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U. S. NAVAL AIR TEST FACILITY (SI)

LAKEHURST, NEW JERSEY

Report NATF-EN-1086

DEVELOPMENT AND EVALUATION
OF THE
TC13 MOD 1 STEAM CATAPULT
(30 Jan 1964 to 19 Oct 1965)

Periodic Report No. 1
22 March 1966

by

S. W. Brocklebank
Launching Division

Prepared under Bureau of Naval Weapons
Problem Assignment Number RSSH-02-105

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U. S. NAVAL AIR TEST FACILITY
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LAKEHURST, NEW JERSEY
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ABSTRACT

This is the first periodic report on the development and evaluation programs for the TC13 Mod 1 steam catapult and presents the results of the following test programs:

NAEL(SI) deadload calibration, preliminary aircraft launchings, and retraction-engine development tests; and

NATF(SI) deadload calibration, aircraft compatibility, and effect of cylinder elongation.

Events 1 through 4,913 were accomplished during the test period (1,205 deadload, 398 aircraft, and 3,310 no-load launchings). An average of 6.5 deadload/aircraft launchings per day was achieved. Four Type I failures (must stop to fix) occurred, and yielded a mean-time-between-failures (MTBF) of 909 and a reliability of 95.5 percent with respect to 40 consecutive launchings (nearly 75 percent of the launchings conducted were no-loads, which accounts for the high reliability index).

The evaluation program revealed two major deficiencies resulting from the long stroke of the TC13 Mod 1 steam catapult:

The retraction-engine ram can be damaged if a launching occurs with the grab accidentally latched (problem was corrected by C13-1 Catapult Design Change 60, which provides weaker grab latches).

The service life of the standard piston guides is less than 1,000 launchings. Extended piston guides originally designed for the seven-foot water brakes are being tested as a possible solution to this problem.

Repeated failure of the main hydraulic accumulator piston and packing also created a major problem.

Catapult repairs and modifications accomplished during the installation of new dry and wet steam accumulators are also discussed.

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LIST OF ILLUSTRATIONS

I INTRODUCTION

A. This is the first periodic report on the development and evaluation programs for the TC13 Mod 1 steam catapult, and covers the period of 30 January 1964 through 19 October 1965. Tests are being conducted under Bureau of Naval Weapons (BUWEPS) Problem Assignment Number RSSH-02-105/204/1. Maintenance and modification work is being accomplished under BUWEPS Problem Assignment Number RSSH-02-104/204/1. The catapult was checked out and started in accordance with U. S. Naval Air Engineering Laboratory (Ship Installations) (NAEL(SI)) report NAEL-ENG-6961 (reference (a)); these tests initiated the NAEL(SI) development support phase. The U. S. Naval Air Test Facility (Ship Installations) (NATF(SI)) evaluation phase was started at the completion of the initial tests with component development tests being continued on a concurrent basis.

B. Tests were conducted from 30 January 1964 through 12 March 1965. The major test programs were:

1. NAEL(SI) deadload calibration, preliminary aircraft launchings, and retraction-engine development tests.

2. NATF(SI) deadload calibration, aircraft compatibility, and effect of cylinder elongation.

Various other NAEL(SI) component development tests were conducted concurrently throughout the period.

C. The site was then shut down in order to install new wet and dry steam accumulators, which was accomplished during the period 13 March 1965 through 19 October 1965. The major work accomplished during this site modification period included: installation of two new dry steam accumulators and piping, installation of a new wet steam accumulator and piping, optical check of power-cylinder alignment, installation of all available design changes, inspection of major catapult systems and repair as necessary, and installation of constant receiver pressure control system, wrap-around console, and other NAEL(SI) development modifications.

II SUMMARY OF OPERATIONS

A. Test launchings were conducted during one 8-hour shift daily on a five-day-week basis from 30 January 1964 through 12 March 1965 except for 28 days of two-shift operations. Of the 280 available operating days, 213 were totally or partially utilized for conducting tests, resulting in a site-utilization factor of 76.1 percent.

B. Events 1 through 4,913 were accomplished during this report period (1,205 deadload, 398 aircraft, and 3,[illegible] no-load launchings).

C. An average of 6.5 deadload and/or aircraft launchings per day was achieved (days utilized solely for no-load events or other programs that precluded deadload or aircraft events were subtracted from the total days available when calculating deadload/aircraft events per day).

D. Four Type I failures (must stop to fix) occurred, and yielded a mean-time-between-failures (MTBF) of 909 and a reliability of 95.5 percent with respect to 40 consecutive launchings. Nearly 75 percent of the launchings conducted were no-loads, which accounts for the high reliability index.

III CATAPULT CONFIGURATION

A. The flush-deck catapult was converted to a longer-stroke version of the C13 steam catapult, designated TC13 Mod 1, in accordance with C13-1 Catapult Design Change No. 2. Details of the conversion were reported in report NATF(SI)-EI-107 (reference (b)). In addition, the following design changes were incorporated during the conversion:

C13-1 Catapult Design Change No.	Subject
3	Locking screws in shuttle roller assembly; replacement of
5	Check valves, launching valve assembly; removal of
6	Lubrication system injector pump components; adjustment and assembly of
7	Retraction engine four way solenoid operated maneuver aft; incorporation of manual override
8	Control console wiring; standardization of
11	Bearing pads and buffer plate on grab assembly; replacement of
17	Exhaust valve cutout valve and accumulator steam thermometer on control console; removal of
18	Tab lock washer in positive lock grab; installation and adjustment of

C13-1 Catapult Design Change No.	Subject
19	Water brake vent body and plug; lockwiring of
22	Exhaust valve shut solenoid valve; wiring modification of
25	4 Ft and 10 Ft power cylinders, cover bracket holes; relocation of

B. The following developmental modifications were also incorporated during the conversion:

1. NAEL(SI) Engineering Order (EO) 62-71: Development of 2,500 psi maneuver system for Flush Deck Catapult retraction engine.

2. NAEL(SI) EO 61-575: Modification of TC13 and TC13-1 catapult strip tensioner (air) supply piping. (NOTE: Piping arrangement only; 450-psi pressure instead of 2,500 psi to be used at TC13 Mod 1.)

3. The 55-gallon lube-oil storage tank was replaced by a 200-gallon tank, NATF(SI) Drawing 300039.

4. In order to obtain a clearance volume (piping volume between the launching valves, exhaust valve, and pistons after bridle tension) closer to that of the shipboard (CVA66) design, a 14-inch outer-diameter pipe capped at both ends was installed in the exhaust header. This reduced the TC13 Mod 1 clearance volume from 57 cubic feet to approximately 46 cubic feet, versus 25.5 cubic feet for the C13 Mod 1 catapult on the CVA66. This change also required the installation of larger capacity constant-spring supports under the header to support the increased weight.

5. An additional set of chronograph contacts was installed at a position equal to the TC13 stroke length in accordance with NATF(SI) Drawing 300050. This will permit concurrent collection of C13 performance data. This modification was also covered by NAEL(SI) EO 63-1265.

IV TEST PROGRAMS AND RESULTS

A. TC13 Mod 1 Steam-Catapult Performance

1. Deadload Calibration: Two accumulators with a total steam volume, including piping, of 2,690 cubic feet were used. The results

of the calibration program are presented in the minimum and average performance charts, Figures 1 and 2. Power-cylinder elongation during the calibration was maintained at approximately 7.0 to 7.3 inches; and no adjustment of end speeds for elongation was made. The minimum performance chart was drawn with all curves passing through or below the minimum end speed occurring at any point, and no correction factors or allowances were applied.

