

UNCLASSIFIED

AD NUMBER: AD0862759

LIMITATION CHANGES

TO:

Approved for public release; distribution is unlimited.

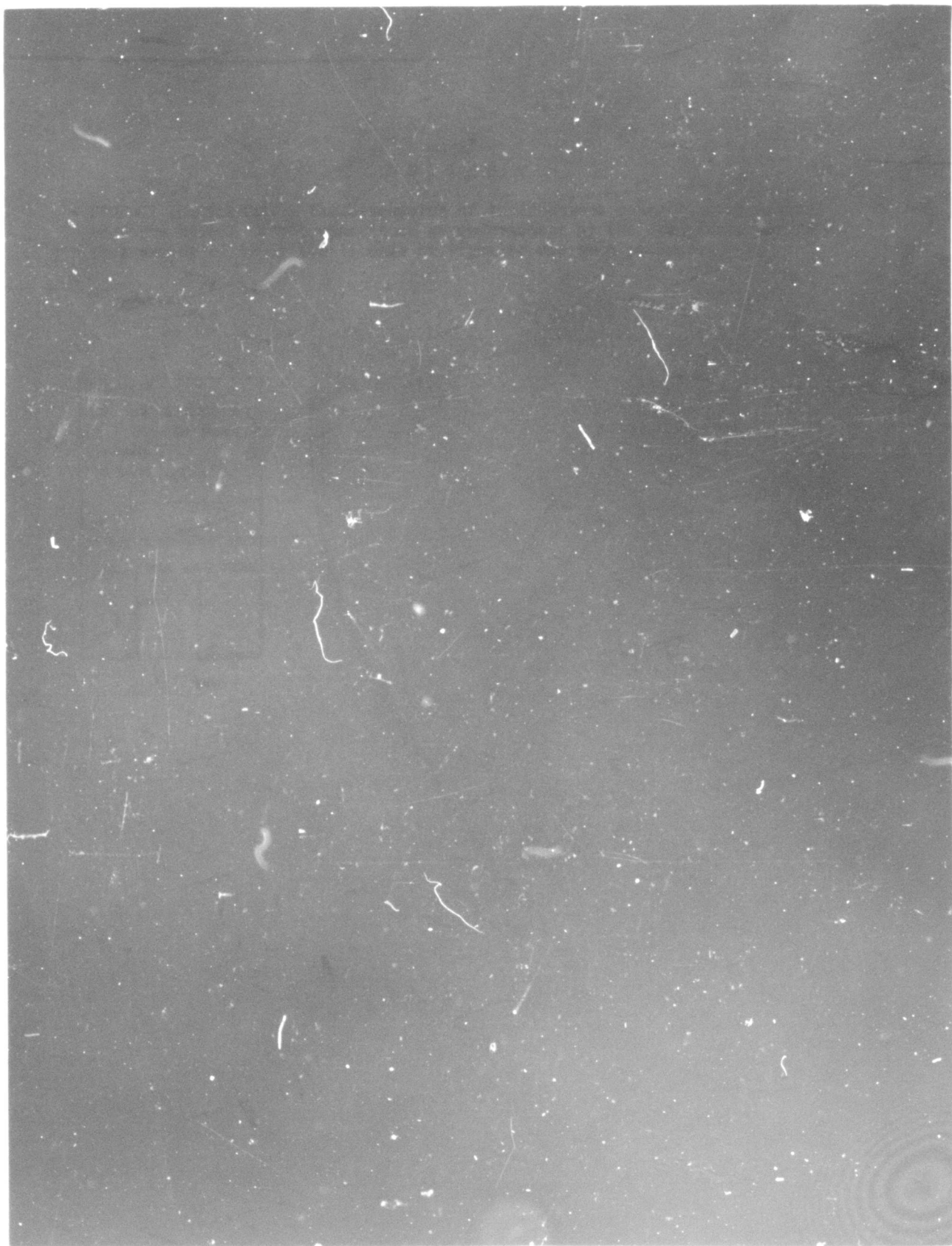
FROM:

Distribution authorized to U.S. Government agencies only; Test and Evaluation; 18 Sep 1969. Other requests shall be referred to Naval Air Development Center, Warminster, PA 18974.

