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1 Navy Case No. 77118

2
3 SYSTEM FOR VERIFYING NUCLEAR WARHEAD PREARM/SAFING SIGNALS

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5 STATEMENT OF GOVERNMENT INTEREST

6 The invention described herein may be manufactured and used
7 by or for the Government of the United States of America for
8 Governmental purposes without the payment of any royalties
9 thereon or therefor.

10
11 BACKGROUND OF THE INVENTION

12 (1) Field of the Invention

13 The invention relates to the field of test instrumentation
14 and in particular to testing of weapons interface systems for
15 Tomahawk nuclear cruise missiles.

16 (2) Description of the Prior Art

17 During development of the AN/BSY-1 Submarine Combat System
18 (SCS) and, in particular, during the detailed interface testing
19 which is a part of the final certification testing, the
20 Department of Energy determined that the W80 nuclear warhead-to-
21 submarine combat system interface was invalid. At this late
22 stage of development, the Submarine Combat System could not
23 correctly pre-arm and safe the nuclear weapon. As a result, a
24 costly and time consuming redesign was necessary. In this
25 particular instance, the cost to the U.S. Navy for correction of
26 a problem discovered so late in the development cycle was

1 approximately \$1.5 million. This cost would have been greatly
2 reduced if the Navy had a capability to verify weapons interface
3 signal earlier in the development life cycle. Over the lifetime
4 of a project, the costs of correcting problems increases
5 exponentially as development progresses and a larger percentage
6 of components become fixed or relied upon by other parts of the
7 system. A system is needed which provides verification of SCS
8 signals at an early stage of development; especially those
9 signals associated with nuclear warheads where redesign efforts
10 are particularly costly. Additionally, in order to perform tests
11 at early development stages, it is necessary to have a portable
12 or transportable test system which can be moved to various
13 development sites. In order to fully capture the data provided
14 by a modern weapons interface, the system must be fast, reliable
15 and automated. The system must also provide permanent storage of
16 test results for documentation purposes.

17 18 SUMMARY OF THE INVENTION

19 Accordingly, it is an object of the invention to collect
20 samples of pre-arm and safing signals for nuclear warheads.

21 It is another object of the invention to provide a system
22 for verifying pre-arm and safing signals generated by a Submarine
23 Combat System for nuclear warheads.

24 It is yet another object of the invention to provide a
25 transportable system which can be setup at different development
26 sites as needed.

1 It is a further object of the invention to provide a system
2 in which the key components are fully redundant to prevent system
3 downtime due to component failure.

4 A still further object of the invention is to provide fast,
5 real-time collection and analysis of data as well as permanent
6 storage of test data.

7 In accordance with these and other objects, a method and
8 apparatus for collecting nuclear warhead verification information
9 comprising a portable notebook computer, an expansion station
10 containing a data interface module and two data acquisition
11 boards, a strip chart recorder, a weapon pre-arm load simulator,
12 and an adapter cable for attachment to a MK75 Digital Missile
13 Simulator and the Submarine Combat System is provided. The
14 system is operated by the notebook computer using four executable
15 programs, SAMPLE.EXE, which operates a data acquisition board
16 located in the expansion station; W80GRAPH.EXE, which allows
17 viewing of individual data points; W80EVAL.EXE, which provides
18 for comparison of the actual nuclear weapon pulse train with
19 verification samples; SAMPLE.EXE, which provides the verification
20 samples; and, READ.EXE, which allows the user to quickly browse
21 through a weapon sample file. The entire system is compact,
22 weighing approximately 250 pounds and is easily transportable
23 from one test site to another. The method of the invention is a
24 computer-driven process in which the Submarine Combat System
25 pulse train is acquired and stored, the pulse train is then
26 graphed, and finally compared against known samples.

1 BRIEF DESCRIPTION OF THE DRAWINGS

2 The foregoing objects and other advantages of the present
3 invention will be more fully understood from the following
4 detailed description and reference to the appended drawings
5 wherein:

6 FIG. 1 is a schematic of the components of the nuclear
7 warhead verification system; and

8 FIG. 2 is a flowchart of the process of verifying nuclear
9 warhead test data.

10
11 DESCRIPTION OF THE PREFERRED EMBODIMENTS

12 Referring now to FIG. 1, the complete weapon safe and arm
13 verification system, designated generally by the reference
14 numeral 100, is shown with its major components. Weapon
15 verification system 100 is connected to submarine combat control
16 system 210 through torpedo tube breech door 212 using MK75
17 adapter cable 200. MK75 adapter cable 200 has three ends, one of
18 which connects to the submarine combat control system 210 via
19 torpedo tube breech door 212, one of which connects to digital
20 missile simulator 214, and the last of which connects to the
21 weapon Pre-arm Load Simulator 140. When connected in this
22 fashion, signals from combat control system 210 travel through
23 MK75 adapter cable 200 into Pre-arm Load Simulator 140. Pre-arm
24 Load Simulator 140 also monitors signals between digital missile
25 simulator 214 and combat control system 210 which simulate the
26 prearm and safe/reset commands. Pre-arm Load Simulator 140 also