2. Acceleration Characteristics: Figure 3 shows the variation of peak acceleration with end speed. Each point represents the average peak acceleration and end speed of all the launchings made at a given launching pressure.

3. Effect of Cylinder Elongation: To determine the effect of cylinder elongation on performance, launchings of 13,500-, 30,000-, 60,000-, and 90,000-pound deadloads were conducted with elongations varied from 4.5 to 9.0 inches by using both internal and external preheat. Launchings of 13,500- and 60,000-pound deadloads were also conducted with elongation varied by using either internal preheat or external preheat only.

a. The effect of cylinder elongation on end speed varies with both deadload weight and launching pressure, and is presented in the chart of Figure 4. The method of obtaining elongation had no noticeable effect on the change in end speed.

b. Peak acceleration also appears to be little affected by the method of obtaining elongation; however, the data obtained for this comparison were incomplete because of time limitations.

4. Effect of Clearance Volume: Launchings of a 30,000-pound deadload at 1,000-psi launching pressure were conducted with varied clearance volumes, ranging from 46 cubic feet to 124 cubic feet. The increase in clearance volume from 46 to 124 cubic feet increased the end speed by approximately 12 knots and the peak acceleration by approximately 0.5 G. Extrapolation of the data indicates that the difference in clearance volume between the TC13 Mod 1 (46 cubic feet) and the fleet C13 Mod 1 (25.5 cubic feet) would cause a difference in end speed (of 30,000-pound deadload) of approximately 7.5 knots and a difference in peak acceleration of 0.2 G. (The TC13 Mod 1 provided higher values.)

5. Aircraft Compatibility: Results of aircraft launchings were reported in NATF(SI)-EI-116 (reference (c)).

B. TC13 Mod 1 Steam-Catapult Component Evaluation

1. Failures: Appendix A is a tabulation of failures that occurred during this period. The following four were classified as Type I failures:

Event No.	Failure
752	Tailpiece, cracked
1,081	Silbraze joint, cracked
2,089	Retraction-engine piston rod, bent
3,639	Shuttle wheel, broke

These four Type I failures yielded a mean-time-between-failure (MTBF) of 909 launchings for a reliability of 95.5 percent with respect to 40 consecutive launchings. This is an excellent reliability; however, it is undoubtedly somewhat inflated because nearly 75 percent of the launchings were no-loads. The four Type I failures are plotted in Figure 5, a continuous plot of reliability.

2. Cylinder-Slot Width Measurements: These measurements, taken 862 events after peening, showed a rapid growth in slot width. Consequently, the cylinders were removed and peened again (except cylinders 17, 19, 24, and 25 port; and 23, 24, and 25 starboard). The rate of slot-width growth during the 4,051 launchings after the peening was within acceptable limits.

3. Problem Areas

a. Piston Assemblies, Guides: It became evident early in the test program that the added length of the TC13 Mod 1 steam catapult caused a severe increase in piston-guide wear. The first four sets of piston guides reached the wear limit specified in the C13 Mod 1 Handbook of Maintenance and Overhaul Instructions within 400 to 700 launchings (average 600). Piston guides on the TC13 steam catapult normally do not wear out in less than 1,500 launchings. The fifth and sixth sets of piston guides were the heavier type used for the seven-foot water-brake installation. The fifth set was used for 1,159 launchings and the sixth set 1,087 launchings before reaching the wear limit. The guides on the fifth and sixth set were rotated 90° for further use. In addition to their increased service life, the extended piston guides

have almost eliminated loosening of guide securing screws and breaking of guide screw lockwire. It should be noted that wear on all the guides mentioned above was greater than normal because of the large number of no-load launchings (50 to 90 percent).

b. Retraction-Engine System

(1) Three problems caused by the high reeving ratio (20:1) of the retraction engine were uncovered:

(a) If a launching occurs with the positive lock grab accidentally latched, the resulting load is sufficient to bend the retraction-engine piston rod. This occurred during event 2,089 and was classified a Type I failure as indicated in paragraph B1. C13-1 Catapult Design Change No. 60 provides a weaker grab latch that will fail before enough load to bend the piston rod is generated.

(b) The crosshead and fixed-sheave assemblies are susceptible to overheating if lubricated at the normal intervals. Consequently, the maximum interval between lubrications was reduced to 100 normal cycles or 25 rapid cycles by Type C Mark 13 Mod 1 Catapult Service Bulletin No. 29.

(c) The retract buffer is inadequate to prevent overrun of "Ideal" during retraction. The overrun was reduced by adding an O-ring to the buffer piston; however, further improvement is necessary, and NAEL(SI) is redesigning the metering rod.

(2) The following list summarizes the problems encountered with the main hydraulic accumulator piston and packing:

1964 Date	Event No.	Action and Remarks
20 Aug	2,437	Packing leak - repacked with neoprene 0.024-inch float
25 Aug	2,475	Packing leak - changed from 0.024-inch float to 0.020-inch squeeze
25 Aug	2,482	Retainer screws pulled out of piston (possibly overtightened). Installed piston from TC13 used 33 events, 0.026-inch air/0.025-inch oil float on Garlock packing
9 Sep	3,408	Retainer screws pulled out of piston (possibly overtightened). Tapped new screw holes and reinstalled same packing

1964 Date	Event No.	Action and Remarks
23 Sep	3,499	Replaced aluminum piston with new bronze piston - reused same packing with 0.025-inch air/0.020-inch oil float
29 Sep	3,620	Packing leak - installed Garlock with 0.010-inch air/0.006-inch oil float. Increased retainer screw torque from 10 foot-pounds to 15 foot-pounds because screws loosened
30 Sep	3,624	Packing leak - replaced one ring of air packing and changed 0.010-inch float to 0.015-inch squeeze
7 Oct	3,676	Packing leak - installed Garlock with 0.015-inch air/0.016-inch oil squeeze
6 Nov	3,832	Packing leak - replaced air side only, Garlock with 0.020-inch float
16 Nov	3,883	Packing leak - installed new packing 0.012-inch air/ 0.014-inch oil squeeze. Retainer screws loosened - increased torque to 20 foot-pounds
16 Nov	3,986	Packing leak - increased squeeze to 0.020 inch on air side
25 Nov	4,035	Replaced accumulator cylinder because of scores on old one - new Garlock air-side packing installed because previous packing damaged during installation
1965 Date		
11 Jan	4,480	Packing leak - installed Garlock with 0.026-inch air/0.025-inch oil float
8 Oct	4,914	Packing leak - installed Garlock 0.030-inch air/ 0.024-inch oil float

The last repacking listed above was observed by technical representatives of the Johns-Manville Company; no adverse comments were made regarding the procedure followed. After only 455 launchings, however, the packing leaked and had to be replaced. The problem is being investigated by NAEL(SI) with the assistance of packing manufacturers.

C. Development Programs: The following is a brief discussion of the various NAEL(SI) development programs conducted on the TC13 Mod 1 steam catapult. Detailed reporting of these programs is the responsibility of NAEL(SI).

1. TC13 Mod 1 Steam-Catapult Initial Development Testing: This program was conducted in accordance with NAEL(SI) report NAEL-ENG-6961 (reference (a)) and included static and functional checks of all catapult subsystems followed by deadload calibration and aircraft compatibility tests.

