

[54] FIRE CONTROL SYSTEM

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[51] Int. Cl. F41f 3/06, H04q 9/14

[58] Field of Search 89/1.5 E, 1.814, 37.5 R,
89/40 P, 340/147 R, 163; 343/6.5 R

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[57]

ABSTRACT

A fire control system that can be readily installed with minimum change on existing aircraft, actually tests all weapon positions and stores a number of status words representing the current state of the various weapon positions. Upon occurrence of a selected number of firing conditions such as firing interval, remaining quantity of a salvo to be fired and the fire command, the system will automatically extract from the store of weapon status words, one word corresponding to an unfired weapon of selected type. The extracted word is automatically sent to the weapon firing station in a time division multiplexing arrangement that shares a single communication channel among fire command, test command and sensed status words. Although the system will automatically select an unfired weapon of a chosen type, the pilot is provided with a complete display of status of all weapons and a remaining stores display indicating the total remaining weapons of the respective types. Comparison of a commanded word with the actual status of a given weapon position is employed to provide the pilot with a hung ordnance alarm.

36 Claims, 10 Drawing Figures

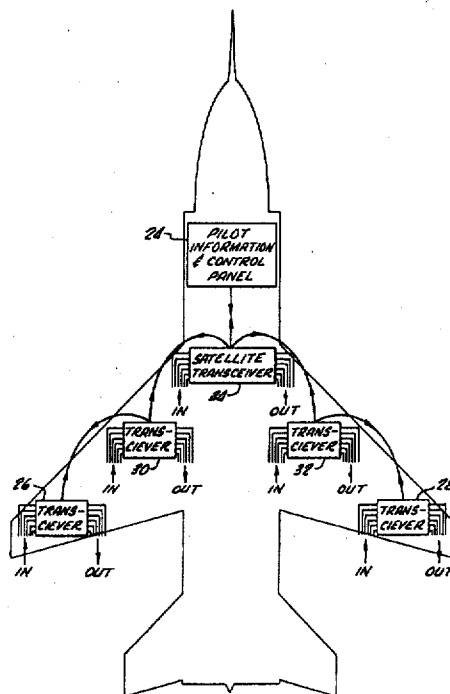


FIG. 1.

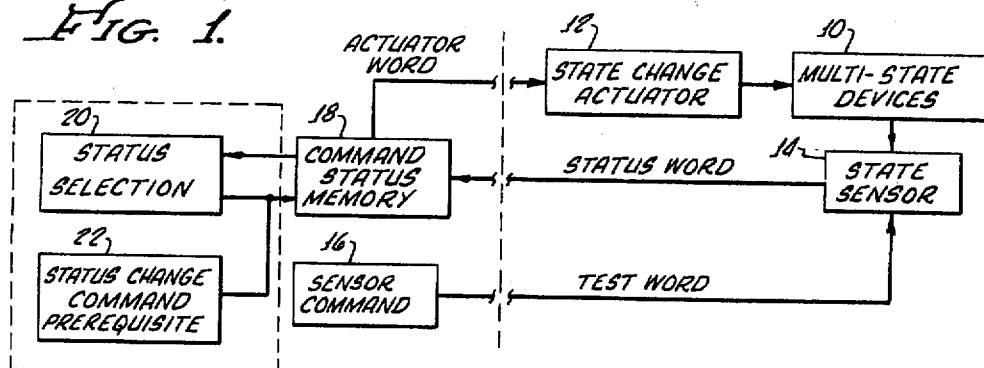
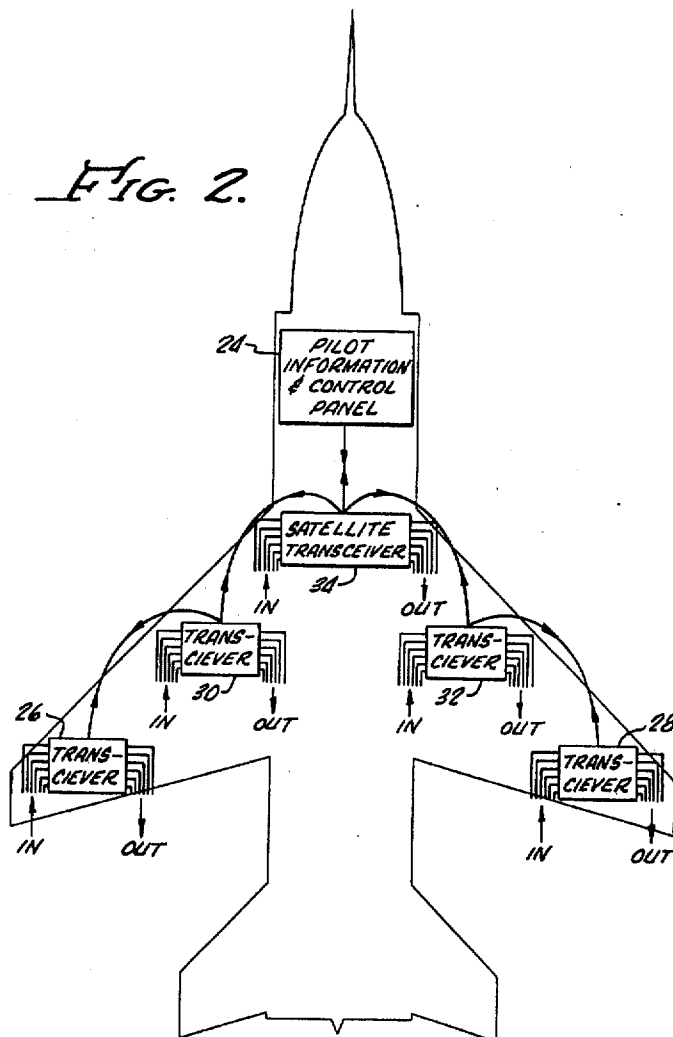


FIG. 2.



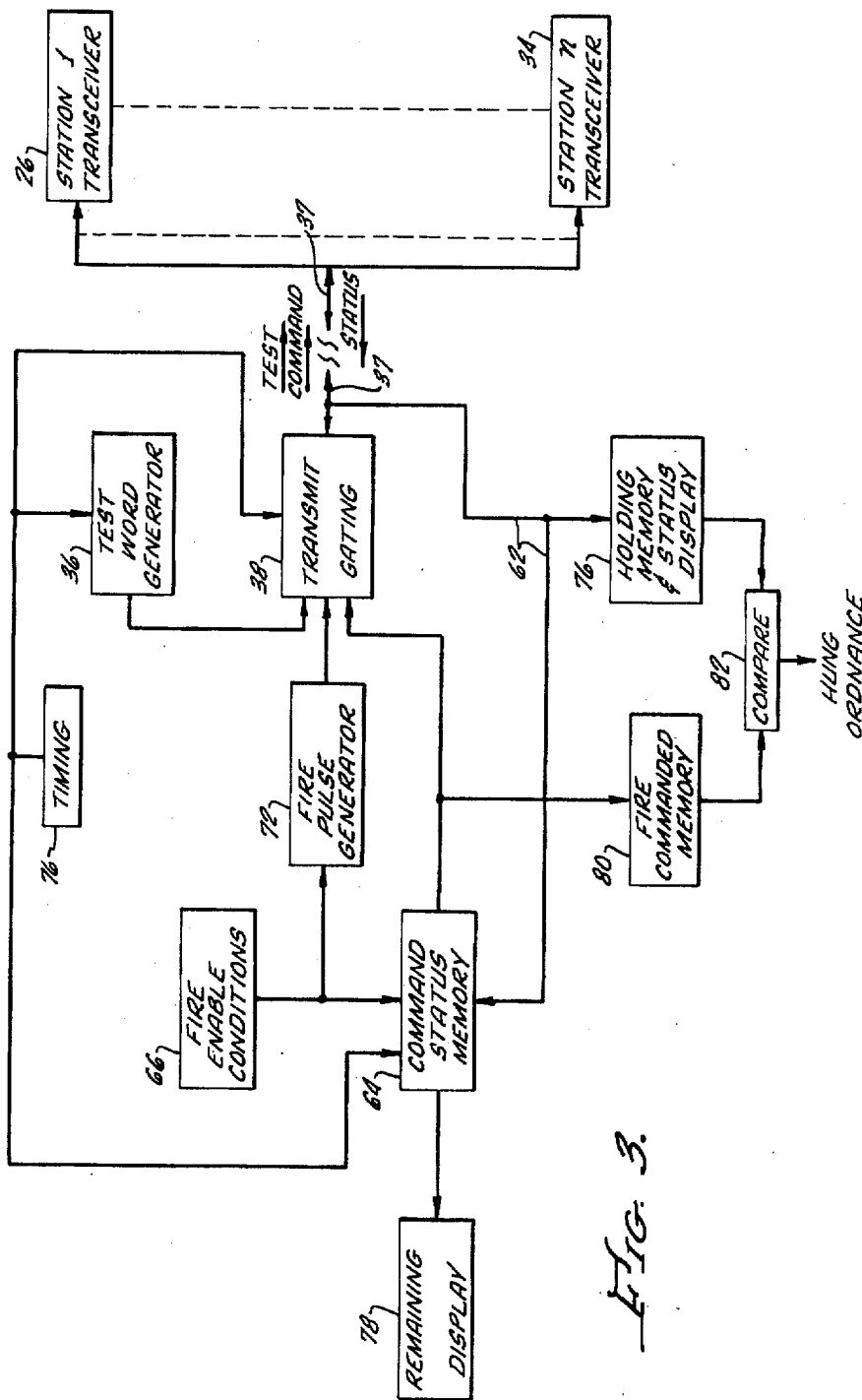


FIG. 3.

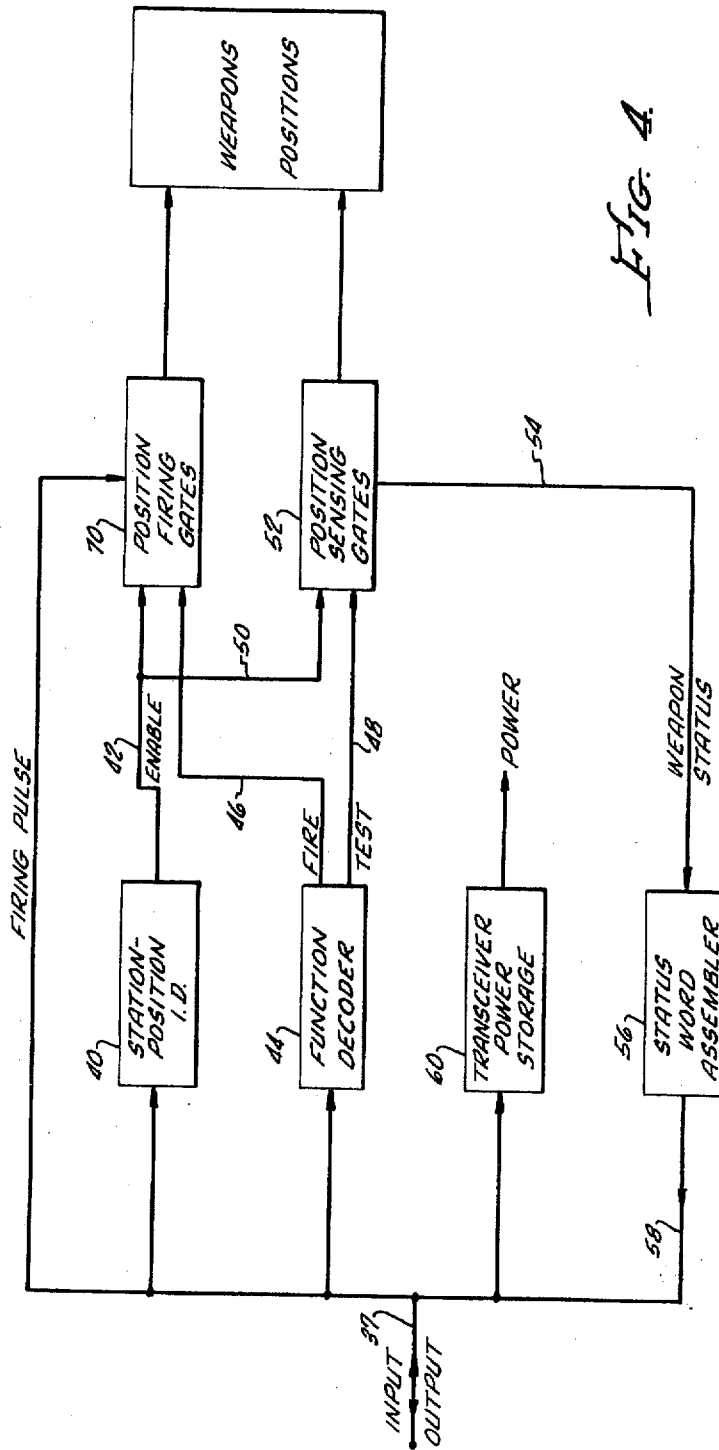


FIG. 4.

