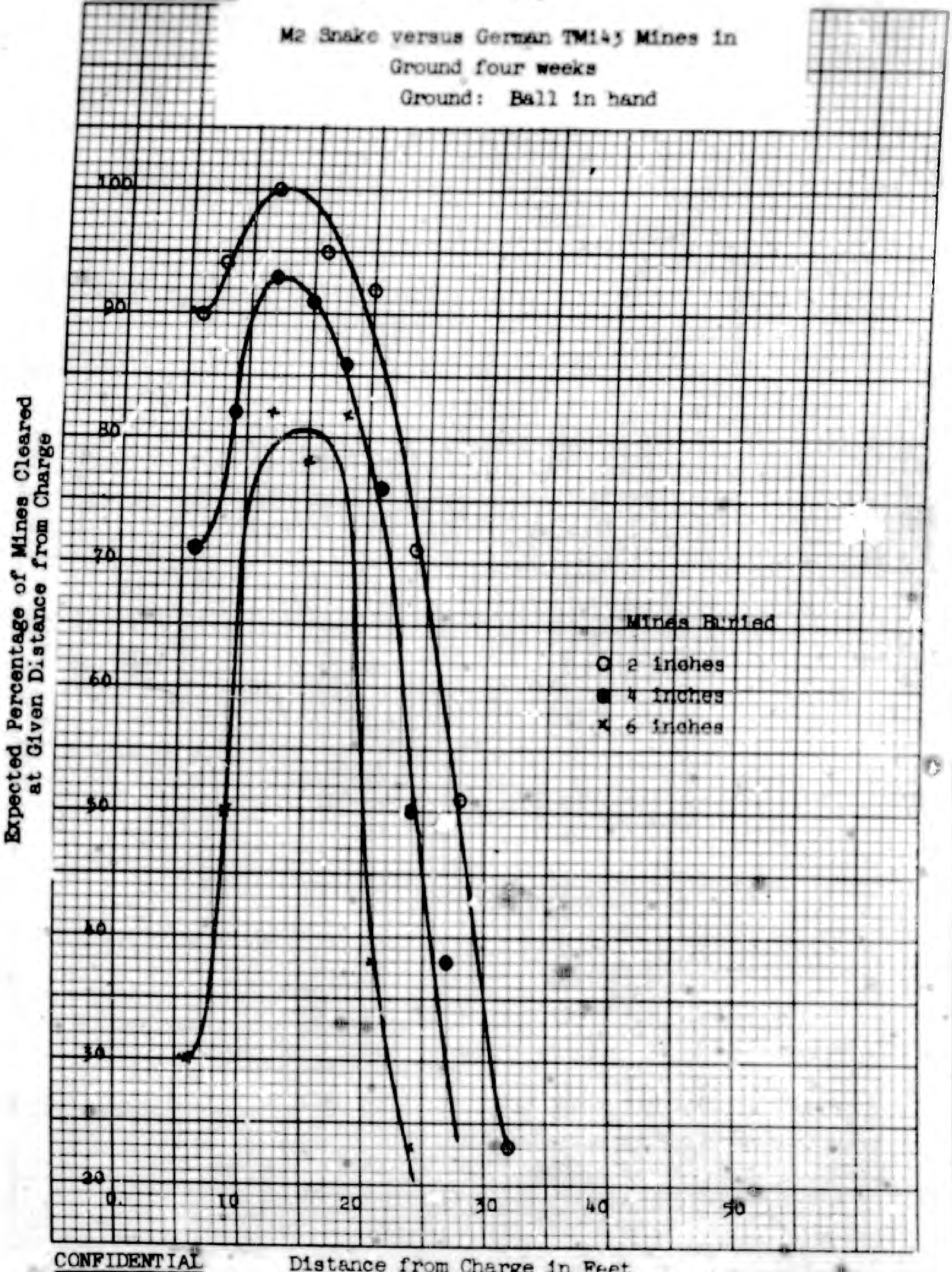

M2 Snake versus German TM143 Mines in
Ground four weeks
Ground: Ball in hand
Expected Percentage of Mines Cleared at Given Distance from Charge
Mines Buried
2 inches
4 inches
6 inches
Distance from Charge in Feet

FIGURE 25

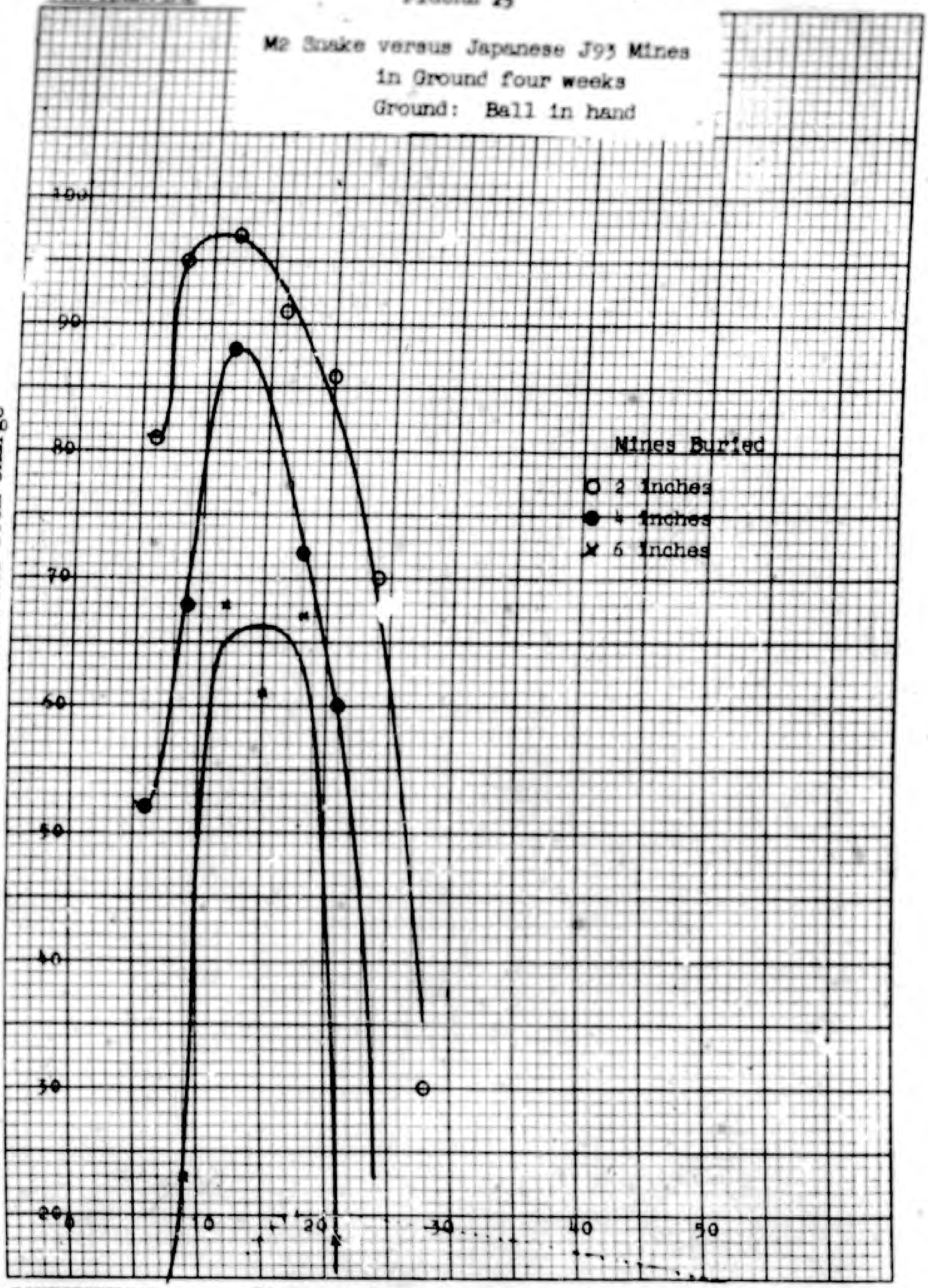

M2 Snake versus Japanese J93 Mines
in Ground four weeks
Ground: Ball in hand
Expected Percentage of Mines Cleared at Given Distance from Charge
100
90
80
70
60
50
40
30
20
0
10
20
30
40
50
Mines Buried
2 Inches
4 Inches
6 Inches
Distance from Charge in Feet