AUTHORITY

USNADC ltr dtd 22 Dec 1971

Reproduced by the  
**CLEARINGHOUSE**  
for Federal Scientific & Technical  
Information Springfield Va. 22151





DEPARTMENT OF THE NAVY  
NAVAL AIR DEVELOPMENT CENTER  
JOHNSVILLE  
WARMINGSTER, PA. 18974

Aero-Electronic Technology Department

REPORT NO. NADC-AE-6920

18 September 1969

DEVELOPMENT OF MANUALLY  
OPERATED CRIMPING TOOL FOR  
SIZE 8 THROUGH 4/0 TERMINALS

FINAL REPORT  
AIRTASK NO. A34534/202/69F32-533-402  
Work Unit No. 3

The manually operated crimping tool will install all MIL-T-7928E copper terminals size 8 through 4/0, and MIL-T-7099 aluminum terminals size 8 through 2, using the applicable MS23002, MS90485, or MS25442 crimping dies. Also, it will install size 8, 4, and 1/0 contacts, using NAVAIRDEVGEN proposed crimping dies. The tool was designed to be fabricated with items primarily obtainable from the military supply system. The recommended ratchet wrench incorporates a safety feature that prevents the application of excessive forces which might result in injury to operating personnel or damage to the tool.

Reported by:

*P. Ardizzi*

P. Ardizzi  
Electrical Division

Approved by:

*L. Cobb*

L. Cobb, Superintendent  
Electrical Division

*D. W. Mackiernan*

D. W. Mackiernan  
Technical Director

*Each transmittal of this document outside the agencies of the U.S. Government must have prior approval of COMNAVAIRDEVGEN or COMNAVAIRSYSCOM.*

## SUMMARY

## INTRODUCTION

AIRTASK No. A34534/202/69F32-533-402, Work Unit No. 3, reference (a), requested NAVAIRDEVGEN to develop a manually operated tool capable of accommodating MS90485, reference (b), MS23002, reference (c), MS25442, reference (d), dies. The tool, with the applicable dies installed, will attach MS20659, reference (e), MS20536, reference (f), copper terminals and MS25435, reference (g), aluminum terminals to their respective wires. The need of the manually operated tool is based on the the reluctance of the fleet to procure the high cost MS25441-1 tool, reference (h), and associated electric-hydraulic pump for operational and intermediate maintenance use. Thus, it became imperative that a cheaper and simpler tool be made available at all levels of maintenance.

## SUMMARY OF RESULTS

The proposed tool accommodated the crimping dies associated with the MS25441-1 hydraulic installing head, and satisfactorily installed sizes 8 through 4/0 insulated and uninsulated MIL-T-7928E, reference (i), copper terminals and splices, plus sizes 8 through 2 MIL-T-7099D, reference (j), aluminum terminals and splices. A completed crimp on any of the aforementioned terminals required a maximum of 3.5 turns of the screw with a maximum torque of 200 ft-lb applied to the square shank of the screw. The handle incorporated a safety device, in the form of a ratchet mechanism, which released when the force applied to the end of the handle exceeded 100 lb. The safety device was intended to protect the operator and prevent damage to the tool and dies in the advent an excessive force was exerted on the handle during the crimping operation. When the tool is in use, the top section of the cap yoke and approximately 1/2 in. of the arms of the swivel yoke are held in a vise, with the square shank of the screw assembly up.

## CONCLUSIONS

1. The proposed tool will satisfactorily install sizes 8 through 4/0 MS20659 and MS20536 copper terminals, and sizes 8 through 2 MS25435 aluminum terminals, using MS90485, MS23002, and MS25442 dies, respectively. In addition, the tool will install size 8, 4, and 1/0 contacts covered by MIL-C-23216A, reference (k), using dies recently developed by NAVAIRDEVGEN under a separate project. MS numbers have not yet been assigned to these dies.
2. The tool will satisfactorily serve the fleet for operational and intermediate maintenance use, as size 1 and larger aluminum wires are infrequently used in aircraft.
3. The proposed tool, when mass produced, will cost approximately one-quarter the cost of the MS25441-1 tool using the MS25441-4 electric-hydraulic pump.