FIG. 5a.

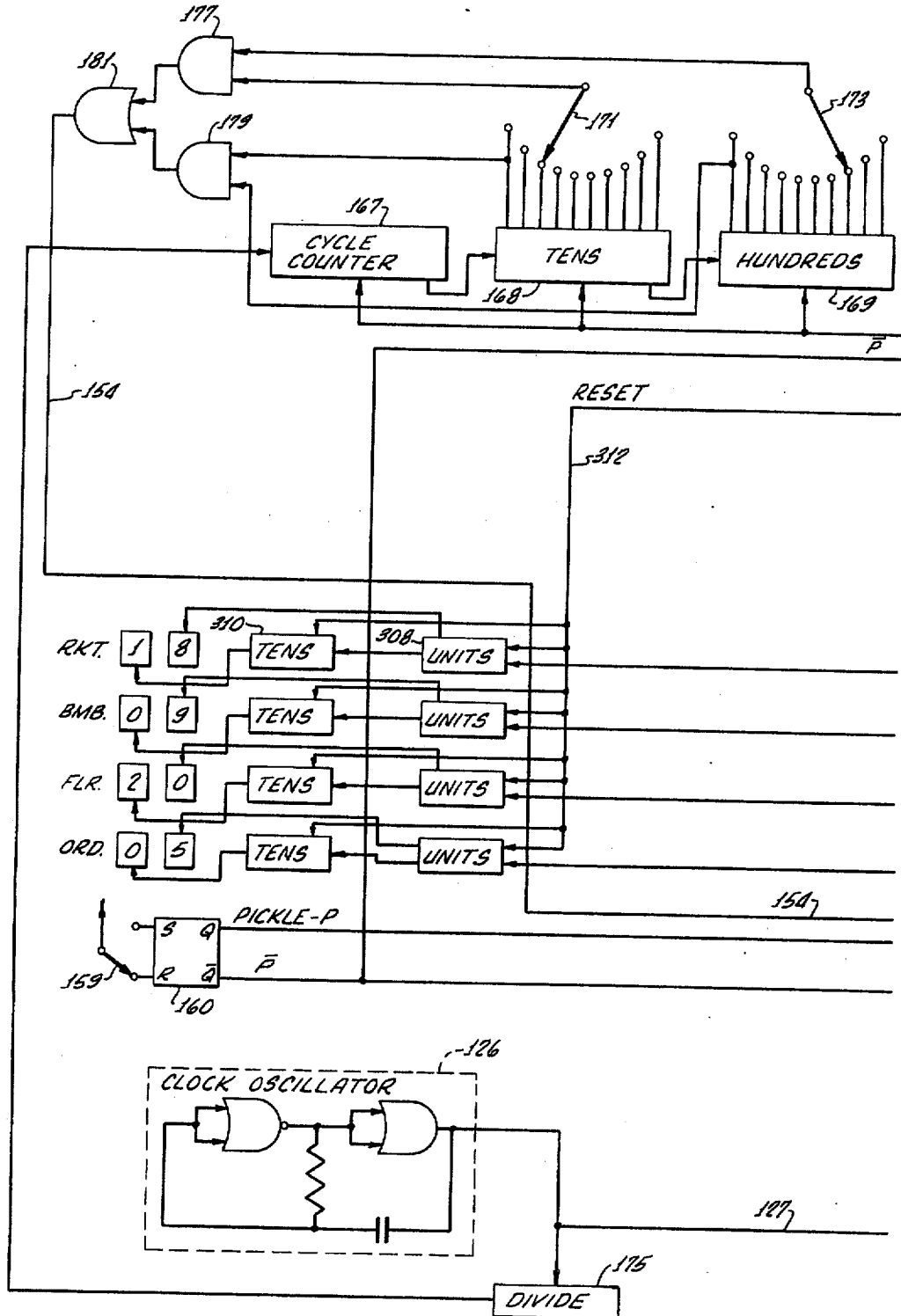


FIG. 5C.

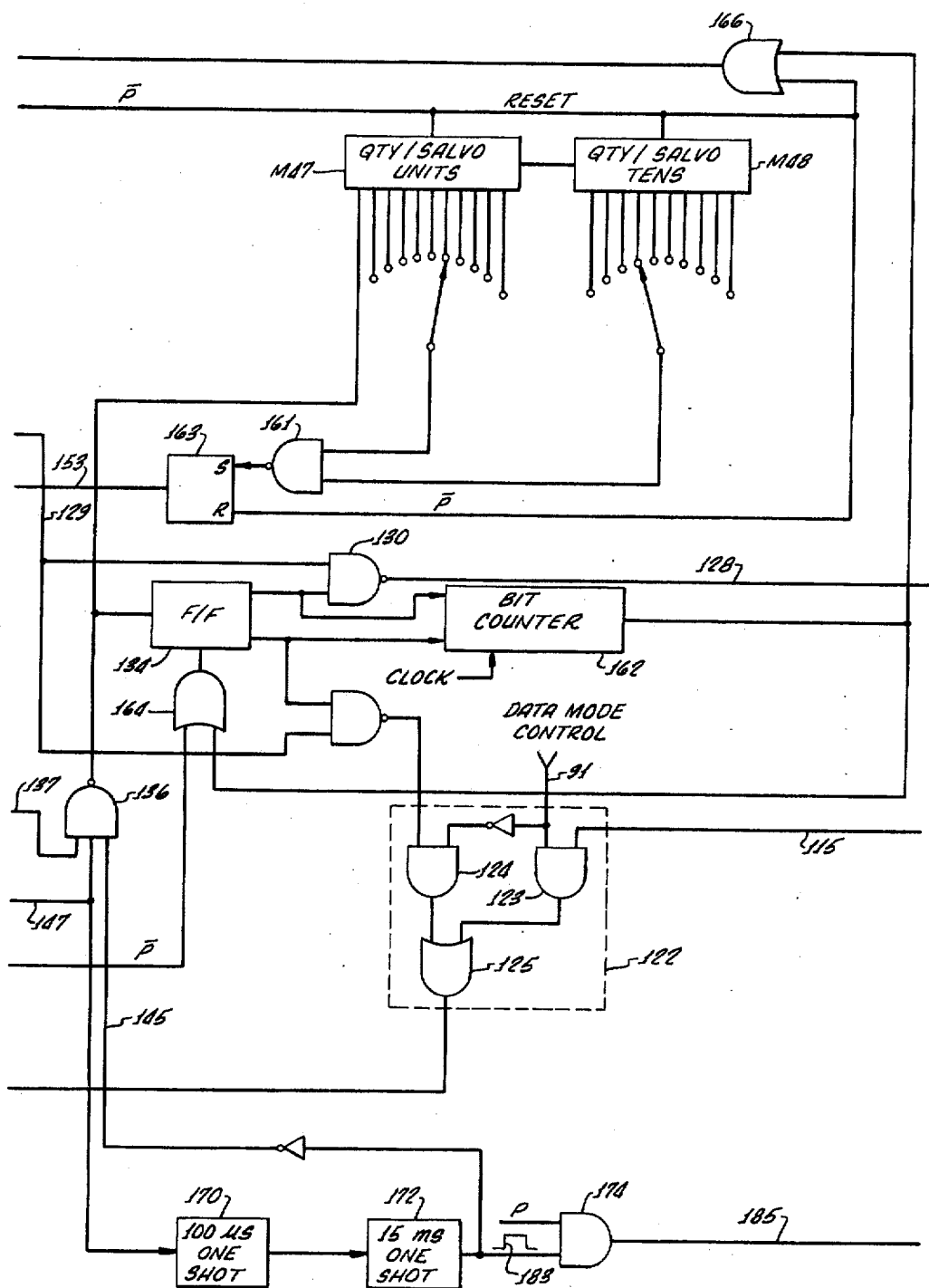
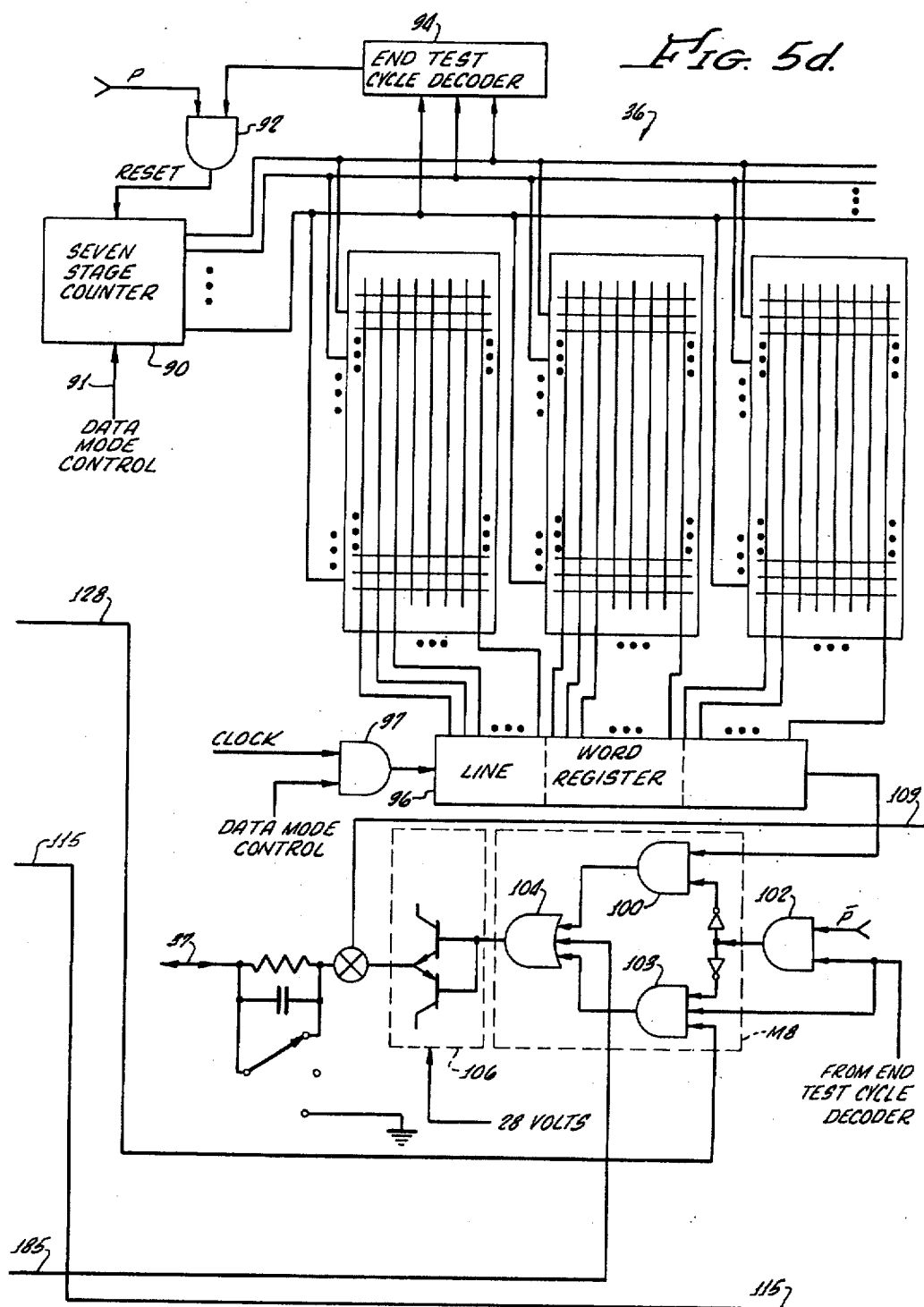


FIG. 5d.