2. Extended Piston Guides: This program is discussed on page 5 , paragraph B3a.

3. Test of Retraction-Engine System: The retraction engine was subjected to 2,906 rapid cycles in four months. Problem areas uncovered are discussed on page 6 , paragraph B3b.

a. It was impossible to make an adequate advance with the piston assemblies. The problem was solved by incorporating a modification (EO 64-654) that makes 3,000-psi hydraulic pressure available during advance.

4. Flexible Hose for Retraction-Engine Piping: Three flex hoses were installed in place of short sections of the 2-inch IPS retraction-engine piping. The length of the short sections is critical, and a shorter connection had to be made to accommodate one hose that was approximately 1/4 inch too long. The three hoses were in use for approximately 1,000 events with no problems. The elimination of O-ring leaks was particularly noticeable.

5. Accumulator Piston Indicator: This system provides protection against making a launch without sufficient hydraulic fluid volume to open the launching valves. Some problems encountered with binding of the switch actuating rod appeared to be solved by changing the limit switch to reduce the side load on the rod. This modification has been formalized by C13-1 Catapult Design Change No. 58.

6. Variation in Performance Caused by Steam Conditions: Because the desuperheater configuration was inadequate, it was impossible to control steam conditions sufficiently to establish any definite variation in performance caused by steam conditions. Also, problems with maintaining cylinder elongation were encountered.

7. Orifice Loop Strainer: Tests were conducted to determine what degree of strainer clogging would affect performance. A restrictor disc was used to raise the pressure drop across the strainer to 70 psi.

This amount of blockage caused a 3-knot loss in end speed of a 30,000-pound deadload programmed for 100 knots. There was no loss for the same deadload programmed for 165 knots.

8. Removal of Forward Bridle-Tensioner Vent: Cycle tests showed the removal had no effect on tensioner operation.

9. Determination of Optimum Steam-Cutoff-Switch Location: During launchings of 30,000-pound deadloads, the cutoff-switch location was varied between 162 and 222 feet from station zero. Based on the data from these events, the cutoff switch was positioned at its original location of 186 feet from station zero.

10. Lubrication-System Hydraulic-Pressure Switch: In an attempt to eliminate failures of the hydraulic-pressure switch (S48), an improved vent system was installed, and the shifting rate of the control valve was slowed by installing a 1/4-inch orifice (NAEL(SI) EO 64-753). These measures reduced peak hydraulic pressures at the switch to below 3,000 psi; however, the standard switch (B40374-12) still failed. After two standard switches had failed, a commercial switch manufactured by Dual-Snap Company was installed. This switch failed after 209 events because of hydraulic fluid leakage into the housing. The Dual-Snap Company switch was replaced by an automotive brake-pressure switch, but no cycles were accumulated this period.

V SITE MODIFICATION PERIOD

The following modifications, maintenance, and repairs were accomplished 13 March through 19 October 1965, during the installation of new dry and wet steam accumulators. NATF(SI) report NATF-EN-1084 (reference (d)) is a formal report on the procurement and installation of the new accumulators.

A. Work Accomplished by Public Works Department, U. S. Naval Air Station, Lakehurst, New Jersey

1. Overhaul of the Burry Company high-pressure air compressors.

2. Modification of the external preheat system to provide 700-psi operation instead of 550. This was accomplished by the addition of a new pressure-reducing station in the powerhouse, addition of new high-pressure impulse-type (Yarway Co.) steam traps under the catapult trough, and complete hydrostatic test to assure structural integrity at the higher pressure. Raising the pressure from 550 to 700 psi will effect a corresponding temperature increase of 58° F in the external preheat

piping. The effectiveness of this higher pressure system will be evaluated during winter operations.

3. The old dry steam accumulators were inspected for record purposes so that a complete history could be available for anyone interested in the cracking condition. Briefly, the inspection revealed cracks in all four accumulators. The depth of the cracks is to be determined by Public Works by means of an ultrasonic tester. Results and past history will be included in a separate report at a later date.

B. Work Accomplished by NATF(SI)

1. Power-cylinder slot readings were taken with the electrical gap indicator (Mouse). The results indicated that no slot-width increase occurred during the last 1,000 launchings prior to the accumulator-replacement shutdown.

2. The lubrication system was checked and the following results were noted: Seven of the 54 injector pumps were inoperative, four of the 162 standard lubrication nozzles were inoperative, and about half of the flex hoses were abraded and leaking. All discrepancies were corrected by replacement or repair as appropriate.

3. The cylinder-cover mounting blocks were hand-ground, as required, to allow a minimum of 1/8-inch clearance between them and the deck covers. This was done to prevent track-cover binding and allow for independent temperature growth of both the power cylinders and track covers.

4. An alignment check of the forward 100 feet of trough section was accomplished by optical methods. Measurements obtained indicated alignment was generally good and did not change in any significant amount from the alignment accomplished during the building of the Mod 1 extension. Six power-cylinder foot pads and the 9-foot-cylinder foot pads required minor reshimming. The buttress plate was about 0.020 inch out-of-square to the catapult centerline as compared to 0.010 inch originally. The water-brake bracket location was good. Approximately one-half the thread length of one buttress-plate support bracket bolt was stripped. This was the first failure of a Catapult Repair Procedure No. 27 bolt to be noted at NATF(SI).

5. Both sealing strips were inspected. The port strip was satisfactory, but the starboard strip could not pass the criteria of BUWEPS 51-ABB-2, paragraph 2-77b, and was replaced.

6. The launching and exhaust-valve hydraulic piping was completely modified to conform with NAEL(SI) Drawing 610382. This provides the latest requirements for slope and long radius bends to eliminate

shock and air from the hydraulic system. The repiping included the necessary valving to allow for either constant or variable accumulator-pressure modes of operation in accordance with NAEL(SI) Drawing 612184. This allows shifting the method of catapult control in approximately 4 to 6 hours.

7. A high-pressure/low-volume hydraulic pump was installed in accordance with NAEL(SI) EO 64-155. The pump is to be used during standby periods to keep the main engine accumulator fully charged by making up for normal leakage throughout the hydraulic system. The main pumps would therefore not be required to go on stroke, saving wear on both the main pumps and the accumulator packing.

8. O-rings were installed on the launching-valve hydraulic operator piston and piston rod in accordance with NAEL(SI) EO 64-797 and 64-899. This installation is to be tested to determine if the O-ring packing life will exceed the old chevron packing service life of 1,200 launchings.

9. The launching-valve gravity-return line was modified in accordance with NAEL(SI) EO 64-886, which provides a small hydraulic/air accumulator. It is hoped the accumulator will reduce the pressure built up in the return line during rapid-cycle operations.

10. A cooling unit and associated water piping was installed in the gravity tank to control the hydraulic fluid temperature during rapid-cycle operations.

11. Additional steel deck plating was placed in the aft end of the catapult to prevent concrete spalling from high-temperature jet aircraft afterburner blast.

12. A sight glass was installed on the lube-oil tank to facilitate pre-operational check out.

13. The low-pressure air systems of the TC13 and the TC13 Mod 1 catapults were interconnected so that either site could use both compressor stations.

14. Steam temperature and pressure instrumentation was added to the new dry accumulators. Special steam-piping pressure-drop instrumentation was also added to both the wet and dry accumulators.

15. The water-brake jet-ring striker ring was installed in accordance with NAEL(SI) EO 64-995, Revision A. This modification allows shims to be used to adjust the striker ring instead of the usual

machining process. The adjustment to obtain proper spear-deflector-to-striker-ring clearance can therefore be done with the catapult assembled.