FIGURE 26

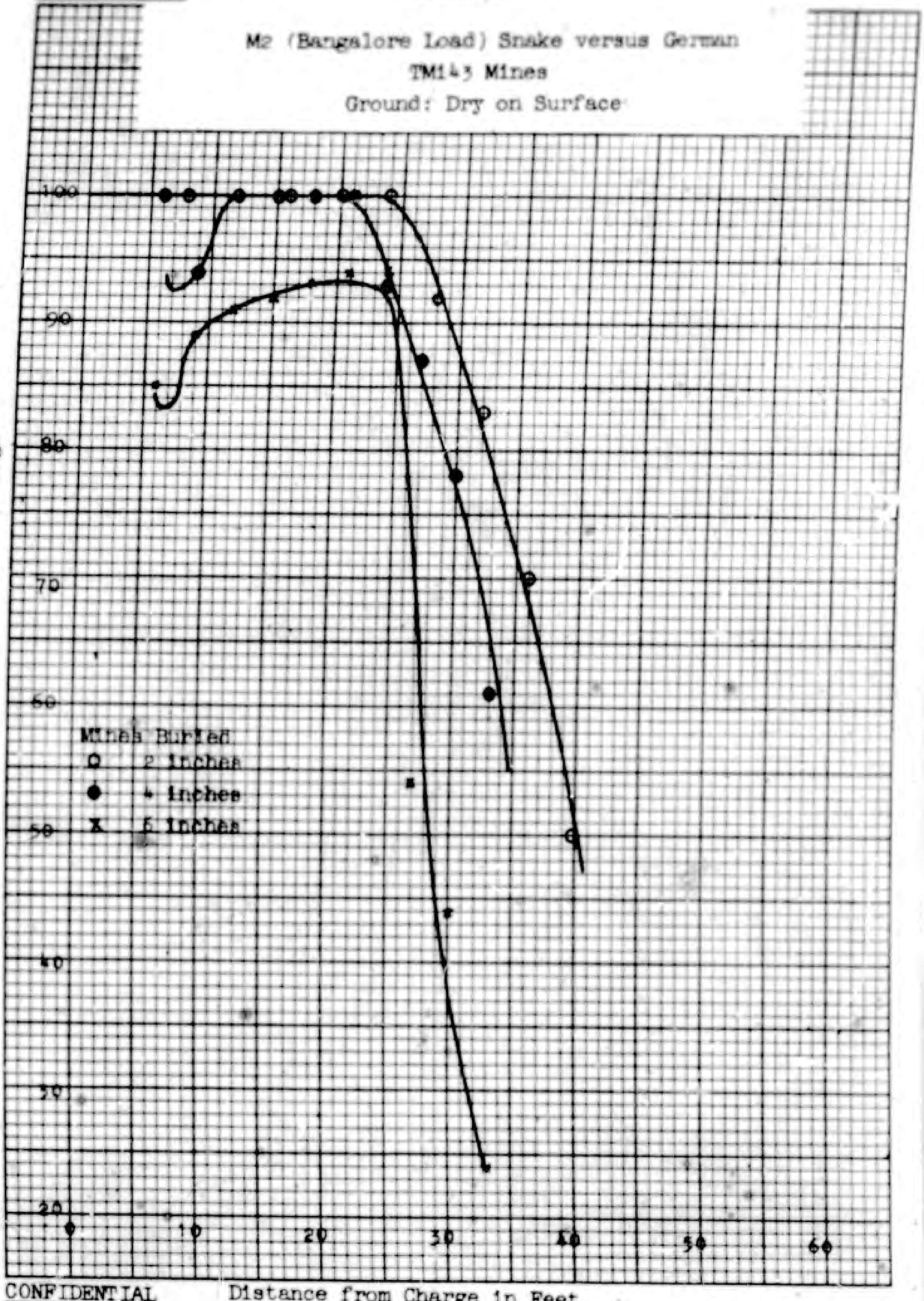

M2 (Bangalore Load) Snake versus German
TM143 Mines
Ground: Dry on Surface
Expected Percentage of Mines Cleared at Given Distance from Charge
100
90
80
70
60
50
40
30
20
0
10
20
30
40
50
60
Mines Buried
2 inches
4 inches
6 inches
Distance from Charge in Feet