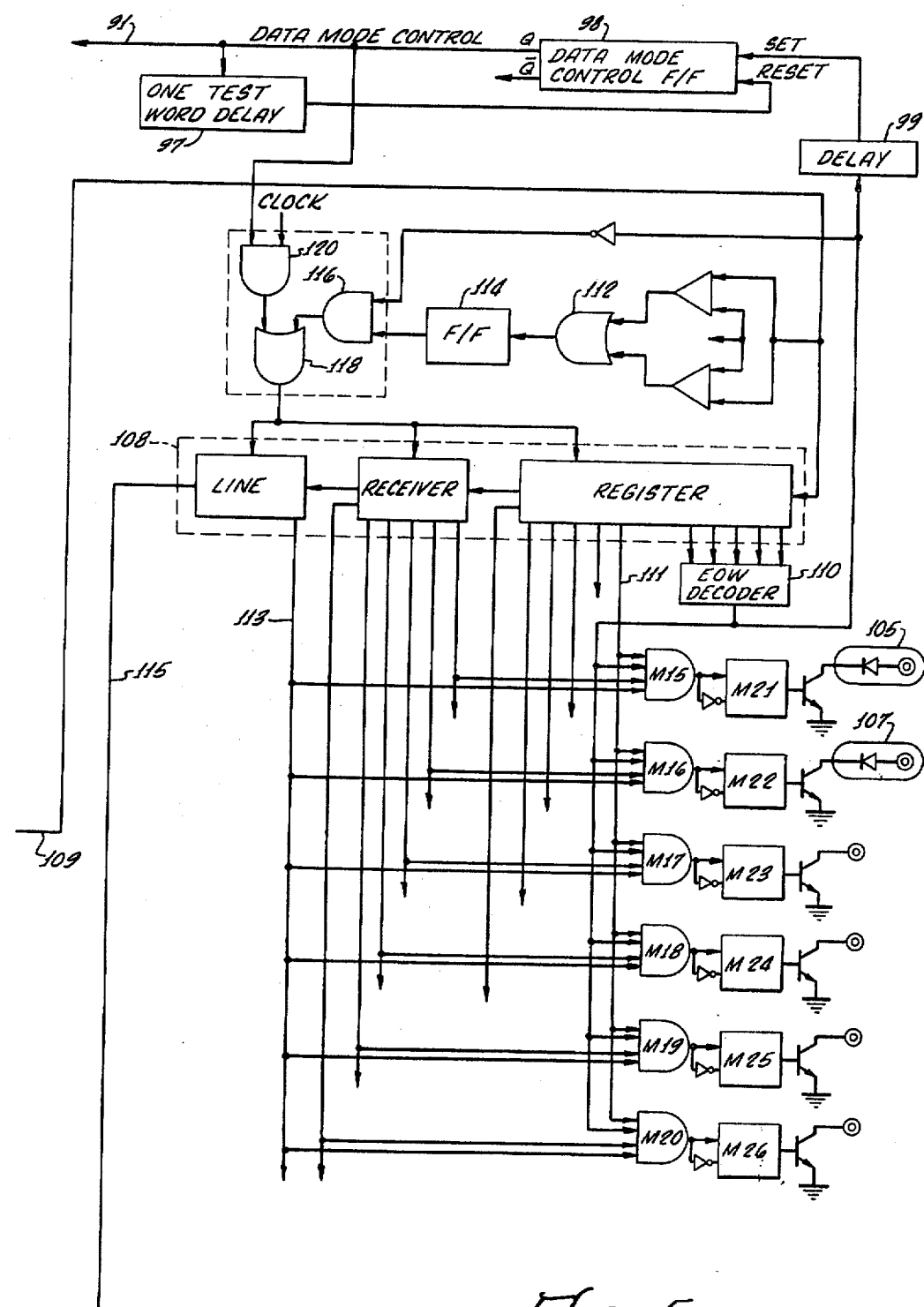


Fig. 5e.

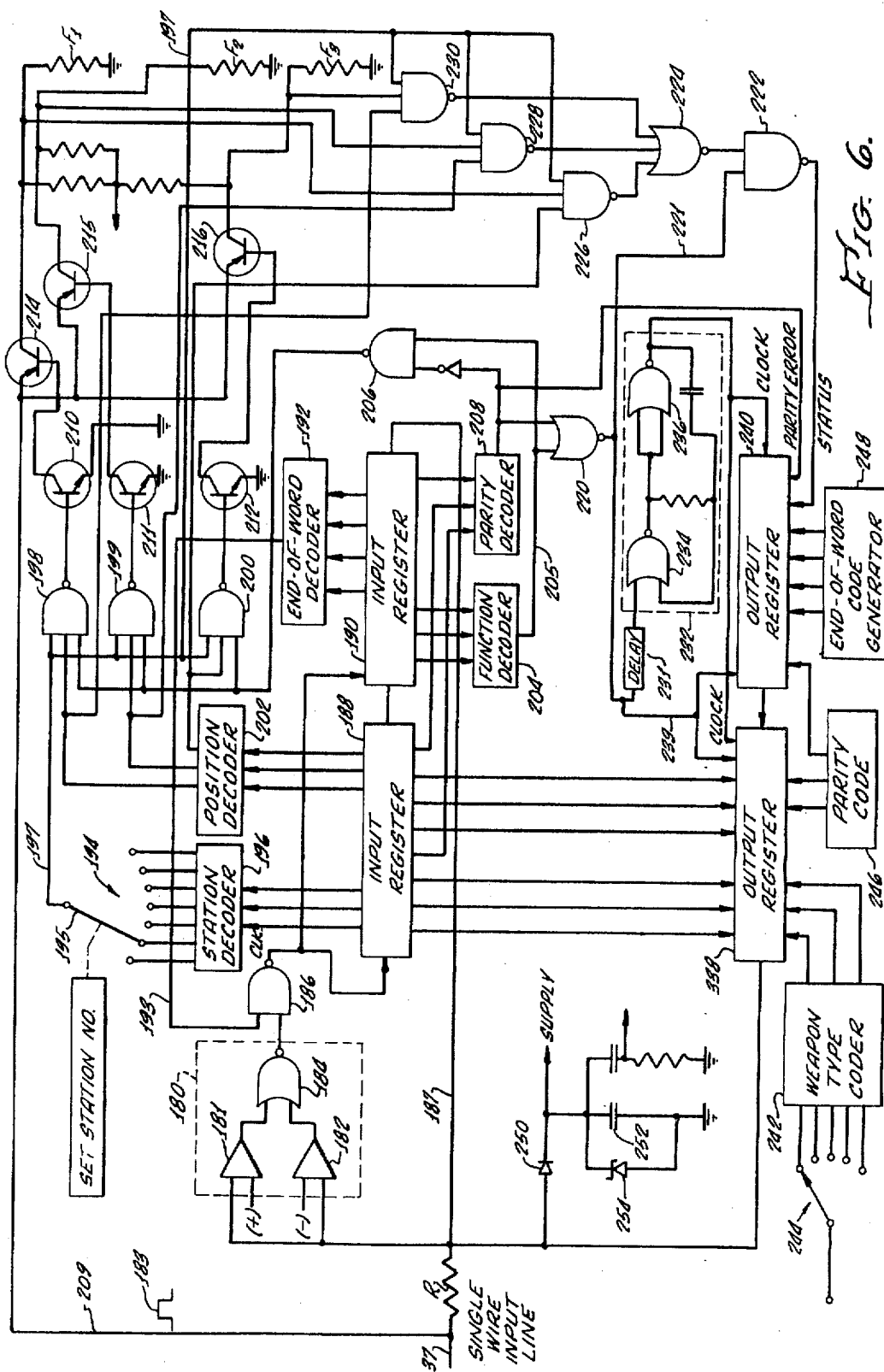


FIG. 6.

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FIRE CONTROL SYSTEM

BACKGROUND OF THE INVENTION

1. Field of the Invention

The present invention relates to control systems for testing and operating devices at a number of stations and more particularly concerns methods and apparatus for testing devices to be actuated and employing information obtained from such testing to select certain of the tested devices for actuation.

2. Description of the Prior Art

Various types of remote control operating systems require the remote operation of numbers of different devices of different types at selected stations according to preselected conditions. The greater the number of stations and variety of devices to be operated, the more complex the system and the more difficult it becomes to achieve error-free selective operation. In present-day military tactical aircraft, for example, a number of different types of ordnance are carried and these must be selectively fired by the aircraft pilot while he is occupied with control of the flight of the aircraft itself. Many problems exist in control of such complex aircraft weapon systems. For example, release devices for bombs, munitions and rocket dispensers in many cases do not provide proper execution of the pilot's command. This may be due to intervalometer malfunction, circuit interruption or a combination resulting from shock and vibration environment on the aircraft wing where the weapons are carried. Further, present cockpit weapons control panels do not provide information for the pilot concerning actual weapon status. Hung ordnance, that is, a weapon that has been commanded to fire but the firing of which has not been carried out, is not identified in present systems.

Various systems have been suggested to provide increased quantity of weapon information display and facility of pilot control of groups of weapons. Such systems are exemplified by the U.S. Pat. No. 3,499,363 to M. J. Lauro, and U.S. Pat. No. 3,598,015 to Delistovich et al. These systems, for example, provide a display of weapon inventory, but this display is simply a record of commanded fire pulses and not a display of actual weapon status. Thus, as previously indicated, even though the firing of a weapon has been commanded, such firing may not necessarily be carried out due to various types of malfunctions to which such aircraft fire control systems are notoriously subject. Although the systems suggested in these patents provide increased quantities of weapon information displayed, there is no actual testing of existing weapons and no selection of a weapon for firing based upon an actual active state of a weapon of known type at a given position. Two-way communication between the pilot and the weapons has not been provided. Only a feedback from the weapon positions can provide true and accurate weapon status information.

At present, the Air Force has nearly 100 different munitions that may be dispensed in tactical operations. There are many ways to arm, disarm, fire or jettison these devices. Some are fired by triggering a present intervalometer as in the case of a 2.75 inch rocket, a settable intervalometer as in the case of a SUU-13 dispenser, or dropable by a single release as in the case of bombs or missiles. There are also several kinds of racks used. The multiple ejection rocket racks employ secondary steppers of fixed programming. This variety re-

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quires the pilot, among his other tasks, to remember what weapon is set where and how it will operate. He may fire or use a particular ordnance but has no return signal to tell him positively what is the ordnance status on his aircraft. Further, accuracy of dispensed ordnance varies with the particular weapon and type of timing or release method.