4. The tool, including its ratchet wrench, could be packaged in a metal box approximately 34 by 9 by 4 in. high, with room to store some crimping die sets. Since the weight of the tool and wrench is a maximum of 20 lb, the number of die sets stored in the box would be dependent on the method used to seat them in the box and the maximum weight permitted for the box and its contents. The following weights are provided for information:

Die Set - Government Designation	Type Terminal	Approx Weight (lb) Per Die Set	No. of Die Sets Required	Approx Total Weight (lb)
MS90485	CU uninsulated	0.5	9	4.5
MS23002	CU insulated	0.5	9	4.5
MS25442	Aluminum	1.4	5	7.0
-	Contacts	0.5	3	1.5

#### RECOMMENDATIONS

1. It is recommended that either the manually operated tool developed by NAVAIRDEVCCEN or an MS25441-1 tool actuated by an MS25441-5 foot operated hydraulic pump be adapted for fleet operational and intermediate maintenance use. Reference (a) indicated that the fleet objection to the MS25441-1 tool actuated by the MS25441-4 electro-hydraulic pump was its high cost, approximately \$2,000.00. A cost comparison of the manually operated and foot pump actuated tools is provided in table I, and shows that the two units would have approximately the same price when the manually operated tool is mass produced. To complete the comparison, however, it should be noted that the foot pump actuated tool has a greater capability, having the ability to crimp all the terminal sizes and types accommodated by the manually operated tool plus sizes 1 through 4/0 aluminum, and can do so without the head being secured in a vise.

2. The Saginaw Steering Gear Division of General Motors will probably assign a new part number to the modified ball bearing screw assembly. It is recommended that figures 1 and 2 be revised to show this new part number when it becomes available.

3. If NAVAIRSYSCOM is going to procure a number of the manually operated crimping tools, it is recommended that the following companies be invited to participate in the procurement program:

Thomas and Betts Company, 36 Butler Street, Elizabeth, New Jersey 07207

Daniels Manufacturing Company, 2677 Orchard Lake Road, Pontiac, Michigan 48053

Buchanan Electrical Products Corporation, 1065 Floral Avenue, Union, New Jersey 07083

Sargeant and Company, New Haven, Connecticut 06509

TABLE OF CONTENTS

	Page
SUMMARY . . . . .	iii
Introduction. . . . .	iii
Summary of Results. . . . .	iii
Conclusions . . . . .	iii
Recommendations . . . . .	iv
DISCUSSION. . . . .	1
Background. . . . .	1
Description of Equipment. . . . .	1
Development Methods and Results . . . . .	3
REFERENCES. . . . .	5
TABLES	
I Cost Comparison of Manually Operated Versus Foot Pump Operated Crimping Tools. . . . .	6
II Compression Force in Pounds to Complete Crimp . . . . .	7
III Tensile Values (LB) of Crimped Terminals. . . . .	8
FIGURES	
1 D-SK-002572 - Die Holder Assembly . . . . .	9
2 B-SK-002573 - Adaptor . . . . .	10
3 Prototype of NAVAIRDEVCEEN Proposed Manually Oper- ated Crimping Tool for Size 8-4/0 Terminals . . . . .	11

## DISCUSSION

## BACKGROUND

The current MS25441 electric-hydraulic tool assembly consists of an electric-hydraulic pump unit (MS25441-4), an installing head (MS25441-1), a control handle (MS25441-2), and a hydraulic hose assembly (MS25441-3). The installing head accommodates MS90485, MS23002, and MS25442 crimping dies for installing Specification No. MIL-T-7928E insulated and uninsulated copper terminals and Specification No. MIL-T-7099D aluminum terminals to their respective wires.

Reference (a) noted that the tool assembly and associated crimping dies cost approximately \$2000. Because of this high cost, the fleet was reluctant to procure these items for operational and intermediate maintenance. However, to ensure that satisfactory electrical crimp terminations were maintained in aircraft electrical systems, it was considered imperative to develop a cheaper and simpler tool that could utilize the above-mentioned crimping dies for installing the proper size terminal to the applicable size wire at all levels of maintenance.