1 connects directly to strip chart recorder 130. Strip chart
2 recorder 130 is a high speed output device which provides an
3 immediate paper copy of the sample data provided by Pre-arm Load
4 Simulator 140.

5 Pre-arm Load Simulator 140 simultaneously provides data to
6 the remainder of the system through a connection to expansion
7 station 150. Within expansion station 150, submarine systems
8 interface unit 159 provides direct electrical connectivity to
9 Pre-arm Load Simulator 140. Submarine systems interface unit 159
10 converts these input signals (ranging from 28 to 32 volts DC)
11 into a range that is usable by the low voltage components in the
12 remainder of expansion station 150. This voltage is reduced
13 through the use of a resistor network and op-amp and, on output,
14 is typically in the range between 0 and 10 volts DC. Once the
15 signal is converted by submarine systems interface unit 159, the
16 signal is passed through electrical connections to primary data
17 acquisition board 153 and backup data acquisition board 156.
18 These boards operate simultaneously and convert the incoming
19 analog signal to a digital signal which can be processed by
20 computational engine 120. In the preferred embodiment, both
21 boards are 12 bit, 16 channel analog/digital converters with
22 acquisition speeds of 200,000 samples/second for primary data
23 acquisition board 153 and 50,000 samples/second for backup data
24 acquisition board 156. In the preferred embodiment, the primary
25 board is a National Instruments™ AT-MIO-16F-5 Data Acquisition
26 Board and the backup board being a National Instruments™ PC-LPM-

1 16 Data Acquisition Board; however, the use of alternate devices
2 for the conversion of the analog data into digital data is within
3 the scope of the present invention. Data from primary data
4 acquisition board 153 and backup data acquisition board 156 is
5 electronically transmitted to computational engine 120. In the
6 preferred embodiment, computational engine 120 is a notebook
7 computer containing an 80386SX-20 microprocessor, an 80387SX-20
8 coprocessor, an 85 MB hard drive, a LCD display, and 4 MB of RAM.
9 The data transmission is accomplished through high speed direct
10 memory access transfers; however, alternate computational engines
11 and alternate means of high speed transmissions of the processed
12 digital data between the data acquisition boards and the engine
13 are within the scope of this invention. Within computational
14 engine 120, data is received through acquisition software 122.
15 Acquisition software 122 immediately archives all incoming data
16 to data storage device 128. Acquisition software 122 may also
17 provide data to graphic display software 124 or data evaluation
18 software 125 at the system operator's discretion. Graphic
19 display software 124 provides a graphical display of the data
20 collected from the combat control system. This is similar to an
21 on-screen version of the output provided by strip chart recorder
22 130. Data evaluation software 125 provides a benchmark of
23 collected data against several user configurable data series.
24 The standard benchmarks contain information detailing the proper
25 signal sequences (reception and transmission order), the
26 allowable time delays between the transmission and/or receipt of

1 successive signals, signal voltage levels, and the like. In the
2 present invention, these benchmarks include the three ICD test
3 standards for warhead and umbilical tests. Both graphic display
4 software 124 and data evaluation software 125 can be started
5 using either data collected by acquisition software 122 or data
6 archived on data storage device 128; however, the processing
7 requirements for high speed data collection when acquisition
8 software 122 is in use may limit the usability of these packages
9 on low bandwidth computational engines. Finally, raw data
10 display software 126 can be used to read and display the numeric
11 test data for any test or standard benchmark stored on data
12 storage device 128.

13 Referring now to FIG. 2, a flowchart for the method of the
14 invention is shown. In order to verify the operation of the
15 submarine combat control system, the present invention uses the
16 steps as shown. First, in step 300, test inputs are provided to
17 the combat control system. These test inputs simulate the
18 desired test scenarios, specifically warhead pre-arm and
19 safe/reset commands. As step 300 is underway, step 303 is also
20 underway. The pulse train data from the submarine combat control
21 system is acquired. Once all of the data has been acquired, the
22 pulse train is permanently stored in step 306. The stored data
23 from step 306 is used to graph the pulse train data in step 309,
24 allowing a visual inspection of the test results. Finally, the
25 data is also compared against benchmark data in step 312. The
26 system, in the preferred embodiment, automates the steps of this

1 method; however, the method can be used in a manual fashion for
2 analysis of combat control systems in cases where the system is
3 not available.