Accordingly, it is an object of the present invention to provide the pilot of an aircraft with two-way communication with the ordnance on the wing and to allow him to select a weapon or weapon type based upon actual sensed weapon status.

Another object of the invention is to prevent inadvertent weapon firing, employing a novel digital code arming system to provide increased safety against accidental firing and radiation hazards.

Still another object of the invention is to provide an improved information and control system that may be readily installed in existing aircraft and employs a minimum of wiring for communication between the pilot and the weapon stations.

SUMMARY OF THE INVENTION

In carrying out principles of the present invention in accordance with a preferred embodiment thereof, actuatable devices at a number of remote stations are tested and test results stored in a status memory. Based upon the stored test results, a particular device to be actuated is automatically selected and an actuating command signal sent to achieve such actuation. According to other features of the invention, means are provided to select devices for actuation according to either position or type and to achieve such actuation only upon the occurrence of certain preselected conditions. Various displays and inventories of device status are provided. Failure to execute a commanded actuation may be detected. The arrangement is achieved by means of a time sharing of a communication channel between a command station and remote stations, and data words sent from the command station are employed not only for their information content but also for their electrical energy content to provide power for the data processing that is carried out in the remote stations.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a broad functional diagram of a method and apparatus for remote operation embodying principles of the present invention.

FIG. 2 illustrates a system according to the present invention applied to a tactical aircraft.

FIG. 3 comprises a broad functional block diagram of the aircraft system of FIG. 2.

FIG. 4 is a block diagram of a typical remote station and its transceiver in the system of FIG. 3.

FIGS. 5a through 5e collectively comprise a detailed electrical diagram of the command station shown in FIG. 3.

FIG. 6 is a detailed electrical diagram of a typical transceiver.

DETAILED DESCRIPTION

1. General System

Illustrated in FIG. 1 is a functional block diagram of certain significant aspects of the testing and device actuation of the present invention. One or a number of operating stations each contains one or a group of mul-

multistate devices 10, which may be any one of a number of different classes of apparatus that are capable of assuming at least two different states or conditions and that can be changed from one of such states or conditions to another. An example of such devices to be described more particularly hereinafter in connection with an embodiment of the invention designed for an aircraft fire control system, may be ordnance devices having firing relays or firing squibs which assume one state, an active state, before they are fired and which may be actuated to launch a rocket or drop a bomb, thereby assuming a second state, an expended state.

Also located at the operating station is a transceiver including a state-change actuator 12 and a state sensor 14. The state-change actuator of the transceiver is arranged to receive an actuator word having an address that identifies a unique operating station and a unique one of the multistate devices. Also included in the actuator word is an actuator (fire) signal that causes the identified device to change its state under command of the actuator word.

The state sensor 14 receives and responds to a test word transmitted from the command station or from some other test station. The test word also uniquely identifies a given station and unique device and causes the state sensor to sense the state of the device so identified. Having sensed the device state, the state sensor assembles a status word that identifies the particular device and includes a status code representing the state of the device. If deemed necessary or desirable, the status word may also include an identification of a fixed characteristic or classification of the identified device. That is, the status word may identify the particular device weapon type, for example, such as rocket, bomb, flare, etc.

The test words for the several devices are generated and transmitted to the state sensor from a state sensor command 16. The status words assembled by the state sensor 14 are transmitted for storage in a command status memory 18. In one form of testing sequence, the sensor command 16 generates and transmits a series of test words, each of which uniquely identifies a different one of the devices to be tested and, each of which is transmitted to the several state sensors, one after the other. In such an arrangement, it is convenient to space the transmission of successive test words so that the corresponding status words assembled by the addressed state sensor may be transmitted from the operating station to command station between transmission of successive test words from the sensor command. With such an arrangement, of course, one may employ a single communication channel for propagating test and status words, time sharing the single channel. The sensor command may operate periodically, going through one or several full cycles of testing all of the multistate devices and storing corresponding status words in the command status memory and thereafter stopping operation for an interval. Alternatively, the system may be arranged to afford continuous testing so that each full cycle of testing all of the multistate devices is immediately followed by a repeated full cycle of testing. In the latter situation, testing is interrupted only to command a change of state and the command status memory is continually updated so that its contents are always current.

Since one of the multistate devices is to be changed from one state to another, and since several of the

states are different, it is desirable to command a change of state of only those devices that exhibit a predetermined condition. For example, it will be desired to send a change of state signal namely, a fire signal, only to those weapons or weapon positions that have not yet been fired. Accordingly, such a unique state is selected in a status selection circuit 20 and caused to extract from the command status memory, a given status word (from the totality of status words stored therein) that uniquely addresses one of the multistate devices which is known to have a selected state. The status word extracted from the memory 18 is employed as the actuator word that is transmitted to the operating station for address identification and state change actuation by the actuator 12.

In most operating systems, it is necessary that certain conditions occur before an operation or actuation may take place. Thus, a status change command prerequisite circuit 22 is employed to enable the extraction of a selected actuator word from the command status memory. The command prerequisite circuit 22 may sense any one or group of command prerequisites such as, for example, the interval between successive actuations, the total number of actuations in a given period or in a given group or salvo, and the presence of a command actuation signal. Obviously, many other conditions may be prerequisites that are sensed by the circuit 22 and employed for enabling transmission of the actuator word.

It will be readily appreciated that all of the components described above as forming parts of the illustrated system, may be positioned at any convenient location. Nevertheless, in a specific embodiment, the system is adapted for remote actuation of a number of devices from a single central command station. In such an arrangement, the multistate devices, the state sensor and state change actuator will all be located at one or several remote stations and a single command station having a number of parallel communication channels or having a single time shared communication channel, may be provided for communication with all of the remote stations. Although a parallel multichannel communication system is functionally illustrated in FIG. 1, a time shared single communication channel is employed in a specific fire control embodiment to be described hereinafter.

Where the status words also identify a device classification, the status selection circuit 20 will be arranged to select for actuation either a group or one or more of the devices having a particular classification (a rocket, for example) and having a selected state (active and unfired) as will be described below. The selection circuit may also be employed to select actuation of a device according to a specified position or station location.

2. Aircraft Arrangement

Illustrated in FIG. 2, is an aircraft employing an embodiment of the present invention to provide a pilot with information concerning weapons carried by his craft and to allow him to control the firing of these weapons. It will be readily appreciated that the invention may be applied to systems for obtaining information and control of weapons in other types of craft or at fixed stations. The command or pilot information and control station 24 is preferably located in the cockpit and forms a part of the pilot's control panel. One or more groups of weapons are carried at different sta-

tions in the aircraft. Thus, in the example illustrated in FIG. 2, where five remote weapon firing stations are shown for purposes of exposition, there is a left outboard station 26, a right outboard station 28, a left inboard station 30, a right inboard station 32, and a center station 34. Each of these stations has one or a group of weapon-firing positions and one or a group of weapons and firing mechanisms therefor at each such position. These weapons may include rockets, guns, flares, bombs, missiles and including triple and multiple injection rocket launchers. Each weapon has a release mechanism such as a solenoid for a bomb, a stepper switch for a multiple rocket launcher, or a firing squib (resistance heater) for direct firing of rockets. Each such firing mechanism will be actuated from its active or unfired state to a weapon expended or inactive state upon command from the pilot. Further, the actuating mechanism of each of the weapons is continuously tested in the described embodiment. Status of the weapon at each position is displayed to the pilot, although he need not use this display since unexpended weapons of selected type are automatically chosen. The number of remaining weapons of each category or classification is also displayed. Weapon status is stored in the command status memory so that upon a fire command signal from a pilot, a fire pulse is sent automatically only to a weapon that has not yet been fired.

3. Fire Control System

As illustrated in FIG. 3, the several remote operating stations 26 through 34, each includes a transceiver that operates the individual remote station as more particularly described below in connection with FIGS. 4 and 7. All of the remote stations are connected in common to one end of a communication channel 37 through which information is transmitted between each of the remote stations and the pilot information and control station 24. The pilot information and control station includes a test word generator 36 that separately generates groups of test words, the groups being continuously repeated and each group containing a number of test words each individual to a respective one of the weapon positions. For example, in a system having five stations and six weapon positions at each station, there will be 30 test words generated during each test cycle. Each of these test words includes an address unique to an individual one of the weapon positions. The test word generator may comprise any one of a number of well-known devices for successively and repetitively generating the predetermined words of predetermined format including either read-write or read-only memories. In the exemplary embodiment described herein, a read-only memory is employed. Exemplary word formats are shown in Table I, set forth at the end of this specification.

As shown in Table I, each test word may be made up of 19 bits. The first three bits comprises a station identification code that uniquely identifies a given one of the remote stations. A second group of three bits uniquely identifies a particular weapon position at the given station. A third group of three bits (random) are not employed in a transmitted test word but occupy positions that will bear weapon type information in a reformatted status word assembled at the remote station. Another group of bits identifies a function which for the test word, of course, is the test function that is to be performed upon receipt and identification of the test word station and position address. A final group of bits forms

an end-of-word code that enables identification of the end of the given test word. If deemed necessary or desirable, transmission and circuit errors may be recognized by use of selected parity bits. Such parity bits are illustrated in the test word of Table I as occupying bit position 4, 8 and 15. Bit position 12 is also a parity bit in other words to be more particularly described hereinafter.

Thus, the test words are sent out in repetitive groups through a transmit gating circuit 38, down the common line 37 for reception by the transceiver at all stations. Only one station will recognize its own station address code for a given test word and will, thereupon, enable its testing function to sense the state of the addressed weapon position.

4. Transceiver

Illustrated in FIG. 4 is an exemplary transceiver which is identical to the transceiver of each remote station, each such remote station having its own transceiver. As illustrated in the block diagram of FIG. 4, station and position address codes of the transmitted test word are recognized in an identification circuit 40 that is provided in each transceiver. The identification circuit 40 is preset so as to enable it to recognize its own station code. Accordingly, although every test word and every command word transmitted from the command station is transmitted to every transceiver, only one transceiver will recognize a given station address to thereby generate a station enable signal on a line 42. Each transceiver also includes a function decoder 44 which provides an actuate output on line 46 or a test output on line 48. The station/position I.D. circuit 40 also decodes the position address and provides an enable signal on a line 50 that commands the sensing of the state of a uniquely addressed weapon position by enabling one of a group of position sensing gates 52. Thus, for a given test word, one remote station is enabled, one weapon position gate at such station is enabled, and state sensing (test) is commanded by the function of the test word, and a signal representing state of the sensed weapon is provided on line 54 of the transceiver. The weapon status signal is fed to a status word assembler 56 which provides on an output line 58 a status word having a format of a type illustrated in Table I. The status word includes, in addition to parity bits, station and position address, a group of bits identifying the type of weapons at the particular station, a group of bits representing the sensed weapon status and again, a group of bits forming an end-of-word code.

Although each remote station may be provided with its own power supply for empowering its transceiver or separate additional lines may be employed to send electrical power to the transceiver, it is convenient to provide each transceiver with an electrical energy power storage circuit 60 that receives each data word or at least selected data words sent down the communication channel 37 from the command station. Circuit 60 stores energy contained in such data words. The stored energy is transmitted as energizing power to all of the electrical operating circuits at the transceiver.

The status word assembled at the transceiver is sent from transceiver at line 58 along the single communication channel 37 in the interval between the transmission of two successive test words from the test word generator of the command station. The status word is received at the command station and fed via a line 62 as an input to a command status memory 64 (see FIG.