To implement this intent NAVAIRDEVGEN was requested to develop a manually operated tool that could accommodate the MS23002, MS25442, and MS90485 dies and produce a satisfactory termination on MIL-T-7928E and MIL-T-7099D terminals. In addition, the tool should be capable of producing a satisfactory crimp on size 8, 4, and 1/0 contacts used in connectors.

## DESCRIPTION OF EQUIPMENT

Basically, the proposed manually operated crimping tool consists of the swivel yoke head and cap yoke of an MS25441-1 hydraulic installing head, a ball bearing screw assembly, a few machined parts, a plastic protective boot which fits over the otherwise exposed screw assembly, a 3/4 to 5/8 in. socket square adapter, and a ratchet handle with a safety device that releases when a force exceeding 200 ft-lb is applied to the handle.

Figure 1 (NAVAIRDEVGEN Drawing D-SK-00572) shows the tool assembly and references figure 2 (NAVAIRDEVGEN Drawing B-SK-002573) which delineates the adapter used to mount the ball bearing screw assembly to the yoke head.

Many of the parts comprising the proposed crimping tool assembly are commercially available, and are listed below for guidance. Note that orders for the Saginaw P/N 1000-0250-C2-SRT(RH) ball bearing screw assembly should include the modifications described in the following list, and that the received screw assembly must then be machined at both ends as shown on figure 1.

## MATERIAL LIST AND SOURCE

<u>Item</u>	<u>Quantity Required</u>	<u>Mfr Name and Address</u>	<u>Mfr P/N</u>	<u>Approx Cost</u>	<u>Govt Ident</u>
Ball Bearing Screw Assembly	1	Saginaw Steering Div of General Motors, Saginaw, Michigan	1000-0250- C2-SRT(RH)*	\$105.00	-
Torque Wrench	1	Pendleton Tool Industries, Contract Div, 5211 Paramount Blvd, Pico Rivera Calif 90660	PROTO 6018	\$106.00	-
Specifications: 50 to 300 ft-lb, 3/4 in. square drive size, ratchet head, length 33-1/8 in., weight 7.56 lb					
Socket Square 3/4 to 5/8 in.	1	Snap-On Tools Corp, 8049 28th Ave, Kenosha, Wisconsin 53140	IN-620	\$4.00	
Cap-Yoke (12-ton Capacity)	1	Thomas & Betts Co 36 Butler St Elizabeth, N.J. 07207	13642M-2	\$42.00	Part of MS25441-1
Yoke-Head (12-ton Capacity)	1	Thomas & Betts Co	13642M-29	\$100.00	Part of MS25441-1
Button Unit, Snap, Female Plus Screw	1	Thomas & Betts Co	13642-7	\$1.00	AN227-7
	1	Thomas & Betts8 Co	13642-8		
Button, Unit, Snap, Male, Plus Screw	1	Thomas & Betts Co	13642-31	\$1.00	AN227-10
	1	Thomas & Betts Co	13642-8		

\* Order should request following modifications:

8 in. screw length, 3 in. flange diameter, 7/16 in. flange thickness,  
and 0.375 in. diameter flange mounting holes with holes relocated 10 deg-  
rees counterclockwise from present locations. (Reason for relocation:  
With increased mounting hole and screw size, the screw heads do not clear

the ball bearing return tubes.) When in use, the tool should be mounted in a vise with the top section of the cap yoke and approximately 1/2 in. of the arms of the swivel yoke held in the vise, with the square shank of the screw assembly up. The installation of the terminal on its wire can be accomplished with a maximum of 3.5 turns of the screw and a maximum torque of 200 ft-lb applied to the square shank of the screw, or 100-lb of pressure applied to the wrench two feet from the screw. The ratchet handle obviates the necessity of turning the handle 360 degrees. The safety feature in the handle informs the operator when the crimp has been completed, provides safety for the operator, and prevents damage to the tool and dies.