4 The new features and advantages of the present invention are
5 numerous. The system provides the Navy with the capability to
6 validate SCS-to-W80 nuclear warhead interfaces during various
7 phases of the development life cycle, particularly at an earlier
8 point than was previously possible. Further, the entire system,
9 based on a notebook personal computer and weighing only 250
10 pounds with all necessary components, is easily transportable.
11 This transportability allows testing to be accomplished at
12 development sites having different locations. Additionally, the
13 system uses standard parts for most of the processing
14 requirements; however, for the data acquisition board, the system
15 has built-in redundancy in case the first board should fail.
16 Both boards maintain high acquisition data rates, allowing the
17 complete system to easily sample at very short intervals. This
18 is particularly important for testing of delays in combat control
19 system response. The system also provides permanent storage of
20 all test results, through both a printed hard-copy format and
21 electronically on the disk of the computer system.

22 Although the invention has been described relative to a
23 specific embodiment thereof, it will be understood that many
24 additional changes in the details, materials, steps and
25 arrangement of parts, which have been herein described and
26 illustrated in order to explain the nature of the invention, may

- 1 be made by those skilled in the art within the principle and
- 2 scope of the invention,

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5 ABSTRACT OF THE DISCLOSURE

6 A system for collecting, storing, and verifying the data
7 pulse train for prearm and safing of a nuclear warhead on a
8 submarine using MK 63 or 67 torpedo tubes is provided. The
9 components of the system include a notebook computer operating
10 four software programs. The software programs allow collection
11 of the data pulse train, graphing of the collected data,
12 comparing of the collected data with validated samples, and
13 verifying of the validity of the collected data. The notebook
14 computer operates the system through data acquisition expansion
15 boards and a combat control system interface board connected to a
16 Prearm Load Simulator. Data is also recorded on a strip chart
17 recorder which is connected to the system through the Prearm Load
18 Simulator. An adapter cable connects the system to a digital
19 missile simulator and to the submarine's combat control system
20 via the torpedo tube breech door interface.