3). Command status memory 64 may be any one of a number of different types of storage devices having both read-out and write-in capability. The read-write command status memory may employ magnetic core, random access storage or recirculating shift register storage as described below. The latter is chosen in the exemplary embodiment described herein.

Thus, each time a test word is sent out through the transmit gating 38, it is followed by reception of a status word which is then written into the command status memory. Accordingly, for each complete cycle or group of test words, the command status memory is completely updated.

According to a feature of the present invention, the words in the command status memory are employed to enable the firing circuits of the selected weapon and also to send a firing pulse down the line to achieve the firing of the weapon. To this end, selection circuitry 66 is provided to determine presence of certain fire enable pre-requisites or conditions and, when these conditions exist, extract from the command status memory an actuator or command word having a format shown in Table I. It will be seen from this table that the command words are nearly identical to status words that are assembled in the transceivers and stored in the command status memory. The bits in bit positions 13 and 14 are identical in the two words but are employed for different functions, being used to denote status of a particular device in the status word and used to denote an actuate or fire function in the command word. Thus, even these bits of the command and status words are identical although they have different functions.

The command word extracted from the memory 64 under control of the fire enable condition circuits 66 is fed through the transmit gating 38 and thence down the communication channel 37 to all of the transceiver stations. Referring again to FIG. 4, a station identification circuit 40 at one of the remote stations will recognize the station address code of the received command word and its function decoder will provide a fire enable signal on its output line 46. This fire enable signal will fully enable a particular one of a group of position firing gates 70, all of which are partially enabled by the station identification signal provided from station I.D. 40.

Referring again to FIG. 3, recognition of selected conditions by the circuit 66 not only commands extraction of a given status word from memory 64, but also initiates operation of a fire pulse generator 72 which, after a delay sufficient to allow complete extraction of a command word from memory 64, sends an actuator firing pulse through the transmit gating 38 and through the channel 37 for reception at all remote stations. As indicated in FIG. 4, the firing pulse is fed to the position firing gates 70 of each transceiver. The command word that preceded the firing pulse included a unique station and position address so that one and only one unique position at one and only one station (in this exemplary embodiment) is enabled. The enabling of this unique gate in effect arms a specifically addressed weapon so that when the firing pulse is received, the weapon is fired. If desired, two positions may have the same address so that two weapons may be fired simultaneously. Alternatively, as will be described in detail below, two or more different positions may be armed (enabled) before sending a single firing pulse to all.

Timing of the time-multiplexed transmission is under control of a timing circuit 76 that controls operation of several of the circuits including the test word generator 36, transmit gating 38 and command status memory 64.

The timing is such that transmission of each test word is followed by reception of a status word and storage of the received status word in the command memory. When a firing command is given, the test cycle may be interrupted to permit the firing and the testing may be resumed after firing has been completed. Alternatively, each test cycle may be caused to continue until its completion and any firing command may be automatically delayed so as to occur only at the end of test cycle. The latter arrangement is employed in the embodiment that is described in detail below.

As each status word is received during a test cycle, it is not only written into the command status memory, but it is also stored in a holding memory 76 for display at the pilot's control station. Holding memory 76 may comprise a group of flip flops, each individual to a given weapon position and each, when in set condition, for example, being connected to light a light representing a particular weapon. In such a holding memory, of course, there will be one flip flop and one light for each weapon of the entire store. The holding memory includes suitable address and position decoding to enable selective operation of a given memory position.

Also of interest to the pilot is the quantity of weapons of a given type that remain unfired. Accordingly, a remaining stores display 78 is connected for operation by words in the command status memory 64 to provide a count according to the weapon type code of each status word of the number of such weapons having an active status. These counts are conveniently displayed to the pilot according to weapon type groups.

It may happen that a given weapon may malfunction and fail to fire or a bomb may fail to be released even though an appropriate fire command signal has been transmitted. Such a "hung" ordnance creates a potentially dangerous condition. It is essential that a pilot know at all times whether or not he is carrying live ordnance. In order to advise the pilot of the occurrence of a hung ordnance, each command word extracted from the memory 64 during the course of one complete mission, is fed to a fire commanded memory 80. The latter, accordingly, stores every command word extracted from the command status memory. The fire commanded memory will retain its information content until it is manually reset, which may occur when the various weapon positions are again loaded for a subsequent mission. The commanded words (words that have been used to fire a weapon) in memory 80 are continuously compared with information that represents status of the various weapons as indicated by the continuous testing. Since the status words contained in the command status memory, contain this information, being updated continuously after each firing, the words in the fire commanded memory may be compared with the words in the command status memory, comparing the status bits of words having identical station and position addresses. Alternatively, as shown in FIG. 3, the words in the fire commanded memory are continuously compared in a comparator 82 with information derived from holding memory 76. The latter also contains information identifying status and address of individual weapons. Accordingly, in the event that the comparison of commanded weapon positions with tested status

of such weapon position, indicates that a particular fire command has not been executed, comparator 82 will provide an output signal warning the pilot of the existence of a hung ordnance and will also identify the position of such hung ordnance. With such warning, a pilot may select the identified position of the hung ordnance and, by a priority override firing system to be more particularly described below, send a second or additional fire command to the malfunctioning position.

From the described functions of the command station shown in FIG. 3, including details to be described hereinafter, it will be readily appreciated that this command station may largely comprise a standard small scale general purpose data processing digital computer. In particular, with the widespread advent of computers made of large-scale integrated circuits, and particularly the LSI-MOS circuits, standard computers capable of being programmed to perform the required functions of the described command station are available at quite low cost. Such computers include memories capable of storing several thousand bits of information, which is more than adequate for the described exemplary embodiment of this invention, together with the required data processing and appropriate input, output circuitry. Alternatively, a special purpose computer may be employed to carry out the functions of the command station of FIG. 3. Such a special purpose computer is shown for purposes of exposition in the detailed drawing collectively formed by FIGS. 5a through 5e inclusive.

5. Test-Mode Details

FIGS. 5a through 5e collectively illustrate details of the pilot command station shown in FIG. 3. These five sheets of drawing form a single diagram when arranged consecutively from left to right with FIG. 5a on the left. All test words are stored in a read-only memory (FIG. 5d), the test word generator memory 36, and read out one after the other upon being sequentially addressed by the output of a seven-stage address counter 90, of which the count is augmented by a true data mode control signal. The address counter sequentially addresses successive words of the test word generator memory and is reset from an AND gate 92 that is enabled by the pickle signal P (from the pilot's fire control switch) together with a signal from an end-of-test cycle decoder 94. As the address counter 90 steps to a given address of the test word generator memory, a particular test word is read out in parallel to a line word register 96. The test word is clocked out of the line-word register by the output of an AND gate 97 that is enabled by the data-mode control signal (when true) together with the system clock.

The true data-mode control signal is provided from a data-mode control flip-flop 98 (FIG. 5e) (when set). The test word is clocked out to a first AND gate 100 of a transmit control gate M8. AND gate 100 is enabled by the output of an AND gate 102 receiving the signal $\bar{P}$ (absence of P) together with a signal from the end-of-test cycle decoder 94. AND gate 100 of transmit control gate M8 will send the test word through an OR gate 104, through a line driver 106, and then down the line 37 to the transceiver where the word is recognized, weapon status identified, and a status word reformatted and transmitted back to the pilot control system for reception in a line receiver register 108 (FIG. 5e).

Although various voltage levels may be employed for logic and fire pulse, it is found convenient to use logic

signal levels of 15 volts in both command and remote stations. Because a fire pulse of 28 volts is normally used in a weapon firing system to which the present invention may be retrofitted, the 15 volt logic (data word) is employed to gate 28 volt pulses through the line driver so that all data words sent from the command station, and the fire pulse itself, are formed of 28 volt pulses. The data words (but not the fire pulse) are conveniently attenuated to 15 volt pulses at the transceiver. The status words are sent back as 15 volt pulses.

Upon reception of the status word via an input line 109 of the line receiver register 108, an end-of-word decoder 110 sends a signal via delay 99 to set the data-mode control flip-flop 98. This flip-flop resets itself after a delay that is provided by a delay circuit 97 that is slightly greater than the length of one test word (about 19 bits). Alternatively, the data-mode control signal, which is to be true for one word time, may be a one shot (monostable multivibrator) that is triggered by the output of end-of-word decoder 110 and returns to its stable state at the end of its timing interval. Now the data-mode control signal is high and a second address advance signal is sent to the counter 90 via line 91 to achieve readout of the second test word.

This testing cycle continues throughout a full readout of all of the words of the test word generator memory. That is, each test word is readout, sent down the line 37 to the appropriate transceiver where it is reformatted and sent back as a status word to be received and retained temporarily in the line receiver register. The status word in the line receiver register 108 is read out in parallel to a group of AND gates including gates M15-M20 that have a first enabling input from the end-of-word decoder 110. Outputs of these gates are connected to set flip-flops including those designated M21-M26 that form the holding memory 76.

Each of the flip-flops of the holding memory when set operates a corresponding indicating light, such as lights 105, 107, that are mounted in a pilot information display. Thus, if one of the flip-flops is set to light its corresponding light, a display is provided to the pilot indicating that the weapon at the position corresponding to the activated light is in active state. In addition to the first enabling inputs provided from the end-of-word decoder 110, station and position address information is fed as second and third enabling inputs to the decoding AND gates M15-M20. For example, the six gates shown in FIG. 5e represent six weapon positions at a single station. Corresponding gates, flip-flops and lights for weapon positions at other stations are not shown. Thus, a station enabling input corresponding to a given station enables all of the gates M15-M20 via a line 111. Additional enabling inputs, one for each of the gates M15-M20, are provided each individual to a bit designating a specific position as contained in the status word temporarily stored in line receiver register 108. A fourth enabling input to the decoding gates M15-M20 is the actual status information from the status bit position of the line receiver register, and is fed to all of the decoding gates via a line 113. Each of the holding memory flip-flops is reset via an inverter connected between its reset input and the output of its own gate. Accordingly, each flip-flop is reset after the brief interval during which a status word corresponding to the particular position is held in the line receiver register. However, the light driving circuitry and the lights have

sufficient inertia (acting as an integrator) and the test cycle is repeated so rapidly (each 30 milliseconds for example) that each light corresponding to an active weapon position will remain continuously lit. Only when a weapon has been fired, so that a status word no longer provides excitation for a given light, will the light of the holding memory display be extinguished.

After a suitable delay sufficient to allow the holding memory flip-flops to settle, the status word is serially read from the line receiver register into the recirculating command memory via a line 115. At the same time, the second test word is read into the line word register from the read-only memory 36, and clocked out to the appropriate transceiver.

When the last address of the test-word generator is activated, the end-of-test cycle decoder 94 produces an end-of-test cycle signal. The end-of-test cycle decoder signal is combined with the pickle signal in AND gate 92 to reset the address counter 90. The end-of-test cycle signal also enables an AND 103 in the transmit gate M8 so that a fire command signal may be transmitted (if commanded) only at the end of a full test cycle.

6. Reception of Status Word

As a status word comes down the line 37 from a transceiver, it is simultaneously fed via line 109 to the input of the serial-in/serial-out/parallel-out line receiver register 108 and also fed to a self-clocking generator comprising an OR gate 112 and a toggle flip-flop 114. The output of the toggle flip-flop is fed to an AND gate 116 which is enabled by the absence of an output from end-of-word decoder in 110. The output of gate 116 is fed through an OR gate 118 as a self-clocking input to the line receiver register.