A torque of 200 ft-lb applied to the square shank of the screw provides 20,800 lb of pressure to the dies, and is the manufacturer's maximum pressure recommended for the ball bearing screw assembly. The use of the MS25441-1 swivel yoke head and cap yoke, which were designed to withstand 12 tons (24,000 lb) of pressure, provide an adequate safety factor, and permits easy installation and interchangeability of all die sets accommodated by the MS25441-1 crimping head. The maximum permitted pressure of 20,800 lb provided by the proposed tool permits the installation of the following listed items on their wires:

<u>Spec No.</u>	<u>Item</u>	<u>Size</u>	<u>MS No.</u>
MIL-T-7928	CU insulated terminals and splices	8 thru 4/0	MS23002
MIL-T-7928	CU uninsulated terminals and splices	8 thru 4/0	MS90485
MIL-T-7099	AL terminals and splices	8 thru 2	MS25442
MIL-C-23216	Contacts for connectors	8, 4, and 1/0	Number not yet assigned

#### DEVELOPMENT METHODS AND RESULTS

##### Preliminary

The investigation was initiated by ascertaining the applied force in pounds necessary to complete the crimp on sizes 8 through 4/0 insulated (MS25036) and uninsulated (MS20659) copper terminals covered by MIL-T-7928E and aluminum (MS25435A) terminals covered by MIL-T-7099D.

The force was measured by utilizing only the swivel yoke and cap yoke of the MS25441-1 hydraulic crimping tool. These two yokes accommodate and retain all the standard crimping dies for the above-mentioned terminals. A ram was designed that would apply a force from a 30,000 lb compression machine directly to the movable die contained within the swivel yoke of the crimping tool. Applicable size MIL-W-5086A, reference (1), copper and MIL-W-7072B, reference (m), aluminum wires were used with the

copper and aluminum terminals, respectively. The crimp was considered completed when the interfaces of the two die-halves met, and the force in pounds necessary to bring them to that point was recorded. The applied forces are shown in table II, and the tensile values of the crimped terminals are shown in table III.

### Design of Tool

Early in the investigation a decision was made to use the cap yoke and swivel yoke head of the MS25441-1 crimping tool as the basic parts of the proposed tool, as these parts were designed to withstand the great pressure necessary to install the terminals on their wires, and all the pertinent dies were designed to easily snap into and out of the yokes. In addition, consideration was given to the availability of these parts in the Navy supply system.

The next step was to design the ram and a means of applying manually the necessary pressure to the ram, based on an operator applying a maximum of 100 lb of pressure on the handle or arm of the tool. Various means of supplying the pressure were attempted, including the use of a large, heavy-built vise, a truck jack, and an arbor press. None were satisfactory, being inefficient, heavy, awkward, and in most cases not capable of supplying the required forces.

A review was made of commercially available, manually operated power developing devices capable of being easily joined to the swivel head without disrupting unduly the desired weight, size, and configuration of the unit. The search revealed a ball bearing screw assembly capable of developing a maximum safe pressure of 20,800 lb with a torque of 200 ft-lb applied to the screw. The device was procured and modified to fit the application. With the addition of certain machined parts necessary to attach it to the swivel yoke head and make interface with the dies more efficiently, the device was installed in the swivel head. A photograph of the NAVAIRDEVGEN prototype of the tool is shown in figure 3.

The tool's maximum output of 20,800 lb permits its use when crimping sizes 8 through 4/0 copper (MS20659 and MS25036) terminals, but restricts its use to crimping sizes 8 through 2 aluminum (MS25435) terminals.

The prototype tool was tested by crimping the above terminals to their respective wires, using the applicable dies. When in use, the cap yoke is enclosed to a depth of 1-1/2 in. in the jaws of a large vise mounted securely to a table. This results in about 1/2 in. of the stationary die and arms of the swivel yoke also being enclosed in the vise, but exposed the nest of the die. The square shank of the screw is up.

The tool installed the terminals to their wires, and the tensile tests of the crimped terminals showed results within the range indicated on table III. The tests revealed that improvements could be obtained by the following revisions:

1. Revise the flange of the ball bearing screw assembly by increasing the diameter to 3 in., the thickness to 7/16 in., the diameter of the mounting holes to 0.375 in., and relocating the mounting holes 10 degrees counterclockwise from their present locations. The revisions will increase the strength of the assembly and will permit the larger mounting screws to clear the bearing return tubes.
2. Replace the handle with a ratchet torque wrench locked permanently at 200 ft-lb to protect the operator and the tool.
3. Specify installation of a protective boot to exclude contaminants from the screw and to protect the ball bearing return tubes.
4. Specify that the 3/4 to 5/8 in. socket square be fastened permanently to the square shank of the screw so as to eliminate a loose part, and to prevent the screw from falling out of the yoke head when the dies and cap yoke are removed.
5. Specify that the installation of the set screws holding the buffer to the bumper be such that they permit the buffer to rotate freely, thus reducing friction and wear during the crimping operation.