16. One of the port advance-cable turning sheaves had to be relocated to provide fairlead tubing clearance with the new shipboard-type exhaust manifold.

17. The piston assemblies were reinstalled, utilizing used extended piston guides that were rotated 90° to compensate for wear.

18. The flat-groove capacity-selector-valve spindle (PN 509730-1) and the flat-groove metering rods (PN 509725-1) were installed to conform to the latest NAEL(SI) constant pressure configuration.

19. The internal parts of the standard pressure-breaking valve were replaced with an orifice plate (PN 413788-2) which should simplify maintenance.

20. The air/oil separator piston of the retraction engine accumulator was repacked prior to placing the catapult in operation. "Garlock" type packing was installed under the observance of Johns-Manville representatives who are making a study of the packing problem so that service life can be increased.

21. The following is a summary of Design Changes installed from 13 March through 19 October 1965:

C13-1 Catapult Design Change No.	Subject
12	Butterfly exhaust valve shaft seals; replacement of
13	2,500-psi maneuvering system for retraction engine; incorporation of
16	Launching valve operating cylinder cover positioning pin; incorporation of

C13-1 Catapult Design Change No.	Subject
20	Shutoff valve for lubrication system injector pump; incorporation of
29	Piston, launching engine; reduction of wear contact area on
33	Operating cylinder assembly; reduced height needle valve; installation of
34	Piston barrel; machining to prevent cracking and alteration of upper flange bolts
35	Torque instruction plaques; installation of
41*	Cylinder expansion indicators; replacement of
42	Lubrication at maneuver forward and aft; removal of
43	Rear cylinder cover joint screws; replacement of
51	Retraction engine orifice modification and operating valve piston replacement
58	Accumulator hydraulic fluid normal limit switch; replacement of
63	Retraction engine speed control orifice; relocation of
64	Interruption of "advance" by water brake pressure fluctuations; elimination of
66	Bridle tensioner limit switch actuating arm; increasing thickness of
71	Advance stroke buffer cam contour-retraction engine; reworking of
97	Blocking valve surge accumulator; removal of

* The installation was very difficult. The parts supplied were for a shipboard installation and not completely compatible with the test site. Modifications to both the Design Change kit materials and the site deck plates were accomplished and the system was satisfactorily installed.

C. Special Projects

1. Launching-Valve Poppet and Seat Tolerance Problems

a. During the modification period, NAEL(SI) received reports from the fleet that launching-valve poppets and seats were being manufactured sufficiently out-of-tolerance to appreciably affect catapult performance. NAEL(SI) then requested NATF(SI) to conduct a detailed inspection of the TC13 Mod 1 launching valves. Results of the inspection indicated that the port launching-valve seat was within drawing tolerances, but that the starboard seat would require replacement. Replacement of the seat was accomplished in accordance with Catapult Repair Procedure No. 35. The launching-valve poppets, although not seriously out-of-tolerance, were replaced at the request of NAEL(SI) so that the upcoming wet-accumulator program could be run with the best possible components. Obtaining good poppets was no easy task; a total of six poppets had to be inspected before an acceptable pair was obtained. The new poppets were installed and satisfactorily hydrostatically tested prior to the start of the wet-accumulator program.

b. In order to obtain a clear picture of the exact effects of poppet/seat tolerance, special tests are being conducted on the TC13 Mod 0 catapult with both out-of-tolerance and good poppets. Results of these tests will be included in future TC13 Mod 0 reports.

2. CVA67 Wrap-Around Control Console (NAEL(SI) PN 612619-1)

a. The wrap-around console is designed to take the place of the regular C13-type console and affords a significant increase in ease of operation. The console employs human engineered features and provides a chair to reduce fatigue of the operator.

b. The console was installed in the TC13 Mod 1 control room in accordance with NAEL(SI) Drawing 612816. Figure 6 shows the completed installation. The console was wired and piped in parallel with the existing standard console so that control could be executed from either unit. Upon completion of the installation, the wrap-around console was functionally checked, and after correction of minor discrepancies, the system operated satisfactorily. Special tests will be conducted to determine the effectiveness of this new-type console.

VI REFERENCES

(a) NAEL(SI) Report NAEL-ENG-6961 of 11 November 1963, Procedure for Functional Checkout and Calibration Testing of the Type TC Mark 13-Mod 1 Catapult

(b) NATF(SI) Report NATF(SI)-EI-107 of 8 July 1964, Conversion of the Flush-Deck Catapult to the TC13 Mod 1 Catapult

(c) NATF(SI) Report NATF(SI)-EI-116 of 11 June 1965, Aircraft Compatibility Tests with the TC13 Mod 1 Catapult/Mark 4 Mod 2 Bridle Arrester

(d) NATF(SI) Report NATF-EN-1084 of 16 February 1966, Procurement and Installation of Wet and Dry Accumulators for Use at the TC13 and TC13 Mod 1 Catapult Sites, Final Report