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FIGURE 27

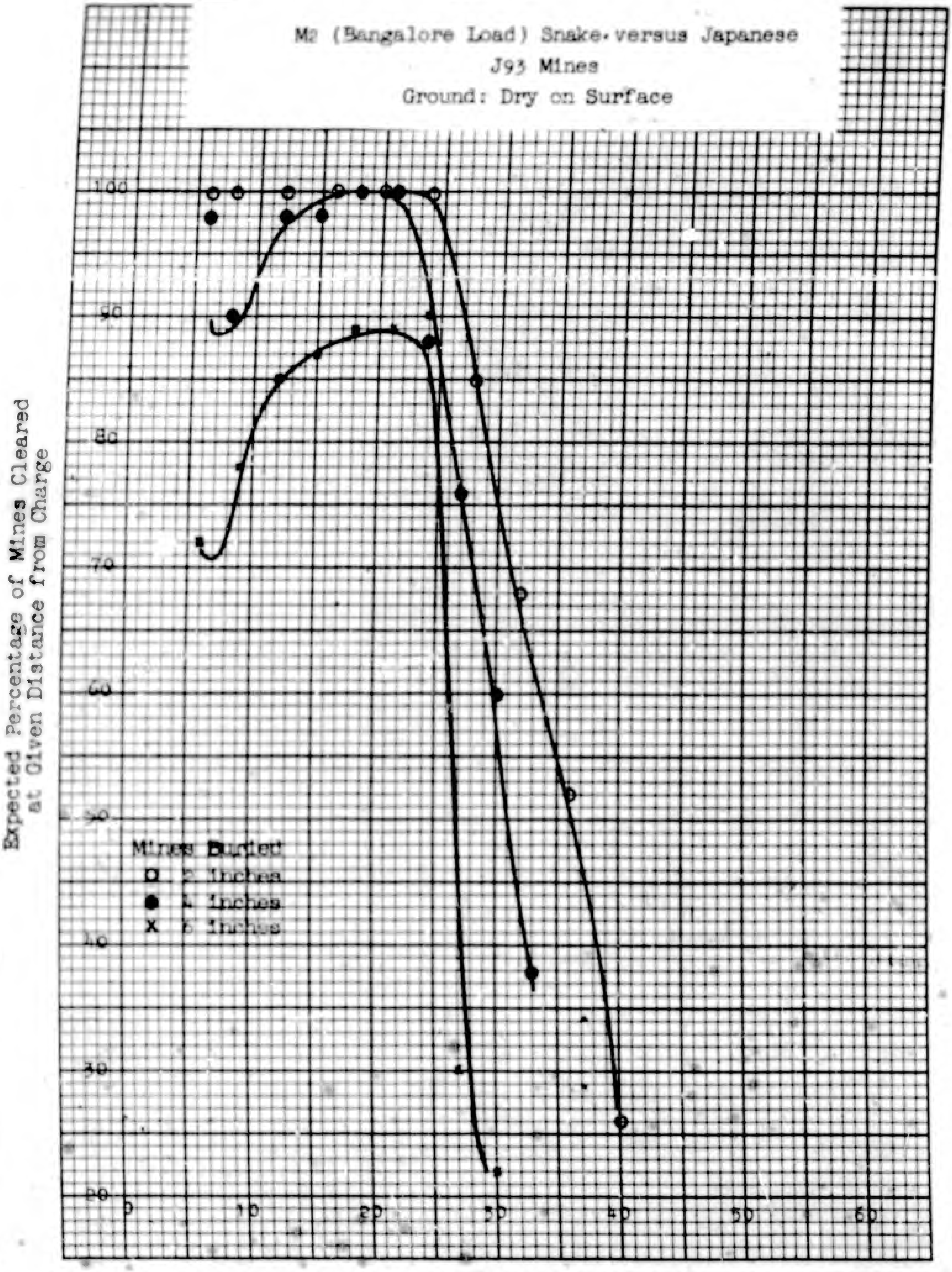

FIGURE 28

M2 (Bangalore Load) Snake versus German TM1 43 Mines

Ground: Muddy from Thaw

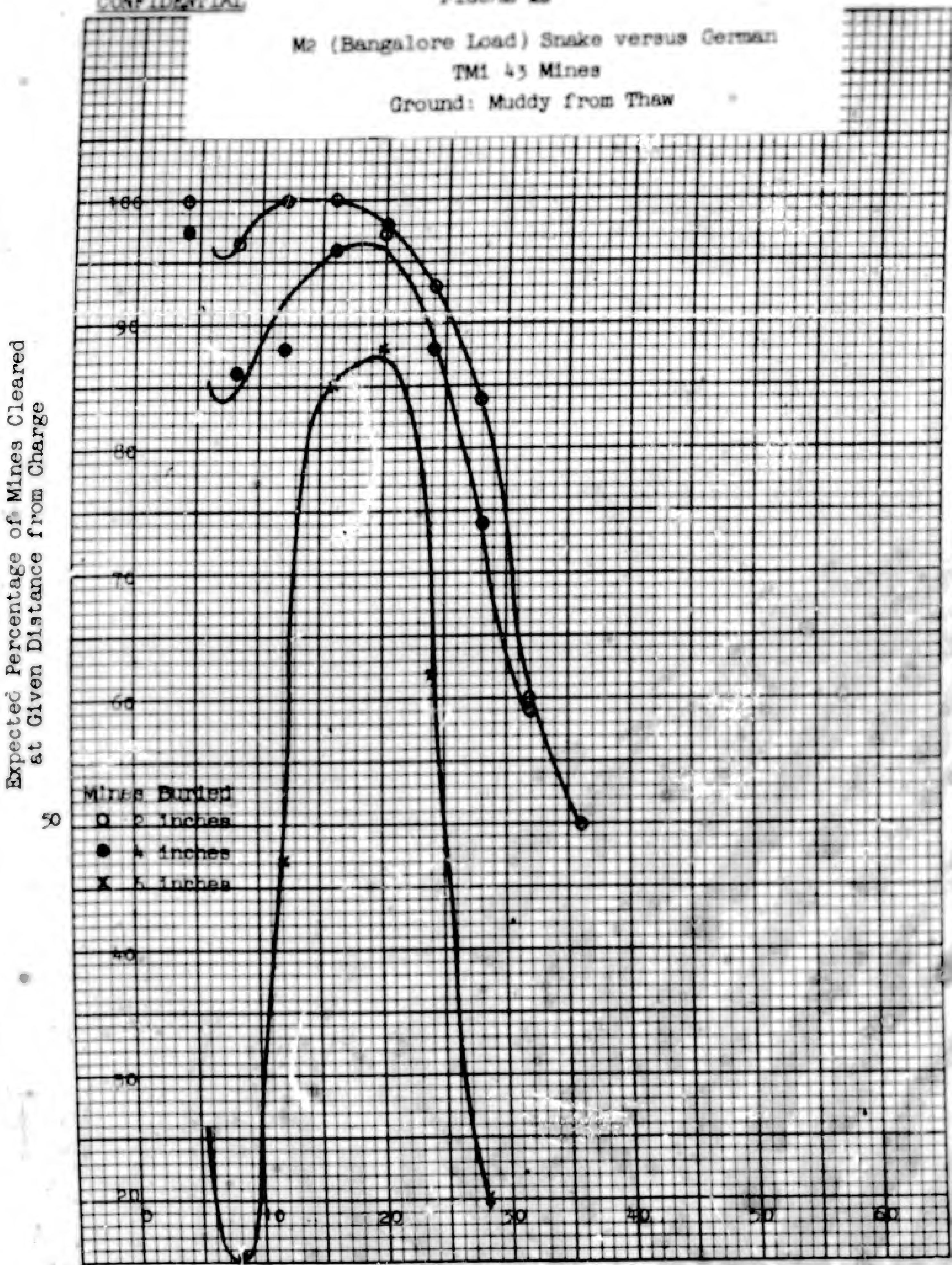

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FIGURE 29

M2 (Bangalore Load) Snake versus Japanese J93 Mines

Ground: Muddy from Thaw

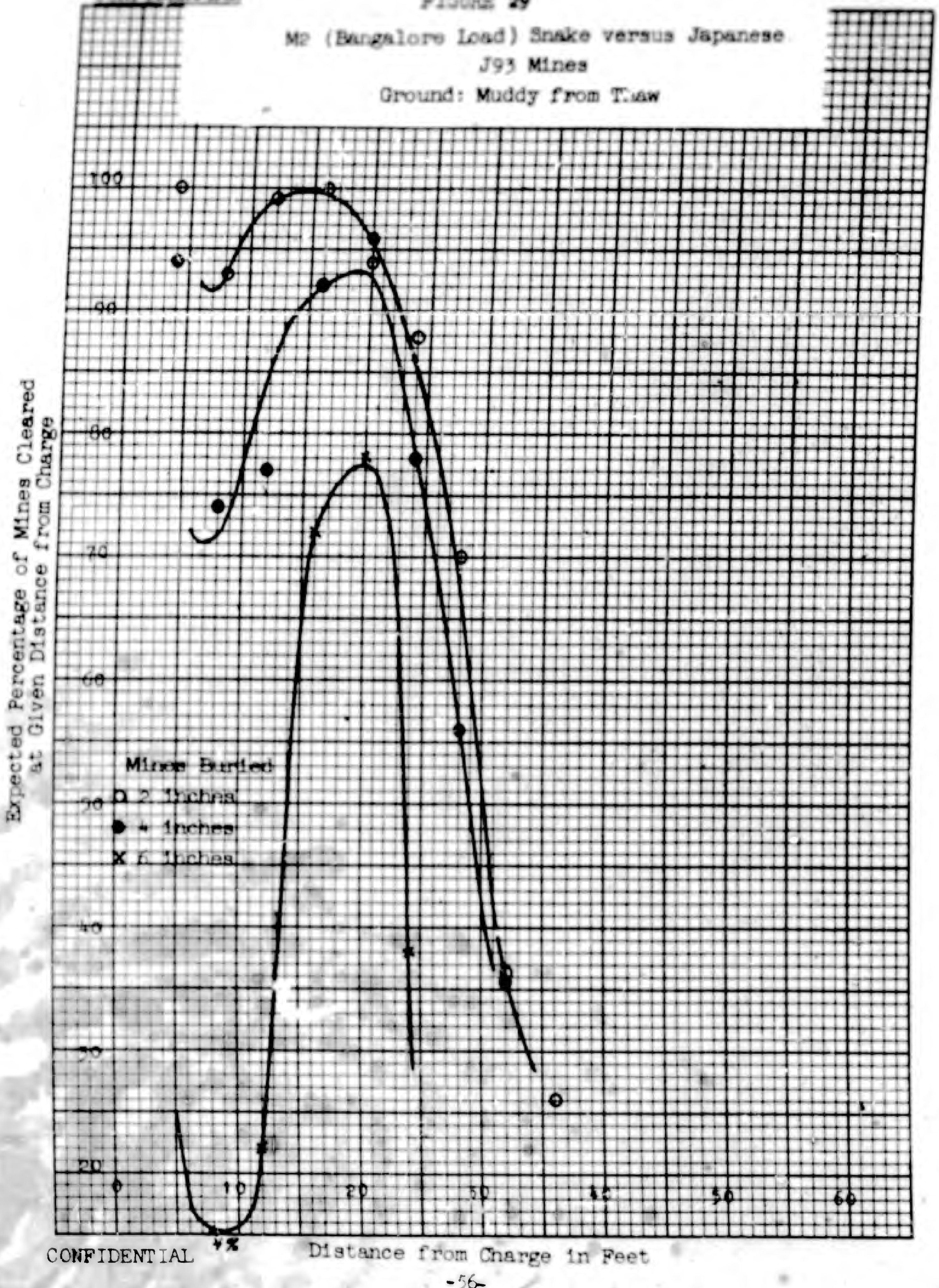

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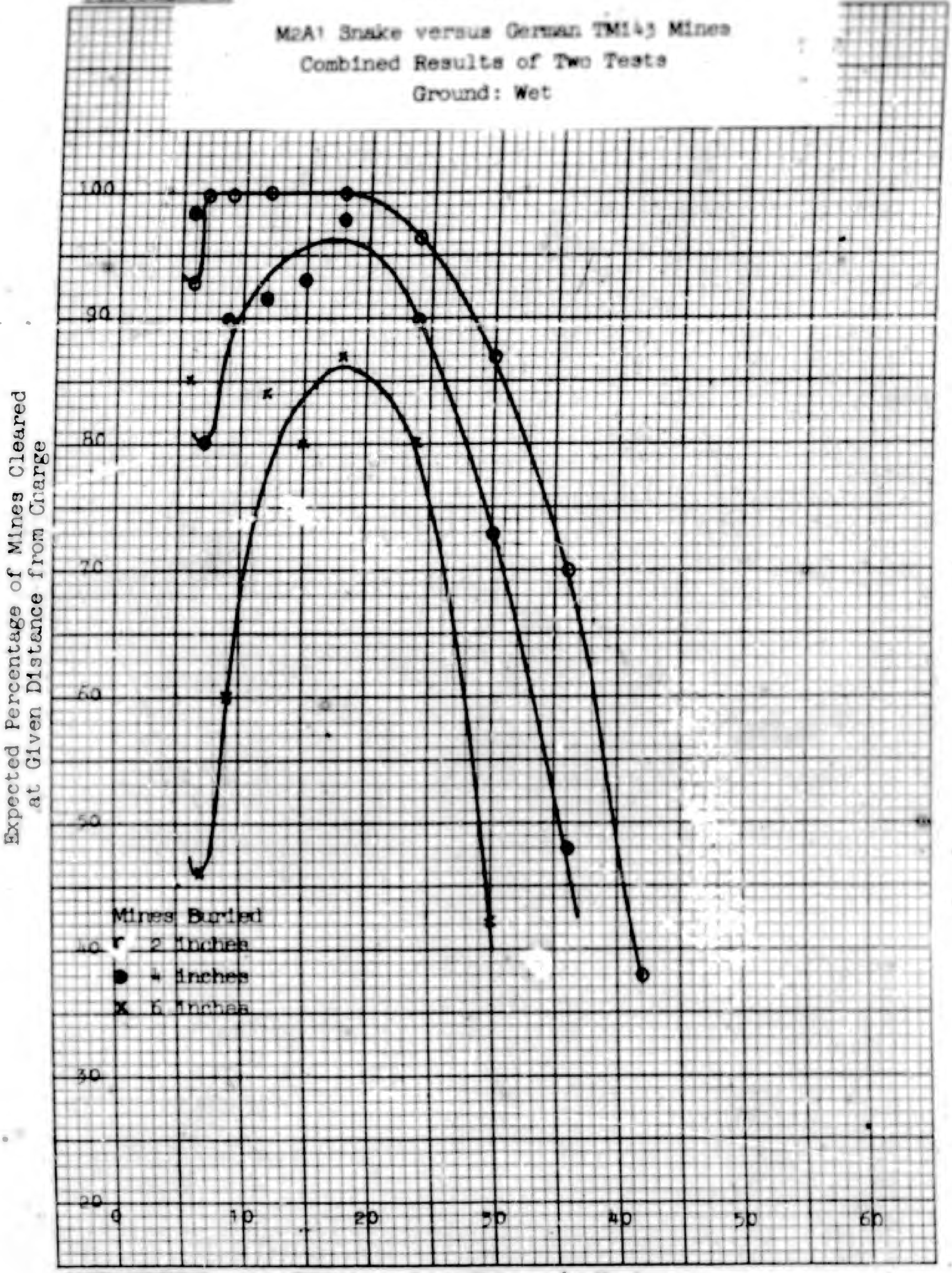
FIGURE 30