In addition, the tool was used to crimp sizes 8, 4, and 1/0 MIL-C-23216 contacts used in connectors. The crimping dies installed in the tool were developed by NAVAIRDEVGEN specifically for this purpose under a separate project. Tensile tests on the crimped contact-wire combination provided results comparable with those obtained on the copper terminals.

The proposed tool incorporating the above improvements is shown in figure 1.

#### R E F E R E N C E S

- (a) NAVAIRSYSCOM ltr AIR-340E:SES of 11 Jul 1968.
- (b) Std No. MS90485, Dies for MS25441 Hydraulic Crimping Tool (for Use with MS20659 Uninsulated Wire Terminals).
- (c) Std No. MS23002, Rev C, Die, MS25441 Crimping Tool - For Use with MS25036 Size 8 Through 4/0 Terminals.
- (d) Std No. MS25442, Rev C, Dies for MS25441 Hydraulic Crimping Tool (For Use with Aluminum Wire Terminals).
- (e) Std No. MS20659, Rev B, Terminal, Lug, Crimp Style, Copper, Uninsulated, Class 1.
- (f) Std No. MS25036, Rev D, Terminal, Lug, Crimp Style, Copper, Insulated, Class 1.
- (g) Std No. MS25435, Rev A, Terminal, Lug, Crimp Style, Straight Type, for Aluminum Aircraft Wire, Class 1.

- (h) Std No. MS25441, Rev C, Crimping Tool, Terminal, Hydraulic Operated, Wire Size 8 Through 4/0.
- (i) Spec No. MIL-T-7928E, Terminals, Lug and Splice, Crimp Style, Copper.
- (j) Spec No. MIL-T-7099D, Terminals, Lug Crimp Style, for Aluminum Aircraft Wire.
- (k) Spec No. MIL-C-23216A, Contact, Crimp Style, Electric Connector, General.
- (l) Spec No. MIL-W-5086A, Wire, Electrical, 600 Volts, Copper, Aircraft.
- (m) Spec No. MIL-W-7072B, Wire, Electric, 600 Volt, Aluminum Aircraft, General Specification for.

T A B L E I

COST COMPARISON OF MANUALLY OPERATED  
VERSUS FOOT PUMP OPERATED CRIMPING TOOLS

<u>Hydraulically Operated</u>	<u>Manufacturer's Price as of Spring 1969</u>
MS25441-1 12-ton installing head	\$210.00
MS25441-3 10-ft hydraulic hose assembly	60.00
MS25441-5 foot operated hydraulic pump	140.00
Total	<u>\$410.00</u>
 <u>Manually Operated (NAVAIRDEVCEEN Developed)</u>	
Cap yoke (part of MS25441-1)	\$ 42.00
Swivel yoke head (part of MS25441-1)	100.00
Ball bearing screw assembly	105.00
Torque wrench	106.00
Socket square (3/4 to 5/8 in.)	4.00
Button Units, snap	2.00
Machine shop work	?
Manufacturer's markup	?
Total*	<u>\$359.00 + ?</u>

\* The price of the manually operated tool would be considerably below that shown if it were mass produced.