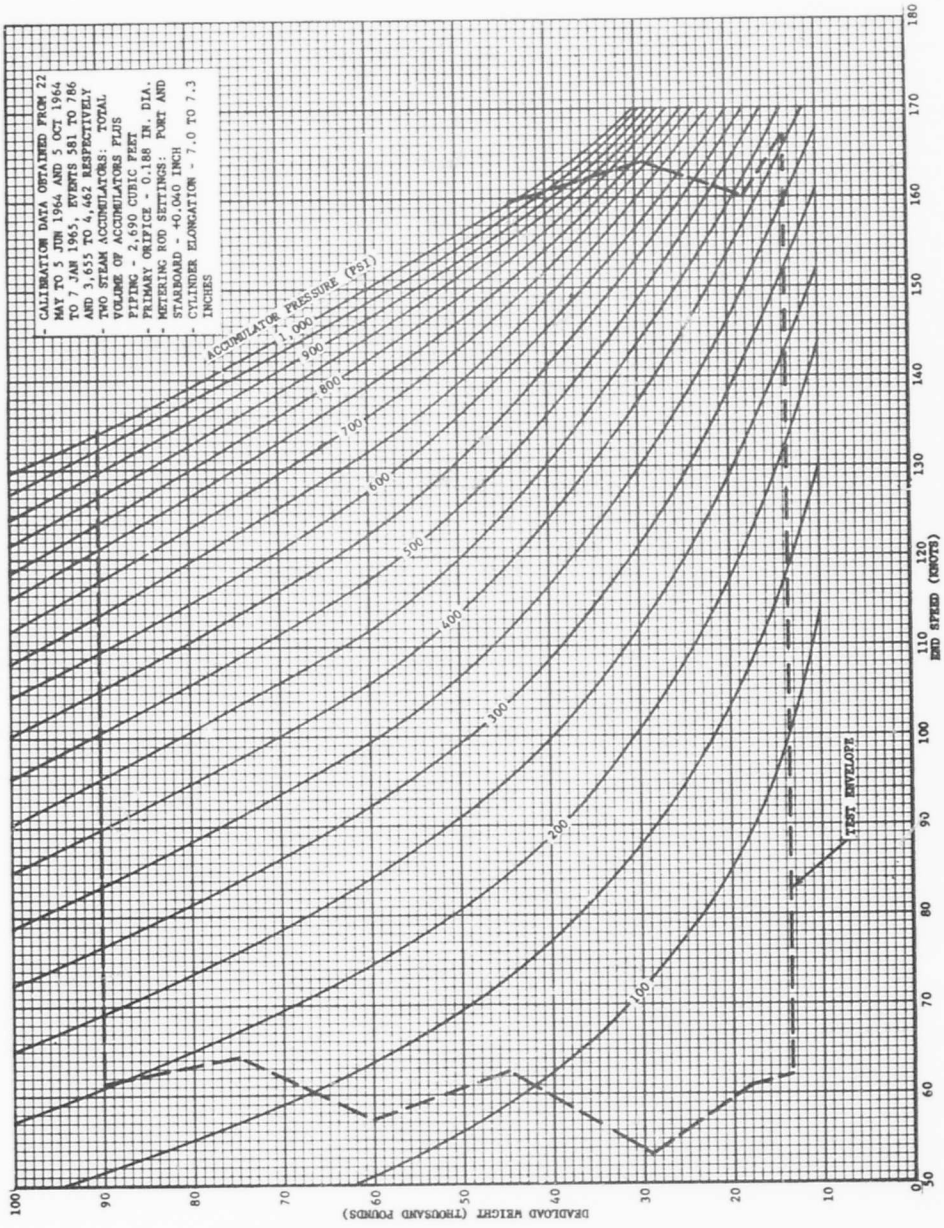

Figure 1 - Minimum Performance of the TC13 Mod 1 Steam Catapult (Old Steam Accumulators)

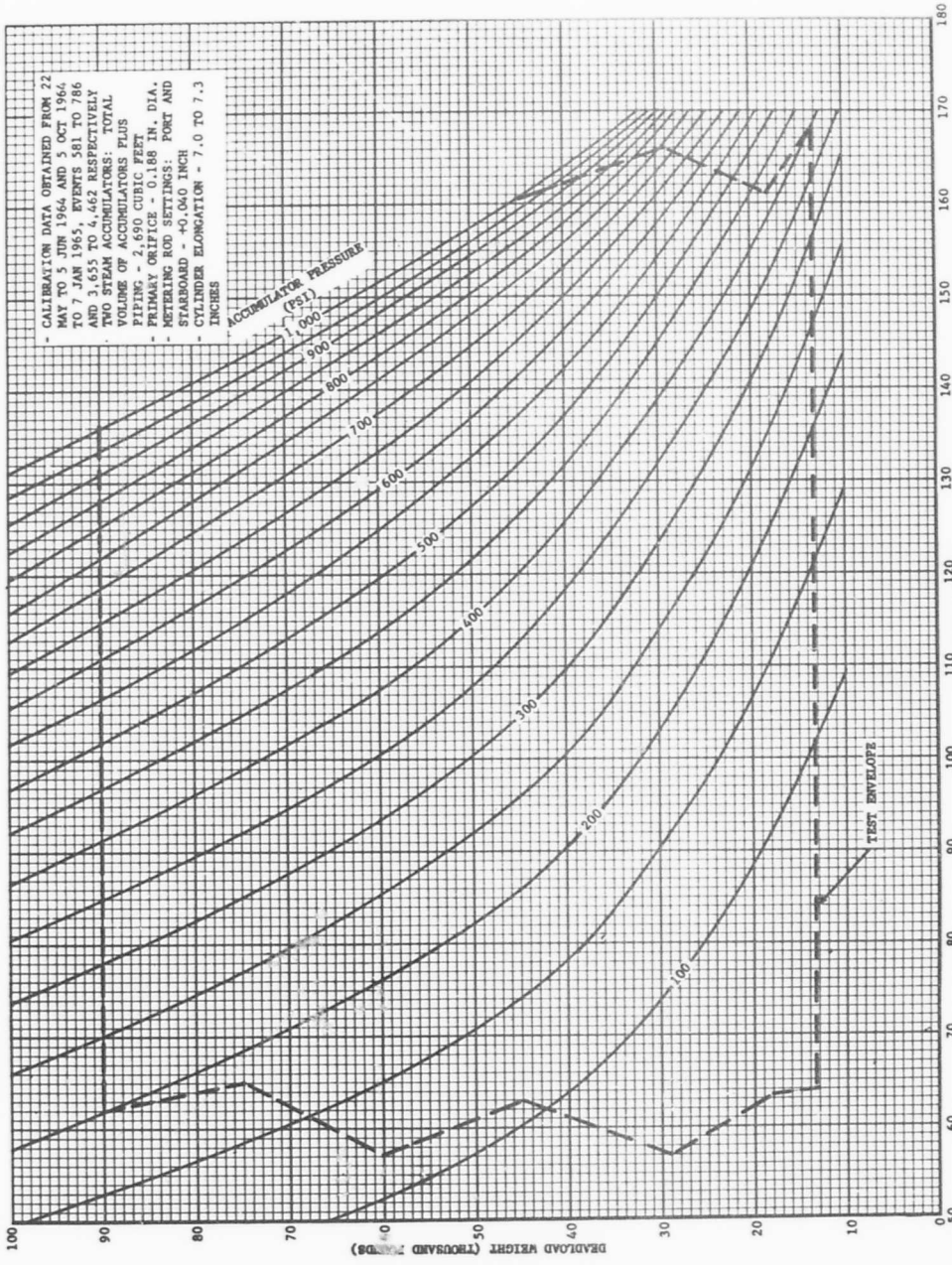

Figure 2 - Average Performance of the TC13 Mod 1 Steam Catapult (Old Steam Accumulators)