When the end of the status word is recognized in the decoder 110, the self-clocking AND gate 116 is disabled and, after a delay, the data-mode control flip-flop 98 is once again set to thereby advance the address counter of the test-word generator memory. The data-mode control flip-flop 98 now also enables a system clock AND gate 120 and also blocks the recirculating path of the command status memory and enables the data entry path of the command status memory, as will be described below.

The true data-mode control signal from flip-flop 98 signal enables clock gate 120, which accordingly clocks out the status word via line 115 to the data entry gating 122 of the recirculating command status memory (FIG. 5c). Data entry into this memory is enabled by a true data-mode control signal fed to an AND gate 123, whereas an AND gate 124 in the recirculating path of this memory is concomitantly disabled by such a true data-mode control signal. Nevertheless, the system clock continues to cause recirculation of the words in the memory so that the recirculating data words fed into AND gate 124 are simply erased and replaced by words coming from the line receiver register through now enabled gate 123 and the OR gate 125 of the data entry gating.

Thus, during each test cycle, all of the words in the command status recirculating memory are replaced by updated status words. Therefore, a full complement of status words, one word for each weapon position, is contained in the command status memory.

7. Command Status Memory

The command status memory may be any one of a number of different types of read-write memories, such

as for example, a random access core memory or a recirculating shift register type memory. In the latter, a large part of the storage may be placed on a magnetic disc or magnetic tape or the like with suitable read-out and write-in devices interconnected by conventional flip-flop shift registers. In the illustrated embodiment, the recirculating memory is a single closed loop of flip-flop shift registers including chips M28-M34, although provision for both serial and parallel read-out from certain portions of this memory is included as well be described hereinafter.

Information flow through the memory is under control of a system clock pulse train that is generated by a clock oscillator 126 and clock generator 128, interconnected by a line 127, at a frequency that will provide a single bit time of, for example, 1 microsecond. Obviously, clock rates and timing intervals may be varied as deemed necessary or desirable. Speeds of available circuits are more than adequate to handle all necessary information flow rates.

The function of the recirculating memory is to store status words identifying each weapon type, station and position address, and the status of the weapon at such an address, that is, whether the weapon is active or expended, for example. An exemplary status word format is shown in Table I. The storage of these status words is arranged so that when appropriate fire conditions (prerequisites) exist, as selected by the pilot, or as occurring in the system, a command word may be released from the recirculating memory and sent down the line to the several transceivers. That one of the transceivers which recognizes its own identification (station address) contained in the fire command word, arms a selected weapon and conditions itself for receipt of the fire pulse that automatically follows each command word that is sent down the line.

A command word is released from the recirculating memory along a command output line 128, from a NAND gate 130. Such command word is fed through the NAND gate 130 via a line 129 from the output of one section M34 of the recirculating shift register memory. NAND gate 130 is enabled by the high output (when in set condition) of a fire enable flip-flop 134. The latter is set by the output of a NAND gate 136, having a first enabling input via a line 137 from a NOR gate 138. The latter receives a first input on line 140 which input identifies a type of weapon selected by switch 141. The weapon type input on line 140 may be overridden by a priority override position command signal provided at the output of an AND gate 142 via position and station selector switches 144 and 146, respectively. When station switch 146 is in the "norm" position, one input to gate 142 is disabled and firing is effected by weapon type. The priority override of switches 144, 146 allows selection of a given position. The contacts of switches 141, 144, 146 and connected to the outputs of the illustrated decoders that have inputs from status word code bits for weapon type, position and station, respectively.

The pilot may desire to fire a particular weapon at a known position under various circumstances. For example, he may know such position has a hung ordnance that has been commanded to fire but has not actually fired. Alternatively, it may be known that a special type of weapon, such as a smoke flare for example, is located at a particular position. In any event, a first fire

condition signal is provided either by weapon type or priority override position to enable gate 136.

Additional command prerequisites or fire conditions, namely, conditions that must exist before a fire command word is released down the line, are provided by means of a NAND gate 148. When and only when all of the inputs to NAND gate 148 are true, a command enable input is fed via a line 147 to NAND gate 136 to thereby provide an output to set the fire enable flip-flop 134. This will release a command word to the command word output line 128. To ensure that any commanded firing pulse has been terminated before a second fire command word is released, gate 136 is temporarily disabled during such firing pulse by a third input on line 145.

A first condition input to gate 148 is a word position input on a line 149 which is derived from an end-of-word decoder 150 which produces an output signal whenever an end-of-word code of the circulating status words is recognized as existing in predetermined positions of the recirculating memory. Knowing the position of the status word in the recirculating memory, the status code bit or bits (only 1 bit is required if there are no more than two possible states) are sensed to provide on a line 152 a second input, the status input, to the fire condition gate 148. The status input is true only when the status code indicates that the store in the particular address of the given status word is active.

A third input to fire condition gate 148 is provided on line 153 as a quantity per salvo signal that is true when and only when the quantity of stores fired in any one salvo is less than that set into the salvo counter.

A predetermined quantity of units to be fired in a given salvo is selected by the pilot by operation of manual switches connected to output terminals derived from units and tens salvo quantity counters M47, M48 (FIG. 5c). Each fire enable signal from NAND gate 136 is sent as a counting input to the units counter M47, and when both units and tens counter reach the preselected count, a NOR gate 161 is enabled to set a quantity per salvo flip-flop 163. This flip-flop is normally reset to provide the quantity per salvo enabling input to gate 148 via line 153. The quantity per salvo flip-flop 163 is reset by the signal $\bar{P}$ (absence of pickle) that is provided from a pilot's pickle flip-flop 160 (FIG. 5a). Thus, the salvo flip-flop 163 is reset before a fire command or pickle signal is executed. When the pickle signal occurs it remains reset until the quantity counters M47, M48 indicate that the preselected numbers of weapons have been fired during the occurrence of the given pickle signal. With flip-flop 163 set, the enabling input on line 153 is removed and firing ceases.

A fourth input into the fire condition gate 148 is provided on a line 154 as an interval signal that is true only when a predetermined or preset interval (preset by the pilot) has elapsed since the last fire command word was released.

Where parity bits are included in the several words, a parity enable signal on a line 155 from a parity decoder 156 is a fifth input to the fire condition AND gate 148 and is true when the output of parity decoder 156 determines that predetermined parity of the particular status word exists.

Still another input to the fire condition gate 148, is provided on line 158 as the pickle signal. This is the signal derived from the true output of fire control flip-flop 160 when the latter is in set condition. The pilot's

pickle (fire control) switch 159 is spring actuated so as to normally rest in a position to provide a true input to the reset side of flip-flop 160 to thereby ensure the absence of a pickle signal. When the pilot depresses the pickle switch, a true input is provided to set the flip-flop and even through the pickle switch should be subject to severe bounce, the flip-flop is and remains set, acting as a self-latching switch.

When all of the conditions or inputs to fire condition gate 148 are true, whereby all inputs to NAND gate 136 are true, fire enable flip-flop 134 is set to enable the read-out gate 130, which whereupon releases a status word to the command output line 128. The word positioning of the end-of-word decoder 150 is so chosen that when the enable flip-flop 134 is set, the next bit of status word that is fed into output gate 130 is the first bit of the word.

With the fire enable flip-flop set, an enable signal is fed to a bit counter 162 that counts system-clock pulses. When counter 162 has counted a number equal to the number of bits in a word (19 in the illustrated embodiment), and end-of-command word signal is fed via an OR gate 164 to reset the fire enable flip-flop 134. If two or more weapons are to be fired (substantially) simultaneously bit counter 162 is (manually) set to count the bits in the desired number of command words so that a plurality of weapons will be armed and ready to receive the fire pulse that is sent to the transceivers after transmission of the chosen command word or words. The end-of-command word signal provided at the output of bit counter 162 is also sent via an OR gate 166 to provide a reset signal to reset an interval counter comprising serially connected counters 167, 168 and 169.

The interval counter provides an enabling input on line 154 for gate 148 either when both tens and hundreds counters 168 and 169 are set to zero (via manually settable switches 171, 173) or when a particular finite interval as determined by preselected position of switches 171, 173 has elapsed. The interval counter counts pulses received from clock oscillator 126 via a divider 175 and provides an output from the respective switches 171, 173 to an AND gate 177 that is fed together with the output of an AND gate 179 to an OR gate 181 to produce the elapsed interval signal on line 154.

8. Fire Pulse

As each fire command word is released down the line, it is recognized by the addressed transceiver station which thereupon arms that one of the weapon positions at such a station that is addressed by the particular command word. Having armed the weapon position, a fire pulse is thereupon sent down the line to fire the armed weapon. The fire pulse generating circuitry is triggered from the command enable signal that is provided at the output of fire conditioning gate 148. The output of the latter on line 147 is fed to trigger a one shot or mono-stable multivibrator 170 that provides a delay, such as 100 microseconds, for example. This delay is long enough to ensure that several command words may be sent out, head to tail, along the command output line 128, when the bit counters 162 is set to count several words. At the end of the delay of the fire one shot 170, a fire pulse one shot or mono-stable multivibrator 172 is triggered, having a delay period of the duration of the fire pulse itself. In an exemplary embodiment, this period of the second or fire pulse one

shot is about 15 milliseconds. When the second one shot is triggered, the fire pulse 183 is initiated and remains high until termination of the delay period of the second one shot. The fire pulse is fed through an AND gate 174 that is enabled by a true pickle signal. The output of this AND gate is fed via a line 185 as a third input to the OR gate 104 of the transmit control gating and thence through the line driver 106 down the line to the several transceivers.

In order to be sure that another fire command word is not sent down the line until the fire pulse is terminated, the output of the second one shot is inverted and fed via line 145 as a third input to AND gate 136 so that the latter is disabled whenever the fire pulse is high.

After the fire pulse has been sent down the line, another fire command word will follow, if the pilot still has the pickle switch depressed and a pickle signal still exists. If the pickle signal no longer exists, the system immediately returns to its test mode. The transmit control gating, in the absence of the pickle signal, now enables gate 100 (FIG. 5d) and disables gate 103 to allow the first word from the test word generator memory to be passed down the line and the next full test cycle commences. The first test word of this next test cycle was read from the test word generator memory into the line word register 96 during the preceding test cycle, while the last status word of such preceding test cycle was being read from the line receiver register into the recirculating memory. Thus, in the absence of the pickle signal, the test cycle starts again and when the first test word is returned as the first status word, the test word generator memory is advanced and the next test cycle continues as previously described.

9. Remaining Stores Display

Although many codes of mechanization of the display of active stores remaining in each of the various weapons types are possible from the formation contained in the command station, a preferred mechanization is illustrated in that portion of the diagram contained in FIGS. 5a and 5b. A plurality of coincidence gates 300, 302, 304, 306, each individual to a selected weapon type such as rocket, bomb, flare and ordnance, for example, are each fed with a first enabling input from the respective output terminals of the weapon type decoder switch 141. Thus, each time a status word representing a rocket passes through the recirculating register, gate 300 is enabled, for example. Each time a status word representing a bomb passes through the recirculating register, gate 302 is enabled. Similarly, gates 304 and 306 are enabled by status words for flare and ordnance devices, respectively.

A second input to each of the coincidence gates 300, 302, 304, 306 is derived from the fire or status bit signal on line 152 that is extracted from the status word at recirculating register section M32. Accordingly, if a status word includes a status bit indicating active or unfired state, and also identifies a particular weapon type such as rocket, for example, gate 300 provides an output which feeds a pulse to a units counter 308 having a carry input to a tens counter 310. Units and tens counters 308, 310, respectively, operate display lights in the remaining rockets display panel. Accordingly, there is a display provided of the total number of unexpected rockets. Similarly, gates 302, 304 and 306 provide outputs that trigger corresponding counters for numerical displays of bombs, flares and ordnance, respectively.

