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Checkout Unit For Polaris Aids Reliability

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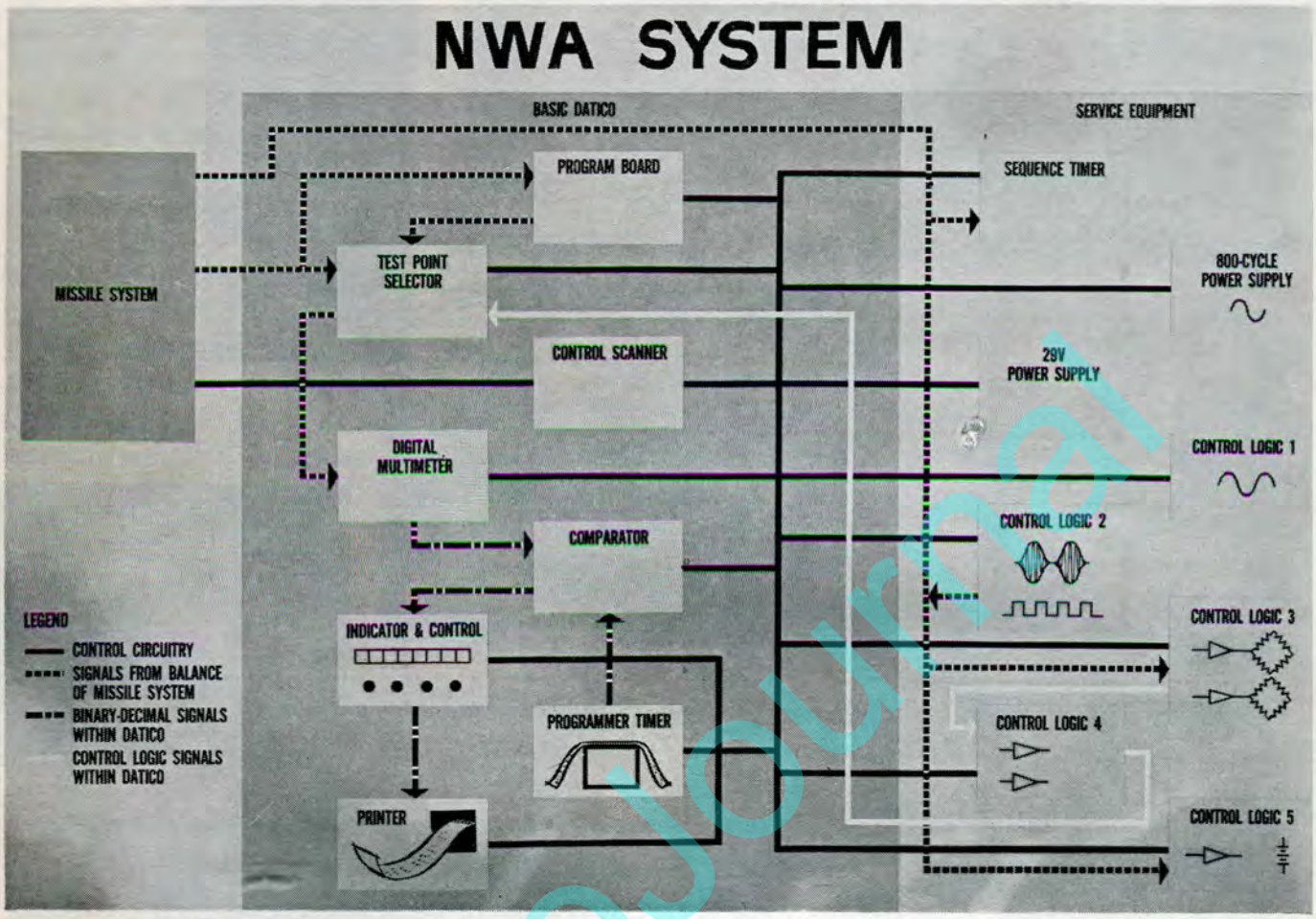


DATICO equipment similar to that used in missile-carrying submarines and their AS-19 tenders will be installed at the Naval Weapons Annex, Charleston, S. C. The equipment is nearly identical except for addition of power supplies and a sequence timer.

New Polaris Checkout Devices Developed

By Russell Hawkes

Anaheim, Calif.—Datico automatic checkout equipment for Navy's Polaris fleet ballistic missile, source of almost $15 million of business for Nortronics Division of Northrop Corp., grew out of a basic unit designed for no particular application and was developed with $70,000 of company money.

Lacking all of the specialized test components which must be associated with a specific application, Datico (digital automatic tape intelligence checkout) was intended by Nortronics to be tailored to a variety of systems by the addition of proper signal sources, measuring devices and displays. The engineering needed to adapt the basic Datico to a system to be tested is much less than that needed to develop a completely new set specially for the system to be tested, according to Nortronics officials.