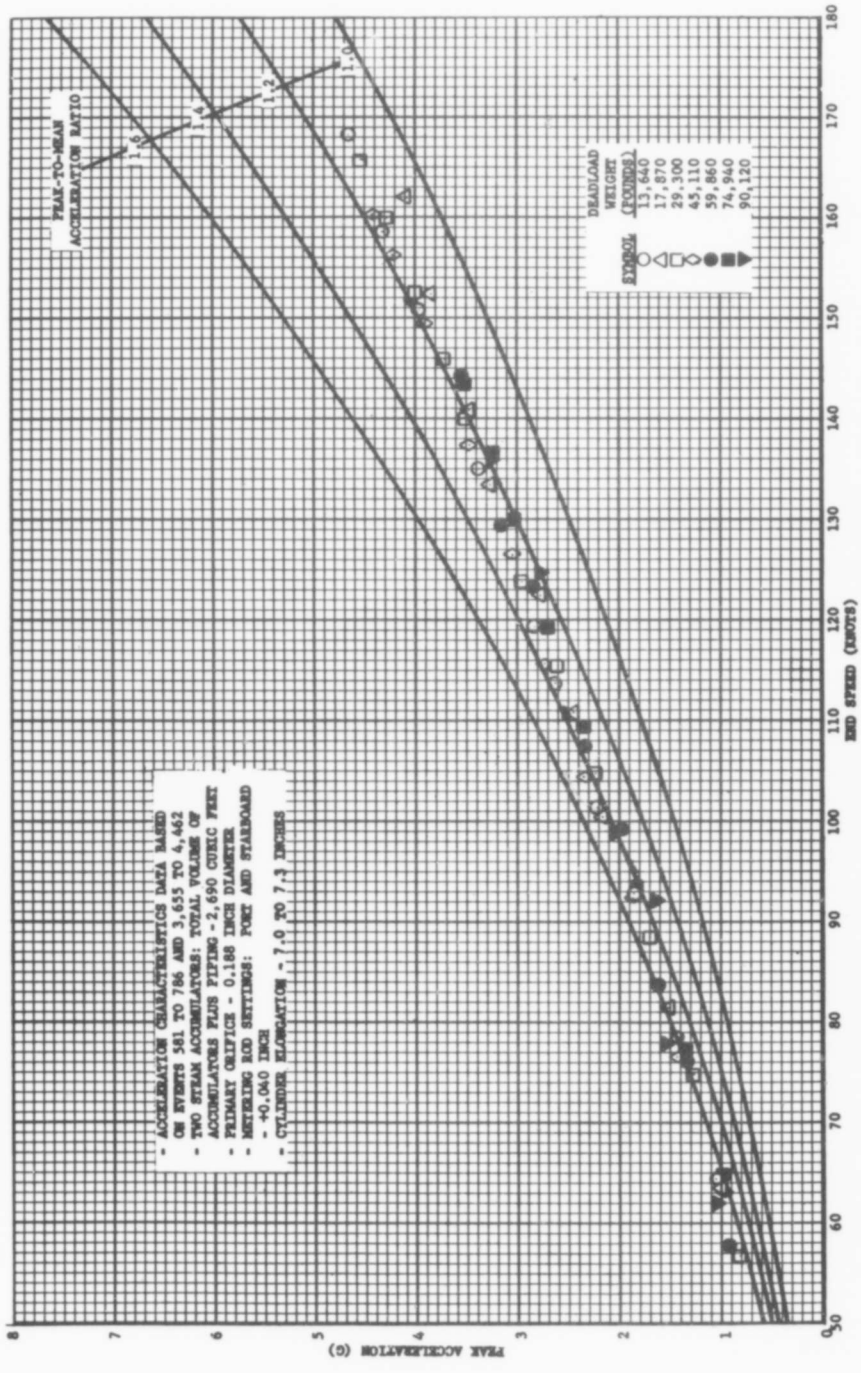

Figure 3 - Acceleration Characteristics of the TC13 Mod 1 Steam Catapult (Old Steam Accumulators)

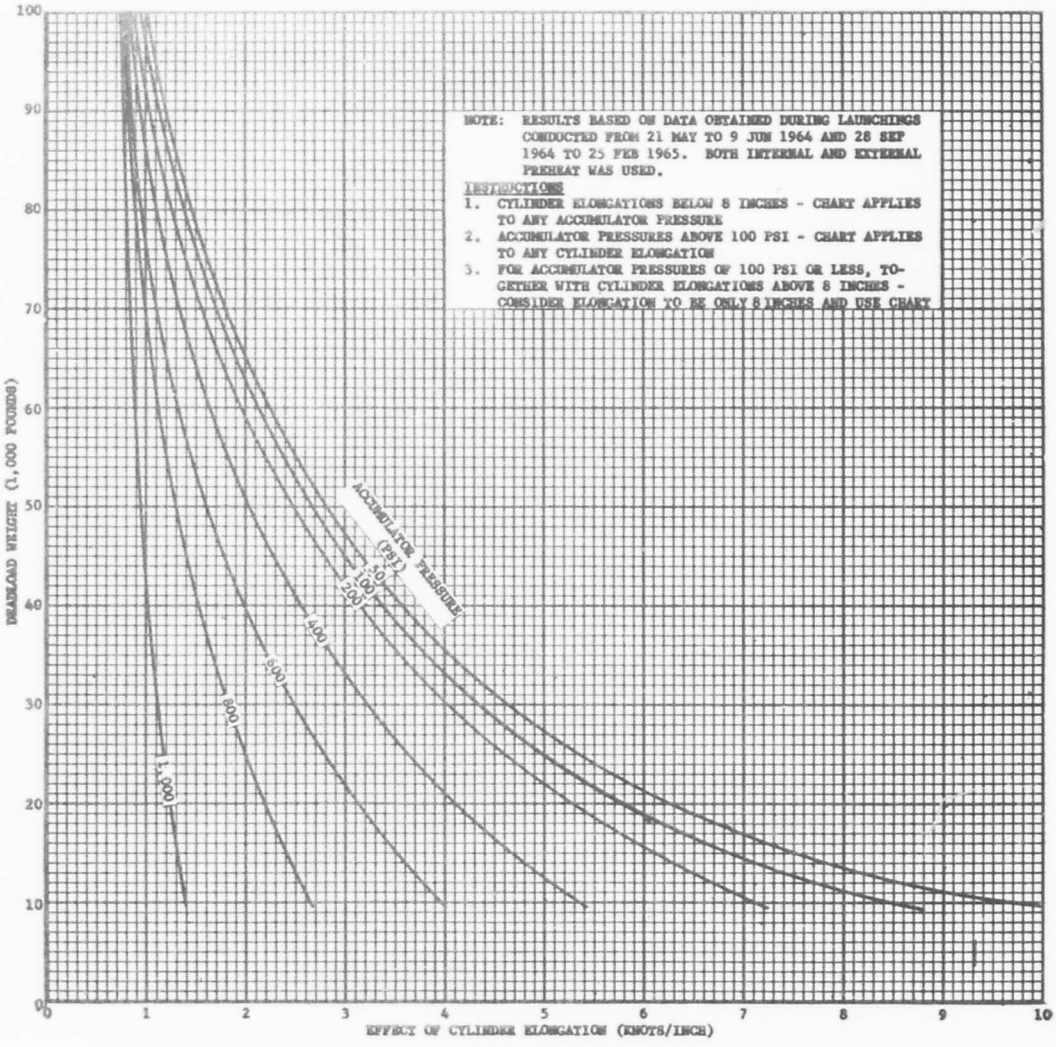

Figure 4 - Effect of Cylinder Elongation on End Speed of TC13 Mod 1 Steam Catapult (Old Steam Accumulators)