TABLE I I

## COMPRESSION FORCE IN POUNDS TO COMPLETE CRIMP

<u>Terminal and Wire Size</u>	<u>MS20659 (CU Uninsulated)</u>	<u>MS25036 (CU Insulated)</u>	<u>MS25435A (Aluminum)</u>
8	3,410	3,750	5,575
6	4,050	6,000	9,250
4	5,650	7,800	13,250
2	5,675	10,750	12,675
1	6,875	10,125	-*
1/0	8,000	10,850	22,375
2/0	8,500	15,500	21,775
3/0	13,950	18,750	-*
4/0	15,350	20,750	-*
High	15,350	20,750	22,375
Low	3,410	3,750	5,575
Dies used	MS90485	MS23002	MS25442
Wire used	MIL-W-5086	MIL-W-5086	MIL-W-7072

\* Terminals not available

T A B L E   I I I  
TENSILE VALUES (LB) OF CRIMPED TERMINALS

Terminal and Wire Size	MS20659		MS25036		MS25435	
	Measured	Specified (min)	Measured	Specified (min)	Measured	Specified (min)
8	Hi	400	394	225	280	130
	Lo	365	378		240	
6	Hi	621	558	300	352	200
	Lo	555	542		234	
4	Hi	649	600	400	622	300
	Lo	506	362		362	
2	Hi	850	1030	550	1240	500
	Lo	675	720		1150	
1	Hi	960	1250	650	-*	700
	Lo	770	1120		-	
1/0	Hi	1150	1360	700	1840	900
	Lo	1035	790		1630	
2/0	Hi	1300	1510	750	2134	1100
	Lo	1160	1310		1986	
3/0	Hi	1740	1780	825	-*	1300
	Lo	1470	1610		-	
4/0	Hi	1925	2010	875	-*	1500
	Lo	1820	1925		-	