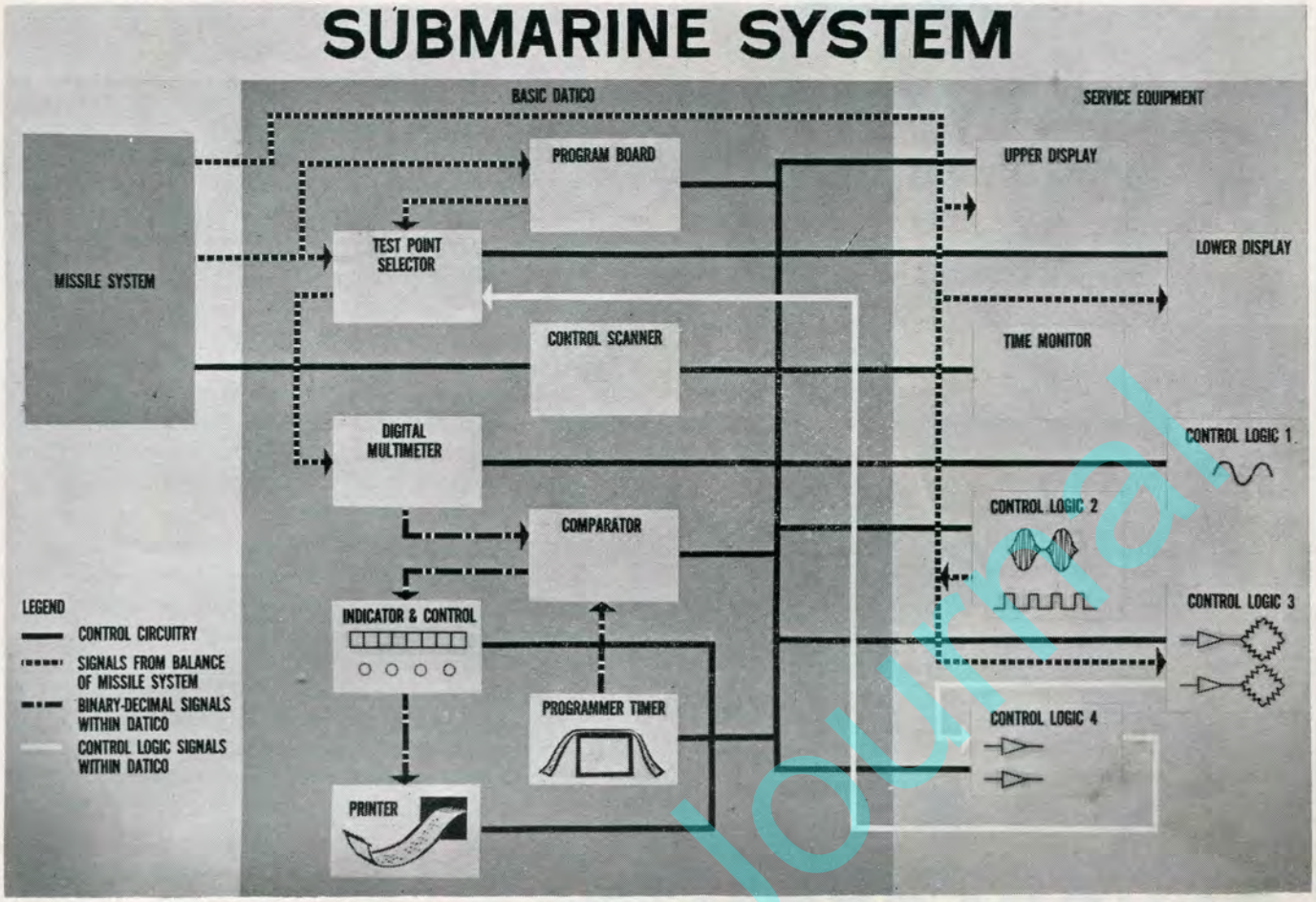
This advantage paid off in February 1959 when Navy Special Projects Office decided it needed a new Polaris checkout system quickly. After studying Datico for two weeks to determine whether it was suitable for the job, Navy let a contract to Nortronics to deliver a test unit built to commercial standards five months later on Aug. 1. Since then Nortronics has received orders for militarized versions to be installed on all George Washington-class submarines, their AS-19 Proteus-class tenders and at the Naval Weapons Annex, Charleston, S. C.

Tight Schedules

Dr. William F. Ballhaus, Nortronics general manager, attributes the success of the company in winning the Polaris-Datico contract largely to the ability to meet tight Polaris program schedules because of the building block development technique. Ballhaus says the rapid advance of technology in the field of checkout equipment has tempted most companies to incorporate each new discovery in their equipment while sacrificing any possibility of early delivery. Because of this, missile systems are usually in the field ahead of their checkout equipment. Often, he reports, the performance margin sought cannot be used by the system for which the equipment is designed.