M2A1 Snake versus German TM143 Mines
Combined Results of Two Tests
Ground: Wet



Distance from Charge in Feet

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FIGURE 11

M2A1 Snake versus Japanese J93 Mines
Combined Results of Two Tests
Ground: Wet

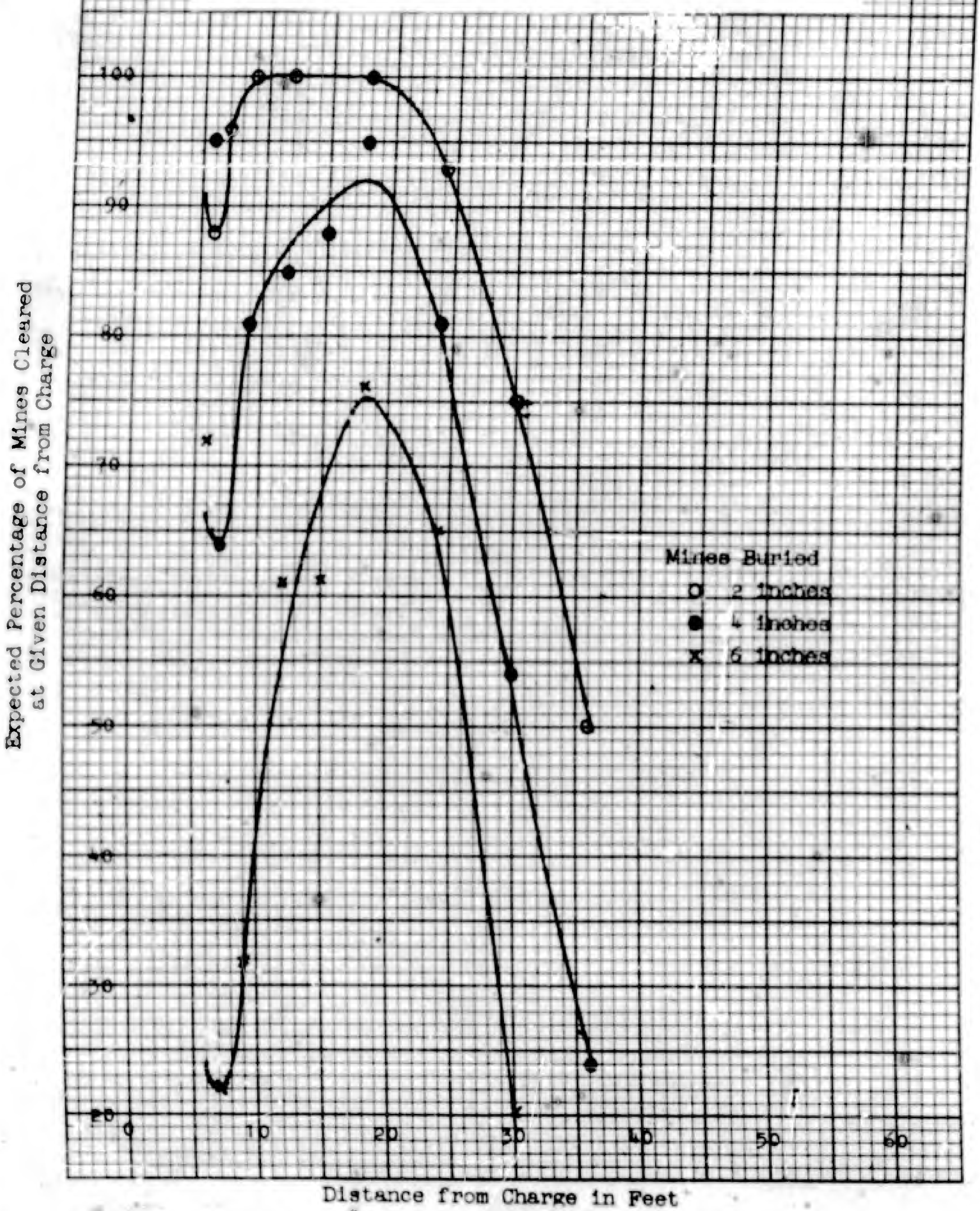

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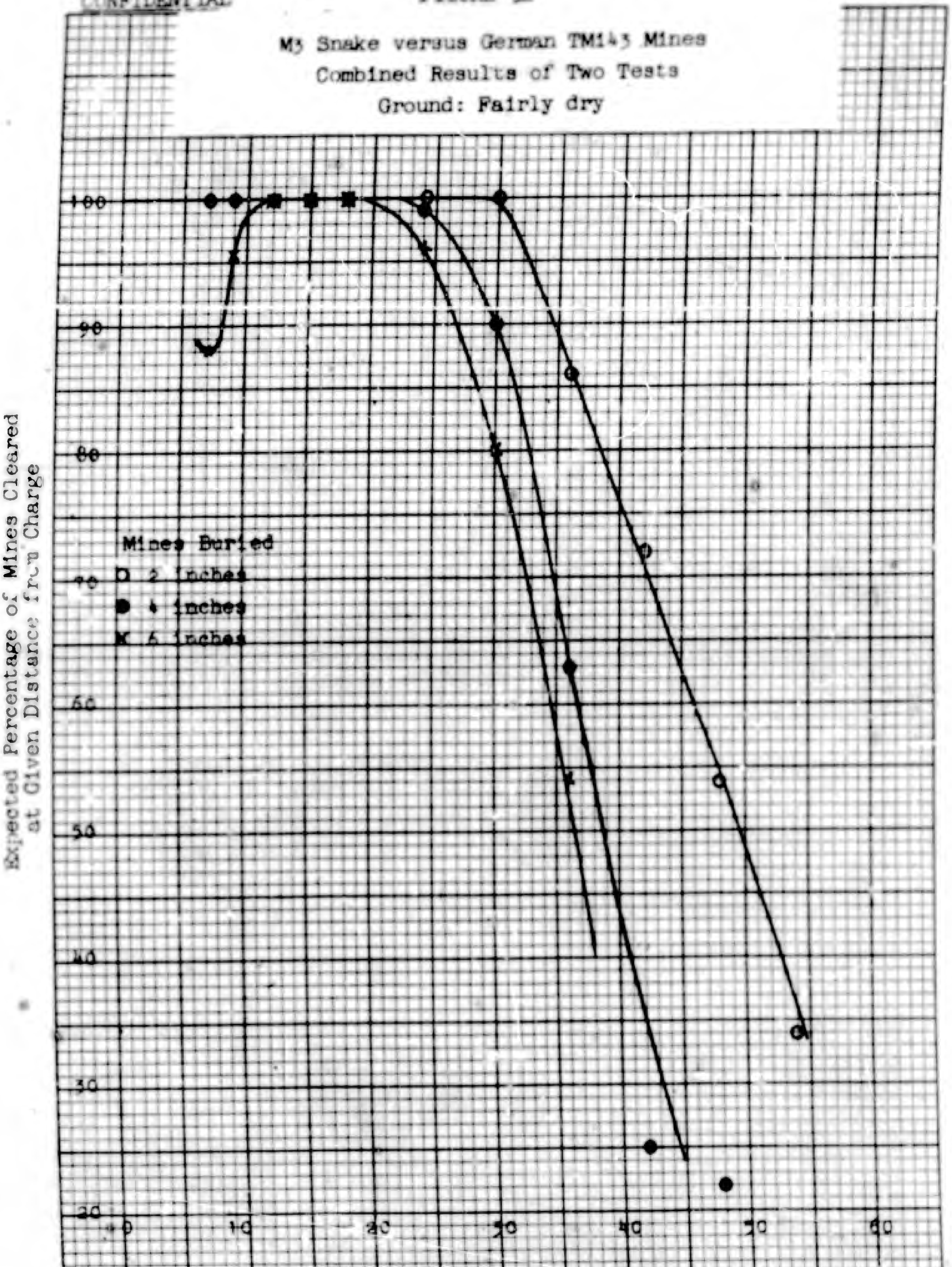
FIGURE 32

M3 Snake versus German TM43 Mines
Combined Results of Two Tests
Ground: Fairly dry



Distance from Charge in Feet

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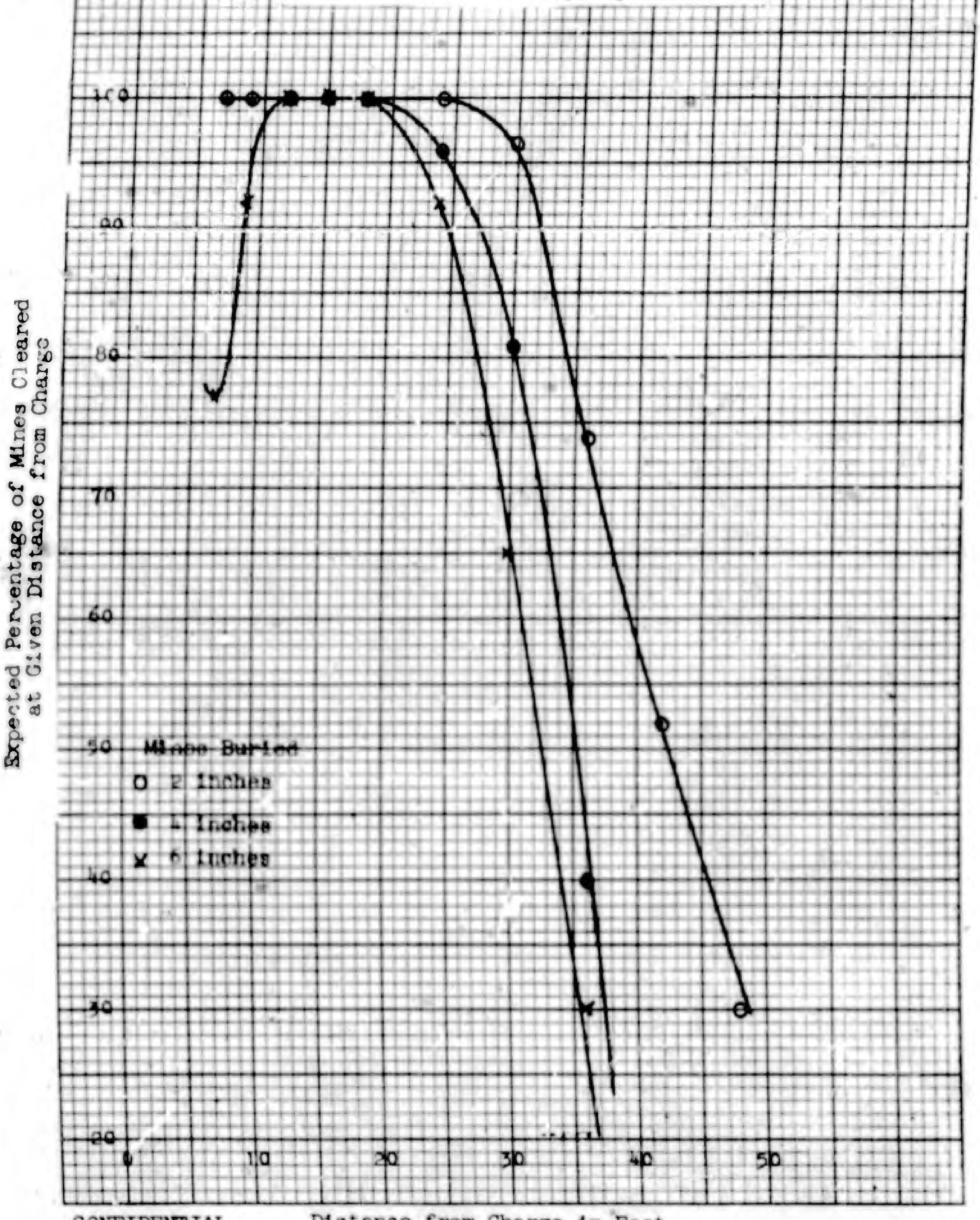
FIGURE 33

M3 Snake versus Japanese J93 Mines

Combined Results of Two Tests

Ground: Fairly dry



Distance from Charge in Feet

FIGURE 34

3" Hose versus German TM43 Mines
Combined Results of Two Tests
Ground: Dry
Detonation: Apparently low order