Counters 308, 310 and corresponding counters for bombs, flares and ordnance are reset by a signal on a line 312 from the output of a counter 314 (FIG. 5b). Counter 314 receives as its counting input an output from the end-of-word decoder 150, previously described, so that the counter 314 augments its count by a single unit for each full status word in the recirculating register. Counter 314 provides an output on line 312 when it has counted a number equal to the total number of status words in the recirculating register. Accordingly, when all of the recirculating words have been monitored by the coincidence gates 300, 302, 304 and 306, the remaining stores display will now display a correct number representing the number of stores remaining of the respective weapon types. When the counters 308, 310 and their counterparts for each of the other weapon types, are reset by the signal on line 312, they again begin to count active weapons of the several types.

Even though the remaining stores display counters are reset after each complete recirculating cycle, the persistence or delay inherent in the display devices operates as a short-term memory sufficient to provide the pilot with the maximum counted information. If such "memory" is not considered to be adequate, the connection between the units and tens counter 308 and 310 and the display devices may be temporarily disabled upon occurrence of the reset signal so that the number contained in such display will not immediately be changed by resetting or by several succeeding counts. This may be achieved by a suitable delay and gating not shown in the drawings.

10. Transceiver Details

FIG. 6 illustrates details of an exemplary transceiver unit of the type shown in FIG. 4. As previously described, the transceiver unit receives a digital data (test or command) word from the transmission line, conditions it and executes the data function contained in the word. In addition, the transceiver will assemble a data word (the status word) to be transmitted and returned to the pilot information command station for processing.

Serial data words comprising a series of asynchronous bits are sent down the transmission line 37 from the pilot information command station. The data words are transmitted through an attenuating resistor R, via a line 187, to an input register 188, 190. The data words are also fed through resistor R, and thence, to a clock regenerator 180, comprising a pair of differential amplifiers 181, 182, each of which has one of its differential inputs connected to a plus or minus source of potential, as indicated, and each of which has the other of its inputs connected to receive the serial bits of the data word. The amplifier outputs are fed through a NOR gate 184 and, thence, through a normally enabled NAND gate 186 to provide a clock signal for the transceiver. The clock pulses from the clock regenerator are employed to clock the input shift register 188, 190 which has serial inputs and both serial and parallel outputs. This transceiver input register may be conveniently made up of several sections of the previously described shift register chips employed for memories and registers of the pilot information command station.

An end-of-word decoder 192 senses occurrence of the last four end-of-word code bits of the command or test words and generates a signal which is sent via a line 193

to disable the normally enabled NAND gate 186 that feeds the regenerator clock pulses to the transceiver. Thus, the data word has been clocked into the input register and remains there until the transceiver receives another command or test word.

A manually controllable station number rotary switch 194 has its movable arm 195 set to a particular one of its contacts that identifies the station number associated with the individual transceiver. The several station number contacts are connected with a station decoder 196 having inputs from the three bits that form the station code of the word retained in the input register. Accordingly, when the station code of the command or test word matches the preset identification of station established by the switch position, a station ID signal appears on a line 197 as a first enabling input to each of three coincidence NAND gates 198, 199 and 200. The exemplary transceiver shown in FIG. 6 is adapted for operation of three different weapon positions. It will be readily appreciated that any given transceiver may be readily adapted to operate more or less than three different weapon positions by suitable changes in the number of gating and related circuits.

A position decoder 202 senses the three position bits of the command or test word and, depending upon which position is identified by the code, provides a position enabling signal on that one of its output lines that is connected to enable that one of the coincidence gates 198, 199 and 200 that is arranged to arm the chosen position.

A function decoder 204 is connected to sense the bits in the function code of the command or test word, and provide as its output on a line 205 a signal having one state or the other to evidence either fire or test respectively. If the output of the decoder 204 evidences a fire function (e.g., a command word has been recognized), a first input of a fire coincidence gate 206 is enabled. Where parity decoding is employed, gate 206 will operate only in the presence of a true parity signal from a parity decoder 208 having inputs connected to sense the several parity bits of the test or command word. The output of the fire gate 206 is fed as a third enabling input to all of the position coincidence gates 198, 199 and 200. Accordingly, upon recognition of (a) the given station code, (b) the fire function and, (c) true parity, all of the gates 198, 199 and 200 are disabled ("armed") whereby that one selected by an output of position decoder 202 will pass a signal to the base of an associated one or driving transistors 210, 211 and 212.

Firing transistors 214, 215 and 216 are provided, individual to each of the firing squibs or firing resistors F_1 , F_2 and F_3 of the respective weapons at the several positions. The firing squibs F_1 , F_2 and F_3 are shown as resistances only for purposes of exposition. These are the actuated elements of the remote stations and may be relays, solenoids or the like, or other firing or weapon release mechanisms as appropriate for the weapon employed. Each firing transistor 214, 215 and 216 is connected in series with a firing resistor F_1 , F_2 and F_3 and with the transmission line 37. When a fire pulse 183 is received, having a level of 28 volts, for example (unattenuated by the resistor R), it will be passed via fire pulse line 209 through one and only one of the firing transistors 214, 215, 216 depending upon which has been energized by an arming signal fed to its

base by an associated one of the driving transistors 210, 211, 212.

The several circuits need not be reset since each receives and responds to succeeding incoming signals. Alternatively, reset of the transceiver circuits at each data word reception may be provided by a word beginning code that is recognized by a decoder (not shown) in the transceiver to provide a brief transceiver resetting signal at the beginning of each word sent down the line.

Accordingly, the selected weapon has fired and the transceiver input register 188, 190 awaits the next command or test word. If the next word is a second command word, the above-described procedure is repeated for the particular weapon position addressed by such next word. This cycle may continue until all weapons at the given station have been fired or until a selected number of weapons at the station or at other stations have been fired. Now, if the next data word is a test word, the above-described operations relative to response to a command word will occur with the exception of the function decoder output and firing circuit operations. For a test word, the function decoder output will not enable the fire enable gate 206, wherefore none of the firing transistors 214, 215, 216 will be turned on. Further, no fire pulse will be sent down the line, although no firing would occur even if such pulse should occur inadvertently. The system will not fire a weapon unless a given position is first armed by a command word.

The output of the function decoder in the case of a test word will be transmitted through a coincidence gate 220 which receives as its second input a signal representing true parity. Accordingly, if parity exists and the data word function code is test, a test enable signal appears on a line 221 to provide an enabling input to a test coincidence gate 222. The second input to gate 222 is provided from a NOR gate 224 that receives the outputs of three coincidence gates 226, 228, 230. Each of the latter has a first enabling input on line 197 from the station enable signal provided from the station switch arm 195. A second enabling input is provided to that one of the gates 226, 228, 230 which is associated with the position identified in the position code of the test word. This second enabling input is from the outputs of position decoder 202. The third input to each of gates 226, 228, 230 is provided as a continuity circuit to ground through a respective one of the firing squibs or resistors F_1 , F_2 , F_3 . This third input provides the weapon status sensing and generates for the system the indication of the state of the weapon. If the weapon has not been fired and is in an active state, a continuity signal is provided to the respective gate. If the weapon has been fired, no such signal is provided. Accordingly, the output of the coincidence gate 222 provides a weapon status signal for the weapon in the position identified by the position code of the test word, and which position is at the station identified by the test word station code.

The output of function decoder 204, when a test word is contained in the input register 188, 190 is also fed, after a delay in a circuit 231, to enable a local clock oscillator 232 comprising a NOR gate 234 feeding a NOR gate 236 and having a resistance-capacitance feedback network as indicated. When enabled, the local clock oscillator 236 provides a clock input to a transceiver output register 238, 240 which is

of the parallel in serial out type. The clock input causes a status word in this register to be clocked out bit by bit and transmitted from the transceiver to the command station.

The status word clocked out of register 238, 240 is assembled during the state sensing carried out in response to this test word. The output register is the data assembler of the transceiver. It is employed to assemble and format the transceiver status word. Station and position coding are transferred from station and position coding of the input register 188, 190 directly to appropriate positions of the output register when the parallel inputs to this register are enabled by the clock enable signal on line 239 (without delay).

A weapon type encoder 242 has a weapon type code indicative of a particular type of weapon, such as bomb, rocket or the like, set into it by means of a manual switch 244 so that a particular station and transceiver can be coded to identify the weapon type that has been loaded at such station. The weapon type encoder, having connection to the status word bit positions that represent weapon type provides this coding for the status word. Similarly, a parity code generator 246 and an end-of-word code generator 248 provide inputs to the output register to insert the corresponding parity and end-of-word code information therein. The output of coincidence gate 222 is employed to establish the bit representing status. Only a single bit is required where only two states are available.

As previously noted, the output of parity decoder 208 is fed to the coincidence gate 220 together with the test function output of decoder 204. The parity decoder output is also fed into the output register 238, 240 to indicate existence of a parity error. If the parity bit indicates that a test word received by the transceiver is in error, the parity decoder 156 (FIG. 5b) connected with the recirculating memory will prevent enabling of the fire condition gate 148. Further, if deemed necessary or desirable, additional circuitry (not shown) may be provided to repeat transmission of an erroneous test word. However, the continuing and repetitive test cycles of the test word generator, requiring only about 30 milliseconds or less per full cycle, will repeat this erroneous word in the next test cycle.

11. Transceiver Power Supply

The data word pulses, comprising a train of positive going and negative going 15 volt pulses (having been attenuated by resistor R) have their positive going portions fed through a diode 250 to charge a storage capacitor 252 that has its maximum charge value limited to the selected transceiver supply voltage level by a zener diode 254. The transceiver supply, at the function of diode 250 and capacitor 252, is fed to provide electrical power to all of the transceiver circuits. The data bits have sufficient magnitude and energy content to operate the describing processing circuits and also to charge capacitor 252 and maintain such charge. If deemed necessary or desirable, the discharge time (the RC time constant) of the energy storage circuit is made greater than the length of a single test cycle so that if words of a first test cycle are unacceptably attenuated by a completely discharged storage capacitor, the test cycle is repeated before the capacitor is again discharged.

TABLE I

Status Word	Command Word	Test Word
1 Station	Station	Station
2 Parity	Parity	Parity
3 Position	Position	Position
4 Parity	Parity	Parity
5 Weapon Type	Weapon Type	Random
6 Parity	Parity	Parity
7 Status	Function (Fire)	Function (Test)
8 Parity	Parity	Parity
9 End of Word	End of Word	End of Word

The foregoing detailed description is to be clearly understood as given by way of illustration and example only, the spirit and scope of this invention being limited solely by the appended claims.

What is claimed is:

1. In a system having a plurality of weapon stations and at least one multistate weapon device at each station,

A. means for testing said devices to detect the state thereof,

B. means responsive to said testing means for generating status words each including information denoting the state of one of said devices,

C. storage means responsive to said status word generator for storing said status words,

D. means for extracting from said storage means a status word corresponding to one of said devices having a preselected state, and

E. means responsive to said extracted status word for actuating said one device to change its state.

2. The system of claim 1 including means for including in each status word information designating a classification of the device whose state is denoted thereby, said means for extracting a status word from said storage means including means for extracting words corresponding to devices of a selected classification and selected state.

3. A control system for changing the state of one or more of a group of multistate aircraft weapon devices, said control system comprising

A. a remote station including

1. actuator means for effecting a change of state of one of said devices,

2. state sensor means for sensing the states of said devices and transmitting status words each including a representation of the sensed state of a device,

B. a command station comprising

1. sensor command means for generating test words,

2. means for transmitting said test words to said state sensor means to actuate said sensor means and cause transmission of said status words,

3. a command status memory for receiving and storing status words transmitted from said state sensor means,

4. means for selecting a word having a predetermined state from said command status memory, and reading out the selected word as an actuator word, and

5. means for transmitting said actuator word to said state change actuator means to effect a change of state of one or more of said multistate devices.