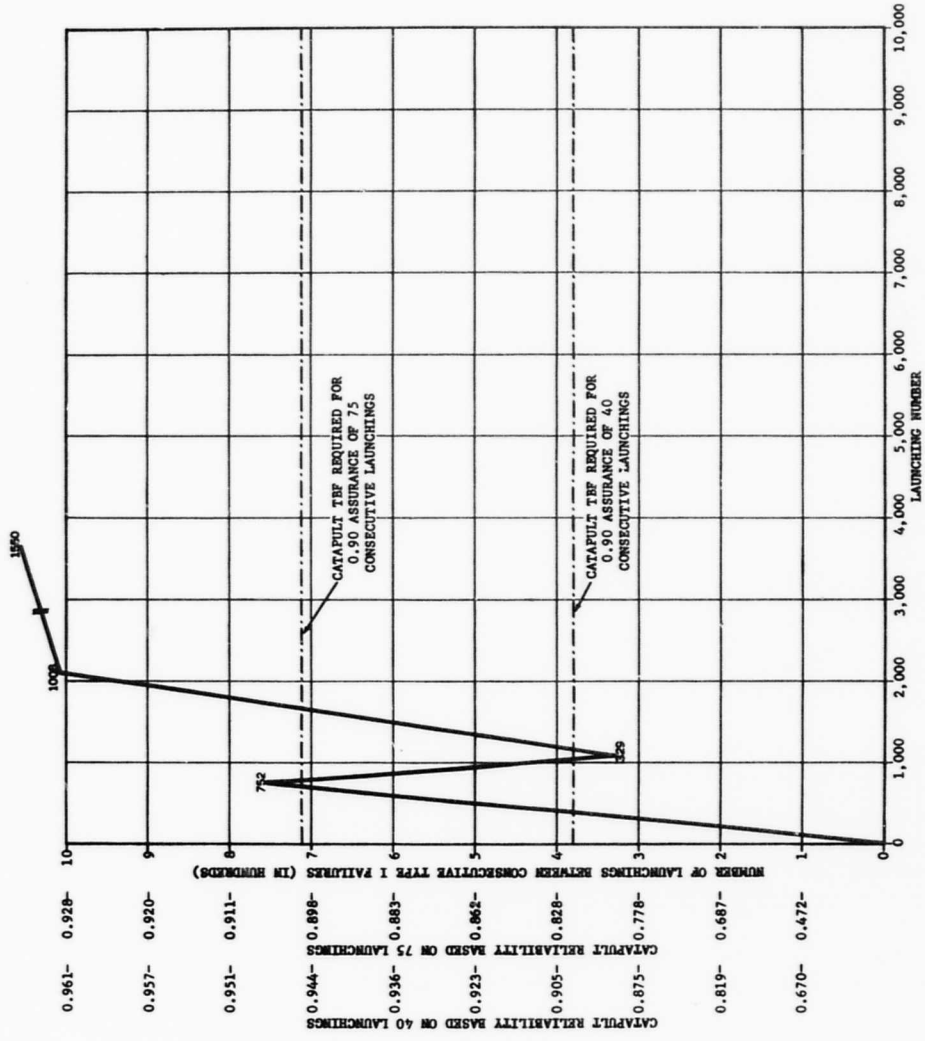

Figure 5 - Number of Launchings Between Consecutive Type I Failures versus Launching Number (TC13 Mod 1 Steam Catapult)

Figure 6 - CVA67 Wrap-Around Control Console (NAEL(SI) PN 612619-1)
Installed in TC13 Mod 1 Control Room

TC13 MOD 1 STEAM CATAPULT COMPONENT FAILURES

NOTES

Launching No.: The total number of launchings accomplished on the TC13 Mod 1 steam catapult, including no-loads.

Frequency of Failure: The total number of failures of the component since the initiation of the TC13 Mod 1 evaluation program on 30 January 1964. The frequency is related to the component, not particularly to the part of the component that failed.

Launching No.	1964 Date	Component	Frequency of Failure	Hours Downtime	Man-Hours to Repair
3	6 Feb	Replaced starboard water-brake choke ring	1	8	16
13	17 Feb	Cleaned actuator piston of S5 steam-pressure switch	1	2	4
185	5 Mar	Replaced O-rings between bridle-tension control valve and main engine cylinder at main engine cylinder	1	1	2
		Replaced both chronograph brushes	1	2	4
212	16 Mar	Silbrazed leaks at the port and starboard connecting piping between the water-brake connector and water-brake pressure switch	1	1/2	1/2
		Replaced starboard S48 lubrication-pressure switch	1	3/4	3/4

Launching No.	1964 Date	Component	Frequency of Failure	Hours Downtime	Man-Hours to Repair
220	17 Mar	Replaced O-ring between blocking-valve and main engine cylinder, at the blocking valve	1	1	2
		Replaced the surge accumulator of the retraction engine	1	1/2	1
246	18 Mar	Replaced O-ring between advance valve and the bridle-tension valve, at the advance valve	1	1	2
		Replaced the starboard chronograph brush	2	1	2
335	31 Mar	Replaced broken shaft of stroke-control limit switch	1	8	24
411	9 Apr	Replaced the bridle-tensioner pressure gauge on main control console	3	1	1
484	24 Apr	Replaced broken grab latch	1	3-1/2	14
		Replaced O-ring between bridle-tension valve and main engine cylinder, at bridle-tension valve	2	1	2
494	27 Apr	Replaced O-ring in union at port D of the launching-valve control valve	1	1	2

Launching No.	1964 Date	Component	Frequency of Failure	Hours Downtime	Man-Hours to Repair
498	28 Apr	Replaced failed flexitallic gasket between the outlet flange and the steam-valve body of the port launching valve	1	21	63
499	4 May	Silbrazed broken foot-pad lubrication tubing lines to the port and starboard 9-foot forward launching-engine cylinders	1	1	1
511	11 May	Replaced O-ring in the union at port D of the launching-valve control valve	2	1	2
528	13 May	Replaced O-ring in the union at aft end of the deck bridle-tensioner cylinder	1	2	4
		Cleaned actuator piston of S5 steam-pressure switch	2	2	4
536	14 May	Replaced O-ring between bridle-tension valve and advance valve at the bridle-tension valve	3	1	2
585	21 May	Replaced O-ring in unions at both sides of Grove regulator on the retraction engine	1	1	1
		Cleaned the shaft of the stroke-control limit switch	2	7	16

Launching No.	1964 Date	Component	Frequency of Failure	Hours Downtime	Man-Hours to Repair
655	27 May	Replaced O-ring between bridle-tension valve and advance valve, at advance valve	2	1	2
677	28 May	Replaced port chronograph brush	2	3	6
752	4 Jun	*Tailpiece in the 1/4-inch tubing between advance and bridle-tension valve cracked	1	3/4	1-1/2
790	5 Jun	Replaced leaking strip-tensioner blowdown valve	1	1/2	1/2
		Replaced both chronograph brushes	3	2	4
862	26 Jun thru 8 Jul	Replaced piston assemblies - guides worn	1	20	64
		Replaced 44 worn launching-engine cylinder cable support plates (NOTE: In service 10,000 launchings on flush-deck catapult)	1	4	8
		Replaced air solenoid valve of retraction control valve	1	1/2	1/2
		Replaced several shuttle rollers because of failed bearings and/or binding	1	24	48
		Replaced air solenoid valve of retraction control valve	2	1/2	1/2

* Type I Failure

Launching No.	1964 Date	Component	Frequency of Failure	Hours Downtime	Man-Hours to repair
948	8 Jul	Replaced O-ring between bridle-tension valve and advance valve, at advance valve	3	1	2
1,081	9 Jul	*Silbrazed joint in 1/4-inch tubing was cracked between advance valve and bridle-tension valve	2	2	4
1,091	9 Jul	Replaced broken starboard barrel to spear attaching bolt	2	1/2	1/2
1,105	10 Jul	Replaced O-ring between bridle-tension valve and advance valve, at advance valve	4	1	2
1,184	10 Jul	Sight glass of retract cable equal-izer reservoir failed	1	1	1
1,345	13 Jul	Replaced O-ring between bridle-tension valve and advance control, at advance valve	5	1	2
1,585	15 Jul	Replaced air-flask globe valve because of leakage past stem	1	1	1
		Rebuilt piston assemblies; piston guides worn and starboard spear bent	3	40	120

* Type I Failure

Launching No.	1964 Date	Component	Frequency of Failure	Hours Downtime	Man-Hours to Repair
1,643	22 Jul	Replaced O-ring between orifice plate and adapter of exhaust-valve actuator	1	2	2
1,691	24 Jul	Replaced broken gravity-return pipe from launching-valve control valve	2	5	10
2,013	29 Jul	Replaced worn shuttle-ramp pin and plunger	2	1-1/2	1-1/2
		Replaced worn port and starboard launching-engine guide pistons	4	22	66
2,089	31 Jul	Replaced broken grab latch	2	3-1/2	14
		*Replaced retraction-engine piston rod that bent when grab latch above did not unlatch from shuttle	1	96	384
2,102	5 Aug	Replaced air-flask globe valve because of leakage past the stem	2	1	1
2,309	14 Aug	Replaced air solenoid valve of deck-tensioner panel because of leakage	1	1	1
2,437	20 Aug	Replaced two broken starboard side-plate attaching hex socket-head screws of the grab	3	2	2