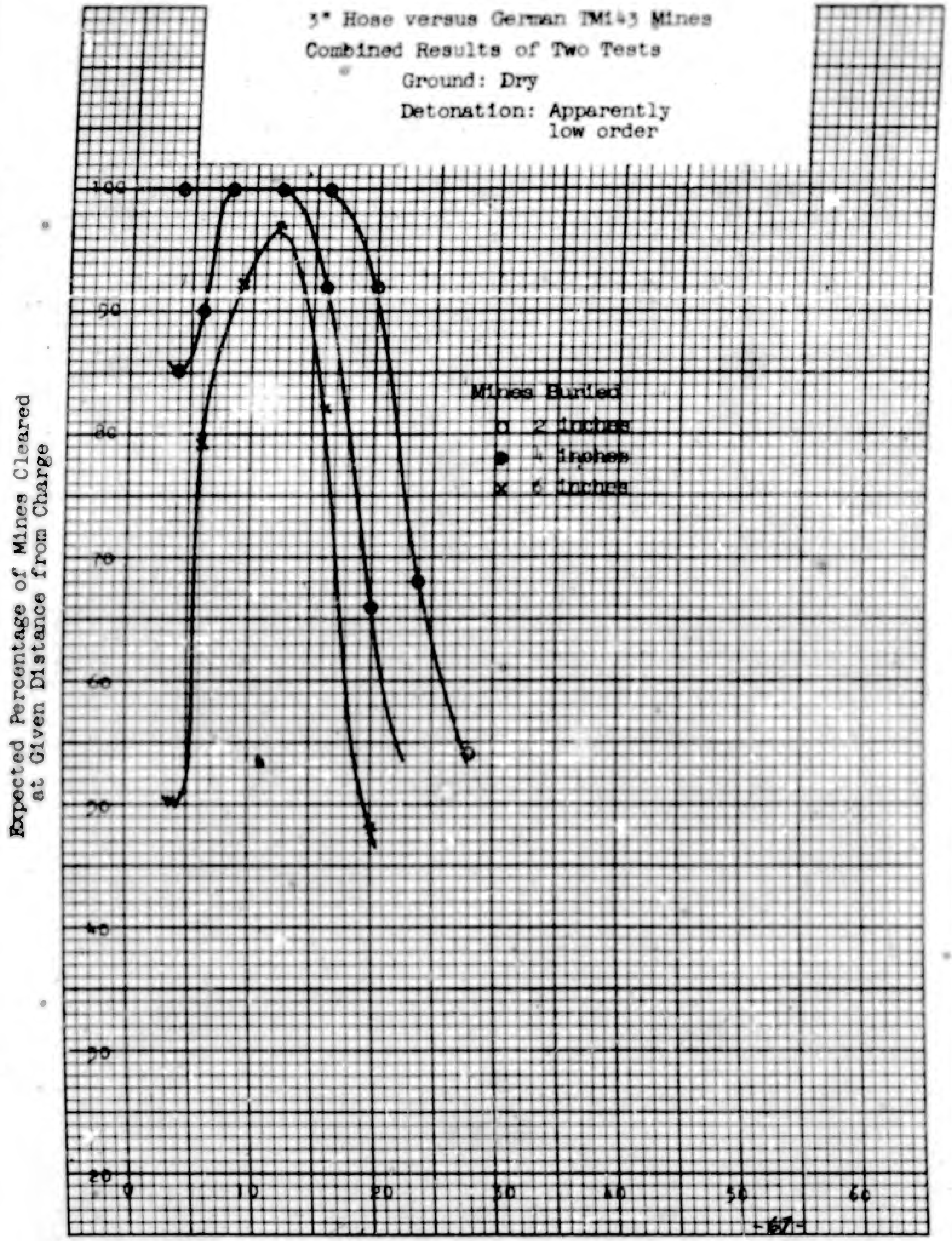


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FIGURE 35

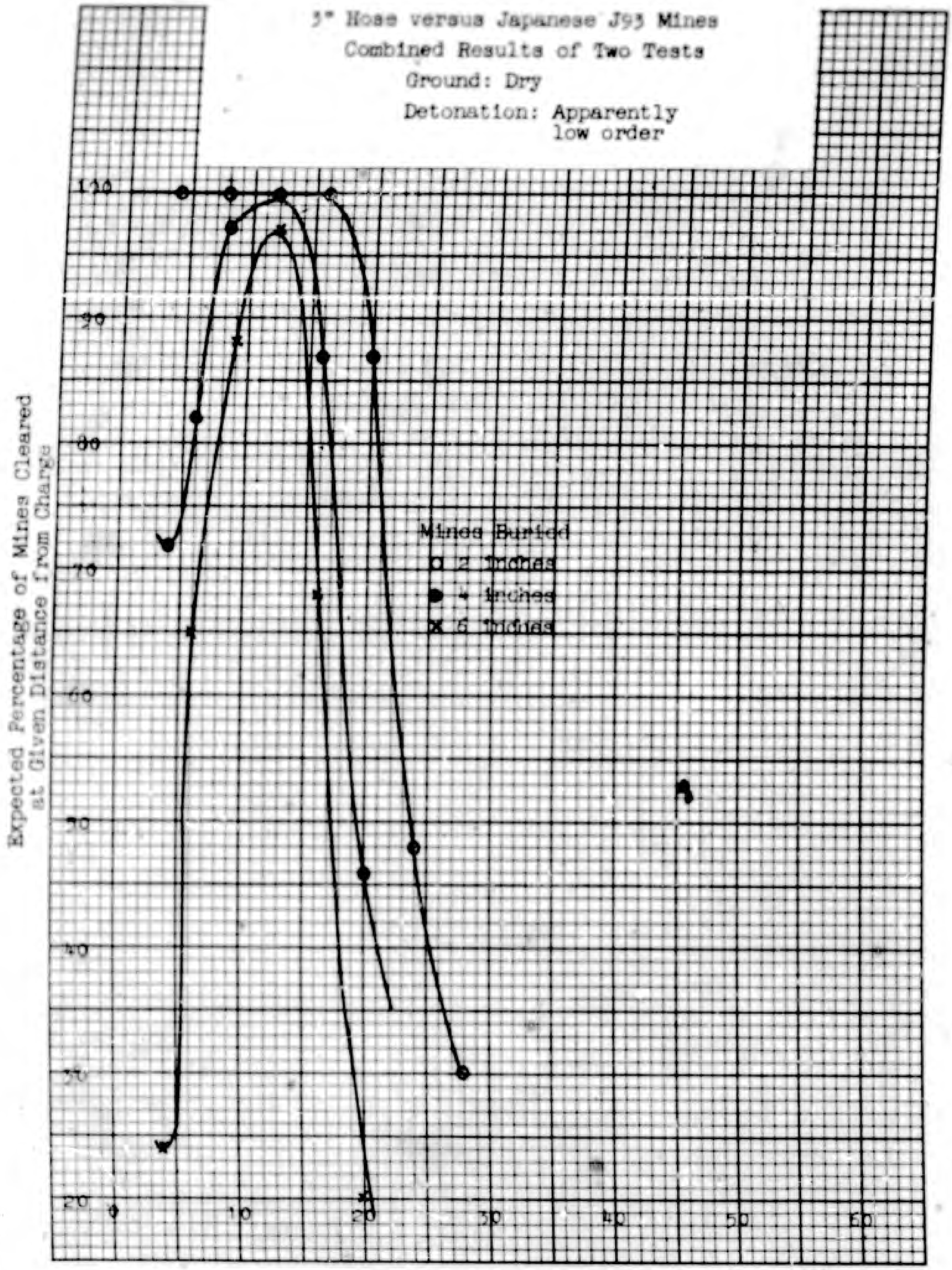

FIGURE 36

3" Hose versus German TMi43 Mines

Ground: Wet

Detonation: High order

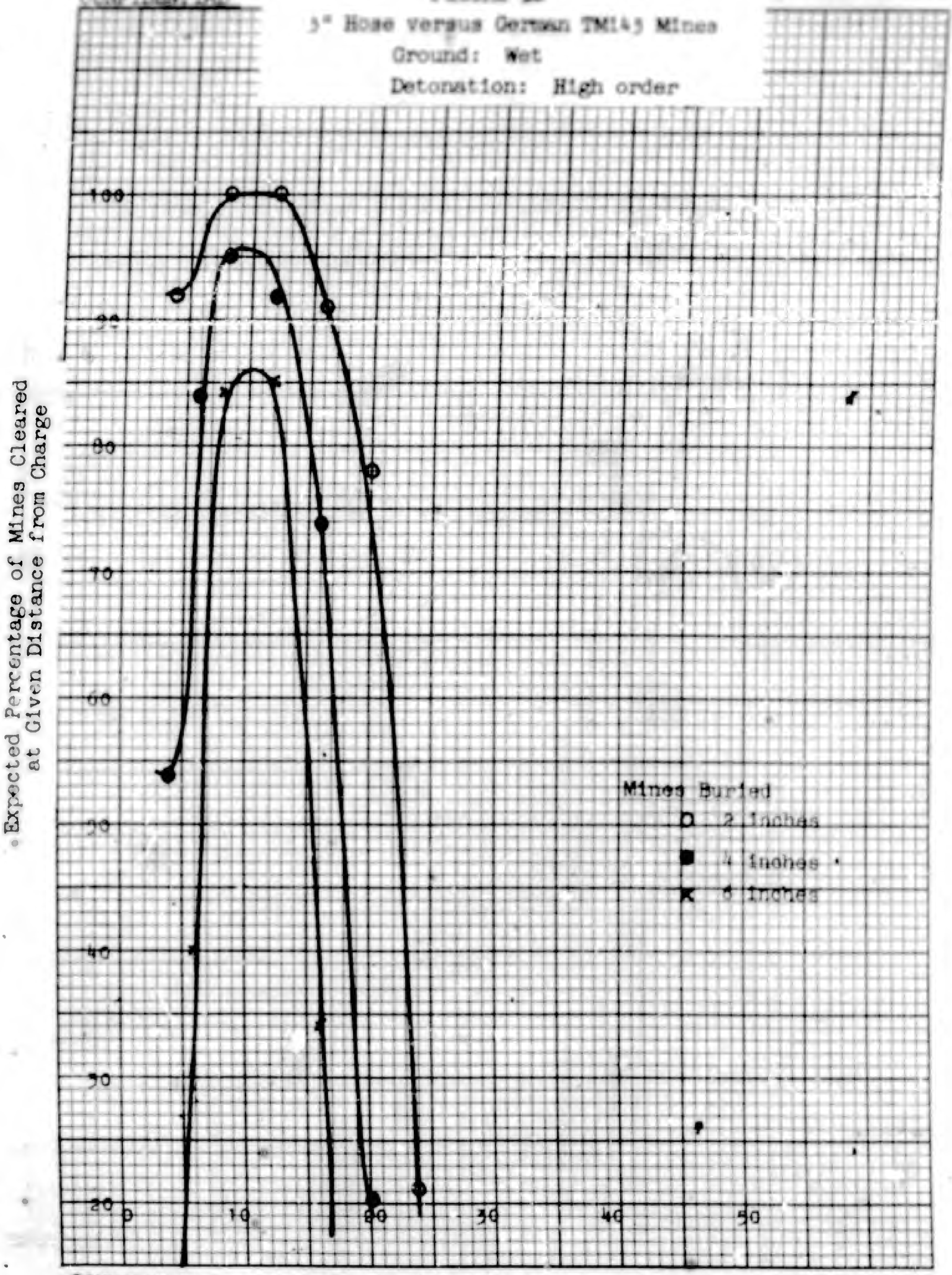

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FIGURE 37

3" Hose versus Japanese J93 Mines
Ground: Wet
Detonation: High order

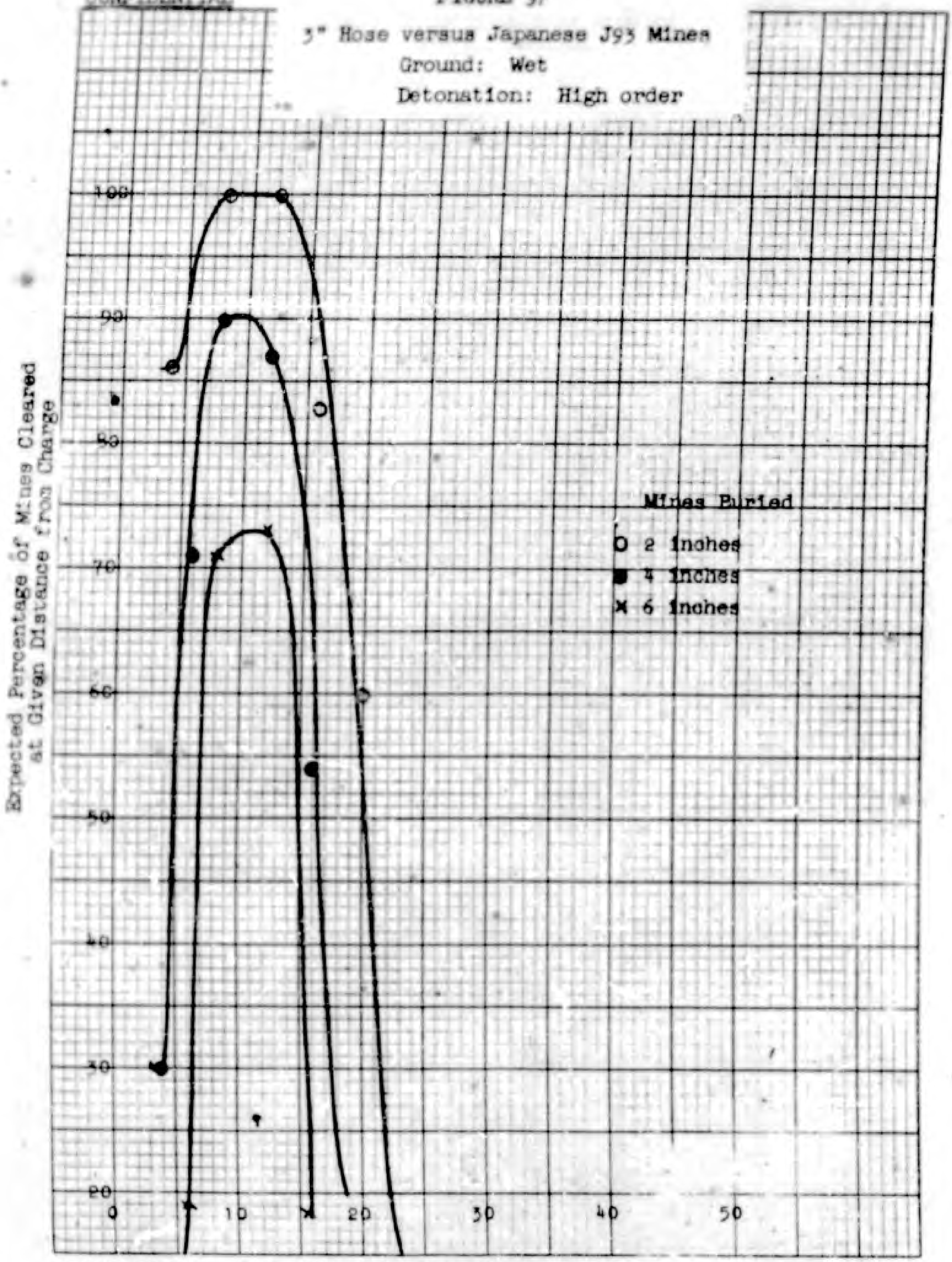

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FIGURE 38

53

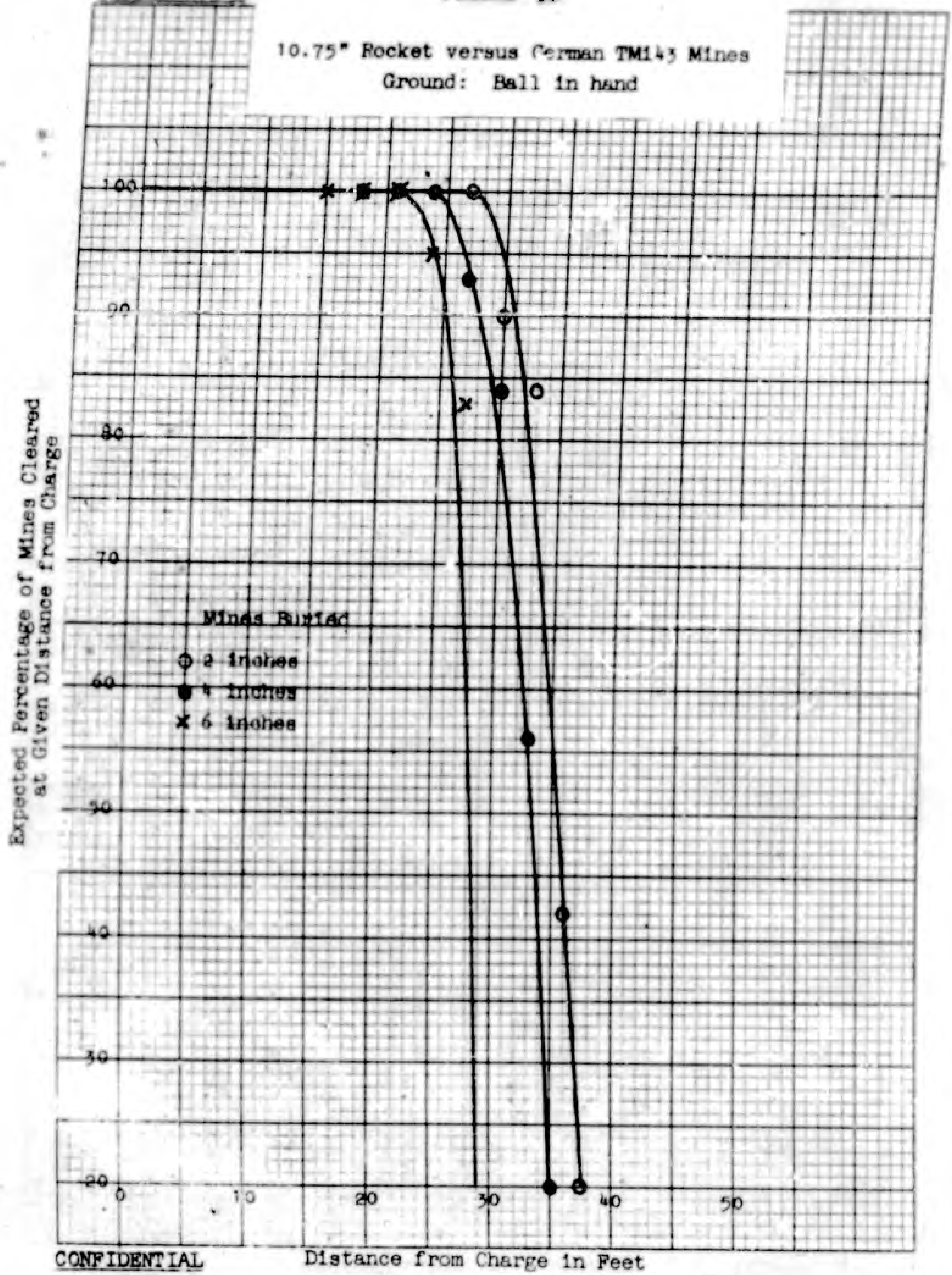