\* Terminals not available





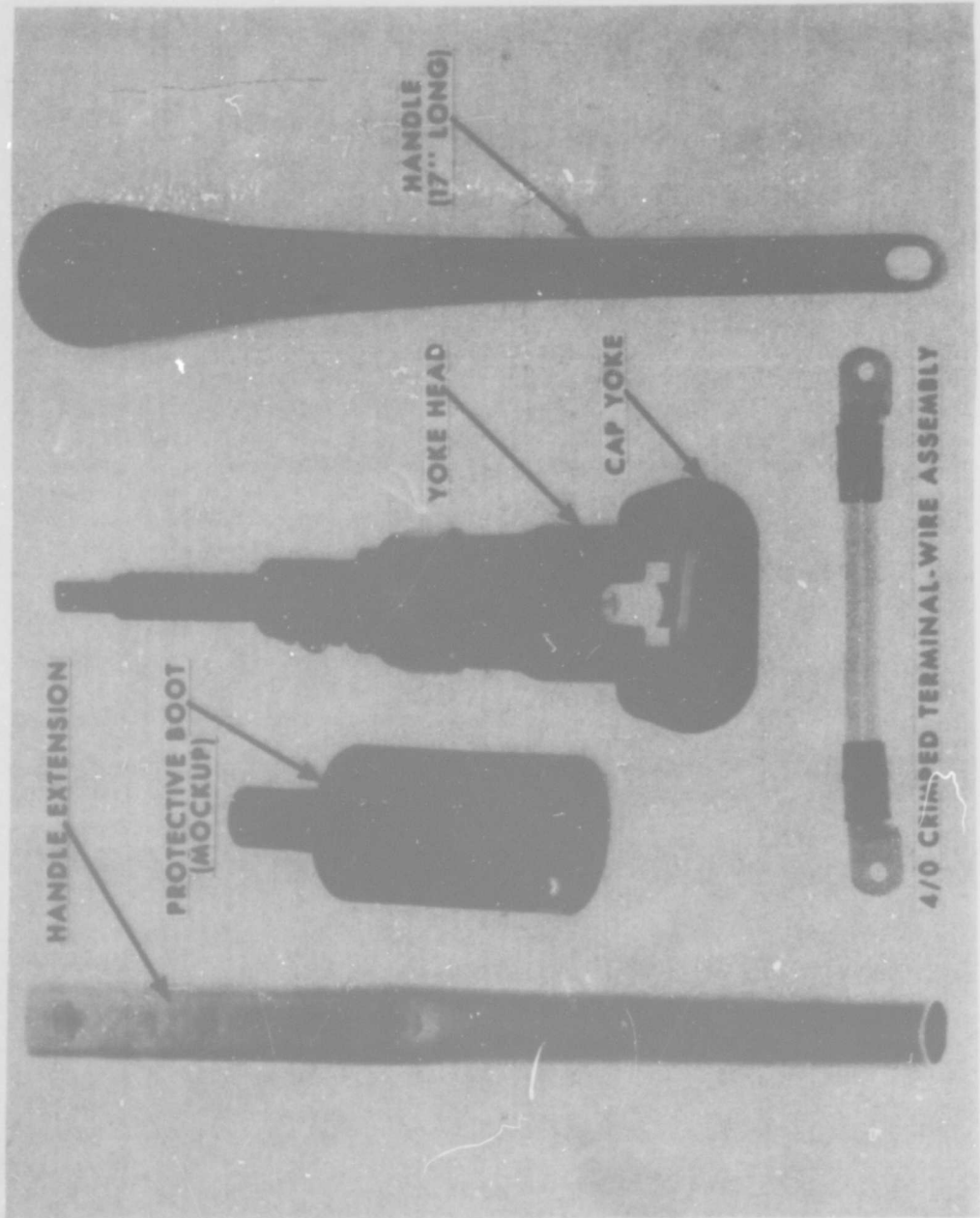


FIGURE 3 PROTOTYPE OF NAVAIRDEVCEEN PROPOSED MANUALLY OPERATED CRIMPING TOOL FOR SIZE 8-4/0 TERMINALS

UNCLASSIFIED

Security Classification

DOCUMENT CONTROL DATA - R & D

Security classification of title, body of abstract and indexing annotation must be entered when the overall report is classified

1. ORIGINATING ACTIVITY (Corporate author) <b>AERO-ELECTRONIC TECHNOLOGY DEPARTMENT NAVAL AIR DEVELOPMENT CENTER, JOHNSVILLE WARMINSTER, PENNSYLVANIA 18974</b>		2a. REPORT SECURITY CLASSIFICATION <b>UNCLASSIFIED</b>	
		2b. GROUP	
3. REPORT TITLE <b>DEVELOPMENT OF MANUALLY OPERATED CRIMPING TOOL FOR SIZE 8 THROUGH 4/0 TERMINALS</b>			
4. DESCRIPTIVE NOTES (Type of report and inclusive dates) <b>FINAL REPORT</b>			
5. AUTHOR(S) (First name, middle initial, last name) <b>P. ARDIZZI</b>			
6. REPORT DATE <b>18 SEPTEMBER 1969</b>	7a. TOTAL NO OF PAGES <b>16</b>	7b. NO OF REFS <b>13</b>	
8a. CONTRACT OR GRANT NO		9a. ORIGINATOR'S REPORT NUMBER(S) <b>NADC-AE-6920</b>	
b. PROJECT NO <b>AIRTASK A34534/202/69F32-533-402</b>		9b. OTHER REPORT NO(S) (Any other numbers that may be assigned this report)	
c. WORK UNIT NO. 3			
d.			
10. DISTRIBUTION STATEMENT <b>EACH TRANSMITTAL OF THIS DOCUMENT OUTSIDE THE AGENCIES OF THE U.S. GOVERNMENT MUST HAVE PRIOR APPROVAL OF COMNAVAIRDEVCCEN OR COMNAVAIRSYSCOM.</b>			
11. SUPPLEMENTARY NOTES		12. SPONSORING MILITARY ACTIVITY <b>NAVAL AIR SYSTEMS COMMAND DEPARTMENT OF THE NAVY</b>	
13. ABSTRACT <p>↓</p> <p>The manually operated crimping tool will install all MIL-T-7928E copper terminals size 8 through 4/0, and MIL-T-7099 aluminum terminals size 8 through 2, using the applicable MS23002, MS90485, or MS25442 crimping dies. Also, it will install size 8, 4, and 1/0 contacts, using NAVAIRDEVCCEN proposed crimping dies. The tool was designed to be fabricated with items primarily obtainable from the military supply system. The recommended ratchet wrench incorporates a safety feature that prevents the application of excessive forces which might result in injury to operating personnel or damage to the tool.</p> <p>↑</p>			

14 KEY WORDS	LINE A		LINE B		LINE C	
	WOLI	WI	WOLF	WI	WOLI	WI
<b>CRIMPING TOOL LARGE SIZE TERMINALS AND CONTACTS MANUALLY OPERATED</b>						