In the second generation of Polaris-carrying submarines, Datico elements will be incorporated as part of an improved system called TRACE. Nortronics is conducting development work for TRACE under contract to Lockheed Missile and Space Division, system integration and airframe contractor for Polaris.

The design philosophy behind Polaris-Datico is to assure the readiness of the missile with a minimum amount of testing. This approach improves reliability of both the missile and the checkout equipment by simplifying circuitry and cutting down operating time on components. Datico installation aboard submarines is limited to determining whether or not the missile can be launched safely and reach the target. Therefore, the emphasis is on the functional testing of complete subsystems



BOX DIAGRAM for submarine-installed Polaris Datico shows the versatile programmer-controller in shaded area headed "Basic Datico." Nortronics adds a variety of service equipment to adapt the basic programmer-controller to a particular missile, airplane or electronic system.

rather than on detailed trouble-shooting.

The value of knowing exactly which component has failed would be limited in the submarine environment since the opportunities for repair work are limited. Only one small crawl hole gives access to the base of the missile in its launcher.

The one major subsystem which can be replaced at sea as a standard practice is the guidance capsule, including the stable platform and the guidance computer. A complete supply of spare capsules will be carried aboard to replace installed ones which malfunction. These will be kept in a controlled environment, continuously monitored by Datico, and maintained in storage just like those in the tubes to ensure a quick change if needed.

Nortronics officials point out that in war there is usually more extemporized maintenance than is foreseen in peacetime. Some room for this is allowed in the Polaris checkout and maintenance plan, though it would be contrary to standard procedures. If there is time and need to replace or repair parts other than the guidance capsule, it is possible to reach and check some components with test scopes and other standard trouble-shooting sets. Ordinarily, if a subsystem other than the guidance capsule is found to be seriously out of

NORTRONICS Datico Mk. III missile test and readiness equipment is tested at Anaheim, Calif. plant before purchase by Navy. Special acceptance tester simulates missile circuits.

tolerance, the missile must remain in the tube. The standards of reliability designed into the missile are set high enough to make the probability of this acceptably low.

While Datico is not intended to provide a detailed check of individual components, a skilled operator can sometimes identify a fault below the replaceable module level by noting the amplitude of an out-of-tolerance reading, the way the reading varies with time, etc.

Ballhaus says it would be possible to give Datico the capability of checking the components of a system in complete detail if the missile umbilical were thicker and if a great increase in size, complexity and unreliability in the checkout equipment could be accepted. However, such a piece of equipment cannot be justified in the Polaris weapon system. Ballhaus likened the role of Polaris-Datico to that of a man checking the operation of a television set by watching the picture and listening to the sound. Without any equipment or skill he can decide whether the set is operating badly enough to call in a repair man. But to find a single bad component causing trouble calls for complex tools and a much higher degree of training.

Related Systems

Nortronics officials predict a widening market for the Datico and advanced checkout systems named Datimite and Daticomp. Datimite is a smaller checkout system using a larger percentage of solid-state circuits and designed for easier integration with digital computers. Daticomp will include computer elements and will come closer to the ideal of a universal checkout set. Some improvements learned in the advanced version programs are being fed into late model Daticos for Polaris.

Some of the features of more advanced Nortronics checkout systems which are being fed into the Datico improvement program include transistorized circuits, replacement of a mechanical punch tape reader by a photovoltaic one and replacement of stepper motors in the control system by switching diodes. One of the advantages sought in these changes is reduction in the noise level to make enemy detection more difficult.

Datico reflects Nortronics thinking on the subject of universal checkout equipment. A universal checkout would have been too large and complex at the time Datico was conceived because of the necessity of duplicating many components for the full inventory of missile, airplane and electronic systems. However, all system checkout sets must have certain features in common. They must be able to turn

equipment on and off, feed control signals to the system, measure its response against selected criteria, and report the results of the comparison to its operator. The Datico idea was to build a set having these features and then custom-engineer the elements which must be peculiar to the system being tested.

A universal problem in the design of checkout equipment is that of determining whether a malfunction indication is produced by a failure in the system being tested or in the checkout set itself. To some extent, self-checking features can be designed into the set, but Nortronics engineers regard this as a luxury item bringing with it additional complexity and a certain amount of additional unreliability. In Datico-Polaris, it is used only in the digital multimeter and in test signal sources. To evaluate the functioning of the complete Datico, Navy crews will be able to run taped self-varification exercises with missiles switched out of the checkout loop.