10.75" Rocket versus German TM143 Mines
Ground: Ball in hand
Expected Percentage of Mines Cleared at Given Distance from Charge
100
90
80
70
60
50
40
30
20
Mines Buried
2 inches
4 inches
6 inches
0
10
20
30
40
50
Distance from Charge in Feet

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FIGURE 39

10.75" Rocket versus Japanese J93 Mines
Ground: Ball in hand

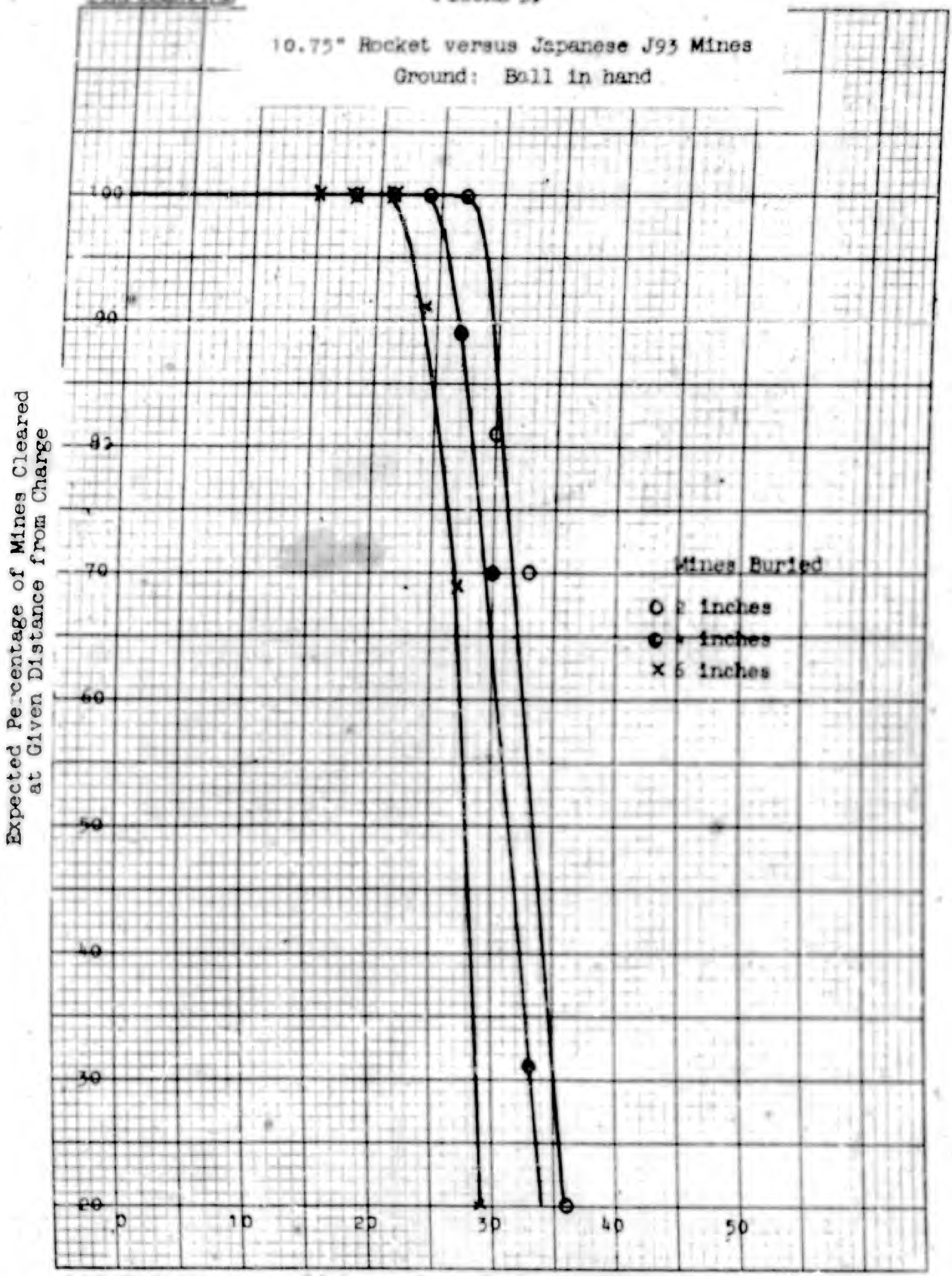

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FIGURE 40

10.75" Rocket versus German TM143 Mines
Combined Results of Three Tests
Ground: Fairly dry