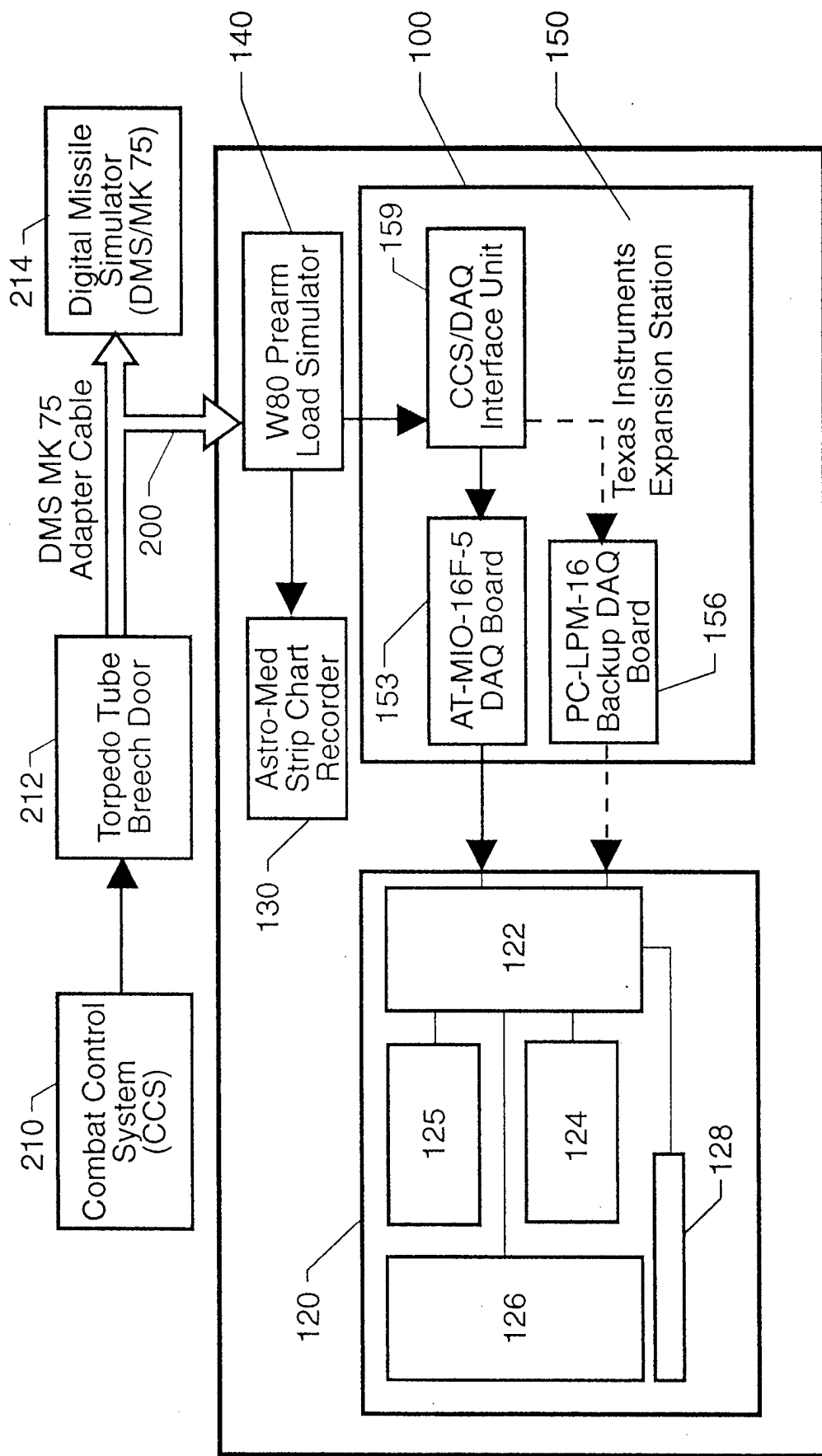


FIG. 1

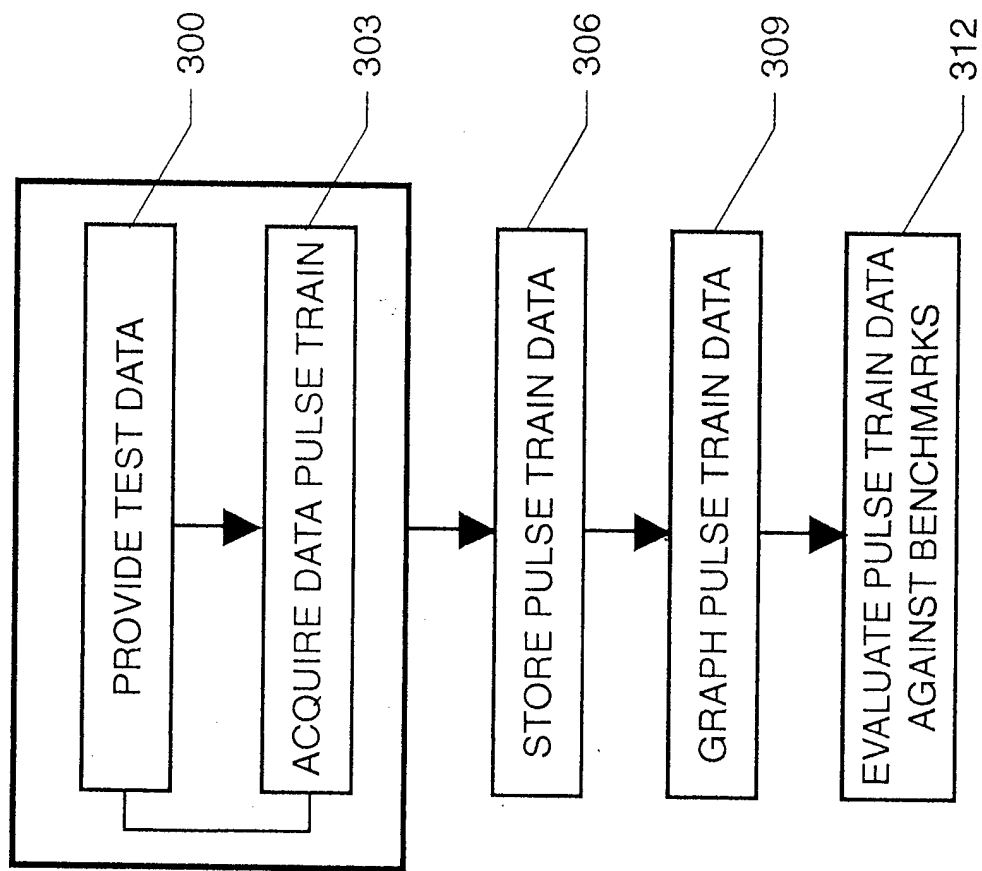


FIG. 2