Modified for Submarines

Nortronics drew on the experience of Naval Electronics Laboratory, San Diego, for help in modifying Datico for use aboard submarines. NEL has collected much information on the stresses placed upon electronics at sea. Following NEL recommendations, Nortronics has required electronic components and modules to withstand 25g shock loads. The massive enclosure of the Datico equipment racks is designed for 50g shock loads and 10-33 cps. vibrations. Its three bays of modules are wired together through quick disconnect fittings so the bays can be passed through narrow hatches singly to be installed in the boat. Coolant air for the electronic equipment is passed through the double walls of the enclosure.

The mounting of the enclosure is made flexible to let it compensate for the straining of the ship's structure under sea loads. When submerged, compression of the hull by sea pressure can cause the soft deck in the missile control center to move up or down as much as two inches. The enclosure is suspended from double hinges on the bulkhead above it to allow the enclosure to move and tip without being crushed or ripped apart by the motion of the ship. Flexible mounting is also some protection against damage to equipment by the shock of detonating depth charges.

Each Polaris-carrying submarine will have two Datico sets installed in the missile control center. Either one can check all the missiles or they can be divided for speed. The arrangement also allows the operator to switch sets to determine whether a malfunction

signal is being caused by the missile or the checkout set.

The basic Datico consists of a programmer-timer with an integral punched-tape reader, control scanner, program board module, test point selector, digitizer, comparator, indicator and control, tape magazine and printer. It commands service equipment specially adapted to Polaris to generate preselected test signals and other service equipment measures the output of missile subsystems for comparison by the basic set.

Three Levels of Use

Datico-Polaris has three levels of use —watch mode, test mode and operate mode.

- **Watch mode** is a continuous monitoring of aspects of the missile system which could involve hazard to the boat as well as the monitoring of the readiness of critical missile and warhead circuits.
- **Test mode** is the periodic maintenance check to make sure the launch and flight control systems are ready to function properly.
- **Operate mode** is the final count-down check made under pressure of time.

The watch mode begins when the first missile comes aboard and remains in effect continuously with a technically qualified man always on duty at the display panel. Datico is connected to the various subsystems of each missile through the fire control switchboard. Watch mode measurements are displayed on a separate panel. Part of the panel is used to report on special hazardous circuits in each missile including:

- **Safe ready switch** position.
- **Warhead arming-fuzing.**
- **Igniters and first stage** separation charges.

Eleven environmental factors are monitored in the other half of the watch mode display panel:

- **Guidance temperature.**
- **Guidance coolant flow.**
- **Internal pressure** of solid propellant motors.
- **Tube humidity.**
- **Tube coolant flow.**
- **Spare guidance capsule** temperature.
- **Spare guidance capsule** coolant flow.
- **Header** (annulus around launcher tube) temperature high.
- **Header temperature** low.
- **Air sampler** to detect hazardous nuclear radiation products.
- **Launch tube temperature.**

Some of the environmental factors are not associated directly with the missiles. In these cases a No-Go condition in the circuits responsible for these factors will sound an alarm and turn on a malfunction indicator without placing a missile on a No-Go status. After launch of a missile, an action

cut-off signal is automatically sent from fire control to inactivate the display for that missile.

Procedure for the conduct of test mode operation will require the operator to use a precut taped program to prevent ill-informed innovations. The tape cannot be changed in the boat.

When a reading in the test mode is out of tolerance, the test program is halted at that point. A measurement repeat button can be pressed to double check the out-of-tolerance reading. If the reading is marginally out of tolerance, the fire control supervisor can order the operator to push an override button. This can be used to continue the test to search for effects related to the out-of-tolerance condition. If the measurement repeat control causes a later reading to indicate "Go," the taped progress of the test program will continue automatically, unless the Datico is placed under manual control to prevent it.

While operating in the test mode, Datico performs these three system loop tests:

- **Flight control loop gain** check is made with the stable platform gimbals caged at zero, the guidance computer off, rate gyro excitation windings grounded. Datico bypasses all other subsystems in the submarine and the missile under test and supplies a signal simulating that of the inoperative guidance capsule. The loop gain is obtained by measuring the feedback voltages from the jetevator potentiometers, amplifying them and comparing them with limits or tolerances programed on the tape. An in or out of tolerance condition is then signaled and the actual value of the comparison is printed on a read-out tape for a permanent record.
- **Guidance computer-flight control** loop is performed with the stable platform gimbals caged at zero and rate gyros squelched. Fire control initiates three reversals of the flight control stepped motors, which are to come to a stop in an indexed position. Only one channel (pitch or yaw) of each stage is exercised in the test. Jetevator potentiometer feedback provides the test signal for comparison with tape values.
- **Stable platform-flight control** loop is tested with the guidance computer out of action, the flight control system stepper motors indexed to zero. Stable platform-flight control loop gain is checked by caging the stable platform pitch, roll and yaw gimbals separately and at predetermined angles. With the gimbals caged at a known angle, jetevator deflection is measured to see if the control response is within tolerances.

Also checked are hydraulic pressure, fluid level, and fluid temperature.