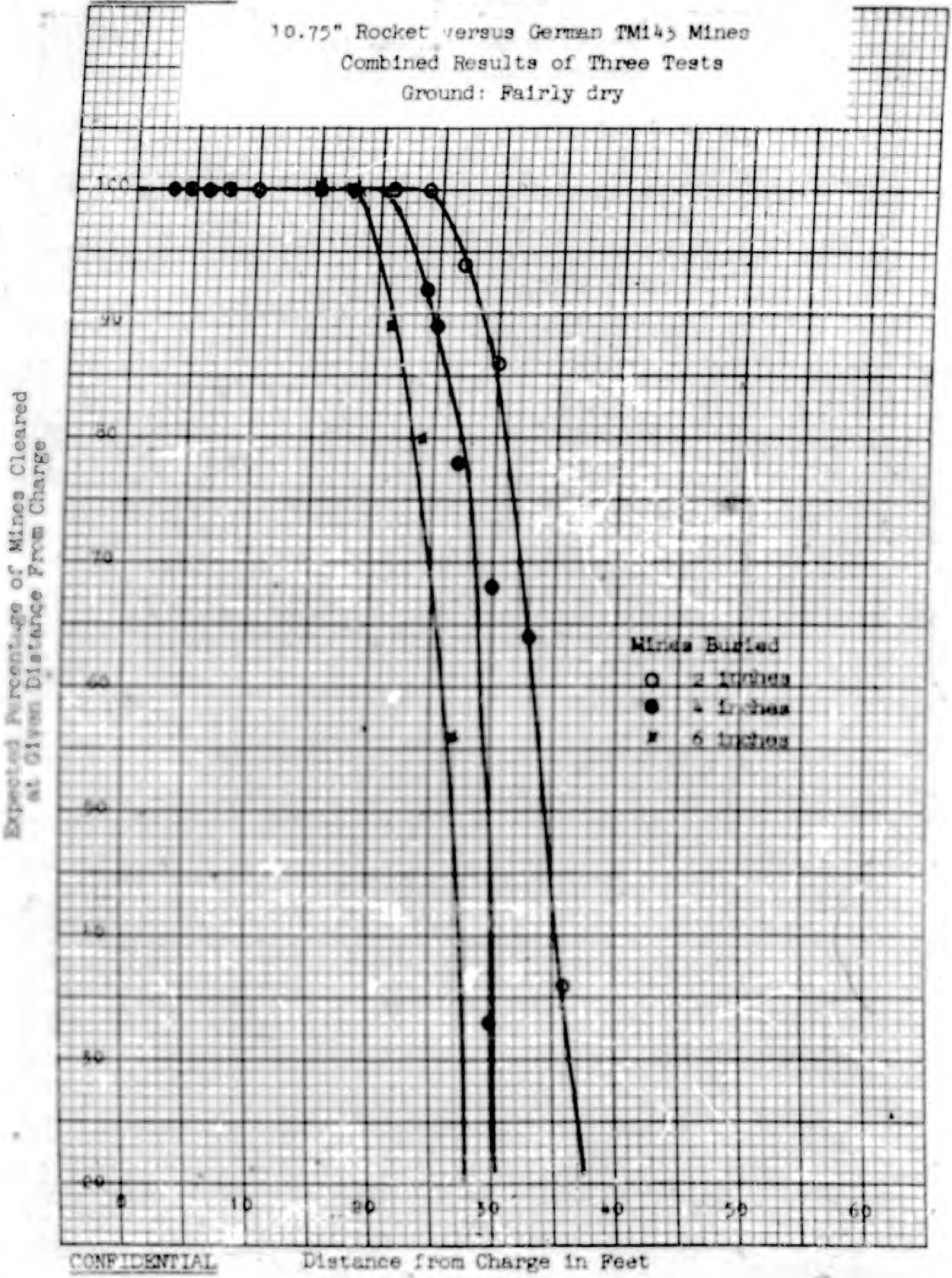

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FIGURE 41

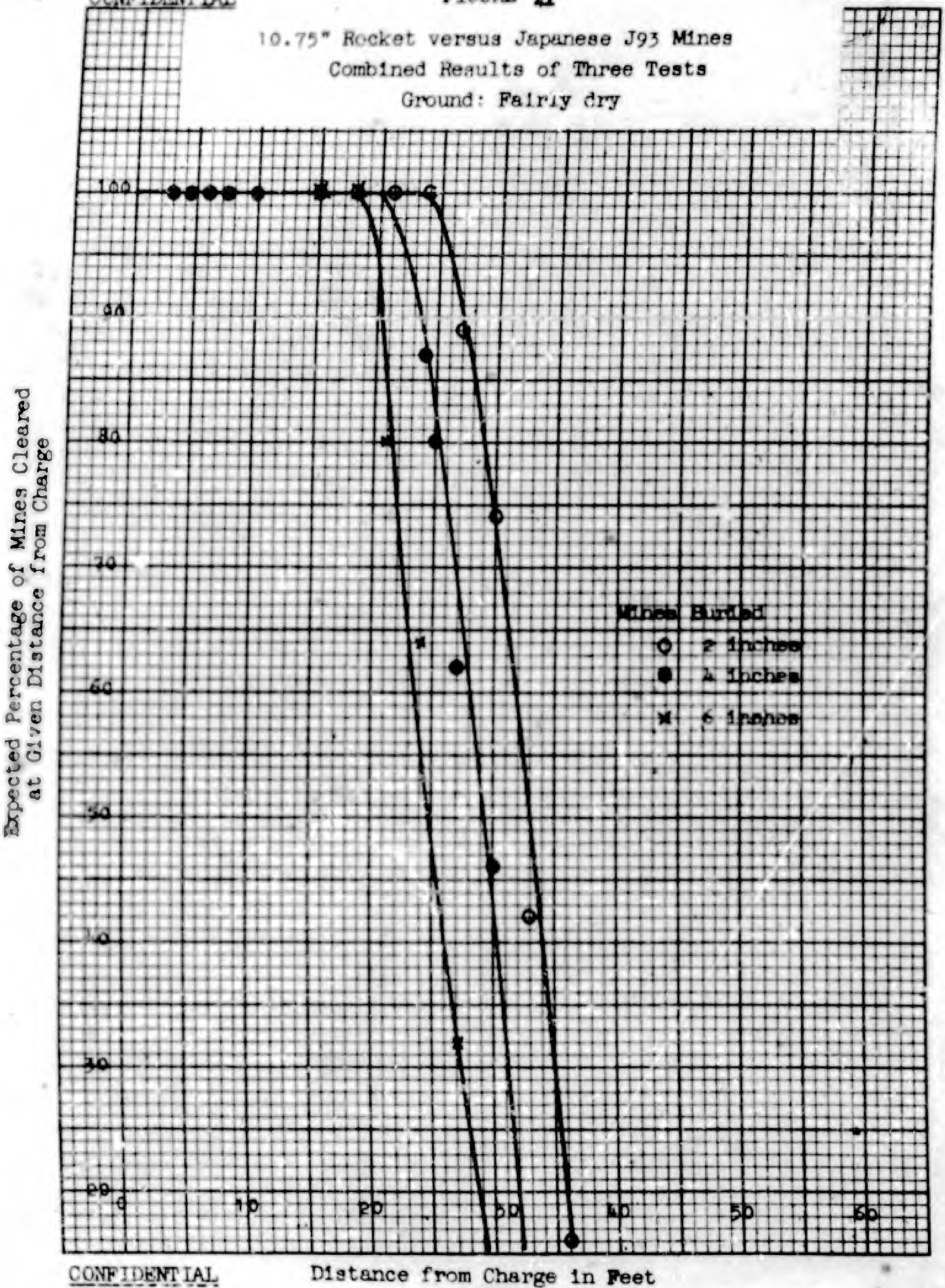
10.75" Rocket versus Japanese J93 Mines
Combined Results of Three Tests
Ground: Fairly dry
Expected Percentage of Mines Cleared at Given Distance from Charge
100
80
70
60
50
40
30
20
0
10
20
30
40
50
60
Mines Buried
2 inches
4 inches
6 inches
Distance from Charge in Feet

FIGURE 42
Antipersonnel Mine Clearing Devices versus
Mustard Pots (Buried Flush)