* Type I Failure

Launching No.	1964 Date	Component	Frequency of Failure	Hours Downtime	Man-Hours to Repair
2,437	20 Aug	Replaced the broken capscrews of port sealing-strip support	1	1-1/2	1-1/2
		Repacked the main hydraulic accumulator piston	1	8	24
2,482	25 Aug	Retaining bolts of bearing and packing pulled out of aluminum-alloy piston of main hydraulic accumulator at the cover end	2	7	21
		Replaced O-ring between bridle-tension valve and advance valve, at advance valve	6	1	2
		Replaced O-ring between retract valve and blocking valve, at retract valve	1	1	2
2,585	27 Aug	Piston stop ring of bridle-tension valve broke loose from weld at port B	4	1	1
2,667	31 Aug	Replaced worn piston guides with modified piston guides of EO 64-936	5	18	56
3,009	3 Sep	Replaced broken grab latch	4	3-1/2	14
3,227	4 Sep	Replaced O-ring between advance valve and bridle-tension valve, at advance valve	6	1	2

Launching No.	1964 Date	Component	Frequency of Failure	Hours Downtime	Man-Hours to Repair
3,264	4 Sep	Repacked both launching-valve hydraulic operators	1	10	20
		Replaced O-ring at port B of exhaust-valve actuator	2	3/4	3/4
3,408	9 Sep	Retaining bolts of bearing and packing pulled out of aluminum-alloy piston of main hydraulic accumulator at the cover end	3	7	21
3,424	11 Sep	Replaced both Vickers hydraulic pumps: No. 1 - low capacity, No. 2 - excessive noise	1	5	10
3,428	14 Sep	Repacked bridle-tensioner cylinder	2	3	9
3,578	23 Sep	Replaced starboard chronograph brush	4	1	2
3,620	28 Sep	Replaced advance buffer cylinder because it was scored	1	3-1/2	7
		Repacked main hydraulic-accumulator piston	4	8	24
3,639	1 Oct	*Most forward starboard wheel broke off shuttle	4	1-1/2	5-1/2
3,649	2 Oct	Replaced O-ring on piston of bridle-tension valve	4	1	1

* Type I Failure

Launching No.	1964 Date	Component	Frequency of Failure	Hours Downtime	Man-Hours to Repair
3,649	2 Oct	Replaced cracked adapter of bridle-tension valve	5	3/4	3/4
3,669	6 Oct	Replaced both O-rings of indicator shaft of limit switch of advance buffer	2	1	2
3,676	7 Oct	Repacked main hydraulic accumulator piston	5	8	24
3,705	14 Oct	Replaced O-ring at inlet end of bridle-tensioner cylinder	3	2	4
3,740	19 Oct	Replaced thermocouple of hydraulic-fluid gravity tank	1	1/2	1/2
3,826	27 Oct	Replaced grab spring	5	1/2	1/2
		Replaced worn port and starboard extended piston guides of launching-engine piston and spear assemblies	6	20	60
		Replaced worn shuttle guides and rollers	5	2	2
3,832	6 Nov	Replaced air-side packing of main hydraulic accumulator	6	6-1/2	19-1/2
3,832	6 Nov	Replaced rubber diaphragm of Grove regulator on bridle-tensioner panel	1	1	1

Launching No.	1964 Date	Component	Frequency of Failure	Hours Downtime	Man-Hours to Repair
3,836	9 Nov	Replaced air-flask globe valve on retraction engine because of internal leakage	3	1	1
3,841	10 Nov	Replaced bridle-tensioner air regulator on main control console because of internal air leakage	1	1/2	1/2
3,883	16 Nov	Repacked main hydraulic accumulator piston	7	8	24
3,981	20 Nov	Replaced O-ring at port G of exhaust-valve control valve	2	1/2	1/2
4,035	25 Nov	Replaced main hydraulic-accumulator cylinder because of deep score marks, rust, and pitting	1	7-1/2	22-1/2
		Replaced both O-rings on indicator shaft of advance buffer limit switch	3	5	12
4,278	8 Dec	Replaced relief valve Z ir retraction-engine piping between isolation valve J and main hydraulic accumulator	1	1	2
4,317	10 Dec	Welded a cracked silbrazed fitting at port strip-tensioner cylinder	1	4-1/2	4-1/2
4,331	11 Dec	Replaced O-rings in both flex hoses at strip-tensioner cylinders	2	1	1
4,378	17 Dec	Replaced two O-rings at launching-valve hydraulic lock valve	1	1/2	1/2
		Replaced O-ring at port F of launching-valve control valve	3	1/2	1/2

Launching No.	1965 Date	Component	Frequency to Failure	Hours Downtime	Man-Hours to Repair
4,480	11 Jan	Repacked main hydraulic-accumulator piston	8	8	24
4,499	14 Jan	Replaced S48 lubrication-pressure switch because bellows was ruptured	3	3/4	3/4
4,509	15 Jan	Retorqued loose bolts of launching-engine piston spears	7	1	1
4,583	20 Jan	Replaced S5 steam-pressure switch because actuator piston bound	3	1/2	1/2
4,654	28 Jan	Replaced bridle-tensioner pressure gauge on main control console	2	1	1
4,698	8 Feb	Replaced O-ring at port strip-tensioner cylinder	3	1/2	1/2
		Replaced O-ring at port B of launching-valve control valve	4	1/2	1/2
4,711	15 Feb	Repacked deck bridle-tensioner cylinder	6	3	9
4,731	17 Feb	Replaced stripped attaching nuts of cylinder covers at track cover No. 16, port side	1	1	2
4,851	10 Mar	Replaced O-ring at port A of launching-valve control valve	5	1/2	1/2
4,851	10 Mar	Replaced solenoid-operated pilot valve of No. 1 Vickers pump because of internal leakage	1	1/2	1/2

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13. ABSTRACT

-This first periodic report presents the results of the following test programs: NAEL(SI) deadload calibration, preliminary aircraft launchings, and retraction-engine development tests; and NATF(SI) deadload calibration, aircraft compatibility, and effect of cylinder elongation.

-Events 1 through 4,913 were accomplished (1,205 deadload, 398 aircraft, and 3,310 no-load launchings). An average of 6.5 deadload/aircraft launchings per day was achieved. Four type I failures (must stop to fix) occurred, and yielded a mean-time-between-failures of 909 and a reliability of 95.5 percent with respect to 40 consecutive launchings (nearly 75 percent of the launchings conducted were no-loads, which accounts for the high reliability index).

-The evaluation program revealed two major deficiencies resulting from the long stroke of the TC13 Mod 1 steam catapult:

  -The retraction-engine ram can be damaged if a launching occurs with the grab accidentally latched (problem was corrected by C13-1 Catapult Design Change 60, which provides weaker grab latches).

  -The service life of the standard piston guides is less than 1,000 launchings. Extended piston guides originally designed for the seven-foot water brakes are being tested as a possible solution to this problem.

-Repeated failure of the main hydraulic accumulator piston and packing also created a major problem.

-Catapult repairs and modifications accomplished during the installation of new dry and wet steam accumulators are also discussed.

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14. KEY WORDS	LINK A		LINK B		LINK C	
	ROLE	WT	ROLE	WT	ROLE	WT
CATAPULT STEAM CATAPULT AIRCRAFT LAUNCHING EQUIPMENT EVALUATION DEVELOPMENT						

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