4. The control system of claim 3 wherein said command station includes means for establishing a state change command prerequisite, and wherein said means for reading out a selected word includes means responsive to both said means for selecting a word and to said means for establishing a prerequisite.

5. The system of claim 3 wherein each said actuator word, test word and status word includes an address identifying a unique one or group of said multistate devices, and wherein said remote station includes means for identifying a unique address in each transmitted actuator and test word and for controlling state change or state sensing respectively of the device or group of devices uniquely identified by the actuator or test word address.

6. The system of claim 5 including a single communication channel interconnecting said remote station and said command station, and wherein at least a group of said words is transmitted between said command and remote stations along said single communication channel.

7. The system of claim 6 wherein all of said actuator words are transmitted to said remote station through said single channel of communication.

8. The control system of claim 6 wherein all of said test words are transmitted to said remote station through said single channel of communication.

9. The control system of claim 6 wherein all of said status words are transmitted from said remote station through said single channel of communication.

10. The control system of claim 6 wherein said single channel of communication comprises a single electrical current path interconnecting said remote and command stations.

11. The control system of claim 3 wherein said remote station comprises a plurality of remote substations each having a transceiver and each having a plurality of multistate devices of a predetermined type, each remote substation transceiver comprising a state change actuator means for changing the state of a selected device at the associated remote substation and state sensor means for sensing the state of selected devices at the associated remote substation, each said transceiver further including means for identifying a unique address contained in an actuator or test word that uniquely identifies the associated remote substation and selecting and uniquely identifying one of the devices at said substation that is uniquely identified by the actuator or test word.

12. The control system of claim 11 wherein each transceiver includes means for including in each status word generated thereby a type code uniquely identifying fixed characteristics of devices at the associated substation, and wherein said status selection means at said command station includes means for selecting from said command status memory a word having a preselected type code, whereby devices of a particular type may be selected for actuation.

13. The system of claim 12 wherein said command status memory includes priority override means for selecting a word from said command status memory which word has an address code identifying a unique address of a unique remote substation, said priority

override means including means for overriding operation of said type code selecting means.

14. The control system of claim 11 wherein said command station includes means responsive to status words transmitted from said remote stations for providing a display of the state of each of a plurality of said devices.

15. The apparatus of claim 11 including a command actuator memory for storing actuator words transmitted from said command status memory, and means responsive to status words transmitted from said remote station for comparing the state of said multistate devices with the state of devices whose state is commanded to be changed by actuator words transmitted from said command status memory, and means responsive to said means for comparing for providing a failure to actuate signal that indicates one of said devices has failed to properly change its state in response to a change of state command embodied in an actuator word transmitted from said command status memory.

16. The control system of claim 11 wherein said command station includes means for establishing state change prerequisites, and wherein said means for reading out a selected word includes means responsive to both said means for selecting a word and to said means for establishing prerequisites.

17. The control system of claim 16 wherein said remote stations are armanent stations of an aircraft and wherein said multistate weapon devices are ordnance devices each having an active state in which state the ordnance may be fired and having an expended state that exists after firing of the ordnance, wherein said command station is accessible to the pilot of the aircraft, and wherein at least a plurality of said state change prerequisites may be manually established by the aircraft pilot, and wherein one of said state change command prerequisites is a pickle signal that commands firing.

18. The control system of claim 17 wherein said state change command prerequisites comprise at least one of the following conditions

- A. a predetermined timed interval has elapsed since the previous firing,
- B. a predetermined quantity of ordnance has not been fired since the beginning of a presently command salvo of firing,
- C. an ordnance of a preselected type exists in an active state at one of said remote substations,
- D. an ordnance exists in an active state at a preselected position of a preselected substation,
- E. a pickle signal exists.

19. The control system of claim 18 including means responsive to said command status memory for providing a display of quantities of ordnance of different type remaining in active state at said remote stations.

20. The control system of claim 5 wherein each said actuator word includes an actuator pulse, and wherein each state change actuator includes means for transmitting said pulse to effect a change of state for one of said devices identified by the actuator word address.

21. The control system of claim 5 wherein each said actuator word includes an actuator function code and an actuator pulse and wherein each state change actuator includes decoder means for recognizing said actuator function code and means responsive to said decoder means for transmitting said actuator pulse to effect

change of state of one of said devices identified by the actuator word address.

22. The control system of claim 5 including timing means for controlling said sensor command means and said command status memory, said timing means including means for disabling reading from said command status memory during a period including the transmittal of a test word from said command station and during the subsequent transmittal of a status word in response to such test word.

23. The control system of claim 22 wherein said timing means includes means for transmitting a plurality of test words during said period, and receiving at said command station a plurality of status words in response to respective ones of said transmitted test words, said command status memory including means for writing said plurality of status words therein during said period.

24. A weapon control system comprising

- A. a command station comprising means for transmitting a data word having information coded therein in the form of data bits,
- B. a communication channel connected at one point to receive data words transmitted from said command station, and
- C. a remote weapon station connected to another point of said communication channel to receive data words transmitted from said command station, said remote station including
 1. means for processing information contained in a data word received by said remote station, and
 2. power supply means for supplying energizing power to said information processing means, said power supply means comprising
 - a. storage means responsive to data words received from said communication channel for storing electrical energy contained in said data words, and
 - b. means responsive to said storage means for supplying said electrical energy from said storage means to said means for processing information.

25. The control system of claim 24 wherein said remote station includes a plurality of substations, wherein each said data word includes an address unique to at least a given one of said remote substations, wherein each said substation includes recognition means for recognizing a unique address code in a received data word and for providing a station identification signal and wherein said storage means includes means for supplying electrical energy to said station address recognition means.

26. The control station of claim 25 wherein at least one of said substations includes a weapon device adapted to be actuated by an actuator signal and wherein said command station includes means for sending an actuator signal through said communication channel in sequence with a transmitted data word, said information processing means including means for enabling said device at said one substation so that it may be actuated by an actuator signal received by said one remote substation.

27. The control system of claim 26 wherein the amplitude of said actuator signal transmitted through said communication channel is substantially equal to the amplitude of the data word pulses transmitted through said communication channel, each said substation in-

cluding means for attenuation received data word pulses, whereby an actuator signal having a relatively high energy level is fed to actuate said device and data pulses of relatively low energy level are received by said transceiver data processing means and said transceiver power storage means.

28. The method of selectively changing the states of a plurality of multistate weapon devices at a remote station comprising the steps of

- A. sending a plurality of test words to each of said remote stations through a communication channel, each said test word including a station address and a test function code,
- B. receiving each test word at each remote station and enabling a particular one or more of said stations identified by the test word address code,
- C. determining the state of a device at a station enabled by an identified address code in response to a received test word test function code, and transmitting from such station through said communication channel a status word including an address unique to such transmitting station, said status word also including a status code representing sensed state of the device at the station enabled by the address code,
- D. storing status words from said remote stations in a command status memory,
- E. extracting from said command status memory a status word having an address code, an actuate function code and a preselected status code,
- F. transmitting said extracted status word through said communication channel to said remote stations, and
- G. changing the state of a device at one of said remote stations in response to receipt of a transmitted status word having the address code of such station.

29. The method of claim 28 including the step of transmitting an actuator signal through said communication channel after transmission of a status word extracted from said command status memory, and employing said actuator signal to change the state of a device at the station whose address is identified by the address code of the command status word received by such station.

30. An armament information and control system comprising

- A. a command station comprising
 1. a test word generator for generating said transmitting a plurality of test words each having an address code and a test function code,
 2. a command status memory for receiving and storing status words each having an address code and a device status code,
 3. command enable means for extracting a status word from said command status memory having a preselected device status code, said extracted status word comprising a command word,
 4. means for transmitting said extracted command word from said command station,
- B. a plurality of remote stations each including
 1. means for receiving a command word transmitted from said command station,
 2. a multistate weapon device,
 3. station identification means for recognizing the address code of a command word received by the remote station,

4. actuator means for effecting a change of state of the device,
5. sensor means for determining the state of the device,
6. function decoding means for selectively enabling the actuator and sensor means,
7. means for enabling said remote substation in response to said station identification means,
8. means responsive to said sensor means for assembling a status word including an address code and a status code representing the state of the device,
9. means for transmitting the status word from said remote station to said command station,
10. C. a communication channel connecting said command station with all of said remote stations, each said test word and command word being transmitted from said command station to all of said remote stations through said communication channel and each said status word being transmitted from respective remote stations to said command station through said communication channel.
15. 31. The system of claim 30 wherein said command station includes timing means for causing said test word generator to transmit a plurality of test words one after the other and for causing a status word transmitted from a remote station to be entered into said command status memory after each test word is transmitted from said command station, said timing means including means for causing the test words transmitted from said command station through said communication channel to alternate with status words transmitted from said remote stations through said communication channel.
20. 32. The control system of claim 31 wherein said command station includes means for generating an actuate pulse after the extraction from said command status
25. 33. The control system of claim 32 wherein said command station includes means for displaying the status of devices at each of at least a group of said remote sub-
30. 34. The control system of claim 33 wherein said command station includes means for storing command words extracted from said command status memory for transmission from said command station, and means for comparing
35. a. the status of devices at said remote stations, as represented by said status words transmitted from said remote stations after transmission of a command word with
40. b. the status of the device represented by such extracted command word, thereby indicates whether or not the commanded change of state occurred.
45. 35. The control system of claim 33 including means for counting and storing the total of all words in the command status memory having a preselected status.
50. 36. The control system of claim 31 wherein each said remote station includes energy storage means for receiving and storing electrical energy contained in said command word test words transmitted from said command station through said communication channel, said remote station actuator means, sensor means, station identification means, decoding means, and status word assembler means, each comprising electronic circuits, said power storage means including means for providing operating power to at least one of said electronic circuits of the remote station.
55. *
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65. *

memory of a predetermined number of command words, and means for transmitting said actuate pulse to said remote stations after transmittal of said predetermined number of command words.

33. The control system of claim 32 wherein said command station includes means for displaying the status of devices at each of at least a group of said remote sub-

stations.
34. The control system of claim 33 wherein said command station includes means for storing command words extracted from said command status memory for transmission from said command station, and means for comparing

a. the status of devices at said remote stations, as represented by said status words transmitted from said remote stations after transmission of a command word with

b. the status of the device represented by such extracted command word, thereby indicates whether or not the commanded change of state occurred.

35. The control system of claim 33 including means for counting and storing the total of all words in the command status memory having a preselected status.

36. The control system of claim 31 wherein each said remote station includes energy storage means for receiving and storing electrical energy contained in said command word test words transmitted from said command station through said communication channel, said remote station actuator means, sensor means, station identification means, decoding means, and status word assembler means, each comprising electronic circuits, said power storage means including means for providing operating power to at least one of said electronic circuits of the remote station.

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UNITED STATES PATENT OFFICE
CERTIFICATE OF CORRECTION

Patent No. 3,803,974 Dated April 16, 1974

Inventor(s) Charles E. Everest; Henry P. Voznick

It is certified that error appears in the above-identified patent and that said Letters Patent are hereby corrected as shown below:

In the claims, claim 30, Column 24, line 49, the word "said" should be -- and --.

Signed and sealed this 24th day of September 1974.

(SEAL)
Attest:

McCOY M. GIBSON JR.
Attesting Officer

C. MARSHALL DANN
Commissioner of Patents