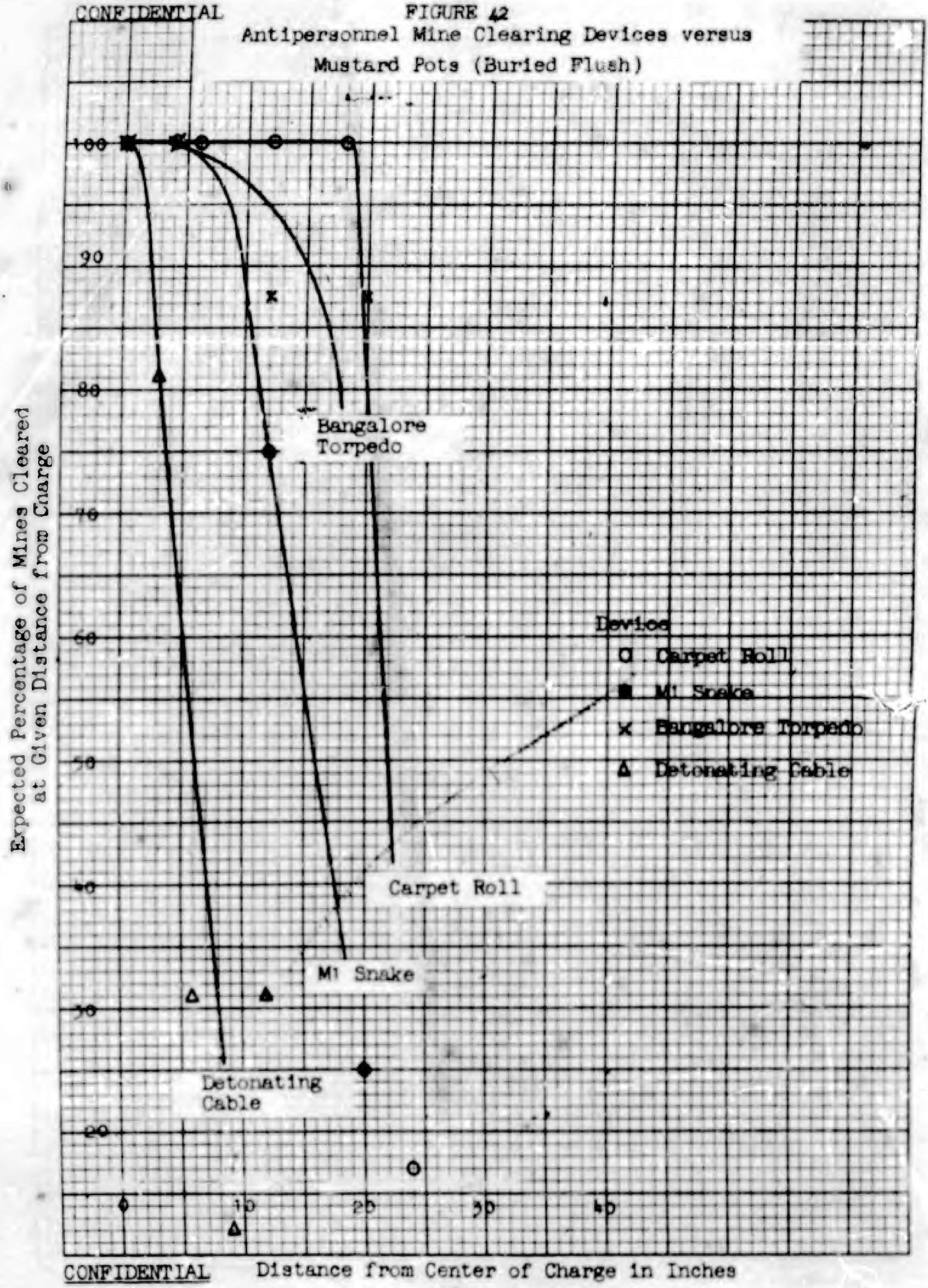

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FIGURE 43

Antipersonnel Mine Clearing Devices versus S Mines (Without Trip Wires)

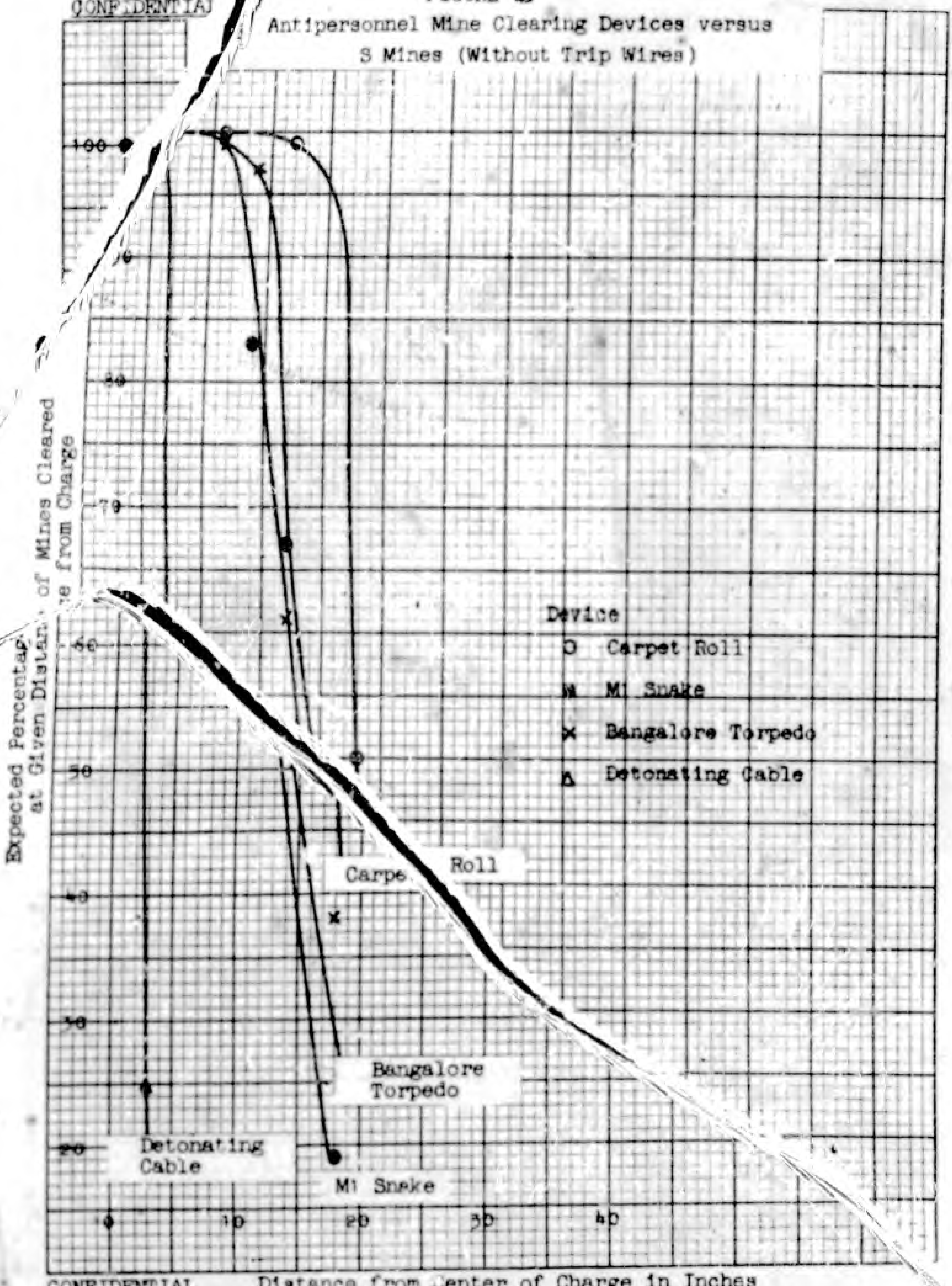

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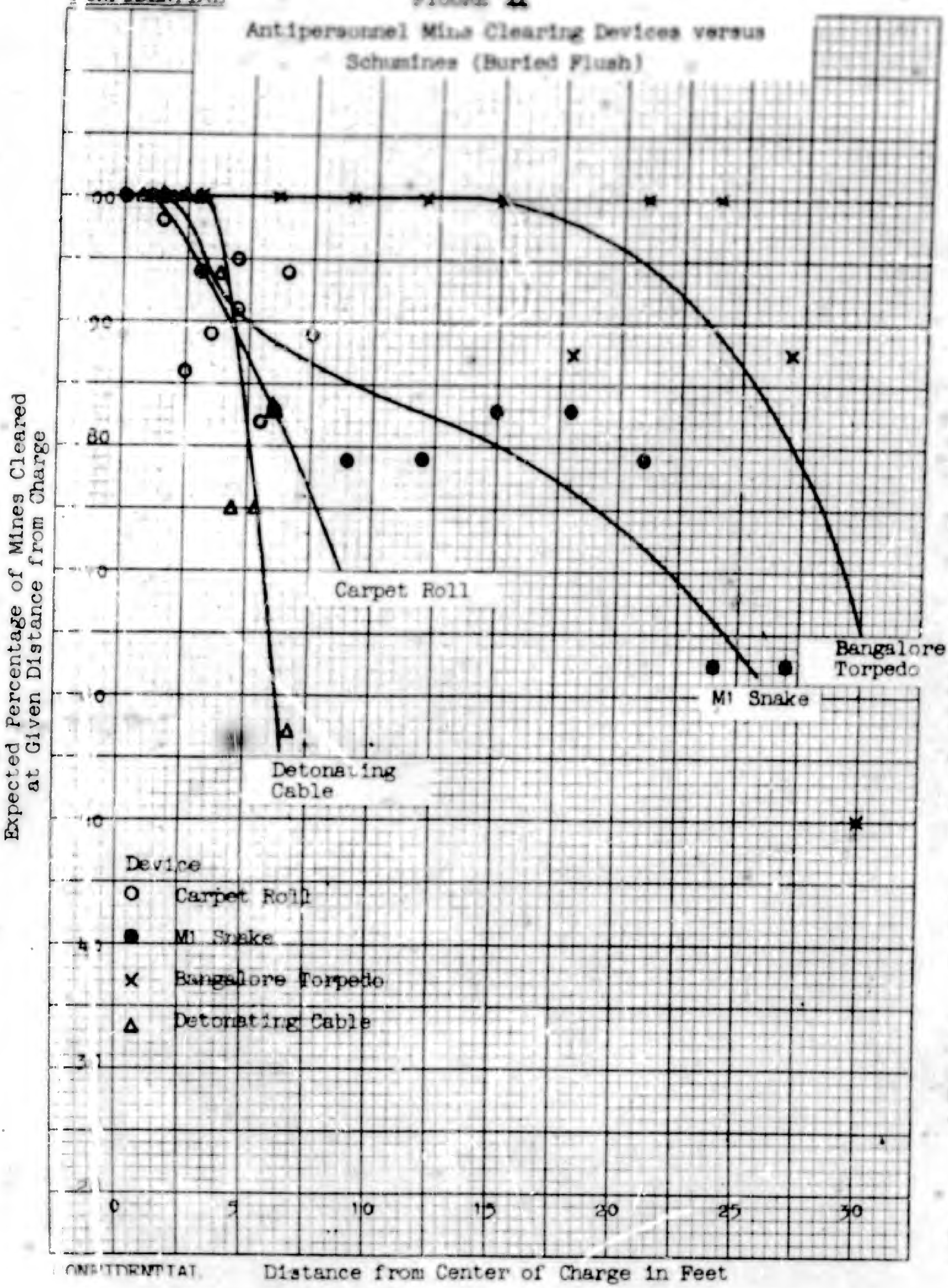
FIGURE 44

Antipersonnel Mine Clearing Devices versus Schumines (Buried Flush)



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